Abstract Book

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Selección de una cartera de inversión utilizando el método ELECTRE III
Claudia Peretto; Leticia Tolosa; Tomas Barbaroy; María Gracia Frascaroli

December 12, 2022 (Monday), 09:00 - Room 1101

El objetivo del trabajo es aplicar el método ELECTRE III para seleccionar acciones de empresas a incluir en una cartera de inversión. Los métodos ELECTRE (Elimination et Choix Traduisant la Realite) se basan en las relaciones de superación, que pretenden identificar si existe o no una relación de dominancia entre dos alternativas. Si bien se han desarrollado diferentes versiones del método ELECTRE, se propone utilizar el método ELECTRE III, que utiliza pseudo-criterios para la construcción de relaciones de superación difusas y permite obtener un ordenamiento de las alternativas. La metodología consiste en estimar índices de concordancia, de discordancia y de credibilidad, para llegar a un ordenamiento completo. Los datos a utilizar corresponden a empresas, no bancarias, listadas en el S&P MERVAL (Argentina), para los años 2018-2019-2020. Se considerarán como criterios las variaciones de precios anuales obtenidas por las empresas en el mercado y los indicadores contables de liquidez, solvencia, rentabilidad del Patrimonio Neto y estructura de capital de las mismas. Con respecto a las preferencias de los analistas financieros e inversores, se asigna una ponderación del 0,5 al Índice de Rentabilidad, dado que están interesados en el rendimiento y esperan maximizar en sus carteras activos rentables. Las variaciones de los precios de las acciones en el mercado, se ponderan con 0,20. La estructura de capital de la empresa puede condicionar el rendimiento de las acciones por su influencia sobre la liquidez y la solvencia, por lo que cada uno de estos aspectos recibe una ponderación de 0,10. En los resultados obtenidos con este enfoque multicriterio, se observa que la conformación de la cartera sugerida, en cada año seleccionado para la muestra, no es la misma, aunque hay coincidencia en las empresas que ocupan los primeros lugares. Se exploran, las razones que explican la selección de acciones en cada período en función de las variables consideradas.

Keywords: RED-M; ELECTRE III; selección de cartera; índice S&P MERVAL

Prioritization of FICs taking into account multiple criteria for the constrction of efficient portfolios
Eduar Fernando Aguirre Gonzalez; Pablo Cesar Manyoma Velasquez; Diego Fernando Manotas Duque

December 12, 2022 (Monday), 09:00 - Room 1101

Alternative investments have been vital in large investment portfolios worldwide, especially in emerging countries. Likewise, due to the lack of structured information on this type of investment, the large portfolios of institutional entities such as pension funds and trust funds have taken the position of investors with end and not means objectives. That is to say, it does not guarantee profitability, but rather it depends on the performance of these investments. That is to say, it does not ensure profitability but instead relies on the performance of these investments. We find a particular type of "speculative" collective portfolio called Collective Investment Funds, FICs (acronym in Spanish: Fondo de Inversión Colectiva). This type of investment sees a higher return by including alternative investments in isolation or as part of a portfolio composed of traditional assets. Hypothetical collective portfolios are those whose main objective is to carry out speculative operations, including the possibility of carrying out operations for amounts more significant than those contributed by the investors (leverage). FICs are any mechanism or vehicle for raising or managing sums of money or other assets with the contribution of a plural number of people that can determine once the fund

becomes operational. In addition, it will manage the resources collectively to obtain collective economic results. Considering the above, the objective of this research is, through a combination of methodologies for multicriteria decision making (MCDA) and Borda's approach, to generate a ranking that allows the prioritization of these in the conformation of optimal portfolios for this type of investment in Colombia.

Keywords: RED-M; Efficient frontier; Portfolio Optimization; MCDA; Prioritization

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Multi-criteria hesitant sorting of projects in a brazilian electrical power company

Javier Pereira; Elaine Oliveira; Danielle Morais; Luciana Alencar; Ana Paula Costa

December 12, 2022 (Monday), 09:00 - Room 1101

Electrical power companies use to handle project portfolios by decision processes featured by multiple and conflicting criteria, sources of imperfect information, and stakeholders with different points of view and unstable preferences. Although different multi-criteria decision making/aiding (MCDM/A) methods may be applied, few approaches consider sorting methods to better allocate strategic resources, depending on each project categorization. In this work, a group-decision approach based on the ELECTRE TRI-C multi-criteria sorting method is proposed which includes the following features: 1) several decision-makers are considered and a decision analysis process is run for each of them; 2) hesitant fuzzy sets are used to aggregate the characteristic preference functions and criteria weights elicited from each decision-maker; 3) robustness analysis is run, both at the individual and aggregated levels; 4) a voting procedure is proposed to draw up a recommendation. The application in a Brazilian company is presented. Contributions of our approach are: 1) lower cognitive effort as compared to other hesitant fuzzy sets based approaches; 2) analysis performed for each decision-maker, without interfering with every individual process; 3) a group decision-making approach that may include heuristics proposed by the managers themselves; 4) the approach enables the managers to identify the projects surely assigned into each category, but also the candidates where ambiguity exists.

Keywords: RED-M; Multi-criteria; Group-decision; ELECTRE TRI-C; Hesitant Fuzzy Sets; Robustness analysis

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Management team classification by competencies: A case study in the civil construction sector

Camila Campos Gómez Famá; Luciana Hazin Alencar; Joseph Hakkinen Alves Santos

December 12, 2022 (Monday), 09:00 - Room 1101

There is a growing industry awareness of the relationship between achieving project success and project management competencies. Successful construction organizations focus on ensuring that project managers acquire the essential competencies needed to be effective in their assignments. Managers can perform better if their competencies and personal characteristics meet the demands of the position. Studies highlight the leadership capabilities of managers in terms of administrative skills for project success within an organization. However, individual team member competencies are presented in separate areas. This research sought to carry out a classification of teams of managers by competencies from a case study in the construction sector. The case study was carried out with a small company located in the Brazilian northeast that operates in the segment of construction of high standard houses. The decision maker (DM) chose the following positions as the most relevant among the company's employees: Senior Manager; Works Manager; Administrative Manager. It was found that the competencies considered most important for the management team were: Teamwork, cooperation and communication; Initiative; Analytical thinking; Technical knowledge; Team leadership; Success orientation; Impact, influence and negotiation; Self-control. In order to assess the managers' competency level who represent the alternatives to be classified in the chosen positions, the performance of the three company employees who held these posts was then evaluated. The answers to the questionnaire reveal how well each manager is able to exercise the competencies that the DM considers the most important. The classification was performed using an outranking method for nominal classification by comparing the competencies of each manager with an ideal vector for each position. Based on the results, the main competencies gaps of each manager are

identified and measures are proposed to carry out their training.

Keywords: RED-M; competencies; managers

Diseño de una red de distribución a través de un modelo de localización e inventario multiescalón con múltiples productos, múltiples periodos y tiempos de entrega definidos en la red.

Javier Arias-Osorio; Carlos Poches; Natalia Tarazona

December 12, 2022 (Monday), 09:00 - Room 1208

Hoy en día, los investigadores han dado importancia al desarrollo de problemas de inventario de cadena de suministro basados en múltiples escalones más acorde a la realidad. Considerando una sincronización en la gestión de los inventarios a lo largo de una cadena de suministros, donde cobra importancia el tiempo de entrega de un nivel a otro y el almacenamiento de diferentes productos en los diferentes niveles. En esta investigación se diseña un modelo de inventario multiescalón con múltiples productos y con demanda conocida y variable por periodo, teniendo en cuenta tiempos de entrega y donde las variaciones a las características del modelo permiten analizar las implicaciones en las decisiones logísticas relacionadas con el diseño de una red de distribución. Para esto, el crecimiento del modelo es presentado formulando cuatro modelos, cada vez más robustos. En particular en esta investigación se analiza la consideración de especializar o no los centros de distribución, como un elemento importante en la aplicabilidad del modelo en cadenas de suministro multi-producto y considerando costos asociados a la localización del centro de distribución y los costos de mantenimiento del inventario en él.

Keywords: Diseño de la red de distribución; modelo de optimización; localización e inventario multiescalón; multi-item; multi-periodo

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Elevators and bikeways network design problem considering the preference of users

Pablo Torrealba-Gonzalez; German Paredes-Belmar; Gabriel Gutiérrez-Jarpa

December 12, 2022 (Monday), 09:00 - Room 1208

Passenger transport in cities requires clean modes to reduce contamination emissions and pollution. One of the alternatives is combining elevators and bikeways for a transportation network, especially in geographic areas with hills and mountains. This research presents two models for the intermodal network design problem considering elevators and bikeways. The two objectives of the problem are the minimization of the total construction cost and the maximization of the passenger capture. Also, we include the passenger's preferences to identify potential transportation routes. We use a branch-and-cut approach to solve the problem, and we apply this methodology to a real-world instance in the city of Valparaíso, Chile.

Keywords: Network Design; Branch and Cut; Multiobjective

An analysis of Argentine’s railway infrastructure in the soybean supply chain operation

Milagros Verrengia; Aldo Vecchietti

December 12, 2022 (Monday), 09:00 - Room 1208

Argentina has increased 52% of CO2 emissions (GHG) between 1990 and 2016, and they are projected to grow significantly, around 30-37% above 2010 levels, by 2030. With 27%, the transport sector is the largest contributor, followed by electricity and heating generation as well as the industrial sector, with 26% and 28%, respectively. In this context, the soybean production in Argentina, which average about 53 million tons per year, is the most important crop grain production ranking 1st in the country. The soybean complex is the main export chain in the country surpassing the cereal and the automotive chain. Around 83% of the transportation of soybeans from harvest to factories is carried out by trucks, generating about 3 million annual trips, only for this product. To reduce the GHG emissions produced by the transport sector of this supply chain (SC), it is important to analyze some

alternatives, in particular the infrastructure of the railway system in Argentine where exists some installed capacity which is not used and that can be exploited, but it is necessary to invest money to maintain and renew the infrastructure. For this reason, this paper presents a mathematical model of the soybean supply chain for Argentina where the different actors and the flows of materials among them are formulated. The goal is to perform an analysis of the cargo railway system, considering different investment alternatives in the infrastructure, with the objective of increasing the transportation via this media to reduce the GHG emissions produced by the operation of the SC. The proposed model is a multi-period/multi-objective mixed integer linear one, aimed at minimizing the operating costs and GHG emissions. The results show the trade-off between costs and emission reduction, where it is possible to achieve up to 20% GHG reduction at a reasonable cost. The proposed model is an important tool to improve the economic, social, and environmental aspects of the soybean supply chain.

Keywords: soybean; supply chain; emissions; transportation; railway.

Comparison of radiotherapy planning optimization models including dose-volume constraints
Daniela Cantane; Juliana Freitas; Helenice Florentino Silva; Thalita Obal

December 12, 2022 (Monday), 09:00 - Room 1209

Radiotherapy is an option for cancer treatment, where ionizing radiation is emitted from the linear accelerator (LA) to planning target volume (PTV). The goal is to deliver dose as maximum as possible to the PTV and avoid high dose in surrounding tissues (OAR). The LA can rotate on a gantry around the patient emitting radiation in order that the dose is well distributed in PTV. Optimization models are used to assist radiotherapy planning process, and two frequently applications are fluency map optimization (FMO) and beam angle optimization (BAO). The BAO determines the number and the values of the gantry angles and the FMO consists in calculate the radiation intensity for each beam angle. Both problems could be incorporated in the same mathematical model and solved using matheuristic methods, where firstly BAO is solved by a metaheuristic, and then the FMO is solved by an exact method. In order to verify the planned treatment acceptance, dose-volume histograms are analyzed, considering the dose limitation for each tissue. To improve the dose by volume verification, studies have recently proposed that dose-volume constraints should be integrated in the optimization models. In this work two optimization models are compared, and the methodology is applied in a prostate cancer case using data provided by Common Optimisation Dataset for Radiation Therapy (CORT), available for research purpose. The models are implemented in Python, where Variable Neighborhood Search is used to solve BAO and Interior Point Method to solve FMO. Results show that each model selects a different beam set and, consequently, the objective function values are different. Also, the computational time to solve the models vary according its characteristics. Dose from each tissue and obtained dose-volume histograms are compared. The decision maker can decide which solution is better to be incorporated in the planning routine, considering the treatment plan specifics.

Keywords: Applied Mathematics in Healthcare; Nonlinear Optimization; Variable Neighborhood Search; Interior Point Method

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Análisis de estrategias para el control del patosistema Diaphorina citri - HLB
Camilo Velez; Doris Campo; Lilian Sepulveda

December 12, 2022 (Monday), 09:00 - Room 1209

Los cultivos de árboles de cítricos se han visto afectados por la propagación de la enfermedad Huanglongbing (HLB), una infección bacteriana causada por tres diferentes especies de proteobacterias Candidatus Liberibacter, que se transmiten por el vector conocido como Diaphorina citri Kuwayama. El HLB causa que los árboles infectados presenten pérdida de las hojas, clorosis y maduración irregular en los frutos, además de acortar su esperanza de vida, destruyendo los árboles en un periodo aproximado de 5 años. Al momento de entrar en contacto con el hospedador, la enfermedad se dispersa por toda la planta antes de presentar síntomas o indicios de contagio, generando una identificación tardía y aumentando el riesgo de presencia en todo cultivo. En este trabajo se pretende comparar diferentes estrategias de control para el patosistema D. citri – HLB.

Para ello se usará un modelo matemático, basado en ecuaciones diferenciales ordinarias, que describe la dinámica del patosistema enfocándose en las interacciones del vector con los árboles donde la enfermedad esté presente sin mostrar síntomas y también con aquellos que sí los desarrollaron. Se realizará un análisis cualitativo para determinar sus puntos de equilibrio y su estabilidad, luego se incorporaran variables de control que permitan analizar estrategias dirigidas a:

1. disminuir la población del vector como por ejemplo: aplicación de insecticida y el uso de trampas,

2. erradicación de árboles infectados asintomáticos y sintomáticos.

Dado lo anterior, esta investigación está enfocada en aportar diferentes estrategias óptimas que ayuden a mitigar el riesgo de propagación de la enfermedad en los cultivos cítricos con el fin de evitar pérdidas económicas en la agricultura de cítricos y promover la vida productiva de los árboles.

Keywords: Patosistema Diaphorina citri - HLB; Ecuaciones diferenciales; Modelación matemática

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Modelo matemático para el manejo óptimo del Psílido Diaphorina Citri

Doris Campo; Lilian Sepulveda

December 12, 2022 (Monday), 09:00 - Room 1209

Una de las plagas que genera mayor destrucción de árboles cítricos en el mundo es el Psílido asiático Diaphorina citri Kuwayama, que en estado adulto es vector de la bacteria Candidatus Liberibacter agente causal de la enfermedad Huanglongbing (HLB). El Psílido ha estado presente principalmente en países donde se plantan grandes extensiones de cultivos cítricos tales como EEUU, Asia y Colombia. Las pérdidas económicas ocasionadas por la enfermedad van desde reducciones en los cultivos hasta la pérdida total de la plantación, debido a que los árboles infectados con HLB tienen que eliminarse a fin de evitar la proliferación de la bacteria. Uno de los problemas en términos de estrategias de control de D. citri y contención del HLB, consiste en disminuir la propagación del vector para ello resulta importante el aporte del modelamiento matemático ya que estos pueden establecer ideas sobre la eficacia cualitativa, cuantitativa de políticas aplicables al control del vector. Las formas de controlar el vector de HLB se pueden subdividir en:

- Control Químico (uso de insecticidas)

- Control biológico (Uso de agentes biológicos que reducen la población del vector)

Esta investigación se centrará en estudios cualitativos de estrategias de control biológico que permita disminuir la población del Psílido, vector de la enfermedad HLB. Analizando un modelo que describa la densidad poblacional de la Diaphorina y su interrelación con los brotes frescos del cítrico y un depredador natural que afecta a los huevos y su estado ninfal. El estudio se completará realizando un análisis de costos-beneficios con el fin de evaluar la utilidad práctica del método de control. También se analizaran el modelo en ausencia de control desde el punto de vista de la teoría de sistemas dinámicos, es decir, comportamiento asintótico, de estabilidad y sensibilidad de los parámetros. Se aplicará la teoría de control óptimo asignando diferentes prioridades en la toma de decisiones.

Keywords: Control óptimo.; Diaphorina Citri.; Modelación matemática.

Modelo matemático para estimar la distribución del índice de masa corporal (IMC) en la población adulta chilena.

Fernanda Suazo-Morales; Óscar C. Vásquez

December 12, 2022 (Monday), 09:00 - Room 1209

En este trabajo se propone un modelo matemático no lineal para estimar la distribución del índice de masa corporal (IMC) en la población adulta basado en un modelo de transporte que adopta una matriz de origen-destino y la maximización de la entropía. En particular, se consideran los datos obtenidos en las Encuestas Nacionales de Salud Chilena de los años 2003, 2009/2010 y 2016/2017, separando a la población por sexo, IMC y rango etario, para luego estimar el tránsito de la población dado un cierto periodo de tiempo. La propuesta es novedosa y permite enfrentar la incertidumbre

respecto a la distribución del IMC en una población dada, considerando un período prolongado entre encuestas de salud. Los resultados obtenidos son promisorios y permitirían evaluar y simular el impacto de políticas públicas el IMC altos, i.e. obesidad tipo I y II, presentes en el país.

Keywords: Índice de masa corporal; Modelo no lineal; Maximización de la entropía

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Periodic vehicle routing with consistency and synchronization constraints: formulation and solution methods

Juan G. Villegas R.; Juan Carlos Rivera

December 12, 2022 (Monday), 09:00 - Room 1301

In this work we study the periodic vehicle routing problem with consistency and synchronization constraints (ConSyncPVRP). The problem consists in designing delivery routes to periodically visit a set of nano-stores on a time horizon by two different resources: presellers (that take the orders) and trucks that deliver the ordered goods. The ConSyncPVRP adds resource synchronization constraints between the preseller and truck visits, and consistency constraints of the preseller visits to the traditional periodic vehicle routing problem. This problem arises in modeling the presale operation commonly used for order fulfillment of nano-stores in emerging markets. For the modeling and solution of the ConSyncPVRP, we present mixed-integer linear programming formulations strengthened by several symmetry-breaking constraints that allow the solution of small-scale instances. Therefore, for the solution of larger instances, we present metaheuristics that combine constructive/destructive and local search moves and mathematical programming subproblems. The results of the different solution approaches are compared against the industry practice of taking the routing decisions for each resource independently.

Keywords: Periodic vehicle routing problems; Synchronization and Consistency constraints; Mixed-integer linear programming; Metaheuristics

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El problema del ruteo de furgones escolares selectivo, con carga mixta, flota heterogénea y ventanas de tiempo

Maddlen Benedicto Villagra Aguayo; Carlos Obreque Níñez; Guillermo Latorre Núñez; Patricio Álvarez Mendoza; Barrales Araneda Alex; Carlos Bizama Fica

December 12, 2022 (Monday), 09:00 - Room 1301

En Chile, el transporte escolar lo realiza principalmente la empresa privada a través de vehículos con capacidad de 12 a 24 estudiantes. Los vehículos, que son de color amarillo, se conocen como Furgones Escolares y se utilizan para trasladar a los escolares desde los domicilios a sus correspondientes establecimientos educacionales. En este trabajo se propone un modelo de programación lineal entera mixta para determinar la ruta óptima de una flota heterogénea de furgones escolares que maximiza la cantidad de estudiantes que son trasladados. Se permite carga mixta, lo que significa que los furgones pueden trasladar, en el mismo viaje, escolares que se dirigen a escuelas diferentes. Además, se considera la restricción legal que impone una permanencia máxima de 60 minutos de viaje de cada estudiante y en cada viaje un furgón no puede exceder su capacidad. También, se consideran restricciones de ventanas de tiempo sobre los colegios y sobre los estudiantes. El problema es selectivo en el sentido de que no es obligación tener que trasladar a todos los estudiantes y por tanto el modelo decide cuál escolar se traslada, en qué furgón y qué ruta debe seguir, cumpliendo con todas las restricciones impuestas. Se resuelven instancias de la literatura e instancias creadas con datos reales de la ciudad de Concepción, Chile. Todas las instancias son resueltas utilizando el lenguaje de programación algebraico AMPL con el Solver Cplex.

Keywords: Programación lineal entera mixta; School bus routing problem; SBRP; Múltiples escuelas; Flota heterogénea; Carga mixta; Ventanas de tiempo; Demanda selectiva

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Ruteo de furgones escolares selectivo, con carga mixta, flota homogénea y transbordo
Carlos Obreque; Guillermo Latorre-Núñez; Patricio Álvarez; Alex Barrales; Carlos Bizama; Maddlen Benedicto Villagra Aguayo

December 12, 2022 (Monday), 09:00 - Room 1301

El transporte en furgones escolares se caracteriza porque los estudiantes se recogen en sus hogares y son trasladados a sus correspondientes establecimientos educacionales. En Chile, esto es así, debido a que la mayoría de los estudiantes son niñas y niños con edades que fluctúan entre cuatro y trece años de edad y, por tanto, es responsabilidad de los padres y apoderados seleccionar a la empresa de transporte para el traslado de sus hijos que le brinde seguridad y calidad en el servicio. En este trabajo proponemos un modelo de programación lineal entera mixta para determinar la ruta óptima de una flota homogénea de furgones escolares que maximiza la cantidad de estudiantes que son trasladados, considerando selección de escolares y carga mixta. Con el propósito de proporcionar mayor flexibilidad y mejorar la eficiencia en la gestión operacional de la empresa, se incluye en el modelo la alternativa de que un furgón recoja a un estudiante en su hogar y lo traslade a un establecimiento educacional, y posteriormente otro furgón se encarga de llevarlo a su correspondiente escuela. Se asume que los estudiantes que pueden realizar transbordo están autorizados por sus padres y que éstos reciben un incentivo por esta opción. También se analiza el caso en que el transbordo se puede realizar en el domicilio de otro estudiante. Se resuelven instancias de la literatura e instancias creadas con datos reales de la ciudad de Concepción, Chile. Todas las instancias son resueltas utilizando el lenguaje de programación algebraico AMPL con el Solver Cplex.

Keywords: Programación lineal entera mixta; School bus routing problem; Carga mixta; Transbordo; Ventanas de tiempo; Flota homogénea

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Optimizing vehicle routing problems with material convergence and deprivation costs in multi -dimensional representation network
Luis Yáñez-Sandivari; Cristián Cortés; Pablo Rey

December 12, 2022 (Monday), 09:00 - Room 1301

The key idea in our formulation is that, starting from decisions taken as parameters for the tactical and strategic scope of humanitarian logistics (such as location of facilities, inventory management and prepositioning, distribution of resources and allocation), during the stage prior to the occurrence of a natural disaster, we proceed with a model that responds to decisions of an operational nature, such as vehicle routing and sequencing associated with visits to aid beneficiaries. This model is risk averse and incorporates epistemic uncertainty, considering in a robust and possibilistic formulation the routing problem, which also incorporates the treatment of the convergence of materials generated by the flow of over demand for a critical supply, through reverse logistics and circular economy principles. Uncertainty is manifested in the state of the network (distances and travel times, available pre-positioned supplies) and demand, considering as planning horizon the post-disaster period where the delivery of a critical supply can save lives. For this critical supply, deprivation is considered as a socio-technical measure associated with stock out or late delivery with respect to the suffering that this causes in critical cases such as drinking water. This measure is taken from field studies and contingent valuation existing in the literature. For this purpose, a multi-dimensional representation network is proposed, which incorporates the state of deprivation as a "resource" in each node of the network, in order to implement minimum path algorithms that implicitly solve routing and sequencing decisions, fleet management, deprivation and demand satisfaction.

Keywords: vehicle routing problems; material convergence; deprivation costs; robust optimization

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Optimal sequential stochastic shortest path interdiction
Juan Borrero; Denis Sauré; Natalia Trigo

December 12, 2022 (Monday), 09:00 - Room 1302

Motivated by recent work in sequential bilevel problems under uncertainty, in this work we study

sequential shortest path interdiction in settings where arc costs form an i.i.d sequence of random vector, drawn from a common distribution known by the evader, but initially unknown by the interdictor. We model this problem of sequential decision making under parameter uncertainty using the multi-armed bandit framework. In a first contribution, we extend the techniques used to find a fundamental bound on policy performance for the classic bandit problem, and adapt them to obtain an asymptotic performance lower bound in this setting. We show that the regret , a measure of performance degradation due to the initial lack of information commonly used in the bandit literature, is proportional to order log(T), where T denotes the time horizon, and to a constant that depends non-trivially on the combinatorial structure of the underlying full-information interdiction problem. We show that the aforementioned constant is the solution to a lower bound problem that optimally searches for sufficient information to guarantee the optimality of the full information solution, which cannot be obtained in finite time by observing the evader's reaction to different interdiction actions. We use the insight gained by lower-bound result to develop efficient policies that mimic the combinatorial structure of the asymptotic result and are able to obtain asymptotic optimality. We test the performance of the proposed policies in exhaustive numerical experiments, where we contrast their performance with relevant benchmark arising from more naive approaches to the problem. Our results provide key insight on the difficulty of the setting, and should serve to close the gap between the practice and theory on sequential interdiction problems – which typically ignore the difficulty associated with learning parameters in real time.

Keywords: Multi-armed bandit; interdiction; shortest path

Capability design for a modular block-based organization via robust optimization

Luis San Martin; Jorge Vera

December 12, 2022 (Monday), 09:00 - Room 1302

A capability is an organization's ability to accomplish an operational task. Capabilities are related to minimal organizational modules called building blocks (BBs), which means that a BB delivers a particular capability. The design problem for an organization is the allocation and combination of different BBs to achieve a desired total capability. This problem exhibits a combinatorial nature and several sources of uncertainties, for example, the capabilities and the required tasks to fulfill. In this research we propose a novel and tractable binary optimization model to allocate the BBs following an additive rule i.e., all modules contribute with a particular capability that is aggregated to reach the global capability balance. We use robust optimization to address uncertainties and reformulate some nonlinear constraints to make them tractable. The results show that the robust solution at optimality can effectively control the effects of uncertainty. Complementarily, we present a heuristic for solving the capability allocation problem that, in most instances, provides an optimal solution in a fraction of the time of the optimization model. This heuristic delivers an advantage to the decision-makers because it lets them know a feasible and near-optimal solution in less than a couple of seconds even if we only run the construction stage. Both the optimization model and the heuristic can be combined with time-dependent models that address the capability life-cycle behavior once implemented exhibiting its flexibility. Finally, the relevance of this work is that we obtained an effective formulation that let the decision-makers plan the organizational design not only from a qualitative perspective but also by estimating quantitative behaviors. This is especially important for emergency and first-response organizations all of which are service providers that cannot exhibit a lack of capabilities because of their relevance to society.

Keywords: Robust optimization; Capability allocation problem; Uncertainty; Organizational design

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A multi-product aggregate production planning using stochastic programming: case study in a furniture company

José Emmanuel Gomez-Rocha; Eva Selene Hernández-Gress

December 12, 2022 (Monday), 09:00 - Room 1302

In this study a two-stage stochastic programming model is developed for a multi-product aggregate production plan (APP), an approximation is used with a model that employs discrete distributions with three values and their respective probabilities of occurrence for the random variables, which are

demand and production capacity, each one for every products family and we compared them with the Sample Average Approximation (SAA). The developed models were solved using the deterministic equivalent of the multi-stage problem using the stochastic solver integrated in optimization software Lingo 19.0, the main objective of this research is to determine a feasible solution to a real APP, in a reasonable computational time. The developed model was solved using the here and now approach (EV), as well as wait and see approach (WS), performing a sensitivity analysis, where the cost parameters are varied to see how they affect both solutions and some decision variables. The impact of the service level constraint on the value of the objective function was analyzed under the here and now and wait and see approaches, it was also reported how the decision variables change in this sensitivity. Finally, a sensitivity analysis by varying the parameters of the probability distribution in random variables are performed.

Keywords: Aggregate production planning; stochastic programming; Sample Average Approximation

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Analyzing the impact of beliefs errors in the planning of wine grape harvesting operations

Alejandro Milani; Alejandro Mac Cawley

December 12, 2022 (Monday), 09:00 - Room 1302

Forecasts and future beliefs play a critical role in the harvest labor hiring planning, especially when fixing previously made decisions implicate to incur in high costs. In this article, we study the effect that a bad forecast/belief has on the wine grape harvest planning process. To achieve this we induce mistakes in the prediction of yields and errors in the estimation of transition probabilities through the yield stock states. Using a multi-stage stochastic programming model we analyze the impact that errors in the forecast accuracy have on the profits and efficiency of the harvesting process. We also study how flexibility, in the form of second-stage decisions, affects the ability to fix the planning decisions and generate value. In a first step, we develop a multi-stage stochastic model which considers grape growth uncertainty given a belief in future events The model decision variables are: hiring, firing, and maintaining harvest labor through periods, and also the harvested quantities in each period and block. Once the model defines the plan for the coming epoch, the mistake in the forecast is revealed and the decision-maker can adjust his future decisions and beliefs. Results indicate that the effect of the errors in yield determination is not symmetrical; underestimations of the yields have a more significant negative effect on the objective function, while overestimation does not. Flexibility to revise the hiring decisions does not make a significant difference if the yields are overestimated.

Keywords: Harvesting planning; Multi-stage stochastic optimization; Uncertainty modeling; Errors in future beliefs; OR in agriculture

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Proposal of a model for optimizing the project portfolio of the Brazilian National Institute for Space Research

Alberto de Paula Silva; Mercedes Bustos Díaz

December 12, 2022 (Monday), 09:00 - Room 1303

The objective of this work is to propose a project selection method for the institutional portfolio of the National Institute for Space Research (INPE) using a linear optimization model and exact algorithms. The model applied for portfolio optimization takes into account the contribution of each project to the achievement of strategic objectives and its costs, project category, origin coordination, financial availability and deadlines. A comparison is made between the institutional portfolio established by direct decision of the institute's top management and the possible portfolio configurations with the application of the proposed method. The contribution of the method to decision making is also discussed.

Keywords: portfolio; optimization; exact methods; mathematic model; strategic decision

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Review and contribution in the MTZ formulation for the Traveling Salesman Problem
Gabriel Solari

December 12, 2022 (Monday), 09:00 - Room 1303

The mathematical formulation of the Traveling Salesman Problem (TSP) dates back to the work of Dantzig, Fulkerson and Johnson (DFJ) in 1954 and Miller, Tucker and Zemlin (MTZ) in 1960. These algorithms are based on the formulation of the Assignment Problem (AP) by adding a constraint that eliminates the subcycles. For this they use a model of Mixed Integer Linear Programming. In this research, the MTZ formulation is reviewed and a mechanism is designed to reproduce similar formulations. A procedure to generate other formulations of the TSP is added. which are more robust. Different formulations have been designed and tested with optimal results in all cases.

Keywords: Linear Programming; Mixed Integer Linear Programming; Traveling Salesman Problem

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Un Modelo matemático y una metaheurística para una nueva variante del Pollution Traveling Salesman Problem
Karen García-Vásquez; Carlos Contreras-Bolton; Rodrigo Linfati

December 12, 2022 (Monday), 09:00 - Room 1303

Se presenta una nueva variante del Pollution Traveling Salesman Problem enfocada en el consumo de combustible y las emisiones de polución. El Pollution Traveling Salesman Problem generaliza el TSP, por tanto es clasificado como NP-Hard. El PTSP consiste en el que un vehículo entregue a cada cliente una carga, que posee como atributo su masa, mediante un ciclo hamiltoniano que minimice una función objetivo que considera la velocidad de cada arco, la masa del camión, la masa de la carga del camión, pendiente de entrega, y la distancia recorrida. Se presenta un nuevo modelo matemático, y se realizan extensos experimentos computacionales para determinar el comportamiento de solver de programación lineal entera (Gurobi, Cplex, COPT, HiGHS, SCIP) para cinco variantes del Pollution Traveling Salesman Problem. Basado en resultados preliminares se propone una mateheurística que permite por el medio de heurísticas mejorar soluciones enteras y/o fraccionarias en el árbol de branch-and-bound por medio del uso de Callback. Se presentarán resultados preliminares sobre la aplicación de la mateheurística. Para la implementación de heurísticas y modelos matemáticos se utilizó Julia 1.7 y JuMP 1.0; se consideraron las bibliotecas de instancias del PRP y luego fueron adaptadas al PTSP. Los resultados preliminares muestran que el mezclar heurísticas y técnicas exactas para resolver modelos matemáticos impactan en el tiempo de cómputo y en %gap obtenido.

Keywords: TSP; Heurística; Sucursal y encuadernado; PTSP; Algoritmos hibridos

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Exact models for a robotics assembly cell schedulling problem to minimize tardiness
John Andres Muñoz Guevara

December 12, 2022 (Monday), 09:00 - Room 1303

Las celdas robóticas de ensamble RAC (Robotic Assembly Cell), han sido diseñadas para cumplir con los requerimientos de flexibilidad que exige el mercado globalizado en la actualidad. Fabricar una alta variedad de productos a bajos costos, requiere de equipos con un alto nivel de flexibilidad como los robots. La necesidad de programar una variedad alta de trabajos en una RAC representa un gran problema dado que la eficiencia y la productividad dependen de la secuencia en la cual se programan los trabajos. Los estudios alrededor de esta problemática han desarrollado modelos con enfoques heurísticos, simulación y modelos expertos que buscan mejorar medidas de desempeño basadas principalmente en el tiempo, el grado de utilización y el costo. En esta investigación se proponen unos modelos basados en la programación lineal entera mixta para optimizar la programación de trabajos en una RAC con el objetivo de minimizar la medida de desempeño de las tardanzas de los trabajos y obtener un ahorro de los costos de fabricación. La programación es un proceso de toma de decisiones que juega un papel vital en la mayoría de las industrias manufactureras. Pocos estudios se han dedicado a la investigación del problema de la programación de tareas en las RAC. La mayoría de los problemas de programación de la vida real son difíciles con

tiempo polinomial no determinista (NP-hard) y tienden a tener una serie de restricciones para generar una solución confiable, por ende, los modelos exactos permiten encontrar las soluciones optimas a problemas pequeños, con pocos trabajos, pero los cuales son claves a la hora de validar la calidad de los métodos heurísticos o metaheurísticos propuestos para solucionar dichos problemas. Como resultado se obtuvieron varios modelos exactos que permiten optimizar pequeños problemas de programación de trabajos en una RAC para diversos escenarios focalizando la tardanza como medida de desempeño.

Keywords: Scheduling; Robotics Assembly Cell; Tardiness

A dynamic discretization discovery algorithm for the routing of multiple and highly perishable commodities: an application to the transportation of biomedical samples

Daniel Mauricio Ocampo-Giraldo; Ana Maria Anaya-Arenas; Claudio Contardo

December 12, 2022 (Monday), 09:00 - Room 1304

In this talk I will present an exact solution algorithm to solve a vehicle routing problem for the distribution of multiple highly perishable commodities. Inspired by an application in healthcare services, the biomedical sample transportation problem, numerous commodities with short lifespan presume multiple transportation requests at the same facility in a day and restrict the maximum time to reach destination. These two characteristics create an interdependency between the routing and the pickup decisions in time that is highly complex. To address these timing issues, we model this problem as a service network-design problem over a time-expanded network. Our solution method aggregates the network at two levels. First, the commodities are aggregated and artificially consolidated, reducing the symmetry arising when multiple transportation requests are solicited within a short period of time. Second, the space-time nodes in the network are constructed dynamically, thus reducing the size of the mathematical model to be solved at each iteration. Our algorithm proves to be efficient to solve a set of real-life instances from the Quebec laboratory network under the management of the Ministère de la Santé et des Services sociaux (Ministry of Health and Social Services).

Keywords: time-expanded network; vehicle routing problem; biomedical samples transportation problem; healthcare logistics; highly perishable products; blood transportation; interdepency; dynamic discretization algorithm

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An error-tolerant branch-and-prune algorithm for distance geometry

Simon B. Hengeveld; Antonio Mucherino

December 12, 2022 (Monday), 09:00 - Room 1304

The Distance Geometry Problem (DGP) asks whether a simple weighted undirected graph G=(V,E,d) can be realized in the K-dimensional Euclidean space so that the distance constraints implied by the weights on the edges are satisfied. This problem was proved to be NP-hard in the context of graph embeddability, and has several applications, ranging from structural biology to computer graphics. When some particular assumptions are satisfied, it is possible to prove that the DGP search space, which is in general continuous, can be discretized and represented by a binary tree. In the ideal situation where all distances are given with extreme precision, a singleton can be assigned to every node of such a tree. In real-life applications, however, the distances are generally provided with low precision, and they are actually likely to carry error measurements. For this reason, we are working on alternative representations for the DGP search space where a continuous region of the K-dimensional space is instead associated to every node of the binary tree. This novel representations allow us to employ a well-known and accustomed algorithmic framework named the Branch-and-Prune (BP) algorithm, which was initially proposed for those ideal cases mentioned above. The BP algorithm can potentially perform the complete enumeration of the solution set, differently from other approaches based on heuristics. Moreover, our alternative representations open the doors for several possible algorithmic extensions for the BP, where the use of continuous methods for optimization is a necessity. We will review and compare against one another our most recent developments in this research area. This work is partially supported by the ANR project ANR-19-CE45-0019.

Keywords: distance geometry; branch-and-prune; graph embeddability; local optimization

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Robust linear regression and minimization of Jaeckel's dispersion via the ellipsoid method with oracles

Michal Cerny

December 12, 2022 (Monday), 09:00 - Room 1304

Rank estimators for robust linear regression are based on minimization of Jaeckel's dispersion. This optimization problem can be written down as an LP with n! constraints, where n stands for the number of observations. The only currently known polynomial algorithm for this problem is based on the ellipsoid method with membership and separation oracle; details can be found in [M. Černý et al., A class of optimization problems motivated by rank estimators in robust regression, Optimization, Latest articles, DOI 10.1080/02331934.2020.1812604]. We also point out why it is difficult to construct an IPM for this problem. Notwithstanding, this is the main challenge: an IPM is a natural candidate for a theoretically polynomial algorithm which need not suffer from the well-known implementation drawbacks of the ellipsoid method, such as the blow-up step or other undesirable numerical properties resulting from the essential role of Big-L arguments.

Keywords: Linear programming; Oracle-based ellipsoid method; Robust regression; Rank estimators

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An uncapacitated facility location approach for finding optimal diameter constrained minimum spanning trees with diameter no larger than four

Amanda Ferreira de Azevedo; Victor Hugo Rodrigues Do Nascimento; Abilio Pereira de Lucena Filho

December 12, 2022 (Monday), 09:00 - Room 1304

We address two closely related restricted variants of the minimum cost spanning tree problem, with applications in the design of different types of real-world networks. One is the Diameter Constrained Minimum Spanning Tree Problem (DCMSTP), which seeks a minimum cost spanning tree where the maximum number of edges between any pair of vertices should not exceed a given constant, i.e., a maximum diameter for the tree. The other, the Hop Constrained Minimum Spanning Tree Problem (HCMSTP), differs from DCMSTP in that it pre-defines a vertex to act as the spanning tree root. Moreover, it restricts the maximum number of edges, i.e., the maximum distance it might be from any other vertex in the tree. Accordingly, DCMSTP decomposes into some properly defined HCMSTPs. Furthermore, for diameters four and five DCMSTPs and distance two HCMSTPs, the two problems remain NP-Hard and may be reformulated as properly defined Uncapacitated Facility Location Problems (UFLPs). Given that Lagrangian bounding schemes tend to be very effective for UFLP, we adapted them for these particular cases of the two problems. The approach proved competitive with the best existing exact solution algorithms for DCMSTP/HCMSTP, all the way up to the largest instances tested in the literature (i.e., grid graphs with up to 161 nodes). Additionally, we also managed to find, in acceptable CPU times, proven optimal solutions for new test instances with up to 281 nodes.

Keywords: spanning tree; diameter-constrained; network design; uncapacited facility location; lagrangian relaxation

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An application of data mining to build the OD matrix in developing countries: An Argentinean case study

Fabio M. Miguel; Diego G. Rossit; Mariano Frutos; Antonella Cavallin

December 12, 2022 (Monday), 09:00 - Room 1305

Providing an efficient public bus transport system is a critical issue in modern cities, as it is a fundamental element for the well-being of citizens. How-ever, this system is generally very expensive and this cost is not usually offset by the income from the system. Therefore, governments have to spend a significant amount of their public budget to provide an efficient, accessible and good quality service. Considering this, new ideas to minimize the cost of the system are very welcome, especially

in developing countries that tend to suffer from a shortage of resources. Moreover, in the last decades, sustainability has also been integrated as an important criterion in public transportation system since this system can be an important contributor to air pollution of a city. This work aims to address the public bus transport system in the city of Bahía Blanca located in the South of Argentina. The contribution of this work consists in the development of a processing methodology to analyze the data of the travel smart cards of the users of the system to estimate the origin-destination matrix of passengers and the use of this information to optimize the frequency and layout of the bus lines (UTN FRBB PID TVECBBB0008249). The result is the OD matrix of the city.

Keywords: Bus Transport System; OD matrix; Data analysis; Simulation

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Statistical modelling of tennis results prediction
Gian Franco Lancioni; Guillermo Duran

December 12, 2022 (Monday), 09:00 - Room 1305

Widely recognized as the world's most popular individual sport, tennis has a number of characteristics that distinguish it from other individual sports with fewer fans (and sports bettors) around the globe. Attempts to modify or compare for use with tennis the results prediction models designed for other sports such as football run into a series of problems that limit their robustness. These originate in a number of factors, including differences between players in their adaptability to the various types of court surfaces, differences in tournament formats and their importance levels, the improvement or decline in players' individual athletic performance due to injuries or simple ageing, variable match durations, the alternation of service from game to game, and the diversity of conditions at each tournament location on the Association of Tennis Professionals (ATP) tournament calendar. In this talk we will examine a number of ways of dealing with these issues as they arise in the adaptation to tennis of statistical models based on other sports such as football, basketball and rugby, which have previously been studied by the Operations Research Group at the Instituto de Cálculo in the University of Buenos Aires. The formulations we propose are derived mainly from a paper by Dixon & Coles in 1997. In addition to their use as results predictors and potential for mathematical outreach activities, these models can serve as performance indicators for a sport governed by official rankings that tend to be highly variable and subject to a number of biases, due essentially to a system that grants fixed points per tournament and round without regarding opponent matchups and surfaces. We will also present some of the results of our models for past tennis tournaments and how they compare with those of existing methodologies such as Elo ratings and the ATP's rankings.

Keywords: Sport prediction; Dixon-Coles model; Statistical modeling; Ranking evaluation

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A new validity index for dynamic clustering
Richard Weber; Ignacio Carvajal; Fernando Crespo; Ramiro Saltos

December 12, 2022 (Monday), 09:00 - Room 1305

Clustering is an important task in analyzing large datasets. The solution obtained by a particular algorithm must be validated using so-called validity indices evaluating e.g., the clusters' compactness and separation. Since in most applications static data are analyzed, the respective indices validate static solutions. In most real-world applications, however, the analyzed phenomena are dynamic by nature. An example is customer segmentation where customer behavior changes over time. Therefore, techniques for dynamic clustering are applied which could detect the creation, elimination, and movement of clusters, among other possible changes. The question that arises is how to validate the solution of such dynamic clustering. In this work, we propose a new validity index for dynamic clustering to evaluate the solution of a particular algorithm, i.e., the detected changes. We show its performance on artificially generated as well as on real-world data sets.

Keywords: Analytics; Clustering; Segmentation

Sistema de apoyo a la toma de decisiones para el pronóstico de rating televisivo
Josué Salinas; Jaime Miranda

December 12, 2022 (Monday), 09:00 - Room 1305

En los últimos años el negocio de la televisión y el entretenimiento se ha visto afectado por múltiples y profundos cambios, el crecimiento del número de actores que ofrecen contenido a través de diferentes plataformas ha generado un ambiente de mayor competitividad al querer atraer al mayor número de televidentes o audiencia con el fin de generar ingresos mediante la venta de espacios publicitarios a diferentes empresas y organizaciones. Esto genera gran preocupación en los tomadores de decisiones. A nivel estratégico, su foco es mantener una posición rentable en el mercado. A nivel táctico, los tomadores de decisiones deben decidir qué programas crear o adquirir de modo que maximicen los ratings en el mediano plazo y, a nivel operacional, se debe determinar estrategias para maximizar el rating de corto plazo considerando la posición temporal semanal y el público demográfico objetivo que se desea alcanzar. El presente trabajo propone un sistema de apoyo a la toma de decisiones con foco en el nivel táctico y operativo, el cual entrega como resultado un pronóstico del rating para una parrilla programática dada. El sistema entrega un pronóstico de rating desagregado en bloques de 15 minutos, y con un alcance de hasta 6 semanas de programación hacia el futuro. Para lograr esto, se utilizó la técnica llamada XGBoost, la cual tiene una serie de características como la escalabilidad y rápida convergencia, con tiempos computacionales 10 veces más rápido que otras técnicas predictivas en promedio. Algunas de las variables de entrada que considera el modelo son el rating de la audiencia pasado, características de los programas como el género y subgénero, así como características temporales y de ubicación como la hora y día en que se transmite el programa. Para la evaluación del modelo, se utilizó un indicador de error MAPE. A nivel de 15 minutos se alcanzaron niveles de error de un 20% aproximadamente.

Keywords: Audience Prediction; Machine Learning; Data Mining; Decision Support Systems

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Modelos predictivos de cobranza basados en aprendizaje de máquinas tradicional y causal
Sebastián Maldonado; Catalina Sánchez; Carla Vairetti

December 12, 2022 (Monday), 09:00 - Room 1306

Los bancos e instituciones financieras enfrentan un porcentaje importante de clientes morosos, lo que acarrea pérdidas importantes. Uno de los principales intereses de este tipo de entidades es recuperar los montos adeudados de forma económica y expedita. Para enfrentar este problema, los bancos e instituciones financieras contratan servicios de Contact Center con el fin de mejorar sus estrategias de recolección de deuda. Estos servicios, sin embargo, no siempre son capaces de entregar los resultados esperados, lo que se refleja en el incremento en el número de deudores en los últimos años. El presente estudio se enfoca en la utilización de modelos predictivos aplicados a la cobranza. El objetivo de esta tarea de analítica de negocios es estimar la probabilidad de que un determinado deudor realice el pago de su deuda en un futuro cercano. Si bien los modelos de cobranza suelen considerar exclusivamente información financiera y sociodemográfica de los deudores, en este trabajo se propone considerar una fuente de información adicional para complementar estos modelos predictivos: la información de los contactos con clientes obtenida del Contact Center. Finalmente, el estudio presenta un análisis del desempeño de modelos predictivos de tipo causal, es decir, que se enfocan en identificar aquellos clientes que pueden tener una respuesta positiva a las estrategias de cobranza realizadas por una empresa. Como referencia, el enfoque tradicional busca predecir quienes pagarán sus deudas contraídas con la empresa, pero existe un porcentaje importante que paga sin haber sido contactados, por lo que este enfoque es, en teoría, menos efectivo que el enfoque predictivo causal.

Keywords: Analytics; Analítica de Negocios; Cobranza; Aprendizaje de Máquinas

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Diseño de paisajes resistentes a incendios usando Reinforcement Learning
Tatiana Andrea Castillo Jaimes; Andres Weintraub; Jaime Carrasco

December 12, 2022 (Monday), 09:00 - Room 1306

Los impactos del cambio climático en el ecosistema terrestre han aumentado la cantidad de incendios forestales, la gravedad y el área que consumen a nivel mundial. En la última década, se han implementado varios tratamientos de paisaje para combatir incendios desde una perspectiva preventiva. Sin embargo, debido a las altas incertidumbres que rodean el fenómeno, la asignación de estos tratamientos esta principalmente influenciada por la expertiz de los tomadores de decisión lo que a su vez conlleva una difícil medición de las posibles pérdidas económicas, humanas y ambientales que se evitan. Para tratar de resolver este problema, la comunidad científica ha buscado entender el comportamiento del fuego y se han diseñado diferentes simuladores con modelos de ignición y propagación de incendios forestales. Con ayuda de estos simuladores se han aplicado diferentes técnicas que permiten priorizar y localizar los tratamientos de combustible en el paisaje. Hasta el momento, esto se ha hecho a través de algoritmos sencillos, heurísticas y modelos de optimización; donde estos últimos tratan de incorporar la incertidumbre propia de la naturaleza del fenómeno a través la optimización estocástica. Sin embargo, al tratar de modelar este problema se cae fácilmente en las maldiciones de modelado y de dimensionalidad dado su complejidad. Por ello, la presente investigación se enfoca en usar por primera vez algoritmos de Reinforcement Learning junto con Redes Neuronales para resolver el problema de posicionamiento de cortafuegos como tratamiento al combustible forestal en paisajes reales. De esta forma se solventan varias limitaciones de las técnicas usadas anteriormente y se desarrolla una herramienta novedosa para la prevención de incendios forestales que soporte la toma de decisiones.

Keywords: Paisajes resistentes a incendios; Reinforcement Learning; Incendios forestales; Tratamiento de combustible forestal; Inteligencia Artificial; Aprendizaje Reforzado; Machine Learning

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A common weight multi-layer DEA composite indicator to assess the quality of undergraduate courses in Brazil

Lívia Mariana Lopes de Torres; Francisco de Sousa Ramos

December 12, 2022 (Monday), 09:00 - Room 1306

Composite indicators (CI) have gained recognition due to their usefulness in multidimensional evaluation. The higher education context is complex and vital to social and economic development. In Brazil, the Ministry of Education and Culture (MEC) developed a range of CIs in the process of accreditation and evaluation of Brazilian higher education institutions (HEIs). One of these indicators is the Preliminary Course Concept (CPC), which is destined to assess undergraduate courses' quality. The current model used by the government contemplates eight indicators, and it is criticized due to the lack of justification in selecting the weights for the chosen indicators. Since the eight indicators belong to four different categories (student performance, added value by the education provided by the undergraduate course, Faculty, and Student perception of the undergraduate course conditions), it is necessary to consider the hierarchical structure of the indicators in the evaluation. This study considers a common set of weights in a multi-layer Data Envelopment Analysis model to construct a new CPC. Therefore, this study develops a new CI that aims to reflect the hierarchical structure of indicators used, and this new alternative can provide a fair comparison between courses. In order to validate the model, a sample of 107 public management engineering courses was used to validate our proposition. It is also relevant to mention that the proposed approach can aid MEC in identifying a different pattern in courses of distinct areas of knowledge, and in this sense since the analysis proposed with DEA obtains weights in an endogenous way, no pre-assumption would be necessary for any course.

Keywords: Data Envelopment Analysis; Composite Indicator; Multi-layer; Common-weights

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Intelligent exploration of a backtracking algorithm for scheduling residential load

Sebastián Taboh; Isabel Mendez-Diaz; Paula Zabala

December 12, 2022 (Monday), 09:00 - Room 1307

According to the European Commission, “a Smart Grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it in order to ensure an economically efficient, sustainable power system with small losses and high levels of quality and security of supply and safety”. Through a demand response (DR) program, the utility companies can

have a pricing policy that punishes the energy consumption during peak times to indirectly control the peak energy demands. Knowing this pricing policy beforehand and responding to incentives such as lower energy prices, the users may avoid using much energy in times when it is more expensive. Therefore, scheduling the residential load considering the user's preferences is an essential task. We deal with the problem of scheduling residential appliances under a DR program abiding to energy consumption bounds for each interval. We consider a day-ahead pricing scheme and aim to minimize the economic cost of energy and the discomfort felt by users. Appliances are categorized into two groups. Those of the first group work with fixed powers but are delayable and interruptible. The discomfort in this case is a consequence of the time the users have to wait for the appliances to end their operation. The others operate continuously on determined time windows but have flexible powers and the discomfort is related to the difference between the actual powers of operation and the ones that should be. Despite the fact that this is an NP-hard problem, we are developing an exact algorithm to solve it. As could be expected, this algorithm, which is based on backtracking and quadratic programming, requires ingenious strategies, such as smart ways of exploring the tree, to obtain results in reasonable execution times. In this presentation we will explain many developments and ideas that were fundamental to achieve an effective exact algorithm for the described problem, as well as computational results.

Keywords: smart grids; day-ahead price; residential power scheduling; interruptible appliances; energy consumption bounds; backtracking; NP-hard

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Simulación de los efectos de la penetración de tecnologías renovables no convencionales en la seguridad energética en Colombia

Alexandra Valencia; Yris Olaya; Santiago Arango

December 12, 2022 (Monday), 09:00 - Room 1307

En Colombia alrededor del 70% de la electricidad se genera con tecnologías hidráulicas convencionales. Dada la variabilidad de la generación hidráulica, y los compromisos de descarbonización del país, es de interés comprender los efectos que tiene la incorporación de tecnologías renovables no convencionales sobre la seguridad energética, entendida como la disponibilidad ininterrumpida de fuentes de energía a precios asequibles. En este trabajo se desarrolló un modelo para simular el despacho de las plantas de generación y la formación del precio de bolsa en el Mercado Eléctrico Mayorista Colombiano. El modelo combina métodos estocásticos y de optimización y se configura para evaluar diferentes escenarios de penetración de generación renovable no convencional. Con base en los resultados del modelo, se estima el impacto de la generación de electricidad en la seguridad del suministro y los precios. La disponibilidad de las plantas de generación es estocástica para centrales eólicas, solares fotovoltaicas e hidráulicas tipo embalse y se calcula con parámetros técnicos de las centrales y con las series de recursos. Así mismo, se proponen modelos estocásticos para las ofertas de cada planta y se encuentra un despacho ideal usando técnicas de optimización. Entre los resultados obtenidos con el modelo están que, bajo la estructura del mercado eléctrico actual, i) las tecnologías renovables son siempre despachadas, al beneficiarse de la regla de orden de mérito, ii) las tecnologías térmicas convencionales disminuyen su participación en el despacho y con ello se reducen las emisiones de gases de efecto invernadero emitidos por el sector, ii) el precio de bolsa baja y es más volátil en los escenarios con mayor penetración de tecnologías de generación renovables no convencionales.

Keywords: Mercado eléctrico; Simulación; Seguridad energética; Fuentes no convencionales de energía

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Técnicas de análisis y optimización para la identificación de línea en las redes de distribución inteligentes mediante datos metrológicos

Larraitz Aranburu; Aitziber Unzueta; M. Araceli Garín; Juan I. Modroño; Aitor Amezua

December 12, 2022 (Monday), 09:00 - Room 1307

Uno de los problemas a los que se enfrentan los operadores de sistemas de distribución de energía eléctrica es conocer con certeza la ubicación real de todos sus activos para poder gestionar adecuadamente la red y ofrecer el mejor servicio a sus clientes. En este trabajo, presentamos un

procedimiento para la identificación de alimentadores o líneas de distribución de baja tensión en redes inteligentes que se basa en la formulación matemática del problema como un modelo de optimización. En particular, definimos el modelo con variables 0-1 (tantas como contadores a identificar en los distintos alimentadores) y con tantas restricciones como puntos en el tiempo se consideren. Dado el gran tamaño del problema en la práctica, el uso de software de optimización convencional se hace inviable. Basándonos en este planteamiento, y haciendo uso de la relajación lineal del problema, de algunas analíticas sobre los coeficientes (es decir, las cargas de los contadores) y de la especial estructura del propio problema, hemos desarrollado un procedimiento iterativo que nos permite recuperar la solución completa del modelo inicial de forma eficiente. Hemos realizado una experiencia computacional sobre un conjunto de datos reales anonimizados, obteniendo resultados que avalan la eficiencia del procedimiento propuesto.

Keywords: energía eléctrica; programación matemática; datos metrológicos

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MaxCut is hard when restricted to geometric intersection model graph classes

Celina Figueiredo; Alexsander Melo; Fabiano Oliveira; Ana Silva

December 12, 2022 (Monday), 09:00 - Room 1309

A cut is a partition of the vertex set of a graph into two disjoint parts, and the maximum cut problem (denoted by MaxCut, for short) aims to determine a cut with the maximum number of edges for which each endpoint is in a distinct part. In the 1985 column of the Ongoing Guide to NP-completeness by David S. Johnson, a two-page summary table was presented, with a column for each of the ten most famous NP-complete graph problems, and a row for each of thirty selected graph classes. The emphasis was on the restrictions and how they affect the complexity of the considered NP-hard problems. Many important graph classes are defined or can be characterized by a geometric intersection model. Two particularly well-studied examples are sub-classes of perfect graphs: the classes of interval graphs and of permutation graphs. In their respective models, the intersecting objects are line segments in the plane, with different restrictions imposed on their positions. In interval graphs, each line segment must have its endpoints on a single line, while in permutation graphs, their endpoints must lie on two distinct parallel lines. We present two recent advances concerning the hardness of MaxCut when restricted to intersection graphs, settling two long-standing open entries of the two-page summary table of Johnson. MaxCut restricted to interval graphs has been announced to be NP-complete by Adhikary, Bose, Mukherjee, and Roy, and subsequently we were able to prove that MaxCut remains hard when restricted to interval graphs of interval count 4. Additionally, we were able to establish that MaxCut restricted to permutation graphs is NP-complete. The complexity of MaxCut is open when restricted to unit interval graphs, and when restricted to graphs that are interval and permutation. The largest class in the intersection of permutation and interval graphs for which the complexity is known is the class of the threshold graphs, on which MaxCut is polynomial-time solvable.

Keywords: JS; MaxCut; geometric intersection model; permutation graphs; interval graphs; NP-complete

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The time complexity of oriented chromatic number for subgraphs of grids

Erika Morais Martins Coelho; Hebert Coelho Da Silva; Luerbio Faria; Mateus de Paula Ferreira; Sulamita Klein

December 12, 2022 (Monday), 09:00 - Room 1309

Let m,n be a pair of positive integers, a grid graph G=(V,E) has V={(i, j): i□{1,…,m}, j□{1,…,n}} and E={(i, j)(k, l): |i-k|+|j-l|=1}. An oriented k-coloring of an oriented graph G is a partition of V into k color classes such that there is no pair of adjacent vertices belonging to the same class and all the arcs between a pair of classes have the same orientation. The smallest k such that G admits an oriented k -coloring is the oriented chromatic number $\chi_o(G)$ of G. It is known that recognize [1] whether a graph G is a grid subgraph is NP-complete even when G is a tree. However it is a polynomial time problem [2] to find a grid subgraph H minor of a planar graph G. The oriented k-coloring problem asks whether an oriented graph G has oriented chromatic number at most k. It is polynomial [3] when $k \leq 3$ and NP -complete when $k \geq 4$ even when the underlying graph is bipartite, cubic and planar [4]. In 2003,

Fertin, Raspaud e Roychowdhury [5] studied grid subgraph classes, having established oriented chromatic number exact values and bounds. In this work we prove that the oriented k-coloring problem is NP-complete even when the underlying graph is a subgraph of a grid.

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Keywords: JS; oriented graphs; oriented chromatic number; grid graphs; planar graphs; NP-complete; algorithms

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Contributions in channel assignment and distance geometry with Nelson Maculan
Rosiane de Freitas

December 12, 2022 (Monday), 09:00 - Room 1309

We consider graph coloring problems involving distance constraints as weighted edges. We proposed theoretical modeling based on distance geometry and defined a hierarchy of coloring problems that we called distance graph coloring problems (deFreitas et al., 2019). Thus, the vertices of the graph are considered as embedded on the real line and the coloring is treated as an assignment of positive integers to the vertices, while the distances correspond to line segments, where the goal is to find a feasible intersection. We proposed integer and constraint programming formulations and showed feasibility and optimality conditions for some problems (Dias et al., 2021). We also propose implicit enumeration methods for some of the optimization problems based on branch-and-prune algorithms proposed for DGPs in the literature. A polyhedral combinatorics study was conducted to define a distance polytope and facet-inducing inequalities (Dias et al. 2018). We propose new variations of vertex coloring problems in graphs, involving a new theoretical model in distance geometry (DG) for vertex coloring problems with generalized adjacency constraints, promoting the correlation between graph theory and DG fields. We also give a characterization and formal proof of polynomial cases for special graph classes, since the general main problem is NP-complete.

Note: This talk is a tribute to the 80 years of Jayme Szwarcfiter (July 2022) and Nelson Maculan (March 2023), leading Brazilian researchers. A summary of the results obtained together with these researchers and Bruno DIas (Brazil), Javier Marenco (Argentina), and Philippe Michelon (France) will be presented.

Keywords: NM; JS; Channel assignment problems; Distance geometry; Integer programming; Constraint programming; Polyhedral combinatorics; Vertex coloring problems

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Contributions in scheduling theory and distance-constrained graph colorings with Jayme Szwarcfiter
Rosiane de Freitas

December 12, 2022 (Monday), 09:00 - Room 1309

In commemoration of the eightieth birthday of the Brazilian researcher Jayme Szwarcfiter, a reference in graph theory, algorithms, and combinatorics in general, this talk summarizes the contributions in scheduling theory, especially involving UET (Unit Execution Time) jobs and identical

parallel machines, scheduling on parallel machines considering job-machine dependency constraints, project scheduling involving directed graphs, and vertex coloring problems with distance constraints.

Keywords: JS; algorithms; distance graph coloring; Jayme Szwarcfiter; job-machine constraints; precedence constraints; project scheduling; T-coloring; UET scheduling

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Optimal bidding strategies in Energy Markets

Rafael Benchimol Klausner; Bernardo Freitas Paulo da Costa; Joaquim Dias Garcia

December 12, 2022 (Monday), 14:00 - Room 1208

This study focuses on the solution of the bid-based hydrothermal dispatch over a finite horizon, in contrast to the classical cost-based problem. In the cost-based approach, the objective is to find the optimal generation of thermal and hydro plants, given the fact that all the plants are controlled by a centralized operator. The cost problem is often modeled by multi-stage stochastic decision process, due to uncertainties associated with inflows, and it can be solved by a dynamic programming algorithm called Stochastic Dual Dynamic Programming. In energy markets, where several companies compete with each other to increase their own revenue, this problem can be set into a game-theoretic framework. This game approach represents the strategic bidding of multiple agents in a liberalized market, and each agent decides its energy generation through a bi-level optimization program. The interaction among agents is dealt with using a fixed point iteration algorithm in order to find a Nash equilibrium. To make this setup computationally tractable, we explore possible relaxations to the bi-level problem. We observe how these relaxations affect the proposed equilibrium in toy models and case studies, for one-stage and multi-stage stochastic models.

Keywords: Stochastic Optimization; Game-Theory; Strategic Bidding; Power Markets

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Impact of climate change on long-term energy generation and demand in Chile

Tito Homem-De-Mello; Frédéric Babonneau; Constanza Zavala

December 12, 2022 (Monday), 14:00 - Room 1208

Currently, Chile and the world in general, are focused on mitigating the effects of climate change and on the development of an energy transmission that promotes a more sustainable future in the long term. In this context, the Long-Term Energy Planning report of the Ministry of Energy presents an optimization model that allows projecting energy demand and supply, considering different future scenarios. Similarly in the literature, the ETEM-Chile model manages to simulate the Chilean energy system finding the optimal energy transition. However, the climate factor has not been considered in the development of both models. Based on the above, the possibility of inducing stochasticity in the projections of both energy demand and wind, hydroelectric and solar generation in Chile arises. The main objective is to estimate and evaluate the impact of climate change on the demand for heating and cooling services, as well as the generation of various energy sources using the ETEM-Chile model, in order to provide valuable information for decision makers to compensate for the effects of climate variability. The focus of the research is on analyzing the behavior at the level of representative nodes, contemplating two concentration trajectories RCP 2.6 and 8.5 provided by the Center for Climate Science and Resilience, which correspond to climate scenarios. To measure the impact of climate change on energy demand, the degree days method was used, with the understanding that the effect of climate change on the demand for each of the services is proportional to the degree days of heating and cooling. Preliminary results show a decrease in heating demand and an increase in cooling requirements. Subsequently, the economic impact was analyzed at the nodal level and globally.

