XX CONGRESSO APDIO

2019

22>24 julho
Politécnico de Tomar

Livro de Resumos
Abstract Book

APDIO
ASSOCIAÇÃO PORTUGUESA
DE INVESTIGAÇÃO OPERACIONAL

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HOTEL DOS TEMPLÁRIOS

IO 2019

XX Congresso da APDIO

Livro de Resumos

Instituto Politécnico de Tomar

22, 23 e 24 de Julho de 2019

Conteúdo

Mensagem de Boas-Vindas

Caros participantes

Em meu nome pessoal e em nome da Comissão Organizadora, sejam muito bem-vindos ao Instituto Politécnico de Tomar e ao *IO2019*!

A edição presente do Congresso da APDIO traz em simultâneo duas particularidades diferenciadoras. Trata-se por um lado da sua vigésima edição – uma marca que traduz em definitivo a sua maioridade, consolidando uma posição que já detém há longos anos no panorama dos eventos nacionais na área da Investigação Operacional. Por outro, insere-se num esforço, promovido pela Direção da APDIO, para converter este evento em anual. Do lado da Comissão Organizadora, entendemos este esforço também como um desafio – manter a qualidade de todas as edições anteriores, quer do ponto de vista organizativo, quer no volume e nível das sessões plenárias e paralelas em cada evento. Tentámos estar à altura deste desafio, procurando que o *IO2019* seja, à semelhança dos anteriores, um espaço de reflexão e de partilha de conhecimentos e de experiências. O programa foi desenhado com este objetivo em mente, e gostaria nestas linhas de agradecer à Comissão de Programa, por tão bem ter conseguido materializar este desiderato no Programa que aqui vos apresentamos.

Uma caraterística muito interessante deste XX Congresso da APDIO prende-se com o incremento do protagonismo do EstudIO, que nesta edição passa a ocupar uma sessão plenária, por forma a aumentar a sua visibilidade no contexto de todo o evento. Esta opção justifica-se à luz do desejo de dar mais relevo àquilo que se entende ser o futuro da Investigação Operacional em Portugal.

Como é mencionado na nota introdutória patente no portal do *IO2019*, esta edição do Congresso da APDIO decorre sob o lema da confluência entre a Investigação Operacional e a Aprendizagem Automática. Neste contexto, durante estes três dias de participação e de convívio, procuraremos explorar em conjunto as sinergias que se poderão criar entre estas duas áreas de conhecimento, com a ajuda dos nossos três oradores plenários – Professores Emilio

Carrizosa, Sofiane Oussedik e José Valério de Carvalho, a quem estamos profundamente reconhecidos pela sua disponibilidade – com a participação ativa das empresas e demais entidades que se juntaram a nós neste esforço conjunto, assim como com as mais de cem contribuições paralelas propostas pelos nossos participantes. A todos eles estamos bastante gratos. Finalmente, não poderíamos deixar de dar um agradecimento muito especial à Direção da APDIO, por ter confiado em nós e pela sua disponibilidade permanente e incansável para nos ajudar.

Terminamos desejando que o *IO2019* seja um momento privilegiado de convívio e partilha para todos. Da nossa parte tudo faremos para que assim seja, de modo a que todos se sintam no Instituto Politécnico de Tomar e na cidade de Tomar como em sua casa.

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Programa

22 de Julho (segunda-feira)		23 de Julho (terça-feira)		24 de Julho (quarta-feira)	
9.00 - 11.00	Registo	9.00 - 10.30	TA1: Transportation Management and VRP II** TA2: Energy, Environment, Nat. Resources and Climate I* TA3: Production and Operations Management I* TA4: OR in Industry* TA5: Scheduling*	9.00 - 10.30	W1: Transportation Management and VRP III** W2: Other OR Applications* W3: Production and Operations Management II* W4: Supply Chain Management II** W5: Invited Session and Continuous Optimization**
		10.30 - 11.00	Coffee break	10.30 - 11.00	Coffee break
11.00 - 11.30	Sessão de Abertura	11.00 - 12.30	TB1: Decision Suppport Systems* TB2: Energy, Environment, Nat. Resources and Climate II* TB3: Production and Operations Management II* TB4: Supply Chain Management I* TB5: MCDA*	11.00 - 12.00	Sessão Plenária: José Valério de Carvalho
11.30 - 12.30	Sessão Plenária: Emilio Carrizosa			12.00 - 12.30	Entrega de Prémios e Sessão de Encerramento
12.30 - 14.00	Almoço	12.30 - 14.00	Almoço	12.30 - 14:00	Almoço
14.00 - 16.00	EstudIO - SISCOG	14.00 - 15.00	Sessão Plenária: Sofiane Oussedik		
		15.00 - 15.30	Coffee break		
16.00 - 16.30	Coffee break	15.30 - 17.30	TC1: Meet the editors TC2: IBM Hands on		
16.30 - 18.00	M1: Transportation Management and VRP I** M2: OR in Health and Life Sciences* M3: Data mining and Data analysis* M4: DEA and Performance Analysis* M5: Discrete Optimization, Graphs**	17.30 - 18.30	Assembleia Geral da APDIO		
19.00	Tomar de Honra	20.00	Jantar do Congresso		

*Sessões em Português/Inglês

*Sessões em Inglês

22 de Julho (segunda-feira)

9:00 - 11:00	**Registo**
11:00 - 11:30	Sessão de Abertura (Auditório Pacheco de Amorim)
11:30 - 12:30	Sessão Plenária 1 (Auditório Pacheco de Amorim): Emilio Carrizosa
12:30 - 14:00	*Almoço*
14:00 - 16:00	EstudIO - SISCOG (Auditório Pacheco de Amorim)
16:00 - 16:30	*Coffee break*
16:30 - 18:00	M1 (sala B253): Transportation Management and VRP I** M2 (sala B255): OR in Health and Life Sciences* M3 (sala B254): Data Mining and Data Analysis* M4 (sala B257): DEA and Performance Analysis* M5 (sala B259): Discrete Optimization, Graphs and Geometry**
19:00	Tomar de Honra

*Sessões em Português/Inglês

**Sessões em Inglês

Sessão Plenária 1

22 de Julho, Segunda-feira, 11:30 - 12:30
Sala: Auditório Pacheco de Amorim

Moderador: Carlos Henggeler Antunes

One day optimizers became data scientists...

Emilio Carrizosa *Instituto de Matemáticas de la Universidad de Sevilla, Sevilha, Espanha*

Resumo. Data Science is a discipline in between traditional Statistics, Mathematics, Computer Science and many others. Many important challenges in Data Science involve the resolution of nontrivial mathematical optimization problems, either convex or nonconvex, continuous or (mixed) integer, usually in large dimension. These include supervised and nonsupervised classification, and dimensionality reduction.

In this talk we will illustrate the use of Mathematical Optimization in different problems in Data Science, showing how broad and exciting the field is, and how important is the role played by Mathematical Optimization.

EstudIO - SISCOG

22 de Julho, Segunda-feira, 14:00 - 16:00
Sala: Auditório Pacheco de Amorim

Organização: Tânia Ramos
Moderadora: Tânia Ramos

Staff Scheduling at an Emergency Medical Service
A meta-heuristic approach

Katrin Munzenrieder, Inês Marques

Delivery time slot management methods in online retail

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Modelo de Gestão de Operações em Postos de Transformação de Distribuição

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Oleksandr Pavlenko, Lia Oliveira

Operational Planning of Aluminium Profiles Production by Direct Extrusion

Sofia Almeida, Eliana Costa e Silva, Fátima de Almeida, Aldina Correia

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Exact and hybrid optimization algorithms for the integrated personnel shift and task re-scheduling problems

Rita Martins, Cláudio Alves, Telmo Pinto

In-Store Capacity Planning - The Case-Study of a Furniture Retailer

Bernardo Silva, Susana Relvas

Optimizing Kidney Exchange Programs with Budget Constraints

Valeria Romanciuc

Otimização de uma rede de recolha e valorização de pneus usados O caso da Valorpneu

Mariana da Cruz Teixeira

Otimização do *Product Mix* baseado num sistema de custeio baseado nas atividades usando programação inteira mista

Ana Carvalho, Eliana Costa e Silva, Rui Silva

Integration of inventory management and distribution scheduling: An optimization model for a hospital context

Maria Madalena Lima, Inês Marques

Designing In-House Logistics Operations towards Industry 4.0: Volkswagen Autoeuropa Case

Sebastião Graça, Susana Relvas

Ver resumos alargados nas páginas seguintes.