Keywords: Climate change; Energy planning; Energy demand; Energy generation; Energy demand scenarios; Heating degree days; Cooling degree days

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On the analysis of contract optimization for high seasonal electrical consumers
Francisco Gasparin Fabrin; Daniel Pinheiro Bernardon; Vinícius Jacques Garcia; Alejandre Pose; Sebastian Butto; Lucas Melo de Chiara; Daiana Wichmann da Silva

December 12, 2022 (Monday), 14:00 - Room 1208

Rural consumers of electricity have particularities in terms of consumption profile, associated with the type of rural activity developed. Particularly, rice farmers are highly representative in southern Brazil, particularly in the extreme west of the state of Rio Grande do Sul, with the characteristic related to significant demand in the periods from October to March, followed by a consumption close to zero in the periods of April to September. With these characteristics, it is necessary to develop a contract that remunerates the distribution system more adequately, based on the composition of the contractual elements that refer to the frequency of use of the system throughout the year and the level of demand. The methodological proposal is based on the application of specific tariffs for intervals of demand, as well as the attribution of minimum consumption levels to remunerate the maintenance of the distribution system over a period of 12 months. The tariff structure will not be changed, but the adjustment of the components will be based on the optimization of the minimum value to be reached for each consumer to increase the remuneration for the use of the distribution system. Case studies are developed to assess the impact of changes in tariff components.

Keywords: Irrigante; Rural Consumers; Tariff; Distribution system

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The role of alternative combustion vehicles and the modal changes on the path to decarbonizing road transport
Santiago Arango-Aramburo; Yris Olaya; Verónica Valencia

December 12, 2022 (Monday), 14:00 - Room 1208

One of the most important challenges of today's cities is more sustainable transport. In this article we develop a system dynamics model that proposes an integrated framework that evaluates two ways of reducing emissions in the transport sector in a region of Colombia: modal changes and the diffusion of vehicles with alternative propulsion sources. The model has four interconnected modules: 1) vehicle/motorcycle stock, 2) use of transport, 4) fueling points infrastructure, 5) electricity consumption, and 6) emissions. We find that by 2050 HEVs could have a 48% share and BEVs 16%. Modal and vehicle fleet changes could lead to the avoidance of 36.4 Mt of CO2 equivalent between 2016 and 2050 but could also increase electricity demand to 1,530 GWh per year in 2050.

Keywords: Electric vehicles; electric motorcycles; sustainable transport; development countries; system dynamics; simulation

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A stochastic programming approach for airline maintenance scheduling under uncertainty
Matias Villafranca; Felipe Delgado; Mathias Klapp

December 12, 2022 (Monday), 14:00 - Room 1209

Aircraft maintenance tasks present variability in their processing time. If these times take longer than expected, then an airline operator could end up with delayed flights and/or infeasible maintenance schedules. Despite this potential cost increase, in the specialized literature the effect of task time variability in flight delays has not yet been anticipated and accounted for in aircraft maintenance planning operations. We acknowledge this gap and study an aircraft maintenance scheduling problem with stochastic task processing times to help planning an airline's daily operation. Decisions involve choosing the subset of tasks to execute in each aircraft and each task start time considering that aircraft relocate among multiple airports, that airports have a limited resource of technicians, and that longer task time realizations can delay subsequent aircraft scheduled flights. The objective is to minimize the expected daily cost of flight delays and postponed maintenance tasks. We propose a solution to our two-stage stochastic model based on scenario sampling and a Benders' type decomposition approach. Finally, we provide computational experiments to validate our approach, estimate the potential cost savings obtained by our solution when compared to a simpler airline maintenance policy, and estimate the cost of task time variability by comparing our approach to the

solution of a model with perfect information.

Keywords: Aircraft maintenance.; Task scheduling.; Stochastic programming.; Mixed integer programming.; Benders' decomposition.; Flight delay.

Formulación MILP y aplicación de algoritmo de horizonte rodante para la Programación Maestra de la Producción en una industria de alimentos para mascotas

Joan Cusimano; Romina Alejandra Ríos; Fernando Herrero; Emilce Faba; Pablo Andrés Marchetti

December 12, 2022 (Monday), 14:00 - Room 1209

Este trabajo aborda la Programación Maestra de la Producción (PMP) de una empresa dedicada a la producción de alimentos para mascotas. Como en otras industrias, para garantizar la eficiencia y eficacia del funcionamiento de la planta, resulta crítico alinear la PMP con el resto de las decisiones realizadas a lo largo del ciclo completo de planificación. El proceso de fabricación involucra varias etapas que van desde la dosificación de las materias primas hasta el envasado del producto final, utilizando equipamiento tanto batch como continuo a lo largo del mismo. El problema abordado consiste en definir los volúmenes de producción para cada producto, asociados a campañas para cada familia, en cada una de las líneas disponibles en la instalación. Se considera un horizonte de mediano plazo, con una extensión de 3 a 5 meses, modelando las decisiones con un nivel de agregación semanal. Para resolver el problema se desarrolló un modelo matemático mixto-entero lineal (MILP), en conjunto con un método de resolución basado en un algoritmo de Horizonte Rodante, con el fin de reducir la complejidad combinatoria y lograr soluciones de calidad en tiempos acotados a las necesidades reales de la empresa. Para encontrar el balance más adecuado entre tiempo de resolución y calidad de la solución, se llevó a cabo un estudio de parámetros del algoritmo, optando por la configuración con mejores resultados. La metodología propuesta fue aplicada satisfactoriamente para resolver la PMP de una empresa de gran escala de la industria de alimentos para mascotas, con producción de cientos de productos distintos agrupados en familias. En comparación con las metodologías manuales/heurísticas utilizadas por la empresa, los resultados fueron ampliamente superiores no sólo en términos del cumplimiento de la demanda y la política de stock objetivo, entre otros indicadores, sino también en el tiempo necesario para hallar soluciones de calidad para el problema.

Keywords: Programación Maestra; Alimento para mascotas; Horizonte Rodante; Optimización

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Planificación de la producción con máquinas paralelas multi-producto, recursos compartidos y tiempos de configuración dependientes de la secuencia

Joaquin Velázquez; Héctor Cancela; Pedro Piñeyro

December 12, 2022 (Monday), 14:00 - Room 1209

La producción de neumáticos requiere de un proceso de vulcanizado o curado, en donde los neumáticos adquieren la forma y propiedad necesarias para su futura utilización. En un trabajo de investigación anterior, se desarrolló un modelo de programación matemática y procedimientos de resolución heurísticos para la planificación del vulcanizado en la fábrica cooperativa de neumáticos uruguaya FunsaCoop. Para ese problema se contaba con una demanda dada por tipo de neumático (moldes), máquinas (heaters) capaces de albergar hasta dos moldes a la vez, piezas compartidas entre moldes, restricciones de compatibilidad molde-molde y molde-heater, así como tiempos de configuración que dependen de la secuencia de producción. El objetivo era encontrar la menor cantidad de períodos de tiempo necesarios de producción (makespan) para cumplir con la demanda de cada tipo de neumático. En el presente trabajo se busca generalizar el problema de vulcanizado descrito anteriormente para poder resolver otros problemas similares en la industria. En particular, consideramos máquinas que puedan albergar cualquier cantidad de moldes a la vez y generalizamos el concepto de recursos compartidos entre moldes. Para esta versión extendida del problema, se propone en primer lugar un modelo de programación matemática que generaliza, pero que también simplifica y ajusta algunas de las restricciones y variables del modelo desarrollado para el problema original de planificación de vulcanizado de neumáticos de FunsaCoop. Teniendo en cuenta la complejidad computacional del problema, se sugieren y evalúan diferentes técnicas de resolución. En particular, se comparan los procedimientos desarrollados contra otros métodos de

resolución de la literatura sobre instancias conocidas de problemas similares.

Keywords: Scheduling; Makespan; Lot-Sizing; Mathematical Programming; Optimization

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A personalized activity scheduling problem considering stress, deadlines, and teamwork
Pablo Rosas; Yasmin Rios-Solis; Romeo Sánchez Nigenda

December 12, 2022 (Monday), 14:00 - Room 1209

In recent years, due to the pandemic, stress has become more relevant as it negatively affects people's health and, in many cases, decreases performance. The effects of stress on people's performance change according to different factors, such as how stressful situations are faced, the causes of stress, and even the state of physical and mental health. Some research suggests that the relationship between stress and performance is inverted U-shaped, implying that very high or low-stress levels lead to sub-optimal performance. In contrast, moderate stress levels can improve performance. On the other hand, other works suggest that it has a negative linear relationship; higher stress levels lead to lower performance. One way to deal with this situation and increase academic efficiency in the educational field is to implement personal learning paths that consider stress. A learning path is a set of activities that must be carried out in a particular order, allowing us to achieve specific academic objectives. This work aims to show that some features like stress and IQ are fundamental when creating a sequence of activities that humans must carry out through an optimization problem that seeks to minimize the time required by a student to achieve a minimum score considering such subjective characteristics. For this, we propose three solution methods; the first is a mathematical model, which includes a learning effect based on position and associated with a person's IQ, and a deterioration effect that depends on mental stress. We also consider deadlines to carry out an activity or meet a minimum score and team activities. In the same way, we propose a constraint programming model (CP), given that it has given excellent results for activity sequencing problems. And a hybrid metaheuristic algorithm VNS-GRASP would allow us to find good quality solutions in a very short time.

Keywords: Scheduling; learning effect; stress; MILP; CP

Combining optimization and fire simulation modeling to protect ecological values at landscape scale
Rodrigo Mahaluf; Jaime Carrasco; Fulgencio Lisón; Cristobal Pais; Andrés Weintraub

December 12, 2022 (Monday), 14:00 - Room 1301

One way to mitigate the uncontrolled effect of fires and at the same time protect our communities and ecological values is through Fuel Management. Theses activities constitute a means of fire prevention involving planned changes to living or dead wildland fuels (prescribed burning, pruning, firebreaks, etc) in order to lessen fire behaviour potential. In this study, we propose a strategy to locate firebreaks on the landscape, so that the ecological damage resulting from the removal of vegetation in areas allocated to firebreaks is offset by the preservation of ecological values as a result of firebreaks' protective action. Our solution approach comprises an integrated fire-simulation and optimization framework, along with a prioritization metric that identifies crucial cells that have a significant influence on the spread of fires on the landscape and the potential for ecological loss. Our solution approach was tested on a real landscape located in Araucania Region, Chile, whose wildland fuels were classified according to the KITRAL fire behavior system and with real species observations taken from GBIF data bases.

Keywords: Decision making at landscape-scale; Fire ecology; Fire risk; Mitigation of fire effects

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Riesgo de incendios forestales en el interfaz urbano rural de Concepción, usando machine learning y simulación espacial
Gabriela Alfaro; Jaime Carrasco; Andres Weintraub; Alejandro Miranda; Cristobal Pais

December 12, 2022 (Monday), 14:00 - Room 1301

El aumento de los incendios forestales ha afectado gravemente a zonas de gran interés como es el caso las interfaz urbano rural, que es el espacio en el que coexiste población humana y área silvestre. Es por esto, que vemos la necesidad de identificar el riesgo de incendios al que se enfrenta la población humana habitante de éstas zonas, así optimizar la distribución de recursos y evaluar las mejores estrategias de prevención. El estudio se realizó en la zona urbano rural de Concepción, ciudad ubicada en el centro sur de Chile. Lo que se busca es integrar un modelo de ocurrencia de incendios con uno de propagación y de esta manera conocer las zonas que son más susceptibles a verse afectadas por incendios. En una primera instancia se realiza un modelo de ocurrencia, utilizando un modelo de Machine Learning, Bagged Decision Tree (con muy buen resultado de testeo, AUC = 0,97), con el objetivo de aprender en qué zonas es más probable que se inicie un incendio. Considerando donde es mayor la probabilidad de ocurrencia, se utilizó el simulador de incendios Cell2Fire para evaluar la propagación del fuego y así conocer aquellas zonas que son más propensas a quemarse. Con esto se construyó un Burn Probability Map. Finalmente, este resultado se cruzó con un mapa de densidad poblacional, para conocer el riesgo al que se ve enfrentada la población humana en la zona urbano rural de Concepción. Como resultado final se obtuvo un mapa donde se identifican aquellas zonas con un mayor riesgo y por tanto conocemos el porcentaje de la población que tiene mayor probabilidad de verse afectada por incendios forestales. El trabajo que se presenta a continuación es una prueba de conceptos de una herramienta que busca apoyar la toma de decisiones en la planificación urbana y productiva, de manera tal de lograr diseñar paisajes resistentes a incendios forestales y disminuir el riesgo a que se ve afectada la población humana.

Keywords: Riesgo de incendios forestales; Machine Learning; Burn Probability Maps; Simulation espacial

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Mean field semi-Markov control models for interacting objects systems under a discounted optimality criterion

M. Elena Martínez-Manzanares; J. Adolfo Minjárez-Sosa

December 12, 2022 (Monday), 14:00 - Room 1301

We deal with the study of systems composed by N interacting objects evolving in continuous time. There is a central controller that at each decision epoch takes an action that influences the behavior of the objects. We will assume that the number of objects N is too large (of the order of infinity), and depending on their characteristics or properties, they can be classified in a finite number of classes, say s. The system we are interested in evolves as follows. The objects will be distributed among the s classes. Then, at the moment of the nth decision epoch (n=1,2,..), the controller observes the configuration of the system through a vector whose components are the proportion of objects in each class and selects an action. Consequently, the objects move randomly among the classes according to a semi-Markov process. In addition, costs by the immediate decision and the period duration of the epoch are accumulated through the system. The above defines the so-called N-Semi Markov Control Model (N-SMCM). The goal is to study the optimal control problem associated with the N-SMCM. Clearly, the fact that N is extremely large will confront us with the “curse of dimensionality”, which implies that in practical terms the problem is impossible to solve. Is in this context that the Mean Field Theory is applied to present a computationally viable solution. Specifically, computing the limit as N approaches infinity on the N-SMCM, we obtain a new model known as the Mean-Field Model (MF), independent of N in which the system configuration results a probability measure over the set of classes. Furthermore, the associated control problem on the MF-model results deterministic, and, in a way, easier to analyze. In this sense, we can calculate an optimal policy in the MF-Model and measure the optimality deviation when it is used to control the N-SMCM.

Keywords: Systems of interacting objects; Mean field theory; Semi-Markov control problems; Discounted criterion

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Stochastic modeling of modern call center data via Markovian arrival processes

Pepa Ramirez Cobo; Rosa Lillo; Marcos Gonzalez Bernal

December 12, 2022 (Monday), 14:00 - Room 1301

Modern call center data are characterized by overdispersion and a non-negligible correlation

structure. In this work we propose the Markovian arrival process (MAP) as a suitable stochastic model in this context. We fit the model by solving an optimization problem based on both the moments of inter-arrival times as well as the correlation-based descriptors of the counting process. Applications to queueing theory using a real database are shown.

Keywords: Call center data; Markovian arrival process; Counting process; Correlation; Queueing theory

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Territory design for Multi-Period Vehicle Routing Problem with Time Windows
Hernán Lespay; Karol Suchan

December 12, 2022 (Monday), 14:00 - Room 1302

This study introduces the Territory Design for Multi-Period Vehicle Routing Problem with Time Windows (TD-MPVRPTW), motivated by a real-world application at a food company's distribution center. This problem deals with the design of contiguous and compact territories for delivery of orders from a depot to a set of customers, with time windows, over a multi-period planning horizon. Customers and their demands vary over time. The problem is modeled as a mixed-integer linear program (MILP) and solved by a proposed heuristic. The heuristic solutions are compared with the proposed MILP solutions on a set of small artificial instances and with the food company's solutions on a set of real-world instances. Computational results show that the proposed algorithm can yield high-quality solutions within moderate running times. A methodology is proposed in which the territories computed by the proposed heuristic on the historic demand of one month are used for the operational routing during the following month, in which the demand is known only one day in advance. An evaluation shows that the territories obtained with our methodology would have led to levels of service significantly better than the ones that were experienced by the company, using a significantly lower number of vehicles to execute the deliveries.

Keywords: territory design; vehicle routing; last-mile logistics; heuristics

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A heuristic algorithm for solving the school bus routing problem with multiple periods
Igor E. S. Melo; Raphael Kramer

December 12, 2022 (Monday), 14:00 - Room 1302

We address the Multi-Period School Bus Routing Problem (MP-SBRP), derived from the (single period) School Bus Routing Problem (SBRP) presented by Schitekat et al. (2013) [A metaheuristic for the school bus routing problem with bus stop selection. European Journal of Operational Research, 229(2), 518--528, 2013]. The MP-SBRP extends the SBRP by taking into account variable demands in different periods (e.g., days), which is a common characteristic in the higher education context, where students do not have to go to the university every day of the week. This approach allows obtaining routes potentially shorter than the routes obtained by the traditional approach. The considered MP-SBRP includes the subproblems of locating bus stops, allocating students to the selected bus stops and routing of buses. The objective is to minimize the total distance traveled by the buses in the analyzed periods, taking into account vehicles capacities and the maximum distance that students can walk to the stops (i.e., maximum walk distance). In addition, each student must be allocated to the same stop in the subset of periods which he/she has demand, in order to facilitate the use of the service. To solve the problem, a mixed integer linear programming formulation (MIP-F) and an algorithm based on the Iterated Local Search (ILS) metaheuristic are proposed. Such algorithm is evaluated by means of computational experiments. In this way, we first extend the instances proposed by Schitekat et al. (2013), in order to include the number of periods (5 days) and the student demands. By varying the percentage of students with demands on all days (75%, 50%, 25%, 0%), 192 instances were generated involving up to 10 candidate stops and 200 students. In summary, the costs of the solutions obtained by the ILS algorithm have an average gap of -1.90% when compared with the ones obtained by solving the MIP-F with Gurobi (2h of time limit), using a shorter computational time (9sec in average).

Keywords: Bus Routing Problem; Multi-Period; Route Generation; Stop Selection; Mathematical

Model; Metaheuristic

A multi-agent architecture for solving the dynamic vehicle routing problem with time windows
Cristian G Gómez-Marín; Conrado A Serna-Uran

December 12, 2022 (Monday), 14:00 - Room 1302

This paper proposes a multi-agent architecture to solve the dynamic vehicle routing problem with time windows DVRPTW. The different agents have behaviors, capabilities, and resources and perform a coordination process guided by the well-known Contract Net Protocol (CNP) and FIPA Brokering Interaction Protocol. The agents can generate new customer, cancellation, and quantity change requests considering different dynamism degrees, allocating them to the best vehicle proposal, and monitoring the system. The routes are designed considering the static and dynamic request with an allocation-routing heuristic based on a greedy algorithm for the allocation and an insertion algorithm for a single-vehicle. To increase the new request acceptance the system uses a transit inventory for each vehicle strategy. Computational experiments show a high new request acceptance with a lower possible cost.

Keywords: Multi-agent system; Dynamic vehicle routing problem; Hybrid heuristic

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Two-phase heuristics for the novel multi-compartment truck and trailer routing problem
Laura Davila Pena; David Rodríguez Penas; Balbina Casas Méndez; Maria Antónia Carravilla; José Fernando Oliveira

December 12, 2022 (Monday), 14:00 - Room 1302

Vehicle routing problems admit different variants depending on the clients' needs. One of them is the truck and trailer routing problem, TTRP, where a fleet of trucks and trailers serves a set of customers such that when the trailer is not able to reach a customer, they are attended only by the truck. This work proposes a novel mixed-integer linear programming approach to combine the TTRP with product compartmentalization, which we call the multi-compartment truck and trailer routing problem (MC-TTRP). The combination of these two features is motivated by the needs of a Spanish agricultural cooperative that produces feed for cattle. Given that MC-TTRPs have an NP-hard complexity, optimal solving via exact methods for large-size instances is computationally expensive. Thus, the use of approximated techniques, such as heuristics, becomes necessary in order to obtain quality solutions in a reasonable time. We present two heuristic algorithms for the MC-TTRP: an iterated tabu search (ITS) and an adaptive large neighborhood search (ALNS). Both proposals consist of two stages: the first phase iteratively builds an initial solution, based on the savings method of Clarke and Wright, and then the second phase aims to refine the solution. We carried out a computational study on new 21 test problems adapted from those in preexisting literature. The results obtained prove the effectiveness of our proposals. In particular, the ITS outperforms previous approaches for some truck and trailer routing problem instances. Furthermore, an application of the proposed model and heuristics is demonstrated in the field of agricultural logistics by comparing the obtained results through different approaches.

Keywords: Truck and trailer routing problem; Compartmentalized vehicles; Heuristics; Logistics

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Decision-focused learning under the lens of bilevel programming
Víctor Bucarey

December 12, 2022 (Monday), 14:00 - Room 1303

In the last years decision-focused learning (DFL), also known as predict-and-optimize approaches, has received increasing attention. In this setting, the predictions of machine learning models are used as estimated cost coefficients in the objective function of discrete combinatorial optimization problems for decision making. Decision-focused learning approaches propose to train the ML models, often neural network models, by directly optimizing the quality of decisions made by the optimization solvers. In this work, we take another approach. DFL can be seen as a bilevel

optimization problem where the upper-level problem is the regret of the decision, and the lower-level problem is the underlying optimization problem. We discuss optimistic and pessimistic approaches and propose several mathematical programming formulations and algorithms to find exact and approximate results.

Keywords: Bilevel programming; Data science; Integer programming

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Identificación de variedad y etapas de crecimiento en cultivos mediante redes neuronales y descriptores de características: Un caso aplicado en un cultivo de lechugas en Chile

Nicolás Reyes-Reyes; Marcela González-Araya; Wladimir Soto-Silva; Javier Gómez-Lagos; Irlanda Ceballos-Fuentealba

December 12, 2022 (Monday), 14:00 - Room 1303

En las últimas décadas, el interés por técnicas de Aprendizaje Profundo (Deep Learning) ha aumentado considerablemente en el sector agrícola. Esto, porque han permitido abordar distintos problemas de reconocimiento y clasificación en este sector económico, logrando reducir los riesgos en la toma de decisiones sobre distintos cultivos. Sin embargo, todavía existen brechas cuando se realiza un análisis entre variedades de una misma especie de cultivo. Por otro lado, las técnicas de Aprendizaje Profundo requieren de tiempos de cómputo elevados para obtener un modelo permita generalizar con alta precisión. Por esta razón, se propone en este estudio una metodología para la identificación rápida y precisa de variedad y etapas de crecimiento en una misma especie, con el propósito de mejorar el monitoreo y control de cultivos. Esta metodología, consiste en utilizar una red neuronal feed-forward de una única capa oculta (SLFN) junto a descriptores de características obtenidos de las imágenes del cultivo. La red neuronal fue entrenada mediante el algoritmo conocido como Máquina de Aprendizaje Extremo (ELM) y descriptores de características como Histogramas de Gradientes Orientados (HOG) y Patrones Binarios Locales (LBP). La metodología propuesta, fue aplicada en un caso estudio real de una granja de lechugas ubicada en la región del Maule en Chile. De esta granja, se recopilaron imágenes de tres variedades diferentes de lechuga (romana, gallega de invierno y iceberg), y en tres etapas de crecimiento distintas (plántula, roseta y encabezamiento). Los resultados computacionales muestran que es posible identificar las distintas variedades y etapas de crecimiento de lechuga con una precisión general de 85% y 97% respectivamente. Además, los tiempos requeridos para identificación (entrenamiento y test de la red neuronal) son mínimos ya que estos no superan los 52 segundos sin el uso de Computación de Alto Rendimiento (HPC) ni Unidades de Procesamiento Gráfico (GPUs).

Keywords: Red neuronal; Máquina de aprendizaje extremo; Descriptor de características; Variedad; Etapas de crecimiento; Cultivo de lechugas

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Un enfoque de machine learning para la estimación de pérdida hortícola: un caso aplicado en un cultivo de lechugas en Chile

Irlanda Ceballos-Fuentealba; Javier Gómez-Lagos; Marcela González-Araya; Wladimir Soto-Silva; Nicolás Reyes-Reyes

December 12, 2022 (Monday), 14:00 - Room 1303

Cada año el 40% de la producción mundial de alimentos se pierde y desperdicia a lo largo de las diferentes etapas de la cadena de suministro de alimentos. Al respecto, los productos hortícolas son uno de los más susceptibles, alcanzando pérdidas que van desde un 26% a un 55% anual. Para minimizar estas cifras, primero se debe cuantificar la pérdida asociada a algún producto o conjunto de productos con características fisiológicas similares. En la actualidad, en su mayoría, las pérdidas hortícolas se estiman de forma empírica por los tomadores de decisiones presentes en las producciones agrícolas, y, en menor medida, se estiman de forma teórica utilizando curvas de decaimiento de calidad que dependen de la especificidad de los datos. La principal desventaja en ambos casos, es la falta de una metodología que pueda ser replicable a una gran variedad de productos. Este trabajo desarrolla un marco metodológico con un enfoque de machine learning para cuantificar las pérdidas en la producción agrícola de productos hortícolas que posean características de crecimiento observables. Esta metodología posee un enfoque híbrido, pues emplea un árbol de decisión para determinar si el producto estará apto para el mercado, y, asimismo, ajusta sus

parámetros para mejorar la precisión de la predicción utilizando la técnica de análisis envolvente de datos. La metodología propuesta es aplicada en un caso de estudio real de un cultivo de lechugas de distintas variedades en la zona centro de Chile, el cual fue monitoreado en todas sus etapas fenológicas en 2019. Los resultados preliminares, evidencian que es posible realizar la predicción y cuantificación de las pérdidas del cultivo en referencia, previo a su comercialización y con un margen de error mínimo.

Keywords: food losses; food waste; machine learning

A two-stage stochastic bilevel program for coordinating a hierarchical fresh food supply chain

Victor M Albornoz; Patricio I Vera; Lia C Araneda

December 12, 2022 (Monday), 14:00 - Room 1303

This paper considers a harvest planning problem in the context of a hierarchical fresh food supply chain, which integrates also the definition of management zones for harvesting and the coordination between the producer and the wholesaler. The problem is represented through a two-stage stochastic bilevel program that allows the representation of the hierarchy between the producer (leader) and a wholesaler (follower). The producer decides planning and scheduling of the harvest for each homogeneous management zone into the resulting partition, and the wholesaler decides the amount to be acquired to satisfy demand requirements. At each decision level, a stochastic optimization model is proposed for representing the uncertainty in future crop yields, prices and demands, using a finite set of scenarios. A reformulation of the bilevel model into a mixed--integer linear program is provided by the use of Karush--Kuhn--Tucker conditions and replacing the non--linear complementary constraints allowing for the introduction of auxiliary binary variables and a big--M term. This model was applied in a case study for harvesting of grapes with data collected from. Our research shows valuable results of the proposed methodology from a set of instances representing the behavior of both decision makers under uncertainty.

Keywords: OR in Agriculture; Supply chain management; Stochastic optimization; Bilevel programming; Harvest planning problem

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A multi-objective mathematical optimization approach for the forest planning problem

Frank Piedra-Jimenez; Diego Broz; Juan M. Novas; Maria Analia Rodriguez

December 12, 2022 (Monday), 14:00 - Room 1304

A general mathematical framework based on a Generalized Disjunctive Pro-gramming (GDP) approach for optimal forest planning problems is proposed in this work. For this purpose, a Multi-objective GDP (MO-GDP) model is constructed and it is reformulated as a Multi-objective Mixed Integer Linear Programming (MO-MILP) model. The model determines the optimal forest management alternative (combination of silvicultural treatments), the proportion of land area to be harvested, and the flow of timber products from harvesting nodes to forest industries. The proposed mathematical formulation simultaneously addresses two conflicting objectives: the maximization of the net present value and the minimization of the absolute deviations of timber assortment production between consecutive periods. FlorExel® growth simulator is used to estimate timber yields, and the MO-MILP developed model is solved in GAMS. In addition, two alternative iterative procedures, the so-called, ϵ-constraint and the AUGMECON methods are used to obtain the Pareto optimal solutions. The feasibility of the proposed model is tested using real data from a company located in the north of the province of Misiones. Computational results show that the designed framework serves as a decision-making tool to provide diverse solutions with different trade-offs among the considered criteria.

Keywords: Forestry planning; Generalized Disjunctive Programming; Multi-Objective Pro-gramming

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Comparison of metaheuristics for the optimization of the firebreak allocation in real landscapes

David Palacios; Jaime Carrasco; Sebastián Dávila; Cristobal Pais; Maximiliano Martínez; Andrés Weintraub

December 12, 2022 (Monday), 14:00 - Room 1304

In this research, different metaheuristics are studied, implemented and compared in order to offer a tool that allows, through operations management, the adoption of firebreak alllocation strategies to reduce the area burned due to forest fires as much as possible. It incorporates the randomness of the nature of wildfires through variations in ignition points and wind direction. In addition, the metaheuristics are tested on different sizes and types of forests (with homogeneous and heterogeneous fuels) and a real application with the 2001's Dogrib fire. For simulations, the wildfire simulator Cell2Fire is used. In a first implementation, different metaheuristics are tested (Ant Colony Optimization, Simulated Annealing, Artificial Bee Colony algorithm, among others). In the final implementation, 3 metaheuristics were compared: Genetic Algorithm, GRASP (Greedy Randomized Adaptive Search Procedure) and Tabu Search, which correspond to those that gave better results in basic implementations, with GRASP achieving the best result. This result is consistent with one of the conclusions obtained by Mark Finney et al. in the 2008 paper: "Simulation of long-term landscape-level fuel treatment effects on large wildfires", where he finds topologies that better favor firebreak performance compared to other topologies. It is also proposed some improvements, such as not seeking to minimize the burned area in the average of simulated scenarios in Cell2Fire, but seeking to minimize the burned area of the fire that burns the most area within the simulated scenarios in Cell2Fire. Finally, it is concluded that GRASP and the Genetic Algorithm (the latter if there is a high operational capacity to locate a greater number of firebreaks) could be a good tool to assist in preventing the impact of forest fires in zones like Chile, where most of the disastrous fires arise in the wild-urban interface (WUI).

Keywords: metaheuristics; operations research; Wildfires; firebreaks; Cell2Fire; GRASP; Tabu Search; Genetic Algorithm

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Optimización de las operaciones forestales con consideraciones medioambientales: una aplicación a un aserradero de Uruguay

Karina López; Victor Viana; Pedro Piñeyro

December 12, 2022 (Monday), 14:00 - Room 1304

En este trabajo se presenta un estudio realizado sobre la planificación de la producción de un aserradero con el objetivo de evaluar alternativas a implementar para obtener un mayor beneficio económico para la organización, teniendo en cuenta el impacto ambiental de sus operaciones. Inicialmente se presenta una revisión bibliográfica con hincapié en trabajos recientes, llevada a cabo para relevar y analizar los métodos utilizados y desarrollados para el modelado y resolución de problemas de planificación de las operaciones en logística forestal a nivel internacional. En segundo lugar, se presenta una aplicación de las técnicas de Investigación de Operaciones para formular y resolver un problema de optimización sobre la planificación de la producción de un aserradero de Uruguay, que comercializa sus productos de forma internacional. El problema de optimización consiste en determinar las cantidades de trozas a comprar de diferente calidad y qué tipos de cortes aplicar sobre las mismas (dentro de un conjunto preestablecido) para maximizar las ventas, teniendo en cuenta restricciones de presupuesto, de rendimiento y de impacto ambiental, entre otras. Para ello fue necesario el desarrollo de un modelo de programación matemática que contemple los diferentes objetivos planteados. A partir de la resolución del modelo se obtienen soluciones de buena calidad (óptima o cercanas a la óptima) tomando en consideración la complejidad del problema. Se realiza, además, un análisis de sensibilidad para evaluar cómo ciertas variaciones en los datos de interés obtenidos de la realidad, impactan en las soluciones. Finalmente, se presentarán algunas direcciones de trabajo futuro, entre las cuales se incluye la aplicación de los conocimientos adquiridos a otros problemas de optimización del sector forestal.

Keywords: Sustainable Production Planning; Forest Logistics; Mathematical Programming; Optimization

Forestry harvest planning considering social impacts and soil compaction issues
Daniel Rossit; Diego Broz; Cristóbal Pais; Andrés Weintraub

December 12, 2022 (Monday), 14:00 - Room 1304

Forest harvest planning implies great challenges for wood supply companies. This type of planning involves complex decision processes involving different stakeholders, as well as factors outside the stakeholders that directly affect the resolution of the problem. Within these factors that affect, one of special interest is the conditioning by risk of soil compaction. This factor can be decisive in planning since it functions as a restriction or prohibition on harvesting operations. This phenomenon depends on the hydrological balances of the soils, which in turn depends on the meteorological and climatic conditions. That is why to properly address these decision processes, stochastic approaches are required. On the other hand, there exists a large number of SMEs and micro-SMEs that are dedicated to forest harvesting operations, which work as contractors for industries and provide. These companies have a direct interference in the industrial matrix and in the labor offer in the regional economy of the Argentine Northwest. However, a purely utilitarian approach to forest harvesting would tend to prioritize the hiring of larger companies with superior technical capacity, which would allow production costs to be reduced. However, this would impede the possibility of growth of the regional economy, leaving out smaller companies, which do not have the resources for technological migration. This issue has gained relevance after United Nations included this topic in its Sustainable Development Goals agenda (ODS 8). To contribute to this line, an approach based on mathematical programming is proposed that allow addressing the stochastic complexity of the problem (due to the risk of soil compaction), but that balance the workload delivered to each contractor, ensuring compliance with the demand. For this, a goal programming model is developed, which contemplates the minimization of costs and the balancing of the workload among contractors.

Keywords: Forestry harvest planning; Sustainability; Soil Compaction; Social impact; regional economies

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Using prize-collection concepts to solve time-limited search problems: Application to humanitarian operations
Rajan Batta; Nastaran Oladzad-Abbasabady

December 12, 2022 (Monday), 14:00 - Room 1305

Time-limited search problems are of high relevance in humanitarian operations. This can include applications from the perspective of government organizations, such as searching for injured people, assessing road damage, assessing building damage. This can also include applications from the perspective of the affected population, such as searching for essential commodities, such as food, supplies, water, and gasoline. We explore suitably defined prize-collection problems to help develop effective time-limited search strategies for such application settings. The challenge is to translate the information available for the search problem, including data on the spatial and temporal distribution of search objects and viewing time, to suitably defined prize values, locations and time windows for prizes. The solution of the defined prize-collection problem establishes the search path to be used Theoretical constructs of the relationships between these prize-collection problems and the search problem being modeled are explored. Computational tests are conducted, along with extensive simulation testing to determine the effectiveness of these methods. Also, two case studies are developed and analyzed. One of these case studies is based on a problem that arises from the perspective of the government organization, and the other is based on a problem that arises from the perspective of the affected population.

Keywords: Time-limited search problems; Humanitarian operations; Prize-collection problems

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Dynamic relocations in car-sharing networks
Mahsa Hosseini; Joseph Milner; Gonzalo Romero

December 12, 2022 (Monday), 14:00 - Room 1305

We propose a novel dynamic car relocation policy for a car-sharing network with centralized control and uncertain, unbalanced demand. The policy is derived from a reformulation of the linear programming fluid model approximation of the dynamic problem. We project the full-dimensional fluid approximation onto the lower-dimensional space of relocation decisions only. This projection results in a characterization of the problem as n+1 linear programs, where n is the number of nodes in the network. The reformulation uncovers structural properties that are interpretable using absorbing Markov chain concepts and allows us to write the gradient with respect to the relocation decisions in closed form. Our policy exploits these gradients to make dynamic car relocation decisions. We provide extensive numerical results on hundreds of random networks where our dynamic car relocation policy consistently outperforms the standard static policy. In fact, it reduces the static policy's optimality gap in steady-state by more than 23% on average. Moreover, in the short-term time-varying setting, the lookahead version of our policy provides a percentual improvement over the static lookahead policy of over 3% on average, which is slightly better than the results in steady-state, both on hundreds of random networks and on a case study using real data.

Keywords: car-sharing; fluid limit; closed queuing network; car relocation

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Metodología basada en Costos Logísticos Totales para el análisis estratégico del Corredor Bioceánico Capricornio y su impacto en los puertos del norte de Chile

Macarena Vergara; Felipe I. Díaz; Luis M. Ascencio; Sergio Cruz; Rosa G. Gonzalez Ramirez; J. René Villalobos

December 12, 2022 (Monday), 14:00 - Room 1305

El corredor bioceánico Eje Capricornio comprende 6 regiones de Brasil, Paraguay, Argentina y Chile; 2.290 kilómetros entre Campo Grande y Antofagasta. Esta conexión entre el atlántico y pacífico representa una alternativa al actual flujo de mercancías de comercio exterior de esta zona que tradicionalmente emplean como puertos de salida aquellos ubicados en el atlántico, siendo el Puerto de Santos en Brasil y el de Buenos Aires en Argentina los principales puertos de entrada o salida de estas mercancías. Para que la construcción de la carretera bioceánica tenga un impacto positivo en las actuales cadenas logísticas y más aún, capte y genera nuevas, se deben generar en paralelo mejores condiciones de infraestructura y servicios logísticos. La región de Antofagasta en la Macrozona Norte de Chile está geográficamente ubicada en un sector estratégico del corredor y que pudiera convertirse en un Hub y Gateway comercial y logístico para Sudamérica hacia países del Asía-Pacífico. En este trabajo se propone una metodología de análisis basada en un modelo de costos logísticos totales de comercio exterior que permita identificar las oportunidades de captación de cargas por los puertos del norte de Chile, a partir de las oportunidades que genera el desarrollo del Corredor Bioceánico Capricornio, y a su vez, determinar cuáles serían las inversiones necesarias y niveles de servicio de los puertos del norte de Chile para captar dichas cargas. Este análisis se aplica a un grupo de productos y cadenas logísticas priorizadas que actualmente realizan transacciones comerciales con los mercados objetivos.

Keywords: Costos Logístico; Hinterland portuario; Captación de Carga y prospectiva; Análisis de Inversiones de Infraestructura.

A analytical approach for infrastructure capacity planning in higher education

Jaime Miranda

December 12, 2022 (Monday), 14:00 - Room 1306

Solution approaches based on operations research and Analytics provide support for a range of academic and administrative problems at higher education institutions. This paper presents an novel approach to the capacity planning problem that determines the number and type of classrooms needed for an institution's program and course offerings. The approach consists of three sequential stages. The first two stages generate estimates that create the input information on course demand forecasts to be used in the third stage, which solves a mixed integer linear programming model (MIP). The model incorporates certain short and mid term conditions that affect decisions in the long term. The proposed approach was applied at the School of Economics and Business of University of Chile to test the effect on the School's planning process of different scenarios.

Keywords: Education planning; Curriculum planning; University timetabling; Case study models

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Modelo matemático para nivelar la carga estudiantil, en las distintas franjas horarias de IES, y favorecer el distanciamiento social; caso de estudio, Universidad Central en Bogotá Colombia

Jainet Bernal; Valentina Rodríguez; Catalina Martínez

December 12, 2022 (Monday), 14:00 - Room 1306

La pandemia del COVID-19, llegó a Colombia en el 2020, y fue en marzo de ese año, cuando el gobierno declaró estado de emergencia sanitaria imponiendo medidas que buscaban reducir la velocidad de contagio en la sociedad. Esto, generó cambios en el estilo de vida de las personas, pero también en la operación de empresas, entidades estatales e instituciones educativas. El presente trabajo, centra su aplicación en instituciones de educación superior que, a causa de las medidas impuestas por la pandemia, puntualmente el distanciamiento social, buscan nivelar la carga estudiantil en sus instalaciones a lo largo del día, con el fin de evitar tenerlas muy llenas a unas horas y muy vacías en otras. El objetivo es nivelar, lo mejor posible, el número de aulas ocupadas para cada franja, con el fin de contribuir a aumentar el distanciamiento social, producto de evitar tener las instalaciones muy llenas. Para ello se diseñó y aplicó un modelo de optimización Timetabling school, con una perspectiva diferente, en lo referente a la función objetivo, para responder a una condición generada por las restricciones dadas en pandemia, pero que puede ser replicado a otros contextos organizacionales, en los que se busque un uso equilibrado de recursos o instalaciones en distintos periodos de tiempo. Es por ello que el modelo se diseñó para programar la oferta académica de la Facultad de Ingeniería de la Universidad Central, tal que nivele el número de grupos programados en las diferentes franjas de la semana. Esto, consistió en identificar la franja horaria en la cual asignar a cada grupo de cada una de las 167 asignaturas, de 5 pregrados de la Facultad, cada una con un número de grupos no mayor a 19, en 33 franjas horarias. Los resultados mostraron una reducción promedio del 8% en el máximo número de grupos en una preferencia horaria. Para la del día se logró que 16 grupos fuera el máximo número de grupos en paralelo y para preferencia noche 45.

Keywords: carga estudiantil; timetabling school; optimización

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Asignación de árbitros en campeonatos de fútbol multisede usando un modelo de optimización multiobjetivo. Caso de estudio Copa América

Julian Osorio; Mauricio Cepeda; Jainet Bernal

December 12, 2022 (Monday), 14:00 - Room 1306

Se presenta un modelo de optimización multiobjetivo para apoyar la asignación arbitral en campeonatos de fútbol multisede, en el marco del problema Referee Assignment Problem (RAP). Para ello, se toma en cuenta el caso de la Copa América, campeonato de la Confederación Sudamericana de Fútbol que reúne a los equipos nacionales de los países sudamericanos cada 4 años. El trabajo se compone de 3 fases: En la fase 1, se indaga sobre las condiciones y los criterios en las distintas organizaciones de fútbol a nivel mundial, para la asignación de árbitros en campeonatos de fútbol. Posterior a ello, en la fase 2, se construye el modelo matemático multiobjetivo, se implementa, opera y valida frente a las especificaciones y criterios ya identificados. En la fase 3, se utiliza TOPSIS para establecer la mejor solución para el caso de estudio dentro de los posibles escenarios generados. Uno de los atractivos de este trabajo radica en el aporte a las comisiones arbitrales, para que cuenten con un instrumento neutral y objetivo, que efectúe rápidamente la asignación arbitral de cierto campeonato, a partir de las calificaciones previas de los jueces y la relevancia del encuentro, tomando como referencia el ranking FIFA de selecciones. El modelo de optimización se validó con los partidos de la fase de grupos de la Copa América 2021 ajustándose a todos los criterios y condiciones establecidas; dicho modelo, puede ser ajustado para ser utilizado en el contexto de otras competencias de fútbol a nivel mundial. Los resultados obtenidos señalan, frente al escenario real, una reducción del 51% en los desplazamientos de los árbitros durante el campeonato, y a su vez, mejora en un porcentaje similar el ajuste de las calificaciones de los árbitros frente a las calificaciones de los partidos a los que se asignan, cumpliendo con todas las restricciones identificadas para este tipo de campeonatos.

Keywords: Asignación de árbitros; Optimización multiobjetivo; Copa América de fútbol

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Application of the Quasi-Netwon in interior point methods for solving the predispatch problem

Silvia Maria Simões de Carvalho; Aurelio Oliveira

December 12, 2022 (Monday), 14:00 - Room 1307

Brazilian energy matrix is essentially based on hydroelectricity with long transmission lines, allowing the exchange of energy produced in all regions of the country, the increased demand for energy and the search for lower costs, the application of more efficient and robust methods to minimize generation and transmission losses is necessary, since these are functions of generated and transmitted power, respectively. The purpose of this work is to implement primal dual interior point method for the predispatch of a hydroelectric system, with partial replacement of the Newton method with the quasi-Newton method in order to compute the system Jacobian matrix and reduce the computational costs of the iterations arising from approximations of the inverses of the Hessian matrix. This means that, in order to obtain a search direction, only a matrix vector product is necessary, which is much more efficient, for example, than the Newton method, in which a linear system has to be solved at each iteration. Computational results prove the efficiency of the approach used

Keywords: interior point methods; Newton's Method; Preconditioner

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On the achievement of the complementary approximate Karush-Kuhn-Tucker conditions and algorithmic applications

Renan W. Prado; Sandra A. Santos; Lucas E. A. Simões

December 12, 2022 (Monday), 14:00 - Room 1307

Focusing on smooth constrained optimization problems, and inspired by the complementary approximate Karush-Kuhn-Tucker (CAKKT) conditions, this work introduces the weighted complementary Approximate Karush-Kuhn-Tucker (WCAKKT) conditions. They are shown to be verified not only by safeguarded augmented Lagrangian methods (Andreani et al., 2010), but also by inexact restoration methods (Gomes-Ruggiero et al., 2009), inverse (Bertsekas, 1999) and logarithmic (Andreani et al., 2014) barrier methods, and a penalized algorithm for constrained nonsmooth optimization (Helou et al., 2020). Under the analyticity of the feasible set description, and resting upon a desingularization result, the new conditions are proved to be equivalent to the CAKKT conditions. Due to its generality and strength, the new conditions may help to enlighten the practical performance of algorithms in generating CAKKT sequences.

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Keywords: Nonlinear programming; Sequential optimality conditions; Mathematical programming methods; Analytic sets

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Nonregular multiobjective problems: Necessary and sufficient optimality conditions
Marko Rojas-Medar; Lucelina dos Santos; Adson Melo; María Beatriz Hernández-Jiménez

December 12, 2022 (Monday), 14:00 - Room 1307

In this talk we give higher-order necessary optimality conditions for mixed-constrained multiobjective problems. We study the case when the constraints of the problems are not assumed to be regular at a solution. We introduce some new generalized regularity conditions and we obtain Karush-Kuhn-Tucker type necessary optimality conditions. Some examples are presented to illustrate our results. Also, we give some sufficient optimality conditions.

Keywords: Nonregular problems; Optimality conditions; Generalized constraint qualifications; P-regularity

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On strong stability of C-stationary points for MPCC
Jan-J. Ruckmann; Daniel Hernandez Escobar

December 12, 2022 (Monday), 14:00 - Room 1307

In this lecture we consider mathematical problems with complementarity constraints (MPCC). Under an appropriate constraint qualification we present an algebraic characterization for the strong stability of C-stationary points for MPCCs. The concept of strong stability was introduced by Kojima for stationary points of standard nonlinear optimization programs; it refers to the uniqueness and existence of stationary points where perturbations up to second order are allowed. This lecture applies and generalizes this concept and its algebraic characterization to the context of MPCC.

Keywords: Mathematical programs with complementarity constraints; C-stationary point; strong stability; constraint qualification

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Increasing willingness to pay in the food supply chain: a Blockchain approach
Xavier Brusset; Hussein Naseraldin; Aseem Kinra; Rami Alkhudary

December 12, 2022 (Monday), 14:00 - Room 1308

Marketers advertise food product quality information on labels but do customers believe them and are they willing to pay for the advertised quality? This study investigates the link between blockchain technology (BT) and the consumers willingness to pay (WTP) for products of quality. Our model explains how revealing verified information about product quality throughout the supply chain will generate optimal WTP in consumers and maximise rent. At each level of the chain a buyer holds a Bayesian belief about the quality of the intermediate produce. This belief is shaped by the accuracy and veracity of the information about this quality. Managerial effort is required to ensure that full and verified information maximises the WTP of each intermediate buyer and consumer. We show why this effort must be made across the chain and how opportunistic behaviour may be circumscribed by adequate governance mechanisms. BT and supporting technologies are needed to provide a sufficient guarantee.

Keywords: supply chain management; information disclosure; blockchain; willingness to pay; Bayesian belief

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Performance of risk and return on ESG financial assets in international markets: A preliminary analysis
André Salles; Dayana Alves

December 12, 2022 (Monday), 14:00 - Room 1308

This work aims to examine the performance of ESG financial assets, comparing these assets with the average of the financial assets traded in the respective market or the reference market. Financial assets classified as ESG consider environmental, social and governance criteria for the portfolio

selection and productive projects or financial assets management. In this sense, the objective of this work is to verify the performance of ESG financial assets compared to the most traded financial assets in the market. Cointegration tests were performed, and autoregressive vector and volatility models were estimated. The data used are from a sample of weekly quotations in US$ of the ESG stock indices and their respective reference indicators between the years 2008 and 2021. The hypothesis of cointegration between the ESG indices and their respective reference indices cannot be rejected, which indicates that the benchmarks have been appropriately selected. Furthermore, it can be inferred that there is bidirectional causality between these indicators. The other results obtained indicate that, in general, ESG assets performed better than the profitability indexes of the benchmark stock markets. It occurs in terms of returns and volatilities estimated through heteroscedastic conditional autoregressive models. Regarding the impact of the crises that affected the world economy in the period studied, it was found that both the 2008 financial crisis and the health crisis caused by the Covid-19 pandemic caused an increase in volatility in all indicators of international financial markets. It should be noted that the performance indicators of ESG assets proved to be more sensitive to these crises than their respective benchmarks.

Keywords: ESG Financial Assets; VAR Models; Volatility Models

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Competition and recall in selection problems

Fabien Gensbittel; Dana Maria Pizarro; Jerome Renault

December 12, 2022 (Monday), 14:00 - Room 1308

We extend the prophet inequality problem to a competitive setting. At every period, a new sample from a known distribution arrives, which is publicly observed. Then, two players simultaneously decide whether to pick an available value or to pass and wait until the next period (ties are broken uniformly at random). As soon as a player gets one sample, he leaves the market and his payoff is the value of the sample. In a first variant, namely no recall case, the agents can only bid in each period for the current value. In a second variant, the full recall case, the agents can also bid at each period for any of the previous samples that has not been already selected. For each variant, we study the subgame-perfect Nash equilibrium payoffs of the corresponding game, as a function of the number of periods and the distribution. More specifically, we give a full characterization in the full recall case, and show in particular that both players always get the same payoff at equilibrium, whereas in the no recall case the set of equilibrium payoffs typically has full dimension. Regarding the welfare at equilibrium, surprisingly it is possible that the best equilibrium payoff a player can have is strictly higher in the no recall case than in the full recall case. However, symmetric equilibrium payoffs are always better when the players have full recall. Finally, we show that in the case of 2 arrivals and arbitrary distributions, the prices of Anarchy and Stability in the no recall case are at most 4/3, and this bound is tight.

Keywords: Optimal stopping; Competing agents; Recall; Prophet inequalities; Price of anarchy; Price of stability; Subgame-perfect equilibria; Game theory

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Modelo de optimización multiobjetivo para un caso genérico de una cadena de suministro de bucle cerrado considerando elementos de sostenibilidad y economía circular

Jonathan Lozano Oviedo; Cristian Cortés Carrillo; Pablo Andres Rey

December 12, 2022 (Monday), 14:00 - Room 1308

Actualmente uno de los retos cardinales de las cadenas de suministro de cualquier industria o sector, es cómo reinventarse para responder con eficacia y eficiencia ante los requerimientos de los diferentes stakeholders (e.j. clientes-consumidores, gobiernos, legislaciones, políticas, instituciones privadas y públicas, entre otros) en términos del desarrollo de una conciencia de sostenibilidad no solamente económica, sino también ambiental y social. Cada vez es más fuerte la presión que se ejerce a los dirigentes de los diferentes eslabones de las cadenas de suministro (proveedores, fabricantes, distribuidores, bodegas, minoristas) en términos de la contemplación del desarrollo sostenible en las diferentes actividades organizacionales. Una de las propuestas de solución frente a esta complejidad, es la adopción de las denominadas cadenas de suministro de bucle cerrado sustentables (SCLSCs), las cuales sientan bases desde la perspectiva de la Economía circular y la

Sustentabilidad. De hecho, gracias a su estructura circular y enfoque hacia el desarrollo sostenible, las SCLSCs estimulan la minimización de efectos negativos hacia el medio ambiente y la sociedad, salvaguardando paralelamente el valor económico agregado de forma sostenible, al incorporar, entre otros aspectos, procesos de reciclaje, reparación, renovación, reacondicionamiento y remanufactura. El presente trabajo de investigación tiene como propósito presentar un modelo de optimización multiobjetivo aplicado a un caso estudio genérico de una cadena de suministro de bucle cerrado sustentable, que sirva como una herramienta para balancear y optimizar objetivos de sostenibilidad durante el proceso de toma de decisiones a nivel estratégico y táctico.

Keywords: Sostenibilidad; Economía circular; Optimización; Cadenas circulares sustentables

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Development of strategic map (BSC) with fuzzy logic and multi-criteria optimization
Armando Meza; Juan Pérez; Héctor López-Ospina; Luís Quezada

December 12, 2022 (Monday), 14:00 - Room 1309

The most relevant task for the implementation of the Balanced Scorecard(BSC) is the mapping of strategies, since it provides a structure to demonstrate how strategies link the intangible properties of an organization with the value creation process,in turn; it shows how the objectives of the different perspectives are related to achieve the vision.The main objective of this research is to contribute to models and cutting-edge methodologies in the context of the systematic development of strategic maps of organizations, through the creation of a framework to help in decision-making. Our objective is the design of a methodology that supports the construction of BSC strategic maps, through the implementation of multicriteria decision making methods (MCDM) and lineal programming optimization model (LPOM) that allow establishing and reducing causal relationships between the strategic objectives of the 4 perspectives of the BSC and the selection of the most representative for the fulfillment of the strategy. We propose a framework to analyze the strategy mapping problem faced by organizations, which could allow clarity in planning and indicate where efforts and resources should be concentrated to achieve the goals that generate the greatest impact and value in management and a better decision making. The MCDM used was DEMATEL, which determines the causal relationships and the effects of the variables of the strategic map with the information obtained from a group of experts. The LPOM applied is based on reduction of arcs within the strategic map, eliminating the objectives that obtained the lowest rating in the expert consultation carried out, the maximization of the selected financial objectives and the maximization of the levels of fulfillment ni of the objectives. An optimization model is designed with 3 objectives at the same time and the sum of the weights w must be equal to 1. The weighted sum technique can be used, in which the 3 normalized objectives are weighted.

Keywords: Balanced Scorecard (BSC and Strategic maps); Multi-criteria decision-making method (Fuzzy DEMATEL); Linear Programming (Management & Competitiveness)

Pareto local search for direct aperture optimisation on IMRT
Mauricio Moyano; Carolina Lagos; Guillermo Cabrera-Guerrero

December 12, 2022 (Monday), 14:00 - Room 1309

Radiotherapy is a cancer treatment that uses high doses of radiation to destroy cancerous cells and shrink tumours while sparing surrounding organs at risk (OARs). One of the most common techniques within radiotherapy is Intensity Modulated Radiation Therapy (IMRT). Usually, the IMRT problem is approached sequentially, that is, we first need to determine the set of beam angles from which radiation will be delivered. Then, the radiation intensities for each selected beam angle are computed. Finally, the sequence of aperture shapes we need to use to deliver the computed treatment plan is generated. Unfortunately, the treatment plans generated by this sequential approach have many apertures, which leads to longer treatment times. Unlike the sequential approach, in the Direct Aperture Optimisation (DAO) problem, constraints associated with the number of deliverable aperture shapes, along with machines' physical constraints, are taken into consideration while the intensities optimisation process is taking place. The DAO problem is studied more and more in recent years as it is capable of producing treatment plans that are comparable to plans produced using the traditional inverse planning approach while using significantly fewer

apertures. Although IMRT is inherently a multi-objective optimisation problem, where irradiate the tumour while sparing surrounding organs at risk are two criteria with a trade-off, most of the heuristics proposed in the literature consider only the single objective version of this problem. For this reason, we extend a local search algorithm proposed in the literature to a Pareto local search algorithm to solve the multi-objective DAO. We apply our proposed local search algorithm to a set of prostate cases and compare it with the single objective local search algorithms.

Keywords: Direct aperture optimisation; Intensity modulated radiation therapy; Pareto local search

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A multi-objective algorithm based on decomposition for optimal design Manganese briquettes
Letícia Maria de Melo Silva Cheloni; Rodrigo de Carvalho; André L. Maravilha; Érica Linhares Reis

December 12, 2022 (Monday), 14:00 - Room 1309

Manganese ore processing generates about 30% of material below the particle size specification (fines) for producing manganese ferroalloys. Although this material is composed of a significant amount of this metal, it is usually stored. Then, particle agglomeration techniques - such as sintering, pelletizing, and briquetting - can minimize this environmental liability. Briquetting is a cold agglomeration method. It is advantageous as it does not require high temperatures to harden the agglomerate. It contributes to mitigating the environmental impacts due to decreasing carbon dioxide emissions in this production process. Besides, this technique allows the recycling of other waste in the preparation of briquettes at a lower cost than other agglomeration methods. Briquettes' physical quality can be evaluated according to strength studies, such as compression, abrasion, and drop shatter. These strengths are measured from destructive testing, requiring many briquette samples to obtain a quality configuration. This kind of test is more expensive and wasteful when compared to non-destructive testing. Therefore, this work aims to apply computational regression methods (non-destructive testing) to obtain better quality briquette configurations in terms of strength. Previous laboratory experiments provided the necessary information to create a dataset. Those data were used in a model able to predict the outcome of strength and density because a function to measure such properties is not yet known. A multi-objective problem is formulated to find the maximum compression, abrasion, drop shatter, and minimum bulk density. The multi-objective problem is decomposed by Chebyshev decomposition, and a Differential Evolution algorithm is used to solve it to better approximate the Pareto front. Results show that the proposed methodology can find briquette configurations of good quality.

Keywords: Regression; Decomposition; Optimization; Manganese briquettes

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Equitable location-allocation driven by socioeconomic concerns
Douglas Alem; Aakil Caunhye

December 12, 2022 (Monday), 14:00 - Room 1309

This paper strives to design an equitable location-allocation approach in humanitarian supply chains under resource scarcity, where targeting more vulnerable people is fundamental to building an effective and fair disaster management response. For this purpose, we develop a novel multi-objective relief aid prepositioning supply chain model to address various conflicting objectives that aim to capture not only the logistics costs but also the effectiveness of the disaster response operation and a measure of equity to mitigate an unfair relief aid allocation. Our model is built upon the premise that by strengthening both the coping capacity and the resilience of more vulnerable communities, we can reduce their susceptibility to climate-related hazards and trigger a faster and more effective response in the disaster aftermath. In this way, the long-term development of these communities is supposed to be less compromised, which is aligned with three Sustainable Development Goals (SDGs) for the promotion of economic development and welfare: Goal 1, end poverty in all its forms everywhere; Goal 11, make cities and human settlements inclusive, safe, resilient and sustainable; and Goal 13, take urgent action to combat climate change and its impacts. Our overall results are based on weather-related disasters in Brazil and span more than 20 years of disaster data. We empirically show how more deprived areas can be prioritized in receiving humanitarian aid. As the utmost goal, we hope to help policymakers and disaster managers to justify the selective targeting of specific communities over others in the injection of resources, thus

contributing to more sustainable and resilient livelihoods by guaranteeing socially-equitable disaster management practices across poor and marginalized communities in Brazil.

Keywords: Multiobjective optimization; Location-allocation; Humanitarian Logistics; Equity and social concerns

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Heuristic algorithms for a stochastic optimization problem in production and distribution planning

Enrique Fernández; Javier Marenco

December 13, 2022 (Tuesday), 09:00 - Room 1208

The case herein presented poses the problem of production and distribution of a product that is used to neutralize the effect produced on a crop that is attacked by an agent seeking its destruction. Such agent has the following features:

1. It emerges through a non-deterministic process.

2. Once it has emerged, it has the ability to evolve over time.

3. Once it has emerged, it may move to other areas.

A mixed integer linear optimization model is proposed for the production and distribution process planning, covering a yearly time horizon structured in weeks, annual production campaign - distribution - sale in an extensive region. The localities in which soybean is produced in the Argentine with a temporary extension of 48 weeks are established as the object of study for the evaluation of the results. No exact solution is found in an acceptable computational time due to the number of variables involved in the model. Therefore, a heuristics set is designed to adjust the optimal solution of linear relaxation, looking for results that may be closer to an optimum, in an acceptable computational time. An optimal production and distribution plan depends on product demand, which is, essentially non-deterministic. This demand is simulated with a mechanism for scenarios generation, each of which has an associated probability of occurrence. These scenarios are generated applying Monte Carlo mechanisms, geographic dispersion simulation and population dynamics concepts based on Lotka-Volterra equations. All the heuristics are compared with each other, with the optimal solution of the linear relaxation and against the solution found by the CPLEX package, in a limited computation time. It can be seen that one of the heuristics provides for quality solutions which are, in many cases, superior to the solution found by the CPLEX package in a tenth of its time. In cases where the solution obtained is not the best one, the difference between them does not exceed 1% of its value.

Keywords: Heuristic algorithms; stochastic optimization; production and distribution planning

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Stochastic model for the two-dimensional cutting stock problem: usable leftovers and uncertainty in demand

Douglas Nascimento; Adriana Cherri; José Oliveira; Beatriz Oliveira

December 13, 2022 (Tuesday), 09:00 - Room 1208

The Two-Dimensional Cutting Stock Problem with Usable Leftovers (2D-CSPUL) consists in cutting a set of rectangular plates to produce smaller rectangular items while optimizing an objective function. The cutting process is planned considering the generation of usable leftovers which are not wasted and return to stock to meet future demands. From a multiperiod perspective, the main difficulty of the 2D-CSPUL is planning the production of both items and leftovers without knowing future orders. In this context, we approach the 2D-CSPUL under uncertainty in the demand by proposing a stochastic mathematical model to represent this problem. Mathematically, the decision variables of the stochastic model are divided into first and second stage variables. First stage variables are the frequencies of the cutting patterns used to solve a deterministic problem with known demand. Second stage variables are the frequencies of the cutting patterns used to solve a finite set of problems associated with possible scenarios for items demand, each scenario with a probability of occurrence. The model was solved by an exact solver using as input parameters a set of previously created cutting patterns and a set of scenarios generated from an evolution method based on a

genetic algorithm framework proposed in the literature. The efficiency of the model was verified through computational tests with instances from the literature.

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Keywords: Two-dimensional cutting stock problem; Usable leftovers; Uncertainty in demand; Stochastic model

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Non-convexity measures with applications to improve the convergence of stochastic dual dynamic programming

Iago Leal de Freitas; Bernardo Freitas Paulo da Costa

December 13, 2022 (Tuesday), 09:00 - Room 1208

We investigate the behaviour of optimal value functions for non-convex stochastic optimization problems, focusing on their approximation via cutting-plane methods. We introduce different natural ways to measure how non-convex a function is: the gap between a function and its convex relaxation, a function's second derivative (both in the classical and distributional sense), and a function's minimal Lipschitz constant as used in the Stochastic Lipschitz Dynamic Programming (SLDP) algorithm. All of them have similarities in how they behave with respect to taking averages of functions in a stochastic setting. Finally, we propose a framework for non-convexity measures that generalizes these methods using the tools of cone-convexity. By further inspecting the gap between a function and its convex relaxation, we show that in a two-stage stochastic problem it is possible to construct a linked formulation for the second stage that always produces tighter cut approximations than the standard scenario decomposition methods. This linked formulation works for both risk-neutral and risk-averse problems, and we show how to reformulate both the average value and Conditional Value-at-Risk to take advantage of it. We also reformulate the Stochastic Dual Dynamic Programming (SDDP) algorithm using this linked formulation to generate strengthened Benders cuts on the backward step. This allows us to reduce the duality gap of Mixed Integer Stochastic Problems. We present results comparing our linked methodology to other convex and non-convex dynamic programming approaches, including tests on a model of the Brazilian Operation Planning problem with 4 equivalent reservoirs. Our numerical experiments show that although the linked formulation has a higher computational cost, it is able to achieve significantly smaller gaps between calculated and simulated costs for the same running times.