Staff Scheduling at an Emergency Medical Service A meta-heuristic approach

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Problem description

The goal of automated staff scheduling is to design fair and efficient work timetables to satisfy an organizations' demand while saving time and minimizing the overall costs. Numerous constraints, such as legal and contractual regulations, as well as personal preferences need to be considered to obtain feasible and pleasant schedules. Due to efficient employee utilization, productivity may be increased [1]. Additionally, staff satisfaction may be improved [2] [3].

In Emergency Medical Services (EMSs), efficient personnel scheduling is crucial as staff shortages directly influence quality of care for patients. Sufficient coverage needs to be ensured, 24 hours a day, 7 days a week. Different objectives, constraints and a high number of variables make the staff scheduling problem at EMSs a complex combinatorial problem [3].

The present staff scheduling problem is motivated by the Portuguese EMS (Instituto Nacional de Emergência Médica, INEM). Approximately 290 heterogeneous skilled staff members need to be assigned to different services, namely the dispatch centers (Centro de Orientação de Doentes Urgentes, CODU) and the emergency vehicles (EVs). It is a new staff scheduling problem in the context of EMSs as the CODUs and EVs share the same pool of technical personnel. Both services are divided into teams and each of those teams has a set of specific tasks to perform as well as a set of people. Nevertheless, staff members can also perform tasks belonging to other teams to fulfill the staffing requirements if they have the needed skills. The number of employees required for each task is known in advance, but differs between different shift types (morning, afternoon and night shifts). In total, there are 22 teams (5 in the CODUs and 17 in the EVs), working in different locations, and 61 different tasks. The complexity of the INEM scheduling problem is also influenced by the length of the planning period, which is 28 days. The goal is to find a schedule that fulfills the required demand for each task on each day and in each shift to ensure the functionality of the services, while simultaneously guaranteeing high staff satisfaction. The generated schedule should be as equitable as possible.

In [4], a scheduling tool to tackle a first version of the problem encountered at INEM is proposed. To make it usable in real-life settings, a range of

extensions need to be made, requiring changes in the model formulation as well as in the method to solve the problem. It needs to be taken care of holidays, staff preferences and requests for days-off and days-on.

Relevance of the Problem

Although automated staff scheduling is widely studied in the literature, the number of implemented methods in EMSs is low. This problem shares similar characteristics to the Nurse Scheduling Problem (NSP), a NP-hard problem extensively investigated. Nevertheless, due to the special characteristics, such as the geographically dispersed, heterogeneously skilled workforce, and the high complexity of the INEM scheduling problem, no published approach can be straightforward applied without major transformations.

Currently, the schedules at INEM are built manually, which is time-consuming and produces considerable administrative work to two emergency technicians overseeing this task. Besides saving time and money, an automatic scheduling tool improves the solution quality and transparency, as the algorithm to generate the schedules uses rules agreed upon in advance. This also enhances the employees' perception of fairness of the resulting timetables [4].

Materials and Methods

Two different meta-heuristic approaches are implemented to solve the complex staff scheduling problem encountered in the EMS in reasonable time.

The first proposed meta-heuristic is an extension of the Variable Neighborhood Decomposition Search (VNDS) proposed in [4] and the second one is an Adaptive Large Neighborhood Search (ALNS). The VNDS consists of a local search in a randomly chosen subspace of the problem and a shake phase to avoid getting stuck in a local minimum. Three different neighborhood structures – fixed days, fixed shifts and fixed tasks – are used to improve the outcome. The second proposed meta-heuristic, ALNS, is based on destroy and repair heuristics. The different subspaces are chosen based on statistics, collected during the local search phase. Three different parameters (time limit of the subproblems, number of iterations between the weight-updates and a parameter α to adjust the influence of new and historical data) are fine-tuned to improve the outcome [5].

The performance of both approaches is compared to understand which one is more appropriate to be embedded in a decision support system for INEM. For the tests, 20 different instances are used. The solutions are also compared to an actual schedule at INEM and the advantages of its use in a real-life setting are explored.

Finally, a graphical user interface is designed to allow the scheduling tool in practice. Besides displaying the calculated schedule, shift changes by the end users are also possible.

Preliminary Results

Due to the high number of variables and constraints, the INEM problem cannot be solved with a commercial Integer Programming solver in reasonable time. Therefore, the two proposed meta-heuristic approaches can be applied to tackle complex staff scheduling problems.

Computational tests of the VNDS-based meta-heuristic show that the performance of the JAVA implementation is slightly better compared to the implementation in C++ described in [4] when the time limit is set to one hour.

First computational tests of the ALNS-based meta-heuristic show the importance of the three adjustment-parameters. To determine the best time limit for the subproblems, parameter α was first set to 0, which means that all destroy methods have the same probability to be chosen. After fixing the time limit, the influence of parameter α and how it can be set to escape local minima as well as the best number of iterations are further investigated.

References

[1] X. Cai and K. N. Li, "A genetic algorithm for scheduling staff of mixed skills under multi-criteria", *European Journal of Operational Research*, vol. 125, pp. 359-369, 2000.

[2] J. Li, E. K. Burke, T. Curtois, S. Petrovic and R. Qu, "The falling tide algorithm: A new multi-objective approach for complex workforce scheduling", *Omega*, vol. 40, pp. 283-293, 2012.

[3] J. M. M. N. Rosa, *Optimizing Staff Scheduling in Emergency Medical Services: a case at INEM*, 2017.

[4] H. Vermuyten, J. Namorado Rosa, I. Marques, J. Beliën and A. . Barbosa-Póvoa, "Integrated staff scheduling at a medical emergency service: An optimisation approach", *Expert Systems With Applications*, vol. 112, pp. 62-76, 2018.

[5] M. A. F. Belo-Filho, P. Amorim and B. Almada-Lobo, "An adaptive large neighbourhood search for the operational integrated production and distribution problem of perishable products", *International Journal of Production Research*, vol. 53, no. 20, p. 6040 - 6058, 2015.

Delivery time slot management methods in online retail

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Keywords -Time slot, Online retail, Attended home delivery, Vehicle routing.

Problem description

For the comfort of customers, e-grocers normally practices attended home delivery (AHD). This implies that the client has to be at home to receive their package. To optimize the distribution cost, customers are presented with time slots to choose from when making a purchase. We can try to influence this customers' choice, possibly resulting in a more optimized and cost-efficient delivery process. This work contemplates the case of a Portuguese retailer that practices AHD and studies how the resource to time slot management methods can help to improve their profits, preserving the overall satisfaction of its customers.

Their transaction process goes as follows: the customer first logs into the website with their information and adds the products that he wants to buy into the cart. Afterwards, he proceeds with the purchase, he checks out and choose the delivery option: pick up in store or home delivery. If he chooses home delivery, he then has to choose a delivery slot from the set offered by the retailer.

The retailer is in charge of managing the routing schedule, which is planned periodically. The fulfillment of the orders is mostly made by physical stores. More precisely, there is a pre-association between stores and certain delivery zones. For deliveries, the retailer has its own fleet.

Their current procedure, regarding the time slots strategy, is to limit the orders for each slot, focusing on a single day. The objective is now to make the process more dynamic. Their delivery service consists in a fixed price policy, so the idea will be to develop a sophisticated method of dynamic slotting. The assumption that a customer choice is day-dependent or flexible will be investigated, i.e., customers are willing to make their orders on a different day as long as it is in the desired time.

Problem relevance

Over the years, the online industry have been focused on improving the existent methods of online distribution, in order to increase profitability. While most e-tailors already offer time slots for the customer to choose from, a lot of them use a simple decision tree and are not very efficient. Several approaches to aid this problem have surfaced, such as dynamic slotting of delivery time

schedules and dynamic slot pricing, to lead customers to choose more convenient slots.

This project aims to assist the study of this area, where although there is a lot of literature, it's necessary to study different variants, relaxing certain assumptions. In existent literature, the methods used focus on independent days, without predicting that a client can be flexible with the day and have preference only at a specific time. Moreover, the strategies proposed are usually hard to implement in practice or use pricing strategies that some retailers don't have the ability to perform. As such, there is a need for simpler but effective strategies.

Methodology

Real e-grocer data is used to portray customer behavior, to support us in predicting the choices made by them through several methodologies, which in turn will help us to estimate the opportunity cost of inserting a client in a given delivery route. While a new slotting approach is being proposed for time slot management, we use state-of-the-art methods to model customer behavior and estimate opportunity cost. With this project, we intend to analyze different methods that define strategical rules around slots that retailers should offer to their clients, with the goal to lead customers to choose more beneficial slots for distribution while ensuring a good service to the customers.

As starting point, the study provided by Jochen Mackert in 2019 [1] was used as basis to construct a mixed-integer linear program (MILP) to approximate the opportunity cost, also considering the routing consequences of future customers to come. These opportunity cost values are used to decide which time slots to offer to customers, with a model that incorporates customer choice behavior using a generalized attraction model (GAM).

To simulate a real case, we formulate the dynamic time slot offer problem proposed by Mackert, 2019 [1]. In each period, if a customer arrives, we calculate the value function of each time slot (we consider 6 time slots) as well as the value function if the customer leaves without placing an order. These values are used to calculate the opportunity cost in the final model that selects the time slots to offer. Parallel to this, there are created routes (5 different routes, one for each vehicle) with every customer already scheduled, so we can check if the current customer can be placed among the already accepted customers, and in which slot. This is used to create a set of slots in which the customer can be feasibly inserted. This set is also used for the final model.

Afterwards, we finally choose the set of time slots to offer to the customer including the no-purchase option, that characterizes the option to leave without ordering. With this set, we calculate the probability of the customer to choose each time slot based on the attraction values of the choice model in use, and simulate the selection of a time slot by the customer. With this

choice made, our algorithm proceeds to update the information related to the customer, such as the time slot chosen and respective vehicle (based on the routes formed previously), and update several parameters that will be used in the next period, such as: the travel distance of accepted and scheduled customers, number of scheduled customers and order size of scheduled customers (all three based on the routes formed previously); approximated travel distances for expected customers applying a dynamic seed-based scheme.

Other parameters are defined by the user, such as the vehicle capacity, time slot length, delivery fee, expected revenue, among others. This MILP approach was implemented in C++ using Visual Studio 2017 with IBM CPLEX 12.9 libraries.

Results

The work done until this moment provided us the results in table 1 for a fleet size of 5 vehicles and different approaches: in NO-Opp, the opportunity cost is replaced by zero in the time slot offer decision problem; Opp considers the opportunity cost of placing the customer in each time slot; Opp-MinSlot is the same as Opp, but ensuring a minimum of 2 time slots to offer to the customer whenever possible; Opp-MinProb is again the same as Opp, but ensuring a minimum probability of customer satisfaction by the time slots offered of 25% whenever possible.

Table 1: Results for different approaches.

Slotting approach	Scheduled requests	Average number of slots offered	Total profit	Delivery cost	Gap
NO-Opp	214	3.77	6411	171.51	-3.96%
Opp	197	3.54	6675	162.84	0.00%
Opp-MinSlot	203	3.36	6630	150.53	-0.67%
Opp-MinProb	206	3.24	6612	176.13	-0.94%

In figure 1 we can see the evolution of the number of customers scheduled and profit for both NO-Opp and Opp. As expected, in NO-Opp the number of customers scheduled grows faster because every time slot feasible is offered to him, while in Opp the number of customers scheduled grows steadily because we don't offer every time slot available when we could be more profitable customers in the future.

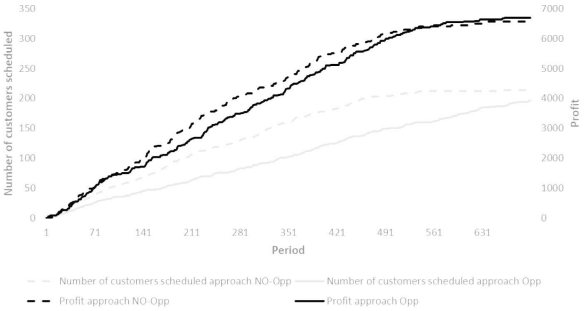

Figure 1: Evolution of customers scheduled and profit for NO-Opp and Opp.

References

[1] Jochen Mackert, "Choice-based dynamic time slot management in attended home delivery", *Computers & Industrial Engineering*, vol. 129, pp. 333-345, 2019.

Modelo de Gestão de Operações em Postos de Transformação de Distribuição

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Descrição do problema

A EDP Distribuição é a principal responsável por transportar a energia elétrica até ao consumidor. Um dos trabalhos efetuados pela empresa é a instalação e manutenção de equipamentos que permitem a receção das leituras que estão situados nos postos de transformação de distribuição (PTD).

Atualmente, existe na empresa um grande volume de ordens pendentes (instalação e manutenção) a resolver de forma a tornar os equipamentos mencionados funcionais. Nesse sentido, foi desenvolvido um modelo matemático que permite realizar de forma eficiente o agendamento das equipas para proceder à gestão de operações dos problemas dos equipamentos existentes nos PTD. Este modelo permite encontrar uma solução para a afetação dessas equipas com as ordens pendentes de forma a satisfazer os requisitos da empresa. Deste modo, é possível determinar o número de equipas mínimo a disponibilizar e a forma como alocá-las em cada tarefa. Assim, modelam-se dois processos (número de tarefas resolvidas e número de equipas a disponibilizar) numa única estrutura, usando uma formulação de tempo discreto de programação linear inteira mista. O estudo separado de cada um destes problemas é discutido na literatura em outros contextos. No entanto, quando se consideram os dois problemas em simultâneo, a literatura é mais escassa.

O objetivo principal deste trabalho é o desenvolvimento do modelo que visa dar resposta ao problema proposto pela empresa. A solução obtida com o modelo permite uma alocação dinâmica dos recursos e ajusta os valores consoante as necessidades em cada período. Efetua-se ainda, uma análise do desempenho da solução determinada e compara-se com a situação atualmente praticada pela empresa.

Relevância do problema

InovGrid é um projeto inovador que dota a rede elétrica de informação e equipamentos inteligentes capazes de automatizar a gestão da energia, melhorando assim a qualidade do serviço, como a diminuição os custos e um aumento da eficiência energética e da sustentabilidade ambiental.

São estas inovações que fazem com que constantemente existam planos novos de trabalho aos quais é preciso dar resposta. O trabalho aqui apresentado surgiu nesse contexto, permitindo dar resposta a um problema atual. Com a implementação do projeto InovGrid, a instalação e manutenção destes novos equipamentos implica um ajuste nas equipas para a execução de novas

tarefas. Atualmente um dos ajustes mais necessário é no número de equipas que estão responsáveis pela resolução das ordens pendentes existentes nos PTD. Neste contexto surge o problema aqui referido onde de pretende minimizar o número de ordens pendentes em PTD e o número de equipas.