Keywords: Non-convex optimization; Duality gap; Stochastic Dual Dynamic Programming; Risk-averse Optimization

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Application of Constraint Programming to the sequencing of non-identical parallel machines with sequence-dependent setup and stochastic availability

Carlos Ernani Fries; Luigi Gianni

December 13, 2022 (Tuesday), 09:00 - Room 1208

Constraint Programming is a paradigm surfaced in the Artificial Intelligence literature to solve combinatorial problems. The main advantage of this technique is its capacity to represent and solve problems with very complex constraints – which explains its popularity in scheduling. Despite its growing reputation, there is little literature on real applications of this technique to solve problems in the industry. This work proposes a Stochastic Constraint Programming model to solve a real scheduling problem with non-identical parallel machines, sequence-dependent setups, and stochastic machine availability, to minimize the number of late jobs. This work also proposes to estimate the impact of this new scheduling algorithm, a rolling horizon Monte Carlo simulation, which emulates the daily process of scheduling activities one year long by using the method proposed by

Hoyland and Wallace (2001) to generate random scenarios. The main advantage of using this technique was the possibility of representing correlated data with asymmetric distributions, thick tails, and other peculiar characteristics. Results from the simulation indicate that if the company started using the proposed algorithm to schedule its jobs, the percentage of delayed jobs in a year would be reduced from 25% to 4%. Furthermore, even considering the randomness of machine availability times, the sequencing algorithm presented extremely robust results (i.e., with low amplitude).

Keywords: Stochastic Constraint Programming; Scheduling; Monte Carlo simulation; Rolling horizon; Scenario generation

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Evaluation of the probability of default in a solidarity economy entity with a low default rate using Data Mining

Ivan Mauricio Bermudez Vera; Jaime Mosquera Restrepo; Diego Fernando Manotas Duque

December 13, 2022 (Tuesday), 09:00 - Room 1209

The study and subsequent management of credit risk is an area of renewed interest for any type of institution that carries out credit activities. If adequate preventive measures are not taken, defaulter clients can generate large losses for the entity. Thus, the importance of having highly efficient credit rating models in the default classification of a client, based on the information available a priori about him/her, is highlighted. In the particular case of solidarity economy entities, it is common for a very low fraction of their associates to default on their credit obligations. This creates a great challenge for training default classification models. Under the previous condition, through data mining, using a consumer credit portfolio of a solidarity economy entity in Cali, Colombia, the training and evaluation of several credit risk scoring models is carried out appropriately, adapted for the low default rate condition. In the modelling, traditional models based on statistical learning approach, such as logistic regression, and models based on the machine learning approach, such as KNN algorithms, classification trees, among others, are adjusted. The performance of these methodologies is evaluated through classification goodness metrics such as: correct classification rate, F1 measure, Sensitivity, Specificity, which measure the power of discrimination between “default” and “no-default” clients.

Keywords: credit score; solidarity economy entities; logistic regression; machine learning; low default rate

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Fire sales and default cascades in complex financial networks

Hamed Amini

December 13, 2022 (Tuesday), 09:00 - Room 1209

In this paper, we study two channels of loss amplification in the financial system. In the first part, we model the propagation of balance-sheet or cash-flow insolvency across financial institutions as a cascade process on a network representing their mutual exposures. We derive rigorous asymptotic results for the magnitude of contagion in a large financial network and give an analytical expression for the asymptotic fraction of defaults, in terms of network characteristics. We also introduce a criterion for the resilience of a large inhomogeneous financial network to initial shocks. We next present a general tractable framework for understanding the joint impact of fire sales and insolvency cascades on systemic risk in financial networks. Our limit theorems quantify how price mediated contagion across institutions with common asset holding could worsen cascades of insolvencies in a heterogeneous financial network. Our numerical studies investigate the effect of heterogeneity in network structure and price impact function on the final size of default cascade and fire sales loss. This is based on joint works with Zhongyuan Cao and Agnès Sulem.

Keywords: Fire sales; default cascades; financial networks; random graphs

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Monitoring performance, organizational culture, and the efficiency of public procurement
Olivares Marcelo

December 13, 2022 (Tuesday), 09:00 - Room 1209

We design a field experiment to study how information-based, implicit monitoring technologies affect performance in public services while keeping organizational structure fixed. In collaboration with the Chilean Public Procurement Office, we randomly assigned monthly reports with systematic information about the purchasing performance of procurement officers and services to a sample of 2,600 procurement officers in 184 public services, and randomly varied whether the individual performance was disclosed to managers (public) or not (private). After 5 months of treatment exposure, we find the reports generated significant reductions in overspending, but only when individual performance was observable for managers, meaning that extrinsic motivation is a necessary condition for performance information to generate a change in purchasing behavior of officers. We further find that most of the treatment effect comes from organizations where values associated to efficiency were highly aligned across managers and officers, suggesting that organizational culture plays a key role in easing the impact of implicit monitoring technologies in preventing the misuse of public resources.

Keywords: public procurement; experimentation; public services

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Introducing competition for the market: A field study of framework agreements in government procurement
Weintraub Gabriel; Marcelo Olivares

December 13, 2022 (Tuesday), 09:00 - Room 1209

In conducting their procurement process, large organizations can choose among different mechanisms to select their supplier base. An approach widely used in practice is to use framework agreements (FAs), where the organization pre-select a subset of suppliers and then each sub-organization can purchase from this selected assortment. In government FAs, the decision of pre-selecting suppliers is usually conducted through an auction, where the central procurement unit faces a fundamental tradeoff between variety and price competition. If sub-organizations can have heterogeneous preferences or needs (e.g. specific food restrictions, computer software requirements), then allowing more entry generates more variety while reducing competition for entry in the market. With the focus of analyzing this trade-off, we collaborated with the Chilean government procurement agency (ChileCompra) in the redesign of the 2017 auction for the food FA, in which the government buys US$ 200 million dollars annually. An analysis of the data from previous FA design reveals that there is low competition to enter the market: about 40% of the auctions had a single bid, where suppliers were able to “game” the auction by artificially differentiating their products in order to avoid competition. In the new auction design, products were standardized based on a set of attributes, thereby creating competition to enter the market. Through an experimental design, we varied the percentage of bids that were selected for each product, setting different thresholds to award the winning bids (20% and 80% of the lowest bids), which generated exogenous variation in the degree of competition to enter the market vs. competition inside the market, thereby allowing us to measure the trade-off between these two types of mechanisms.

Keywords: government procurement; competition; field study

Prioritization model for the installation of electric Microgrids
Angelica M. Gonzalez O.; Leonardo Rivera Cadavid; Diego Manotas Duque

December 13, 2022 (Tuesday), 09:00 - Room 1301

A population that does not have access to electricity is considered to be suffering from energy poverty. An area of a country that is not connected to the national electricity grid is known as a Non-Interconnected Zone (NIZ). The problem of supplying energy to these zones has been an important research topic since the twentieth-century. A solution to this problem has been the installation of Micro-Grids (MG). However, due to technical and budgetary constraints, it is not feasible to install MG

in all of the NIZs of a country. Additionally, there are several economic factors related to energy poverty such as household income, expenditure indicators, energy income, and GDP per unit of energy use. In order to synthesize these factors we propose an Energy Poverty Index. This paper provides a mechanism to prioritize the installation of MGs to provide energy in the NIZs of a country following the aforementioned index. The model is based on a multicriteria decision tool that generates a prioritized list of NZIs by comparing them according to non-correlational parameters. The criteria used in the prioritization include the aforementioned energy poverty index, as well as the population density, generation capacity, operational costs, among others. We also present a case study on prioritization of some NIZs identified by the IPSE in Colombia.

Keywords: Multicriteria; Energy poverty index; Non-interconnected Zone; Microgrids

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Optimal allocation of battery and switches in distribution networks to improve reliability
Tales Moreira Tavares; Christiano Lyra Filho

December 13, 2022 (Tuesday), 09:00 - Room 1301

This work studies the optimal allocation of energy storage systems (ESSs) and switches in radial distribution power networks to improve grid reliability. This combinatorial problem consists of placing ESS and switches in the network to supply parts of the grid during faults, increasing the system's reliability. The system's reliability measures its capacity to deliver power to customers continuously. This delivery can be interrupted by faults, which causes dissatisfaction and monetary losses to clients and utilities. Traditionally, studies have focused on optimizing the allocation of sectionalizing switches to isolate the faulty area and mitigate the problem. However, in recent years, power networks have witnessed changes driven by automation and the installation of distributed energy resources, including ESSs. As a result, recent works have begun to consider ESSs as an energy source alternative to supply power to customers during faults. Most of these studies consider only the optimal placement of ESS or the placement of ESS together with switches at the same grid node. This research innovates by considering the placement of both ESS and switches independently as a strategy to improve reliability. Such consideration increases the allocation possibilities, making the combinatorial problem more complex. The optimization problem aims to minimize the reliability index Energy Not Supplied (ENS), which measures how much energy is left unsupplied due to faults. The problem is solved with a biased random-key genetic algorithm (BRKGA) approach, which has shown good performance in addressing difficult combinatorial optimization problems. Case studies with distribution networks test systems illustrates the reliability improvement as a result of optimal placing of ESSs and switches in the grid.

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Keywords: Reliability; Distribution Networks; Battery; BRKGA

On the simulation of demand response alternatives to high seasonal electrical consumers
Henrique Silveira Eichkoff; Daniel Pinheiro Bernardon; Vinícius Jacques Garcia; Lucas Melo de Chiara; Alejandre Caamaño Antelo Pose

December 13, 2022 (Tuesday), 09:00 - Room 1301

In southern Brazil, electric power in rural feeders is used mainly for irrigation of rice crops. These consumers are known as rural and irrigators, and present some particularities, such as seasonal characteristics and high demand in restricted periods of the year. These characteristics provide some concerns for the electric power utilities, especially in the evaluation of the loading levels of their feeders. Thus, it is essential to employ a demand-side management methodology for rural consumers who use their irrigation systems throughout the day. Demand Side Management (DSM) are methodologies applied to the electric demand side seeking to address actions such as energy efficiency, operational cost, participation in energy markets and load management. In this context, the concept of Demand Response (DR) is inserted, which are strategies of changes in the use of electric energy by consumers in relation to their normal consumption patterns in response to tariff changes and operational conditions of the electrical system. From the operational point of view of a power

grid, DR seeks to reduce or shift the load's power consumption in critical periods. In this paper, a study for demand management applied to irrigating consumers is presented, seeking to improve loading conditions on a group of feeders through shifting and load reductions strategies. The methodology proposed for this work is divided into three steps. The first step consists of extracting information from a database of an electric power utility, where a random selection of a feeder will be made, evaluating its loading conditions, already corresponding to the prospecting of the load management study. The second step corresponds to the identification of irrigating consumers in the selected feeder. In the third and final stage, demand response strategies are carried out for rural consumers, verifying the characteristic behavior of the load and whether the loading conditions imposed on the feeder have been met.

Keywords: Demand Side Management; Demand Response; Irrigating consumers; Loading conditions; Rural Feeders

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A two-phase metaheuristic for solving the multi-depot cumulative capacitated vehicle routing problem

Alan Osorio-Mora; John Wilmer Escobar; Paolo Toth

December 13, 2022 (Tuesday), 09:00 - Room 1302

This talk presents a two-phase metaheuristic to solve the multi-depot cumulative capacitated vehicle routing problem (MDCCVRP). The MDCCVRP is a variant of the well known multi-depot vehicle routing problem which seeks for minimizing the global latency of the system. The latency can be defined as the sum of the arrival times at the customers. In the literature it is possible to find two heuristic algorithms and three exact methods for solving the MDCCVRP. This talk presents a new metaheuristic for solving the MDCCVRP. The first phase of the proposed algorithm consists of a matheuristic procedure, which is able to provide good quality initial solutions. The second phase corresponds to an iterated local search algorithm (ILS) which consists of three steps: perturbation, local search, and a hybrid simulated annealing-variable neighborhood search procedure. Extensive computational experiments on MDCCVRP benchmark instances were performed. The results show that the proposed algorithm is competitive with the state-of-the-art algorithms both in terms of computing time and solution quality. The two-phase metaheuristic is able to find several proved-optimal solutions, and new best known solutions for large size instances.

Keywords: cumulative routing; latency; MDCCVRP; ILS

Vehicle routing with time windows and step cost functions: metaheuristic approaches

Débora P. Ronconi; João L.V. Manguino

December 13, 2022 (Tuesday), 09:00 - Room 1302

This work addresses a vehicle routing problem in which companies hire a third-party logistics company whose freight charges are calculated using discontinuous step cost functions with fixed costs for each distance range according to the type of vehicle being used. The focused problem also takes into account a diverse fleet of vehicle that can be chosen and time windows for every client and in the depot. Given its complexity, efficient customized metaheuristics are proposed: variable neighborhood search and greedy randomized adaptive search procedure. The constructive heuristic SCIH2 provides the initial solution of VNS and the basis of the random constructive method applied in the GRASP due to the fact SCIH2 has shown a good performance for the considered problem. A hybrid metaheuristic is also proposed. A computational analysis is conducted on 168 benchmark instances, small-size instances, and instances based on a real-world problem. The results show that the three proposed metaheuristics outperform SCIH2 associated with a local search. VNS and the hybrid strategy exhibit superior performance, when compared to GRASP, obtaining a lower average total cost. In the instances based on real cases all proposed metaheuristics achieve better results than the reported values by the company. Optimal solutions of 42 small-sized instances were achieved using the CPLEX 12.6 (time limit 2 hours). VNS and the hybrid method reach 92.9% of the 42 known optimal results and the average percentage cost difference to the optimal results is limited to 0.7%. The hybrid method and VNS show strong performance on all instances test sets and, based on statistical tests, cannot be differentiated. However, it should be noted that the VNS framework

proposed has only one parameter that had to be calibrated, the runtime limit. Numerical experiments indicate that the proposed methods are suitable for solving practical instances of the problem and show good performance in different scenarios.

Keywords: Vehicle Routing Problem; Time Windows; Step Cost Functions; Third-Party Logistics; VNS; GRASP; Hybrid Metaheuristic

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Multi-depot heterogeneous on-demand bus routing problem
Michell Queiroz; Kenneth Sörensen

December 13, 2022 (Tuesday), 09:00 - Room 1302

Millions of individuals use some form of public transportation on a daily basis. Unfortunately, traditional fixed-route public transportation is not adaptable to meet the user's needs. With the rise in popularity of mobile phones and global positioning systems (GPS), on-demand bus services have lately emerged as an an alternative in a high-demand urban setting. Routes are not pre-determined and buses operate based on passenger demand. Taking that into account, we present a metaheuristic for the Multi-Depot Heterogeneous On-Demand Bus Routing Problem (MD-H-ODBRP). The problem consists on serving transportation requests in an urban environment. Passengers are picked up and dropped off by a bus at assigned bus stations nearby their origin and destination locations. A fleet of heterogeneous vehicles must serve the passengers within their time windows and the objective function is to minimize the total user ride time (URT) of all passengers. We introduce the dynamic version of the problem, as well as a simulated annealing algorithm to provide solutions.

Keywords: on-demand bus routing problem; metaheuristic; simulated annealing

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Agent-based genetic algorithm for solving the multi-depot vehicle routing problem
Conrado Augusto Serna Uran; Cristian Giovanny Gomez Marín

December 13, 2022 (Tuesday), 09:00 - Room 1302

This paper presents a genetic algorithm for solving the multi-depot vehicle routing problem (MPVRP). The research analyzes the use and fittingness of genetic algorithms used to solve multi-depot routing problems. There are many contributions in this academia and research field, but few have incorporated the use of agents. To address this, a genetic algorithm is designed under an agent approach that follows the paradigm of distributed computing and allows representing local evolution processes that obtain information that can later be transmitted to the rest of the population following genetic diffusion processes according to natural evolution. The designed algorithm adapts very well to the multi-depot routing problem and serves as a basis for solving similar problems. Computational experiments are developed in the Jade framework and demonstrate a simplified and enriched solution of the MPVRP compared to a canonical genetic algorithm.

Keywords: multi-depot vehicle routing problem; genetic algorithm; Agent-based model

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Factor de corrección para disminuir el sesgo generado por diferencias de criterio de los evaluadores en la postulación a fondos concursables
Manuel Cepeda; Pedro Toledo

December 13, 2022 (Tuesday), 09:00 - Room 1303

Muchos trabajos han analizado la forma en que se asignan recursos de fondos concursables o se evalúan los artículos científicos a partir de la revisión de pares (peer-review). Desde hace más de 40 años, hasta nuestros días, muchos autores han publicado diversos artículos que hablan del alto grado de incertidumbre e insatisfacción con los procedimientos de revisión de pares, entre los postulantes a fondos concursables, y en especial se repite el efecto del factor suerte, producto de la diferencia de criterios o grados de exigencia entre los diversos evaluadores. Si todos los proyectos fueran evaluados por el mismo conjunto de jueces, entonces no habría sesgos importantes en la evaluación; sin embargo, es muy común que a diversos proyectos se le asignen distintos pares,

especialmente cuando la cantidad de postulaciones es alta, y sería imposible que un par las evalúe todas. En dicho caso, la evaluación de cada proyecto postulado tendrá una componente aleatoria en su evaluación, en acuerdo a los pares a los cuales fue asignado. Para poder aislar el efecto de las diferencias de criterio entre los pares, es necesario hacer comparaciones entre las evaluaciones de diversos evaluadores sobre una misma propuesta. La información cruzada debe permitir comparar de manera directa o indirecta a todos los evaluadores. Para ello la asignación de propuestas a pares debe ser hecha de manera de maximizar la cantidad de información disponible para cuantificar los sesgos, y posteriormente poder eliminarlos. En concreto, este trabajo contiene una propuesta sobre el mecanismo de asignación de pares a propuestas, y sobre el mecanismo de identificación y eliminación del sesgo producido en la evaluación producto de la diferencia de criterio de los evaluadores. Todo con el propósito de disminuir o eliminar en factor suerte, y aumentar la selección por mérito en la selección de propuestas a fondos concursables.

Keywords: peer review; grant applications; selection procedures; arbitrariness; founding; proposal; grant allocation

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Bayesian inference of a Markovian model of soccer with application in scouting

Pablo Galaz; Sebastián Mena; Denis Sauré

December 13, 2022 (Tuesday), 09:00 - Room 1303

In this paper we propose an analytical approach that uses granular data from professional soccer to model soccer matches considering player-level interactions to predict the development of a match. This modeling approach represents a significant advance with respect to the literature, which until now has focused mainly on predicting the outcome of a match in aggregate way, since it allows analyzing the influence of individual players on the collective performance of a team, for which it has Multiple applications in the administration of a soccer team, such as the scouting process. The proposed model visualizes the development of a match as a Markov chain in discrete time, in which the probabilities of transitions depend in a non-trivial way on parameters that speak of the cognitive-perceptual and technical characteristics of the players. The proposed approach uses Bayesian inference to estimate the posterior distribution of the parameters that define the characteristics of the players. We illustrate the feasibility and potential use of this approach using data from the 2017– 2018 English Premier League season. Once calibrated, we use the proposed model to perform multiple sensitivity analyses, typical of the tasks associated with the scouting process. Our results speak of the great potential for the practice of using this type of models in particular, and of sports analytics in general.

Keywords: bayesian inference; Markov model; simulation; scouting; football; soccer

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Finding Criminal Groups in Suspect Networks

Fredy Troncoso; Richard Weber

December 13, 2022 (Tuesday), 09:00 - Room 1303

The behavior of criminal groups has been studied using social network analysis and decision support systems. Several quantitative models to identify the members of such a group responsible for certain crimes have been proposed and used successfully. The existing models to identify crime associations require at least two suspects to be connected using modified shortest-path algorithms or more sophisticated models. However, many crime investigations start with just one suspect, thus making existing approaches inapplicable. We present an optimization model based on a particular case of Steiner trees to detect criminal associations when only one confirmed suspect is available. An application of our model to a real-world case highlights its potential to support decision-making in crime investigation. The proposed model opens new avenues for applied research in crime investigation. It is concluded that starting a police investigation considering a single suspect using this model allows us to obtain results as good as those obtained by applying existing approaches that begin with two suspects individuals.

Keywords: Crime Analytics; Data Science; Networks; Decision Support Systems

Aplicación de ciencia de datos en patrones de consumo post-pandemia: estudio del caso e-commerce

Pablo B. Savian; Julián E. Tornillo; Guadalupe Pascal; Andres Redchuk

December 13, 2022 (Tuesday), 09:00 - Room 1303

El mundo del e-commerce se ha visto fuertemente influenciado por el contexto epidemiológico ocasionado por el COVID-19. Durante el periodo 2020-2021 se implementaron diversas normativas sanitarias que impactaron sobre la actividad comercial generando restricciones y limitaciones. En este contexto, el comercio electrónico se ha posicionado como una alternativa viable y accesible para negocios tanto consolidados como emergentes. Tal es así, que este canal de ventas ha crecido un 84% del año 2019 al 2020 en Argentina. (CACE). A su vez, tanto en Argentina como en otras partes del mundo, existen dos eventos que revolucionan el mundo e-commerce: el Hot Sale y el Cyber Week. Durante estas semanas, múltiples empresas ofrecen promociones y descuentos que producen un incremento considerable en las ventas. Frente a este nuevo escenario, los principales actores de este negocio encuentran la necesidad de entender nuevos patrones de comportamiento en los hábitos del consumidor, facilitando la toma de decisiones estratégicas para el crecimiento del negocio. En este trabajo se busca, mediante técnicas de data science e investigación operativa, entender cuáles son los factores que más influyen en este aumento brusco de transacciones e identificar si existen variaciones en los hábitos de compra de los consumidores ante tales ofertas. Los resultados del trabajo forman parte del banco de casos sobre Técnicas Estocásticas de la asignatura de Investigación Operativa de la carrera de Ingeniería Industrial.

Keywords: E-commerce; Data Science; Investigación Operativa

Wolbachia-based biocontrol for dengue reduction

Helenice Florentino; Claudia Pio Ferreira; Antone Benedito

December 13, 2022 (Tuesday), 09:00 - Room 1304

Wolbachia-based biocontrol has been widely investigated due to its great potential for preventing and controlling dengue and other arboviruses. These studies seek answers to questions related to the type of bacteria strain to be used, the frequency of release of Wolbachia-infected female mosquitoes, and the minimum viable size of populations of infected mosquitoes to be released, among others. To support these searches, mathematical modeling and control theory have been important tools. Among these, the modeling of competition systems for vital resources between populations of wild Aedes aegypti female mosquitoes and those infected with Wolbachia has been of great interest, since there is evidence that wild mosquitoes have better fitness than Wolbachia carriers, depending on the bacteria strain, there is a reduction in fecundity, egg viability, and mosquito lifespan, which may lead to competitive exclusion, in which only one of the two competitors survives. In this sense, this work proposes the investigation of techniques to determine optimal control strategies, aiming to control a system that involves the coexistence and interaction between populations of wild female Aedes aegypti mosquitoes and those infected with Wolbachia, which live in the same place and compete for food, breeding, mating opportunities, etc. The mathematical techniques investigated are based on Exact Linearization and on the Genetic Algorithm (GA) metaheuristic. The results achieved in this research show that the proposed methodology has great potential to help programs for the application of biocontrol based on Wolbachia for dengue reduction.

Keywords: Dengue; Wolbachia-based biocontrol; Mathematical modeling

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A space-temporal clustering methodology for Dengue prevention in Fortaleza/CE

Leonardo Neves; Marcos Negreiros; Bruno Chaves

December 13, 2022 (Tuesday), 09:00 - Room 1304

We consider the problem of identifying the territorial evolution of dengue disease human cases in the city of Fortaleza/CE, during the period of 2007-2022, where we propose auto-regressive models (ARIMA and SARIMA) to describe more accurately the prediction of the number of human cases with

a considerable advantage in time. With this result, we found that the constant periodic behavior of dengue cases can bring us the necessary information to identify places in the geographical region of the city where the cases will occur using previous mean average annual information about the behavior of the disease. We propose clustering techniques to identify the natural groups of human cases and the dominant dynamic regions, and finally we concept, build and show a formal space-temporal software derived from Dynagraph where it is possible to forecast accurately the places (minimum circle-regions) where dengue cases will occur in the next epidemiological week.

Keywords: HC; Clustering; Autoregressive Forecasting; Space-Temporal Clustering; Dengue Disease

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Incendios forestales y enfermedades respiratorias en la región del Biobío, Chile
Valeria Scapini; Javiera Nuñez; Ramiro Moreno

December 13, 2022 (Tuesday), 09:00 - Room 1304

La exposición a las emanaciones provocadas por los incendios forestales genera una serie de consecuencias que son consideradas negativas para la salud de las personas, en este contexto, existen algunos trabajos al respecto que evidencian esta relación. La presente investigación tiene como propósito cuantificar el efecto de los incendios forestales en el número de atenciones por causa respiratorias en la región del Biobío de Chile, para lo cual se utilizaron datos de incendios forestales proporcionados por la Corporación Nacional Forestal (CONAF) y datos del número de atenciones por causa respiratoria en el sistema público de salud, los cuales fueron obtenidos del Departamento de Estadísticas e Información de Salud del Ministerio de Salud. Se estimó un modelo de mínimos cuadrados ordinarios para determinar dicho efecto y los resultados obtenidos fueron estadísticamente significativos e indican que, en promedio, las zonas afectadas por incendios forestales tienen una mayor cantidad de atenciones por causas respiratorias que las zonas no afectadas por incendios forestales. Por último, los resultados obtenidos pueden ser útiles para generar políticas públicas en los servicios públicos del área de la salud.

Keywords: Incendios forestales; Enfermedades respiratorias; Salud pública

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A continuous scoring model for fair liver transplant allocation
Shubham Akshat; S. Raghavan

December 13, 2022 (Tuesday), 09:00 - Room 1304

The United States Department of Health and Human Services is interested in increasing geographical equity in access to liver transplant. We develop a novel method to design heterogeneous scoring functions in a continuous scoring policy for deceased donor liver transplantation that equalizes supply to demand ratios across transplant centers. We discuss the benefits of the proposed policy via simulation experiments.

Keywords: OR in Health and Healthcare Services; health care policy; liver transplant; geographical disparity; optimization

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Extensions to the guaranteed-service model for safety stock placement in industrial practice
Victoria G. Achkar; Braulio B. Brunaud; Rami Musa; Ignacio E. Grossmann

December 13, 2022 (Tuesday), 09:00 - Room 1305

Safety stock allocation intends to determine an overall strategy for deploying inventory levels across the supply chain to buffer it against sources of uncertainty (Graves and Willems, 2003). De Kok et al. (2018) state that multi-echelon inventory systems are still a very active area of research because of their complexity and practical relevance. The objective of this work is to develop an MEIO model based on the Guaranteed-Service Model (GSM) (Eruguz et al., 2016; Graves and Willems, 2000; Simpson, 1958) that accounts for different issues and characteristics arising in pharmaceutical industrial practice. To the best of our knowledge, nobody has developed a model that can achieve optimum safety stocks on complex supply chains while integrating all the features typical of industrial

environments presented in this work. The proposed model is that it combines several features: (i) hybrid nodes that have both dependent and independent demands, (ii) manufacturing plants at any location, (iii) fill rates level used as an alternative customer service measure (iv) minimum order quantities (MOQ) and, (v) Normal or Gamma distributed demands. The resulting model is a nonconvex Nonlinear Programming (NLP), and the computational time required to find a global solution may be very extensive. To overcome this difficulty, the NLP model is reformulated as a Quadratically Constrained Problem (QCP) by exploiting the structure of the constraints of the base model. Moreover, we propose a piecewise linear and a stepwise approximation to simplify two complex formulations that affect the computational burden. Several examples of real industrial systems from a pharmaceutical supply chain are presented with their resulting improved computational performance. The solution approach can find the optimal solution in seconds while the NLP model is not able to find feasible solutions in reasonable CPU time. Future research may include capacity constraints.

Keywords: multi-echelon; inventory; optimization; guaranteed-service model; stochastic demand; stochastic lead time; fill rate; QCP

Enfoque temporal para controlar la escasez en sistemas de inventario

Mario Ramirez; Enrique Simpson; Pablo Escalona

December 13, 2022 (Tuesday), 09:00 - Room 1305

En este artículo se estudia la fracción del tiempo sin stockout durante el ciclo de reabastecimiento como nivel de servicio en un sistema de inventario bajo una política de revisión continua (Q,r) con lead time determinístico. Además, se compara este nivel de servicio temporal con otros niveles de servicio popularmente usados.

Keywords: Nivel de servicio; Política de revisión continua; Stockout

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Supply chain network design integrating supplier selection decisions

Francisco J. Tapia-Ubeda; Pablo A. Miranda; Gabriel Gutiérrez-Jarpa

December 13, 2022 (Tuesday), 09:00 - Room 1305

The proposed research integrates supplier selection decisions for designing a three-echelon supply chain network (i.e., supplier selection, warehouse location, customer assignment). It is assumed that each located warehouse control its inventory under a continuous review (s,Q), where s represents the reorder point and Q represents the fixed order size. An Inventory Location Problem model is proposed that is of a Nonconvex, Nonlinear, Mixed Integer Programming Model nature. Integrating supplier selection decisions considerably affects the optimal supply chain network structure compared to the optimal structure assuming fixed and known suppliers. The optimal solution is determined by minimizing the total system cost (i.e., fixed, transportation, inventory). It is worth pointing out that integrating supplier selection yields that the lead-time for each warehouse becomes variable, depending on which supplier is selected to serve each warehouse. Considering the mathematical complexity of the model, a Generalized Benders Decomposition-based solution approach is proposed to efficiently and effectively solve the model. The GBD-based solution approach yields a Mixed Integer Master Problem and Convex Nonlinear Subproblems. Performing competitive times, the optimal solution was found for each of the synthetic instances tested. Relevant managerial and scientific insights are discussed based on the obtained results.

Keywords: Supply Chain Network Design; Inventory Location Problem; Generalized Benders Decomposition

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El problema del ruteo de un furgón escolar, generalizado, selectivo, con carga mixta y ventanas de tiempo

Richard Riffo; Carlos Obreque; Guillermo Latorre; Patricio Álvarez; Alex Barrales; Carlos Bizama

December 13, 2022 (Tuesday), 09:00 - Room 1305

En este trabajo se presenta el problema de determinar la ruta que debe seguir un furgón escolar para recoger a un conjunto de estudiantes en sus domicilios y trasladarlos a sus respectivos establecimientos educacionales. Se considera que el furgón puede transportar en el mismo viaje estudiantes que se dirigen a diferentes colegios. Para cada estudiante se proponen diferentes localizaciones donde es posible que sea recogido, los cuales son agrupados en clústeres disjuntos. Se asume que el número de estudiantes disponibles es superior a la capacidad del furgón y es necesario decidir a cuáles de ellos se deben transportar en el viaje. Además, se incluyen ventanas de tiempo tanto para los estudiantes, que indican el horario, más temprano y el más tarde, que pueden ser recogidos, como para los colegios, que establecen la hora de ingreso y la hora de inicio de clases en tal establecimiento educacional. Para resolver este problema, se propone un modelo de programación lineal entera mixta que maximiza el número de estudiantes a trasladar, sujeto a restricciones de ventanas de tiempo y que ningún estudiante puede permanecer más de 60 minutos en el furgón durante el viaje para cumplir con la ley de transporte en Chile. Para resolver todas las instancias, se utiliza el Lenguaje de programación algebraica AMPL, junto con el solver CPLEX.

Keywords: SBRP.; TSP Selectivo.; Generalizado.; Ventanas de Tiempo.; Carga Mixta.

Forecasting time series COVID 19 using deep learning methods: South America comparative case study

Miguel Alfaro; Manuel Vargas; Dali Grado; Jorge Zamorano; Natalia Karstegl

December 13, 2022 (Tuesday), 09:00 - Room 1306

La enfermedad coronavirus (COVID-19) se ha extendido por todo el mundo y presenta nuevos desafíos a la investigación. Aunque se han implementado diferentes medidas de contención y distanciamiento social, la capacidad de los sistemas de salud ha sido afectada drásticamente, junto con el manejo efectivo de los pacientes infectados durante la actual pandemia. En este estudio, el objetivo es predecir las condiciones futuras de COVID-19 para reducir su impacto, esperando encontrar pronósticos significativos a corto y largo plazo. Para lo anterior, los modelos de aprendizaje profundo han demostrado mejoras significativas al manejar datos de series temporales en diferentes aplicaciones, y en este estudio se utilizarán algoritmos de red neuronal recurrente simple (RNN), memoria a largo plazo (LSTM), unidades recurrentes cerradas (GRU) y red convolucional temporal (TCN), para el pronóstico casos de COVID-19 basados en los datos existentes durante el período 2021-2022, en 12 países a nivel latinoamericano.

Keywords: COVID-19; Pronostico; Serie temporal

Optimización del rendimiento de redes móviles utilizando técnicas de aprendizaje automático

José-Miguel Rubio; Juan José Gutiérrez Terraza; Sebastián Ríos

December 13, 2022 (Tuesday), 09:00 - Room 1306

El uso de diferentes herramientas de aprendizaje automático (Machine Learning por sus siglas en inglés) ha permitido optimizar y ahorrar recursos en diversos sectores industriales. En particular, en el sector de las telecomunicaciones se dispone de un alto volumen de datos asociado a la operación de la red, más aún considerando el ingreso de la tecnología 5G, la que está dotada de altas velocidades y bajísimas tasas de latencia con el objetivo de ofrecer una mayor calidad y disponibilidad de servicio, gracias también a una serie de nuevas funcionalidades como el Network Slicing, por ejemplo. Por otro lado, una de las problemáticas transversales para la tecnología actual 4G LTE y para el despliegue de redes 5G es la caída de performance que pueden experimentar las celdas de la red, lo que impacta directamente en la calidad de servicio percibida por los usuarios finales. En este trabajo, se propone el uso de clasificadores y regresores como Random Forest y XGBoost para generar predicciones en relación a los niveles de rendimiento del indicador "Download User Throughput" de las celdas de la red móvil 4G LTE en la región metropolitana de Santiago de Chile, y el uso de redes LSTM para generar pronósticos de alta exactitud respecto al comportamiento de esta variable. Adicionalmente, se propone el uso de LDA con información de la variable "Download Traffic Volume" de las celdas de la red móvil para identificar patrones de uso de la red tanto a nivel geográfico como temporal. Entre los resultados más relevantes, se destaca que los modelos XGBoost logran predecir, con una precisión sobre el 80%, las bajas de desempeño en

la red con una semana de desfase. Por otro lado, se logró identificar 5 patrones de uso característicos directamente relacionados con las ubicaciones geográficas de cada celda en la zona metropolitana de Santiago de Chile.

Keywords: Machine Learning; 4G LTE Networks; Download User Throughput; Download Traffic Volume

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Re-etiquetado de categorias en informes de delitos criminales a través de análisis de texto y aprendizaje profundo

Carla Marina Vairetti; Sebastian Maldonado

December 13, 2022 (Tuesday), 09:00 - Room 1306

El aprendizaje profundo se ha convertido en el método "de facto" para el análisis de texto gracias a su capacidad para modelar el lenguaje a partir de grandes conjuntos de datos y luego transferir este conocimiento a tareas específicas. En este trabajo, aplicamos el aprendizaje profundo para mejorar el etiquetado de los informes de seguridad pública realizados por personas comunes en una aplicación móvil chilena. Los usuarios seleccionan una categoría para reportar un incidente entre una amplia variedad de opciones posibles que van desde mascotas perdidas o ruidos molestos hasta accidentes con heridos o robos. También tienen la opción de acompañar el informe con una descripción del incidente. El problema principal es que los usuarios a menudo informan los eventos en la categoría incorrecta; generalmente en la primera categoría presentada en la aplicación. La aplicación ha sido de gran ayuda para los municipios y departamentos de policía para desplegar recursos y patrullas de manera eficiente para atender los incidentes y disuadir la ocurrencia de delitos. Sin embargo, tienen un esquema de priorización que se basa en la categoría proporcionada por el usuario. Este trabajo presenta una solución de aprendizaje automático en la que se utilizan BERT y otras arquitecturas de Transformer para aprender de la descripción del incidente e inferir la etiqueta correcta, lo que lleva a una mejor priorización de eventos. Nuestros resultados preliminares muestran las excelentes capacidades predictivas del modelo. El modelo también tiene el potencial de capturar información adicional de las descripciones, enriqueciendo la priorización con, por ejemplo, una evaluación de la gravedad de un accidente o un delito.

Keywords: Deep learning; Text analytics; Crime report categorization

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Un modelo hibrido de Machine Learning con Web Scrapping para determinar la dinámica urbana de las construcciones de Medellín - Colombia

Julian Andres Castillo; Yony Fernando Ceballos; Juan Pablo Barrero Velez

December 13, 2022 (Tuesday), 09:00 - Room 1306

El crecimiento de las ciudades tiene como principal razón que más del 50% de la población mundial habita en zonas urbanas, en Latinoamérica ese porcentaje sobrepasa el 75%. En muchos aspectos se estudia el crecimiento de las ciudades en una mirada de territorio incrementando el área de ocupación sólo en dos dimensiones. Las ciudades crecen en territorio y en volumen, el presente estudio se centra en estudiar el crecimiento vertical desde una vista compuesta por dos modelos independientes para determinar el crecimiento vertical de la ciudad de Medellín, el primero utiliza un modelo de Machine Learning de clasificación usando valores estadísticos de los últimos diez de cambios de niveles de pisos y otras variables para predecir si una propiedad presentaría un crecimiento vertical, mientras que por otra parte se crea un modelo donde se valida esta información con base en la extracción de datos de ofertas de mercado con el mismo espacio temporal usando la técnica de Web Scrapping del sitio web de ofertas inmobiliarias mas popular de Colombia. Estos dos datos se proyectan geográficamente sobre los barrios de Medellín y mediante un modelo ráster de densidad media de cambios por barrio se suman para brindar como resultado los barrios de la ciudad de Medellín donde se tendrá la mayor probabilidad de nuevas construcciones, esto con el fin de mejorar la gestión del territorio en cuanto a aportar al estudio de ciudad y los aspectos fiscales y catastrales del territorio.

Keywords: machine learning; ArcGIS; ArcPy; crecimiento vertical; web scrapping; regresión logística

Análisis de Eficiencia para los puertos ubicados en el Corredor Bioceánico Capricornio basado en la metodología de Análisis Envolvente de Datos

Agüero-Tobar Magdiel; Marcela González-Araya; Rosa G. Gonzalez Ramirez; Luis M. Ascencio

December 13, 2022 (Tuesday), 09:00 - Room 1307

El corredor bioceánico Eje Capricornio comprende 6 regiones de Brasil, Paraguay, Argentina y Chile; 2.290 kilómetros entre Campo Grande y Antofagasta. Esta conexión entre el atlántico y pacífico representa una alternativa al actual flujo de mercancías de comercio exterior de esta zona que tradicionalmente emplean como puertos de salida aquellos ubicados en el atlántico. En este trabajo, se presenta un análisis comparativo en términos de eficiencia que tienen los puertos del pacífico y atlántico a través de la metodología de análisis envolvente de datos (DEA por sus siglas en inglés). Se consideraron 14 terminales portuarias para el análisis, incluidos tres puertos de la macrozona norte de Chile, junto con un grupo de terminales de Brasil y Argentina. Como variable de salida (output) se consideró la transferencia de carga contenedorizada. Se propuso el modelo BCC de DEA orientado a resultados (Banker et al. 1984), considerando como variables de entrada la longitud de muelles para uso de carga contenedorizada, grúas de muelle equivalentes, superficie del terminal portuario y el máximo calado del muelle. Dado que varias terminales portuarias son de tipo multipropósito, fue necesario incorporar algunos factores de corrección en las variables de entrada para poder estimar las variables de entrada para la transferencia de contenedores. Los resultados muestran que los puertos de Antofagasta y Angamos están bajo la frontera de eficiencia. Como parte del análisis, se proponen metas para los puertos bajo la frontera de eficiencia y algunas recomendaciones sobre inversiones que se deberían realizar para ser atractivos ante las oportunidades de carga que ofrece el desarrollo del corredor.

Keywords: Eficiencia portuaria; Corredor Logístico; Análisis Envolvente de Datos

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A Stackelberg model for transport infrastructure planning

Oscar Mauricio Cepeda Valero; Jose Fidel Torres Delgado; Luis Felipe Jimenez Sanchez; Andres Bernardo Ocampo Melo

December 13, 2022 (Tuesday), 09:00 - Room 1307

Problem: our research is about Urban Transport Network Design Problem (UTNDP). This design must consider factors such as the growth of urban centers, the need for new routes and the preference of citizens. Additionally, this design has an impact on traffic congestion and air pollution.

Methodology: we work with Stackelberg model. On the upper level model, users make the decision to use the transport based on the coverage of the transport system. Thus, the users choose the best station by distance and capacity. Therefore, x_ij represents the users flow, with a distance d_ij between i and j. The objective function maximizes the number of citizens who take the system transport with the shortest distance. The results of first model are loaded in the lower-level model. Thus, the demand is relocated in station, where citizens arrived. This second model defines the infrastructure transport, in which h_i is a binary variable that indicates if the station i is functional and u_ij if the arc (i,j) is functional. Additionally, e_i^- is unmet demand by the transport system. The objective function is cost minimization, this includes building cost, transport cost and cost of unmet demand. The model was evaluated on six (6) transport networks taken from existing systems (Derrible, S., 2012).

Results and discussion: The best behavior in our model was in Cairo metro, because network form facilitates fulfilling transportation requirements. We note increase efficiency, and its coverage. Moreover, we found that the transport systems with a high level of connections and high degree of centrality require more budget to expand. In fact, square networks showed the best performance for covering demand. While circular and asymmetric polygon network design did not show good sceneries. In brief, through our model can suggest management or investment policies to system operators or (leaders), who plan or design the transport system considering the behavior of users (followers).

Keywords: Stackelberg model; Transport network design problem; Infrastructure transport

A model-based predictive control strategy for minimizing relocations in inland logistic terminals

Juan Pablo Cavada; Cristián E. Cortés; Pablo A Rey

December 13, 2022 (Tuesday), 09:00 - Room 1307

We focus our study on an inland terminal that we called the Logistic Services Container Terminal (LSCT), a small to medium terminal where all containers arrive and leave by truck and the main material handling equipment are reach-stacker cranes. In this context we studied the dynamic container relocation problem, that has two objectives: 1) finding the best location to newly arrived containers and 2) find the optimal sequence of relocations to reach a leaving container. The overall objective is to minimize the number of present and future relocations. The core of our control strategy is an IP model. In this model we have discretized the time horizon into a set of stage. This is a very large combinatorial problem, in our test yard, the number of variables exceeded five billion. To address we propose a series of techniques thar reduces the size of the model, by taking advantage of some of the assumptions presented. The experiments and results are evaluated with the help of a discrete-event simulator developed explicitly for this problem

Keywords: Logistics; Containers; Optimization

Sistema ridesharing con puntos de pickup/drop off y jerarquización de nodos

Francisco Vilches; Cristián E. Cortés; Andrés Fielbaum

December 13, 2022 (Tuesday), 09:00 - Room 1307

Gracias a los avances tecnológicos y al uso masivo de teléfonos celulares observado en los últimos años, los sistemas de movilidad basados en la demanda (demand responsive) han surgido como una opción de transporte atractiva, donde las decisiones de despacho y ruteo deben hacerse casi en tiempo real. En particular, los sistemas de viajes compartidos (ridesharing) representan una opción de movilidad eficiente, en términos de costo y tiempo de los pasajeros así como en tamaño de flota requerido para satisfacer la demanda. La implementación de un sistema de tipo ridesharing involucra un desafío computacional importante, dada la dificultad de sincronizar correctamente los viajes entre vehículos y pasajeros, lo cual se torna más desafiante al incorporar características que permitan una representación más realista de la ciudad. En el presente trabajo, basándose en modelos en el estado-del-arte, se incorporan caminatas enlazadas con puntos de pickup y drop off, variaciones en los pesos de los arcos de la red y jerarquización de nodos. La técnica de jerarquización de nodos corresponde a las Customizable Contraction Hierarchies, que permiten la actualización del orden de los nodos en el momento en que los valores de los arcos se modifican. En este trabajo se propone la implementación de un modelo para un sistema ridesharing, en donde se clasifica los nodos de la red utilizando la técnica de jerarquización antes mencionada, para luego definir los nodos que representarán los distintos puntos de encuentro desde(hacia) los cuales los pasajeros deberán caminar, que llamaremos puntos de pickup y drop off. En el caso de presentarse una variación en los pesos de los arcos, se recalculará la jerarquía de los nodos y se actualizarán los puntos de encuentro. Se contempla validar el modelo y posteriormente simular escenarios en un contexto urbano utilizando como referencia alguna sección de la ciudad de Santiago.

Keywords: ridesharing; pickup/drop off; jerarquización de nodos

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Exact methods for the Minimum Spanning k-Forest Problem

José Costa; Gabriel Sousa; Manoel Campêlo

December 13, 2022 (Tuesday), 09:00 - Room 1308

The Minimum Spanning k-Forest (MSkF) problem consists in, given an undirected edge-weighted graph G and an integer k, finding a spanning forest of G with k trees, in order to minimize the weight of the heaviest tree. In the particular case k = 1, the problem comes down to determining a Minimum Spanning Tree. The problem was proposed in Madkour et al. (2019) motivated by applications in computational topology. The MSkF has already been shown to be NP-Hard even for k = 2 (Madkour

et al., 2019) or for unit weights (Vaishali et al., 2018). In Costa et al. (2022) two integer programming formulations were presented, one based on representative vertices (F-REP) and another one based on tree labeling (F-TREE). In this work we present valid inequalities for the two models as well as a pre-processing procedure based on a Maximum Clique heuristic that aims to strengthen the F-REP model. We also present a heuristic for the problem based on a modification of the Kruskal algorithm. Furthermore, we prove a lower bound from the solution generated by this heuristic. Finally, we present an enumerative algorithm for the problem. We propose two branching strategies and pruning rules for infeasibility, bounds and optimality. Computational experiments were carried out with the aim of evaluating the effectiveness of the existing exact methods from the literature and comparing them with those proposed in this work. For the tests, random graphs were generated based on two parameters: number of vertices and density of edges. From the same graph, different instances were generated by varying parameter k, with k=2^r, r=0,1,2,..., such that k <= |V|. In total, 215 instances were generated.

Keywords: Minimum Spanning k-Forest Problem; Integer Programming; Valid Inequalities; Enumerative Algorithm

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MILP + Metaheuristic: A matheuristic for the maximal covering location problem with accessibility indicators and mobile units

Salvador J. Vicencio-Medina; Yasmin A. Rios-Solis; Nestor M. Cid-Garcia

December 13, 2022 (Tuesday), 09:00 - Room 1308

Given a set J of demand zones, a set I of facilities that can be used, and a number n of facilities that must be used, the Maximal Covering Location Problem (MCLP) consists in finding the n facilities that maximize the coverage in the different demand zones. In this work, we present a new mixed-integer linear programming model named the Maximal Covering Location Problem with Accessibility Indicators and Mobile Units where different accessibility measures i.e., covered, accessibility, distances, opportunities, etc., are utilized to maximize the covered and access of the demand zones. Besides, each facility can send temporally mobile units close to demand zones to increase the coverage and access to them. To test our new model, we have used the Mexico COVID-19 situation where at the begging of the pandemic, the Mexican government classified a few hospitals as COVID, which means that only they can receive tests. Through the information mentioned before, we have made 37 instances where Mexico was divided by state, zones, and country (small, medium, and large instances, respectively). The MCLPAMU can solve small and medium instances in a reasonable computational time. For large instances, we have proposed a Matheuristic (the combination of metaheuristics and exact methods), based on an Estimation of Distribution Algorithm (EDA) and a modification of the MCLPAMU. Using the methods proposed, the experimental results show a huge increment in the coverage and accessibility compared with a simple version of the Maximal Covering Location Problem without mobile units for each instance proposed.

Keywords: Coverage; Location; Accessibility; Estimation of Distribution Algorithms; Mixed-Integer Linear Programming

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Extending generalized disjunctive programming to model hierarchical systems

Héctor Pérez; Ignacio Grossmann

December 13, 2022 (Tuesday), 09:00 - Room 1308

Modeling systems with discrete-continuous decisions is commonly done in algebraic form with mixed-integer programming models. A more systematic approach to modeling such systems is to use Generalized Disjunctive Programming (GDP), which generalizes the Disjunctive Programming paradigm. GDP allows modeling systems from a logic-based level of abstraction that captures the fundamental rules governing such systems via algebraic constraints and logic. The models obtained via GDP can then be reformulated into the pure algebraic form best suited for the application of interest. The two main reformulation strategies are the Big-M reformulation and the Hull reformulation, the latter of which yields tighter models than those typically used in standard mixed-integer programming (MIP). Although GDP provides a more general way of modeling systems, it warrants further generalization for systems presenting a hierarchical structure (e.g., integrated design

and planning, integrated long-term planning and short-term scheduling). Such systems can be modelled via nested disjunctions inside the GDP formulation (Nested GDP, NGDP). Methods for transforming these NGDPs models into algebraic discrete-continuous models have not been formalized yet. In this work, we formalize the extraction approach to convert NGDPs to equivalent single-level GDPs, which can then be reformulated to algebraic discrete-continuous models via Big-M or Hull reformulations to MI(N)LPs. We also formalize the inside-out approach to directly reformulate NGDPs to MI(N)LPs. The reformulated equivalent single-level GDP and the direct inside-out reformulation are compared in terms of the model tightness and size. The results show the computational benefits of the direct (inside-out) reformulation of NGDPs.

Keywords: Generalized Disjunctive Programming; Nested Disjunctions; Discrete-Continuous Optimization

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Coverings with minimum radius identical balls

Ernesto G. Birgin

December 13, 2022 (Tuesday), 09:00 - Room 1309

The problems of covering bounded sets or the whole space with balls, in any dimension, have been extensively studied in the literature. A mathematical investigation of such a problem seems to appear for the first time in a paper of Neville in 1915, where he illustrates a numerical method for solving systems of nonlinear equations with the problem of covering a disc by five smaller discs. Extensive work on the covering of a disc by smaller discs was done by Kahn Jr. in 1962. In his work, approximating the area covered by a given configuration, Kahn Jr. set out to extensively test different optimization algorithms available. In a way, it is possible to say that Kahn Jr.'s work was a precursor to the many subsequent works that were devoted to the covering problem with the help of computer-aided strategies. In the present work, we consider the problem of covering a region of the plane with a fixed number of minimum-radius identical balls. The problem is formulated as nonlinear programming problem. Using nonsmooth shape optimization techniques, we obtain analytical expressions for first- and second-order derivatives. Singular cases are also studied using asymptotic analysis. For regions given by the union of disjoint convex polygons, algorithms based on Voronoi diagrams that do not rely on approximations are given to compute the derivatives. Numerical examples in which the nonlinear programming problem is solved with an Augmented Lagrangian approach are presented.

This presentation is based on the recent works:

E. G. Birgin, A. Laurain, R. Massambone, and A. G. Santana. A shape optimization approach to the problem of covering a two-dimensional region with minimum-radius identical balls. SIAM Journal on Scientific Computing, 43(3):A2047– A2078, 2021; and

E. G. Birgin, A. Laurain, R. Massambone, and A. G. Santana. A shape-Newton approach to the problem of covering with identical balls. SIAM Journal on Scientific Computing, 44(2):A798– A824, 2022.

Keywords: NM; Covering with balls; shape derivatives; numerical optimization

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Valid inequalities and a new integer programming model for the k-color shortest path problem

Rafael Andrade; Rommel Saraiva; Emanuel Elias Silva Castelo

December 13, 2022 (Tuesday), 09:00 - Room 1309

The operations research community has recently addressed combinatorial optimization problems defined under labeled graphs (e.g., Silvestri et al., 2016; Saraiva et al., 2018; Carrabs et al., 2018). In this context, we find the k-color shortest path problem (kCSP). Given a weighted digraph with colored arcs, the problem aims at finding the path of minimum cost between two of its vertices such that the number of distinct arc colors of the path does not exceed a given integer value. The kCSP is known to be NP-Hard as it is a particular case when the arc costs are zero. The state-of-the-art integer programming models for this problem are due to (Ferone et al., 2019) where the authors present a straightforward integer linear programming formulation (ILP). In this sense, we discuss new valid

inequalities and give an alternative ILP formulation for the problem. To show the importance of our findings for the solution of the kCSP, we present computational experiments for benchmark instances consisting of random and grid digraphs. Because the optimal solution for these instances is found in the root node of the branch-and-bound CPLEX search tree for most cases, we also take into account harder instances known as layered digraphs that have been used as challenging instances for the minimum colored path problem (Kumar, 2019). In addition, trying to obtain harder instances for the problem, we introduce forwarding and expensive arcs connecting some non-neighbor layers. For these new instances, we can easily obtain feasible solutions at a high cost. However, CPLEX generally does not solve them at the root node of the search tree. Experiments show that the valid inequalities reduce the execution times when incorporated into the base formulation. For the benchmark (resp. new) instances, the improved formulation was faster in 84,62% (resp. 96,66%) of the cases. Also, the new formulation alternates better results when compared to the original one.

Keywords: NM; k-color shortest path; valid inequalities; combinatorial optimization

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Improved solution strategies for the spanning tree problem with variable node degree
Rafael Andrade; Adriano Freitas

December 13, 2022 (Tuesday), 09:00 - Room 1309

We are interested in the spanning tree problem with variable node degree (Gouveia et al. (2014)). Given a graph G = (V, E) of nodes V and edges E, we must assure data communication among the nodes V of G by considering a spanning tree (ST) topology. There are some transmission systems to be installed on the edges of the spanning tree. The more expensive the system installed, the larger the node degree connectivity of the edge extremities. When different systems are installed incident to a node, its maximum degree is imposed by the less expensive among these systems. The ST cost is the sum of the system's cost installed on its edges. We aim at finding the ST of minimum cost. The existing models for this NP-Hard problem are due to Gouveia et al. (2014). They are adaptations of ST models of Magnanti & Wolsey (1995). The authors consider binary variables to determine the systems installed on the edges and indicate the node degrees. Our contribution is to address the problem from a multigraph perspective. We consider the set of available transmission systems available for some pair of nodes as edges leading to a multigraph. The advantage of this approach is that when we select an edge (transmission system) to be part of the solution, we determine the maximum degree of its extremities. We show how better explore integer linear programming formulations based on sub-tour elimination constraints and network flow models. We also strengthen the linear relaxation of the considered models using new valid inequalities for the problem. Computational experiments performed on benchmark instances show that our best formulation reduces the execution times for about 87% of them while reducing the overall average execution time by 74.96% compared to the best formulation in Gouveia et al. (2014).

Keywords: NM; spanning tree problem with variable node degree; multigraph approach; combinatorial optimization; valid inequalities

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Regularized version of the minimax probability machine
Julio Lopez; Miguel Carrasco; Sebastián Maldonado

December 13, 2022 (Tuesday), 09:00 - Room 1309

By extending the Minimax Probability Machine (MPM) approach, we present novel robust formulations for binary classification. Inspired by Support Vector Machines, a regularization term is included in the MPM and Minimum Error Minimax Probability Machine methods. This inclusion reduces the risk of obtaining ill-posed estimators, stabilizing the problem, and, therefore, improving the generalization performance. Our approaches are first derived as linear methods and subsequently extended as kernel-based strategies for nonlinear classification. Experiments on well-known binary classification datasets demonstrate the virtues of the regularized formulations in terms of predictive performance.

Keywords: NM; Minimax probability machine; support vector machine; regularization

An application of the FITradeoff method for ranking problematic in a problem related to the retail sector

Maria E. B. T. Pessoa; Eduarda A. Frej; Adiel T. de Almeida

December 13, 2022 (Tuesday), 12:30 - Room 1101

The FITradeoff method is used to elicit scaling constants in multi-criteria decision-making/problems in the context of Multi-Attribute Value Theory (MAVT). This method combines two perspectives of preference modeling: the elicitation by decomposition and the holistic evaluation. This paper presents a practical case of a company in the retail sector that intends to make partnerships based on marketing strategies with its suppliers. In this way, suppliers gain more visibility and the company obtains advantages such as improving its cash flow. This study is relevant because the retail sector has shown growth in Brazil even in the face of the crisis scenario caused by the pandemic. In addition, this sector is highly competitive, so companies need to develop strategies to strengthen themselves. In this problem, some objectives were identified, which have been measured by six criteria. In addition, thirty-five alternatives have been selected to compose the space of actions in the problem. Thus, the alternatives represented each supplier. This decision problem was solved using the FITradeoff method for ranking problematic. The decision maker answered twelve questions during the decomposition elicitation process and ended the decision process with a holistic evaluation. The information provided by the FITradeoff Method until that moment was already suficiente for the decision maker. As a final result, a ranking with twenty five levels was obtained.

Keywords: RED-M; Multi-Criteria Decision-Making/Aiding (MCDM/A); FITradeoff Method; Retail sector

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A multicriteria decision model based on FITradeoff Method for prioritizing police officers to participate in a special operation

Ciro Corrêa Vieira de Melo; Jônatas Araújo de Almeida

December 13, 2022 (Tuesday), 12:30 - Room 1101

The Brazilian Federal Police is responsible for investigating crimes involving the Brazilian Union. Some of those investigations require more invasive techniques or complex judicial measures, receiving the name of Police Operation. One phase of those operations consists of executing precautionary measures, a situation that usually requires many police officers. Therefore, the state responsible for these investigations must make a ranking to prioritize the officers to participate in those judicial precautionary measures. The demand for officers at this stage may be higher than the contingent available to the state, requiring another federated state unit to provide police officers to supplement the quantity. However, given the options available to meet the needs, the problem arises as a selection of the best officers for the operation reducing impacts on the state that will provide them. This paper proposes a multicriteria ranking model for officers prioritization based on the flexible elicitation method - FITradeoff. The results indicated that the model allowed finding a prioritization of police officers that was aligned with the interests of the corporation, through a flexible and cognitively easier process for the decision maker.

Keywords: RED-M; Multicriteria Decision; FITradeoff; Prioritizing

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A BIM implementation actions prioritization model in AEC organizations

Ana Carolina Silva; Luciana Alencar

December 13, 2022 (Tuesday), 12:30 - Room 1101

In recent years, building information modeling (BIM) has increasingly been the focus of architecture, engineering, and construction (AEC) organizations that want to innovate and improve their processes. Especially in developed countries, BIM has emerged as a primary tool for managing construction projects throughout their lifecycles. Although many studies reveal a significant increase in the number of professionals involved in the use of BIM, the BIM adoption worldwide is still considerably short of its potential. Efforts have been made to raise awareness of the BIM benefits

and understand the reason for the difficulty in its implementation. Some studies point out that the reasons and obstacles, technological or managerial, for the BIM adoption differ in different AEC contexts. Furthermore, in developing countries, where BIM is not widely used, the resource limitations companies face to investing in new technologies must be taken into account. Therefore, there appears to be no way to have a consistent path to BIM adoption. Thus, to fill this gap, this article proposes to structure the problem of BIM adoption, identifying the factors and consequences of failures in BIM adoption, and identifying preventive and protective actions for each context. Once the actions have been identified, defining how to allocate resources to each action is a difficult step. How to establish the priority of each measure to be implemented in the organization? In the light of what criteria should this decision be made? In planning for the BIM adoption, the prioritization stage is characterized as a multi-criteria decision support problem. A decision model was proposed to support it, especially in the context of small and medium-sized companies in northeastern Brazil. This article presents a multi-criteria decision model to support the prioritization of actions based on the FITradeoff method. A case study was developed to illustrate the application of the proposed prioritization model.

Keywords: RED-M; BIM adoption; multi-criteria decision model; FITradeoff

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Cadena de suministro para la valorización de neumáticos fuera de uso desde un enfoque ambiental: Una aproximación desde la optimización

Ignacio Castañeda; Andrea Teresa Espinoza Pérez

December 13, 2022 (Tuesday), 12:30 - Room 1208

La creciente preocupación por la contaminación ambiental y el calentamiento global ha provocado un endurecimiento de la legislación gubernamental en países de todo el mundo para conseguir una mitigación. Este es el caso de Chile, donde la ley REP responsabiliza a los productores de la gestión de residuos que provocan los bienes que comercializan dentro del mercado nacional. Uno de estos bienes son los neumáticos fuera de uso (NFU), para los que el decreto de esta ley establece metas de recolección del 50% de neumáticos comunes y la valorización del 25% de estos para el año 2021, aumentando gradualmente a través de los años. Así, se presenta la oportunidad de implementar tecnologías de valorización de neumáticos que exploren nuevas alternativas energéticas y permitan generar productos con valor agregado, a la vez que se minimizan los impactos negativos en el ambiente. En la búsqueda del proceso óptimo para el tratamiento de neumáticos, la pirólisis se presenta actualmente como la más estudiada en la literatura, obteniendo resultados ambiental y económicamente ventajosos. Sin embargo, aún no existe experiencia suficiente para poder afrontar los retos que implica el proceso a escala industrial, existiendo muy poco desarrollo de la cadena de suministro a nivel mundial, lo que propone un desafío para la investigación en el área de ingeniería industrial y diseño de redes. Este trabajo presenta un modelo de optimización que soporta la toma de decisiones para el diseño de una cadena de suministro que permita la implementación de plantas de pirólisis para el tratamiento de NFU con foco en la reducción de los impactos ambientales de estas. Para validar este modelo, se presenta un caso de estudio para Chile, proponiendo una distribución que abarque cuatro regiones de la zona centro sur del país, promoviendo la descentralización.

Keywords: Pyrolysis; Waste tire; Environmental; Optimization

Representando la sostenibilidad en el diseño óptimo de una cadena de suministro: Una propuesta integrada y reducida a partir de la revisión de la literatura

Andrea Teresa Espinoza Pérez; Óscar C. Vásquez

December 13, 2022 (Tuesday), 12:30 - Room 1208

La población mundial se ha duplicado en los últimos años, mientras que los recursos vitales se han vuelto cada vez más limitados. En este contexto, las preocupaciones gubernamentales y sociales con respecto a los problemas de sostenibilidad han presionado a las industrias para que reevalúen sus cadenas de suministro. En consecuencia, se ha observado un aumento exponencial de la investigación relacionada con el diseño de la cadena de suministro sostenible (CSS) desde 2010, tendencia que ha implicado diferentes enfoques para evaluar la sostenibilidad. Esta diversidad

conlleva al menos dos nuevos problemas significativos a abordar. Por un lado, la adopción de múltiples métricas para evaluar la sostenibilidad podría ser intratable en la búsqueda de una solución factible, idealmente óptima, por cualquier enfoque de método de resolución. Por otro lado, la selección de un conjunto limitado de métricas podría no abordar en toda su extensión el concepto de sostenibilidad. Este estudio aborda el problema de la medición de la sostenibilidad en el diseño de la CSS, proponiendo un marco integrado y reducido de métricas para abordarlo. Nuestra investigación se ha basado en una revisión exhaustiva de la literatura para analizar la incorporación de las dimensiones de sostenibilidad, en conjunto con el uso de técnicas relacionales y estadísticas multivariadas. Consecuentemente, se proponen cinco métricas para medir la sustentabilidad en base a un método de criterios de agregación y Cluster Analysis, reduciendo las 51 funciones a optimizar de un total de 541 artículos analizados.