Metodologia utilizada na resolução

Antes de se construir o modelo pretendido é necessário definir os parâmetros e variáveis a trabalhar. Importa mencionar que para a resolução do modelo se consideram doze zonas geográficas distintas que perfazem Portugal Continental, onde em cada uma delas se admite que existe uma empresa responsável para a resolução de tarefas necessárias. As tarefas correspondem a ordens pendentes, podendo ser estas de manutenção ou de instalação. As primeiras tratam tarefas relacionadas com anteriores avarias enquanto que o segundo tipo de tarefas é relativo a equipamentos que se pretende instalar.

Os parâmetros necessários para a definição do modelo incluem o período de estudo, a duração de tempo de trabalho de cada equipa, o número de horas laborais por semana, a taxa de avaria associada a cada equipamento com ordens pendentes de manutenção, o número máximo de equipas disponíveis a trabalhar em cada empresa e ainda o máximo de equipas a trabalhar por todas as empresas. São necessários também parâmetros da base de dados da EDP Distribuição, como o número de equipamentos existente em cada zona geográfica, o número de equipamentos avariados em cada uma dessas zonas geográficas e o número de equipamentos que se pretende instalar ao longo do período de estudo. Ainda, é necessário saber o tempo de execução de cada tarefa por cada empresa, sendo esse um input dado por cada empresa. Já as variáveis de decisão são o número de novas equipas a disponíveis em cada semana por empresa e a fração de equipas que está alocada por tarefa em cada semana por empresa.

Após definidas as variáveis mencionadas anteriormente, é necessário construir o modelo estabelecendo as relações entre elas. As restrições do modelo permitem descrever a número de avarias e a atualização do número de ordens pendentes em cada semana. Além disso, permitem estabelecer outras características na solução definidas pela empresa, como por exemplo: o número de reparações feito semanalmente é inteiro, a duração do tempo que cada equipa está a trabalhar é fixa, o limite sobre o número de equipas que estão disponíveis numa semana tem de ser respeitado e as ordens pendentes de instalação tem de ser resolvidas uniformemente ao longo do período de estudo.

Neste trabalho são apresentados dois modelos, sendo o primeiro focado na minimização do número de ordens pendentes. No segundo modelo, a partir de uma determinada semana, o número de ordens pendentes de manutenção não pode ultrapassar um limite estabelecido e pretende-se minimizar o número de novas equipas disponíveis. Ambos os modelos foram implementados no CPLEX e comparados para os dados reais fornecidos pela empresa relativos

ao final de 2018 com a intuito de prever o número de equipas necessárias e a afetação de tarefas no ano 2019.

Resultados

Resolvendo o problema com os dados anteriores e comparando com a situação atual implementada na EDP Distribuição para o mesmo exemplo, constata-se que no global a solução obtida com o modelo apenas necessita cerca de metade das equipas que estão a ser disponibilizadas atualmente.

Esta melhoria deve-se sobretudo à possibilidade de alterar o número de equipas e a semana em que devem começar a trabalhar ao longo do período de estudo (mantendo-as durante o tempo de trabalho estipulado) e à forma dinâmica que são alocadas as equipas semanalmente para cada tarefa. Na situação atual implementada pela empresa, esses valores são fixos em todas as semanas.

A análise destes resultados também permitiu concluir que, em duas empresas específicas, o número de equipas disponíveis atualmente não vai ser suficiente para resolver todas as ordens pendentes no período de estudo pretendido. Esta observação está em concordância com o aumento do número de ordens pendentes nessas empresas observado nos dados históricos recolhidos.

De salientar que a implementação deste modelo na EDP Distribuição facilita a obtenção de novas soluções na forma mais ágil e eficiente, na medida que existe exibilidade do modelo para se necessário mudar os vários parâmetros. A EDP Distribuição está a equacionar a possibilidade de utilizar a solução obtida pelo modelo na gestão das operações durante o corrente ano.

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Redução do impacto ambiental com recurso ao planeamento de rotas de veículos

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Descrição do problema

A competitividade de uma empresa nos mercados atuais passou de uma mera dinâmica entre custos e qualidade, para um cenário que requer constante inovação proporcionando a necessidade de integração de novas tecnologias focadas na otimização dos processos. O ciclo de vida dos produtos são cada vez mais curtos, dada a crescente diferenciação e customização requisitadas pelos mercados, traduzindo-se em fluxos mais complexos, mais tensos e com maior risco de disrupção, visto que, a constituição de inventário é cada vez mais considerada como um risco. Este cenário provoca a necessidade de encomendas frequentes, em lotes de dimensão reduzida, em associação a prazos de entrega cada vez mais curtos. Para continuarem competitivas as cadeias de abastecimento têm de apostar em elevados níveis de serviço e cada vez mais em tempos de resposta reduzidos, substituindo previsões pelo conhecimento da procura. Deste modo, torna-se crucial que as empresas estejam aptas a desenvolver os seus sistemas de produção e distribuição, bem como as suas estratégias, para serem capazes de corresponder às expectativas do cliente com o menor custo possível (Ertogal, Darwish, & Ben-Daya, 2007)

Em associação à competitividade, a Comissão Europeia aliou a sustentabilidade ambiental como uma prioridade nas políticas europeias, lançando um conjunto de medidas no "Livro Branco de 2011". Neste traçou metas para o sector dos transportes a serem alcanças até 2050 publicadas no documento europeu "Roteiro do espaço único europeu dos transportes – Rumo a um sistema de transportes competitivo e económico em recursos". (Kallas, 2011; Margaritis, Anagnostopoulou, Tromaras, & Boile, 2016) Este documento tem sido amplamente analisado pela comunidade científica e industrial. E foi neste sentido, que surgiu o presente projeto.

A multinacional norte-americana Brunswick Marine a operar em Portugal é produtora de barcos de recreio e pretende alinhar as suas necessidades constantes de transporte, em território europeu, com as metas traçadas pela CE para 2050. Numa primeira fase, definiu a integração de veículos livres de emissões de CO2. O seu produto final possuí característica peculiares que requerem transporte especial, ou seja, necessitam de um camião com reboque de design customizado para poder transportar os barcos de recreio (tipicamente 2 barcos por camião) por forma a permitir a estabilidade do produto, mas

também devido à sua dimensão. Esta situação origina o retorno em vazio do veículo até à empresa, percurso que a empresa terá de suportar economicamente, sendo que o serviço é subcontratado. A empresa já abordou diversas opções junto de fornecedores de serviços logísticos não obtendo soluções mais vantajosas. O envio, em análise, é realizado por rodovia para toda a Europa existindo mercados com cadência previsível. O grupo empresarial a que pertence possuí mais empresas na Europa que interagem entre si, quer pelo envio de produto final (barcos de recreio com dimensões de 5 metros até 8,5 metros), quer pelo envio de matérias primas (bobines de fibra de vidro palatizada, eletrodomésticos, produtos decorativos, cabos elétricos, volantes, entre outros). Neste contexto, a empresa propôs o estudo do planeamento de rotas estruturando circuitos com integração da distribuição produto final e recolha de matéria-prima, considerando as particulares do caso de estudo e recorrendo a veículos sem consumo de combustíveis fósseis. (Brar, 2011)

Relevância do problema

Os problemas de planeamento de rotas de veículos (*Vehicle Routing Problems* - VRP) não são novidade. Este possuí diversas variantes em que se verificam alterações nas suas restrições, umas são adicionadas, outras eliminadas ou relaxadas. (Golden, Raghavan, & Wasil, 2008) Atualmente o objetivo do VRP não contempla apenas tempo e custos (por exemplo: minimização do número de veículos, distâncias percorridas), mas também questões ambientais, dando assim resposta às políticas mundiais que pretendem combater as mudanças climáticas. Neste contexto assumem uma relevância distinta dadas as características especificas do produto que exigem veículos customizados. A integração dos fluxos em rotas com fluxos Inbound e Outbound possibilitada pela aquisição de um reboque duplo customizado, já permite um significativo impacto na redução das emissões de CO2. (Figliozzi, 2010) No entanto, o objetivo passa pela aquisição de um veículo sem consumo de combustíveis fósseis, assim, considerando a disponibilidade da rede de abastecimento do combustível do veículo selecionado (considerando as tipologias e autonomias no mercado) o impacto ambiental será muito significativo, expectando-se um impacto económico e operacional significativo.

Metodologia utilizada na resolução

Para a resolução do problema baseamo-nos na variação mais clássica do modelo de VRP, O Green Vehicle Routing Problem (GVRP), uma extensão do VRP, surge na literatura com o objetivo de minimizar a distância percorrida e as emissões de carbono. (Wu, Visutarrom, & Chiang, 2018) Para além da modelação base do VRP, foi necessário refletir as restrições de capacidade distintas nos circuitos inbound e outbound (apenas 1 dos reboques permite fechar e retornar matéria-prima) para cada um dos reboques, impor distância máxima entre pontos de recolha/descarga num mesmo circuitos e incorporar a rede de abastecimento europeia para o veículo. Para o cálculo

dos custos foram consideradas todas as componentes variáveis e fixas com o objetivo de permitir o resultado mais preciso possível para comparação com os custos atuais, considerando um período de amortização do veículo a 6 anos. Os dados utilizados relativamente a veículos, consumos, autonomia e a redes de distribuição foram recolhidos junto dos fabricantes e distribuidores possibilitando um cenário realista e operacional.

Resultados

Atualmente, com apenas um veículo disponível, está a ser testado um primeiro circuito que integra um cliente final na Itália (taxa de ocupação de 100%), realiza recolha em 2 ou mais fornecedores com matéria-prima destinada a Portugal (taxa de ocupação sobe para 50% em vez de retornar em vazio) e ainda recolha na Italia um 1 ou 2 barcos de recreio isuflaveis destinados aos clientes franceses ou para distribuidor Iberico situado em Madrid (taxa de ocupação de retorno pode subir de 50% para 75% ou 100%). Os restantes circuitos não foram descartados, mas não ofereciam resultados operacionais tão positivos (custos, tempos de trânsito e taxas de ocupação).

Circuito atual apresenta dados extimados mas ainda carece ajustos operacionais tais como rota com pontos de paragens e abastecimentos (ajustar com fornecedores tempo de carga para evitar horas perdidas que influenciam no tempo de chegada a Portugal). Em termos dos custos são semelhantes. Hesiste uma redução de 25% dos custos de combustive, segundo dados obtidos no IVECO – redução de 20% do custo de manutenção do veiculo a gas liquido e redução de CO2 em 95%, mas armotizasão mensal do veiculo com combustivel fosseis é 45% mais baixa do que veiculo a gas (por ser tecnologia nova). Custo por quilometro varia consoante o preço de barril fixado a três meses. Os dados do preço do barril retirado do site European Commission - Energy Policy (European Commission, 2019).

Referências

[1] Bektas, T. and Laporte, G., "The pollution-roting problem", *Transportation Research Part B: Methodological*, vol. 45, no. 8, pp. 1232-1250, 2011.

[2] Brar, G. S., "Milk run logistics: literature review and directions", *Proceedings of the world congress on engineerin*, vol. 1, pp. 6-8, 2011.

[3] Butner, K., "The Smarter Supply Chain of the Future", *Strategy and Leadership*, vol. 38, no. 1, pp. 22-31, 2010.

[4] Ertogal, K., Darwish, M., and Ben-Daya, M., "Production and shipment lot sizing in a vendor-buyer supply chain with transportation cost", *European Journal of Operational Research*, vol. 176, no. 3, pp. 1592-1606, 2007.

[5] European Commission. Energy - European Commission, "Obtido de Weekly Oil Bulletin": https://ec.europa.eu/energy/en/data-analysis/weekly-oil-bulletin, 31 de May de 2019.

[6] Figliozzi, M., "Vehicle routing problem for emissions minimization", *Transportation Research Record*, vol. 2197, no. 1, pp. 1-7, 2010.

[7] Goetschalckx, M., "Supply chain engineering", *Springer Science and Business Media*, vol. 161, 2011.

[8] Golden, B., Raghavan, S., and Wasil, E., "The vehicle routing problem: latest advances and new challenges", *Springer Science and Business Media*, vol. 43, 2008.

[9] Kallas, S., "White Paper on Transport: Roadmap to a Single European Transport Area–towards a Competitive and Resource-efficient Transport System", Office for Official Publications of the European Communities, 2011.

[10] Margaritis, D., Anagnostopoulou, A., Tromaras, A., and Boile, M., "Electric commercial vehicles: Practical perspectives and future research directions", *Research in Transportation Business & Management*, vol. 18, pp. 4-10, 2016.

[11] Wu, C., Visutarrom, T., & Chiang, T. (2018). Green Vehicle Routing Problem: The Tradeoff between Travel Distance and Carbon Emissions. 2018 15th International Conference on Control, Automation, Robotics and Vision (ICARCV), pp. 1659-1664.

[12] Zhang, J., Zhao, Y., Xue, W., & Li, J. (2015). Vehicle routing problem with fuel consumption and carbon emission. Int.J. Production Economics, 170, 234-242.

Operational Planning of Aluminium Profiles Production by Direct Extrusion

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Problem description

Industrial needs are becoming more and more complex pushed by an ever more demanding market and an increasingly fierce competition. Nowadays, companies are required to meet tight deadlines that are set with the customers, while maintaining high quality products. Failing to do so may result in significant financial and productivity losses, and ultimately in losing the customer [1, 2]. Manufacturing strategy provides a powerful framework for creating and sustaining competitive advantages. Therefore, in the current market, effective sequencing and scheduling have become an essential requirement for the survival of companies. Many activities in industry require the scheduling of tasks. In fact, it is a common that one activity can start only if a set of previous tasks (sometimes carried out by different resources) have been completed. Scheduling deals with the allocation of resources to tasks over a set of given time periods. Its goal is to optimize one or more objectives [1].

In the aluminium industry, profiles are produced from aluminium alloys by the extrusion process. Saha [3] points that extrusion is a process of mechanical conformation by plastic deformation of an aluminium billet, in which the material is subjected to high pressures, applied by a punch, and forced to pass through the hole of a die, in order to reduce and/or change the shape of its cross-section.

This paper address a real case of a company that operates in the aluminium market, whose core business is the development and production of aluminium profiles for application in several areas, such as, engineering, architecture and industry works in general.

The aim is, on the one hand, to minimize production waste, commonly known as scrap, and on the other, to reduce product delivery times, maintaining quality and increasing productivity. In this company, after the customer's orders have been received, the production manager has to develop a production plan that must take into consideration the specific characteristics of the customer's order, the production capability of the factory, the existing stock, the deadline for the delivery of the final product to the costumer, among other factors.

Problem relevance

Energy conservation and emissions reduction have been a fundamental concern for the sustainability of the aluminium industry. Scheduling in the aluminium industry is directly related to energy consumption during the production process [4, 5]. Energy conservation and emissions reduction have been a fundamental concern for the sustainability of the aluminium industry, therefore companies seek sustainable planning [6, 7]. Minimizing energy consumption has been study for example by Esteban and Penia[8], which have built a model for scheduling orders and optimizing the casting process.