Keywords: Cadena de suministro; Sostenibilidad; Cluster Analysis; Revisión sistemática

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An appropriate assessment of the supply chain performance considering different indicators
Nicolas Vanzetti; Gabriela Corsano; Jorge M. Montagna

December 13, 2022 (Tuesday), 12:30 - Room 1208

The supply chain (SC) is comprised of members committed and integrated to satisfying customer needs. Its successful operation depends on the agreement and coordination of the resources involved. There are numerous works that study the SC from different points of view, emphasizing the competitive advantages that firms have being part of a SC. When SC performance is assessed, appropriate criteria must be determined. This evaluation should be multidimensional and representing it with a single metric is often an inappropriate approach. Although different perspectives are considered in some papers, evaluations use to be global without analysing how these objectives impact each member. Generally, SC members are not affected in the same way, and benefits and difficulties are not shared equally. In this context, this work evaluates the SC performance considering different criteria, emphasizing how they influence the SC as a whole and each member in particular in different ways. For this analysis, the forest SC will be taken as an example, considering the strong relationship of cooperation and competition that exists among its members. In this industry, there are various alternatives for obtaining resources and generating product and, thus, the operation of each of its members has a significant impact on the rest. For this study, economic, operational and environmental indicators are considered, and the evaluation will be carried out using a mixed integer linear programming model. In the first instance, the influence of these objectives on the global SC performance is evaluated. Then, for each criterion, the individual performance of each member is optimized and compared with the global performance in order to assess the influence of the entire behaviour on each SC member. Finally, a multiobjective approach is proposed to provide a useful tool to decision makers to appropriately manage the SC performance.

Keywords: Supply chain; Performance; multiobjective optimization

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The impact of Bullwhip Effect within Supply Chain Network Design
Luis Olivares-Álvarez; Pablo A. Miranda-González; Francisco J. Tapia-Ubeda

December 13, 2022 (Tuesday), 12:30 - Room 1208

The bullwhip effect is the phenomenon generated due to poor communication within a supply chain producing batches of distorted orders which transmit oversized variability upstream. Among the main repercussions that it causes is an increase in transportation cost, holding cost and reducing the level of service, reducing the revenues between 15%-30%. It is important to mention that this effect is always present within a chain, but it is not included in the network design process, since it is considered and dealt with once it is detected. Not considering the bullwhip effect in the initial design of the network implies suboptimal configurations that do not guarantee a good response to this phenomenon. This work aims to generate an optimization model to support decision-making process from an integrated strategical-tactical perspective capable of designing a supply chain network. The proposed integration seeks to determine the structure of a network through the location of facilities and the incorporation of inventory control policies, all this considering the distortion of the information present in the chain. This allows generating the first optimization model that explicitly incorporates

distortion in the optimization process. Being the nature of the model nonlinear-nonconvex, a reformulation of the original model is presented through the Generalized Benders Decomposition, separating the initial problem into a master problem, similar to a Facility Location Problem, and an analytical resolution sub-problem. Preliminary results indicate that incorporating the bullwhip effect in the network design process alters the structure, which implies a clear importance of including this phenomenon. Consequently, if there is no information distortion the structure changes, but when this network configuration is confronted with the real cost ascend to 19,6%, proving the existence of decisional sub-optimality.

Keywords: Supply Chain Network Design; Inventory Location; Bullwhip Effect; Generalized Benders Decomposition; Mixed integer nonlinear-nonconvex programming

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Mobile traceability as a machine learning resource in predictive modeling of inland transport fuel demand

Irma Noemi No; Julián E. Tornillo; Guadalupe Pascal; Leandro Rabbione

December 13, 2022 (Tuesday), 12:30 - Room 1209

The health emergency due to COVID-19 generated that many countries take measures about social isolation and restricted mobility. The Argentinian government instrumented the preventive and obligatory social isolation (ASPO), which has generated new conditions for the logistics problem within the national territory. The significant change in vehicle flow and fuel consumption associated with inland transport required the creation of new predictive models associated with a set of new and unprecedented data (for example, the geolocation of drivers). The manipulation and adequate analysis of these data provide a "prognosis" (diagnosis + prediction) which improves forecast to the actual logistics. In this work, we analyze the fuel consumption databases (fuel and diesel) available and open on official websites and data from the YPF company. Results show a positive correlation between the variables associated with the demand for these fuels and the Google mobility records. We develop a new predictive model that discards old indicators and proposes new ones for the adjusted estimation of the demand for gasoline and diesel.

Keywords: Fuel demand; Google Mobility; Time series; Logistics prediction; Machine Learning

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Implementation of a Machine Learning tool for automatizing abstract screening in literature reviews

Angel Ruiz; Ana Maria Anaya-Arenas; Julia Isabel Serrato

December 13, 2022 (Tuesday), 12:30 - Room 1209

Literature reviews, as the pillar of scientific work, should be valid, reliable, and repeatable. In particular, the methodology to conduct systematic literature reviews is well identified and defined, involving three major stages (planning the review, conducting the review, and reporting the review). The second stage in the methodology includes activities that are very time consuming, particularly the screening for inclusion, where the researchers screen the abstract of each article produced by the search of the literature to decide whether it should be included for further data extraction and analysis. Some recent papers have proposed the use of Machine Learning (ML) tools to help researchers in this task, demonstrating the usefulness of such tools filtering and selecting papers that fit inclusion criteria. However, these papers address mostly technical aspects of the tools and focus on their performance, providing little or no information on the process involving the configuration, validation and verification. To fill, at least partially, this gap, this talk focuses on the implementation of Machine Learning tools for automatizing of the abstract screening, and provides some insights on how to improve the performance of the tool and how to deal with the inconveniences that might be encountered in the process.

Keywords: systematic literature review; machine learning tools; abstract screening

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A multi-armed Bandit Approach for house ads recommendations
Marcel Goic; Nicolás Aramayo; Mario Schiappacasse

December 13, 2022 (Tuesday), 12:30 - Room 1209

Nowadays, websites use a variety of recommendation systems to decide the content to display to their visitors. In this work, we use a multi-armed bandit approach to dynamically select the combination of house ads to exhibit to a heterogeneous set of customers visiting the website of a large retailer. House ads correspond to promotional information displayed on the website to highlight some specific products and are an important marketing tool for online retailers. As the number of clicks they receive not only depends on their own attractiveness, but also on how attractive are other products displayed around them, we decide about complete collections of ads that capture those interactions. Moreover, as ads can wear out, in our recommendations we allow for non-stationary rewards. Furthermore, considering the sparsity of customer-level information, we embed a deep neural network to provide personalized recommendations within a bandit scheme. We tested our methods in controlled experiments where we compared them against decisions made by an experienced team of managers and the recommendations of a variety of other bandit policies. Our results show a more active exploration of the decision space and a significant increment in click-through and add-to-cart rates.

Keywords: Multi-Armed Bandits; House Ads; Personalization; Deep Learning

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One-to-one and many-to-one Counterfactual Explanations for score-based models
Jasone Ramírez-Ayerbe; Emilio Carrizosa; Dolores Romero Morales

December 13, 2022 (Tuesday), 12:30 - Room 1209

Due to the increasing use of complex Machine Learning models in high-stakes decisions, it has become increasingly crucial to be able to understand how these models arrive at decisions. Assuming an already trained Supervised Classification model, an effective class of post-hoc explanations are counterfactual explanations, i.e., a set of changes that can be done to an instance such that the given Machine Learning model would have classified it in a different class. In this talk, for score-based classification models, we propose a novel Mathematical Optimization formulation for constructing different types of counterfactual explanations. We are able to generate the so-called collective counterfactual explanations, i.e., explanations for a group of instances in which we minimize the perturbation in the data (at the individual and group level) to have them labelled by the classifier in a given class. Moreover, we calculate representative counterfactuals for a batch of individuals, minimizing the distance while maximizing the probability of belonging to a specific class. Our methodology can generate sparse and plausible counterfactuals when dealing either with tabular data or with functional one. We illustrate our method with various real-world datasets.

Keywords: Counterfactual Explanations; Explainability; Mathematical Optimization; Machine Learning; Score-based Classification

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MIP-Heuristics for the multi-level capacitated lot sizing problem
Fernanda Ueno; Marcos Furlan; Maristela Santos

December 13, 2022 (Tuesday), 12:30 - Room 1301

The multi-level lot-sizing problem determines a production plan to meet the demand for final items and/or their components without backlogging and considering the available production capacity. The objective of the problem is to minimize the setup and holding costs. To deal with this problem, we developed a fix-and-optimize heuristic. We investigate the impact on the quality of the solutions by considering classical partitions of the binary variables by period, items, and by resources. Also, we consider partitions of these variables constructed by unsupervised learning based on a work in the recent literature. This study uses the k-medoids to obtain non-balanced and balanced groups of the binary variables in our local search approach. The local search heuristic tends to local optima, so several strategies are used to build and use the obtained partitions. We use a relax-and-fix heuristic with decomposition by period and an LP-and-fix strategy to get feasible initial solutions. Solution

methods are implemented in Python integrated with the commercial LP/MIP solver Gurobi. Computational tests are performed using data from the literature. The solutions are compared with the BFO (bees-and-fix-and-optimize) heuristic, an approach of the literature developed to solve the problem that obtained the best results.

Keywords: Lot sizing problem; MIP-Based Heuristics; Fix-and-optimize heuristic; unsupervised learning

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The economic lot sizing problem with remanufacturing and lost sales : complexity analysis and algorithms

Lucas Gana Reyes; Franco Quezada; Sebastián Dávila

December 13, 2022 (Tuesday), 12:30 - Room 1301

Motivated by global warming and the need of industrial companies to reduce both CO2 emissions and natural resource consumption, we study a new extension of the single-item lot-sizing problem first investigated by Wagner and Whitin (1958). In this extension, we consider the case of remanufacturing end-of-life products to obtain new products to meet demand over a finite discrete-time planning horizon. As in the classical lot-sizing problem, in case that in the period is produced a amount positive, then is incurred in a fixed cost -called setup cost-, besides of production cost per unit produced, and inventory holding cost per unit held in stock between two consecutive periods. In addition, due to a limited quantity of end-of-life products being returned by customers at each time period, the production system might not be able to satisfy the demand the customers demand on time. The corresponding demand is lost in this situation, incurring a high penalty cost to account for the loss of customer goodwill. Regarding that, the objective of this work is to build a production plan over a remanufacturing system so that the customers' demand is met in each time period and the total costs is minimized, i.e., the sum of setup, production, inventory holding costs, and lost sales, are minimized over the whole planning horizon. We thus first prove that the problem is NP-hard in its general case. Then, to solve the problem, structural and dominance properties of the optimal solution are investigated under several assumptions. These properties are then embedded within a branch-and-cut algorithm as valid inequalities to solve the problem. Computational experiments are carried out to assess its performance, and numerical results suggest a good performance of the proposed approach at solving the problem as compared to the one of a stand-alone mathematical programming solver.

Keywords: Lot sizing; Remanufacturing; Complexity; Valid inequalities; Branch and Cut algorithm

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The economic lot-sizing problem with remanufacturing, backlogging and carbon emission constraint

Andrés Vallecilla; Franco Quezada; Sebastián Dávila

December 13, 2022 (Tuesday), 12:30 - Room 1301

The global warming makes us pay special attention to the greenhouse gas emissions produced by industrial companies, which significantly contribute to their release into the atmosphere that directly harms the care of the environment and the population's health. One way of mitigating this impact is to produce from end-of-life products rather than raw materials, reducing thus pollution and natural resources consumption. Governments have also committed to reducing their carbon emissions by promoting new regulations that restrict the production by industrial companies, which have responded by adapting the production processes to assuage these new limitations. We thus address a new extension of the single-item economic lot-sizing problem with carbon emission constraints. This extension aims to plan remanufacturing activities, which consist of deciding the timing and level of production as well as the resources to be used to meet the customers' demand in the most efficient and economical possible way. Moreover, in contrast to the classical manufacturing system, the remanufacturing production is limited by the number of end-of-life products returned by customers at each time period and, hence, the production system might not be able to deliver to all customers on time in a given period. We thus consider the case where it is still possible to satisfy the demand later than required (back-orders), incurring a penalty cost for delays proportional to the amount backlogged and the duration of the backlog. To address this problem, we study the structural

properties of the optimal solution under several assumptions and investigate several mixed-integer linear programming formulations to find optimal solutions. Computational experiments are carried out to assess the performance of the proposed formulations, and numerical results suggest that one formulation might be more suitable than others at solving medium- to large-sized instances in reduced computations time.

Keywords: Lot-sizing; Remanufacturing; Carbon emissions; Backlogging; Mixed-Integer linear programming; Extended formulations

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Analysis of the lot-sizing problem with remanufacturing and uncertainty in demand and returns

Fernando Islas; Pedro Piñeyro; Carlos E. Testuri

December 13, 2022 (Tuesday), 12:30 - Room 1301

The economic lot-sizing problem with remanufacturing (ELSR) is an extension of the traditional problem, in which demand can also be satisfied by remanufacturing used products that are returned to the origin. Our work considers two variants of ELSR with uncertainty in the quantities of demand and returns: with a single line for both production and remanufacturing, and with dedicated lines for each one of these two activities. The natural formulation of the problem is reformulated as a facility location problem, which has shown good results for ELSR in its deterministic version. Our objective is to strengthen the natural formulations by incorporating valid path and tree inequalities. We also present a modification of the relax-and-fix heuristic for the problem. Finally, we present the results obtained of the numerical experimentation carried out for the case of dedicated lines. The findings that emerge from the computational study: the formulation with tree valid inequalities has the potential to improve the linear programming relaxation of the problem; compared to a natural formulation, the performance of the path inequalities and the facility-location reformulations decrease as the planning horizon of the problem increases; and the heuristic procedure seems to be promising for large problems.

Keywords: Lot-Sizing; Remanufacturing; Reformulations; Valid Inequalities

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Simultaneous optimization of the supply chain configuration and material flows for cogeneration of electrical and thermal energy from forest biomass.

Salomé Rodriguez; Diego Broz; Luis Zeballos; Rodolfo Dondo

December 13, 2022 (Tuesday), 12:30 - Room 1302

Biomass comes from a wide range of raw materials. Consumption of biomass for generating energy presents several difficulties (as availability, cost, quality, conversion performance, transport-cost and the performance of the logistics system) that must be overcome for its use as fossil-fuels replacement. High managing costs of a biomass supply chains constitutes a strong incentive for the optimal design and optimization of them. In Argentina, forest biomass mainly originates from waste derived of the exploitation of implanted forests. Biomass of the industrial type is usually classified considering the waste generated in sawmills, such as sawdust, wood chips; bark chips and slash. The selection of materials to generate power and/or to industrialize in order to add value to the raw materials is a critical problem of the forestry industry. Indeed, this work develops a mathematical model for optimizing the topology and the material flows of a forestry industrial company supply chain located in the north of Misiones (Argentina). The feasibility of operating a 3.5 MW cogeneration plant with several biomass alternatives as raw materials is included in the developed model. The objective function aims at setting the supply chain configuration that maximizes the profit obtained by commercializing the remaining biomass while taking into account the supply flow toward the thermal plant. Optimal flows within the chain are also computed. The model, which adds the time dimension in order to improve the representation of the problem, is developed to define the supply flows of raw materials from different origins to customers and to a cogeneration plant producing electrical and thermal energy. The MILP model of the supply chain is implemented in GAMS. The formulation is proposed as a tool to determine the optimal network configuration and material flows for different scenarios considering the diverse alternatives of forest utilization, products use and energetic demand.

Keywords: Biomass; Cogeneration; Supply chain

Multi-objective math-heuristic for optimizing the location of electric-scooter sharing-stations
Enrique Gabriel Baquela; Ana Carolina Olivera

December 13, 2022 (Tuesday), 12:30 - Room 1302

Electrical scooters are a recent alternative to cars and motorcycles based transportation in urban environments. Competing with bicycles, they offer mobility with less CO2 net emissions than petrol-based vehicles and, when distances are long, more comfort and lower travel times than bicycles. In this context, having good public police about electrical scooter sharing is crucial to the adoption of this kind of transport. The two main decisions about designing an electrical scooter sharing network are to stablish where to install sharing stations, and what should be the stations' capacity. Common approaches found in the literature deal with this planning problem trying to minimize the user traveling time, having a fixed budget, or, the opposite, trying to minimize the investment by having a desired service level i.e. mono-objective approaches. Taking both objectives into account help the decision-maker have a better understanding of the trade-off dynamic between the mean-travel time and the required investment, allowing to reach better choice. In this sense, in this work is proposed a framework for obtaining the Pareto Frontier of the problem. The well-known NSGA-II algorithm is combined with a Mixed-Integer Linear Programming model, in order to approximate the non-dominated solutions of the problem.

Keywords: Math-heuristics; Meta-heuristics; Mixed-Integer Linear Programming; Facility Location Problem; E-Scooter; Sharing Stations; Public Transport

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Decision tools from index fund finance to explore the path towards a scenario of renewable energy generation with globalization and high specialization of regional electricity markets
Orlando Joaqui-Barandica; Diego Fernando Manotas-Duque; Jorge M. Uribe

December 13, 2022 (Tuesday), 12:30 - Room 1302

Past literature has extensively explored portfolio optimization techniques similar to those developed from a capital allocation perspective, in finance, to construct an optimal generation mix of electricity that consists of different renewable energy technologies (wind, sun, hydro) and diverse geographical locations to conduct the energy transformation. We consider a different although related problem. We provide a way for a government to decide, in a globalized market of electricity, which firms (and power plants) should be ideally preserved (and encouraged) in case that specialization dictates concentrating the national generation efforts on a fixed number of firms (or a few locations), and therefore, on fewer power plants than those already in operation. We use weather and generation data associated with 106 power plants located across Argentina and adapt tools from integer portfolio optimization in finance to solve the posited problem. These tools were originally developed to construct index funds that replicate the risk and reward dynamics of a portfolio consisting of a larger number of assets than the index fund itself. Our results include the number and the identities of firms that should be ideally kept if one power plant was removed at a time, until the arrival to a scenario in which national generation concentrates only on a few plants. We find that in Argentina, around 71 power plants diversified across the three generation technologies suffice to preserve the weather risk of the original 106 plants without loss of information. In this way, we provide an optimal means to transit towards regional and company-level specialization, while stabilizing generation risk due to weather configurations at similar levels to those observed at the beginning of the transition.

Keywords: Energy transition; Integer portfolio optimization; Renewable energy; Climate risk.

Economic comparison of alternatives for the production, storage, and transportation of renewable hydrogen in Colombia
Yovany Arley Erazo Cifuentes; Juan Pablo Orejuela Cabrera; Diego Fernando Manotas Duque

December 13, 2022 (Tuesday), 12:30 - Room 1302

The growing need for energy generation from renewable sources has caused the industry to face two problems, the first one is the seasonal intermittency of power production from these sources and the second one is the economic infeasibility of directly electrifying heat-intensive industries and the long-distance freight transportation industry. Green or renewable hydrogen (RH2) is presented as a promising alternative solution to these problems due to the possibility of being used as an energy carrier and as a fuel with minimal environmental impact. However, the logistic configuration of its supply chain is a determining factor in its practical implementation. This study is aimed to determine the best alternative for the configuration of the Hydrogen Supply Chain (HSC) in which RH2 is produced by electrolysis using renewable energy in the Colombian Caribbean region; it is converted into different forms: Liquid Organic Hydrogen Carrier (LOHC), Cryogenic Liquid Hydrogen (LH2) and Compressed Hydrogen Gas (GH2); it is transported by trucks and delivered to meet the demand of the transportation sector in the Caribbean region. In the base scenario it is identified that the best alternative is to produce RH2 using wind energy, with an AEC type electrolyzer and convert it to GH2 at 350 bar for transportation and storage. Based on the initial result, different demand scenarios, distance between the production site and customer and WACC were considered, in projections between 2030 and 2050. The results show that, under this configuration, it is possible to determine the distance from which converting and transporting RH2 as LOHC is the best alternative. On the other hand, it is also possible to determine this limit for demand values, which allows to establish which is the best alternative HSC configuration.

Keywords: Green hydrogen; Renewable hydrogen; Renewable energies; Electrolysis; Liquid Organic Hydrogen Carrier; LOHC

Cuckoo Hashing with perfect rehash

Vinícius Gusmão Pereira de Sá; Judismar Arpini Junior

December 13, 2022 (Tuesday), 12:30 - Room 1303

The time to insert a key in the classic cuckoo hashing scheme is a random variable that may assume arbitrarily big values, owing to the strictly positive probability that an endless sequence of rehashes take place --- the worst-case is infinite. We propose a cuckoo hashing variant in which the worst-case insertion time is polynomial. To accomplish this, we use two basic ideas. The first is to employ a perfect hashing method on one of the tables whenever a rehash is called for (a perfect rehash, so to speak). The second idea is to make it so that the number of underlying hash tables is no longer constant, but rather an appropriate function of the number of keys. The price to pay is a larger lookup time, which is no longer constant, but doubly logarithmic. Preventing infinite worst-case times is not new in the literature, e.g. a Las Vegas algorithm can be converted into a Monte Carlo algorithm to yield finite predictable time, for the price of some positive, albeit controllable, error probability. Our insertion algorithm follows a random walk approach. When a predefined limit of iterations is reached, we pick a table with some empty slot and rehash all its entries in perfect fashion, including the new key being inserted. With the perfect rehash approach, all cuckoo hashing operations become predictable and finite. Our variant is not dominated by any existing data structure we know of (e.g., the classical cuckoo hashing, the standard hashing with collision handling via synonym lists, or even, say, self-balancing binary search trees). While it cannot be claimed to be an undisputed improvement over those traditional data structures (and it surely has disadvantages as well as advantages when compared to each one of them), it may suit well applications where a highly competitive average-case performance for lookup and insertion operations is desired, without prescinding from a predictable, polynomial bound for their worst-case behavior.

Keywords: Hashing; Data structures; Computational complexity; Algorithms

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A pseudo polynomial algorithm for optimizing a linear function at the intersection of the closed ball and integer lattice in the n-dimension space

Eleazar Madriz; Camilo Rocha; Nelson Maculan; Mauricio Romero

December 13, 2022 (Tuesday), 12:30 - Room 1303

In this work, we consider an “integer quadratically constrained linear problem” (IQCLP) which consists of maximizing a linear function over the intersection of a closed ball and the integer lattice in

the n-dimensional space. For solving this problem, first we prove that in every closed ball there is an integer polytope P with the property that in the region between the polytope and the ball there are no integers points. This allows to solve the IQCLP by maximizing the linear objective function over the set of vertices of P. In addition, denoting by r the radius of the ball, we show that all the vertices of P are contained in the region bounded by the balls of radius r and lambda where lambda is equal the product of the square root of n and the integer part of the quotient of r divided by the square root of n, minus the square root of n. Finally, we present an algorithm which maximizes a linear function over this region and is pseudo polynomial in the dimensions of the problem (n and r).

Keywords: Integer quadratically constrained linear problem; polytope; pseudo polynomial algorithm

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Quasilinear approximation for interval-valued functions via generalized Hukuhara differentiability

Beatriz Hernández Jiménez; Rafaela Osuna-Gómez; Yurilev Chalco-Cano; Tiago Mendonça da Costa

December 13, 2022 (Tuesday), 12:30 - Room 1303

A new generalized Hukuhara differentiability concept for interval-valued functions defined on R^n is proposed, which extends the classical Fréchet differentiability notion and provides an interval quasilinear approximation for an interval-valued function in a neighborhood of a point at which such function is gH−differentiable. Moreover, it overcomes the shortcomings generated by the use of the gH-differentiability concept previously presented in the literature, and this presents a good perspective on interval and fuzzy environments. Several properties of this new concept are investigated and compared with the previous concept properties.

Keywords: Interval-valued Functions; Quasilinear Functions; Generalized Hukuhara Differentiability

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Flowshop with additional resources during setups: mathematical models and a GRASP algorithm

Juan Camilo Yepes Borrero; Federico Perea; Fulgencia Villa; Eva Vallada

December 13, 2022 (Tuesday), 12:30 - Room 1303

Machine scheduling problems appear in many production processes, and are an essential part of the supply chain. Among them, flowshop scheduling problems arise when a number of jobs have to be sequentially processed by a number of machines. In this paper, we introduce for the first time the Permutation Flowshop Scheduling problem with additional Resources during Setups (PFSR-S). In this problem we assume that machines need setups between the processing of different jobs, and that such setups require a number of additional resources, e.g. operators, of limited availability. We propose two Mixed Integer Linear Programming formulations for this problem, as well as an exact algorithm. Due to the complexity of the PFSR-S, these approaches can only solve small-sized instances, and therefore we also propose a GRASP metaheuristic for much larger instances. All the methods designed for the PFSR-S in this paper are computationally tested over a benchmark of instances adapted from the literature. The results obtained show that the GRASP metaheuristic finds good quality solutions in short computational times.

Keywords: Scheduling; Flowshop; Metaheuristics

Análisis comparativo de técnicas de minería de datos para la estimación de precio de fruta de exportación: Caso de estudio en una empresa exportadora chilena

Myriam Gaete; Marcela González-Araya

December 13, 2022 (Tuesday), 12:30 - Room 1304

La industria de las exportaciones de fruta es cada día más competitiva, debido a múltiples factores entre como las características de la fruta y las condiciones del mercado. Con respecto a las características de la fruta, los principales elementos son las condiciones físicas (categoría, calibre y

color) y las condiciones químicas del mismo (grados brix). Desde la perspectiva del mercado se destaca como factor importante el mercado destino, la cláusula de venta (en firme o libre consignación), el medio de transporte (marítimo, aéreo o terrestre), la oferta de productos en el destino, el valor de las divisas (dólar, euro, renminbi, entre otros) y la demanda por parte de los clientes. Tal como se puede apreciar, en la cadena de valor de la fruta de exportación interactúan diferentes actores que influyen directamente en el precio final del producto. Este articulo tiene como finalidad comparar el pronóstico de precios de la fruta de exportación, considerado múltiples factores. El análisis comienza con los métodos de selección de variables, seguido de los métodos de pronóstico y comparación con las métricas más utilizadas en Machine Learning (RMSE, accuracy). Los modelos por utilizar van desde los métodos de pronóstico clásicos como Arboles de decición y Navie bayes hasta algoritmos basados en redes neuronales. Los resultados preliminares muestran resultados con un accuracy cercano al 50% considerando los métodos clásicos de pronóstico.

Keywords: pronóstico; fruta; exportación; precio; minería de datos

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Power indices of game theory and agricultural land use in Brazil

Fernando L. Garagorry; Moacir Pedroso Junior

December 13, 2022 (Tuesday), 12:30 - Room 1304

Traditionally, the areas under different forms of land use, recorded by the agricultural censuses in Brazil, have been grouped into six main classes: perennial crops, annual crops, natural pastures, planted pastures, natural forests and planted forests. In each geographic region, defined by the official Territorial Division of Brazil, the six classes have been interpreted as being players in a voting (additive) game, where each one has a value given by the percentage of its area in the total for the region, and the winning coalitions are those with a value of more than 50%. In a recent study of the Caatinga region, in the North East of Brazil, 120 microregions of the official division were identified. For each one, land-use data from the three more recent agricultural censuses were considered. Therefore, for each census year, a total of 121 games was determined (since the full Caatinga region was also treated as a voting game), where each one was characterized by a distribution of nonnegative numbers adding up to 100. The Banzhaf power index of game theory was determined for each game and was used as a tool in order to identify clusters of microregions with similar land-use patterns. In particular, since Banzhaf indices can be seen as new voting games, the procedure was applied repeatedly to them up to reaching indices that were fixed points. In general, that happened in one or two stages. The microregions were allocated to clusters defined by these final indices. The results show some substantial changes in land use that happened between census years. Some of these changes were not detected by distances used frequently in clustering algorithms; that is, two distributions can be quite close according to some distance but have very different power indices. Besides a program used to calculate the Banzhaf index, a special rounding method had to be implemented in order to ensure that successive power indices did not converge to a wrong fixed point.

Keywords: Game theory; Agricultural land use; Banzhaf power index

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Agricultural operations planning addressing sustainability: a case study for family farmers in Paraguay

María Margarita López de Recalde; Jorge Vera; Lluís Miquel Plà Aragonés; Jorge L. Recalde-Ramírez

December 13, 2022 (Tuesday), 12:30 - Room 1304

Family farmers in developing countries experience the self-consumption of few crops available on their farms, the uprooting of their communities, and inadequate diets. The above issues occur, although they are predominant in achieving the population's food security. In the short term, through the Sustainable Development Goals (United Nations), the provision of food and assistance to vulnerable regions is expected. However, the increase in sustainable productivity depends on the feeding systems in the long term. In this work, we design a network and an operations planning scheme for multiple producers and crops, involving cooperatives of family farmers to obtain profitability and food security for their members. We formulated a mathematical model for the

network, considering relevant decisions and operations: supply of agricultural inputs, production, harvest and crop rotation, storage, distribution of products to other producers, external consumers, and self-consumption. We developed a base case and three scenarios for Caazapá (Paraguay), with 80% rural population and 40% poor. They are five cooperatives (107 farmers), 60 months, 12 crops, and 6 rotation crops. Comparing the model results with the actual production was possible to increase and vary the crop mix to 12 proposed items against the 3 traditional products produced per farm (corn, cassava, and beans). The model results address sustainability through lower-cost plans, crop rotation and expansion of the product mix, and satisfaction of a percentage of families' nutritional requirements. We expect to expand the work after identifying the primary sources of uncertainty for production and consumption (yield and demand).

Keywords: Family farmers; Food security; Sustainability; Linear programming

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A mathematical programming model for the logistic design of an agricultural network and rural schools.

Jorge L. Recalde-Ramírez; Jorge Vera; Lluís Miquel Plà Aragonés; María Margarita López de Recalde

December 13, 2022 (Tuesday), 12:30 - Room 1304

According to UNESCO (2017), some 264 million children and young people do not go to school worldwide. The causes can be complex: there are attributions to corruption, poverty, hunger, and lack of public policies, among others. Nations have discussed the issue, drawing sustainable objectives regarding the right to education, the number of hungry people, and goals they wish to achieve by 2030. In this sense, have been created the Programs of School Feeding (PAE) as support tools in public policies. The PAE tendency at the Latin American and rural levels has been to seek social protection to meet children's food requirements and, on the other hand, to promote family farming. This project aims to support decision-making regarding the logistics network design that links the rural schools attached to the PAE with the farms of small local farmers who serve as food providers. To this end, it is proposed to use the situation of rural schools and small agricultural producers in the department of Caazapá, Paraguay, as a case study. In this region of the country, 82% of the population lives in rural areas. The conditions lend themselves to the research project development due to the data availability. Since it is expected to have a relatively high number of variables and constraints, a mathematical programming model was formulated to address the problem. For a representative mathematical model, restrictions of sustainable agricultural planning must be addressed, such as crop rotation and crop selection, as well as meeting the demand for school lunches by schools, among other social issues. The inclusion of only one objective is pertinent for the moment: the minimization of costs in distributing and generating food rations for schools. As a second objective, independently, a social objective is proposed: the maximization of benefits for small farmers. As the work is in progress, it is hoped in future work to merge the two objectives and treat the problem as a bi-objective.

Keywords: Small scale farmers; Sustainability; Program of School Feeding; Linear programming; Mathematical programming

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Costing post-COVID-19 surgeries in Colombian hospitals using analytics

William Guerrero; Julian A. Hincapie; Julian Alberto Espejo-Díaz; Juan Manuel Aranda; Valeria Barajas; Wilson A. Camargo

December 13, 2022 (Tuesday), 12:30 - Room 1305

Surgical departments in hospitals are often subject to a high level of variability, uncertainty, and risks. Variability in operations is due to emergency surgery requests, delayed procedures, canceled surgeries, irregular times for performing tasks, and variable demand for supplies and equipment. Standardization in surgical procedures is a goal that hospitals must achieve to increase efficiency, safety, and profitability. After COVID-19 pandemics, the times and costs for many surgeries have suffered significant changes. For example, some surgeons perceive an increased variability in the operation. In this study, we present a descriptive and predictive analysis of the data about the times and costs of the activities of the surgeries. Using analytics, we develop a model to describe the

variability and patterns in the data. To do so, we test several types of regression and data clustering techniques. These techniques allow us to develop a “control tower” for the surgical department, which is composed of various dashboards that provide real-time information about surgery hey-performance indicators. The results of the real-case study provide managerial insights for better tactical planning of the operation theater. As ongoing research, we will use the control tower to build a scheduling system for elective procedures and an inventory management system for surgical supplies.

Keywords: Healthcare Services; OR in Health; Operation Theater; Surgery planning; Analytics; Control tower

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Evaluación de la programación laboral a través de un modelo de optimización multiobjetivo en el contexto de la pandemia COVID-19

Federico Corral Marchant; Eric Forcael Durán; Rodrigo Linfati

December 13, 2022 (Tuesday), 12:30 - Room 1305

Una de las industrias más afectadas por la COVID-19 es la Construcción, debido a los atrasos y paralización de proyectos en desarrollo. Las actividades propias del sector requieren ser necesariamente ejecutadas de forma presencial, por lo que ha sido necesario tomar estrictas medidas de higiene y seguridad para minimizar riesgos de contagio. No obstante, las restricciones operativas y el temor al contagio han causado que muchas empresas estén enfrentando problemas de potencial quiebra. En el presente estudio se propuso un modelo matemático de optimización multiobjetivo (S-MOP), para evaluar la programación laboral horaria de trabajadores en el sector de la construcción, bajo el contexto de la pandemia COVID-19. El modelo fue resuelto utilizando el software AMPL IDE, con el cual se condujeron experimentos basados en los métodos de Ponderaciones y Restricción Epsilon (ε-constraint). Utilizando las funciones objetivo se obtuvo una Frontera de Pareto que permitió comprender la relación de eficiencia entre desviaciones horarias, exhibiendo pares de soluciones que asocian los menores costos respecto a programación laboral. Se determinaron diagramas de Cartas Gantt bajo escenarios con y sin COVID-19, para contrastar niveles de libertad y desplazamiento laboral en terreno. Esto llevó al desarrollo de análisis numéricos relacionados con las horas contractuales de los trabajadores por sector. Para un tomador de decisiones de la industria de la construcción, los resultados demostraron la importancia de las horas extra y no trabajadas, la planificación laboral correctamente dimensionada, y el surgimiento de nuevos costos COVID derivados de las nuevas restricciones, dada la necesidad de mantener la ejecución de una obra bajo un entorno laboral seguro. Por lo anterior, el modelo matemático podría representar una potencial herramienta para la toma de decisiones, respecto a efectos y costos COVID-19 sobre la programación laboral en obras del sector construcción.

Keywords: COVID-19; Distanciamiento laboral; Costo COVID; Trabajadores de la Construcción

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Mathematical programming application for the assignment of patients, with Covid-19, to ICU beds

Sannie Román; Betania Echagüe; Jorge L. Recalde-Ramírez; María Margarita López de Recalde

December 13, 2022 (Tuesday), 12:30 - Room 1305

A problem with high notoriety worldwide and nationally during the Covid-19 pandemic is the lack of resources (beds, medicines, nurses, doctors) in the called reference hospitals to attend to patients infected. Also, the hospital managers affront the congestion and the priority order to attend to patients. Even more, some users are left on the waiting list to occupy a bed or to be transferred to other hospitals with available capacity. We can represent this problem through mathematical programming considering restrictions such as the number of beds available per hospital, the distance between hospitals, and the priority level of patient care. The objectives could be minimizing the distance traveled, maximizing the use of hospital beds, minimizing the work time of health personnel in congested hospitals, minimizing the cost of treating patients in hospitals, among others. We analyze the case of the effective reassignment of patients with Covid-19, on the waiting list to be treated in the reference hospitals in Asunción and the Central Department (Paraguay) with data provided by the Ministry of Health and Social Welfare. In previous results, we describe and graph a "Protocol for the referral of patients who require an ICU bed in the public health system." Also,

analyzing the data collected, the relevant parameters were determined, as the capacity of ICU beds (Intensive care unit) available in the reference hospitals, the level of occupancy of the beds, the care priority criteria, patient stabilization and transfer time, and the number of requests for ICU beds. It is expected to obtain a schedule for the effective assignment of patients, in this case with COVID-19, considering the levels of congestion of other hospitals, the priority of patient care, and other restrictions related to the problem. For the computational programming of the model, we will employ Gurobi 8.1.1 optimization software with the Python programming language.

Keywords: Mathematical programming; ICU beds; Congestion; Rference hospitals.

A proposal mathematical model for the vaccines COVID-19 distribution network: A case study in Mexico

Isidro Soria Arguello; Rafael Torres Escobar; Hugo Perez; Tomas Guillermo Perea Rivera

December 13, 2022 (Tuesday), 12:30 - Room 1305

Coronavirus disease 2019 (COVID-19) has been the most recent disease, with millions of deaths worldwide. Fortunately, vaccines have been developed to immunize the population. However, the distribution of the vaccines is also a significant challenge. Generally, each country defines its strategy to bring it closer to the target population, considering that depending on the type of vaccines is defined the adequate transport for their conservation. In this work, a mathematical model is proposed for the distribution of different COVID-19 vaccines in Mexico. Our results suggest an efficient strategy to meet demand in a given period.

Keywords: Distribution Network; Vaccines COVID-19; Mixed Integer Linear Programming; Optimization

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On perspectivization of convex functions over polytopes

Jon Lee; Luze Xu

December 13, 2022 (Tuesday), 12:30 - Room 1306

Mixed-integer nonlinear optimization formulations of the disjunction between the origin and a polytope via a binary indicator variable have broad applicability in nonlinear combinatorial optimization, for modeling a fixed cost associated with carrying out d activities and a convex variable cost function f associated with the levels of the activities. The perspective relaxation is often used to solve such models to optimality in a branch-and-bound context, especially when f is univariate (e.g., in Markowitz-style portfolio optimization). But such a relaxation typically requires conic solvers (such as MOSEK, SDPT3) and are typically not very compatible with general-purpose NLP software (e.g., KNITRO) which can accommodate additional classes of convex constraints that maybe be outside of what conic solvers consider. For the perspectivization of a convex function, a conic solver needs to be equipped with the barrier function of the associated cone. In the context of perspectivization, conic solvers typically can handle only exponential cones and (multidimensional) power (including SOCP) cones. For general convex functions, there is no reason in principle that a conic solver cannot handle its perspectivization, but the infrastructure is not yet there. On the other side, general-purpose NLP software is not well equipped to directly handle the perspectivization of any (nonlinear) convex function, as constraint qualifications will typically not hold (at the origin). This motivates us to study when simpler but weaker relaxations may be adequate. In particular, relaxations that do not employ perspectivization. Considering the volume (i.e., Lebesgue measure) of relaxations as a means of comparing, we lift results for univariate functions to the multivariate case over some polytope domains, particularly simplices and hypercubes. Because the difficulty of multi-dimensional integration grows with the dimension, we must restrict the types of convex functions that we can consider.

Keywords: NM; mixed-integer nonlinear optimization; global optimization; convex relaxation; perspective; simplex; hypercube; polytope; volume; integration

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The Periodic Capacitated Centred Clustering Problem
Marcos José; Nelson Maculan

December 13, 2022 (Tuesday), 12:30 - Room 1306

We consider the periodic capacitated centred clustering problem, where there are a number of items with many attributes including their location, in Rn, a demand and a period between services associated to each of them. The problem wants to minimize the total dissimilarity between items of the same group and the cost associated to open a new cluster while also accomplish the constraints of the problem. We propose a combinatorial formulation for the problem and we reduced it to a quadratic version with cone constraints, making possible to be considered by the quadratic solvers like Gurobi and Xpress. We present results obtained with tested instances of moderate size.

Keywords: NM; Clustering; Constrained Clustering; Periodic Constraints

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Convergence, rate of convergence and finite termination of inexact proximal point methods for multiobjective quasiconvex minimization on Hadamard manifolds
Erik Alex Papa Quiroz; Nancy Baygorrea; Nelson Maculan

December 13, 2022 (Tuesday), 12:30 - Room 1306

In this talk we extend the proximal point algorithm to find Pareto-Clarke critical points of quasiconvex multivalued functions defined on Hadamard manifolds considering vectorial and scalar errors on the subdifferential. Furthermore, under some assumptions we obtain the global convergence of the sequence to a Pareto-Clarke critical point and finally linear/superlinear rate of convergence and finite termination of the algorithm. In the convex case, we prove the convergence to a Pareto efficient solution point (more than a weak Pareto efficient solution point). The results of the paper are new even int the Euclidean space.

Keywords: NM; Proximal point method; Quasiconvex Functions; Hadamard manifolds; Multiobjective minimization

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Considering environmental effects in the scheduling of multi-site research projects.
Mauricio Vega-Hidalgo; Lorena Pradenas; Victor Parada

December 13, 2022 (Tuesday), 12:30 - Room 1306

Research on natural ecosystems is relevant to understanding how important it is to conserve biodiversity and attracts the attention of scientists worldwide. However, any human activity harms the sites under investigation. Consequently, resources for implementing research projects in these regions are minimal. Therefore, it is relevant for organizations to manage the efficient use of these resources, select and schedule logistically feasible projects, maximize scientific impact and minimize adverse effects on the environment. This study will address the problem of selecting and scheduling multi-site research projects. Each project has a time duration and may precede another project. A subset of pre-selected projects must be scheduled during the current season. There are resources of various types, where a limited number of units of each type are available. Some of these resources cannot be used at specific sites and periods. Each project requires certain resources for its execution. Each unit may be fixed at a site or transported from one site to another within a certain number of days. In addition, each unit has a daily usage cost that considers consumption (e.g., food or fuel), a monetary penalty for emissions generated (e.g., waste or gases), and a fixed cost of use. The objective is to maximize the total benefit of the selection and scheduling, considering the difference between the revenue generated by each project and the cost of using each resource. An integer programming model was proposed to represent the problem. The model's performance was tested in CPLEX with 288 test instances classified into 36 classes. Preliminary results show that in almost 20% of the instances, the optimal solution was found before 3600 seconds, suggesting a high complexity of the problem.

Keywords: selection and scheduling problem; multi-site context; environmental effects; NM

Double splitting preconditioner: A new class of preconditioners
Maycon Souza; Aurelio Oliveira

December 13, 2022 (Tuesday), 12:30 - Room 1307

We propose a splitting preconditioner generalization, where the authors present a new approach to working with the augmented system in the context of interior point methods for linear programming. It is also shown that the splitting preconditioner works very well near to a solution of the linear programming problem, a nice feature, since in such case the linear systems tend to be extremely ill-conditioned. We introduce a double preconditioner for the augmented system, including three new parameters. In this way, it allowed us a greater range of possibilities for new preconditioners, which we call Double Splitting Preconditioner. Furthermore, we show an important theorem that tells us that we have a variety of choices for some blocks that make up the double spliting preconditioner and that lead to the same linear system matrix (first block of the doubly splitting matrix) which is the main key to the efficiency of the proposed method. Through new parameters, we obtain a preconditioned matrix with eigenvalues far away to zero. Moreover, through appropriate choices of such parameters, we actually obtain a well conditioned matrix in the final iterations of the interior point method. And in a way, we have a priori knowledge concerning the matrix condition number in the final iterations. In fact, we have some control over the condition number along the whole iterative process. Therefore, the main objective of this work is to provide a preconditioner that improves the condition number of the preconditioned matrix, and possibly in this way also improves the iteration number and total time required to solve the linear programming problem. We perform numerical tests using the Matlab software, to verify the efficiency of the proposed method. In this way, we are able to verify the influence of the parameters of the double splitting preconditioner, showing that for convenient values of these parameters, there is a decrease in the number of the iterative method iterations.

Keywords: Preconditioning; Augmented system; Interior point methods; Linear programming

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Colorectal cancer in Chile: a Latin-American country with marked socioeconomic inequities
Susana Mondschein; Felipe Subiabre; Natalia Yankovic; Camila Estay; Christian Von Muhlenbrock; Zoltan Berger

December 13, 2022 (Tuesday), 12:30 - Room 1307

INTRODUCTION: Colorectal cancer (CRC) is the third most frequent malignant disease in the world. In some countries with established screening programs, its incidence and mortality have decreased, and survival has improved.

AIMS: To obtain reliable data about the epidemiology of CRC in Chile, we analyzed the trends in the last ten years and the influence of observable factors on survival, including explicit guarantees in CRC treatment access.

METHODS: Data were obtained from registries of mortality and hospital discharges, making follow-up of the individuals possible. Crude and age-standardized incidence and mortality rates were calculated, and individual survival was studied by constructing Kaplan– Meier curves. Finally, a Cox statistical model was established to estimate the impact of the observable factors.

RESULTS: 99,846 hospital discharges were registered between 2009 and 2018 in Chile, corresponding to 36,649 patients. In the same period, 24,154 people died of CRC. A nearly linear, steady increase in crude incidence, mortality and prevalence was observed. CRC incidence was the lowest in the North of the country, increasing toward the South and reaching a maximum value of 35.7/100,000 inhabitants/year in terms of crude incidence and 20.7/100,000 inhabitants/year in terms of crude mortality in the XII region. Kaplan– Meier survival curves showed a slight improvement during the study period. Depending on socioeconomic status, survival was significantly better with private insurance than the national insurance system. Patients in the capital city survived longer than those in other parts of the country. We found no significant effect on survival associated with the GES program.

CONCLUSIONS: The introduction of a national screening program is the only way to diminish serious inequality and improve the survival rate of CRC in Chile.

Keywords: Colorectal cancer; mortality; incidence; survival; insurance; Chile

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Modelo compartimental de tuberculosis con tratamiento en individuos latentes

Doris Campo; Lilian Sepulveda; Edwin Barrios

December 13, 2022 (Tuesday), 12:30 - Room 1307

La tuberculosis es una enfermedad infecciosa bacteriana causada por una especie de bacteria patógena llamada Mycobacterium tuberculosis o bacilo de Koch. Esta bacteria suele atacar los pulmones, pero también puede afectar otras partes del cuerpo, como los riñones, los genitales y el cerebro. La tuberculosis se contagia de persona a persona a través del aire, cuando un individuo infectado tose, estornuda o habla. Una característica epidemiológica notable de la tuberculosis es su largo período de latencia que puede durar desde varias semanas hasta toda la vida. Por un lado, las personas con una forma latente de Tuberculosis no son infecciosas y pueden durar en este estado durante muchos años sin desarrollar activamente la enfermedad y volverse infecciosa, siempre que su sistema inmunológico no presente alteraciones. Por otro lado, individuos latentes con un sistema inmunológico debilitado por desnutrición o con morbilidades(neumonía, COVID19, enfermedad renal, etc.) o aquellas que se someten a un tratamiento inmunosupresor para el VIH, tienen un mayor de riesgo de desarrollar una forma activa de tuberculosis. En este trabajo se considera un modelo matemático donde la población se divide en cuatro compartimentos estándar, a saber: personas susceptibles (S), personas latentes (L), personas infecciosas (I), e individuos que reciben tratamiento para la enfermedad (T). Como una nueva característica se introduce a la dinámica del sistema tratamiento para personas con la forma latente de la enfermedad que evitará que se desarrollen de forma activa la tuberculosis. Al modelo matemático en cuestión se le hará un análisis cualitativo y de sensibilidad. Nuestro objetivo es evaluar el impacto del tratamiento y estimar el número de infecciones activas de TB, las muertes que podrían evitarse mediante el tratamiento estableciendo políticas de control que permitan disminuir los costos de tratamiento analizando cómo afectan estás en la disminución de la infección de TB.

Keywords: Tuberculosis; Enfermedad infecciosa; Control Optimo

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Un problema de ruteo de vehículos periódico en la gestión de residuos industriales

Natalia Paz González González; Cristián E. Cortés; Pablo A. Rey

December 13, 2022 (Tuesday), 12:30 - Room 1307

Dada la creciente importancia de un mejoramiento en el cuidado del medio ambiente para garantizar el cuidado y protección de los recursos naturales, en el último tiempo, diversos planes de contingencia y concientización global de la sociedad han sido desarrollados para lograr una gestión sustentable de recursos. Un elemento fundamental para lograr este objetivo ha sido el tratamiento responsable de los residuos y su reutilización, fomentando la disminución de generación de basura doméstica e industrial. Debido a la compleja naturaleza de estos servicios, los municipios han decidido encargarse solamente de los residuos domésticos, mientras que los industriales deberán ser gestionados por empresas especializadas. Además, desde el punto de vista de la logística, los operadores designados deben encargarse de gestionar en forma eficiente y segura el transporte entre la entidad generadora de residuos y su disposición final, tarea que en el último tiempo se ha vuelto cada vez más compleja debido al incremento en los costos de combustible, mano de obra, maquinaria y al aumento en la demanda. En este estudio se desarrolla un modelo de optimización enfocado en logística, el cual resuelve un problema de ruteo de vehículos periódico cuyo objetivo es minimizar los costos operacionales y las reprogramaciones de visitas agendadas para un holding de gestión de residuos, especialista en recolección de residuos industriales peligrosos, asimilables a domiciliarios y reciclables que opera en la Región Metropolitana de Chile. En una primera etapa se realiza la programación de las visitas semanales a cada cliente según la frecuencia solicitada, buscando un balance de cargas diarias. Posteriormente se continúa con el ruteo de vehículos para cada jornada, agrupándolos por proximidad, tipo de servicio y asignándolos a la flota disponible para el período, designando el orden de visitas según ciertos criterios de importancia definidos para el problema particular.

Keywords: Periodic Vehicle Routing Problem; Optimization; Waste recollection; Logistics system

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Weighted connected matchings

Guilherme C. M. Gomes; Bruno P. Masquio; Paulo E. D. Pinto; Vinicius F. dos Santos; Jayme L. Szwarcfiter

December 13, 2022 (Tuesday), 12:30 - Room 1309

Matching problems in graphs are widely studied over the decades, with applications in many areas. A matching is a set of pairwise non-adjacent edges of a graph. Moreover, M is denoted as a P-matching if the subgraph induced by the endpoints of the edges of M satisfies property P. Some of the properties P studied include that the graph is 1-regular, acyclic, connected, disconnected or has exactly one perfect matching. For these properties, finding large cardinality P-matchings respectively result in the problems Induced Matching, Acyclic Matching, Connected Matching, Disconnected Matching and Uniquely Restricted Matching. Those problems are known to be NP-hard, except for Connected Matching, which can be solved with the same complexity as the classic matching problem. Weighted versions of matching problems are also approached and have many applications. This concept was recently extended to P-matchings, approaching weighted acyclic and induced matchings. Motivated by these facts, we study the problem Maximum Weight Connected Matching, where we want to find a connected matching M whose sum of the edge weights is maximum. We show that Maximum Weight Connected Matching is NP-hard even for bounded diameter bipartite graphs, starlike graphs, planar bipartite, and subcubic planar graphs, while solvable in linear time for trees and graphs having degree at most two. If the edge weights are all non negative, the problem turns out to be polynomially solvable for chordal graphs, while remains NP-hard for most of the cases for which weights can be negative. For parameterized complexity, we show the existence of a single exponential time algorithm when parameterized by treewidth. Also, in terms of kernelization, we show that the decision problem of Maximum Weight Connected Matching does not admit a polynomial kernel when parameterized by vertex cover under standard complexity-theoretical hypotheses.

Keywords: JS; Matchings; Algorithms; Complexity; Induced Subgraphs

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Providing a new approach to the study of split edge coloring classification problem

Diego Amaro Costa; Sulamita Klein; Fernanda Couto

December 13, 2022 (Tuesday), 12:30 - Room 1309

An edge coloring of a graph G is a color assignment to the edges of G. A k-edge colorable graph G is a graph whose edges can be colored with k colors such that adjacent edges have distinct colors. The chromatic index of G, denoted by \chi'(G), is the minimum integer k such that G is k-edge colorable. According to Vizing's Theorem, \chi'(G) is either \Delta or \Delta+1, and even so the problem of classifying a graph as Class 1, i.e., \Delta-colorable, or Class 2, i.e., \Delta+1-colorable is, in general, NP-hard. For this reason, the search for classes in which is possible to solve the classification problem in polynomial time is frequent. A Split graph is a graph whose vertices can be partitioned into a clique and a stable set. Classifying split graphs as Class 1 or 2 is an open problem for several years. However, some partial results are known for subclasses of split graphs such as split graphs with odd maximum degree, complete split graphs and split-indifference graphs. A t-admissible graph G is a graph that has a spanning tree T in which the maximum distance between adjacent vertices of G is t. This tree is called a tree t-spanner and t is the stretch factor associated with the tree. The smallest t for which G is t-admissible is called stretch index, denoted by \sigma(G). The t-admissibility problem consists in determining the stretch index of a graph G. Split graphs are known to be 3-admissible graphs, what means that we can partition split graphs into exactly 3 subclasses: with \sigma(G)=1,2 or 3, providing a new perspective on split edge coloring problems. In general, 1-admissible graphs are trees, and trees are \Delta-edge colorable. In this work we prove that a split graph G with \sigma(G)=2 is Class 2 if and only if \exists H \subseteq G with \Delta(H)=\Delta(G), |E(H)|>\Delta(H)\frac{|V(H)|}{2} and H is induced by a \Delta(G)-vertex and all its neighbors, i.e., G is neighborhood-overfull. Thus, remaining only split graphs with \sigma=3 to be classified.

Keywords: edge coloring; split graphs; 2-admissible split graphs; JS

Certifying Algorithms for Convexity in Graphs
Paulo Sérgio Carreira; Danilo Artigas

December 13, 2022 (Tuesday), 12:30 - Room 1309

A Certifying Algorithm is an algorithm that produces, for each output, a certificate for it. The user, in ownership of the certificate and the response of the algorithm, could verify if the answer is correct. The main idea for the development of certifying algorithms is the possibility to offer a check of the output, thus avoiding some implementation bugs in the program. In this work, we develop certifying algorithms for some classical problems related to geodesic and monophonic convexity in graphs. Let G = (V, E) be a finite, simple, and connected graph and S a subset of V. The geodetic closure I[S] of a set S is the set of all vertices lying on a shortest path between any pair of vertices of S. The set S is g -convex if I[S] = S. The set S is called geodetic if I[S] = V. The geodetic convex hull gCH[S] of S is the smallest g-convex set containing S. A set S is a g-hull set if gCH[S] = V. Analogously, we present the definitions for monophonic convexity. The monophonic closure J[S] of a set S is the set of all vertices lying on an induced path between any pair of vertices of S. The set S is m-convex if J[S] = S. The set S is called monophonic if J[S] = V. The monophonic convex hull mCH[S] of S is the smallest m-convex set containing S. A set S is an m-hull set if mCH[S] = V. For geodesic convexity, non-certifying polynomial-time algorithms to decide if a set S is g-convex, geodetic, or a g-hull set are well known in the literature. In this work, we introduce certifying algorithms for both of these problems. For monophonic convexity, Szwarcfiter et al. proved that it is NP-complete to decide if a set S is monophonic and showed polynomial-time algorithms for the problems of deciding whether a set S is an m-convex or m-hull set. We investigated the polynomial problems for monophonic convexity and proposed certifying algorithms to decide and certify if a set S is an m-convex set or an m-hull set for both of the problems.

Keywords: JS; certifying algorithms; geodesic convexity; graph convexity; monophonic convexity

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Tower of Hanoi variations, pile problems and O.R. applications
Lia Martins; Meng Huey Hsu; Raquel Folz; Rosiane de Freitas

December 13, 2022 (Tuesday), 12:30 - Room 1309

Many real-life situations show up like stacked items that need to be transferred from one stack to another one. Suppose a harbor, where there are several containers, and it is necessary to load or unload cargo from container ships. Assume large pieces of concrete, for a modern bridge or building construction, or diversion of trains in a marshaling yard. All these problems can be modeled by applying pile problem principles under constraint resources, such as the Tower of Hanoi (ToH). These puzzles are connected to graphs, which means they can be modeled using graphs. This set consists of three rods, labeled 0, 1, and 2, and n disks with different radii numbered from 1 to n in ascending order of size. They are initially stacked in descending order on the 0 stacks. For each disk there are three conditions, being on the 0, 1, and 2 stacks. So we set T = {0, 1, 2}. So each state is uniquely represented by an element s = s_n ... s_1 \in T^n, where s_d is the stack on which the disk d is at that moment. The object of the game is to move the entire pile from stack 0 to stack 2. ToH can be represented by a simple, connected, and planar graph, as an approximation of the Sierspink triangle: the Hanoi graph H_n= (V, E), where the vertices V of the graph represent the configuration and the edges E define the possible moves of the puzzle. There are other tower game applications such as a computer data backup rotation scheme, where multiple tapes/media are involved, so important variations of the ToH were created such as the Tower of Oxford (ToO), the Tower of London (ToL), and the Tower of Bucharest (ToB) which differ in terms of stack number and size/capacity, types of discs, rules, and gameplay. We are interested in exploring its properties in graphs and its algorithms. Furthermore, we present the Tower of Hanoi-London as ongoing research.

Keywords: JS; Combinatorial game; Computational complexity; Graph theory; Logistics; Sierpinski triangle; Tower of Hanoi

Modelo híbrido de mapeo de talento

Miguel Angel Curchod; Sofia Carla Cortaberria

December 14, 2022 (Wednesday), 09:00 - Room 1101

El trabajo presenta una propuesta metodológica híbrida para el mapeo del talento utilizando las herramientas de gestión: “nine box matrix” y el método de apoyo a las decisiones multicriterio MOORA (Multi-Objective Optimization on the basis of the Ratio Analysis). Mapear el talento es una práctica frecuente en empresas interesadas en: identificar a los empleados que agregan valor crítico y formular políticas de recursos humanos coherentes con sus objetivos. La primera herramienta permite categorizar a los empleados utilizando como ejes centrales el desempeño y el potencial. Los componentes intrínsecos de cada variable son versátiles. La matriz brinda la base sobre la cual se desarrollan las intervenciones sobre los recursos humanos: capacitación, aumentos salariales, reasignaciones, ascensos o desvinculaciones de la empresa. A pesar de la riqueza de la información que proporciona para tomar decisiones globales, ella es escasa cuando se trata de realizar injerencias dentro de una misma categoría. Con el objeto de contar con un ordenamiento completo se profundizó el proceso de evaluación aplicando el método MOORA, considerando como criterios las variables definidas para la matriz “9-Box”. Se estimó el desempeño con los criterios: objetivos y competencias y, se evaluó el potencial usando aspiración, trayectoria y las cinco agilidades de aprendizaje: mental, de resultados, interpersonales, conciencia de sí mismo y de cambio. A los diferentes criterios se les asignó el peso relativo uniforme medio. Analizando los resultados se concluye que ambas metodologías trabajan en un mismo sentido. La matriz agrupa a los colaboradores de acuerdo con una categoría permitiendo medidas generales de intervención y ofrece una mirada integral del talento. El método multicriterio facilita las decisiones específicas. Por estas razones se recomienda el uso de ambas herramientas como complementarias para mejorar el proceso de toma de decisiones.

Keywords: RED-M; Multicriterio; Método MOORA; Mapeo de Talento; Ranking de Colaboradores

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Using a combined MCDA method to support the choice of the architecture that best performs in space system requirements

Ygor Logullo; Lorran Rodrigues; Mischel Carmen Belderrain; Christopher Cerqueira; Pedro Kukulka; Amanda C. S. Silva; Marcos Santos

December 14, 2022 (Wednesday), 09:00 - Room 1101

The concept phase in the life cycle of a complex system leads to decision problems to choose the objectives and needs that have to be incorporated into the system architecture and which alternatives of physical architectures are more suitable regarding the elicited system requirements. The decision problem situated here to choose the best alternative that meets the system architecture, can be characterized as a choice problematic, one of the classic problematic types of Multicriteria Decision Aiding (MCDA), and coping with decision problems, MCDA methods can be applied. Space systems are complex systems; ergo, their architecture performance must achieve stakeholder values. Thus, this work shows how MCDA methods, Combinative Distance-Based Assessment (CODAS) and Analytic Hierarchy Process (AHP), may support decision making when choosing a space system for a national strategic program. In the end, the alternative that had the best performance, with the highest value in the additive function, was the selected, and the use of MCDA was relevant to this choice with the requirements of the system elicited in the design, considering them, criteria and sub-criteria, the decision hierarchy in question. And this conclusion corroborates with the affirmation that there is an interaction between Systems Engineering and Operational Research, as shown by Russel Ackoff and Peter Checkland.

Keywords: Value Model; Choice Problematic; AHP-CODAS; RED-M

Nueva plataforma para el diseño de intervenciones organizacionales. Aplicación a un sistema de mantenimiento en la industria farmacéutica

José Francisco Zanazzi; José Luis Zanazzi; Daniel Pontelli

December 14, 2022 (Wednesday), 09:00 - Room 1101

Las organizaciones implementan Sistemas de Gestión para mejorar sus resultados y los estándares requeridos. Estos Sistemas se orientan a calidad, seguridad o el mantenimiento de activos, entre otros. Aplican estrategias comunes como el enfoque de procesos, métodos de resolución de problemas, trabajo grupal y la mejora continua, mediante el análisis de anomalías en productos y procesos. Esas actividades conducen a diseñar intervenciones organizacionales con acciones de mejora que cuando resultan efectivas se incorporan al sistema de trabajo como lecciones aprendidas. Estas intervenciones son críticas porque si fallan pueden afectar negativamente la autoestima organizacional y la generación de aprendizajes. Autores aseguran que el porcentaje de sistemas que presentan fallas está por sobre el ochenta por ciento. Entre las causas de fallas se distinguen: deficiencias en la estructuración de los problemas, desviaciones en las condiciones de trabajo requeridas, grupos de intervención inadecuados, incertidumbre en la información disponible o errónea asignación de significados a las acciones emprendidas. Ante esa problemática, el trabajo propone actividades para el diseño de esas intervenciones mediante una plataforma que permite integrar métodos provenientes de la Administración de la Producción y de la Investigación de Operaciones. Se realiza una aplicación real sobre el estudio de las falencias de un Sistema de Mantenimiento en la Industria Farmacéutica. El problema se aproxima con un enfoque de investigación-acción donde se identifican herramientas aplicables en la estructuración del problema para obtener un diagnóstico y la definición de potenciales transformaciones de mejora. Entre los resultados se observan mayores posibilidades de obtener beneficios en las intervenciones, mejoras en el conocimiento compartido de los participantes y en su compromiso con las acciones acordadas. Los hallazgos y las limitaciones se resumen en las conclusiones.

Keywords: RED-M; Métodos de Estructuración de Problemas; Investigación de Operaciones; Administración de la Producción; Sistemas de Mantenimiento

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Compromise programming: Proposal of a decision model for investment evaluation in the context of sustainable development of communities

Solange Garcia; Amanda Silva; Yara Cintra; Luiz Antonio Titton; Maria Lúcia Bahia Lopes; Mischel Carmen Neyra Belderrain

December 14, 2022 (Wednesday), 09:00 - Room 1101

Companies and communities must meet multiple objectives to achieve appropriate decisions. There is a need for instituting interactive processes to help communities make autonomous decisions on meeting their needs and addressing issues that affect their life the most. The ever-increasing complexity calls for new approaches to encompass the multiple dimensions of sustainability, particularly to handle the trade-offs, including financial versus non-financial, impacts on the environment and the society, and conflicting stakeholders' interests. This paper aims to propose a decision model for investments in the context of sustainable development of small communities, based on the Compromise Programming (CP) multi-criterion method. The CP is a method based on a distance function, with geometric aggregation metric, partially compensatory, solving problems whose objectives are structured in a hierarchical way. We applied the model in an illustrative case with the participation of undergraduate university students. The case is about the decision to increase the production of an Amazonia native fruit by three groups of stakeholders: a rainforest community, a financial support provider bank, and a supermarket. The problem was structured by means of interviews, bibliographic and documentary research. Three alternatives and twelve objectives were defined to help achieve three main objectives, related to economic, environmental, and social aspects. The model considers a cyclical decision process, with interaction among stakeholders and various iterations for discussion and elicitation of preferences and analysis of the consequences. The results show a series of cognitive (integration of multiple views and knowledge) and relational (team interactions) impacts experienced by participants. The proposed model has great potential for an effective operational research intervention design in similar contexts that requires balanced decisions, mutual learning, cooperation, and commitment.

Keywords: RED-M; Compromise programming; Multi-Criteria Decision Aid (MCDA); Sustainability; sustainable development of communities; Investment evaluation

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On bounds for the minimum spectrum width for routing and spectrum assignment in optical networks

Pedro H. Fernandes da Silva; Herve Kerivin; Annegret Wagler

December 14, 2022 (Wednesday), 09:00 - Room 1208

Given an optical network G, an optical spectrum S, and a set D of communication demands, the routing and spectrum assignment (RSA) problem consists of establishing, for each demand in D, a route in G and a channel in S so that the channels of two demands are disjoint whenever their routes share an optical link in G. It is NP-complete to decide whether there is a feasible solution of the problem within a given spectrum, even if the optical network is a path. To gain insight in the combinatorics behind the problem, we use a combinatorial reinterpretation of the problem as an interval coloring of the edge intersection graph of the selected routes. The interval chromatic number equals the smallest size of a spectrum so that a proper interval coloring exists. Given G and D, the minimum spectrum width $s*(G,D)$ of any solution of the RSA problem equals, thus, the minimum interval chromatic number of an edge intersection graph, taken over all possible routings, and an instance (G,S,D) is feasible if and only if $s*(G,D)$ does not exceed the width of S. We present several lower bounds and one upper bound for $s*(G,D)$ and examine combinatorial structures (cliques and non-superperfct graphs) that can cause gaps between $s*(G,D) $ and all studied bounds. The goal is to understand which characteristics of an instance make the RSA problem computationally hard to solve and how the combinatorial insights can be used to improve existing solution approaches for the RSA problem.

This work was supported by the STIC-AmSud project 22STIC-08.

Keywords: Routing and spectrum assignment problem; edge intersection graphs of paths; cliques; interval coloring; superperfection

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A framework for routing and spectrum assignment in optical networks, driven by combinatorial properties

Pedro H. Fernandes da Silva; Herve Kerivin; Annegret Wagler

December 14, 2022 (Wednesday), 09:00 - Room 1208

The routing and spectrum assignment problem (RSA) is important in operating modern optical networks. The RSA problem consists of establishing, for given communication demands, routes in an optical network and channels in an optical spectrum so that the channels of two demands are disjoint whenever their routes use a same link of the network. It is NP-complete to decide whether there is a feasible solution of the RSA problem within the available optical spectrum. Existing approaches with Integer Linear Programming (ILP) models have limitations such as: non optimality, exponential number of variables or constraints and/or limited capacity when solving large instances. Thus, computing the minimum spectrum width turns out to be particularly difficult. To solve this problem, a framework that does not rely in enumerating all possible routing paths nor in generic column generation has been elaborated. This two steps framework can still assure optimality and is composed by two steps: one that will generate routing paths and give a lower bound and another that will compute a solution, combined with an upper bound. In possession of the gap found between the two bounds, the framework proceeds by adding constraints related to the found routings and iterating between the two steps. We present a detailed overview of the framework as well as computational results that evaluate its performance. It is shown that the framework performs well and also is capable to solve large instances within a given the time limit.

This work was supported by the STIC-AmSud project 22STIC-08.

Keywords: routing and spectrum assignment problem; minimum spectrum width; combinatorial properties

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Solving the Routing and Spectrum Assignment Problem with realistic transmission paths in Elastic Optical Networks

Herve Kerivin; Pedro H. Fernandes da Silva; Michel Morvan; Annegret Wagler

December 14, 2022 (Wednesday), 09:00 - Room 1208

In Elastic Optical Networks (EONs), the frequency spectrum of an optical fiber is divided into many narrow same-sized frequency slots. Any sequence of contiguous slots forms a channel. Given a multiset of traffic demands (each specified by a source node, a destination node, and a required number of frequency slots) that need to be serviced through an EON, the NP-hard Routing and Spectrum Assignment Problem (RSAP) consists of establishing for each demand a lightpath (i.e., a source-to-destination path and a channel) such that no traffic demands share a frequency slot on any optical fiber of their paths. Besides this non-overlapping property, the paths need to fulfill Optical Signal-to-Noise Ratio (OSNR) requirements to guarantee the quality of the end-to-end transmissions. In this work, we consider RASP with the additional constraint that the selected lightpaths have their OSNR values above some thresholds. Because of their nonlinearity, OSNR requirements usually are replaced by upper bounds on the selected-path lengths. We present a compact formulation for RSAP with maximal-length constraints and a Branch-and-Cut (BC) framework to solve it. We then consider two different ways to obtain the OSNR values. The first and simplest one only deals with the number of amplifiers along the path and the second one, called the Gaussian Noise (GN) model, is more accurate as it explicitly takes into account the nonlinear nature of fiber propagation. The amplifier-based approximation leads to new linear constraints to add to our formulation. For the GN model we develop a simplified-but-realistic version that is used in our BC framework to check the operational feasibility of the encountered lightpaths. We conclude by presenting some computational results that show optimal solutions for RSAP with maximal-length constraints that are no more feasible for RSAP with amplifiers-based constraints and also, optimal solutions to the latter that are detected as infeasible by the GN model.

This work was supported by the STIC-AmSud project 22STIC-08.

Keywords: Optical Flexible Networks; Routing and Spectrum Assignment Problem; Optical Signal-to-Noise Ratio Requirements; Integer Linear-Programming Formulation; Branch-and-Cut Framework

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Characterization of balanced graphs within claw-free graphs

Lucía Busolini; Guillermo Durán; Martín D. Safe

December 14, 2022 (Wednesday), 09:00 - Room 1209

A {0, 1}-matrix A is balanced if and only if it contains no odd square submatrix with exactly two 1's per row and per column. A graph G is balanced if its vertex vs. maximal clique incidence matrix is balanced. Bonomo, Durán, Lin and Szwarcfiter (2006) proved that a graph is balanced if and only if it contains no induced subgraphs known as extended odd suns. However, this characterization is not by minimal forbidden induced subgraphs because some extended odd suns contain some other extended odd suns as proper induced subgraphs. The characterization of balanced graphs by minimal forbidden induced subgraphs is open, but some partial results are known. A graph is hereditary clique-Helly (HCH) if every induced subgraph satisfies that the intersection of any nonempty family of pairwise intersecting maximal cliques is nonempty. Balanced graphs are HCH. A graph is clique-perfect if the maximum size of a clique-independent set (a set of pairwise disjoint maximal cliques) and the minimum size of a clique-transversal set (a set of vertices meeting every maximal clique) coincide for each induced subgraph. The class of clique-perfect graphs is a superclass of the class of balanced graphs. The claw is the complete bipartite graph K_{1,3}. Bonomo, Chudnovsky, Durán (2018) proved that HCH claw-free graph is clique-perfect if and only if none of its induced subgraphs is an odd hole or an antihole of length 7. In this work, we prove that a claw-free graph is balanced if and only if it is perfect and HCH or, equivalently, it contains no induced odd holes, antihole of length 7 or a pyramid. Interestingly, our result strengthens that by Bonomo, Chudnovsky and Durán (2018) by showing that a HCH claw-free perfect graphs are not only clique-perfect but, actually, balanced. As a consequence, we prove that there is an O(nm^2)-time algorithm that, given any graph, either decides that it is balanced or gives a certificate of the fact that it is not claw-free balanced.

Keywords: JS; balanced graphs; claw-free graphs; forbidden subgraphs; recognition algorithm

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The tau operator on oriented indifference graphs

Maria Guadalupe Sanchez Vallduvi; Marisa Gutierrez; Bernardo Llano

December 14, 2022 (Wednesday), 09:00 - Room 1209

A tournament is an orientation of a complete graph, or equivalently a directed graph in which every pair of distinct vertices is connected by exactly one directed edge or arc. A tournament T is transitive if $a \rightarrow b$ and $b \rightarrow c$ are arcs of T, then $a \rightarrow c$ is also an arc of T for every three vertices a, b, c of T. Every transitive tournament has exactly one source (a vertex with only outgoing arcs) and one \textit{sink} (a vertex with only incoming arcs). A maximal transitive tournament T of a digraph D is a maximal subdigraph of D isomorphic to T. Let D be a digraph. The intersection digraph of maximal transitive tournaments of D, denoted by $\tau(D)$, is defined as $V(\tau(D))$ is the set of all maximal transitive tournaments of D and

$A(\tau(D)) = \{ T_1 \rightarrow T_2 : T_1,T_2 \in V(\tau(D)), s_1, f_2 \in V(T_1) \cap V(T_2) and f_1, s_2 \notin V(T_1) \cap V(T_2) \},$

where f_1 and f_2 are the sources and s_1 and s_2 are the sinks of T_1 and T_2, respectively. A graph G is an indifference graph if it has a total order of its vertices $v_1,...,v_n$ such that if $v_i \sim v_k$, then $v_i \sim v_j$ and $v_j \sim v_k$ for every $i<j<k$. It was proved in $[1]$ that the class of indifference graphs is a closed class with respect to the clique operator of a graph. A digraph D is an oriented indifference graph if it is obtained from an indifference graph G by directing its edges in such a way that if $v_1, v_2,v_3,...,v_n$ is an indifference order and $v_i \sim v_j$ in G, then $v_i \rightarrow v_j$ in D if and only if $i<j$. We prove that the class of Oriented Indifference Graphs is closed with respect to the τ operator.

[1] B. Hedman: Clique Graphs of Time Graphs, JCT Ser B 37 (1984) 270-278

Keywords: transitive tournaments; indifference graphs; JS

An algorithmic upper bound for the interval count of an order

Lívia Medeiros; Fabiano Oliveira; Jayme Szwarcfiter

December 14, 2022 (Wednesday), 09:00 - Room 1209

A graph G is an interval graph if there exists a bijection θ of V(G) to a family M of intervals on the real line, called a model, in which for all u, v □ V(G) with u ≠ v, (u,v) □ E(G) if and only if θ(u) □ θ(v) ≠ □. An interval order is a partial order on a family of intervals on the real line in which the precedence relation corresponds to that of the intervals, that is, the interval I_a precedes the interval I_b in the order if and only if I_a is entirely to the left of I_b. Ronald Graham suggested the problem of determining a model of a given interval graph having the smallest number of distinct interval lengths, which is called the interval count problem. The problem of deciding efficiently whether an interval graph or order admits a model using exactly one length is solved, since it is equivalent to the problem of recognizing unit interval graphs and orders. However, deciding efficiently whether an interval graph or order admits a model using at most two lengths is open. By employing combinatorial optimization techniques, Joos et. al.[1], efficiently solving a restricted version of the interval count 2 problem. The authors elaborated an efficient algorithm, using linear programming, for the interval count 2 problem given a bipartition of the vertices in size classes. For the problem of determining the general interval count, no similar technique is currently known. We devise quadratic programming formulations, leading to a polynomial algorithm, for providing an upper bound on the general interval count of orders, which is empirically shown to be close to the respective actual values. For the class of semiorders, the upper bound is shown to be tight.

References:

[1] Joos, F., Lowenstein, C., Oliveira, F. S., Rautenbach, D., e Szwarcfiter, J. L. (2014). Graphs of interval count two with a given partition. Inf. Process. Lett., 114:542– 546.

Keywords: Algorithmic upper bound.; Interval count.; Quadratic programming.; JS.

AVL is Always AVL!
Marcos Negreiros

December 14, 2022 (Wednesday), 09:00 - Room 1209

Adelson-Velski and Landis balanced binary tree (AVL) is one of the most successful data structures developed and still in use in computer science. It can be used in many optimization problems as a primary tool for medium and relatively big instances in combinatorial problems like shortest paths, spanning trees and many other searching problems. This structure although so important had been neglected because the literature consider that the balance procedures developed by its authors are only possible to work in the insertion of new data, but when delete a data is performed the AVL tree can turns not balanced or pseudo-avl. In this work, we propose a set of lemmas and theorems that prove the correctness of the AVL rotation methods even in the delete mode, turning AVL always a balanced tree, or AVL.

Keywords: JS; Data Structures; Searching; Balanced Binary Trees

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Optimizing major fruit tactical harvest planning through a multi-objective metaheuristic based on GRASP with path relinking
Javier Gómez-Lagos; Marcela González-Araya; Luis Acosta-Espejo; Wladimir Soto-Silva

December 14, 2022 (Wednesday), 09:00 - Room 1301

The tactical harvest planning for major fruits occurs in the first stage of the fruit supply chain. An optimized harvest planning reduces fruit losses and harvest costs. Previous studies about this topic have considered mainly mono-objective approaches, where the minimization of costs and fruit losses have been incorporated in a single objective function. Moreover, these approaches have been applied to small case studies. Consequently, they have been solved using exact methods. However, the objectives mentioned previously (harvest costs and fruit losses) are in conflict. In this study, we present a multi-objective model for major fruit harvest planning, which, besides the harvest costs and fruit losses minimization, includes the minimization of the harvest days. For solving this model, a multi -objective greedy randomized adapt search procedure with path relinking is developed. Furthermore, two strategies are compared: sequential and weighted construction. The performance of these strategies is evaluated in a real Chilean case study. The obtained non-dominated solutions are compared with those obtained by the weighted method with normalization, which is an exact method. This comparison is carried out using data envelopment analysis and a meta frontier approach. Preliminary results show that weighted construction strategy has the best performance.

Keywords: Multi-objective optimization; Fruit Supply Chain; Metaheuristic

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Production planning optimization of olive growers for the use of mobile Olive-Oil Mills
Bryan Urra-Calfuñir; Carlos Monardes-Concha; Pablo A. Miranda-González

December 14, 2022 (Wednesday), 09:00 - Room 1301

The beneficial properties of olive oil for health have favored the growth of demand, which has increased the market price and, consequently, higher profitability for the olive sector. In this context, the Olive Industry presents an enormous potential development that requires technological and operational support to improve the quality of its products. For this purpose, an integer programming-based decision support system (DSS) is presented, which seeks to solve a location problem with the planning of olive growers for the harvest and production of olive oil. The optimization procedure consists of two steps. The first one is preprocessing, which calculates the most relevant parameters for harvest estimation using remote sensing techniques. The second step is optimizing the mixed-integer linear programming (MILP) model, which maximizes producers' profit by efficiently utilizing olive-oil mills and the low cost of the transportation process, based on the previously calculated parameters. The decisions are based on the geographical dispersion of different olive growers and

the oil concentration of olive varieties in a certain period, which depend on the agroclimatic conditions of each sector. The tactical/operational model is applied to a real case in the Province of Elqui, Coquimbo, Chile, to allow decision-makers to plan the harvest of the different producers and coordinate, if necessary, the temporary set up of production plants in another strategic location. The results will be validated once the 2021-2022 harvest is completed. Finally, future work and the extension of the deterministic model are presented.

Keywords: Mixed-integer linear programming; Decision support system; Harvest planning; Facility location; Olive oil production

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Milk Collection Problem with time dependent energy consumption

Cesar David Osorio Castañeda; Juan Pablo Orejuela Cabrera; Juan José Bravo Bastidas

December 14, 2022 (Wednesday), 09:00 - Room 1301

In Latin America the dairy food production plays an important role in social development, since first-mile production is carried out by many small producers scattered in rural regions, who derive their main livelihood from this productive activity. Therefore, it is necessary, for the socioeconomic development of the regions, to have efficient supply chains for dairy products that overcome difficulties such as inefficient decisions on collection routes and the cold chain breakage of the product during transport. Defining the route of the collection tanks is a challenge in the operational process of the milk supply chain, and it is in the face of this challenge that this paper seeks to contribute. The problem addressed consists in the creation of an efficient route of a refrigerated collecting tank that transport milk from the collection points to the consumption site (depot), considering an environmental approach through the implementation of an electric vehicle, thus seeking to minimize the environmental impact of the operation. One of the main barriers for the adoption of electric vehicles is the limited autonomy that they have, problem that is even more accentuated in refrigerated transport operations, since the refrigeration unit is an additional source of energy consumption. This suggests the need to consider a detailed calculation of cooling energy consumption, so this work proposes the consideration of the main energy consumption loads such as transfer, infiltration and material insert loads; which depend mainly on the temperature delta between the desired temperature and de outside temperature. It is well known that the latter in turn depends on the time of day, therefore, this work provides a time-dependent perspective of energy consumption functions. Additionally, in this work we consider the operations at the point of sales such as waiting for unloading, the unloading time-dependent, and the availability of the products to be marketed.

Keywords: Milk Collection Problem; Energy consumption; Electric vehicle; time-dependet; lost sales; mixed integer linear problem

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A heuristic procedure for the picker routing problem in a warehouse with mixed shelves

Leila Abdala; Javier Marenco

December 14, 2022 (Wednesday), 09:00 - Room 1302

The mixed-shelves warehouses strategy is a goods storage strategy often found in e-commerce warehousing operations. Items are catalogued by assigning them a stock keeping unit (SKU), representing a single product and its origin. Afterwards, items are scattered through different storage positions along the warehouse, generating possibly many storage positions for the same SKU. We propose a heuristic procedure for the picker routing problem in this context, which differs from classical picker routing problems by adding storage position selection, besides the usual picker assignment and route sequencing involved in the process. We assume a strict bound on the running time, which makes it impractical to resort to integer programming techniques. We present an efficient heuristic with multiple criteria, and we perform an exhaustive search on the parameter space to get the optimal combination for several problem instances. We also study the sensibility of the obtained solutions with respect to changes in warehouse distribution. Finally, we evaluate the performance of this procedure on real-world instances.

Keywords: picker routing problem; mixed shelves; heuristics

Diseño de una cadena de suministro sostenible de recuperación de pilas
Alvaro Huerta; Pavlo Santander; Juan Sepulveda

December 14, 2022 (Wednesday), 09:00 - Room 1302

La creciente preocupación mundial por hacer frente a los problemas ambientales de nuestra sociedad, ha provocado un endurecimiento de las legislaciones de diferentes países, en relación con la gestión de residuos. Ejemplo de ello, es el caso de Chile, el cual ha promulgado el año 2016 la ley REP (Responsabilidad Extendida del Productor), y recientemente ha publicado la hoja de ruta a una Economía Circular, producto de su participación en el acuerdo de París el año 2015. La ley REP, responsabiliza a los productores de elementos prioritarios de la organización y financiamiento de la gestión de los residuos de sus productos. Uno de los elementos prioritarios son las pilas de uso doméstico, las cuales desde el primer año de la promulgación del proyecto se espera recuperar y valorizar el 3% de estos productos y llegar al 45% a contar del décimo año. Es por esta razón que se presenta la oportunidad de implementar tecnologías de valorización de pilas que exploren nuevas alternativas energéticas y permitan obtener productos con valor agregado, a la vez minimizar los impactos negativos en el ambiente. Sin embargo, considerando este dominio, la literatura se ha concentrado principalmente en cadenas de suministro orientadas a batería de vehículos al final de su vida útil y a la recuperación de baterías de plomo y ácido desechadas, existiendo poco desarrollo en relación a cadenas de suministro para la recuperación de pilas o baterías domésticas. Este trabajo presenta un modelo de optimización que soporta la toma de decisiones para el diseño, desde una perspectiva de sostenibilidad, de una cadena de suministro de recuperación de pilas. Para validar este modelo, se presenta un caso de estudio para Chile, abarcando el municipio con mayor población dentro de la Región Metropolitana.

Keywords: Reciclaje; Pilas; Diseño de cadena de suministro; Logística reversa

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Cooperación logística aplicada al sector forestal
Mateo Cal; Daniela Duran; Alejandro Chavez; Víctor Viana; Héctor Cancela

December 14, 2022 (Wednesday), 09:00 - Room 1302

La cooperación horizontal puede ser aplicada en distintos puntos del proceso productivo y de las cadenas de suministro. Consiste en identificar y explotar situaciones beneficiosas entre todas las empresas intervinientes, con el fin de aumentar el rendimiento mutuo. En este trabajo se considera únicamente la cooperación logística en el transporte forestal luego de realizada la cosecha. Se desarrolla un modelo matemático con el cual se analiza la viabilidad de la cooperación entre dos grandes empresas del rubro forestal que se encuentran en el territorio uruguayo. Este modelo, permite calcular el porcentaje de intercambio de madera entre ambas empresas, teniendo así como objetivo minimizar los costos generados por el transporte, asegurando el cumplimiento de las demandas de madera en cada periodo de la planificación. Se elaboran varios escenarios con el objetivo de validar el modelo. Se concluye que en base a los datos utilizados, el modelo resuelve que es beneficioso generar la cooperación. Se muestra ahorros significativos en lo que se refiere al costo total de las operaciones de transporte, de kilómetros recorridos por los camiones y barcazas utilizadas en los trayectos fluviales. Se exponen oportunidades de mejora que pueden ser utilizadas como referencia y punto de partida para futuras investigaciones y trabajos.

Keywords: cooperación; logística; forestal; transporte; optimización

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Modelo para la planificación eficiente del transporte forestal: Un análisis del transporte bimodal de trozas en Uruguay
Lara Caraballo; Alejandro Cordatti; Facundo Correa; Pedro Piñeyro; Victor Viana

December 14, 2022 (Wednesday), 09:00 - Room 1302

En este trabajo se presenta un estudio realizado sobre la situación del transporte forestal en el territorio uruguayo, con el objetivo de generar una planificación eficiente para el traslado de trozas mediante la combinación del transporte carretero y ferroviario. La principal motivación para este

estudio es el alto impacto que tiene el incremento del flujo de transporte forestal en el país, donde la infraestructura actual se ve saturada, a la par de estar siendo mejorada y ampliada. Es por esto que se propone un modelo matemático que sirve de base para el estudio de transporte de carga forestal, pudiendo ser utilizado como herramienta para la optimización de recorridos y frecuencias para el transporte de la madera, desde los diferentes lugares de origen hacia los posibles destinos. El estudio considera entre otros aspectos: cumplir con la demanda existente, minimizar los costos de los fletes, evitar la congestión de las rutas y ampliar alternativas al sistema tradicional de transporte. Mediante diferentes análisis de escenarios se proponen distintas líneas de acción para mejoras a la situación actual, las cuales sirven de apoyo a la toma de decisión sobre posibles inversiones en infraestructura como también en la ubicación de nuevos puntos estratégicos dentro de la red. Como resultados obtenidos a destacar, se tiene que:

- la proximidad de los nodos de origen a los destinos o a los centros de acopio es la principal causa de los incrementos o disminuciones de los costos de transporte forestal.

- en los múltiples escenarios planteados se vio como aquellos destinos que cuentan con un sistema de descarga en el propio lugar tienen ventaja al momento de reducir sus costos utilizando el tren como medio de transporte.

Keywords: transporte; forestal; optimización

Rankin of PEMEX Exploration and Production budget assignments in terms of efficiency, with the Data Envelopment Analysis (DEA) technique

Ricardo García; Zaida E. Alarcón-Bernal; Germán López Bautista

December 14, 2022 (Wednesday), 09:00 - Room 1303

As part of the conceptualization of the oil industry throughout Mexican history, the Mexican Oil Company (PEMEX) has been a fundamental element of the country's development. However, at present the oilfields demand better conditions of analysis and study for the budget allocation. Pemex Exploration and Production (PEP) performs the analysis of its investment portfolio in a traditional way, using indicators such as: net present value, present value of investment, investment efficiency, break-even point and accumulated cash flow, which it analyzes and weights jointly. Therefore, this article presents an alternative to generate a robust and characterized portfolio through a mathematical optimization analysis, which allows PEP to perform a better evaluation of its investment portfolio for its budgetary assignment, by considering the technical efficiency of its oilfields using the same economic indicators.

Keywords: Data Envelopment Analysis; PEMEX budget assignation; Budget assignments; Budget ranking

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Simulación discreta de un servicio de salud intermedio: Caso de estudio servicio de atención primaria de urgencia de alta resolución

Sebastián San Martín; Miguel Alfaro; Carlos Castro; Rocío Gajardo; Jeremías Vásquez

December 14, 2022 (Wednesday), 09:00 - Room 1303

La investigación diseña un modelo de simulación discreto para el sistema de salud primario de la República de Chile. El sistema nacional de salud está basado en atención primaria mediante los servicios de atención de urgencia (SAPU/ SAR). Los SAPU/SAR han sido diseñados para lograr estándares de tiempos de atención establecidos por el ministerio de salud. Estos tiempos tienen una clara incidencia en la percepción de los usuarios respecto al nivel de servicio de los sistemas de urgencias. Para abordar la investigación, se realizó el estudio de tiempos de los flujos de los pacientes atendidos en el SAPU/SAR. La validación del modelo de simulación discreta permitió desarrollar una línea base donde se obtuvieron las variables de interés del sistema. La investigación permitió establecer diferentes escenarios y evaluar la relación entre las variables del modelo y los estándares de atención establecidos por la Autoridad. En particular, se establecieron los límites de respuesta del modelo mediante graficas de control usando las variables de categorización de los pacientes. La simulación demuestra la capacidad de respuesta de los SAPU/SAR ante situaciones de tensión del sistema por cambios en las variables del modelo, para los tiempos de espera de

atención.

Keywords: Salud; SAPU/SAR; Atención medica

New efficient set trimming and smart enumeration method for Mixed-Integer Nonlinear Engineering Problems with discrete independent variables

Miguel Bagajewicz; Andre Hemerly Costa

December 14, 2022 (Wednesday), 09:00 - Room 1303

Engineering equipment design uses parts with standardized dimensions, operations' scheduling employs binary decisions and investment planning uses binary resource allocation options, etc. All these problems are characterized by discrete independent variables. They are usually solved employing Mathematical Programming (usually MINLP), which often provides local solutions and sometimes exhibits numerical problems in feasibility steps, or Metaheuristics (SA, GA, PSO, etc.). Both are very often time-consuming. Speed and robustness are needed, especially when they are used to handle uncertainty, which requires repeated runs. We present a new approach to obtain global solutions, one that uses a combinatorial representation of the search space instead of the traditional variable hyperrectangle. First, Set Trimming uses inequality constraints, and sometimes proxy ones, sequentially to eliminate most (or all) infeasible candidates. While techniques for domain reduction by constraint propagation or interval analysis are used for the variable hyperrectangle representation, our method is very different. Instead of recursive evaluation of candidates, we use especial set manipulation routines. Speed relies on this step. Next, Smart Enumeration sorting surviving candidates by an easy-to-compute lower bound of the objective and evaluating them sequentially; when a feasible candidate is found, the incumbent solution is updated, stopping when the lower bound is larger than the current upper bound. This approach is fast, robust (no convergence issues) and guarantees the global optimum. We solve engineering design problems many times considerably faster (10 to 100-fold, occasionally a lot more) than the equivalent MINLP procedures (when these procedures converge). We show mathematical details of the design of complex heat exchangers with discretized models (plate as well as shell and tube exchaners), distillation/absorption columns, and chemical reactor with complex kinetics.

Keywords: Engineering Optimization; Set Trimming; Smart Enumeration; MINLP; Metaheuristics

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Modelado de políticas públicas asociadas al fortalecimiento de las unidades productivas agrícolas en Medellín

Yony Fernando Ceballos; Julián Andrés Castillo Grisales; Lina Maria Bastidas Orrego; Natalia Jaramillo

December 14, 2022 (Wednesday), 09:00 - Room 1303

La presente investigación consiste en la construcción de un modelo espacializado que permita realizar estimaciones de crecimiento en términos de producción de productos agrícolas en zonas de la periferia de la ciudad de Medellín. Estas zonas, también conocidas como corregimientos, son tradicionalmente rurales y la mayor parte de sus territorios corresponde a zonas productivas agrícolas. En este estudio se busca evaluar diversas políticas públicas realizadas por los entes administrativos en los tres últimos periodos administrativos orientadas a mejorar las condiciones asociadas a la producción de productos agrícolas y evaluar su efecto en el tiempo. Posteriormente, se podrán evaluar en el modelo descrito diversas configuraciones de políticas públicas con el fin de tener un marco referencial respecto a la forma en la cual estas pueden mejorar la cantidad de bienes producidos y efectivamente mejorar las condiciones de vida de los agricultores en las zonas de periferia del municipio. La investigación contempla la construcción de un modelo de simulación en el cual internamente el elemento de análisis será cada una de las granjas que tengan área productiva y posteriormente se procederá a la construcción de un autómata celular sobre cada una de estas. En estas se evaluarán diferentes variables asociadas a los niveles de producción de los diversos productos dado el clima en el municipio de Medellín.

Keywords: Simulacion basada en agentes; Politicas publicas; Modelado; Sistemas de información

geográfico; Automatas celulares

Modeling a freight transportation system with hypergraphs
Zaida E. Alarcón-Bernal; Ricardo Aceves-García; Ricardo Ávila-Gómez

December 14, 2022 (Wednesday), 09:00 - Room 1304

Freight transport contributes to moving a large part of Mexico's economy; it is part of diverse supply chains of many economic activities and is a source of jobs that generates 4 million in total. It provides services to 71 economic activities in the country. In 2018 it transported 556.4 million tons, 80% of national and international cargo. It generated 33.3 million dollars, representing 3.3 of the GDP. Situation that makes new companies emerge every year increasing supply and competition. Hence the need for companies to maximize their profits. As with any transportation system, it is possible to separate it into subsystems. In this work we propose a model based on hypergraphs that identifies areas of opportunity and detects the level of connection between the different areas of operation. Thus, the use of hypergraphs is an alternative to the classic systems approach: strategic, tactical and operational. With hypergraphs we have the great advantage of capturing elements of different natures and operating them from a tougher approach than the classic one. Operators, units, workers, clients, routes, agents without control are considered as hyper-nodes and man-truck entities, man-truck entity operation, operation, maintenance, administration, clients, agents without control, non-operation are considered as hyper-edges. The approach allowed an analysis of each area according to the connection of each element, identifying an indicator that represents its performance. For the case study analyzed, for example, evaluating routes and customers by their profitability and probability of delay associated with each this helped determine how a customer is incorporate into the operation. Performing trip assignment based on performance is important, but other factors must be considered, which are included in this work.

Keywords: Hypergraphs; Freight transportation; Operations improvement

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Selección de sistemas sorbato-adsorbente para el tratamiento de efluentes mediante la aplicación de modelos de decisión
Silvia Adriana Ramos; María Natalia Piol; Lucas Lavandeira; Matías Reimondo; Santiago Augusto Pinto; Andrea Saralegui; Susana Boeykens

December 14, 2022 (Wednesday), 09:00 - Room 1304

El vertido de efluentes con altos niveles de contaminación y la emisión de residuos por parte de diferentes industrias es un gran problema ambiental y económico. En diferentes trabajos del Laboratorio de Química de Sistemas Heterogéneos (LaQuíSiHe) se ha demostrado que la utilización de estos residuos para el tratamiento de efluentes es posible y traería un beneficio económico y ambiental, permitiendo el tratamiento de efluentes a un bajo costo además de la reducción de los residuos industriales. La optimización y agilidad de este proceso se resuelve mediante el empleo de métodos numéricos resolubles a través de herramientas informáticas. La presente propuesta consistió en el diseño y desarrollo de un software que, tomando los datos de distintos trabajos de laboratorio realizados, ordene, analice y ajuste modelos teóricos o empíricos a los datos para resolver cuál es el mejor sistema sorbato-adsorbente a utilizar en el dimensionamiento de un reactor prototipo para un problema específico (curtiembres, cervecerías, etc.). El software también permite armar una base de datos experimentales obtenidos para cada uno de los sistemas sorbato-adsorbente en estudio, incluyendo los datos de la legislación argentina para el vertido de efluentes. Este trabajo está encuadrado en el contexto del Proyecto de Desarrollo Estratégico “Metodología para el dimensionamiento de un reactor prototipo para el tratamiento de efluentes”.

Keywords: Optimización; Sistemas sorbato-absorbente; efluentes; tratamiento

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Structural prediction and validation strategies for Sars-Cov-2 macromolecules
Clarice de Souza; João Alfredo Bessa Neto; Micael Davi Lima de Oliveira; Jonathas Nunes da Silva; Kelson Mota; Rosiane de Freitas

December 14, 2022 (Wednesday), 09:00 - Room 1304

The three-dimensional structure of a protein is important because the function of the protein is linked to both its atomic composition and its three-dimensional structure, and in the case of a virus, prediction in a faster and simpler way speeds up the creation of vaccines and medicines to fight it. This work presents mathematical-computational and physical-chemical aspects involved in the reconstruction of the three-dimensional molecular structure of proteins, using proteins from the SARS -CoV-2 virus as a case study, mainly in the variants that reached the state of Amazonas. For this, the main algorithms that solve the Problem were implemented, variations of one of the algorithms were proposed and tested, and a technical visit to the National Center for Nuclear Magnetic Resonance at UFRJ was carried out, where it was possible to analyze the method of obtaining data through Nuclear Magnetic Resonance. After analyzing the implemented methods, the need for chemical validation for the generated structures was identified, since the structural calculation only guarantees the mathematical validity of the results, so a structural reconstruction methodology was created, ranging from data search, and creation from test instances to calculation and structural validation. The methodology was used in the case study carried out with proteins of the new coronavirus, it's proved to be effective in reconstructing the proteins of the SARS-CoV-2 variants, from the existing in silico mutagenesis and crystallography. Through the use of the algorithms and the Ramachandran validations, we verified the great consistency of the structural reconstructions. Among the future perspectives, we intend to structure an algorithmic strategy that takes only the amino acid sequence of the protein as input and that, can predict its tertiary structure, in addition to adding an objective function based on a classical force field to create physicochemical constraints throughout the reconstruction.

Keywords: algorithms; branch-and-prune; clique problems; distance geometry; nuclear magnetic resonance; Ramachandran diagram

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Application of interval arithmetic and constraint programming in the optimization of formal verification processes
Jesse Deveza; Lucas Cordeiro; Rosiane de Freitas

December 14, 2022 (Wednesday), 09:00 - Room 1304

In this work we investigate the application of constraint programming techniques, mainly variable domain contraction algorithms, which involve manipulation of interval arithmetic, in the optimization of formal software verification processes. Software formal verification is an undecidable problem in general. Bounded Model Checking (BMC) is one method that can achieve decidability by searching for violations of properties of a program up to a bound k. BMC reduces the program verification problem to the classic NP-complete Boolean Satisfiability (SAT). However, it can still lead to an exponential state-space exploration due to the program's large and possibly unbounded loops. In this case, there might be many execution paths to traverse through a program during its symbolic execution. Therefore, the control flow or computation during the program's execution, mainly in symbolic execution, can be represented as a directed graph named Control Flow Graph (CFG). In this work, we present the CFG properties and discuss the first results of the application of interval arithmetic and constraint programming techniques~(Rossi et al., 2006) to reduce variable domains as a preprocessing step of the BMC process applying ESBMC-Jimple (Menezes et. al., 2022) for the formal verification of JVM-based (Java Virtual Machine) programs~(Deveza et. al., 2022).

Keywords: constraint programming; contractor algorithms; control-flow graph; interval arithmetic; SAT problem

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New mixed integer nonlinear optimization models for the Clustering Problem
Marcella Braga; Nelson Maculan; Renan Pinto

December 14, 2022 (Wednesday), 09:00 - Room 1305

A new approach to the clustering problem is presented. Mixed Integer Nonlinear Optimization models are proposed. The distinguishing feature of the new models is that they are developed in a way that avoids the problem of non-differentiability and non-convexity in their continuous relaxation. And the relevance of this new approach is consolidated through the computational results developed as comparative experiments to show the strength of the proposed models in contrast to other known and studied models in the literature. Through these computational results using small and medium sized instances, it was possible to verify the superiority of the proposed models in several aspects presented and, consequently, to verify their significant contribution in the scope of research in the area of mathematical modeling for clustering problems in the scope of mixed integer nonlinear optimization.

Keywords: Clustering Problem; Nonlinear Optimization Models; Mathematical Modeling; NM

An integer linear programming formulation for the cutting stock problem with limited open stacks

Gabriel Guimarães; Kelly Poldi

December 14, 2022 (Wednesday), 09:00 - Room 1305

A Cutting Stock Problem (CSP) consists of determining the best way in which a set of larger units (objects) should be cut in order to fulfill the demand for a set of smaller pieces (items) while minimizing material waste. In some industrial contexts, items obtained by cutting objects are stored in stacks, so that items of the same type are stored in the same stack. Due to limitations on item storage, a restriction must be added to the CSP. Such restriction states that the number of stacks opened by the sequencing of the cutting patterns has to be equal to or smaller than some predefined limit, this problem is known as the Cutting Stock with Limited Open Stacks Problem (CS-LOSP). In the literature, only the one-dimensional CS-LOSP is addressed, and even so, by only a few researchers. In this research, we propose an integer linear programming formulation for the CS-LOSP applicable for CSP instances of any dimension. Instead of sequencing cutting patterns individually, the proposed mathematical model seeks to sequence sets of cutting patterns; such change reduces the number of symmetrical solutions and the solution search space. In order to validate the proposed mathematical formulation, we carried out some computational experiments on randomly generated instances of the two-dimensional CS-LOSP.

Keywords: NM; cutting stock problem; open stack; sequencing; integer linear programming

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The Driver-Aide Problem: Coordinated logistics for last-mile delivery

S. Raghavan; Rui Zhang

December 14, 2022 (Wednesday), 09:00 - Room 1305

Last-mile delivery is a critical component of logistics networks accounting for approximately 30-35% of costs. As delivery volumes have increased, truck route times have become unsustainably long. To address this issue, many logistics companies, including FedEx and UPS, have resorted to using a Driver-Aide to assist with deliveries. In the Driver-Aide Problem, a truck is equipped with both a driver and an aide. The aide can assist the driver in two ways. As a Jumper, the aide works with the driver in preparing and delivering packages, thus reducing the service time at a given stop. As a Helper, the aide can independently work at a location delivering packages, while the driver leaves to deliver packages at other locations and then returns. Given a set of delivery locations, travel times, service times, and the jumper's savings, the goal is to determine both the delivery route and the most effective way to use the aide (e.g., sometimes as a jumper and sometimes as a helper) to minimize the total delivery time. We model this problem as an integer program with an exponential number of variables and an exponential number of constraints, and propose a branch-cut-and-price approach for solving it. Our computational experiments are based on simulated instances built on real-world data provided by an industrial partner. More importantly, our results characterize the conditions in which this novel operation mode can lead to significant savings in terms of both completion time and cost. Our computational results show that the driver-aide with both jumper and helper modes is most effective when there are denser service regions and when the truck's speed is higher. Coupled with an economic analysis, we come up with rules of thumb that could be used in practice. We find that

the service delivery routes with greater than 50% of the time devoted to delivery are the ones that provide the greatest benefit. These routes are characterized by a high density of delivery locations.

Keywords: NM; Last mile delivery; Networks; Branch-Cut-and-Price; Vehicle Routing

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Finite termination and estimation of the solution of the proximal point method with quasiconvex functions on Hadamard manifolds

Erik Alex Papa Quiroz

December 14, 2022 (Wednesday), 09:00 - Room 1305

In this talk, we present two hope results of the proximal point algorithm for minimizing quasiconvex functions on Hadamard manifolds. The first result shows some conditions on the problem to obtain finite termination of the algorithm. The second one, shows the estimation and convergence to an optimal solution point of the sequence generated by the algorithm. These results complement previous results: global convergence and linear or superlinear rate of convergence that have been published in a scientific journal.

Keywords: NM; Proximal point algorithm; quasiconvex functions; Hadamard manifolds; Finite termination; Estimation of the solution

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A systematic literature review on ethics in Operations Research

Elias Olivares-Benitez; Jose Humberto Ablanedo-Rosas; Aaron Guerrero-Campanur; Samuel Nucamendi-Guillén

December 14, 2022 (Wednesday), 09:00 - Room 1306

This work presents a study focused on Ethics and Operations (Operational) Research. A systematic literature review is conducted to identify the main journals, papers, and authors that discuss openly the ethical issues related to Operations Research models. Some influential authors were identified, but there is still a limited ethical discourse from the community. A point of view is that this limitation can be caused by the lack of philosophical background of OR professionals, or a conscious avoidance to evade the discussion in the peer-review process. However, it is evident the interest of OR scientists in ethical aspects, that historically were concentrated on environmental and social aspects separately. After the fusion of social and environmental issues in the term of sustainable development, the efforts of OR analysis has been guided to that direction. More recently, Health care has been incorporated to the interest of the OR community. It was evident during the COVID-19 pandemics that high pressure will be put on the efficiency of Health care systems, on ethical implications related, and on public policies. Recent studies are rising the discussion about the norms for the application of rules to the ethical issues on OR models and applications, from a philosophical perspective. The contribution of this work can be considered a complement to the current debate and interest of the community about the role of Ethics in Operations Research.

Keywords: Ethics; Operations Research; Philosophy; Literature review; Sustainability; Health Care

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A quest for methodologically robust composite index development: A case study for the evaluation of global citizens' wellbeing and liveability

Veljko Uskokovic; Mladen Stamenkovic; Veljko Jeremic

December 14, 2022 (Wednesday), 09:00 - Room 1306

The methodological issues encompassing the composite index development and evaluation have been a long-standing point of confronting ideas. In particular, the topics of indicators' selection, weighting scheme, substitutability, etc., have triggered numerous researchers in a quest for a methodologically robust composite index. The benefits of the composite index have consistently overshadowed the range of methodological inconsistencies; however, the continuous efforts have been pushed forward to minimise the effect of a methodological framework on the applicability of the obtained results and the potential to communicate it to a broader audience. As a potential remedy to

the challenges mentioned above, we advocate the novel approaches in a taxonomy-based decision support system. More to the point, by applying the proposed approach, decision-makers are able to enhance the quality of decisions and consequently establish recommendations for sound policies. We evaluated the Cities of The Future Index (CFI), introduced by the EasyPark group as a case study. Furthermore, particular emphasis was given to the potential for improving the CFI.

Keywords: Composite Index; Taxonomy-Based Decision Support System; Methodological Robustness; Cities of The Future Index

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Cloud Manufacturing: state of the art and evaluation of the BaSyx project

Matías Emiliano Videla; Carlos Chiappa; Pedro Piñeyro; Víctor Viana; Daniel Rossit

December 14, 2022 (Wednesday), 09:00 - Room 1306

The emergence of new technologies such as the Internet of Things (IoT) and Cloud Computing has strongly boosted the manufacturing industry, opening the doors to a much broader world of possibilities and starting what many consider to be the Fourth Industrial Revolution. In this context is where the manufacturing paradigm of Cloud Manufacturing (CMfg) emerges, with the goal to connect manufacturing processes through the Cloud in such a way that it allows different organizations to cooperate and to offer services to customers that could not be possible by their own independently. A systematic review of the literature was carried out in order to determine the main characteristics and functionalities that a CMfg system should provide as well as the main current lines of research in this regard. Then, we developed a prototype CMfg system based on the open source middleware Eclipse BaSyx, a software development kit for CMfg systems. The developed prototype consists of a web interface module that allows different users to create new machines and to insert job orders from the customers, and a server logic module that is responsible for accepting jobs, dividing them into subtasks and distributing them among the different machines that work independently from each other. The web module is composed by three main sub-modules: 1) a scheduler to control and distribute the orders among the different machines of the system; 2) a verifier, which is in charge of monitoring the state of the machines in the real time, collecting a large amount of information from them and notifying the scheduler in case of failures or when they need special attention; and 3) a BaSyx module that is in charge of the creation of the Digital Twins. Finally, several numerical experiments were carried out to show the potential of BaSyx for leveraging different production planning and operations management problems that may arise under Cloud Manufacturing environments.

Keywords: Cloud Manufacturing; Industry 4.0; Digital Twins; BaSyx; Production Planning; Scheduling

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El sector bancario argentino entre 2000 y 2017: Un análisis de eficiencia paramétrico con funciones de distancia

Claudia Peretto; Enzo Concordano

December 14, 2022 (Wednesday), 09:00 - Room 1306

El objetivo de este trabajo es evaluar la eficiencia técnica de las entidades bancarias argentinas entre 2000 y 2017, utilizando el enfoque de función de distancia estocástica. Si bien la eficiencia bancaria ha sido ampliamente estudiada, en Latinoamérica las investigaciones se enfocaron, principalmente, en la aplicación de modelos DEA no paramétricos, por lo que son escasos los trabajos que se encuentran utilizando el modelo de frontera estocástica. Más aún, no hay estudios que investiguen la eficiencia de los bancos de Argentina utilizando funciones de distancia. Es por ello que se propone aplicar dos enfoques: el modelo tradicional de frontera estocástica (SFA, Stochastic Frontier Analysis) y el modelo de función de distancia estocástica. Una de las ventajas de la utilización de funciones de distancia es permitir el modelado de un proceso de producción con múltiples inputs y outputs, tal como ocurre en la actividad bancaria. El estudio se realiza sobre las entidades del Sistema Bancario Argentino en actividad durante el período 2000-2017. Para el cálculo de la eficiencia técnica, se consideran tres inputs: Depósitos, Gastos de Operación y Activos Fijos, y como outputs: Ingresos Financieros, Ingresos por Servicios e Inversiones. En la aplicación de SFA, se agrupan los outputs en una única variable que surge de unificar los ingresos que las entidades obtienen por su actividad financiera y de intermediación. En el modelo de función de distancia

estocástica, se utilizan los tres outputs, pero se proponen dos formulaciones con distintas formas de normalización y se aplica una función de distancia translogarítmica orientada a los outputs. Los resultados indican variaciones en los niveles de eficiencia a través de una mejora en la especificación del modelo por la utilización de funciones de distancia estocástica para incorporar los múltiples outputs que se desean considerar.

Keywords: eficiencia; función de distancia estocástica; SFA; Sistema bancario argentino

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Effects of different formulations and software parameters over a Heterogeneous Fleet Multi Depot Periodic Capacitated Vehicle Routing Problem with Time Windows

Alejandro Arenas-Vasco; Juan Carlos Rivera; Maria Gulnara Baldoquin; Simón Álvarez

December 14, 2022 (Wednesday), 09:00 - Room 1307

The Vehicle Routing Problem (VRP) is a problem that can be described as: determining how to schedule a fleet of vehicles to visit a determined number of clients. Researchers nowadays are focusing on VRPs which can model close to real-life scenarios. To do so, attributes are added to the classic VRP. Time windows, multiple depots, or heterogeneous fleet are examples of attributes. This research is performed to solve a problem in the vending machine industry in Medellín, Colombia. In this problem, the company must schedule the routes of its vehicles for a two-week span. This is because the clients are categorized into five patterns of visit: daily, three times per week, two times per week, once per week, or once in the two-week span. The company has two depots with finite capacity to serve the vending machines installed in every customer venue. The routes can be performed with different types of vehicles that have different maximum load capacities. Since the distribution is done in an urban environment, the difference of speed of all the vehicles is not meaningful. Clients specify at which moment of the day their machines can be filled. To solve this problem, a Heterogeneous Fleet Multi Depot Periodic Capacitated Vehicle Routing Problem with Time Windows (HFMDPCVRPTW) is formulated. As this problem is NP-hard, the efficiency of two factors in the solution are considered:

- Formulation. Two root formulations are proposed: one with four indexes (4IF) which considers the usage of an arc each day for every vehicle individually. Another with three indexes (3IF) which does not consider explicitly which vehicle used the arc in the set of variables “x” but does so through other binary variables and constraints.

- Cuts. Valid cuts can be added to the problem prior to or during the branch-and-bound algorithm performance.

The results obtained indicate which combination of formulation and cuts is more efficient to solve the problem.

Keywords: Vehicle routing problem; Mixed linear integer programming; Problem formulation

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A novel stochastic optimization model to solve the Vehicle Routing Problem with Backhauls and Time Windows by integrating the sample average approximation with Goal Programming

Daniel Morillo-Torres; Aura M. Vargas-Quintero; Álvaro I. Ocampo-Jiménez; Gustavo Gatica

December 14, 2022 (Wednesday), 09:00 - Room 1307

One of the most relevant problems in the logistics field is route planning due to its high complexity. It is a classic NP-hard combinational problem known as the Vehicle Routing Problem (VRP) which consists of the creation of fleets of vehicles where each node must be visited by a single vehicle only once. Usually, the objective of the problem is to minimize costs or total distances traveled by all vehicles. This project focuses on the VRP with Backhauls and Time Windows (VRPBTW) under a stochastic environment. Time windows are the time intervals in which customers are available for the reception or collection of commodities. The backhauls networks considered two sets of nodes: linehauls and backhauls. The first ones are customers that must be supplied, and the second ones are nodes for raw material collection. Despite the large variety of studies about the VRP, fewer have focused on the VRPBTW with stochastic considerations. This project focuses on formulating a stochastic optimization model that considers variable travel times. For this purpose, we propose to

implement a methodology based on Sample Average Approximation (SAA) together with Goal programming (GP) and single-stage optimization. This procedure uses Monte Carlo Simulation to approximate the expected objective function, generating samples according to probability distributions and then a new deterministic integer optimization model is solved. The process is repeated with different samples. The objective of the proposed model is to minimize the total costs associated with vehicle routing and scenario related costs (delay cost). To the best of our knowledge, the SAA has not been used to solve the VRPBTW. Numerical experiments carried out for solving this problem show that, on average, yields lower logistics costs with respect to the model that does not consider stochastic components in travel time. In addition to the economic aspect, the proposed model also has a positive impact on the quality of service.

Keywords: Stochastic optimization; single stage; integer programming; VRP; VRPBTW; SAA

The Vehicle Routing Problem with Time Windows and Multiple Deliverymen considering two-level decisions: formulations and solution methods

Fernando R. Senna; Pedro Munari; Antonio C. Moretti; Reinaldo Morabito

December 14, 2022 (Wednesday), 09:00 - Room 1307

The Vehicle Routing Problem with Time Windows and Multiple Deliverymen (VRPTWMD) is a variant of the Vehicle Routing Problem in which each vehicle may carry more than one deliveryman to reduce overall service time. In this problem, customers are divided in clusters. The vehicles travel from the depot to the clusters (primary routes). While the vehicle is parked in a cluster, the deliverymen serve the customers in parallel going through secondary routes from the parking location to the customers. The original definition of this problem considers that the secondary routes do not need to be assessed. Service time in each cluster is approximated based on demand and number of deliverymen. This approximation is coherent when deliverymen have small load capacity compared to customers' demands, not allowing the deliverymen to visit more than one customer in each secondary route. Thus, the optimal secondary routes are trivial. However, when deliverymen capacity is large compared to customers' demands, this approximation does not represent the problem accurately. We present two novel variants of the VRPTWMD evaluating both the primary and secondary routes. The first problem considers that the deliverymen do not have load capacity constraints and each deliveryman travels at most one route in each cluster. The second problem considers that the deliverymen have capacity constraints. To make sure that all customers of a cluster are visited in a single visit of the vehicle, in this second problem each deliveryman is allowed to perform more than one route in each cluster. We present mixed integer programming formulations and tailored exact solution methods for both problems. We discuss their performances in different sizes instances. This work was supported by the São Paulo Research Foundation (FAPESP) under grants 2021/14441– 5, 2019/23596-2, and 2016/01860-1; and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Keywords: Vehicle Routing; Time Windows; Multiple Deliverymen; Combinatorial Optimization; Mixed Integer Programming

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Notes on the Vehicle Routing Problem with time windows and scheduling constraints

Thailsson Clementino; Rosiane de Freitas; Eduardo Uchoa

December 14, 2022 (Wednesday), 09:00 - Room 1307

In this work, we are interested in vehicle routing problems with different time constraints based on scheduling theory. These constraints are especially motivated by the next-day delivery services, where orders arrive continuously and customers expect their delivery on the same or next day in specific time windows. On the first constraint, each delivery is associated with a release date, that is the first time when the package to be delivered is available at the depot to be routed. The main decision feature of the problem is to decide if it is better to wait for additional packages to arrive, or to start the route of the vehicle with the current packages set available. The other constraint, each customer is associated with a time window in which the vehicle should visit this customer. As seen in the literature, the time windows can be Hard, is it, the time windows must be obeyed and the customer can only be served during that interval. Or Soft, where the time windows can be violated

but costs are added to evict it, i.e., total weighted tardiness cost. Different versions of these constraint combinations were studied where the types of time windows were analyzed, the hard ones, the soft ones, and both together. These combinations can be grouped as VRPs with release date and time windows, and also can be seen as a static version of the Dynamic VRPTW. In addition to these analyses, we propose an exact solution to solve one variation of these problems, a Branch-Cut-and-Price algorithm via VRPSolver tool was applied to them. This solution was evaluated through computational experiments on instances available in the literature and adapted instances from traditional CVRP instances.

Keywords: Branch-Cut-and-Price; Due date; Release date; Scheduling theory; Time Windows; VRPsolver

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301060.exactas.uba.ar: A homage to Diego Maradona through mathematical models for Qatar 2022 results prediction

Alejandro Alvarez; Guillermo Duran; Manuel Duran; Ivan Monardo

December 14, 2022 (Wednesday), 09:00 - Room 1309

Sports results prediction using mathematical models is of great interest not only to sports team managers, coaches and players but also fans and bettors. Various methodologies with this objective have been applied in recent years. This presentation reports on the implementation of a mathematical model for football results prediction, done by our OR group at the University of Buenos Aires. Our model is based on a predictive model devised by Dixon and Coles in 1997. These implementations are displayed on the website 301060.exactas.uba.ar, in homage to the late Diego Maradona. The number in the URL has, of course, a special significance. Results prediction about the football world cup Qatar 2022 will be presented in this talk. Extensions of the approach implemented for basketball and rugby are also discussed. Tests on real games and tournaments have demonstrated that the models are good predictors of the actual outcomes, and their success is proving to be an effective way of promoting interest among the general public in the use of mathematical and computational models for solving real-world problems.

Keywords: AW; Sports analytics; Football results prediction; Qatar 2022; Mathematical models

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An optimization framework for fire-related decision making

Filipe Alvelos; David Neto; Eduardo Cunha; Mendes André

December 14, 2022 (Wednesday), 09:00 - Room 1309

We describe a framework implemented in python for addressing fire-related optimization problems. These can be divided in three groups: i) fire prevention and detection, ii) fire suppression and iii) fire-aware forest management. Relevant problems of fire prevention and detection are to decide the location of bases and pre-positioning of resources. Fire suppression includes dispatching and positioning of fire fighting resources. Fire-aware forest management amounts to select prescriptions taking into account different criteria (e.g. net present value, biodiversity, carbon stock, erosion) and also the fire risk. At the core of the framework is a fire spread module based on the minimum travel time principle that, from estimates of fire transmission times between adjacent cells of a landscape, estimates the fire arrival time at each cell. We discuss the inputs required by the framework (e.g. topography, fuels, resource types, prescriptions) and its outputs (e.g. where to locate the fire fighting resources, which prescription for each stand). We also discuss the integer programming models and approximate methods, deterministic and stochastic, that are used in the optimization.

This work is supported by FCT - Fundação para a Ciência e Tecnologia within project PCIF/GRF/0141/2019 "O3F - An Optimization Framework to reduce Forest Fire".

Keywords: AW; Optimization; Computational framework; Fire supression; Forest management

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Marco de integración meso-microscópica enfocada en la simulación de tráfico de buses de transporte público

Benjamín Ulloa Sanhueza; Cristián E. Cortés; Pablo A. Rey; Raúl Espinoza

December 14, 2022 (Wednesday), 09:00 - Room 1309

El constante crecimiento de las ciudades ha hecho necesario desarrollar herramientas de análisis y planificación para los sistemas de transporte público. Ésto con el fin de mantener un nivel de servicio objetivo a medida que las condiciones cambian, enfrentando usuarios y proveedores irregularidades de los tiempos de viaje y confiabilidad. En este sentido, el sistema de transporte público urbano de Santiago no ha sido la excepción y ha requerido incluir indicadores de cumplimiento para garantizar un buen nivel de operación. Sin embargo, al ser operado exclusivamente por empresas privadas, las medidas y políticas adoptadas durante los últimos 15 años han estado enfocadas en evaluar el cumplimiento de cada operador con respecto a los planes de operación comprometidos. De esta forma para Santiago no se ha dado el suficiente énfasis en investigaciones de evaluación y mejora de planes estratégicos, lo que requiere representar la totalidad de la ciudad y sus distintos grados de interacción entre los agentes. En este trabajo se propone un nuevo modelo de simulación enfocado en transporte público, que incorpora el comportamiento de buses, pasajeros y resto del tráfico, con la principal novedad de combinar distintos niveles de simulación. Dentro de la red representada, la simulación permite definir zonas microscópicamente, representando de forma detallada la interacción en lugares críticos, como paraderos o ejes de mayor congestión. Por otro lado, el resto de zonas se simplifica a un nivel mesoscópico, interactuando ambos niveles en tiempo real a lo largo de la simulación. En la modelación mesoscópica se plantea una modificación del modelo de transmisión de celdas, en la cual se mantiene una representación discreta para los buses. En la evaluación de cada escenario se analizan indicadores de interés para operadores y usuarios: regularidad, frecuencia y tiempo de ciclo de los servicios y tiempos de viaje, de espera y hacinamiento de pasajeros.

Keywords: Transporte público; Simulación de tráfico; Integración híbrida; Simulación mesoscópica; Simulación microscópica

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Enfoque de Modelos de Decisión Markovianos para la calendarización de sesiones de quimioterapia en una red de centros oncológicos

Alejandro Cataldo; Arturo Wenzel; Antoine Sauré; Pablo Rey

December 14, 2022 (Wednesday), 09:00 - Room 1309

La quimioterapia consiste en la administración de distintos tipos de drogas para eliminar las células cancerígenas de un paciente, se realiza en un centro oncológico en múltiples sesiones en un régimen denominado protocolo que consiste en definir el número de sesiones, el medicamento y las dosis que se deben entregar en cada sesión, la duración de cada sesión, el tiempo entre sesiones, el número de ciclos y su periodicidad. El oncólogo también especifica una fecha máxima para partir el tratamiento. En este trabajo nos centramos en el problema inter-día, que corresponde a la calendarización de las fechas para cada una de las sesiones asociadas al protocolo de tratamiento asociado a cada paciente. En este problema los pacientes llegan (con su protocolo y según un proceso estocástico conocido) al centro oncológico que se les ha asignado dentro de una red. Cada centro dispone de una cantidad de horas de trabajo y una cantidad de sillones disponibles para cada día. Al calendarizar las sesiones de un paciente, la primera y la última sesión debe ser asignadas al centro oncológico al que ha sido asignado el paciente. Sin embargo, las demás sesiones pueden ser asignadas en cualquiera de los centros de la red. También es posible derivar pacientes al sistema privado, en cuyo caso se derivan todas las sesiones de este paciente. En la resolución de este problema se busca minimizar el costo total de las decisiones de transferencia de sesiones de pacientes entre centros oncológicos y de derivación de pacientes al sistema privado. Finalmente, para abordar este problema proponemos un enfoque basado en Modelos de Decisión Markoviano. Este enfoque nos permite tomar las decisiones antes mencionadas buscando minimizar su costo total, todo bajo condiciones de incertidumbre en la llegada de pacientes. Los resultados preliminares muestran que es posible reducir los costos de operación de un sistema en torno a un 10%.

Keywords: Modelos de Decisión Markovianos; Quimioterapia; Problema Inter-día

Ensino público brasileiro: Proposta de estruturação da implantação do novo ensimo médio pela ferramenta de pesquisa operacional soft SCA

Lana Priscila Cavadas da Silva; Lincoln Campelo Dias; Pablo Luiz Berriel Do Carmo Teófilo; Níssia Carvalho Rosa Bergiante

December 14, 2022 (Wednesday), 12:30 - Room 1101

O sistema educacional do Brasil está um em processo de transformação de grande magnitude a se concretizar no ano letivo de 2022. Isto ocorreu através da proposta de reforma do Ensino Médio brasileiro, por meio da Medida Provisória (MP) 746, convertida na Lei n° 13.415/2017. Esta reforma educacional havia sido pensada há algum tempo pelos legisladores brasileiros através do Projeto de Lei 6.840, que endossou a necessidade de um currículo mais atrativo, uma formação mais técnica e uma ampliação da carga horária. O presente artigo se propõe a compreender a transformação que será submetida a educação de nível médio brasileira. Para tanto, o método de abordagem escolhido foi o da análise bibliográfica conjuntamente a aplicação da ferramenta de Pesquisa Operacional SOFT chamada SCA - Strategic Choice Approach. A aplicação destas ferramentas foi feita em uma escola pública do estado do Rio de Janeiro e a análise bibliográfica foi limitada a base SCOPUS e WEB OF SCIENCE com o apoio do software VOS VIEWER. Os resultados obtidos por esta abordagem híbrida proporcionam um arcabouço técnico para apoio a tomada de decisão dos envolvidos, dos quais destacam-se os gestores educacionais. Ao final, apresentam-se as limitações da pesquisa e as sugestões para estudos futuros.

Keywords: Novo Ensino Médio; Educação Pública Brasileira; SCA; Pesquisa Operacional SOFT; RED-M

Identification of Values and Alternatives for Decision Making through the VFT Approach: a case study in Maracanã Village

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December 14, 2022 (Wednesday), 12:30 - Room 1101

Indigenous peoples represent the culture of native Brazilians and they are present throughout Brazil, and even in cities, where they commonly organize themselves autonomously into associations, as a way to create a legal instrument that represents them to the public authorities. The problem addressed in this paper has its origins in October 2006, when a small group of indigenous people from different ethnic groups organized an unauthorized occupation of the former Indian Museum located in Rio de Janeiro. Currently, this occupation is called Maracanã Village and even though it remains established in an increasingly degraded area, but a neighbor of one of the most famous sights in Brazil, the Maracanã Stadium. So, there is a conflict of interest in the usage of this public area. In this context, this article aims to use the problem structuring method, Value-Focused Thinking (VFT), to capture the values of the different stakeholders in the case of Maracanã Village, representatives of the following sectors were interviewed: Social Movements, Executive and Legislative Power, Justice, National Indian Foundation, Political Parties, and Indigenous Peoples. Thus, it was possible to open space to discussion and to propose solutions that are in agreement with their views. With the results obtained through the research, three fundamental objectives were identified for the parties involved: the Revitalization of the Area of the former Indian Museum, the Integration of Indigenous Peoples into the urban context, and the promotion and preservation of indigenous culture in Brazil. In addition, the analysis allowed the enumeration of seven alternatives understood as possible for solving the problem.

Keywords: Problem Structuring Methods; PSM; VFT; Indigenous Culture; Maracanã Village; RED-M

Using value-focused thinking to support the BIM implementation in construction projects of public administration

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December 14, 2022 (Wednesday), 12:30 - Room 1101

The digital transformation strongly impacts the Civil Construction Industry. In this sense, Building Information Modeling (BIM) technology rises, representing a decisive advance capable of affecting efficiency and effectiveness in project planning and decision-making. In the Brazilian context, the introduction of BIM is accelerated by the legal institution of mandatory BIM in the bidding stages of project preparation, creating an urgency to implement the BIM methodology in public administration. Aiming to support decision-making in structuring Agile-BIM introduction strategies in public works projects, this study proposes to map the objectives of public management, applying the Value-Focused Thinking (VFT) method, through a case study in a town hall Pernambuco. Individual interviews and systematic interactions with two decision-makers of different strategic positions were conducted, followed by analysis content and comparative analysis. The research allowed us to identify the strategic objectives, help the public sector change preconceived ideas, and maximize the social impact of government. It also identified the fundamental and means-end objectives that allow the structuration of the objectives network, used to illustrate the decision context and to guide strategic thinking. The case study also enables recognizing key performance indicators that allow measuring the accomplishment of the strategic objectives concerning the integrated implementation of Agile-BIM. As a result, it was also possible to clarify the decision context for decision-makers and other parties involved, propose guidelines for constructing an Agile-BIM implementation plan, and support decision-making.