Since the existing commercial software does not answer to the company's specifies, the modelling of this industrial real challenge enhances the innovative contribution of the present work. In fact, a more dynamic framework, that supplements models of manufacturing with insights from the field of operational planning, is essential.

Methodology

This case study focuses on a scheduling flow shop problem involving sequence-dependent setup times arising from the need to change the tools used in the process of aluminium extrusion. Each job has to be processed in each of the stages in the same order, i.e., each job has to be processed first in stage 1, then in stage 2, and so on [9, 10].

A mixed integer programming model will be developed and implemented for answering the company's needs. Several instances provided by the company will be solved and compared to the company's current procedure in terms of the fulfilment of the deadlines and also on the quantity of scrap that is generated in the production process. Furthermore, we expect to compare the results of the developed model with some of the most used scheduling rules in literature, such as e.g. FIFO - First In First Out, EDD - Earliest Due Date, CR - Critical Ratio and SPT - Shortest Processing Time.

For the accomplishment of the empirical study, the company provided a data set, with information on the clients' orders of May 2018. It specifies each client's order and includes the following specifications: Order id - code that the company uses for identifying each order; Date of the order - day that the company has received the order; code of the die - die to be used; dimension of bars to be produced - length of each bar, in mm; name of client; code of the alloy; code of the finish treatment; description the type of finish - can be surface or thermal; date of delivery the order - the deadline of the order; total bars - number of bars to be produced; total weight of the bars - in kg; type of profile/die used; profile geometry.

Table 1 shows the descriptive statistics of the clients' orders. A large diversity in the order of clients is observed. In fact, the lengths of each bar to be produced ranges from 1 875 mm to 10 050 mm, while half of the ordered bars have lengths minor or equal to 6 500 mm. Also in terms of the number

of bars to be produced there is a large variability, ranging from 14 to 20 165 bars, while half of the orders correspond to 135 bars or less. The quantity of meters of each order varies from 60 to 120 969,80 meters and the total weight of the order varies between 30,75 kg and 30 000,52 kg. Half of orders have quantities less than or equal to 750 meters and a total weight less than or equal to 488,87 kg.

Table 2: Descriptive statistics.

Variable	Min	1st Qu.	Median	Mean	3rd Qu	Max
Length (in mm)	1,875.00	5,594.00	6,500.00	5,903.00	6,500.00	10,050.00
Number of bars	14.00	53.88	135.00	278.17	299.50	20,165.00
Total length	60.00	343.30	750.00	1,626.80	1,749.00	120,969.80
Total height (in kg)	30.75	254.59	488.87	908.95	999.50	30,000.52

For performing the production scheduling it is also necessary information about: stock of raw material and recovery time; raw material dimensions; time to lubricate the material; when to lubricate the material; number and code of die and tools available; maximum and minimum allowed time for each die; maximum number of simultaneous dies/tools in the heating casting; the time to exchange a die; die heating time; the maximum length of bars after extrusion and before cutting; maximum permanence time in oven; expected stop periods; the calculations performed to determine where the first sections will be cut after extrusion.

References

[1] Michael Pinedo, "Scheduling: Theory, Algorithms, and Systems", Fifth Edit. Springer, 2016.

[2] Helio Yochihiro Fuchigami and Socorro Rangel, "A survey of case studie sin production scheduling: Analysis and perspectives", *Journal of Computational Science*, vol. 25, pp. 425-436, 2018.

[3] Pradip K Saha, "Aluminum extrusion technology", Asm International, 2000.

[4] Xiaohong Xu, Erwei Yin and Fantian Zou, "Researches on optimal scheduling for aluminum industry continuous casting and rolling production", In2010 IEEE International Conference on Intelligent Computing and Intelligent Systems, vol. 1, pp. 348-352, 2010.

[5] Dimos Paraskevas, Karel Kellens, Wim Dewulf and Joost R Duflou, "Environmental modelling of aluminium recycling: a life cycle assessment tool for sustainable metal management", *Journal of Cleaner Production*, vol. 105, pp. 357-370, 2015.

[6] Gang Liu and Daniel B Muller, "Addressing sustainability in the aluminum industry: a critical review of life cycle assessments", *Journal of Cleaner Production*, vol. 35, pp. 108-117, 2012.

[7] Joakim Haraldsson and Maria T Johansson, "Review of measures for improved energy efficiency in production-related processes in the aluminium industry from electrolysis to recycling", *Renewable and Sustainable Energy Reviews*, vol. 93, pp. 525-548, 2018.

[8] Oihane Kamara Esteban and Yoseba K Penya, "Energy-aware foundry pro-duction scheduling", In IECON 2012-38th Annual Conference on IEEE Industrial Electronics Society, pp. 2827-2832, 2012.

[9] Ali Allahverdi, CT Ng, TC Edwin Cheng and Mikhail Y Kovalyov, "A survey of scheduling problems with setup times or costs", *European journal of operational research*, vol. 187, no. 3, pp. 985-1032, 2008.

[10] Jatinder ND Gupta and Edward F Stafford Jr., "Flowshop scheduling research after five decades", *European Journal of Operational Research*, vol. 169, no. 3, pp. 699-711, 2006.

Exact and hybrid optimization algorithms for the integrated personnel shift and task re-scheduling problems

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Definition of the Problem

Personnel scheduling consists of the assignment of shifts and days off to workers so that each one has a line-of-work. This process can be a complex task because schedulers must assign employees to shifts and tasks while accounting different rules and regulations, and also workers' availability. In the literature, several personnel scheduling problems with some different features can be found. This fact can be explained since, as it can be expected, different work environments imply different requirements. Therefore, some features receive particular attention, such as workforce characteristics, shift flexibility, the type of constraints and objective function used to model the problem, and the selection of the solution method to solve the problem.

The integrated personnel shift and task re-scheduling problem (IPSTrSP) is an example of a personnel scheduling problem. This problem can be divided into two different phases. In the first phase, the scheduler has to compose an integrated schedule, making a lot of deterministic assumptions, like the workers' availability, the number of tasks or even the timing of the tasks. These assumptions may not entirely represent the real context due to some existing operational variability. For each worker, a line-of-work is composed, where a particular task is assigned. It is important to keep in mind that a worker works according to shifts. So, a task is assigned to a worker, and different shifts are assigned to that task. The goal is to determine the minimum personnel cost. In the second phase, more accurate information is provided, and so, some estimated values may turn out wrong. Therefore, the original personnel roster needs to be adapted, and a re-scheduling problem has to be solved. The goal of re-scheduling is to rebuild the schedule while minimizing the number of deviations to the original schedule and also to reestablish the feasibility of the personnel roster (Maenhout and Vanhoucke, 2018).

Relevance of the Problem

Over the last years, the importance of studying personnel scheduling problems has been increasing. This is because, in many cases, the labor cost has a significant weight in companies' costs (Van den Bergh, 2013). Therefore, reducing this cost, even just a little, can be very advantageous and worthwhile.

One of the main goals of an organization is to satisfy the customer and the employees in a cost-effective manner. There are many concerns to consider,

such as shift equity, staff preferences, flexible workplace agreements, and part-time work, and thus, it is expectable that, in order to achieve optimized staff schedules, decision support systems must be carefully implemented.

As time goes by, the relative importance of satisfying employee needs in staffing and scheduling decisions has increased. Nowadays, organizations want to offer some conditions to their employees that were not a concern in the past. According to Bard et al. (2003), weak personnel schedules can lead to an oversupply of workers with too much idle time, or an undersupply with an attendant loss of business. Thompson (2003) reports three reasons for taking particular attention to staff scheduling. The first consists of the employee's preferences since a work schedule that comes reasonably close to meeting them can improve customer service. The second reason is related to the real time spent on developing a labor schedule, which can leave less time for the scheduler to manage the employees and to interact with customers. Finally, the third reason is profitability and effectiveness, since short-term overstaffing and long-term understaffing can be reduced.