Keywords: RED-M; Public construction management; VFT; Problem structuring method; BIM

On the weighted Minimum Clique Routing Problem

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December 14, 2022 (Wednesday), 12:30 - Room 1208

Given an undirected graph $G=(V,E)$ and a set of demands D, each of them specified by a source $s_p \in V$, a target $t_p \in V$ and a weight $w_p \in Z$, the (weighted) Minimum Clique Routing problem (w-MCRP) asks for finding a path for each demand, connecting its source to its target. The aim is to minimize the maximum weight of a clique in the edge intersection graph of these paths, where the weight of each path is the weight of the corresponding demand. The particular case when G is a cycle and all weights are equal to one was addressed in [1] in the context of routing and wavelength assignment in an optical ring network without wavelength conversion capabilities. In this work, we study the weighted problem in networks with a ring topology. We prove that w-MCRP is NP-hard in cycles and present two approximation algorithms for this problem, obtained by extending the results of previous works for the unweighted case. The first one is a 2-approximation algorithm based solely on graph combinatorial techniques. The second one is an extension of a 3/2-approximation algorithm presented in [1] which is based on a solving the linear relaxation of an IP formulation of the problem and afterwards applying a rounding scheme.

[1] S. Stefanakos and T. Erlebach, "Routing in all-optical ring networks revisited," Proceedings. ISCC 2004. Ninth International Symposium on Computers And Communications (IEEE Cat. No.04TH8769), 2004, pp. 288-293 Vol.1, doi: 10.1109/ISCC.2004.1358419.

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Keywords: routing and frequency assignment; approximation algorithms; combinatorial optimization

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Valid inequalities for the DR-AOV integer programming formulation of the routing and spectrum allocation problem

Federico Bertero; Javier Marenco

December 14, 2022 (Wednesday), 12:30 - Room 1208

Given a digraph D, a number of available slots, and a set of demands specified by an origin node, a destination node, and a number of required slots, the routing and spectrum allocation problem (RSA) consists in determining a lightpath for each demand (i.e., a path in D from the origin node to the destination node together with an interval of consecutive slots) in such a way that the slot intervals of any two demands that share an arc do not overlap. We explore the DR-AOV integer programming formulation for RSA, which includes an integer variable I(d) for each demand d specifying the first slot

allocated to the demand, a binary variable y(d,e) for each demand d and each arc e specifying whether the lightpath for the demand d employs the arc e, and a binary variable n(d,d') for each pair of demands specifying whether the lightpaths assigned to d and d' share an arc and l(d) < l(d'). We present several families of valid inequalities for this formulation, we explore conditions ensuring facetness for these inequalities, and we study the computational complexity of the associated separation problems.

This work was supported by the STIC-AmSud project 22STIC-08.

Keywords: routing and spectrum allocation; integer programming; valid inequalities

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Algunas reflexiones sobre la brecha de género en la Sociedad Mexicana de Investigación de Operaciones

Laura Plazola Zamora

December 14, 2022 (Wednesday), 12:30 - Room 1209

La igualdad de género es una de las prioridades globales impulsada por diversas organizaciones internacionales. Este tema no es una moda, el interés por la igualdad de los derechos de la mujer tiene una larga historia. La igualdad de género y la incorporación de la mujer en los ámbitos de decisión política, empresarial y social se ha convertido en un tema de la agenda social, además de formar parte de las metas de los Objetivos de Desarrollo Sostenible (ODS) de la ONU, específicamente el ODS 5 relativo a la igualdad de género y empoderamiento de la mujer. Según la Comisión Nacional para Prevenir y Erradicar la Violencia Contra las Mujeres (CONAVIM, 2016) el empoderamiento de las mujeres implica que éstas participen activamente en todos los sectores y a todos los niveles, que logren una mayor autonomía, que sus aportaciones se visibilicen y tengan un reconocimiento. La pregunta obligada es ¿qué se hace desde las Sociedades de Investigación de Operaciones para disminuir las desigualdades? Es imperativo diseñar estrategias dedicadas a aumentar la representación de las mujeres en la SMIO, siendo parte de la solución implementando acciones dirigidas a abatir las desigualdades que continúan presentándose hoy en día. En este trabajo se aborda la necesidad de integrar de la igualdad de género como parte de las tareas fundamentales de la Sociedad Mexicana de Investigación de Operaciones. Se reflexiona sobre la escasa apertura de espacios de participación de las mujeres en nuestra Sociedad a partir de datos estadísticos históricos. Se proponen algunas acciones para atender esta necesidad y para influir de manera positiva en la reducción de desigualdades de género STEM.

Keywords: Investigación de Operaciones; STEM; Brecha de género.

Estrategias para afrontar un test: Una mirada desde la secuenciación con incertidumbre explorable

Cristóbal Mauricio; Óscar C. Vásquez

December 14, 2022 (Wednesday), 12:30 - Room 1209

Al momento de afrontarse a un test existen varias maneras de realizarlo y diversas estrategias que nos permitirán obtener variados resultados. Supongamos que tenemos un test de N preguntas, en donde solo existen preguntas fáciles y difíciles. M representa el número de preguntas fáciles y N-M representa el número de preguntas difíciles. Al momento de realizar un test existen varias estrategias, en este estudio se propondrán dos:

a) la primera consiste en leer la pregunta y responderá independientemente si es fácil o difícil. Esta estrategia será llamada leer y responder (L-R).

b) La segunda estrategia que se propone es que al momento de leer la pregunta, si esta es difícil de "saltará" y se dejará para el final, en cambio si esta es fácil se leerá y se repondrá inmediatamente. Esta estrategia se llamará leer, pensar y responder (L-P-R).

Tomaremos como supuesto en esta primera parte que toda pregunta que se responda será correcta independiente si es fácil o difícil, en lo único que diferirán esta es en su tiempo de lectura y su tiempo en responder. Se le designara la variable t_p al tiempo de lectura de una pregunta fácil, t_q al tiempo de lectura para una pregunta difícil, t_r al tiempo de relectura de una pregunta difícil, p al

tiempo de realización de una pregunta fácil, q al tiempo de realización de una pregunta difícil y T como el tiempo disponible para realizar el test. En resultado de este trabajo, basado en un análisis de secuenciación con incertidumbre explorable, proporciona los valores críticos de las variables descritas anteriormente en donde una de las estrategias propuestas es dominante o donde la estrategia para resolver el test nos sea indiferente. Se espera que la investigación contribuya al estudio del diseño de test y resuelva algorítmicamente el desempeño de ciertas estrategias recomendadas habitualmente.

Keywords: Estrategia; Test; Secuenciación; Incertidumbre Explorable

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A survey on soft IO and multimetodology in Latin America

Melany Segarra Marinetti; María Alejandra Castellini

December 14, 2022 (Wednesday), 12:30 - Room 1209

This work is a continuation of the one presented at the School of Improvement in Operations Research in 2020. The survey ranges from 1980 to the present, in high-impact international journals in the fields of Operational Research and Systemic Thinking. The methodology consisted of the selection of 6 Journals, based on their affinity in the topics; the subsequent definition of keywords, indicative of the different methods, and their disaggregation into the two paradigms. The motivation to continue with this survey is to have historical data with which we can obtain later, predictions regarding how Soft IO research work will evolve in Latin America. The journals surveyed were: European Journal of Operational Research (EJOR), Journal of Operational Research Society (JORS), Omega and International Transactions in Operations Research (ITOR), Systemic Research and Behavioral Science (SRBS) and Systemic Practice and Action Research (SPAR). The survey revealed 75 papers in this period, their breakdown by country and journal, the authors' institutional affiliation and their interaction with European colleagues. In this context, changing variables appear over time, because the amount of work that has been developed over the years on Soft IO in Latin American countries change, in number and distribution of countries. In this sense, we find it interesting to study the data obtained up to the present, and assign probabilities to each of the countries to publish a work over the course of a year. With the assigned probabilities, data could be obtained, for example, for a certain Latin American country to continue publishing the following years. A suitable tool that describes this type of situation is a Markov Chain. We would be interested in applying this tool in the future, in order to obtain predictions regarding how Soft IO research work will evolve in Latin America.

Keywords: Soft Operational Research; Multimethodologies; Latin America

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Desarrollo de casos sobre optimización y programación matemática para la formación de competencias en Investigación Operativa

Marcelo Corbalan; Guadalupe Pascal; Andres Redchuk

December 14, 2022 (Wednesday), 12:30 - Room 1209

En la enseñanza de la Ingeniería, la formación de competencias específicas y complementarias comprende un objeto de estudio complejo y desafiante. En particular, en la Investigación de Operaciones, resulta esencial vincular los conceptos teóricos con la aplicación práctica. Usualmente, la implementación de estás técnicas en el ámbito profesional suele ser una labor asignada no solo a un individuo, sino a un equipo de trabajo. En ese sentido, el desarrollo de contenidos educativos orientados hacia el aprendizaje colectivo ha generado un importante impacto relacionado con la aparición de propuestas e iniciativas que buscan incidir más allá de la herramienta que se enseña. Actualmente, la asignatura de Investigación operativa se estructura según bloques según la cantidad de incertidumbre del problema a resolver, generando dos bloques curriculares: técnicas cuantitativas y técnicas estocásticas. Este artículo aborda el desarrollo de un trabajo integrador aplicado en el bloque de técnicas cuantitativas (principalmente programación lineal y programación entera mixta), para los planes de estudio de Ingeniería Industrial e Ingeniería Ferroviaria. Los equipos de trabajo desarrollan diversos modelos matemáticos para cumplir con las condiciones y restricciones del sistema que se les plantea mediante la utilización del software de modelización Matemática GAMS. Para ello se propone que optimicen distintas problemáticas que pueden surgir dentro del ámbito

profesional y asuman un rol de consultores en vías de concluir con un plan de acción para cada caso. El seguimiento y la evaluación se realiza mediante rúbricas a través de las cuales los equipos de trabajo adquieren información sobre el grado de formación de las competencias esperadas. Se evidencia que esta dinámica permite fomentar el trabajo colectivo y enriquece los análisis por parte de los equipos, dado que el debate, asumir roles y trabajar sobre casos que imitan la realidad capta su atención.

Keywords: Optimización; Trabajo integrador; Investigación operativa; Programación lineal

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A mathematical model for production and distribution planning of credit cards

Lucas Thomaz Januario Pinto; Willy Alves de Oliveira Soler; Maristela Oliveira Santos

December 14, 2022 (Wednesday), 12:30 - Room 1301

This paper presents a mixed-integer programming model to deal with a production and distribution problem based on a Brazilian company of credit cards. The credit card supply chain is complex due to the difficulty of producing cards in factories in different regions and delivering them to customers throughout the country using several logistical operators. The objective of the problem is to minimize the production and transportation costs and costs related to the logistical operators. The demand needs to be met within a time window, ensuring a minimum service level. In addition, there is a maximum number of operators that can operate in the regions/cities. When a logistical operator is chosen to act in an area, a minimum volume of credit cards must be delivered considering the different types of provided services (simple, priority, critical). The developed model was implemented in Python and integrated with the commercial LP/MIP solver Gurobi.

Keywords: Production and Distribution Planning Problem; Mixed-Integer Programming; Credit Card

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Un abordaje mediante PLE para un problema de transporte de mercadería con cambios de tripulación

Mauro Lucci; Paula Zabala; Daniel Severin

December 14, 2022 (Wednesday), 12:30 - Room 1301

Este trabajo se enfoca en un escenario donde se debe realizar una planificación de múltiples días (típicamente una semana) de los camiones y los conductores de una compañía, para cumplir con un conjunto de pedidos de recolección y entrega de mercadería en larga distancia y con ventanas de tiempo, minimizando el costo de la distancia total recorrida por los vehículos y la disconformidad de los clientes por las demoras en las entregas. La planificación debe estar sujeta a diferentes restricciones, entre ellas, las que regulan los descansos de los conductores. Las tripulaciones pueden tener uno o dos conductores y cualquiera de ellos puede cambiar de camión o bajar a descansar en un conjunto de localidades. Para el abordaje del mismo, se construyen digrafos con ciertas propiedades estructurales, que permiten representar rutas de vehículos y de conductores como caminos dirigidos. A partir de esta caracterización, se proponen varias formulaciones de PLE. Además, se estudian algunas familias de desigualdades válidas y su incorporación como cortes en un esquema branch-and-cut. Estos resultados se acompañan con experimentos computacionales sobre instancias con 6 localidades argentinas, un horizonte de una semana, hasta 8 pedidos, 4 vehículos, y 8 conductores.

Keywords: Ruteo de vehículos; Asignación de tripulaciones; Programación Lineal Entera; Branch-and-cut

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Advanced MILP-based strategies for logistics decisions in industrial gases supply chains

Sergio Bonino; Luis Zeballos; José Laínez Aguirre; Akash Moolya; Jose Pinto; Ignacio Grossmann; Carlos Mendez

December 14, 2022 (Wednesday), 12:30 - Room 1301

This paper introduces an efficient and realistic MILP-based heuristic procedure to deal with

distribution scheduling of large size problems of industrial gases. The work proposes new strategies for generating efficient routes for product distribution in combination with an aggregated production scheduling. The problem takes into consideration a predefined time horizon, a set of production plants, a set of customers with daily product demands, a fleet of trucks to distribute gases, min/max production rates in plants as well as min/max tank levels in plants and customers. An efficient discrete time MILP-model is formulated to consider the production routing problem (MPRP) with multiple production plants with different features. Initially, the logistic model is solved considering a problem involving 50 customers, 2 production plants, 6 vehicles and 2 products. The model is successfully solved when a time horizon of three days and direct shipments to customers are considered. In order to consider industrial case studies, with at least a 30-day time horizon and several customers per route, an iterative procedure based on the efficient discrete time MILP-model is described. The iterative procedure considers one day in each iteration and the whole problem is faced by subsequently solving and combining multiple discrete time route generation MILP models. The procedure was tested considering a real case study of an industrial gases supply chain with 5 production plants, approximately 500 monthly deliveries to 120 customers, 14 vehicles and a 30-day time horizon. The results obtained showed that efficient solutions can be generated with a robust solution strategy and stable CPU times. In this way, the problem can be solved by considering multiple visits per route, routes with a duration of two or three days, and multiple routes per day for every vehicle.

Keywords: Inventory routing problem; MILP model; Industrial gases logistics; Optimization

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Optimizing management of a military aircraft fleet

Robert Dell; David Marlow

December 14, 2022 (Wednesday), 12:30 - Room 1301

Managers of military aircraft fleets have many competing priorities that include balancing short-term immediate taskings and long-term management. If short-term needs always take precedence, it is likely that the fleet will be unable to meet those same needs when they arise several years into the future. This is particularly important in appropriately managing the fleet to retirement, such that individual aircraft are neither over-utilized (forcing them to retire before the rest of the fleet) or under-utilized (retiring them with unused flying hours). The consequences of sub-optimal choices can be tens of millions of dollars per fleet. We present a mixed integer-linear program (MIP) for optimal management of a fleet over a multiple-year time horizon. The MIP prescriptions include which aircraft to deploy, when to induct aircraft into depot maintenance (for either elapsed time-based or flying hours-based time windows), and how to fly aircraft in order to both meet ongoing fleet and squadron requirements, and reach retirement targets. We demonstrate the MIP with examples based on real-world experience.

Keywords: Integer Programming Application; Military Application; Large Scale Optimization

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On edge intersection graphs of paths on a triangular grid: Characterization and clique coloring

Vitor Tocci F. de Luca; María Pía Mazzoleni; Fabiano S. Oliveira; Jayme L. Szwarcfiter

December 14, 2022 (Wednesday), 12:30 - Room 1302

We introduce a new class of intersection graphs, the edge intersection graphs of paths on a triangular grid, called EPG\textsubscript{t} graphs. We compare this new class with the well-known class of EPG graphs. A turn of a path at a grid point is called a \emph{bend}. An EPG\textsubscript{t} representation in which every path has at most k bends is called a B$_k$-EPG\textsubscript{t} representation and the corresponding graphs are called B$_k$-EPG\textsubscript{t} graphs. We characterize the representation of cliques with three vertices and chordless 4-cycles in B$_{1}$-EPG\textsubscript{t} representations. We also prove that B$_{1}$-EPG\textsubscript{t} graphs have Strong Helly number 3. Furthermore, we consider the problem of clique coloring, that is, coloring the vertices of a given graph such that no (maximal) clique of size at least two is monocolored. In general, clique coloring can be a very different problem from ordinary vertex coloring. The main difference is that clique coloring is not a hereditary property: it is possible that a graph is k-clique-

colorable, but it has an induced subgraph that is not. Another difference is that even a 2-clique colorable graph can contain an arbitrarily large clique. However, clique coloring has also some similarities with usual coloring. For example, every k-coloring is also a k-clique coloring, moreover the clique number and the clique chromatic number of G coincide if G is triangle-free. The decision problem of clique-coloring on general graphs is coNP-complete and it is NP-complete on graphs with maximum degree 3. We prove that B$_{1}$-EPG\textsubscript{t} graphs are 7-clique colorable.

Keywords: Triangular grid; Intersection graphs; Paths on a grid; Bend; Helly number; Strong Helly number; Clique coloring

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Sobre la Clique Coloración de los Grafos EPT en árbol huésped de grado acotado
Pablo De Caria; María Pía Mazzoleni; María Guadalupe Payo Vidal

December 14, 2022 (Wednesday), 12:30 - Room 1302

Un grafo de intersección por aristas de una familia de caminos en un árbol huésped es llamado grafo EPT. Si el árbol huésped es una estrella diremos que el grafo es EPT-estrella. Cuando el grado máximo del árbol huésped es h, decimos que el grafo es $[h,2,2]$ (respect. $[h,2,2]$-estrella). Se sabe que los grafos EPT tienen número clique cromático no acotado (ver [1]). En este trabajo, consideramos el problema de clique coloración en grafos $[4,2,2]$ y $[5,2,2]$. Primero, probamos que las clases de grafos $[4,2,2]$-estrella y $[5,2,2]$-estrella (exceptuando en este caso a C_5) son ambas 2-clique coloreables. Sin embargo, las clases $[h,2,2]$-estrella, con h≥ 6, no son 2-clique coloreables porque, por ejemplo, el grafo G_h, cuya representación EPT-estrella es $□P_h S_h□$,siendo S_h una estrella de grado h y P_h el conjunto de todos los posibles caminos de dos aristas de S_h, no es 2-clique coloreable (ver [1]). Pero sabemos que las clases $[h,2,2] $-estrella con h≤ 16 son 3-clique coloreables. Por otro lado, si permitimos que el árbol huesped sea diferente de una estrella, probamos que la clase $[4,2,2]$ es 3-clique coloreable y damos ejemplos de grafos minimales en esta clase que no son 2-clique coloreables. Además, demostramos que la clase $[5,2,2]$, sin restricciones en el árbol huésped, es 3-clique coloreable.

[1] M. R. Cerioli and P. Petito, Clique coloring UE and UEH graphs, Electronic Notes in Discrete Mathematics. 30 (2008) 201--206.

Keywords: grafos EPT; clique coloración; grafos de intersección

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On dually-CPT and strong-CPT posets
Liliana Alcón; Martin Charles Golumbic; Noemí Amalia Gudiño; Marisa Gutierrez; Vincent Limouzy

December 14, 2022 (Wednesday), 12:30 - Room 1302

A poset $\textbf{P}=(X,P)$ is said to be CPT (\textit{containment paths of tree}) if there exists a family $\mathcal{F}=(F_x)_{x\in X}$ of paths (set of vertices) of a host tree such that $x< y$ in \textbf {P} $\leftrightarrow F_x\subset F_y$. Recently, interest in CPT posets has been revived and several groups of researchers have considered various aspects of this class [1, 2, 3]. A poset $\textbf {P}$ is called \textit{dually-CPT} if $\textbf{P}$ and its dual $\textbf{P}^d$ admit a CPT representation. A poset $\textbf{P}$ is called \textit{strongly-CPT} if \textbf{P} and all the posets that share the same underlying comparability graph admit CPT representations. From the definition, it is clear that the class of strongly-CPT posets is included in the class of dually-CPT posets. Many families of separating examples between the class of dually-CPT and general CPT posets are now known, however, concerning the strongly and dually-CPT, it was an open problem to determine whether the inclusion is strict or if the two classes coincide. We present in this paper a solution to this question with the following main theorem:

\begin{center}

A poset $\textbf{P}$ is strongly-CPT if and only if it is dually-CPT.

\end{center}

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Keywords: SJ; Comparability graph; Containment; Poset

Characterization of QUBO reformulations for the maximum k-colorable subgraph problem

Rodolfo Quintero; David Bernal; Tamás Terlaky; Luis Zuluaga

December 14, 2022 (Wednesday), 12:30 - Room 1302

Quantum devices can be used to solve constrained combinatorial optimization (COPT) problems thanks to the use of penalization methods to embed the COPT problem's constraints in its objective to obtain a quadratic unconstrained binary optimization (QUBO) reformulation of the COPT. However, the particular way in which this penalization is carried out, affects the value of the penalty parameters, as well as the number of additional binary variables that are needed to obtain the desired QUBO reformulation. In turn, these factors substantially affect the ability of quantum computers to efficiently solve these constrained COPT problems. This efficiency is key towards the goal of using quantum computers to solve constrained COPT problems more efficiently than with classical computers. Along these lines, we consider an important constrained COPT problem; namely, the maximum k-colorable subgraph (MkCS) problem, in which the aim is to find an induced k -colorable subgraph with maximum cardinality in a given graph. This problem arises in channel assignment in spectrum sharing networks, VLSI design, human genetic research, and cybersecurity. We derive two QUBO reformulations for the MkCS problem, and fully characterize the range of the penalty parameters that can be used in the QUBO reformulations. Further, one of the QUBO reformulations of the MkCS problem is obtained without the need to introduce additional binary variables. To illustrate the benefits of obtaining and characterizing these QUBO reformulations, we benchmark different QUBO reformulations of the MkCS problem by performing numerical tests on D-Wave's quantum annealing devices. These tests also illustrate the numerical power gained by using the latest D-Wave's quantum annealing device.

Keywords: Quantum Computing; Quandratically Unconstrained Binary Optimization (QUBO) problems; Combinatorial Optimization; Quantum Annealing

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On Lagrangean Dualization of the RLT1 formulation for the Cross-dock Door Assignment Problem

Maria Araceli Garin; Laureano F. Escudero; Aitziber Unzueta

December 14, 2022 (Wednesday), 12:30 - Room 1303

The Cross-dock Door Assignment Problem (CDAP) deals with the optimizing of strip and stack door assignments given the shape of the cross-dock and the origin-destination volumes of goods. The CDAP includes the Generalized Assignment Problem (GAP) as a subproblem and like the GAP problem is NP-hard, but with smaller dimensions. On the one hand, and with the aim of getting feasible solutions quickly, and thus, upper bounds of the optimal solution, we propose an ad-hoc matheuristic based on local search, designed explicitly for the whole CDAP model which is disclosed into a subset of GAP submodels. On the other hand, and starting from the binary quadratic formulation of the CDAP model, a Linearized mixed Integer Programming formulation is proposed by using the Adams-Sherali RLT-k scheme for k=1 and a new type of binary variables. Taking into account the (possibly) high dimensions of some of the instances, a Lagrangean decomposition scheme is proposed for obtaining (hopefully) tight lower bounds of the optimal solution of the original model. At iteration 0 of the Lagrangean iterative procedure, and with Lagrangean multipliers equal to zero, two new formulations are presented based in the splitting of the dual problem into two submodels, corresponding to the strip- and stack- doors related models, respectively. One of these formulations, allows to recovery the optimal solution of the whole model, while the other, using

decoupled submodels GAP from the strip- and stack- door related submodels, allows to iterate in the updating iterative procedure of the Lagrangean multipliers vector until a tight lower bound of the optimal solution in reached. An extensive computational analysis on benchmark instances from the literature is carried out, comparing the quality of the lower and upper obtained bounds, and thus, the effect of the different decomposition schemes over the problem formulation.

Keywords: Quadratic optimization; Algorithms; Combinatorial optimization; Matheuristics; Decoupled models

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Optimization methods for units' assignment in housing cooperatives

Hector Cancela; Marcos Fierro; Adrián Manera; Martín Prino

December 14, 2022 (Wednesday), 12:30 - Room 1303

In Uruguay, housing cooperatives are a relevant option for many people to have an affordable habitational option. Usually, the units are assigned after the building process is finished; the most usual assignment rule in Uruguay is to do a random draw of the units between the partners. Motivated by this situation, we have explored the use of optimization methods to provide alternative assignment mechanisms which can take into account the preferences of the involved persons. Interacting with the of a cooperative, we found that both the total satisfaction and the minimum individual satisfaction were important criteria. A two-stage Mixed Integer Programming (MIP) optimization model, maximizing as first objective the minimum individual satisfaction and as a second objective the total satisfaction, was implemented and applied in more than 20 cooperatives, with very good results in comparison to random draws. More than 800 homes were assigned with this system, and the members expressed overwhelmingly their content with the solution . During this experience, a number of additional suggestions were collected from participants, regarding further aspects to be taken into account in the optimization model. At this moment we are exploring Constraint Programming models, in order to compare the results with the ones obtained using MIP, and to take advantage of the added expressivity to take into account the users' suggestions in enriched optimization models adding new objectives.

Keywords: Mathematical Programming; Constraint Programming; Assignment problems; Housing Cooperatives

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Comparative analysis of different solution methods for the bus bunching problem

Citlali M. Olvera-Toscano; Yasmín A. Ríos-Solís; Roger Z. Ríos-Mercado

December 14, 2022 (Wednesday), 12:30 - Room 1303

Reliability problems in public transport services have increased in recent years and have significantly impacted transit efficiency and productivity. The most common reliability problem in high-frequency urban transit systems is bus bunching, which refers to the arrival of a bus at a stop with little difference from its predecessor. This problem leads to a relatively poor service level, leading to more prolonged waiting and travel time for most passengers. To mitigate this problem, real-time corrective control strategies can be employed to regularize the frequency of buses passing through the stations. In this work, we consider a linear corridor that serves a set of stops with a bus fleet that travels at an average speed, and for each stop, the arrival rate and the drop-off rate of passengers are known. With this available information, the control strategy to use (bus holding or insertion of buses) must be decided and compute the correct timing. On the one hand, the bus holding decision should determine the duration of the retention and the stations at which it will be applied. On the other hand, the bus insertion decision establishes the stations where it is necessary to add empty buses to reduce congestion at stations with high passenger demand. This research aims to improve the reliability of public transport services by minimizing users' waiting and travel time. For this purpose, we propose three solution methods. The first is a mathematical programming model with linear objective function but some quadratic constraints. The second is a constraint programming model, and the third is a heuristic algorithm. In this paper, we evaluate these methods, show their efficiency, and perform a comparative analysis. In addition, we present the advantages and disadvantages of each of them.

Keywords: Bus bunching; Constraint programming; Heuristic; Public transport

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The two-echelon bicycle repositioning problem with split delivery
Juan David Palacio; Juan Carlos Rivera

December 14, 2022 (Wednesday), 12:30 - Room 1303

The bicycle repositioning problem (BRP) has been mainly described as a variant of the vehicle routing problem (VRP) with pickup and delivery operations. In the BRP, a fleet of capacitated vehicles must visit exactly once each one of the stations in a bicycle sharing system. These vehicles pickup and deliver bikes with the aim to better fit the demand at stations avoiding bike slacks or surpluses. In this talk, we present a new BRP that apart from the pickup and delivery structure of the problem, combines two key features on VRPs: two-echelon configuration and split delivery. This problem is called the two-echelon bicycle repositioning problem with split delivery (2E-BRPSD). The 2E-BRPSD differs from the BRP because not all vehicles must leave (and return) to a depot and, demand at some stations (i.e., satellite depots) is split. Thus, stations can be used to store units that are picked up later or locations can be used to lend bikes temporally. Moreover, if a station is served by more than one vehicle, there exists an inherent synchronized operation. Particularly, synchronization is not explicitly included as a set of constraints within a temporal aspect for our proposed 2E-BRPSD, but a load synchronization is imposed to satellite depots in the problem. We initially propose a mixed-integer linear programming model (MILP) for the 2E-BRPSD. Nonetheless, given the NP-hardness of the problem, we also present matheuristic algorithms. These solution strategies are based on a greedy randomized procedure (GRP) and the Split algorithm. Similarly, mathematical formulations based on the generalized traveling salesman problem (GTSP) and set partitioning problem (SPP) are included in our solution strategies setting the matheuristic nature of the algorithms. Despite our MILP hardly finds optimal solutions for instances with 20 stations, all matheuristic algorithms find solutions for instances with up to 60 stations and one of them solves instances up to 300 stations.

Keywords: Matheristics; Mixed Integer Linear Programming; Bicycle Sharing Systems; Bicycle Repositioning Problem; Pickup and Delivery Vehicle Routing Problem

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Horizontal collaboration in the wine supply chain planning: A Chilean case study
Franco Basso; Guillermo Ibarra; Raul Pezoa; Mauricio Varas

December 14, 2022 (Wednesday), 12:30 - Room 1304

The wine industry faces a highly competitive environment, making cost-effective management of the wine supply chain essential. Literature has shown that this objective can be achieved with the implementation of horizontal collaboration strategies in logistics. In this strategy, firms located at the same level of the supply chain cooperate to reduce costs, improve quality of service and mitigate environmental externalities. This paper analyses the implementation impacts of a horizontal collaboration policy in the wine supply chain. To do so, we propose a cooperative game with transferable costs, in which the characteristic function is obtained by solving a novel linear programming formulation that models the joint planning of the wine supply chain. To evaluate the benefits of collaboration, we conduct a case study involving three of Chile's largest wineries. The results show that the use of collaborative frameworks leads to significant reductions in the logistics costs of the wine supply chain.

Keywords: Wine supply chain; Horizontal collaboration; Cooperative Game Theory; Linear programming; Cost allocation

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Info Gap Decision Theory for handling deep uncertainties in an Agribusiness Supply Chain
Roberto Miranda; Carlos Monardes; Elbio Avanzini

December 14, 2022 (Wednesday), 12:30 - Room 1304

Agriculture is an important economic activity for the Coquimbo region in Chile, mainly cultivating and exporting of fresh fruits such as table grapes. Agribusiness Supply Chains (ASCs) allow the export of

them and have been reported as highly complex with a distinctive feature, the perishable nature of their products. In this context, one of the main deep uncertainties faced by ASCs is the harvest quality of the crop. During the recent COVID 19 pandemic, the deep uncertainty in supply chain disruption by health problems or government lockdown policy added more complexity to the business. In this research work, a two-level mathematical programming model under an Info-Gap Decision Theory (IGDT) approach is proposed for the case of a grape packing industry to face the effects of ASC disruptions. We incorporate deep uncertainty both in the harvest quality of the grape and the start and end periods of the possible disruptions. The objective of this model is to maximize chain profits, subject to the capacity constraints of harvest, transportation, storage, and retailer demand fulfillment. The IGDT approach evaluates Robustness Functions (RFs) and Opportuneness Functions (OFs) of the problem deep uncertainties. For this purpose, two optimization strategies are proposed; a Risk Aversion Strategy, which seeks to maximize the value of the RFs by ensuring that the base value of the objective function does not decrease below a given critical budget; and an Opportunity Seeker Strategy, which seeks to maximize the value of the OFs by forcing the value of the objective function to be above a given opportunity budget. First results of the research have revealed that the curves of the RFs and OFs differ greatly from each other and perform as a novel decision support tool for decision making under deep uncertainty.

Keywords: Agribusiness Supply Chain; Deep Uncertainty; Info-Gap Decision Theory; Two-Level Mathematical Programming

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The impact of supply chain dynamic capabilities and horizontal collaborative networks over collaborative risk management: The case of Hass Avocado in Antioquia - Colombia

Isabel Cristina Alzate Rendón; Eva Cristina Manotas Rodríguez

December 14, 2022 (Wednesday), 12:30 - Room 1304

The impact of supply chain dynamic capabilities and horizontal collaborative networks over collaborative risk management: The case of Hass Avocado in Antioquia - ColombiaThe study presents the findings of a case study of Hass avocado growers' associations in the department of Antioquia - Colombia. The main objective of the study is to analyse how supply chain dynamic capabilities SCDC of actors engaged in horizontal collaboration can dynamize integration between actors and facilitate collaborative risk management between partners and their supply chains. The data for this study was collected empirically and provided by two associations of small and medium-sized Hass avocado growers and their associated farmers, through the application of surveys carried out in a cycle of organizational training (4 modules - 20 hours) that included the study of SCDCs as generators of competitiveness and horizontal collaborative networks as a dynamiser of collaborative risk management CRM. The results show that both SCDC and collaborative networks have a positive influence on collaborative risk management, which also affects organizational performance. In addition to the above, given the current highly changing and volatile environments in which farmers and the agro-industrial sector in general operate, the development and strengthening of dynamic capabilities ecosystem should be promoted, especially in SME farmers, thus generating sustainable and resilient agri-food chains.

Keywords: supply chain; Hass Avocado; Antioquia

Set Covering Problem applied to relocation of a supply center

Eder Renato Delgado Ávila; Lucero Ramírez Melo; Marco Antonio Montúfar Benítez; Gilberto Pérez Lechuga; Sergio Blas Ramírez Reyna

December 14, 2022 (Wednesday), 12:30 - Room 1304

The aim of this study is to apply two models of set covering for the relocation of a food supply center in the city of Pachuca de Soto, Hidalgo, Mexico, through supply modules. The first model is the set coverage model considering one-way road distances, such as round trips, and the second model was generated by adding a restriction to the simple case to take into account proximity to direct competitors. These models were implemented in Gurobi using the Python 3.7 programming language. The population growth of cities in recent years has caused an increase in demand for consumer goods. In Pachuca city, capital of Hidalgo State (Mexico), we can find a large number of

food providers such as: stores of convenience, markets, flea markets, in addition to the main supplier of merchandise for the general population; the "Central de Abastos" (CA), which has been causing problems due to its relative proximity to highly populated neighborhoods of high socioeconomic status and other public service facilities, such as the Central de Autobuses. This article presents a proposal for the relocation at the micro level of the AC, replacing it with supply modules located in different neighborhoods of the Pachuca metropolitan area, thus satisfying the criterion that the inhabitants of the different neighborhoods of the city do not travel more than a predetermined maximum distance to buy its groceries and the module is located at another predetermined distance from its direct competitors. For the study, 68 neighborhoods were taken that were considered demanding, of which only 13 were candidates to locate a supply module. As a result of the models, the minimum number of supply modules necessary to cover the Pachuca metropolitan area was obtained.

Keywords: Location; Optimization; Set-covering; Supply Center; Integer Programming

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Cost optimization and analysis of multi-server queue with working vacation and imperfect service

Anshul Kumar; Madhu Jain

December 14, 2022 (Wednesday), 12:30 - Room 1305

In the proposed model, the cost analysis and optimization of a Markovian queueing system with two-stage service, imperfect service during working vacations, and a second optional service with multiple servers are investigated in this study. This research dealt with a general cost optimization queueing model for retail stores that operate in a hybrid mode with numerous semi-attended checkout counters. Matrix geometric method is used to analyze the model and various performance indices have also been derived. Sensitivity analysis has been derived to validate the proposed model. The particle swarm optimization technique is employed to investigate cost minimization. This study helps the decision makers to improve the service quality with the help of optimal design of system descriptors.

Keywords: Multi-server queue; Working vacation; Matrix geometric method; Particle swarm optimization

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Firefly algorithm for cost optimization of FM/FM/1/WV retrial queue with catastrophes

Sibasish Dhibar; Prof. Madhu Jain

December 14, 2022 (Wednesday), 12:30 - Room 1305

This investigation deals with the performance analysis and cost optimization of the Markovian retrial queueing model in a generic setup by incorporating the working vacation and customers' discouragement behaviour. The server rendering service to the customers is subject to breakdown and can be recovered after getting the repair. The governing system of difference equations has been framed to derive the steady-state probabilities of the queueing model. Using probability generating functions and difference equation theory, we present a simple alternative to carry out the entire analysis in this research work. The queue length distributions and various performance indices are obtained explicitly. The fuzzified parameters are used to develop the fuzzy FM/FM/1/WV model. To determine the optimal design parameters, the cost minimization problem has been solved using the firefly algorithm and quasi-Newton's method. The suitable illustration is taken for both crisp and fuzzified models to facilitate the numerical results of performance indices and optimal service rates.

Keywords: Retrial queue; Fuzzy; Working Vacation; Catastrophes; Balking; Firefly algorithm; Quasi-Newton method.

Multi-objective evolutionary algorithms for Bi-objective Composite Retrieval

Mauricio Moyano; Nicolle Ojeda-Ortega; Paula Zabala; Gustavo Gatica; Guillermo Cabrera-Guerrero

December 14, 2022 (Wednesday), 12:30 - Room 1305

In information retrieval, traditional search strategies only consider one attribute to build up a ranking list of results which depends exclusively on the considered attribute. However, often one needs to rethink the original query to accomplish the right solution as these search strategies do not consider the existing relations among all the other attributes. Composite retrieval (CR) of diverse and complementary bundles has been proposed to respond to this behaviour. Its objective is to group elements into bundles, in which the items are related to each other under both criteria: similarity and complementarity of bundles. These bundles should satisfy users' expectations without needing a new intervention, improving the searching experience. However, to the best of our knowledge, only single-objective models, mainly based on the weighted sum of each criterion, have been proposed in the literature. In this work, considering the inherent multi-objective nature of this problem, we present a novel bi-objective Composite Retrieval model which considers the existing trade-off between diversity and complementarity of each set of bundles. Given the good performance of multi-objective evolutionary algorithms in combinatorial problems, we implement both the NSGA-II and the MOGA algorithms to evaluate our model. We compare the obtained result with those obtained by single objective models previously proposed in the literature.

Keywords: Composite Retrieval; MOGA; NSGA-II

Modeling customer visits by score-driven model with negative binomial distribution
Vladimír Holý; Ondřej Sokol

December 14, 2022 (Wednesday), 12:30 - Room 1305

We model the daily number of customer visits to a brick-and-mortar retail store over several years. Daily visits exhibit overdispersion, autocorrelation, and seasonality. To capture these empirical characteristics, we propose a dynamic count model based on the negative binomial distribution with mean driven by the conditional score and seasonal effects. The resulting model is observation-driven and can be estimated by the maximum likelihood method. Next, we explore implications of the negative binomial distribution of daily visits on the intraday arrival process. With the additional assumption of independent increments, the arrivals follow the negative binomial Lévy process. Finally, we study queueing models with simultaneous arrivals caused by the negative binomial Lévy process.

Keywords: Retail Analytics; Score-Driven Model; Negative Binomial Lévy Process; Queueing Theory

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Mitigation of greenhouse gas emissions through landscape management
Jaime Carrasco; Florencia Cristensen; Jorge Hoyos-Santillan; Mauricio Acuna; Alejandro Miranda; Cristobal Pais; Andrés Weintraub

December 14, 2022 (Wednesday), 12:30 - Room 1306

Due to the large impact of wildfires on global carbon emissions, effective strategies for their mitigation should be investigated, especially as measures to face climate change. In this study, we propose a strategy to prevent and control wildfires known as Fuel Management in the context of reducing greenhouse gas (GHG) emissions. Specifically, we developed a strategy to locate firebreaks on the landscape, so that the release of GHG emissions resulting from the removal of vegetation in areas allocated to firebreaks is offset by the reduction in GHG emissions as a result of firebreaks' protective action. Our solution approach comprises an integrated simulation and optimization framework, along with a prioritization metric that identifies crucial cells that have a significant influence on the spread of fires on the landscape. The results show that using our localization strategy, an optimum is obtained when 3% of the landscape (crucial cells) is allocated to firebreaks. Our solution approach was tested on a landscape located in Alberta, Canada, whose forest fuels were classified according to the Canadian Fire Behavior Prediction System.

Keywords: Decision making; Fire risk; Fuel Management; GHG emissions under fire risk; Greenhouse gas emissions

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Feedback linearization and optimal control for Aedes aegyti populations

Antone dos Santos Benedito; Claudia Pio Ferrreira; Helenice de Oliveira Florentino Silva

December 14, 2022 (Wednesday), 12:30 - Room 1306

Feedback linearization is an approach to nonlinear control design which has attracted a great deal of research interest in recent years. The central idea of this technique is to algebraically transform a nonlinear system into a (fully or partly) linear one, so that linear control techniques can be applied. It differs entirely from conventional linearization (i.e., Jacobian linearization) in that feedback linearization is achieved by exact state transformations and feedback, rather than by linear approximations of the dynamics. Every day, a gret deal of new applications based on feedback linearization has appeared in strategic areas such as aerospace, chemical and petrochemical industries, bioengineering, and robotics. However, its usage is not limited to this ambit and it may be expanded to other research fields. In this context, we investigated an approach to feedback linearization as a tool to determine an optimal control aiming to reduce arboviral diseases transmitted by the mosquito Aedes aegypti such as dengue, chikungunya, yellow fever and others.

Keywords: feedback linearization; optimal control; arboviral diseases; Aedes aegypti

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Evaluación dinámica de los efectos ambientales de la inclusión de hidrógeno como vector energético no convencional en Colombia

Nathaly Martínez Escobar; Jeniffer Guadalupe Insuasty Reina; Juan Carlos Osorio Gómez; Diego Fernando Manotas Duque

December 14, 2022 (Wednesday), 12:30 - Room 1306

El desarrollo económico de un país se ve influenciado por el consumo de energía eléctrica, lo cual ha motivado que se generen mecanismos para abastecer las necesidades energéticas. En este contexto, la modificación de la matriz energética conlleva efectos de mediano y largo plazo que se pueden materializar en aspectos de carácter ambiental. Una de las alternativas que ha tomado más fuerza recientemente, es el uso de hidrógeno como vector energético, donde se encuentran países que tienen proyectos en marcha, que buscan descarbonizar el planeta y disminuir las emisiones de los gases de efecto invernadero. En el caso de Colombia, se ha establecido un marco regulatorio, orientado a la promoción y desarrollo de proyectos de generación con fuentes no convencionales de carácter renovable e incentivos tributarios a la inversión en tecnologías asociadas. Recientemente, se ha fijado una hoja de ruta para el uso de hidrógeno, la cual plantea escenarios a mediano y largo plazo de su incorporación dentro del país y así poder cumplir con el compromiso nacional de reducción de emisiones al 2030. Por tanto, este trabajo presenta el estudio de los posibles efectos al ambiente que tendría la inclusión de hidrógeno como vector energético no convencional en Colombia mediante un modelo de dinámica de sistemas. Partiendo de la revisión en la literatura, se definen las principales variables del sistema y los indicadores a analizar. Posteriormente, se procede a la conformación del modelo de simulación, que contempla el estado actual de la matriz energética. Mediante escenarios de simulación, se realiza la integración gradual del hidrógeno en el modelo propuesto, que permite evaluar los indicadores definidos. Finalmente, se generan recomendaciones asociadas a los impactos considerados, como apoyo a la toma de decisiones.

Keywords: Simulación Dinámica; Efectos Ambientales; Matriz Energética; Hidrógeno

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A multiperiod household solid waste collection system for a set of rural islands with transfer port selection

Michelle Zambra; Pablo Miranda; Carola Blazquez

December 14, 2022 (Wednesday), 12:30 - Room 1306

The design of a household waste collection system must integrate decisions related to planning and control of related operations, which may generate significant economic impacts to the organization in charge of addressing the problem, as well as social impacts to involved communities. Thus, this studio presents a mixed integer linear programming model with multiple periods, which aims at designing a household waste collection system for a set of rural islands, according to a set of

acceptable visit patterns, with a single barge to the whole time-horizon (which usually is a week). The proposed model simultaneously optimizes the selection of collection sites for each island and a transfer port at the mainland to unload all the collected household waste, along with a set of daily visit sequences associated with the selected ports, while minimizing total cost of waste transporting and treatment. The proposed model is applied to a particular rural insular zone in southern Chile. Model solutions provide an efficient system design that allows facing one of the current ecological problems studied area.

Keywords: Household solid waste; Design of collection systems; Routing; Transfer ports; Transportation costs; Linear programming

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A Multicut Approach to Calculate Upper Bounds for Risk Averse SDDP

Iago Leal de Freitas; Joaquim Dias Garcia

December 14, 2022 (Wednesday), 12:30 - Room 1307

When solving Multistage Stochastic Programming problems, a known caveat of adding risk-aversion to Stochastic Dual Dynamic Programming (SDDP) via a risk measure such as Conditional Value-at-Risk (CVaR) is losing the ability to properly estimate an upper bound for the optimal solution during the Forward step; therefore leaving SDDP without a clear stopping criterion. In this paper, we propose using the information already contained in a Multicut formulation of SDDP to solve this problem. By looking at a problem's decision tree, we can view an uncertainty scenario as a sequence of uncertainty realizations (Openings) for each stage. Calculating Multicut approximations during the Backward step, instead of the usual Average cut, preserves the information about which choices of Openings give rise to the worst scenarios, thus contributing more for the CVaR cost. We use this to bias the sampling method on the Forward step, in order to give the same weight to each Opening as it had on the Backward step. We present results using a real Hydrothermal dispatch case based on data from Colombia, a standard approximation of the Brazilian Operation problem, and a problem small enough to calculate its deterministic equivalent, enabling us to see that the calculated Upper Bound is maintained slightly above the real optimal value. Our Numerical Experiments showed that this method consistently calculates Upper Bounds higher than Lower Bounds for those risk averse problems.

Keywords: Multistage Stochastic Programming; Stochastic Dual Dynamic Programming; Multicut; Conditional Value-at-Risk; Upper Bound; Risk averse

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Optimización Estocástica aplicada a la planificación forestal en Uruguay

Victor Viana; Hector Cancela; Lorena Pradenas

December 14, 2022 (Wednesday), 12:30 - Room 1307

El trabajo desarrollado se enmarca en el campo de la optimización estocástica para un problema de planificación forestal, donde se modela un problema lineal entero mixto. Este problema de planificación consiste en la minimización del costo del traslado y operación de los contratistas de cosecha entre los distintos lugares donde deben operar. Ademas se considera la incertidumbre de que los lugares de cosecha estén disponibles durante ciertos periodos a lo largo de todo el horizonte de planificación. Dado que esta incertidumbre se representa a través un árbol de escenarios, llevar a cabo la resolución de este tipo de problemas estocásticos bajo las técnicas de optimización tradicionales se vuelve inabordable en la medida que el tamaño de la instancia aumenta, lo que justifica la utilización de técnicas adecuada para alcanzar resultados en tiempos razonables. La metodología de resolución a utilizar se basa en el algoritmo de descomposición por escenarios Progressive Hedging (PH), que se ajusta para tener en cuenta características del problema a resolver con tal de obtener mejores rendimientos. Ademas, se realizan una serie de comparaciones con técnicas de optimización tradicionales, determinando y analizando las ventajas que ofrece PH para el problema en estudio. Se lleva a cabo un estudio detallado respecto a técnicas de reducción de escenarios, así como del desarrollo de una metodología de simulación que permita comparar de forma cuantitativa el rendimiento de modelos estocásticos y determinísticos, permitiendo estimar el número suficiente de escenarios que logran representar de buena manera la realidad, atendiendo al compromiso entre la calidad de solución y los tiempos de cómputo involucrados. Se presentan casos

de estudios basados en datos reales brindados por empresas forestales uruguayas.

Keywords: optimización estocástica; forestal; progressive hedging

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Lenguaje de dominio específico embebido para programación estocástica multietapa en Scala
Germán Ferrari; Carlos E. Testuri; Alberto Pardo

December 14, 2022 (Wednesday), 12:30 - Room 1307

Los problemas de programación estocástica basados en escenarios suelen ser tratados como problemas de programación entera mixta a través de su forma extensiva, lo que permite utilizar todas las herramientas disponibles para ese tipo de problemas en su implementación y resolución. Sin perjuicio de lo anterior, este encare presenta algunos problemas: exige la incorporación del control de la no anticipatividad de las decisiones en los modelos; no brinda ninguna asistencia en la construcción del árbol de escenarios y la especificación de los valores de los parámetros estocásticos en forma consistente; no permite explotar la estructura particular de los problemas de programación estocástica en su resolución. En este trabajo se desarrolla un lenguaje de dominio específico (DSL), en el que se explora una extensión al lenguaje de modelado algebraico GNU MathProg, para incorporarle soporte para programación estocástica multietapa basada en escenarios. El DSL es embebido en el lenguaje de programación Scala, permitiendo que los modelos puedan ser transformados y manipulados. El DSL desarrollado permite modelar los problemas de programación estocástica utilizando la formulación con escenarios separados. Las entidades del modelo son declaradas con una sintaxis que logra replicar con gran fidelidad la de MathProg. Se proveen primitivas para la especificación del árbol de escenarios, las probabilidades y los valores de los parámetros estocásticos en forma concisa y flexible. Aplicando transformaciones al modelo, se generan automáticamente las restricciones de no anticipatividad y versiones alternativas de los parámetros estocásticos sin escenarios separados, lo que permite construir una forma extensiva que es más eficiente que la se construiría manualmente. La funcionalidad provista puede ser extendida por el usuario, pudiendo definir funciones alternativas para la construcción de árboles de escenarios y la especificación de datos de parámetros estocásticos.

Keywords: programación estocástica multietapa basada en escenarios; lenguaje de dominio específico embebido; MathProg; Scala; programación funcional

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Two stage portfolio optimization for commodity exports
Nicolas Vargas; Mathias Klapp; Alejandro Mac Cawley

December 14, 2022 (Wednesday), 12:30 - Room 1307

Average commodity price volatility between 2004 and 2014 was four times higher than between 1994 and 2004. This price volatility, accompanied by long lead times, represents a major challenge for commodity exporters, who must anticipate the price of the commodity upon arrival in each demanding market. To reduce their exposure to price volatility, exporters can diversify by exporting the commodity to more than one market and in more than one stage. In this way, export profits are less sensitive to fluctuations in the price at which the commodity is traded in some market. In this research we design a tool that allows a commodity exporter to decide where, when and how much commodity to export to each demanding market, depending on the maximum risk it is willing to incur. To do so, we model the problem using Two Stage Stochastic Programming (TSSP) and we bound the risk incurred in maximizing export profits through a maximum variance constraint. Since solving a TSSP usually involves solving a large-scale optimization model and the maximum variance constraint prohibits the use of specialized decomposition techniques for TSSP, we additionally present a heuristic algorithm that allows to efficiently solve large-scale instances of the model developed in this research. Using information on grape export prices from Chile to Brazil, Colombia, United States, Mexico, Netherlands and Germany during 2015 and 2017, we quantify the reduction in profit volatility generated by inter-market and inter-stage diversification. Additionally, through simulation, we show the benefits of implementing the export strategy developed in this research over other known export strategies.

Keywords: Commodity exports; Risk averse optimization; Two stage stochastic programming

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Heurística de asociación y planificación de mensajes periódicos de tiempo real en ciudades inteligentes basadas en una extensión del protocolo LoRaWAN

Rodrigo Santos; Paula Zabala; Matías Micheletto

December 14, 2022 (Wednesday), 12:30 - Room 1308

En los sistemas de IoT, el acceso al canal de comunicación es uno de los problemas a resolver. Los dispositivos son, en general, de bajo costo con limitaciones en el ancho de banda disponible y de baja complejidad computacional, por lo que se deben implementar protocolos simples y que ocupen poco espacio de memoria. Entre las opciones disponibles se encuentran las redes de baja potencia y largo alcance . Una de las más utilizadas es LoRaWAN, que se basa en un modelo de transmisión del tipo spread spectrum que alcanza distancias importantes con baja potencia. Su operación contempla una topología en estrella en la cual los end-devices (eds) transmiten información que es captada por gateways (gws), que la retransmiten al servidor de red para que sea procesada en Internet Los gw son simplemente puentes entre los eds y la red. Si un mensaje de un ed es escuchado por dos gws, entonces ambos retransmiten el mensaje al servidor para su procesamiento, y es éste último quien descarta los mensajes repetidos. LoRaWAN impone restricciones sobre el porcentaje de tiempo que un dispositivo puede transmitir, fijándolo en el 1%. Para poder operar, LoRaWAN puede definir hasta 16 canales y utilizar 5 factores de dispersión de la señal diferentes, escuchando los gws a los 5 en simultáneo, SF7 a SF12. Cuando mayor es el SF, más alcance tiene la señal pero más tiempo requiere para transmitir. Cuando los mensajes tengan vencimientos a cumplir, el problema de asociación de eds a gws, selección de canales de operación y de SF, cumpliendo además con las restricciones de porcentaje de uso, se transforma en un problema NP-duro. Se propone una heurística de asignación de canales, SF y asociación de eds a gws, que cumpla con los vencimientos de los mensajes y el porcentaje de uso en aplicaciones de IoT en ambientes urbanos con decenas de miles de dispositivos que permitan implementar ciudades inteligentes. La heurística busca una solución factible que minimice la cantidad de gws necesarios.

Keywords: LoRaWAN; Algoritmos hurísticos; Internet de las Cosas

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Problema integrado da mistura e dimensionamento de lotes

Diego Fiorotto; Silvio de Araujo; Raf Jans

December 14, 2022 (Wednesday), 12:30 - Room 1308

O problema da mistura padrão consiste em combinar ingredientes para produzir um produto final atendendo uma demanda pré-estabelecida, satisfazendo critérios específicos com respeito a mistura produzida com o intuito de minimizar o custo total. A lista de materiais indica quais ingredientes são utilizados e em quais proporções. Em alguns casos, existe alguma flexibilidade no planejamento com respeito a proporção para cada um dos ingredientes, de forma que a proporção pode variar entre um valor mínimo e máximo ao invés de ser fixa. Este problema foi amplamente estudado considerando um único período. No entanto, o problema torna-se mais complexo quando levamos em consideração um horizonte de planejamento. Neste caso, têm-se a demanda para o produto final em vários períodos e tanto o produto final quanto os ingredientes podem ser deixados em estoque. No problema integrado da mistura e dimensionamento de lotes, as decisões relacionadas à produção do produto final através do processo de mistura, e a produção (ou aquisição) dos ingredientes são realizados ao longo de um horizonte de planejamento. Neste trabalho propõem-se uma formação para este problema integrado e através de experimentos computacionais, é realizada uma análise dos benefícios da flexibilidade. Além disso, analisa-se o valor da integração destes dois problemas comparando a solução do modelo integrado com abordagens de soluções que não são capazes de obter os benefícios totais da integração como por exemplo a abordagem lote-por-lote, a política just-in-time e uma abordagem hierárquica.

Keywords: Problemas integrados; Problema de dimensionamento de lotes; Problema da mistura; Análise de flexibilidade

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Evaluation of quality of life by data envelopment analysis
Jakub Hanousek

December 14, 2022 (Wednesday), 12:30 - Room 1308

This article deals with the evaluation of the quality of life in the municipalities in the Czech Republic. The work aims to find the municipalities which are the best in the evaluation of the quality of life. Evaluation is done by the method of data envelopment analysis. Data envelopment analysis is a method based on linear programming that measures primarily the efficiency of production units. The advantage of this method is an optimization weight of each criterion to maximize a score from each unit. The study includes municipalities which more than 3000 inhabitants. The study applies standard data envelopment models and advanced data envelopment models with uncontrollable inputs and outputs. This approach is innovative because most similar studies have been done by multicriteria decision methods. The methods in this paper can be applied to the evaluation of the quality of life everywhere in the world.

Keywords: Life quality; Data envelopment analysis; Czech Republic

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Surveillance and security managing of municipal parks through servers location: the case of the Asunción Botanical Garden and Zoo
Fabrizio Nadir Recalde Rivas; Jorge L. Recalde-Ramírez; María Margarita López de Recalde

December 14, 2022 (Wednesday), 12:30 - Room 1308

The security and surveillance systems in public spaces with a high flow of users are relevant and a priority for the institutions. However, due to the lack of human, technical and financial resources in public management, they must be employed efficiently. We analyze the case of the Asunción Botanical Garden and Zoo (JBZA), a park of 250 hectares managed by the Municipality of Asunción in Paraguay. The objective is to design a coverage plan for the security and surveillance system of the 28 recreational and sports zones in the JBZA. The mathematical model is based on the Maximum Coverage Location Problem, MCLP, to locate the guards that patrol assigned areas in posts. The first proposal is to minimize the number of guards to be located; then, in the second proposal, we suggest maximizing the demand covered through the security posts, considering the potential risk perceived in the zones previously classified. Finally, we present the results of the Set Covering Location Problem for this case study with levels of coverage from 0 to 2 or more servers. The models were solved with Gurobi Optimization Software in Python. The results compare the number and identification of posts with security guards to be located and the number and identification of zones covered by each post. Another relevant result is the calculus of the zones demand approximation considering the lack of information.

Keywords: Municipal Park; Surveillance and security system; Location of facilities; Linear Programming

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Parametric estimation under diffuse observations: An application on pooling election polls
Charles Thraves; Sebastián Morales

December 14, 2022 (Wednesday), 12:30 - Room 1309

Most techniques to estimate distributions consider observations as a single-point. However, there are several applications in which observations have some degree of uncertainty which is known. We propose a way in which Maximum Likelihood Estimation methods can effectively incorporate this noise dimension of the data. We show that the log-likelihood expression in this more general setting can be expressed in a tractable expression. We show a case study in the US President Election of 2020, in which polls are pooled at each state in order to estimate the distribution of votes in the election day. We show the estimated distribution with the described technique on each state, and compare the results with other benchmark methods, such as classical MLE and other methods (developed in the literature) to pool polls. The proposed method shows to outperform current techniques such as classical MLE in terms of achieving the highest log-likelihood among all methods considered. Besides the problem addressed in this work, the proposed technique can be applied to

several other applications beyond pooling polls. More precisely, the technique can be applied to any setting in which the observations have some inherent known distribution.

Keywords: Elections; Polls; Maximum likelihood; Diffuse observations

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Probabilidade, Jogos de Azar e o Software R
Gastão Coelho Gomes

December 14, 2022 (Wednesday), 12:30 - Room 1309

O objetivo deste trabalho é didático, visando entender probabilidade via o conceito frequentista e clássico com comparação dos dois métodos. Usamos o software R para este fim. O R (http://www.r-project.org) é um pacote, de domínio público. No R, foram elaborado códigos para que, através de simulações podermos calcular, de forma frequentista, as probabilidades referentes aos quatro problemas apresentados aqui: 1-Simulando lançamento de moedas; 2-Total de pontos em dois lançamentos de um dado; 3-Jogo de cinco dados; 4-Jogo de Poker com dados. O ponto de partida do estudo sistemático das probabilidades pode ser situado em meados século XVII, quando Méré desejava descobrir uma estratégia de jogo que otimizasse o ganho ou reduzisse o risco. Há diversas situações práticas onde é possível calcular probabilidades de determinados eventos ocorrerem, fazendo uma analogia entre esses problemas e os jogos de azar. Por isso nos livros de probabilidade é muito comum aparecerem vários exemplos com moedas, dados, baralhos, roletas, etc. Nesses tipos de exemplo os espaços amostrais considerados são finitos e equilibrados, todos os eventos elementares têm a mesma probabilidade de ocorrência. Conceito Clássico de Probabilidade: P(A) = #(A) / #(Ω); onde #(Ω) é o número de resultados possíveis do experimento e # (A) é o número de resultados favoráveis à ocorrência do evento A. Outra maneira de definir probabilidade, de uma forma aproximada, é o Conceito Freqüentista: Considere um experimento onde o evento A pode ou não ocorrer. Suponha que esse experimento foi repetido n vezes, sempre sob as mesmas condições, e que o evento A ocorreu m vezes entre essas n realizações do experimento, Então a fração m/n é uma boa aproximação para a probabilidade de A, se o número n de repetições for bastante grande. Simbolicamente, P (A)=m/n. Os resultados frequentistas, gerados no R foram compararmos com a solução clássica de probabilidade, cujos cálculos também são apresentados.

Keywords: Probabilidade; Simulação Monte Carlo; Software R

Fairness in linear regression. A novel approach from a Bayesian perspective
Rafael Jiménez Llamas; Pepa Ramírez Cobo; Emilio Carrizosa Priego

December 14, 2022 (Wednesday), 12:30 - Room 1309

Fairness is a relatively new branch in statistical and machine learning. It aims to nullify the effect that biases in datasets regarding sensitive variables (gender, race...) provoke in predictions. In this work, we focus on the fairness issue in a linear regression setting using Bayesian tools. We construct fair solutions by selecting proper hyper-parameters in an Empirical Bayes framework. As a measure of fairness, we consider the average prediction difference between sensitive and non-sensitive populations, avoiding the need for individual information regarding the sensitive classes, and thus, avoiding privacy issues. As results show, both in real and simulated datasets, the method provides a tradeoff between the fairness degree and the fit to the data, and allows the user to set a minimum requirements for goodness of fit or for fairness.

Keywords: Fairness; Bayesian linear models; Normal-Gamma probability distribution; Empirical Bayes

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A study of the effects of considering carbon emissions on the production planning and vehicle routing problem in a furniture industry
Felipe Goulart Moraes; Deisemara Ferreira; Reinaldo Morabito; Pedro Miranda Lugo

December 14, 2022 (Wednesday), 12:30 - Room 1309

At the same time that organizations have a competitive scenario with the objectives of maximizing the profit and customer satisfaction along with minimizing costs, there are worldwide concerns regarding production sustainability and the impact on the environment. To better balance and reconcile these important objectives it has been explicitly taken into account the financial and environmental effects in the operations planning of the industrial activity. In that sense the scientific literature has been studying the integration of production and vehicle routing problem with carbon emissions to help in the decision making and support organizations. The present research has the objective of evaluating the effects of considering carbon emissions in the production and distribution planning for furniture company. A mathematical model is proposed to represent the problem and instances based on real data are used to proceed with the computational studies.

Keywords: Pollution production routing problem; Pollution inventory routing problem; Furniture industry

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Suitability analysis for photovoltaic solar energy generation based on GIS-MCDM integration

Jessyca Samarithana Ferreira Aires; Caroline Mota; Duan Vilela Ferreira; Ciro José Jardim de Figueirêdo; Paulo Antônio Xavier Furtado

December 15, 2022 (Thursday), 09:00 - Room 1101

Climate change has been happening all over the world and has been caused, for the most part, by the emission of polluting gases, especially the CO2 that is released from fossil fuels. Thus, one of the main alternatives to minimize this problem is the replacement of energy sources generated from fossil fuels by renewable energy sources (RES) given their sustainable characteristics, and insignificant emission of greenhouse gases, among others. In Brazil, hydroelectricity is the predominant energy grid in the country. However, this capacity has been approaching its limit, bringing the need to implement RESs. Nevertheless, these initiatives are still very rudimentary. In this context, this study aims to apply a methodology to support the decision process of evaluating suitable locations for the implementation of RESs based on photovoltaic plants in Pernambuco State, located in the northeast region of Brazil. Furthermore, considering that climatic factors are relevant for this application and since they vary from location to location, the methodology integrates multi-criteria decision models and geographic information systems (GIS-MCDM).

Keywords: Suitability analysis; renewable energy; GIS-MCDM

Comparison of stochastic multiobjective acceptability analysis based methods in a multi-criteria location problem

Javier Pereira; Pedro Contreras; Danielle Morais

December 15, 2022 (Thursday), 09:00 - Room 1101

Stochastic Multiobjective Acceptability Analysis (SMAA) is an approach that has been used as a stochastic wrapper on different multi-criteria decision analysis methods. SMAA-2 is a stochastic version of an additive utility-based approach. Instead, SMAA-PROMETHEE implements the stochastic version of PROMETHEE, an outranking-based method. SMAA-TODIM is used in cases where prospective-theory-based preference additive functions are considered. In these cases, decision-problem solutions can be built in the form of a ranking whenever uncertainty is present in information sources used to evaluate alternatives and parameters. In this article, we compare results build with these methods by simulating an airport-parcel logistics hub multi-criteria location problem, when the evaluation of a medium-sized set of alternatives and the preferences of decision-makers are modeled by considering uncertain information. We propose a metric to discern the rank position of alternatives in a medium-sized set, based on a curve fit approach to find the expected best rank, drawn up from the cumulative probability that an alternative reaches a given rank or better. Results confirm that, although it is known that the additive functions -based and the outranking-based methods will build different outcomes, the SMAA approaches of these methods also produce different rankings when applied in a specific case.

Keywords: RED-M; SMAA; PROMETHEE; TODIM; Curve Fit

Confección de carteras de activos que cotizan en el mercado de valores argentino aplicando una metodología en etapas

Hernán Pablo Guevel; Josefina Racagni; Mariana Funes; José Miguel Vargas Soria

December 15, 2022 (Thursday), 09:00 - Room 1101

Al momento de analizar la conveniencia de invertir en una empresa o un conjunto de ellas, es frecuente revisar los resultados obtenidos por estas como aproximación a los rendimientos que sería previsible obtener en el futuro. También lo es, vincular los resultados obtenidos con los recursos comprometidos para su obtención, concepto estrechamente relacionado con el análisis de eficiencia. En el presente trabajo, se clasifica un conjunto de 52 empresas que cotizan sus activos financieros en el Mercado de Valores de Buenos Aires a fin de considerarlas candidatas a conformar una cartera de inversión de mediano a largo plazo. El procedimiento para la construcción de carteras implica la ejecución de una serie de etapas. En primer lugar, aplicando métodos de estadística multivariada se seleccionaron cinco ratios representativos de la situación económica y financiera de las empresas (Caro, 2013 y Beaver, 1966) que mejor caracterizan al conjunto considerado. Estos ratios fueron construidos a partir los estados financieros publicados por las empresas para el ejercicio cerrado en 2018. Luego, se clasificaron las empresas en función de su atractivo para la inversión empleando el Modelo Aditivo Básico (DEA) (Charnes, Cooper, Golany, Seiford y Stutz, 1985) en sucesivas etapas, obteniendo 3 categorías, incluyendo 11 empresas la primera, 11 la segunda y las 30 restantes en la tercera. Una vez clasificadas, se ordenaron las comprendidas en la primera categoría aplicando TOPSIS (Hwang y Yoon, 1981), y, finalmente, se conformaron portafolios con diferente número de activos, de los incluidos en la primera categoría. Conformadas las carteras, sus rendimientos se compararon con los de los índices bursátiles más importantes en el mercado de capitales local: S&P Merval y S&P/BYMA Argentina General.

Keywords: RED-M; DEA; TOPSIS; CARTERAS DE INVERSIÓN

Lean Healthcare efficiency assessment in Brazilian public hospitals using Slack-based Measure Data Envelopment Analysis (SBM-DEA)

Samuel Martins Drei; Lidia Angulo-Meza

December 15, 2022 (Thursday), 09:00 - Room 1208

Lean Healthcare focuses on eliminating waste from its processes by reducing non-added value. However, there is a lack of alignment between these gains and the final efficiency of the hospital where it is being applied. Given that Data Envelopment Analysis (DEA) is an approach based on non-parametric mathematical programming to measure the relative efficiency of Decision Making Units (DMUs) with multiple inputs and outputs, and can be widely applied in organizations that have different resources and products, including the health sector, where its use has already brought several benefits, the combination of these two metrics can be advantageous for an overall improvement in decision-making in public hospitals. Thus, the aim of this paper was to determine the efficiency of a set of Brazilian public hospitals, highlighting the performance of a municipal hospital before and after a Lean Healthcare intervention, using DEA. It was used the Slack-based Measure Data Envelopment Analysis (SBM-DEA) which is a non-oriented model of DEA, in the analysis of the efficiency of eleven hospitals before and after undergoing the Lean Healthcare intervention, totaling 22 DMUs. It was possible to observe that the municipal hospital highlighted had both an improvement in its processes, through the reduction of its waste of time and displacement, as an improvement in its efficiency, becoming efficient, within this set of proposed hospitals. Despite this, it was possible to see that some hospitals did not follow this gain, continuing to be inefficient, even after the intervention of Lean Healthcare, and even becoming more inefficient. The analysis of the benchmarks of each inefficient hospital, in turn, can bring more concrete results, given the presence of hospitals before the application of Lean, as well as the hospitals that had it. Therefore, it is concluded that there is a need to establish approaches that align the gains of Lean Healthcare with improving hospital efficiency.

Keywords: Lean Healthcare.; Slack-based Measure Data Envelopment Analysis (SBM-DEA).; Efficiency.; Brazilian public hospitals.; Healthcare evaluation.

Evaluación de la eficiencia de cultivos de Aguacate Hass usando Análisis Envolvente de Datos

Elias Olivares-Benitez; Jose Humberto Ablanedo-Rosas; Aaron Guerrero-Campanur

December 15, 2022 (Thursday), 09:00 - Room 1208

Se considera la importancia de México como el principal productor y exportador mundial de Aguacate, lo que justifica el estudio de este cultivo con respecto al desempeño de los huertos ubicados en la zona de mayor producción, el Estado de Michoacán. Se obtiene información disponible públicamente acerca de la producción de aguacate Hass y diversas variables posiblemente asociadas a esta medida de desempeño. La información se encuentra agregada por altitud sobre el nivel del mar y estación de floración para los años 2014 a 2020, que se usan como unidades de toma de decisión. Para evaluar la eficiencia de los cultivos se usa la técnica de Análisis Envolvente de Datos con Bootstrap. Para evaluar la significancia de las comparaciones de eficiencia se realizan pruebas no paramétricas de Friedman, Wilcoxon y Mann-Whitney, además de un análisis de kernel. Los resultados indican que la eficiencia es diferente de acuerdo a la altitud de los cultivos, siendo menos eficientes las altitudes intermedias dentro del rango analizado. También, la eficiencia varía entre estaciones de floración, siendo más eficientes las estaciones más tempranas. En general, se observa una reducción de la eficiencia a través de los años analizados. Estos resultados son útiles para los productores y comercializadores de aguacate puesto que ayudan a la toma decisiones acerca de precios y negociaciones de compra. También, los resultados son útiles para las agencias gubernamentales puesto que permiten identificar variables asociadas a políticas públicas que ayuden a incrementar la eficiencia en la producción, considerando que la demanda de aguacate sigue en aumento a nivel mundial.

Keywords: Aguacate; Análisis Envolvente de Datos; Altitud; Floración; Eficiencia; Agricultura

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Internal benchmarking to assess the cost efficiency intra and inter production unit: an exploratory analysis combining data envelopment analysis and throughput accounting

Fabio Sartori Piran; Daniel Pacheco Lacerda; Maria Conceição A. Silva; Ana S. Camanho; Ricardo A. Cassel

December 15, 2022 (Thursday), 09:00 - Room 1208

The use of Data Envelopment Analysis (DEA) to assess economic efficiency is scarce compared to technical efficiency. Some aspects justify this scarcity, such as the difficulty of having accurate knowledge of prices, given their variability over time. Also, external benchmarking is hindered in many situations due to the unique nature of organizations and the unwillingness of managers to share information considered critical for companies' competitiveness. An alternative to overcome these difficulties is to use internal benchmarking. Internal benchmarking can consider intra and inter production unit analysis. From this, program efficiency can be assessed. The objective of this study is to conduct an exploratory analysis of cost efficiency in a footwear company using internal benchmarking intra and inter production unit and the program efficiency. We conducted a longitudinal case-based research with panel data over 2.5 years (2017, 2018, and 2019/01) at two production units of the footwear company. The concepts of Throughput Accounting of the Theory of Constraints were used to structure the DEA model (inputs, prices, and output). The results show that the footwear company could reduce 41.53% in internal benchmarking intra or 48.72% in internal benchmarking inter production unit, of the total cost per DMU, if it used the balance of inputs suggested by DEA evaluation. This work contributes to the literature by showing the potential of using internal benchmarking to overcome the limitations of assessing economic efficiency and expands the possibility of identifying improvements in operations management by incorporating inter production unit benchmarking into intra company benchmarking. Also, it contributed by suggesting a solution to the problem of interchangeability of inputs and the evaluation of efficiency in the context of throughput accounting.

Keywords: Cost Efficiency; Internal Benchmarking; Data Envelopment Analysis

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Métodos de selección de variables para la evaluación de la eficiencia con modelos DEA y datos de panel. Revisión de algunos enfoques.

Patricia Alejandra Iñiguez; Juan Manuel Gallardo; Mariana Arburua; Pablo Pagano; Fernando Javier Negro

December 15, 2022 (Thursday), 09:00 - Room 1208

Si bien el DEA registra una importante evolución en las últimas cuatro décadas, una cuestión de estudio que aún atiende la literatura es el problema de la selección de los inputs y outputs a considerar en el modelo empírico. El interés se origina en evitar que cuando se tiene un número bajo de unidades en evaluación en comparación con el número de inputs y outputs se encuentre una gran proporción de unidades eficientes o con índices de eficiencia con valores optimistas. La cuestión de elegir un conjunto de inputs y outputs, se dificulta, particularmente, cuando se pretende realizar una evaluación de eficiencia con más de un período de tiempo. Esta especial situación requiere de algún método que seleccione un conjunto de inputs y outputs común para todos los períodos en los que se pretenda evaluar la eficiencia. En el presente se revisan cuatro propuestas. Dos corresponden a los métodos 1 y 2 presentados por González Araya et al. (2013), la tercera se refiere al programa lineal entero mixto, planteado por Peyrache et al. (2020) en el que se maximiza la eficiencia de la DMU promedio y la cuarta pertenece a los autores y se basa en un indicador multiatributo (Sd). Para confrontar estas cuatro propuestas, se considera un panel de datos con 22 hospitales, 17 variables, observados en 3 años. Cada conjunto se evalúa con el indicador Sd que se construye a partir de los criterios, mejor ajuste a la frontera, máxima discriminación y menor variación interanual y se analiza la solución de los modelos empíricos resultantes. Puede concluirse que el método basado en el indicador Sd brinda un modelo empírico con sentido conceptual y práctico. A partir del método de Peyrache et al. (2020), con algunas variaciones, es factible llegar a un modelo adecuado. La propuesta de González Araya et al. (2013), conduce a un modelo con características poco significativas. No posee buena discriminación entre unidades eficientes e ineficientes y muestra muchas DMUs con características atípicas.

Keywords: Análisis Envolvente de Datos; Métodos de Selección de Variables; Datos de Panel

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The Joint Location-Inventory Problem under continuous review (Q, r) policy with Fill-rate service level constraint

Paulina Tapia; Pablo Escalona; Alejandro Angulo

December 15, 2022 (Thursday), 09:00 - Room 1209

This paper studies the joint facility location and inventory management problem under a continuous review (Q, r) policy with fill-rate service-level defined as the fraction of demand met directly from on-hand inventory. The model, which is formulated as a mixed integer nonlinear problem (MINLP), consider the exact formulation for the fill-rate constraint. The model is reformulated as a second order cone programming optimization problem and solved using outer approximation which provide an epsilon-optimal solution. We compare the optimal configuration and solution with the optimal results of the joint location and inventory problem with alpha service-level, widely used in literature.

Keywords: Fill-rate service-level; Location-inventory problem; Continuous review (Q r) policy; Conic integer programming; Outer approximation

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A profit-maximizing hub network design problem considering users' probabilistic utility functions

Steven Chau Yip; Armin Lüer-Villagra

December 15, 2022 (Thursday), 09:00 - Room 1209

Hub locations are commonly used in the airline, courier, and telecommunication industries to design hub-and-spoke networks. Recent literature has studied profit-maximizing hub location models. Users are commonly modeled as passive entities with a simple travel decision process in general network design problems. In this work, we relax this assumption, considering the heterogeneity between users and including different factors that may affect their travel decision. We use probabilistic utility

functions to model the users. We incorporate users' preferences into a profit-maximizing hub location model through a path size logit model of their behavior. We propose a mixed-integer linear formulation for small instances and an efficient metaheuristic to solve large instances. We find that the inclusion of users' behavior into the model: changes the network structure and the profit estimation of the model, making the problem harder to solve.

Keywords: location analysis; hub location; multinomial logit models; path size logit

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Effective location of technological laboratories in rural municipalities of the Atlántico department, Colombia: A two-stage stochastic optimization model

Cindy Infante Eguis; Jesús Mora Movilla; Carlos Torres Morales; Kelly Bejarano Movilla; Andrés Porto Solano; Álvaro Mercado Cruz

December 15, 2022 (Thursday), 09:00 - Room 1209

The Atlántico department Government, with the help of National Education Colombian Ministry, develops plans and strategies to improve education in rural areas, making available investment for the acquisition of tools, equipment and the creation of technological laboratories, which allow to accelerate the educational and scientific development. This research project allows establishing, through a two-stage stochastic programming model, the cost-effective location of technological laboratories in rural municipalities of Atlántico department, allowing strategic decision-making for investment, and, therefore, contribute to the development and educational improvement in these areas of the department. For a real case study in the Atlántico department government, the proposed stochastic optimization model establishes 4 location nodes for technology laboratories, which minimize the travel time of students, considering uncertain time scenarios.

Keywords: Two-stage stochastic programming model; Facility location; Technological labora-tories; Education and development

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A two-stage inventory location problem model for resilient and robustness supply chain network design

Giovanni Giuliano; Pablo A. Miranda; Francisco J. Tapia-Ubeda

December 15, 2022 (Thursday), 09:00 - Room 1209

This research addresses the requirement for designing a resilient and robust Supply Chain Network (SCN). Thus, the SCN is able to properly react after the occurrence of disruptive events. The resiliency and robustness must be included into the SCN design process, especially considering the impact of these decisions in the company performance. The problem is addressed though a novel two-stage Inventory Location Problem model, where the scenarios represent events where the located warehouses become unavailable. The model belongs to a Nonlinear Nonconvex Mixed Integer Programming. When a disruptive event occurs, customer assigned to the unavailable warehouses are re-assigned to another available warehouse. For solving the proposed model, a solution approach based on Generalized Benders Decomposition (GBD) is proposed for effectively and efficiently solve the model. The prosed decomposition approach yields a Master Problem considering the strategic decisions (i.e., warehouse location, customer assignment, customer reassignment), and a set of Subproblems involving the tactical decisions (i.e., inventory control). Despite the mathematical complexity of the ILP mode, the proposed GBD-based solution approach ensures optimality for the tested instances in competitive times.

Keywords: Location; Inventory; Generalized Benders Decomposition; Stochastic; Two-Stage; Resilient Supply Chain; Supply Chain Network Design

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Optimal network configuration for multiperiod operation of power distribution systems equipped with smart grid innovations

Ellen Cavalheiro; Christiano Lyra

December 15, 2022 (Thursday), 09:00 - Room 1301

Energy is continuously dissipated in electric transmission and distribution systems due to the electrical resistances in lines and equipment that cause ``technical losses" as currents flow through the networks. This research focuses on reducing technical losses by finding the best network topology for radially operated distribution systems with smart grid innovations, for multiperiod scenarios. The main aspects of smart grid innovations that affect the network reconfiguration problem are distributed generations and batteries in the networks; distributed generations may push voltage values to regions outside the legal bounds, and batteries that allow transferring energy between different time periods. The problem is a generalization of the minimum spanning tree problem, for which costs change as the network configurations change. Furthermore, all loads must be met during each interval of a multiperiod horizon, while satisfying all electrical constraints such as line flow and voltage bounds. This is a difficult combinatorial optimization problem, as the number of possible radial network configurations is associated with a factorial of the size of the network. An optimal solution is a radial configuration that achieves minimal losses and meets all constraints over the multiperiod planning horizon, and unveils the optimal operation for the batteries energy storage. The solution strategy is developed in two levels: at the top level, a metaheuristic built with an architecture of Biased Random-Key Genetic Algorithm (BRKGA) defines the radial structures of the network and looks for the optimal solutions; for each of the radial structures proposed by BRKGA at the upper level, the lower level solves a mixed-integer nonlinear programming model, which defines the best operating policies for the battery and calculates the objective function value. Six distribution networks were used in the case studies to evaluate the methodology.

Funding: The authors kindly acknowledge the support of CAPES, CNPq, Grants No. 88882.329451/2019-01 and 422765/2021-0, and the São Paulo Research Foundation (FAPESP), Grant No. 2016/08645-9.

Keywords: Optimal Network Configuration; Biased Random-Key Genetic Algorithm; Smart Grids

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Renewable energy-based hydrogen supply chains, a Chilean case study for green hydrogen production limited to water conditions

Nicolás Allendes; Francisca Jalil; Tito Homen-de-Mello; Gabriela Pinto

December 15, 2022 (Thursday), 09:00 - Room 1301

Building large-scale green hydrogen supply chains involves strategic decisions that entail high costs and require long construction times. The location of the infrastructure, type and size of technologies to be used, modes of transport between facilities and capacities of storage centers have a direct impact on the costs and efficiency of the supply chains. Based on this, a method is proposed to design supply chains for hydrogen in Chile, considering the proximity to renewable energy generation sources, the wind and solar potentials of each region, its water capacities and availability for seawater desalination, allowing to identify the optimal locations and sizes of the technologies and networks involved in order to reduce negative externalities such as CO2 emissions and unnecessary public expenditures. A mixed integer linear programming model is proposed, which makes investment decisions every 5 years, and operation decisions using typical days, that minimizes the total system cost for a planning horizon between 2020 and 2050. The model chooses the technology type, capacity, and location for wind/solar, electrolysis, and water desalination technologies. In addition, the model chooses the transport mode (pipelines/trucks/transmission lines) of the different flows involved, to find the optimal system configurations for different hydrogen demand scenarios. A second stochastic formulation of this model considers uncertain scenarios of wind and solar potentials. The expected results are green hydrogen supply chain configurations for a set of scenarios, for the Chilean case study, that minimize the levelized cost of hydrogen, using the wind and solar potentials of each region together with their water capacities.

Keywords: "Energy transition plan"; "Green hydrogen"; "Renewable energy system"; "Economic assessment"; "Optimization"

Upstream-Downstream Optimization of Volt-Var Control in distribution networks

Laura Ribeiro Fardin; Christiano Lyra Filho

December 15, 2022 (Thursday), 09:00 - Room 1301

The lecture discusses innovations in methodology to solve the problems of optimal power flows that arise from controlling voltages and reactive power flows (volt-var control) in modern electric power distribution systems that operate with distributed generations and “smart inverters,” with the ability to participate in the control of voltages and reactive power flows. The methodology to achieve the optimal power flow is based on extensions of dynamic programming concepts called UD-DP (upstream-downstream dynamic programming). These ideas merge dynamic programming concepts and network data structures into a methodology suitable for optimizing flows under discrete control variables in radially operated networks. These are attractive for electrical distribution networks permeated by photovoltaic distributed generation (DG), which must deliver energy within the required quality parameters established by regulatory bodies. Failure to comply with these regulations can result in network malfunction, equipment damage, and fines. The proposed methodology incorporates computational efficiency, allowing an online application to reveal viable operating states with minimal energy losses constantly. The control variables are the discrete tap variables in voltage regulators and capacitor banks and the amount of reactive power injected into the grid by smart inverters associated with photovoltaic generators. The control strategy for smart grids in this research assumes that all controllable equipment has the same central controller, which operates at pre-defined intervals of 15 minutes, based on measurements and local adjustments of each equipment (bandwidth, delay, etc.). The methodology was implemented in Python, and case studies illustrate applications in distribution networks from the literature, where there was a significant reduction in total losses and an improvement in the voltage profile of the system buses.

Funding: This work was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES), by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), grants 88887.510356/2020-00 and 304373/2020-6, and by São Paulo Research Foundation (FAPESP), grant 2016/08645-9.

Keywords: Volt-Var Control; Combinatoric Optimization; Dynamic Programming

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Portafolio de generación de energía eléctrica en mercados hidrotérmicos considerando las fuentes no convencionales de energía renovable, caso de estudio Colombia

Maria Camila Aristizábal Cataño; Martha Carolina Lima Rivera; Juan Pablo Orejuela Cabrera; Diego Fernando Manotas Duque

December 15, 2022 (Thursday), 09:00 - Room 1301

El recurso energético se ha convertido en un elemento necesario para la ejecución de las actividades de los sectores económicos y de la ciudadanía en general. Particularmente la energía eléctrica ha contribuido al desarrollo y crecimiento en los países y se ha convertido en una de las fuentes de energía más demandadas a razón de los cambios en la forma de uso de los equipos tanto de la población como de los diferentes sectores económicos. A través de la planificación de la expansión de generación eléctrica se busca garantizar su suministro de forma continua, confiable y que además no incremente el daño ambiental, considerando que a nivel mundial se han planteado metas de descarbonización que buscan minimizar el uso de fuentes fósiles para la generación de energía. Desde el contexto colombiano, la generación de electricidad presenta dependencia a la fuente hídrica, dado que el 67.25% de la capacidad instalada funciona a través de ella. Esto implica riesgos en el suministro debido a la variabilidad de la disponibilidad de este recurso frente a fenómenos climáticos como El Niño. Ante estas consideraciones, la inclusión de las FNCER dentro de los portafolios de generación de electricidad ha cobrado interés dado los beneficios en términos de diversificación, competitividad y reducción de emisiones que estas proporcionan, además de la posibilidad de afrontar de forma eficiente los retos que se presentan en momentos de escasez hídrica. Sobre esta lógica, se propone un modelo de optimización multiobjetivo que considere el incremento de la participación de las FNCER a través de la activación de potenciales proyectos de generación de electricidad y cuyas funciones de desempeño buscan minimizar del portafolio: su varianza en todo el horizonte de planeación, su LCOE marginal y sus emisiones totales generadas. Como elemento diferenciador se considera de manera explícita los proyectos potenciales de generación de acuerdo con el Banco de Proyectos de la UPME.

Keywords: Generation Expansion Planning (GEP).; Fuentes no Convencionales de Energía Renovable (FNCER).; Dependencia Energética.; Levelized cost of energy (LCOE).; Descarbonización.

On Optimal MTZ-like Formulations For The Asymmetric TSP
Gustavo Angulo; Diego Moran

December 15, 2022 (Thursday), 09:00 - Room 1302

The Miller-Tucker-Zemlin (MTZ) formulation is one of the simplest yet versatile formulations for the Asymmetric Traveling Salesman Problem (TSP). We study the strength of an extension where unit-length arcs are replaced with arbitrary distances. We show that the formulations in this family are non-comparable, but their intersection is characterized by optimal choices of the distance vectors. We provide explicit descriptions and compare with existing formulations from the literature.

Keywords: Traveling Salesman Problem; Miller-Tucker-Zemlin; Integer Programming

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Efficient team orienteering problem: A sightseeing tour optimization
Ondřej Sokol; Vladimír Holý

December 15, 2022 (Thursday), 09:00 - Room 1302

We discuss a modification of the traveling salesman problem that finds the optimal route by maximizing the ratio between the time spent at places of interest and the time spent moving under constraints of a set of mandatory places, a minimum number of visited optional places, and a maximum total time. While the problem is non-linear in objective function, it can be linearized using the Charnes--Cooper transformation. However, even then, in practice, finding the optimal solution is significantly more difficult than in the standard traveling salesman model. We propose some heuristics exploiting the special properties of the problem.

Keywords: traveling salesman problem; orienteering problem; integer programming

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A comparison between exact and non-exact methods for solving the Capacitated Family Traveling Salesperson Problem
Saúl Domínguez Casasola; José Luis González Velarde; Yasmín Á. Ríos Solís

December 15, 2022 (Thursday), 09:00 - Room 1302

Radio frequency identification (RFID) systems and other technologies in warehouses allow locations with different products, as well as products located in different locations. This has impacted the picking practices, since we need to decide which locations should be visited to fulfill orders. If the locations to pick are properly chosen, the distances traveled within the warehouse can be reduced, and thus have a favorable effect on the picking process. This real problem motivated the formulation of the capacitated family traveling salesperson (CFTSP), which is a variant of the family traveling salesperson problem introduced by Morán-Mirabal et al. in 2014. In the CFSTP we incorporate not only a demand for each family on the graph but also a set of capacitated agents, and weights for each node families. Consider a complete and directed graph, where nodes are partitioned into disjoint families: The CFTSP consists in finding the subset of nodes that must be visited by the capacitated agents for each family to minimize the total distance traveled. To solve the CFTSP we propose a mixed integer linear programming model, a constraint programming model, a Biased Random-Key Genetic Algorithm and a Greedy Randomized Adaptive Search Procedure. We test all the proposed ways to face the CFTSP and discuss the results and provide conclusions about them.

References:

Luis Fernando Morán-Mirabal, José Luis González-Velarde y Mauricio G.C. Resende. Randomized heuristics for the family traveling salesperson problem. International Transactions in Operational Research, 21(1):41– 57, 2014.

Keywords: GRASP; BRKGA; MILP; Constraint Programming; CFTSP

The Multiperiod Set Team Orienteering Problem with Time Windows
Natalia Villanueva De la Fuente; Carlos Obreque Níñez; Guillermo Latorre Núñez; Patricio Álvarez Mendoza; Alex Barrales Araneda; Carlos Bizama Fica

December 15, 2022 (Thursday), 09:00 - Room 1302

El Orienteering Problem (OP), también conocido como TSP selectivo, es una combinación de la selección de clientes y la determinación de la ruta más corta. Su objetivo es maximizar la ganancia obtenida de cada cliente visitado, tal que la duración del recorrido no exceda un tiempo predefinido. En el Set Orienteering Problem (SOP), los clientes se agrupan en clústeres disjuntos, y la ganancia de cada clúster se recopila sólo si al menos uno de sus clientes es visitado. Al igual que en el OP, el SOP tiene una restricción de tiempo límite, que solo permite que se puedan visitar a un subconjunto de clústeres. Una extensión más reciente es el Set Team Orienteering Problem with Time Windows (STOPTW), en el que los clientes están agrupados en clústeres disjuntos y se les asocia un beneficio por clúster, el cual se cobrará si uno de los vendedores visita al menos uno de sus clientes. El objetivo es maximizar el beneficio total recogido para cada vendedor sin violar las ventanas de tiempo ni las restricciones de límite de tiempo para cada uno de ellos. En este trabajo se extiende el STOPTW al caso de múltiples periodos, denominado Multi-period Set Team Orienteering Problem with Time Windows. En este nuevo problema se considera un horizonte de T periodos, un conjunto de M vendedores y un conjunto de L clústeres que pueden ser visitados a lo más una vez durante los T periodos. Cada clúster establece el o los periodos en que puede ser visitado y cada uno de sus clientes tiene una ventana de tiempo asociada a tales periodos. El objetivo es encontrar para cada vendedor, y en cada periodo, una ruta que comience y termine su recorrido en el depósito, maximizando el premio total recolectado durante los T periodos. Se propone un modelo de programación lineal entera mixta que encuentre la solución óptima de un conjunto de instancias obtenidas de la literatura. Todas las instancias son resueltas utilizando el lenguaje de programación algebraico AMPL con el Solver Cplex.

Keywords: Programación lineal entera mixta; Set Team Orienteering Problem; Ventanas de tiempo; Múltiples periodos

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Mean-Variance optimization in pairs trading using ultra-high-frequency data
Petra Tomanová; Vladimír Holý

December 15, 2022 (Thursday), 09:00 - Room 1303

We present a stochastic spread approach to the intraday pairs trading strategy using ultra-high-frequency data. The spread process is modeled by the Ornstein-Uhlenbeck process with continuous time. To avoid bias in parameter estimation due to the microstructure noise of the ultra-high-frequency data, we propose three noise-robust estimators. For the optimal trading signals, we focus on the mean-variance optimization and determine the first-passage times of the process. In our empirical study, we analyze stocks of 7 Big Oil companies traded on the New York Stock Exchange. We find that the use of the proposed estimators of the Ornstein-Uhlenbeck process with the correct treatment of the market microstructure noise leads to a significant increase in the profitability of the pairs trading strategy.

Keywords: Ornstein-Uhlenbeck Process; High-Frequency Data; Market Microstructure Noise; Mean-Variance Optimization; Pairs Trading

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Applying a multi-objective evolutionary algorithm in portfolio optimization
Carlos Rodriguez; Katya Rodriguez

December 15, 2022 (Thursday), 09:00 - Room 1303

In this study, we explore the application of a Multi-Objective Evolutionary Algorithm based on Decomposition (MOEA/D) in Portfolio Optimization (PO). Harry Markowitz's Modern Portfolio Theory neglects real-life problems that portfolio managers face in the industry, resulting in simple portfolio optimization models that could be easily solved using a traditional method such as Quadratic Programming. Classical PO has traditionally been solved as a single objective optimization with

either one of the following model formulations: The investor minimizes the risk exposure subject to a minimum attainable expected return or the investor maximizes the expected return for a given level of risk. But the financial market behaviour causes the portfolio management process to become even more complex, making it clear that the PO needs to be solved according to its very nature as a multi-objective problem. Advances in Operations Research and Computer Science have risen to new solutions to PO, among them the metaheuristic approach has produced some acceptable tools. But only until recently (a couple of years or so), a multi-objective metaheuristic named MOEA/D has begun to be applied for POP. This algorithm decomposes a multi-objective optimization problem into subproblems and then evolutionary algorithms are employed to optimize these sub-problems simultaneously. In this research, the authors prove such an algorithm to find its goodness in producing portfolios near to the optimum. To evaluate the efficiency, we do the defacto proof in Finance which is a benchmark against an Index (we choose the S&P 500 Index) to see if the portfolio produced with MOEA/D yields alpha, in other words, to see if the portfolio produces a better return than the Index.

Keywords: Metaheuristics; Multiobjective Evolutionary Algorithms; Portfolio Optimization.

A review about the use of metaheuristic algorithms for solving bilevel programming problems: beginnings, consolidation and present

José-Fernando Camacho-Vallejo; Juan G. Villegas; Carlos Corpus

December 15, 2022 (Thursday), 09:00 - Room 1303

A bilevel programming model represents the relationship in a specific decision making process that involves two decision makers that consider a hierarchical structure among them. The upper level is associated with the decision maker with higher hierarchy, while the lower level is associated with the other decision maker, whose problem is nested in the higher hierarchy level. This modeling approach has been applied in several real life situations. For example, toll setting problems, vehicle routing, telecommunication networks, energy markets, among others. In the simplest case of bilevel problems, that is, in the version in which both decision levels are linear programming problems, the resulting bilevel problem is NP-hard. Due to the latter, it is complicated to propose exact methods to solve bilevel problems. A convenient alternative is to design and implement metaheuristic algorithms to obtain good quality solutions within a reasonable computational effort. This research direction has been very active in recent years. Particularly, a significant increase has been notice in the last three years. In this talk, an extensive literature review of all the published papers devoted to solve bilevel problems by metaheuristic algorithms is discussed. Furthermore, a classification based on the components involved in each of the metaheuristics revised is shown. The classification neglects the name and the inspiration of the algorithms reviewed, but it is done based on the characteristics of each algorithm. Some illustrations will be shown to evidence the most preferred algorithms, and the actual tendency of application of metaheuristics will be emphasized. Finally, some future research directions that must be into consideration for maintaining feasibility in the solutions, in terms of the formal concepts of bilevel programming.

Keywords: Bilevel programming; Metaheuristics; Literature review

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An adaptive BRKGA-QL to solve the Patient Bed Assignment Problem and the Operating Room Scheduling Problem

Bruno Vieira; Antonio Augusto Chaves

December 15, 2022 (Thursday), 09:00 - Room 1303

Hospital management is an arduous task that requires solving different optimization problems. Among these problems, we can cite the Patient Bed Assignment Problem (PBAP) and the Operating Room Scheduling Problem (ORSP). The PBAP consists of managing, in the best possible way, a set of beds with particular characteristics and assigning to them a set of patients with special requirements. The ORSP consists of creating a schedule that specifies which operating teams should be allocated to each operating room over the planning horizon. These problems are classified in the class of NP-hard problems. In this paper, we proposed an adaptive Biased Random-Key Genetic Algorithm combined with the Q-Learning method (BRKGA-QL) to solve an integrated approach with

PBAP and ORSP that is modeled as flexible job-shop scheduling. We also developed a lower formulation to evaluate the heuristic performance in two case studies. The first one is available in the literature from an Australian hospital. The second one is modeled from a Brazilian hospital as realistic as possible and has different constraints, including a surgeon and machine scheduling added to the room scheduling and a more flexible available hours schedule for rooms and surgeons. The computational experiments show that the BRKGA-QL found better results than the previous ones in the literature and the lower bounds provided by the formulation are very close to the instances without working hours constraints. Considering the Brazilian case, the BRKGA-QL is efficient in finding good solutions in a hospital scheduling, previously solved manually.

Keywords: Hospital scheduling; Metaheuristic; Machine Learning

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Bounds and heuristics for Multi-Product Personalized Pricing
Guillermo Gallego; Gerardo Berbeglia

December 15, 2022 (Thursday), 09:00 - Room 1304

We present tight bounds and heuristics for multi-product pricing strategies, including heuristics for non-personalized and personalized pricing with applications that bound linear vs non-linear pricing strategies, and bundling heuristics relative to optimal bundle pricing. Under mild conditions we show that offering a non-personalize price in the direction of a given positive vector has a tight profit guarantee relative to optimal personalized pricing. The results can also be used to find heuristics for the non-personalized problem, which is often more difficult to solve relative to the personalized version. A direction that achieves the best possible worst case performance guarantee is presented. We also present an economically motivated direction that performs well on average. Our results yield a tight lower-bound on the performance of linear pricing relative to personalized non-linear pricing and suggests effective non-linear price heuristics relative to personalized solutions. Additionally, our model provides tight guarantees for bundle-size pricing and component-pricing relative to optimal personalized bundle pricing. Performance can be often improved by clustering customer types and offering each cluster a direction along which it can price. Numerical results for a variety of demand models are presented. Our experiments show that the k-means clustering heuristic performed significantly better on average than the FPF (farthest point first) clustering heuristic.

Keywords: pricing optimization; approximation algorithms; demand models

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Economía circular y sistemas productivos en países del Sur Global: ¿Fomentando nuevos commodities?
Paloma Ñuñez-Muñoz; Óscar C. Vásquez

December 15, 2022 (Thursday), 09:00 - Room 1304

En los países tanto desarrollados como en vías de desarrollo, la recolección de residuos y su posterior reprocesamiento se ha vuelto un tema de vital importancia debido a una serie de medidas medioambientales que buscan regular la cantidad generada y fomentar la economía circular. Sin embargo, el reprocesamiento requiere de un desarrollo tecnológico en los sistemas productos asociados y un mercado que permita su viabilidad, componentes que no siempre se encuentran en todos países, en particular aquellos del Sur Global. En este estudio exploramos el comportamiento de los países que teniendo legislación que fomenta el reprocesamiento, no presentan sistemas productivos y económicos eficientes para llevarlo acabo. Nuestra investigación busca responder si el fenómeno de considerar la economía circular de un país sin un plan productivo asociado implicaría un nuevo negocio de commodities "verdes" que son exportados sin un valor agregado, y que luego vuelven al país de origen, reprocesados a un mayor costo, generando riquezas en el exterior. Formalmente, se analizan las características de esta situación basado en los registros oficiales de la U.N. Comtrade, se propone un modelo económico que lo describe y se estudian escenarios que posibiliten el avanzar y adoptar los procesos productivos requeridos - generalmente utilizados por países desarrollados- proveyendo algunas perspectivas para políticas en el futuro.

Keywords: Economía Circular; Sur Global; Sistemas productivos; Commodities

Mapping the startup ecosystem of emerging countries: Methodological challenges and policy implications for Serbia

Veljko Jeremic; Vesna Damnjanovic; Radmila Janicic

December 15, 2022 (Thursday), 09:00 - Room 1304

The mapping of the Startup Ecosystem has long been a challenge, both for researchers and policymakers. From a policymaker's point of view, determining the current state of development, issues and challenges, all of which influence the directions of governmental actions. On the other hand, researchers have persisted with the emphasis given on the methodological aspects of choice of indicators depicting the startup ecosystem, weighting scheme underlying the composite indexes of startup ecosystem evaluation, etc. At the confluence of two sides of the same coin, lies the Global Startup Ecosystem Report, and its flagship Rankings 2021 for Top 100 Emerging Ecosystems. The list itself encompasses the hotspots of the early-stage startup ecosystems across the Globe and is founded upon four domains: Performance, Funding, Market Reach and Talent & Experience. The paper will tackle both the methodological aspects of composite index developments by utilizing the potential of multivariate statistical methods while laying the foundation for policy implications which can benefit emerging countries such as Serbia. Finally, future directions of potential improvement of the Global Startup Ecosystem methodology will be elaborated.

Keywords: Startup Ecosystem; Global Startup Ecosystem Report; Emerging Countries; Multivariate Statistical Methods; Composite Index

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Efficiency and performance evaluation model of collective investment funds in Colombia

Eduar Fernando Aguirre Gonzalez; Diego Fernando Manotas Duque; Pablo Cesar Manoyoma Velásquez

December 15, 2022 (Thursday), 09:00 - Room 1304

Alternative investments have been vital in large investment portfolios worldwide, especially in emerging countries. Likewise, due to the lack of structured information on this type of investment, the large portfolios of institutional entities such as pension funds and trust funds have taken the position of investors with end and not means objectives. That is to say, it does not guarantee profitability, but rather it depends on the performance of these investments. That is to say, it does not ensure profitability but instead relies on the performance of these investments. We find a particular type of "speculative" collective portfolio called Collective Investment Funds, FICs (acronym in Spanish: Fondo de Inversión Colectiva). This type of investment sees a higher return by including alternative investments in isolation or as part of a portfolio composed of traditional assets. Hypothetical collective portfolios are those whose main objective is to carry out speculative operations, including the possibility of carrying out operations for amounts more significant than those contributed by the investors (leverage). FICs are any mechanism or vehicle for raising or managing sums of money or other assets with the contribution of a plural number of people that can determine once the fund becomes operational. In addition, it will manage the resources collectively to obtain collective economic results. This research aims to design a performance measurement model for FICs combining nonparametric and metaheuristic techniques for these funds in Colombia.

Keywords: Efficiency; Performance; Alternative Investments; Collective Investment Fund

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Annualized hours contract with flexible working day: A personnel planning approach

Andrés Porto Solano; Paola Cruz Mayoral; Anyela Mejía Nuñez; Yira Pedrozo Contreras; Sebastián Herazo Pretelt; Lina Piocuda Vasquez

December 15, 2022 (Thursday), 09:00 - Room 1305

Human resource planning (HR) has become a vital aspect within any organization, for this reason, companies direct their efforts to find efficient ways to carry out such planning. With a general case study in a Chilean retail store, a mixed integer linear programming model is proposed, in which a Tour scheduling is represented for a year, considering annualized working contracts (i.e., which allows the

irregular distribution of weekly working hours throughout the year) with flexible shifts (i.e., different lengths of working shifts per day, in the same week). The results obtained shows that the approach is quite attractive in costs terms, and robustness in the face of seasonality and variability scenarios in demand.

Keywords: Personnel planning; Annualized working hours; Flexible shifts

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Design of a realistic multifunctional staffing model for the reduction of labor force costs in the retail sector

Jennifer Izquierdo-Salazar; Sofía Charry-Alvernia; Sebastián Orjuela-Isazaa; Ronaldo Caicedo-Scarpetta; Daniel Morillo-Torres; Gustavo Gatica

December 15, 2022 (Thursday), 09:00 - Room 1305

The retail sector has been known for the high participation of the operational workforce it requires. In this context, factors such as demand variability represent one of the great challenges when it comes to allocating personnel, due to the under and over-staffing problems it represents. This generates increases in the costs associated with human resources, as well as the deterioration in the level of service of the companies. One of the proposals that has shown remarkable results facing situations like this is the use of a polyfunctional (muti-skilling) workforce, since it allows to generate a reduction in workforce costs. Through this project, a more realistic adapted linear programming model was designed according to the Colombian context, which takes advantage of the benefits of the implementation of polyfunctionality in the allocation of personnel. The project is based on two objectives, applied to different instances with a different number of departments and variations in demand. The first is to minimize the costs associated with human resources. In this case, the model achieved a reduction of up to 37% in total costs. The second objective of the project is to achieve a minimum service level of 92%. For this item, the model achieved an increase of 9% in relation to the manual method used in companies, obtaining an average service level of 97%. The results also indicate that the more homogeneous the demand for personnel is, the greater the percentage reduction in total costs. Additionally, it was evidenced that the use of contracts with shorter durations and more varied shifts allowed the satisfaction of requirements more efficiently.

Keywords: Rostering staff problem; scheduling staff problem; polyfunctional staff; integer programming

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Labor Flexibility Strategies: Annualized hours, multiskilling and overtime to solve an a Personnel Scheduling Problem

Andrés Porto; César Henao Botero; Amaia Lusa; Oliver Polo; Roberto Porto

December 15, 2022 (Thursday), 09:00 - Room 1305

This study provides a new perspective regarding the potential benefits of combining three different labor flexibility strategies to solve an annual staffing problem. These labor flexibility strategies are as follows: (i) annu alized hours, which allows an irregular distribution (e.g., weekly, monthly) of an annual number of working hours per employee hired; (ii) multiskilling with 2-chaining, which involves employees being trained to work on up to two task types, so that the training structures form closed chains; and (iii) overtime. A mixed integer linear programming model is proposed to determine how many employees will be hired, how many of them will be multiskilled and in what task types, and how will be the weekly allocation of ordinary and overtime hours for each employee type (single-skilled or multiskilled) according to the agreed annualized hours contract. For a case study in the Chilean retail industry, the results showed that the proposed triple labor flexibility strategy reported greater savings in total cost compared to the single or double flexibility strategies. The results also indicated that multiskilling and overtime are complementary sources of flexibility under an annualized hours contract. In fact, for different store sizes, patterns of seasonality in demand and levels of variability in demand, the proposed strategy achieves close to 100% coverage in demand and over/understaffing levels of approximately 0%.

Keywords: Staffing problem; Labor flexibility; Annualized hours; Multiskilling; Overtime; Retail

Production and inventory planning of silk skeins from the breeding of Bombyx Mori worms using mathematical models

Sara Ruth Peralta Chavez; Sara Alexandra Ruiz Díaz Villagra; María Margarita López de Recalde; Jorge L. Recalde-Ramírez

December 15, 2022 (Thursday), 09:00 - Room 1305

The silk industry in Paraguay is still incipient. The sericulture was inserted in the seventies in the departments of San Pedro, Itapúa, and Caazapá, with a spinning mill in Alto Paraná. Today, the commercial and logistics sector has become more dynamic to the point that access to raw materials - blackberries, eggs, and cocoons - does not present significant challenges beyond the necessary investment and good planning of operations. Also, the industry has excellent potential for generating employment in rural areas due to the interest of silk fabric producers abroad and alliances between public and private institutions. To complement the investment project of González (2020), "Industrialization of Fresh Silk Cocoons from the Breeding of the Bombyx Mori Silkworm," we propose to design mathematical programming models. This work focuses on developing production and inventory plans to obtain skeins of silk from breeding Bombyx Mori worms, considering aspects related to productive operations, from the harvest of blackberries to the inventory of three types of silk skeins (final products). We obtained results for models that were solved stepwise and are related to the production and inventory of silk skeins, silkworms, and blackberries leaves used to feed the worms. We employ Gurobi 8.1.1 optimization software with the Python programming language to solve the models.

Keywords: Production and inventory planning; Silk industry; Mathematical model

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Finding the bottleneck in hospital emergency departments considering the COVID 19 pandemic. Insights from a simulation approach and a case study

David Mora-Meza; Julian Alberto Espejo-Díaz; William Guerrero

December 15, 2022 (Thursday), 09:00 - Room 1306

Emergency departments in hospitals are a crucial part of the health care systems around the world. They provide emergency medical services to patients who need urgent treatments. Due to the multiple sources of variability and uncertainty in their operations, they are considered complex systems. In addition, since the emergent of COVID-19, hospitals have adapted their operations to decrease the contact between patients and medical staff to minimize the infection rate. In this study, we propose a methodology for identifying the bottlenecks in emergency departments to evaluate different scenarios and propose policies considering disruptions such as the COVID-19. The methodology uses a discrete event simulation model to represent and compare the operations of an emergency department before and after considering the regulations regarding the classification and attention of patients with respiratory symptoms. We test the approach using data from a real case study of a hospital that adapted its facilities to classify respiratory and non-respiratory patients. The main computational results show the impact of such differentiation, and by evaluating multiple scenarios, we provide some insights for post-COVID adaptations. In this way, hospitals can be more prepared for the following possible disruptions.

Keywords: Health systems; discrete-event simulation; emergency department; bottleneck; hospital logistics; analytics

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Simulación de agente para la modelación de la epidemia COVID-19 mediante cuarentenas intermitentes

Natalia Karstegl; Manuel Vargas; Miguel Alfaro; Guillermo Fuertes; Diego Muñoz

December 15, 2022 (Thursday), 09:00 - Room 1306

Este trabajo propone la implementación de un modelo basado en agentes para comprender el impacto en la salud pública de las medidas de cuidado personal, la priorización de hospitales y la cuarentena intermitente. Se analizaron cuatro escenarios: (1) un escenario base, sin restricciones, ni

medidas de cuidado personal, (2) un escenario con medidas de cuidado, (3) un escenario con cuidado personal y priorización de hospitalización para adultos mayores, y (4) un escenario con cuarentenas intermitentes. Los resultados de la simulación de la epidemia basada en agentes permiten verificar la reducción de la curva de mortalidad y la duración total de la pandemia, mediante el uso de medidas de protección personal y la priorización de la hospitalización de las personas mayores. Sin embargo, el escenario de cuarentena intermitente tiene el mejor desempeño sanitario. Este modelo de estrategia de cuarentena intermitente aprovecha los tiempos de contagio de la enfermedad COVID-19 para aislar a la población los días posteriores a la posible exposición, y permitir su regreso a sus actividades económicas al finalizar la fase de contagio en un ciclo permanente de 5 negocios. días y 10 días de cuarentena. Finalmente, el modelo propuesto es de código abierto, para permitir que otros investigadores evalúen diferentes escenarios en función de las características particulares de la población de estudio.

Keywords: Biological system modeling; COVID-19; multiagent systems; prognostics; health management

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Estimation of the quantile function using Bernstein polynomials and its use for steady state simulations and VaR estimation

Jaromír Antoch; Lev Klebanov; Michal Cerny

December 15, 2022 (Thursday), 09:00 - Room 1306

Density, distribution function, and quantile function play a crucial role in both stochastics and operations research. While the main attention has been focused on the estimators of density and distribution function, the quantile function was set surprisingly apart from the main stream of interest. In fact, aside the empirical quantile function, statisticians concentrated especially on order statistics and their combination as “appropriate” estimates of quantiles. Therefore, in the lecture, we introduce a class of quantile function estimators based on Bernstein polynomials and show its properties. Especially, we show that convergence of the suggested estimator is uniform and give rate of this convergence under appropriate assumptions. To the best of our knowledge, with the exception of papers [2] or [4], Bernstein polynomials and their variants were practically not used for that purpose. An application of the suggested estimators in the field of resampling and steady state simulations, that play a crucial role in accurately evaluating the long-run performance, risk of complex systems or analyses of financial portfolios, will be given; compare [1], e.g. Aside that, we will also show its use for the value at risk (VaR) estimation; see [3], e.g.

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Keywords: quantile function; Bernstein polynomials; steady state simulations

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A simulation model to analyze the behavior of a faculty retirement plan. A case Study in México

Marco Antonio Montufar-Benitez; Jaime Mora-Vargas; Carlos Arturo Soto-Campos; Gilberto Pérez-Lechuga; José Raúl Castro-Esparza

December 15, 2022 (Thursday), 09:00 - Room 1306

The main goal of this study was to determine confidence intervals for average age, average seniority, and average money-saving, for faculty members in a University retirement system using a simulation model. The simulation – built-in Arena– considers age, seniority, and the probability of continuing in

the institution as the main input random variables in the model. An annual interest rate of 7% and an average annual salary increase of 3% were considered. The scenario simulated consisted that the teacher and the university do contributions, the faculty (5% of his salary), and the university (5% of the teacher's salary). Since the base salaries with which teachers join to university are variable, we considered a monthly salary of MXN 23,181.16, corresponding to full-time teachers with middle salaries. The results obtained by a simulation of 30 replicates showed that the confidence intervals for the average age at retirement were (51.6862, 51.9452) years, for the average seniority (13.4, 13.54) years, and for the average savings amount (630512.88, 638377.2) MXN. Moreover, the risk that a retiree of 60 years of age and 30 years of work, is alive after his savings runs out is more than 90 % and this happens approximately at 64 years of age.

Keywords: Simulation; Modeling; Retirement Plan; Faculty

Optimization of log Inventory and log routing by column generation

Ignacio Vitale; Mariana Cóccola; Rodolfo Dondo

December 15, 2022 (Thursday), 09:00 - Room 1307

Given the supply of several types of logs from a set of forest areas and given demanded quantities of them by a set of mills, a decomposition procedure aimed at optimizing log transportation routes and inventory levels in forest areas, transshipment yards and mills is presented. While forest areas act as suppliers and mills as sinks of logs, transshipment yard may receive logs from forests and supply them to mills in order to save logistic costs. The decomposition procedure is based in the column generation paradigm which handles the problem by decomposing it into a master problem which handles inventory constraints on facilities and sub-problems that iteratively add routes to the master problem. While the master problem deals with products flows and implicit storage decisions, the lower-level problems generate routes. The LP master is solved by CPLEX while sub-problems are solved by an ad-hoc labeling procedure. The objective function of the master problem is a weighted sum of transportation and inventory costs on all facilities while the objective function of sup-problems are the reduced cost of generated routes. As the problem involves a set of $|T|$ time periods, the algorithm must feed the duals associated to the constraints of the master problem to $|T|$ sub-problems which have the same structure but differ just in the values of the duals they receive. This allows feeding routes generated for one period of time into the other periods if they retain a negative reduced cost when duals associated to time periods are changed. Although the idea behind the algorithm is simple, the computational implementation demands a complex work. The algorithm was built in PYOMO. Integer solutions were obtained by running a MIP on the pool of generated columns. Several illustrative examples were solved. Further work should include the embedment of this algorithm into a branch-and-price mechanism in order to get an exact algorithm and optimal solutions.

Keywords: Logs transportation; Logns inventory; Column generation

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Cutting stock problem integrated to the minimization of weighed tardiness

Felipe Lemos; Adriana Cherri; Silvio Alexandre de Araujo

December 15, 2022 (Thursday), 09:00 - Room 1307

This paper addresses the problem of minimizing weighed tardiness and raw material costs in cutting operations. Some industrial applications, particularly assembly lines, can have relevant costs because of not meeting due dates, even heavier than material waste. So, the classic cutting stock problem can deliver unsatisfactory practical results. Particularly, we analyze the case in which processing times of cutting patterns are dependent on the items cut. Different from the independent case, it remains unexplored in the literature. A mixed integer linear programming formulation is proposed, with a column generation procedure as the solution method and a heuristic procedure to obtain an integer solution. Valid inequalities were formulated to improve computational performance. Also, lower bounds were improved using dynamic programming, since the optimal solution of the linear relaxation led to big gaps. Computational results were composed of a real-life industrial instance and a set of randomly generated instances. The first was based on an aircraft assembly line supplier and improved the factory method both in raw material waste and tardiness cost, leading to

42,2% economy of costs. Random instances were generated aiming to explore how parameters influence the performance of the model proposed, particularly scenarios of the tightness of due dates, the size of the items, levels of demand and cost of tardiness of the items relative to the raw material. Results were analyzed statistically using analysis of variance. The main findings of these experiments were that (i) tighter due dates implicated on bigger gaps and smaller material costs, (ii) the prevalence of smaller items implicated on bigger gaps and computational processing times, besides better occupation of objects, (iii) demand levels have not affected significantly neither gaps nor computational times and (iv) more heavy weighs for tardiness costs implicated bigger gaps and less raw material relative costs.

Keywords: cutting stock problem; tardiness; integrated problems; column generation; dynamic programming

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A new branch and price algorithm for the Stop Number Minimization Problem
Victor Hugo Nascimento; Luidi Gelabert Simonneti

December 15, 2022 (Thursday), 09:00 - Room 1307

The stop number minimization problem (SNMP) considers a fleet of autonomous vehicles operating in a closed circuit of stations picking up and dropping off cargo or passengers. The objective is to minimize the number of stops of all vehicles while satisfying all demands and considering each vehicle's capacity. We model this problem as a pickup and delivery variant and propose a new branch and price algorithm approach to solve the SNMP. Thus, the pricing problem is modeled as a shortest path problem with resource constraints (SPPRC) and solved via well know labeling algorithms in the routing problem literature. Moreover, the closed-circuit structure of the problem allowed the introduction of ordered small graphs and strong dominance rules, which greatly reduced the pricing computation times. Overall results were competitive with previous works available in the literature, and we introduced and solved new instances with up to 80 requests.

Keywords: column-generation; branch-and-price; routing-problems; dial-a-ride; pickup-and-delivery

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Computational aspects of column generation methods for nonlinear optimization
Renaud Chicoisne

December 15, 2022 (Thursday), 09:00 - Room 1307

Solving large scale nonlinear optimization problems requires either significant computing resources or the development of specialized algorithms. For Linear Programming (LP) problems, decomposition methods can take advantage of problem structure, gradually constructing the full problem by generating variables or constraints. We first present a direct adaptation of the Column Generation (CG) methodology for nonlinear optimization problems, such that when optimizing over a structured set X plus a moderate number of complicating constraints, we solve a succession of 1) restricted master problems on a smaller set S □ X and 2) pricing problems that are Lagrangean relaxations wrt the complicating constraints. The former provides feasible solutions and feeds dual information to the latter. In turn, the pricing problem identifies a variable of interest that is then taken into account into an updated subset S′□X. Our approach is valid whenever the master problem has zero Lagrangean duality gap wrt to the complicating constraints, and not only when S is the convex hull of the generated variables as in CG for LPs, but also with a variety of subsets such as the conic hull, the linear span, and a special variable aggregation set. We discuss how the structure of S and its update mechanism influence the convergence and the difficulty of solving the restricted master problems, and present linearized schemes that alleviate the computational burden of solving the pricing problem. We test our methods on synthetic portfolio optimization instances with up to 5 million variables including nonlinear objective functions and second order cone constraints. We show that some CGs with linearized pricing are 2-3 times faster than solving the complete problem directly and are able to provide solutions within 1% of optimality in 6 hours for the larger instances, whereas solving the complete problem runs out of memory.

Keywords: Nonlinear Optimization; Conic Programming; Column Generation; Lagrangean Duality;

Portfolio Optimization

Integrality of the representation polyhedron for circular-arc models
Pablo Terlisky; Francisco Soulignac; Javier Marenco

December 15, 2022 (Thursday), 09:00 - Room 1308

A proper circular-arc (PCA) model is a pair M = (C, A) such that C is a circle and A is a finite family of inclusion-free arcs of C. Each arc A of A has two endpoints: its beginning point s(A) and its ending point t(A), which are the first and last points of A reached when C is traversed clockwise, respectively. A PCA model is a (c, l)-CA model when the circumference of the circle is c and all arcs of A have length l. Two PCA models are equivalent if the endpoints of their arcs appear in the same order when C is traversed clockwise. If there is a point in C that is not contained in any arc of A, we say that M is a semiorder. For any given PCA model M, a representation problem for M is one in which the objective is to find a model M' equivalent to M that satisfies some given numerical constraint. If the representation problem asks for a (c,l)-CA model, then the problem can be seen as a system of inequalities where the variables are values of c, l, and the beginning points of all the arcs of A except one. Thus, it describes a convex polyhedron in the R^{|A|+1} space which we call the representation polyhedron of M. In the case of semiorders, Balof, et al showed that representation polyhedrons are totally dual integral, showing therefore that any solution to a linear optimization over them is integral. In their work they allude to the work of Pirlot, who showed that in the context of semiorders the representation problem constitutes a system of difference constraints and can be studied by analyzing the cycles of a digraph he called the synthetic graph of M. Recently, Soulignac generalized the concept of the synthetic graph to apply to all PCA models. In this work we show that the properties of synthtetic graphs allow us to state that indeed the representation polyhedron for any PCA model M has integral vertices, answering one of the open questions of Soulignac's paper. When restricted to semiorders, this result provides a much simpler proof for Balof et. al's results.

Keywords: circular-arc model; linear programming; semiorder; representation polyhedron; synthetic graph; difference constraints

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On a characterization of graphs with perfect neighbourhood matrices
Mariana Escalante; Erica G. Hinrichsen; Valeria Alejandra Leoni

December 15, 2022 (Thursday), 09:00 - Room 1308

The main purpose of this work is to study those graphs G with perfect neighbourhood matrix, N[G]. This property implies the resolution of many optimization problems in polynomial time due to the integrality of the polyhedron of feasible solutions of their linear relaxations. Given a 0-1 matrix M with n columns, Q(M) is the graph with n nodes and such that two nodes i and j are adjacent in Q(M) if there is a row in M with two ones in the corresponding positions. A 0-1 matrix is perfect if it is the clique-node matrix of Q(M) and Q(M) is a perfect graph. Due to the Perfect Graph Theorem, a graph is perfect if it has neither an odd hole nor an odd antihole as a node-induced subgraph. A square 0-1 matrix is an extended clique node matrix of a graph G if every maximal clique in G has its characteristic vector as one of its rows and the remaining rows (if any) correspond to (non)-maximal cliques in G. First, in order to give a characterization of a graph with an extended clique node neighbourhood matrix, we define the set T of seven graphs, including the chordless cycles of length between 4 and 6, and the 3-sun, 1-pyramid, 2-pyramid and 3-pyramid graphs. We prove that N[G] is an extended clique node matrix if and only if every node-induced subgraph of G in the set T has a common neighbour in G. We say that G' is a dominating subgraph of G in the node-set U if for every node of G not in V(G'), there exists a node w in V(G') such that its neighbourhood N[v] is a subset of N[w], restricted to the nodes in U. We found two families of graphs, called H-graphs and A-graphs. Using the previous definitions, we prove that Q(N[G]) does not have an induced odd hole if and only if G has no dominant H-graph, in an appropriate set of nodes of V(G). Finally, we show that Q(N[G]) does not have an induced odd antihole if and only if G has neither an A-graph nor a web graph W^{t}_{4t+3} as dominant subgraphs, in an appropriate set of nodes of V(G).

Keywords: PERFECT GRAPH; CLIQUE NODE MATRIX; PERFECT MATRIX

Planificación del ciclo productivo de lotes avícolas en granjas parrilleras. Caso de estudio
Blanca Irene Rios Ceupen; Jose Colbes; Diego P. Pinto-Roa

December 15, 2022 (Thursday), 09:00 - Room 1308

El trabajo propone un cambio de paradigma de la cadena de producción de una de las empresas avícola más importantes del Paraguay. Actualmente la misma realiza una planificación basada en la estrategia push, donde se produce a una determinada capacidad constante en las granjas avícolas e independiente de las fluctuaciones del mercado. Las granjas avícolas son cargadas de pollos BB para su engorde por un determinado tiempo para luego ser retirados y faenados en las plantas de producción para posterior venta directa o inventariados. Históricamente esta estrategia ha sido aplicada por la empresa dado que las fluctuaciones del mercado presentaban baja varianza. No obstante se ha detectado la necesidad de un cambio en la estrategia de producción debido a las modificaciones del patrón de consumo. El enfoque actual deja vulnerable a la empresa en dos situaciones principales: (a) incapacidad de satisfacer el mercado cuando existen picos de demanda generando un agudo quiebre de stock, e (b) incurre en altos niveles de inventario que son críticos debido al alto volumen de almacenamiento y consumo energético del sistema de refrigeración. Estas dos situaciones generan costos importantes restando competitividad en un mercado donde el margen de errores tiende a ser cada vez más estrecho. En consecuencia, este trabajo desarrolla una planificación basada en programación lineal entera basada en una estrategia pull. En esta estrategia la cadena de producción se planea en función a la demanda histórica del último lustro. El modelo ha sido codificado en lenguaje OPL y ejecutado en la herramienta computacional Cplex sobre un computador de alto desempeño. El modelo ha sido probado en instancias reales de la empresa mostrando su efectividad dotando de una mayor flexibilidad de la cadena de la producción. Esta estrategia ha logrado minimizar los costos operativos y pérdidas de ventas por quiebres de stock en comparación al enfoque operativo actual.

Keywords: Planificación del ciclo productivo; Estrategias push-pull; Producción avícola; Programación Lineal Entera

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Generalization of rank inequalities for several MIP models
Manuela Blaum; Javier Marenco

December 15, 2022 (Thursday), 09:00 - Room 1308

In this work we study a family of valid inequalities for polyhedra associated to certain mixed integer programming problems with binary variables. In the 2008 article “On the asymmetric representatives formulation for the vertex coloring problem”, Campelo et al. present a novel formulation for the vertex coloring problem, and introduce the families of external and internal valid inequalities, among others, for the associated polytope. Similar valid inequalities appear in a 2019 work by Correa et al. for the polytope associated to the two-class single-group classification problem, and in a 2021 work by Blaum and Marenco for the polytope associated with the 2-domination number and the P3-hull number of a graph. The fact that inequalities of the same type appear in such different contexts motivates our study. The inequalities that we present are a generalization of the well-known rank inequalities, so we call them local rank inequalities. These inequalities appear in MIP binary problems whose objective is to minimize the cardinality of certain subsets of a finite set X. These subsets form a collection that verifies that X belongs to the collection, which is closed by intersections, and every subset that contains a subset of the collection must belong to the collection too. In this context, for every subset C of X we can define its local rank inequality, whose support is C, which is valid for every feasible solution of the model. A remarkable fact is that the coefficient corresponding to each variable in the equation is closely related to the global parameter that we are trying to calculate, but is dependent in this case, on the subset that we are considering and also on the element of X that the variable represents. In this work we study this family of valid inequalities, we show several examples in the literature that can be framed in this context, and we study conditions in order to these inequalities be facet-defining for the corresponding polytopes.

Keywords: combinatorial optimization; polyhedral study; valid inequalities

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Efficiency in the CRO industry: A DEA analysis
Blanca Sanchez-Robles; Ricardo Diaz

December 15, 2022 (Thursday), 09:00 - Room 1309

Outsourcing to Contract Research Organizations (CROs) has become a widespread practice by pharmaceutical and biotechnological firms seeking to reduce risks and costs associated to the development of new products. This paper analyzes empirically the efficiency of the CROs industry by looking at a sample of firms operating worldwide over the years 2012-2020. We compute efficiency scores of the firms in the sample by means of DEA non- parametric techniques. We consider different specifications regarding inputs and outputs and obtain baseline and bootstrap estimators for efficiency. Average bootstrap efficiency in the sample is 0.665 and rather robust across specifications. Mean efficiency increases over the period 2012-2020. The best performers in the sample are PPD Australia, Centre Recherches Biologiques and Oy Medfiles. Our results suggest that very big and very small companies outperform the rest in terms of efficiency, pointing to the coexistence of increasing returns to scale and niche competitive advantages in the industry.