Model approach

The main objective of this work is the analysis of optimization problems combining the scheduling of personnel shifts with personnel task assignment, and the development of efficient solution methods to solve them. For this purpose, both exact and hybrid approaches will be analyzed, exploring the theoretical properties of these optimization models, in order to identify weaknesses in the current models that might be improved and to prepare the development of new solution approaches that rely on them. Due to the complexity of the problem, exact approaches will be mostly considered to address small to medium size instances. Nevertheless, the results obtained will be used to devise new hybrid methods relying eventually on the previous exact ones to tackle realistic instances, considering relaxation based approaches preferentially. The best methods identified will be completely implemented and tested, using mostly instances from the literature, and the results will be compared with current state-of-art methods proposed so far in the literature.

References

[1] Bard, J. F., Binici, C. and deSilva, A. H., "Staff Scheduling at the United States Postal Service", *Computers and Operations Research*, vol. 30, pp. 745-771, 2003.

[2] Maenhout, B. and Vanhoucke, M., "A perturbation matheuristics for the integrated personnal shift and task re-scheduling problem", *European Journal of Operational Research*, vol. 269, pp. 806-823, 2018.

[3] Thompson, G. M., "Labor Scheduling: A commentary. Cornell Hospitality Quartely", vol. 44, pp. 5-6, 2003.

[4] Van den Bergh, J., Belien, J., Bruecker, P., Demeulemeester, E. and Boeck, L., "Personnel scheduling: A literature review", *European Journal of Operational Research*, vol. 226, pp. 367-385, 2013.

In-Store Capacity Planning - The Case-Study of a Furniture Retailer

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Problem description

In order to fulfil customer demand and also to take advantage of economies of scale, retailers need to manage storage space in their stores to stock and display products. In addition, because the retailer used in this study works under a franchise agreement, it has to follow certain brand chain rules. One of these rules states that every product offered in a store must be available for customers to purchase it on that same day. This means that not only does the store need to have the products in stock, but that they must also be available at any moment in their respective sales locations. This brings, of course, more complexity into the management of the store's storage space capacity.

The stores from this retailer are divided into four distinct areas: i) a showroom, where some products are displayed for customers to look at and to choose from, to later pick from the warehouse; ii) an area that resembles a typical retail store, where products are available for customers to choose from and pick directly; iii) a self-service warehouse, where most of the products that customers decided to purchase while in the showroom can be picked directly by them; iv) an interdict warehouse, where products that can't be picked by a customer (because they're too large, heavy and/or require customization) are picked by an employee when required.

An important distinction needs to be made: storage capacity versus sales locations capacity. Storage capacity refers to all the products stored while sales locations capacity refers only to the locations within the store where products can be picked (in the showroom, it excludes the product displays and in the warehouses, where the goods are stored in pallet racks, only the floor level and the first level are considered sales locations). In order to manage a store's sales locations capacity, the retailer uses a proprietary tool. This tool asks as inputs the dimensions (m2) of the commercial areas (sales locations within each of the four big areas) of the store, the expected annual turnover (m3) for that store and the number of products within each product category. Then, it uses a database that relates the annual turnover with the number of products within each category and calculates the area needed per category per commercial area. By comparing the needed space in each commercial area and the real dimensions, it provides a measure of the lack/surplus of space.

Although this tool might give managers a qualitative measure of performance (a large lack of space should result in operational inefficiency), it lacks

quantitative information. On the other hand, managers do not fully trust this tool as it has been providing them counterintuitive results: some stores that allegedly lack a lot of space are consistently outperforming stores that apparently have no space problems in almost every logistics Key Performance Indicators (KPI). The goal of this work is to develop a commercial area capacity management tool that distributes references through the stores' space, accounting to each store's specificities, thereby improving each store's individual performance and providing managers with more accurate data about the impact of a certain allocation on some KPIs.

Relevance of the Problem

Retailing has recently been given attention by academics due to its significant impact on the economy. Offering a wide variety of products is a must for satisfying customers, but this is challenging given that shelf space is limited. This is translated into two research areas: i) assortment decisions, which means deciding which set of products to stock; ii) shelf space allocation, which means determining the amount of space to allocate to each product (Mou et al., 2018). Because some of the sales locations of the case-study are within a warehouse, warehousing literature was also tackled. In warehousing literature, the allocation of space to products is described as the storage location assignment problem. In the case of the conventional retail stores, allocation aims at maximizing sales and demand is dependent on the amount of space dedicated to a product and its complementary and substitute products. On the other hand, in warehouses the goal is typically to minimize travelling in the picking process, thereby minimizing operational costs.

The assortment problem in particular has been tackled by retailers in a different way than it has been by researchers. Namely, the depth of the categories and products offered is a strategic decision for retailers, as it contributes to the retailer's position regarding competition. This means that retailers might carry products that are not particularly profitable but that are necessary from a strategic perspective. The process usually starts by dividing products into categories and by forecasting the sales of each category for some time period. Then, space is assigned to each category. Only after this, the number of different products of each category is decided. Academics tend to have a more operational and detail-oriented approach and assume that the set of candidate products and the parameters for each product that determine customer choices are known (Kök, 2009).

Methodology

It was decided, together with the logistics managers of the company, that this study should focus exclusively on the warehouse (both in the interdict and the self-service areas), because these were the areas where the results of their tool were more questionable and also because the management of the space in the other areas is more influenced by the sales and store design teams.

Because of the difficulty of finding the numerical expressions that define the logistics KPIs as functions of space allocation and category depth and taking into account the specificity of the case-study (self-service warehouse), it was decided that a predictive modelling approach was to be used. The goal is to predict the behaviour of some logistics KPIs given the space allocation and the number of products within each category, in order to provide the retailer with a tool that can easily and effectively be used in practice.

The development of the model is divided into three parts: i) predictive model development that allow to predict logistic KPI performance against warehouse configuration variables, ii) aggregate allocation model, that optimizes in a linear formulation the allocation and determines the number of references to allocate per HFB and volume to be used per HFB, while optimizing one or several KPIs (under a multiobjective problem) and iii) develop a detailed allocation model that takes into account the aggregate solution while minimizing the expected travelling distance of customers.

Data collected from real stores of the chain will be used to develop and validate all the tools herein described.

Keywords - operations management, warehouse operations, warehouse design, retail store operations, storage location assignment.

References

Kök, A.G., Fisher, M.L., Vaidyanathan, R. (2009) Assortment Planning: Review of Literature and Industry Practice, in Retail Supply Chain Management - Quantitative Models and Empirical Studies by Agrawal, N. and Smith, S.A. (editors), Springer, 99-153.

Mou, S., Robb, D. J., & DeHoratius, N. (2018) Retail store operations: Literature review and research directions. European Journal of Operational Research, 265(2), 399-422.

Optimizing Kidney Exchange Programs with Budget Constraints

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Problem description and relevance

About one in a thousand people in Europe suffer from end stage renal disease (ESRD) [1], which has two options of treatment available: dialysis and transplantation. The latter has proved to yield better outcomes, resulting in higher quality of life while also being considerably less costly than the former [4].

Traditionally, kidneys for transplants were obtained only from deceased donors, with patients in need of a transplant being placed on a waiting list. However, due to the fast growth of patients suffering from ESRD, the supply has largely failed to keep up with the demand. This allowed for new transplantation strategies to emerge such as obtaining kidneys from living donors, which not only increased the number of transplants being performed, but also improved the results of transplantation. However, in order for the procedure to be conducted, the willing donor must be physiologically compatible with their intended recipient, which fails to happen in over 30% of the cases [3].