Keywords: DEA efficiency; bootstrap; Contract Research Organizations

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A methodological framework for analyzing the physician decision-making process for ICU bed management
Daniel Garcia-Vicuña; Laida Esparza; Fermin Mallor

December 15, 2022 (Thursday), 09:00 - Room 1309

Faced with a full Intensive Care Unit (ICU), physicians need to decide between diverting a new patient in need of critical care to another facility or freeing up a bed by prematurely discharging an already admitted patient. This dilemma is discussed extensively in the medical literature, where the influencing factors are identified, the patient discharge process is described, and the consequences for patient health are analyzed. This work presents a computational simulation tool useful for the analysis of those decisions made by physicians in situations of high occupancy. The analysis of patient-admission and inpatient-discharge decisions can be done safely in virtual environments that reproduce with high fidelity the characteristics and dynamics of an ICU. The developed simulator has two main features that distinguish it from others: the simulation of the patients' stay by evolving their health status (instead of using a single LoS value) and the recreation of realistic discharge and admission processes. Both elements are determinants for creating credible virtual scenarios, allowing the users the management of the ICU as they would do in a real ICU. The simulator records all the admission/discharge decisions made by users on every patient. Bed-management decisions are categorized into three types: shortening the stay of admitted patients, cancelling scheduled surgeries, and diverting unscheduled emergency patients to another facility. The sequences of all decisions made by users in a simulation run are analyzed using four metrics. Each metric accounts for different data and focuses on assessing a particular bed-management aspect. Results obtained from the analysis of real data illustrate the methodology developed here.

Keywords: Intensive Care Units; Decision-Making; Bed Management

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Prioritizing patients for upper gastrointestinal endoscopy: A machine learning approach
Maria Carolina Poveda; David Barrera Ferro; Sally Brailsford; Raul Murillo; Diego Patino

December 15, 2022 (Thursday), 09:00 - Room 1309

Gastric cancer is a public health concern. In Colombia, according to GLOBOCAN 2020, this type of cancer represents 7.3% of the diagnosed cases and 11.7% of the deaths. Further, nearly 60% of the cases are diagnosed in the latest stages and mortality rates show disproportionate impact among low -income patients. Therefore, an effort is required to increase early diagnosis and improve timely access to treatment. Although there is not clinical guideline on gastric screening, using an upper gastrointestinal (GI) endoscopy it is possible to increase early detection. In this work, we leverage electronic health records to prioritize patients that should be recommended to undergo a GI endoscopy. Three machine learning techniques are implemented to predict individual probabilities of

being diagnosed with this disease. The algorithms use patient-level information about previous diagnosis, prescribed medication, and undergone medical procedures over a one-year time window. The performance of the models is assessed the average AUC score from a 10-by -10 cross validation process. Our results show high levels of accuracy and will be used to design a decision support system.

Keywords: OR in health; Preventive Care; Machine Learning

Scheduling home health care services: a case study in the Chilean public sector
Juan Pablo Contreras; Mauricio Varas; Franco Basso; Raúl Pezoa; Felipe Baesler; María Francisca Rojas; Ricardo Ronco

December 15, 2022 (Thursday), 09:00 - Room 1309

The increase in life expectancy and formal care has fostered the demand for home health services. In this context, decision-makers must assign caregivers to clients and schedule their working times as efficiently as possible. We devise a new mixed-integer programming formulation to tackle this problem that incorporates several industry-specific features: matching patients to medical specialties, synchronized visits of multiple specialists, fast delivery of time-sensitive exams, and supervising complex medication treatments. The proposed model also includes other constraints that reflect the operations of the Home Health Care units, for example, the workload of the specialists, fixed shift schedules, and mandatory breaks. This model can be reduced to a Vehicle Routing Problem with Multiple Times Windows, known to be NP-hard. Therefore, we developed a constructive heuristic algorithm to compute feasible daily planning schedules in a reduced computing time. For a real-world instance gathered from the operations of the Hospital Padre Hurtado in Santiago, Chile, we show that our modeling framework saves planning time and provides high-quality routes, making it a promising alternative for experience-based scheduling methods. Moreover, our computational experiments show that the constructive heuristic is quite competitive in both quality and solution times to state-of-the-art solvers like CPLEX.

Keywords: Home health care; Vehicle routing problem; Staff planning; Mixed linear programming; Heuristics

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Priorización de objetivos para el desarrollo de cadenas de abastecimiento sostenibles
Matias Ponce Toro; Andrea Espinoza

December 15, 2022 (Thursday), 14:00 - Room 1208

En el mundo, los recursos son cada vez más escasos y la población crece rápidamente, lo cual obliga a las empresas a rediseñar sus cadenas de suministro en busca de la sostenibilidad. Sin embargo, en la literatura existen más de 50 funciones utilizadas para describir aspectos de la sostenibilidad, e intentar utilizarlas todas implicaría un gran gasto de tiempo y recursos, o incluso podría ser infactible. En este contexto, este estudio tiene como objetivo validar la selección de 8 funciones objetivo para representar el concepto de sostenibilidad en el diseño de cadenas de abastecimiento para el uso del recurso hídrico. Para esto se realiza una encuesta, donde primero se determina la muestra representativa de la población involucrada en la cadena de suministro. Luego se validan los objetivos mediante una ponderación simple entre los valores asignados por los expertos a los atributos “relevancia”, “facilidad de medición” y “fiabilidad” entregando un indicador llamado “importancia”. Por último, se priorizan los objetivos mediante la metodología Proceso Analítico Jerárquico (AHP) generando pesos para cada objetivo. Estas ponderaciones podrán ser utilizadas en una optimización multi objetivo para definir la configuración óptima de una cadena de abastecimiento para un caso de estudio.

Keywords: Cadena de abastecimiento; Proceso Analítico Jerárquico; Sostenibilidad

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La influencia de la sustentabilidad social en la eficiencia de las ciudades al enfrentar una pandemia

Karen Angelica Pérez Rojas; Marcela González-Araya; Lidia Angulo Meza; Alfredo Iriarte

December 15, 2022 (Thursday), 14:00 - Room 1208

Las pandemias han cambiado la economía y la política del mundo a lo largo de la historia. Han impuesto presión sobre la economía mundial, e incrementado la pobreza y el hambre en el mundo. Generando así, un impacto en el bienestar de las sociedades. La pandemia del COVID-19 es un ejemplo de ello, lleva más de seis millones de muertes a nivel mundial, y se estima que la mayoría de las principales economías han perdido cerca del 4,5% del PIB. En el enfrentamiento de las pandemias el dilema para la mayoría de los gobiernos radica entre la decisión de invertir en mecanismos de prevención o reparar los impactos de la catástrofe. Sin embargo, estudios sobre pandemias anteriores coinciden en que las acciones de prevención tendrían mejores resultados. En este sentido, es sabido que cada región geográfica tiene distintas características sociales y estructurales que pueden proteger a las sociedades en las pandemias, las que pueden o no, ser manejadas por los gobiernos nacionales y locales. En la última revisión de literatura sobre COVID-19 y sustentabilidad, destacan las evaluaciones del impacto de la pandemia en las tres dimensiones, económica, ambiental y social. No obstante, no se ha analizado cómo el nivel previo de sustentabilidad de un lugar puede protegerlo, frente al impacto de este tipo de catástrofes. Con el objetivo de que la sustentabilidad social pueda ser foco en el desarrollo de estrategias y políticas públicas que generen sociedades más robustas y resilientes, capaces de enfrentar estas catástrofes de mejor forma. Se propone realizar un análisis de eficiencia del impacto de la pandemia del COVID-19 en las principales ciudades de Chile y un análisis posterior, sobre cómo el nivel de sustentabilidad social influyó en ese resultado. Para ello, se utiliza el método de dos pasos, que consiste en realizar un análisis de eficiencia utilizando modelos DEA y posteriormente, analizar la influencia de variables exógenas, por medio de análisis estadísticos.

Keywords: Análisis Envolvente de Datos; Sustentabilidad; Pandemia; COVID-19; Sustentabilidad social

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Optimización sustentable en una cadena de suministro empleando un modelo de ruteo vehicular con tiempos de servicio estocásticos

Virna Ortiz-Araya; Adela Pagès-Bernaus

December 15, 2022 (Thursday), 14:00 - Room 1208

La gestión en las cadenas de suministro de productos lácteos se considera uno de los grandes desafíos abarcando problemas tan fundamentales y relevantes como el traslado de materias primas, bienes terminados e insumos entre empresas y clientes. La complejidad que se plantea en los temas de distribución y entrega se orientan a las condiciones de seguridad alimentaria, al cumplimiento en los horarios de entrega, a la diversidad de clientes, a la variabilidad en la demanda, entre otras. El problema que se aborda en este estudio emplea un modelo de ruteo vehicular con ventanas de tiempo y, tiempos de servicio estocásticos, aplicado a una empresa de productos lácteos. Para determinar las mejores rutas, el modelo considera los tres tipos de clientes con los que cuenta la empresa: grandes, medianos y pequeños. Los tiempos de servicios son modelados como una fila de espera M/M/1 con distribución exponencial y representan el comportamiento de llegada de los vehículos de reparto a los clientes. El objetivo de este estudio nace de la necesidad de agilizar la determinación de las rutas de reparto de la empresa en estudio, asignaciones que actualmente se llevan a cabo manualmente. Por una parte, se busca minimizar los tiempos totales de las rutas sobre todo para los grandes clientes, los cuales poseen ventanas de tiempo acotadas y son los que proporcionan las mayores ganancias a la empresa. Para las simulaciones del modelo se toma una base de datos proporcionados por la empresa de estudio correspondientes a una localidad. Los datos se procesan con la librería de Java provista por IBM ILOG CPLEX Optimization Studio 12.8. Los resultados obtenidos por el modelo de optimización estocástica permiten, por una parte, minimizar los tiempos esperados de reparto cumpliendo con la demanda comprometida y por otra, minimizar los desperdicios contribuyendo a mejorar las jornadas de trabajo de repartidores teniendo directa incidencia en el medioambiente y en los contratos legales establecidos.

Keywords: gestión de cadenas de suministro; productos lácteos; modelo de ruteo vehicular; optimización; sustentabilidad; tiempos de servicios estocásticos

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Towards the optimal management of carbon intensity indicators in the operation of sustainable supply chains

Demian J. Presser; Diego C. Cafaro; Ignacio E. Grossmann; Pratik Misra; Sanjay Mehta

December 15, 2022 (Thursday), 14:00 - Room 1208

In the coming years the world expects a substantial growth in demand for consumer goods, natural resources, and in particular, energy products. International agreements have set ambitious targets for medium-term reductions of environmental impact. The operation of supply chains accounts for more than 80% of the environmental impact of goods and services. Carbon intensity (CI) refers to a key indicator that quantifies greenhouse gas emissions per unit of output in production and logistics tasks. CI represents a critical measure to reduce the environmental impact of products and constitutes a key factor of survival, competitiveness and validity in the market for many companies. In this context, the optimal design and planning of modern supply chains requires rigorous techniques for the evaluation of the economic impacts of CI limitations, as well as product quality assurance by means of CI. Unlike the tracking of other properties, the CI associated to products flowing through a network depends on numerous decisions such as the selection of means of transportation, speed, processes, and energy sources used at each facility, among others. The need to manage several sources of feedstocks together with final markets with different CI requirements, often condition decisions that require detailed monitoring of CI along the supply chain. In this work, we introduce the concept of CI in the optimal planning of environmentally sustainable supply chains, from an operational point of view. We discuss fundamental guidelines and challenges for modeling and solving supply chain planning problems through mathematical programming approaches under CI constraints. In addition, we assess the impacts of this indicator on the optimal solutions and how companies can optimally determine their CI targets. Two illustrative case studies are proposed to discuss different approaches for the supply chain planning problem under CI constraints using mixed-integer linear and nonlinear formulations.

Keywords: supply chain; carbon intensity; mathematical programming; sustainability; MINLP

Two-phase approach model for sizing microgrids in non-interconnected zones of Colombia

Sebastian Felipe Castellanos Buitrago; Pablo Andrés Maya Duque; Walter Mauricio Villa Acevedo; Santiago Marulanda Escobar; Mateo Giraldo Zuluaga

December 15, 2022 (Thursday), 14:00 - Room 1209

Microgrids have become an important alternative to provide energy to non-interconnected zones (ZNI), because it does not need to be connected to the main network, there are tax incentives and gives the possibility of integrating renewable generation sources with the aim of creating sustainable projects. Different studies have been carried out for the sizing of the microgrids, since this strategic decision is essential for it to be viable and thus guarantee reliability in the supply at the lowest possible cost. To address the isolated microgrid-sizing problem we designed a two-phase approach model. At the first phase, decisions are made regarding which technologies and specific generators and batteries to install, based on a portfolio defined by the decision maker. The second phase evaluates the performance of the microgrid, with the usual constraints of the literature such as energy balance and generation equations. Additionally, the model incorporates other relevant constraints such as the available installation area, lpsp with moving ranges and batteries management. The two phases evolve iteratively guided by an iterated local search framework until a satisfactory sizing criteria is reached. This approach allows managing the computation time and allows including the stochasticity in the demand and in the environmental factors. The proposed approach is tested using real data from four non-interconnected zones in Colombia and a portfolio of products available in the zone. Results are promising as they draw insights to support decision making on the design of microgrids for these regions.

Keywords: Microgrid Sizing; Stochastic optimization; Iterated Local Search

Modeling uncertainty processes for multi-stage optimization of strategic energy planning
Tito Homem-de-Mello; Frederic Babonneau; Esnil Guevara

December 15, 2022 (Thursday), 14:00 - Room 1209

In this work we study the modeling of stochastic processes in long-term multi-stage energy planning problems when little information is available on the degree of uncertainty of such processes. In the literature, works related to energy planning, in which several investment periods are considered, typically assume that the processes are stage-wise independent, i.e., the information revealed in each period does not depend on past information. However, the scenarios generated from a stage-wise independent process also involve the appearance of “zigzag” scenarios that do not occur in the real world. We circumvent such an issue by incorporating time-dependence into the input processes. Starting from simple estimates of variation intervals for uncertain parameters, such as energy demands and costs, we model the temporal correlation of these parameters through autoregressive (AR) models. We introduce a coefficient for zigzag effects in the evolution of uncertain processes that controls the likelihood of extreme scenarios. To preserve the convexity of the stochastic problem, we discretize the AR models associated with the cost parameters involved in the objective function by Markov chains. The resulting formulation is then solved with an advanced SDDP algorithm available in the literature that handles finite-state Markov chains. Our numerical experiments, performed on the Swiss energy system, show a very desirable adaptation strategy of investment decisions to uncertainty scenarios, a behavior that is not observed when the temporal correlation is ignored. Moreover, the solutions lead to better out-of-sample cost performances, especially on extreme scenario realizations, than the non-correlated ones which usually yield overcapacities to protect against high, but unlikely, parameter variations over time.

Keywords: Energy planning; Multi-stage stochastic optimization; Autoregressive models

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Some considerations on similarities of the energy transition processes of national economies using clustering models
Andre Salles; Ana Carolina Carvalho Souza

December 15, 2022 (Thursday), 14:00 - Room 1209

Energy is an essential production factor for productive activity. Its consumption is one of the determining factors for the overall reduction in greenhouse gas emissions, which is directly related to the planet's climate change. In this context, to reduce greenhouse gas emissions, developed and emerging economies have been establishing energy consumption goals from fossil fuels and sponsoring the transition of their energy matrices, reducing the participation of fossil energy sources and non-renewable, increasing the share of low-carbon and renewable energy sources. This work aims to verify the energy transition processes similarities of developed and emerging economies using a methodological approach based on clustering models. Thus, hierarchical clustering and partition clustering models were used. These similarities make it possible to identify patterns of these energy transition processes and consider the levels of development of national economies and economic blocks or geographic regions. Thereby, classify the countries selected by their geopolitical and climatic characteristics according to their energy transition processes. In general, the results indicate that the developed countries around the world and emerging countries of Latin America have participation in renewable and low carbon energy greater in their matrix than the other countries. Some of these countries show a low carbon energy consumption profile, while others show a predominant energy transition from fossil energy to low carbon energy. The sample used comprises annual time series of primary energy consumption from fossil fuels, renewable sources and low carbon sources from 48 countries from 1965 to 2019.

Keywords: Energy Consumption; Energy Transition; Clustering

Optimized reinforcement planning of modern power distribution systems to support the electric vehicle charging infrastructures

Caio dos Santos; José Carlos Garcia Andrade; Christiano Lyra

December 15, 2022 (Thursday), 14:00 - Room 1209

Modern power systems increasingly rely on distributed energy resources. Small renewable sources, storage systems, electric vehicles, and recharge infrastructure provide additional capacities where needed. The mass insertion of distributed energy resources allows greater customer participation in managing the generation and consumption of their energy; this scenario requires the development of new planning practices. This research provides an approach to assess the necessary recharge infrastructure for electric vehicles. A mixed-integer linear programming model defines the optimal strategy to address potential technical issues observed after installing recharge infrastructures (say, charging stations and additional facilities) in modern distribution systems. The model assumes a green field perspective in the planning of the distribution networks to search for the minimum reinforcement cost to mitigate the circuit overload and voltage violations. Another assumption is that the locations of the charging station are already defined; consequently, the power magnitudes for the equipment have defined values. As planning alternatives, the model evaluates the rearrangement of the power transformers of the feeder circuits and the replacement of overloaded power transformers and overloaded conductors. A preprocessing strategy provides the forecast of recharge power demand for each site of the distribution network based on the traffic flow in these areas; the capacity of each charging station is computed based on the number of electric vehicle owners to be served. The results of two scenarios, using a synthetic test system and a real-world Brazilian case, certify the benefits of the proposals in saving investments to reinforce the distribution network to accommodate the charging stations and additional facilities.

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Keywords: Facility location; Combinatorial optimization; Uncertain data; Modern power systems; Electric vehicles

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A bi-objective optimization model for simultaneous short-term production and distribution scheduling in process industries

Aldana Stefanía Tibaldo; Jorge Marcelo Montagna; Yanina Fumero

December 15, 2022 (Thursday), 14:00 - Room 1301

The emergence of advanced manufacturing and Industry 4.0 technologies are moving companies towards new ways of operating in order to follow market trends and maintain their positioning. In environments that operate using the make-to-order manufacturing approach, where products must be supplied directly to customers after their completion, as well as in industries that due to the characteristics of their products (perishable or time-sensitive) adopt a just-in-time policy, a joint consideration of production and distribution scheduling is crucial. However, the integrated resolution of these activities requires a great effort considering that the objectives, capabilities and performance criteria of the different stakeholders are often conflicting (e.g., cost versus customer satisfaction). In the area literature, some works have studied the integrated problem with multiple objectives but considering certain limitations and simplifications for the operational decisions involved. For this reason, a bi-objective mixed-integer linear formulation is presented to simultaneously manage production and distribution decisions in multiproduct batch plants. The augmented ε-constraint method (AUGMECON) is used to solve the bi-objective model, minimizing production and distribution costs for different admissible values in the delay of delivery times to customers, and generating a set of optimal Pareto solutions [1]. The model determines: number and size of batches processed for each product (batching), their allocation and sequencing in the units, and timing of these batches, as well as number and type of vehicles to be used, allocation of batches to vehicles, departure and arrival times of vehicles to customers. Finally, once the efficient solutions to the problem are obtained, the decision maker can select among them the preferred one. The capability of the approach is evaluated through a case study and different trade-offs are analyzed.

[1]https://doi.org/10.1016/j.amc.2009.03.037

Keywords: multi-objective optimization; MILP; production and distribution scheduling; AUGMECON

Optimizing the production scheduling of a manufacturer of bottle closures
Guillermo A. Durán; Manuel Durán; Nazareno A. Faillace Mullen; Juan Velasquez

December 15, 2022 (Thursday), 14:00 - Room 1301

Operations research techniques are applied to optimize the production scheduling of a bottle closures manufacturer located in Córdoba, Argentina. The goal is to develop software that generates production plans for periods of up to one month which minimize both overproduction and customer order response times. The basic manufacturing technique for all closures is to inject plastic into a metal mold. The products are classified by the four different variations on the technique: simple injected, co-injected, monoblocco, and bicolour. The first two require a single type of mold, monoblocco uses two types simultaneously and bicolour consists of two parts that are produced sequentially. Each product is defined by its colour and the mold(s) required to make it. The factory currently has ten machines with various numbers of injector groups, production speeds, and mold compatibilities. Each injector group on a machine can be used to manufacture a different product simultaneously. Machines must be switched off while a mold is being changed. Our solution approach divides the problem into three stages. The first stage is further divided into two phases. In the first phase, a MILP model determines which mold is used with each injector group on each machine in each interval of the model's time partition, with the objective of minimizing response times subject to the relevant constraints. In the second phase, the same model sets the order production deadlines based on the first-phase solution with the objective of minimizing overproduction. Since the first stage results overestimate down times due to mold changes, the second stage consists in running an LP model to correct them. Finally, in the third stage a MILP model determines the colour for each mold type in each time interval with the objective of minimizing colour changes.

Keywords: scheduling; total tardiness; heuristic; parallel machine problem

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Scheduling in additive manufacturing problems
Jeanette Rodriguez; Daniel Rossit

December 15, 2022 (Thursday), 14:00 - Room 1301

Scheduling problems in additive manufacturing is a problem that can involve considerably more complexity than single-stage scheduling problems, since machines can process more than one part with different geometries simultaneously [1]. To achieve efficiency in terms of the used capacity of the machine, it is necessary to group as many parts as possible in a single job. Since the use of the machines in terms of time depends on the job being processed, how parts are grouped within each job comes critical. This implies that the resolution of the nesting problem will have a direct impact on the objective function of the jobs Schedule. In this work, the objective function to be minimized is the Total Completion time, wich is obtained by the sum of the completion time of each job. The biggest difficulty is that the problem is NP-Hard [2], so a purely mathematical approach is insufficient. For this reason, a hybrid method is proposed that allows linking the benefits of an approach based on mathematical programming but enhanced by heuristic methods. In this way, heuristics are developed that address the nesting problem incorporating knowledge about the nature of the problem, such as the influence of the parameters "height" and volume" of the parts in the definition of the Jobs; and the structure of its solutions. Then, using mathematical programming, solve the scheduling in parallel additive manufacturing machines. For the nesting stage, several heuristics were proposed and compared, showing that those heuristics that best captured the influence of the parameters contributed more to solving the problem.

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Keywords: Scheduling; Additive Manufaturing; Heuristics; Nesting; Total completion time

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An optimization approach for process quality profile modeling
Jean P. Morán-Zabala; Juan M. Cogollo-Flórez

December 15, 2022 (Thursday), 14:00 - Room 1301

Process Quality Profile Modeling consists of collecting data on the behavior of the variables and the product quality characteristics and quantifying the interrelations between process key inputs and outputs. It allows estimating the results of the products quality characteristics from the process variables values. The main objective of quality profiling is to develop models for improving processes and product quality. This work develops a model of process quality profile using Goal Programming (GP) to determine the optimal levels of process variables and product quality characteristics in a carbonated beverages process. The model has one input variable and four process variables influencing the performance of the response variable (main quality characteristic of the product). Initially, a process capability study and a multiple linear regression analysis were carried out, obtaining the general equation and four associated constraints. Then, a variability analysis was carried out to determine the correlation coefficients between the variables and the quality characteristic. Next, the general regression equation was modified by transforming the variables. From this, the objective function was obtained considering the penalized equation of the response variable. The minimization, penalization, and constraints of the objective function allowed us to find a satisfactory solution to ensure compliance with the quality characteristic specifications. The development of this process quality profiling GP model allowed us to obtain a complete mapping of the optimal operating ranges of the process variables and the response variable. In addition, it is possible to estimate the stability of the process and the ability to meet the quality characteristics. The most important contribution of this work is to develop and apply a flexible model that integrates optimization tools for solving complex problems of product and process quality profiling.

Keywords: Process optimization; Design of quality control profile; Advanced process analysis

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Aceptabilidad de políticas ambientales y reducción de emisiones
Maria Ignacia Rivera; Manuel Vargas; Jorge Zamorano

December 15, 2022 (Thursday), 14:00 - Room 1302

La necesidad de reducir las emisiones contaminantes, limitar el consumo de energía no renovable por el daño que genera y considerando el bajo grado de implementación de estas energías limpias obliga a las autoridades reguladoras a buscar incentivos económicos para lograr una transición tecnológica, y al mismo tiempo garantizar la participación de las empresas en la política ambiental. La relevancia de esta investigación es ampliar el rol de protección de estas regulaciones estudiando la eficiencia social (bienestar) y la aceptabilidad por parte de las empresas cuando el regulador incentiva la adopción de tecnologías limpias de reducción de contaminantes. Nos concentraremos en regulaciones ambientales del tipo impuesto sobre las emisiones e implementación de mercados de permisos a contaminar. Consideramos empresas de sectores oligopolísticos de la Unión Europea que poseen tecnologías convencionales de reducción de contaminación y además reciben asignaciones de permisos gratuitos para incentivar su participación en la política. Los permisos gratuitos pueden ser asignados mediante dos mecanismos distintos; Grandfathering y Output-based allocation. En particular, este trabajo estudia el rol de estos mecanismos en la aceptabilidad de la política ambiental cuando las empresas son incentivadas a una transición hacia tecnologías eficientes, y el impacto de la política ambiental en el sector eléctrico. La literatura actual considera que las asignaciones del tipo Grandfathering es el mecanismo que más incentiva la aceptabilidad de la política. Sin embargo, el Output-based allocation posee un componente estratégico que incentiva la producción mediante la asignación de permisos gratuitos para cada empresa, además de otros beneficios distintos que son explorados en este artículo. Finalmente se presenta una ilustración de una fase del EU-ETS para sustentar nuestros resultados.

Keywords: Regulación Ambiental; Impuesto sobre emisiones; mercado de permisos; Oligopolio;

Tecnologías de reducción

Localización de empresas bajo regulación ambiental y tecnologías de abatimiento
Felipe Rivera Pradenas; Jorge Zamorano; Manuel Vargas

December 15, 2022 (Thursday), 14:00 - Room 1302

A nivel mundial las políticas económicas-ambientales son más bien localizadas y descentralizadas, debido principalmente a la escasa coordinación internacional en materias ambientales. Si bien, la naturaleza de las políticas se diferencian entre ellas según el objetivo que busca el regulador, existen instrumentos económicos como el impuesto, que buscan desincentivar la producción contaminante, internalizando el daño, y por consiguiente, reducir las emisiones. Entre los efectos más importantes que genera el impuesto sobre las empresas, es el aumento de los costos, que puede llegar a generar cambios en la decisión de localización e incentivar la deslocalización a países con políticas ambientales más laxas. En esta investigación nos centraremos en la aplicación de un impuesto sobre las emisiones establecido por un gobierno local, que afecta a empresas oligopolísticas que compiten en cantidades y a sus decisiones estratégicas de localización de plantas. Se supone además que las empresas adoptan tecnologías de abatimiento como otra forma de disminuir las emisiones. Por lo tanto, el objetivo de este estudio es establecer los niveles impositivos que los gobiernos pueden aplicar para maximizar el bienestar social y, en consecuencia, modificar la localización geográfica de las empresas. Además, esta investigación proporciona un ejemplo en el contexto de tres sectores intensivos en emisiones utilizando un modelo de optimización de dos niveles para su resolución. Este enfoque contribuye directamente a resolver estos problemas, ya que proporciona una solución global y garantiza la aceptabilidad de las políticas por parte de las empresas y la relación jerárquica entre el gobierno y la industria. Entre los resultados más importantes incluyen que la adopción de tecnologías de abatimiento reducen el incentivo de deslocalización a países extranjeros y, por tanto, aumentan el bienestar social.

Keywords: Impuesto a las emisiones; Oligopolio; Localización de firmas; Tecnologías de abatimiento; Optimización binivel

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Rol del mecanismo de asignación de permisos de contaminación en los incentivos de reubicación de empresas.
Jorge Pavez; Isabel Trivino; Jorge Zamorano; Manuel Vargas

December 15, 2022 (Thursday), 14:00 - Room 1302

Una de las preguntas importantes en la implementación y el diseño de políticas ambientales es cómo incentivar a las empresas a participar de dichas regulaciones. Es decir, la aceptabilidad y la reducción de los incentivos a reubicar la producción por parte de las empresas son aspectos claves en el diseño y eficiencia de la política. La literatura ha demostrado que, por medio de asignaciones gratuitas de permisos a contaminar, que neutralizan el beneficio (PNA), las empresas pueden ser incentivadas correctamente asegurando aceptabilidad y reduciendo el riesgo de reubicación. Este trabajo tiene como objetivo comparar dos mecanismos diferentes, tales como la asignación de permisos gratuitos de contaminación y la asignación proporcional a la producción en un contexto de implementación de una regulación ambiental. En particular, se estudian ambos mecanismos por separado y sus efectos en la reducción de los incentivos de reubicación de empresas, así asegurando aceptabilidad de la política. Además, en un modelo de competencia espacial, se estudian los efectos sobre la competitividad del mercado para cada tipo de mecanismo considerado por el regulador. La justificación de este estudio recae en que la reubicación tiene consecuencias negativas sobre el bienestar social. En particular, la asignación gratuita permite disminuir en su totalidad el riesgo de reubicación, mediante asignaciones PNA, dado que se puede compensar los beneficios de las empresas mediante transferencias monetarias directas a ellas. Mientras que la asignación proporcional a la producción puede cumplir con objetivos menos estrictos que los que presenta el mecanismo de asignación gratuita y que igualmente aseguran la aceptabilidad. Finalmente, se estudian las ventajas estratégicas del mecanismo proporcional y cómo se logra modificar la decisión estratégica de la producción en las empresas.

Keywords: Regulación Ambiental; Asignación gratuita de permisos; Asignación proporcional a la

producción; Riesgo de reubicación

Localización de firmas bajo múltiples instrumentos económicos en la consistencia temporal de la regulación ambiental

Felipe Rivera Pradenas; Katherin López; Jorge Zamorano

December 15, 2022 (Thursday), 14:00 - Room 1302

El problema de la contaminación ambiental es generalmente abordado mediante múltiples instrumentos económicos, tales como el impuesto y las subvenciones. La implementación de varios instrumentos recae en los diferentes objetivos que persigue el regulador. Por lo mismo, el enfoque de esta investigación es estudiar dos instrumentos que son implementados conjuntamente, pero con objetivos distintos. El primero de ellos es el impuesto a las emisiones, que busca internalizar el daño generado por una producción contaminante, mientras que, el segundo es la subvención a tecnologías más limpias, que tiene como propósito incentivar la adopción de tecnologías de abatimiento. Ambos instrumentos buscan maximizar el bienestar social, considerando cómo la temporalidad de la decisión (ex ante o ex post) afecta a la competitividad del mercado. Es decir, fijar una política ex ante indica que, se establece el impuesto antes de que la empresa decida dónde localizarse o ex post, después de que la empresa haya decidido su localización y su reducción. Para modelar el problema anterior, consideramos empresas de sectores duopolísticos que compiten en cantidades, en un contexto de un sector intensivo en emisiones, donde el impuesto y la subvención se establecen como las políticas medioambientales que implementa el regulador, ya sea ex post de su localización, o ex ante, previamente comprometidas. El método de resolución que se utiliza es la optimización binivel (dos niveles), donde en el nivel superior se maximiza el bienestar social y, en el nivel inferior, el beneficio de las firmas. En particular, el objetivo de la investigación es establecer los niveles óptimos de impuesto y subvención que debe fijar el regulador mediante los dos mecanismos de temporalidad (ex-ante y ex-post), con el propósito de maximizar el bienestar y los beneficios de manera conjunta, y ver así cómo se modifica la decisión de localización de las firmas.

Keywords: LOCALIZACIÓN DE FIRMAS; COHERENCIA DE LA TEMPORALIDAD DE LAS DECISIONES; IMPUESTO A LAS EMISIONES; SUBVENCIÓN A LAS TECNOLOGÍAS; OPTIMIZACIÓN BINIVEL

Spot fare inspections under non-adaptive opportunistic passengers and mass inspection policy using a Stackelberg game approach

Enrique Simpson; Pablo Escalona; Nathalia Wolf; Luce Brotcorne

December 15, 2022 (Thursday), 14:00 - Room 1303

This paper studies the design of unpredictable spot fare inspection strategies and their implementation in public transport networks when opportunistic passengers can evade fare payment by the most convenient path and the transit authority implements a mass inspection policy. A spot fare inspection strategy defines the frequency with which the transit authority should control each transit network location to inhibit the action of opportunistic passengers. The spot fare inspection strategy implementation is done using a collection of spot fare inspection schedules where each of them defines the transit network locations to be controlled by the transit authority. We use a Stackelberg game approach to represent the hierarchical decision making process between the transit authority and opportunistic passengers, whose decision to evade the fare and the path to take depends on the control frequencies set by the transit authority.

Keywords: Spot fare inspection; Non-adaptive opportunistic passengers; Mass inspection policy; Stackelberg game

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Fare inspection patrolling under in-station selective inspection policy using a Stackelberg approach

Mario Ramirez; Pablo Escalona; Luce Brotcorne

December 15, 2022 (Thursday), 14:00 - Room 1303

In this paper, we study the design of unpredictable fare inspection patrols at station in a public transport network to inhibit the action of opportunistic passengers. We consider a Stackelberg game approach to represent the hierarchical decision-making between the transit authority (the leader) and the opportunistic passengers (the followers), whose decision to evade depends on the inspection probabilities set by the transit authority. Two approaches to Stackelberg games can be distinguished. First, a marginal-based approach Stackelberg game that only concerns the inspection probabilities that the transit authority must set to inhibit the action of the largest number of opportunistic passengers in the network. Second, a mixed-based approach Stackelberg game that considers a collection of inspection schedule and their respective probabilities of being selected whose systematic implementation in the medium term converges to the inspection probabilities defined by the marginal approach.

Keywords: Patrol scheduling; Stackelberg game; Selective inspection policy

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Competencia en la difusión de la información y estrategias de centralidad en redes sociales
Juan Tejada; Elisenda Molina; Fairouz Medjahed

December 15, 2022 (Thursday), 14:00 - Room 1303

El análisis de la difusión de la información es un tema central en los estudios sociológicos, políticos y económicos de las redes sociales. En particular, el problema de seleccionar un conjunto semilla de nodos a partir de los cuales maximizar la difusión esperada de una información, ha recibido en los últimos años una gran atención. Kempe, Kleinberg y Tardos (2003) formalizaron este problema de optimización que fue considerado previamente por Granovetter (1978) y Domingos y Richardson (2001). Para los modelos de cascada y umbral que definen la función de difusión esperada es submodular lo que garantiza una cota de optimalidad para el algoritmo voraz (greedy). Posteriormente, se han desarrollado multitud de algoritmos que pugnan por ser más eficientes. Un paso natural es extender estos modelos al caso en el que dos o más agentes tratan de difundir información competitiva en la misma red social. La selección del grupo semilla por parte de un agente debe tener en cuenta las posibles elecciones de sus rivales. En esta comunicación consideramos que las estrategias de selección de semillas se reducen, en principio, a un conjunto finito dado por algunas de las más importantes medidas de centralidad. El modelo de difusión en competencia es el introducido por Li et al. (2016) para el que se consideran dos posibilidades para resolver el problema inicial de empates en la selección. Utilizando un conjunto de redes sociales de uso común en la literatura, se determinan los equilibrios de Nash del juego no cooperativo resultante. Aunque los algoritmos de difusión basados en centralidad no son, en general, los más eficientes, en el caso competitivo muestran tener mejores resultados que otros algoritmos de difusión que se encuentran entre los mejores propuestos en la literatura.

Keywords: Redes sociales; Difusión de la información; Juegos no cooperativos; Medidas de centralidad

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Communication in weighted networks. A game theoretic approach
Elena Gavilán; Conrado Manuel; Daniel Martín

December 15, 2022 (Thursday), 14:00 - Room 1303

We deal with TU-games with cooperation restricted by a graph, also called communication situations or graph games. The first attempt in this setting is due to Myerson (1977). He defined the graph-restricted game and then he applied the Shapley value to this game. Meessen (1988) and Borm et al. (1992) introduced the position value. According to this rule each player receives half of the Shapley value in the link game of all the links he involved in. Feltkamp and van den Nouweland (1992) introduced and characterized a third value, the mixed value, allocating worth not only to players but also to links in a communication situation. They defined the corresponding restricted TU-game in which the actors are both the players in the original game and the links in the graph. In this communication we define a modification of this mixed value to take into account that players and/or links can have weights representing a priori differences between them. As an example, this link weights can represent different flows, lengths, emotional intensities, trust in the transmission of information or even probabilities of relation. Similarly, players can have asymmetries in the bargaining

or cooperation abilities. In all the three previous referred allocations rules, always the Shapley value (Shapley 1953a) of the corresponding new defined game is used. In this communication we propose the use of the weighted Shapley value (Shapley 1953b) to allocate worth in the pseudogame, when players and links have associated weights. The obtained allocation rule will be named weighted mixed value. We present several characterizations of this value using the following properties: mixed component efficiency, weighted mixed fairness, weighted balanced contributions and weighted balanced link contributions. The obtained characterizations also are useful in the particular case in which all the players and links have no weights. Then, in fact, we also obtain new characterizations for the mixed value.

Keywords: Game theory; TU-game; Communication situation; Graph game; Myerson value; Position value; Mixed value

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FLP for last mile distribution centers: comparison between GRASP and Genetic Algorithm metaheuristics

Jefferson Matos; Vitor Curtis

December 15, 2022 (Thursday), 14:00 - Room 1304

This article seeks to define the location of logistics warehouses in the city of São Paulo – SP in order to enable the delivery of products directly to the customer using Unmanned Aerial Vehicles (UAVs), also known as drones, comparing them with the delivery of the products carried out by motorcycles. Proposals for delivery by air can be found resonance in the need for fast delivery of products demanded by e-commerce, as well as in the deliveries of high added value item or that urgently needed, such as medical products and in context of humanitarian support in disasters and wars. The use of drones has grown with various applications, such as leisure, image capture, even logistical operations of proximity to the customer. In the urban environment, delivery operations are performed mainly using land modes, such as motorcycles, cars and small trucks, and have companies that operate only in the final transport of goods, focus on the last stage of the logistics chain, and others with a more vertical chain, having inventories and large trading platforms. In both, the transport of goods with UAVs has been widely studied worldwide due to the great economic potential. The problem to be solved seeks to find the location for the installation of facilities (FLP) considering the direct delivery to the customer, comparing the use of drones and motorcycles, in order to minimize the costs of the operation that includes the fixed installments and variable. Most FLP problems are considered in the literature as NP-hard. In this way, the GRASP and GA metaheuristics will be studied to solve the problem, analyzing their performance in relation to the exact method, the quality of their answers and studying parameters that improve the performance of the algorithm. The obtained results show that the metaheuristics achieved results close to the optimal solution, having a time of reasonable processing.

Keywords: FLP; Metaheuristic; Drone; Logistic

General sector-routing, application results in downtown Petropolis/RJ

Marcos Negreiros; Augusto Palhano; Eduardo Reis

December 15, 2022 (Thursday), 14:00 - Room 1304

We consider the General Sector Routing problem, where it is given a street network composed by nodes and links (oriented and non-oriented arcs) requiring or not services with stochastic demand, a vehicle with known capacity, a departure/garage vertex, and an intermediate/disposal site vertex. The problem considers the design of sectors and routes that can be covered by vehicles in several trips passing through the disposal site where each trip does not exceed the vehicle capacity and the total sector coverage does not exceeds the workload assigned to them. A clustering-routing based approach was developed for this problem. The methodology is presented as its results obtained in a real-life project application at downtown Petrópolis/RJ city. The obtained savings were up to 16% in the total distance travelled and one vehicle less over 5 used by the concessionary to cover daily the same region.

Keywords: Arc Sector-Routing; Capacitated Clustering; Rural Postman Problems; Waste Collection

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Towards better service quality with the dynamic feeder service with a maximum headway at mandatory stops

Bryan David Galarza Montenegro; Kenneth Sörensen; Pieter Vansteenwegen

December 15, 2022 (Thursday), 14:00 - Room 1304

Feeder bus services transport passengers from rural or suburban areas to areas with more public transportation options. On the one hand, fully flexible demand-responsive feeder services efficiently tailor their service to passengers' needs. Traditional feeder services, on the other hand, offer predictability and easier cost control. This paper considers a semi-flexible demand-responsive feeder service that combines positive characteristics of both traditional and fully flexible services. There are two types of bus stops in this feeder service: mandatory bus stops and optional bus stops. Mandatory bus stops have a certain maximum headway for bus departures. Optional stops are only visited when there is demand for transportation nearby. As new passenger requests arrive, the performance of this feeder service is optimized in real time. A metaheuristic with two phases is developed to optimize the service. An insertion algorithm generates an initial solution in the first phase. If possible, an improvement heuristic, which is a combination of local search and greed construction algorithm, improves the initial solution in the second phase. When the dynamic optimization method is compared to a previously developed heuristic that optimized the service in a static manner, the results show that the dynamic method performs quite well.

Keywords: meta-heuristics; real-time optimization; public bus transport; feeder service; demand-responsive transportation

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The two-echelon vehicle routing problem with customer to parcel locations and grey zone for inner-city logistics

Edgar Ricardo Silva Russi; Nacima Labadie; Caroline Prodhon

December 15, 2022 (Thursday), 14:00 - Room 1304

This study addresses the Two-Echelon Vehicle Routing Problem with Grey Zones and Customer to Parcel stations (e.g. lockers and pick-up points). This problem arises in the search for new sustainable delivery schemes for last mile distribution in urban areas. In the considered problem, first echelon Internal Combustion Engine Vehicles (ICEVs) start from a single warehouse and transport parcels to first echelon direct delivery customers and to C2P stations where C2P customers can directly pick up their parcels by themselves. These first-echelon C2P stations can also serve as satellites where synchronization between ICEVs and second-echelon alternative fuel vehicles (AFVs) departing from the second-echelon warehouse is achieved in order to reduce waiting times. From there, AFVs will serve direct delivery customers and drop off goods at the second-echelon C2P stations where customers can pick up their goods themselves. Customers in the grey zone belong to both the first and second echelon and can therefore be served by any vehicle, thus reducing the undesirable long trips of the second echelon vehicles. The proposed Two-Echelon VRP aims to reduce transportation costs in the last mile deliveries. This study proposes a literature review on the subject, a MILP formulation to model the described problem and an approximate approach to solve large instances.

Keywords: Vehicle Routing Problem; Synchronization; Transportation; Multi Echelon

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Uma matheurística de janela deslizante para o floorplanning VLSI

Letícia Pavanello; Carlos Diego Rodrigues; Adriana Cherri

December 15, 2022 (Thursday), 14:00 - Room 1305

O VLSI (Very Large Scale Integration) é uma tecnologia de microeletrônica que integra um grande número de módulos em um chip. Uma etapa essencial na construção de um circuito integrado VLSI é o processo de planejamento da localização física e conexões dos módulos no chip, chamado de

floorplanning. Esse processo envolve determinar as localizações e tamanhos dos módulos, bem como estimar a área total necessária, comprimento dos fios de conexão e desempenho do circuito, fornecendo uma base para o layout. O floorplanning pode ser resolvido como um problema de empacotamento com retângulos flexíveis e, computacionalmente, é um problema NP-difícil. Apesar de amplamente estudados, as formulações existentes na literatura que garantem uma solução exata para o problema de empacotamento, não são viáveis para grandes instâncias, como no contexto de circuitos VLSI. Assim, abre-se espaço para a utilização de diferentes técnicas e métodos heurísticos. Neste trabalho, um modelo matemático e uma matheurística de janela deslizante são propostos para resolver de forma eficiente o problema de planejamento de circuitos VLSI. Para minimizar o comprimento do fio utilizado nas conexões dos módulos, é necessário identificar quais deles devem ser colocados próximos uns aos outros e alocá-los, sem sobreposições, atendendo aos objetivos de comprimento de fio. A matheurística proposta é um procedimento iterativo que conta com uma estratégia de inicialização de ordenação dos módulos a serem alocados. Dessa forma, é possível definir quais deles serão priorizados no planejamento do circuito e resolver um problema parcial a cada iteração, inserindo no layout apenas um módulo por vez, limitando o número de variáveis consideradas e reduzindo a dificuldade de resolução em relação ao problema original. Para avaliar o desempenho do método, foram realizados testes computacionais com instâncias de referência do MCNC configuradas na linguagem de programação C++ com o solver CPLEX.

Keywords: Problema de Empacotamento; Retângulos flexíveis; Circuitos VLSI; Matheurística

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New formulations for perfect domination problems and their algorithmic implications
Abilio Lucena; Vinicius Forte; Said Hanafi

December 15, 2022 (Thursday), 14:00 - Room 1305

Given an undirected graph G=(V,E), a subset of vertices D is called a vertex dominating set if every vertex of V either belongs to D or shares an edge with a vertex of D. Additionally, set D is called perfect if every vertex not in D is dominated by a single vertex of D. The Perfect Vertex Domination Problem asks for a perfect set D with the smallest cardinality possible. Bearing in mind that domination is analogously defined for the edges of E, the Perfect Edge Domination Problem asks for a perfect edge dominating set with as few edges as possible. We propose new formulations for these two problems. They rely on structural properties that are inherent to perfect dominating sets. The new formulations are computationally compared with their existing counterparts from the literature. Comparisons are carried out over 3-regular graphs, taken from the literature, and also over new instances, defined by hypercube graphs, Q_n, n = 3, …, 12. For perfect edge domination, in particular, the new formulation proved very effective, allowing a commercial mixed integer programming solver to attain, with a single instance exception, CPU time speed ups of orders of magnitude over its closest competitor.

Keywords: Perfect Domination in Graphs; Structural Properties; Mathematical Formulations; Exact Solution Algorithms

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Formulations and algorithms for arc reversal, arc addition or arc complement in digraphs
Matheus Corrêa; Abilio Lucena

December 15, 2022 (Thursday), 14:00 - Room 1305

Consider a digraph over which operations of addition, complement or reversal of arcs are allowed. Different costs apply to every distinct arc-operation pair and, whenever applied, all operations must be of a single, predefined, type. The objective is to obtain a digraph that satisfies certain connectivity requirements, at minimum total cost. The problems we address are mostly NP-hard and are commonly associated with the design of particular types of transport or telecommunication networks. Quite frequently the connectivity level one requires for the digraphs reflects the resiliency, flexibility or operation efficiency standards demanded from the physical networks. We describe mathematical formulations and exact algorithms for eight different problems in the class. For some of them, this is done for the first time in the literature. Additionally, we test our formulations and their accompanying solution algorithms over a test bed of instances that proved much harder to solve, in practice, than those previously used in the literature (for similar types of problems). Finally, our algorithms benefit

from procedures that speed up the separation of cutset inequalities, with a very significant impact on CPU time. The computational results we present indicate that our formulations are quite strong and that our algorithms are capable of solving large size instances, to proven optimality.

Keywords: Optimization; Digraphs; Arc Operations; Connectivity

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Combinatorial methods to explore CFG paths in BMC counterexamples
Lanier Santos; Jesse Deveza; Lucas Cordeiro; Rosiane de Freitas

December 15, 2022 (Thursday), 14:00 - Room 1305

Software testing is an integral part of the software quality assurance process to validate the overall design, find bugs in the source code and increase trust in the correctness of a system. Failures might be caused by concrete inputs, but must be fixed in abstract code. A set of inputs that causes the failure shall be defined, so that a fix may be applied to this scenario. In the context of software verification, bounded model checking (BMCs) tools, have already been successfully applied to discover subtle errors in real software projects. When a BMC tool finds an error, it produces a counterexample. BMC tools often produce counterexamples that are either too large or difficult to be understood, in order to avoid validation of paths that may not reach any solution, a CP approach would be a useful technique for optimizing the range checks performed. This work presents an empirical analysis of algorithmic techniques, and exact/heuristic methods, which explore the multiple paths of a flow control graph of counterexamples.

Keywords: algorithms; bounded model checking; combinatorial methods; computational complexity; control-flow graph; satisfiability; theory of computation

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The effects of pregnancy and child birth on consumption
Veronica Diaz; Ricardo Montoya; Oded Netzer

December 15, 2022 (Thursday), 14:00 - Room 1306

Major life transitions such as relocation, a new job or pregnancy, and the birth of a child can have major implications on one’s lifestyle and consumption patterns. In this research, we study how the consumption behavior of first-time parents is affected, both during pregnancy and after birth. We combine a unique dataset that identifies precisely the date of childbirth with supermarket credit card data where we observe detailed supermarket transactions and aggregated purchases made at different external companies using the credit card to investigate the relationship between pregnancy and childbirth and consumption. To examine the causal effect of pregnancy and childbirth on consumption, we combine a difference-in-differences approach with a generalized random forests procedure that matches each first-time parent with comparable non-parents. Our results show statistically significant impacts in a large percentage of the analyzed product categories during the pregnancy period and during the post-birth period. Preliminary results show that the most affected categories by the first-child pregnancy were: home improvement, travel, health, and entertainment services.

Keywords: Consumer behavior; Causal effects; Machine learning; Causal forest; Effects of pregnancy on consumption

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Desarrollo e Implementación de modelo corrector de definiciones en exámenes de Investigación Operativa basado en Inteligencia Artificial. Conozcan a BotIO, una experiencia pedagógica
Xavier Gonzalez; Horacio Rojo; Silvia Ramos; Facundo Andres Toniolo; Sofia Maira Parrino; Joaquin Renovales; Juan Palomeque; Noelia Lucia Florez Uría; Mateo Marco; Julieta Belén Romanelli

December 15, 2022 (Thursday), 14:00 - Room 1306

Como educadores y estudiantes, es interesante proponernos pensar como soluciones basadas en Inteligencia Artificial se pueden aplicar para agregar valor en las actividades de docencia en el

entorno universitario, ayudando en parte a sortear dificultades propias del contexto actual de la educación pública universitaria en Argentina. En particular, nos proponemos construir e implementar un modelo que corrija preguntas sobre definiciones en exámenes de Investigación Operativa. Es decir, que establezca la correctitud de respuestas de texto corto a preguntas como: ¿qué es la investigación Operativa?, ¿qué es un Modelo? ¿qué es un Algoritmo? El desarrollo que proponemos puede entenderse como una función que toma el texto de respuesta y devuelve el puntaje que se le asigna de acuerdo con que tan similar es la respuesta de las alumnas y alumnos con respecto a una respuesta patrón que se asume correcta. El modelo, desarrollado también por alumnes, es de naturaleza simple e integra otros modelos y algoritmos propios de la Investigación Operativa, y consiste básicamente en obtener las palabras claves de la definición correcta y considerar solo el stem, i.e. la raíz; dada una respuesta, se cuenta la ocurrencia de esas palabras y se asigna un score en base a cuantas ocurrencias se observan. Este modelo, si bien es un baseline, tiene performance similar a las evaluaciones realizadas por correctores humanos, docentes y alumnos. La experiencia del desarrollo e implementación 'en productivo' del modelo nos permite ensayar roles como consultores y también como clientes de la puesta en acción de un modelo de AI. La experiencia nos aportó vivencias que nos ayudan entender cómo es una solución de inteligencia artificial, cómo se entrena, cómo se implementa, qué es el error, qué conflictos trae su implementación, etc.

Keywords: Artificial Inteligence; NLP in Exams; Education; Operations Research

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Custom neural networks: an approach to predict-and-optimize

Nuria Gómez-Vargas; Rafael Blanquero; Emilio Carrizosa

December 15, 2022 (Thursday), 14:00 - Room 1306

In real-world applications, the presence of uncertainty in the multiple parameters that model decision problems (e.g., demands, travel times) is standard. Hence the need to create broader pipelines that combine Machine Learning- to leverage auxiliary information (e.g., weather or traffic congestion) and predict unknown quantities- and Mathematical Optimization- which enables decision-making. However, prediction and optimization are separate in traditional approaches. We present here a decision-focused learning framework for training prediction models by gradient descent via their performance on the subsequent optimization problem. For the multiple-output regression we chose neural networks due to their ability of learning a continuous function that jointly models the complex relationships between inputs and outputs. In particular, with the choice of a shallow neural architecture, we explore a sparse update of the weights guided by the optimization problem, together with the explainability of the results.

Keywords: neural networks; predict-and-optimize; prescriptive analytics

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Integration of machine learning with the AHP for the evaluation and improvement of the availability of vital medicines in the Colombian health system: A hospital logistics solution

Danna Vanessa Betancourt Martínez; Lauriza Del Carmen Díaz Díaz

December 15, 2022 (Thursday), 14:00 - Room 1306

Colombia is a country that needs to improve hospital logistics, especially regarding essential medicines where serious deficiencies are evident despite the establishment and implementation of Law 100 of 1993, where within its principles is the guarantee of protection for all people. To provide a solution to the availability of vital medicines, the Backpropagation algorithm was applied where, through an artificial intelligence forecast model of supervised neural networks, the data correlation was established between the amount of medicine by type and the requests made by the pharmaceutical entities, obtaining as a response the quantities of medicines where the complaints are reduced. In a complementary way, the AHP multi-criteria decision method was used considering the criteria: user need, acquisition cost, distribution guarantee, and inventory control. Through this prioritization and the response of the algorithm, the list of priority medicines is proposed, as well as solutions that impact the hospital logistics of the country to have the availability of vital drugs, reducing the impact on costs and improving the level of service.

Keywords: Machine Learning; Artificial Intelligence; Neural Networks; AHP; Multicriteria Analysis;

Hospital Logistics

A branch-and-cut algorithm to solve the knapsack problem with scheduled items
Matias Anabalon; Franco Quezada; Óscar C. Vásquez

December 15, 2022 (Thursday), 14:00 - Room 1307

We consider a new extension of the knapsack problem, called the knapsack problem with scheduled items (KPsi). In this problem, the contribution of each item to total profit is determined by its position in the knapsack via a specific function. While in the classic version, this function could be considered a constant, we study non-linear functions motivated by several real applications, such as traffic congestion on transport networks, the retail shop layout, the TV advertisements scheduling, among others, in which a time window exhibits peak periods (e.g. at the start and the end, at the middle, etc.). In order to solve the problem, we study several structural and dominance properties of the optimal solution. These properties are then integrated within a branch-and-cut algorithm as valid inequalities to solve a time-indexed formulation of the problem. Computational experiments are carried out to assess its computational performance by comparing it with the one of a stand-alone mathematical programming solver and the numerical results suggest a good performance of the proposed approach at solving the problem.

Keywords: Knapsack problem; Scheduling; Non-linear functions; Branch-and-cut algorithm

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An integer linear programming model for the daily transportation planning in the sugarcane industry
Luciana Melchiori; Graciela Nasini; Jorge Marcelo Montagna; Gabriela Corsano

December 15, 2022 (Thursday), 14:00 - Room 1307

This work aims to develop a tool to solve the daily sugarcane transport planning (DSTP) in the context of the Argentine industry. The transportation from the sugarcane harvest areas to the mill (sugarcane processing plant) represent a considerable percentage of the total sugar supply chain cost and have significant influence on supply chain efficiency due to the cane deterioration. Thus, it is important to get a daily scheduling program to avoid this drawback. From operational point of view, the DSTP can be stated as: given a set of suppliers, each one offering a maximum number of sugarcane full-truckloads and with time windows for the pickup activity, the sugar mill demand expressed in number of full-truckloads, and a truck fleet hosted at the sugar mill, the goal is to determine the truck routing and the scheduling arrivals at harvest areas and the mill in order to satisfy the mill demand at minimum cost. The problem involved in the DSTP can be modeled as a particular case of the Unpaired Full truck-load Pickup and Delivery Problem with Resource Synchronization studied in [1]. In the present work, the exact approach formulated in this previous article through an Integer Linear Programm model is applied to for the particular case of the DSTP. The resolution of the proposed model integrates valid and symmetry-breaking constraints, and primal and dual bounds based on the solution of a combinatorial relaxation of the problem, ignoring scheduling restrictions (see [2]). The presented approach is evaluated in several scenarios associated with the Argentine sugar industry, demonstrating in all of them good performance to solve the hard and complex DSTP.

[1] Resources synchronization in a full truck-load pickup and delivery problem: An exact approach (2022)

[2] Problema de recogida y entrega en la industria forestal: nuevos modelos y estudio de su performance (2020)

Keywords: Sugarcane transport; Scheduling; Routing; Mathematical programming; Combinatorial optimization

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Rescheduling the NBA regular season via Integer Programming
Nicolás García Aramouni; Juan Jose Miranda Bront

December 15, 2022 (Thursday), 14:00 - Room 1307

The COVID-19 pandemic generated disruptions across multiple sectors, in particular in the sports industry as many leagues had to re-adapt their competitions as a consequence of lock-downs, travel restrictions and other implemented safety measures. Even when activities started to resume, match suspensions continued throughout the different leagues. Dealing effectively with these unexpected events is extremely relevant regarding both sports and economic aspects of the competitions. In this paper, we propose a framework that builds upon Integer Programming models to systematically reschedule suspended games and generate a contingency fixture that accounts for relevant operational constraints. Using the 2020-21 NBA season as a benchmark, we compare different scheduling approaches under two different objective functions. Computational results show that the approach produces good quality schedules and that the framework has potential to be applied in practice.

Keywords: sports scheduling; integer programming; tournament rescheduling

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Estimando el tamaño del árbol B&B in the Multidimensional knapsack problem (MKP)

Ivan Derpich; Erick Miranda

December 15, 2022 (Thursday), 14:00 - Room 1307

El tiempo de CPU es tema clave cuando se resuelve un problema MIP usando el algoritmo Branch and Bound (B&B). Este depende del tamaño del árbol de búsqueda asociado al algoritmo B&B. Este algoritmo busca la solución dividiendo recursivamente el espacio de búsqueda, el cual se representa por un árbol donde el nodo raíz se asocia con el espacio soluciones enteras y donde los nodos hermanos representan una partición del espacio de solución de su nodo padre. En trabajo anterior se propusieron índices de complejidad para estimar el tamaño del árbol B&B, el cual se aplicó al problema knapsack multidimensional. En este paper en la misma senda, se retoma esta idea, pero se extiende a la idea de contar nodos del árbol de ramificación del algoritmo B&B. La idea es disponer de un método para estimar el tamaño del arbol B&B a priori, es decir, antes de resolver el problema en cuestión. El método se basa en la idea de ganancias, en cada nodo se puede ramificar por la izquierda o por la derecha, y se obtiene una ganancia en el valor de la función objetivo mayor o menor, las que se suponen conocidas. La mayor ganancia será la derecha y la menor ganancia será la izquierda y serán r y l respetivamente. Si llamamos nr al número de ramificaciones por la derecha y nl al numero por la izquierda, entonces la ganancia máxima total será nr *l + nr *r y corresponde al tamaño máximo del árbol de ramificación B&B. En este trabajo se estiman los valores de r y l para el problema knapsack multidimensional usando el concepto de ajuste y se toman valores máximos nr *l + nr *r . Los valores obtenidos son cotas superiores que deben ajustarse en el futuro.

Keywords: integer programming; branch and bound; arbol de ramificacion

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Physician scheduling in Emergency Departments: from the real problem to the solution implementation

Marta Cildoz; Pedro Mateo; Fermin Mallor

December 15, 2022 (Thursday), 14:00 - Room 1309

This work addresses the physician-scheduling problem in Emergency Departments (ED) requiring a long-term work calendar to allocate work days and types of shift among all the physicians. We present all the requirements that a good shift schedule must meet in order to be accepted by the ED managers and by the ED physicians. The search for feasible solutions is complex due to ergonomic constraints (mandatory days off after certain shifts and limited staff) and bounds on the number of shifts of a given type that can be worked. Shifts vary in type: day and night, workday and holidays, short and long shifts, etc. Even within these categories, there are differences in terms of the task requirement. A solution must equally distribute the workload, both globally and in each type of shifts, to be implementable in practice. In addition, variation in the availability and annual working time of the physicians, such that they are not all able to work all types of shifts, must be considered in the “fair distribution” definition. We discuss how to assess the quality of a schedule based on the following two generic criteria: equitable distribution of workload among physicians and uniform temporal distribution of workload, overall and in each shift type, for each physician.We formulate the

problem mathematically as one of mathematical programming. We show that its resolution by exact methods is not possible in practice. We propose a heuristic algorithm (based on GRASP with solution improvement using variable neighborhood search and network flow optimization) and we discuss the quality of the solutions obtained, which leads to the presentation of a new matheuristic-type algorithm. We report the application to a real problem that motivated this research and the implementation of the obtained solutions in practice.

Keywords: Staffing and capacity planning; Emergency Medical Services; Workforce planning; OR in Health Services; Matheuristics

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Approximate dynamic programming to improve the scheduling of chemotherapy outpatients

Thiago A. O. Silva; Mauricio C. De Souza

December 15, 2022 (Thursday), 14:00 - Room 1309

Chemotherapy is largely employed for the treatment of many different cancers. The patients require a series of often complex treatments spread over the weeks. Thus, chemotherapy centers continuously face high demands for scheduling outpatients. On the other hand, these centers are subject to limited resources such as nurses and chairs. To complicate the matter the process is highly subject to uncertainties. In this work, we propose an approximate dynamic programming approach to efficiently deal with the uncertainties and improve the scheduling of chemotherapy outpatients based on a practical situation described in the literature. A treatment is a specific appointment requirement characterized by a patient, a primary nurse, a target date, a time window, and an expected duration. The problem consists of assigning the treatments to days, time slots, and chairs in the planning horizon subject to resources and treatments' specifications constraints. The goal is to minimize costs associated with assigning treatments to non primary nurses, out of their time windows, overtime, and non assigned treatments. We consider the following uncertainties: arrival of new treatments, modification in the treatments' specifications, canceling treatments, nurse absences, patients no-shows, and delays in the duration of treatments. Due to the dynamic nature of the process, at the beginning of each stage the planner can make decisions taking into account the new information available. The state of a treatment can be ready to start, scheduled, non assigned (new arrivals or treatments without scheduling), or concluded. Decisions can be (i) to put non assigned or scheduled treatments to ready to start, (ii) to schedule non assigned treatments, (iii) to reschedule previously scheduled treatments, and (iv) to put back as non assigned previously scheduled treatments not yet ready to start. Preliminary computational experiments show the potential benefits of the proposed dynamic approach.

Keywords: Health care; Chemotherapy scheduling; Scheduling under uncertainty; Approximate dynamic programming

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Simulation in healthcare management: application to the emergency room of a hospital in Uruguay

Ignacio Aristimuño; Valentina Larzábal; María Eugenia Silvera; Pedro Piñeyro; Antonio Mauttone

December 15, 2022 (Thursday), 14:00 - Room 1309

We present a Discrete Event Simulation (DES) model, developed for the study of the Emergency Room of the Pasteur Hospital in Montevideo, Uruguay.

Patients were modeled as entities who arrive to the system, were classified into five categories representing a degree of severity and then were routed through several sections (e.g., quick attention, specific studies, attention boxes, revival). Main resources which constrain the entities' activities are the specific equipment (radiography, tomography), the quick attention section and the regular attention boxes, doctors and nurses. To achieve this, a conceptual model was built from the hospital's actual flow of patients, the infrastructure of the Emergency Room and other information collected, and subsequently a simulation model in the AnyLogic software package was built. Based on historical data, random arrivals of 147 patients were generated in a regular day, who were classified according to historical percentages as well. Activities' durations were modeled using triangular distributions. Outputs of interest were mainly waiting time in queues to start each activity

(revival, specific studies) discriminated by patient category, and resource usage. The scenarios simulated include duplication of the triage (unit for selecting and classifying patients), sensitivity to the number of doctors and nurses, and special events like mass accidents and pandemics, which affect the rate and category of incoming patients. Several independent replications were run, including detection of the steady state. The analysis of results allows for: (i) identifying the change of level of service due to infrastructure investment and slight modification of patient flows protocol, (ii) identifying underutilization of some resources. Regarding the results obtained, the principal bottleneck identified was the execution of the triage.

Keywords: Healthcare Management; Emergency Room; Discrete Event Simulation