KEPs were first proposed by Felix Rapaport in 1986 [2]. The simplest concept is the pairwise exchange, which consists in the following: given a patient P_1 with a willing but incompatible donor D_1, and another such donor-patient pair, D_2 and P_2, respectively, let us suppose that D_1 is compatible with P_2 and D_2 is compatible with P_1 (figure 1). Therefore, by swapping donors, both transplants could be carried out, as opposed to conducting none in the original scenario. This exchange can be generalized to include k incompatible pairs.

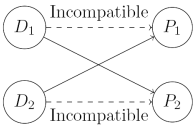

Figure 1: Representation of a pairwise kidney exchange. The dashed arrows represent incompatibility and the full arrows represent compatibility between donor (D_i) and patient (P_i).

To determine compatibility between pairs, a preliminary test is performed (called "virtual" crossmatch) and a transplantation plan is defined based on this information. Afterwards, a more accurate test is conducted on the selected pairs, possibly revealing new incompatibilities and thus leading to the

cancellation of planned transplants. Given the number of combinations, testing every two pairs for compatibility is only feasible in very small donor-patient pools.

The definition of these transplantation plans has been mostly addressed with integer programming based approaches. Different criteria can be maximized in order to determine the best plan, such as the number of transplants, the number of pairwise exchanges or the expected number of transplants.

KEPs have a significant relevance in dealing with ESRD. For instance, in the Netherlands a total of 284 transplants have been performed between 2004 and 2016 as a result of these programs [1]. Optimization approaches had a central role in reaching these figures and may improve them further.

We address the problem of selecting the best possible transplants to be tested, assuming that there is a budget and all tests have an associated cost. We also assume all tests must be conducted simultaneously. The budget constraint is also relevant in multi-agent (i.e., when several agents participate in a joint donor pool) kidney exchange programs, where tests may have different costs, which can simulate the differences of carrying out tests at different facilities and the costs inherent to the logistics and coordination of such a program.

Methodology use in the resolution

KEPs are usually represented via graph theory. We consider a directed graph, where the vertices represent the incompatible donor-patient pairs and the arcs are the compatibilities between these pairs (i.e. an arc exists only if two pairs are compatible). We also take into account the probability of match failure between pairs, which is represented by a weight associated to each arc. Each feasible exchange between two or more pairs is represented by a cycle in the aforementioned graph and we will only consider cycles of lengths 2 and 3 (2-cycles and 3-cycles, respectively), as they are the most common in actual KEPs.

We consider the problem of deciding which arcs should be selected to be tested, such that they form a set of disjoint cycles with the maximum value of the expected number of transplants, and present an integer programming model to solve this problem.

Two approaches were considered: one where there is no possibility of recourse (that is, once a solution is obtained, it can not be modified) and the other where recourse is available (that is, we consider the possibility of rearranging the transplants in case new incompatibilities arise and part of an exchange is cancelled).

Results

Computational tests were conducted in order to evaluate the variation of the expected number of transplants, given an increase in the number of

possible crossmatch tests. This model was implemented in C++ and CPLEX. Tests were carried out with 50 instances of 30, 40 and 50 pairs.

Comparing the model with recourse and the one without recourse, we were able to conclude that the expected number of transplants in the first case is around 10% higher than the expected number of transplants in the second, regardless of pool size, but requires more tests.

On top of this, we also established a comparison with the model that maximizes the number of transplants assuming no failures. We concluded that the expected number of transplants with recourse is between 25% and 30% less than the upper bound given by the previously mentioned model. This provides an empirical estimate of the proportion of cancelled transplants when we do not take into account the uncertainty associated with the crossmatch tests after the transplantation plan is decided.

For a small number of tests, it may be said that the expected number of transplants grows linearly with respect to the number of tests. For each additional test, there is a slightly less than one increase in the maximum number of transplants.

References

[1] Biró, P., Burnapp, L., Haase, B., Hemke, A., Johnson, R., van de Klundert, J., Manlove, D., B́ohmig, G., Bond, G., Kuypers, D., Smeulders, B., Spieksma, F., Fronek, J., Salonen, M., Jacquelinet, C., Macher, M.-A., Menoudakou, G., Ásgeirsson, E. I., Wilson, N., Di Ciaccio, P., Sparacino, V., Kieszek, R., Bolotinha, C., Baltesová, T., Cechlárová, K., V. Munoz, M. d. l. O., Andersson, T., Hadaya, K., and Leishman, R.: Kidney Exchange Practices in Europe: First Handbook of the COST Action CA15210: European Network for Collaboration on Kidney Exchange Programmes (ENCKEP) (2017).

[2] Rapaport, F.: The case for a living emotionally related international kidney donor exchange registry. Transplantation Proceedings. 18:5-9. (1986).

[3] Segev, D.L., Gentry, S.E., Warren, D.S.: Kidney Paired Donation and Optimizing the Use of Live Donor Organs. JAMA. 293, 1883 (2005).

[4] Wolfe, R.A., Ashby, V.B., Milford, E.L., Ojo, A.O., Ettenger, R.E., Agodoa, L.Y.C., Held, P.J., Port, F.K.: Comparison of Mortality in All Patients on Dialysis, Patients on Dialysis Awaiting Transplantation, and Recipients of a First Cadaveric Transplant. New England Journal of Medicine. 341, 1725-1730 (1999).

Otimização de uma rede de recolha e valorização de pneus usados
O caso da Valorpneu

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Descrição do problema

Todos os anos, cerca de 17 milhões de toneladas de pneus atingem o seu fim de vida a nível mundial (WBCSD, 2010). Na europa, cerca de 3.5 milhões de toneladas de pneus usados foram geradas em 2016 (ETRMA, 2018). Estes números reforçam a importância da existência de um sistema integrado de gestão que garanta a recolha e destino adequado deste tipo de resíduos. Em Portugal, o Decreto-Lei n.º 111/2001 veio definir os princípios e normas de gestão de pneus usados transferindo a responsabilidade da recolha, transporte e destino final dos pneus usados para os produtores segundo o conceito da responsabilidade alargada do produtor, EPR (Extended Producer Responsability) (MAOT, 2001). Com o intuito de dar resposta a estes requisitos, a Associação Automóvel de Portugal juntamente com a Associação Nacional dos Industriais de Recauchutagem de Pneus e a Associação Portuguesa dos Industriais de Borracha formou, em 2002, a Valorpneu – Sociedade de Gestão de Pneus, Lda. (Valorpneu, 2019).

A Valorpneu é uma sociedade sem fins lucrativos licenciada pelo ministério português para gerir o sistema integrado de gestão de pneus usados (SGPU) em Portugal. Desde que foi formada, a Valorpneu tem trabalhado no sentido de implementar e gerir eficientemente uma complexa rede que conta com mais de 4 000 origens, 48 centros de recolha, 22 transportadoras, 23 recauchutadores, 1 fragmentador, 3 recicladores e 6 valorizadores energéticos e cujo o objetivo é o correto encaminhamento dos pneus usados de modo a cumprir com as metas de recolha, recauchutagem e reciclagem impostas (Valorpneu, 2017). A implementação e gestão desta rede é um desafio que inclui não só a gestão dos fluxos de pneus usados e das interações entre os diferentes operadores, mas também o desenho e planeamento da própria rede.

O problema retratado neste estudo prende-se precisamente com este último ponto sendo necessário determinar a localização e o número de centros de recolha que permitem maximizar a recolha e a valorização dos pneus usados e a sua circulação ao longo da rede, evitando a criação de inventário excessivo nos operadores. Este problema é inerentemente desafiante tendo em conta a incerteza associada à quantidade e qualidade de produto recolhido. Para além disso, estas decisões devem ser tomadas de modo a garantir a sustentabilidade económica, ambiental e social da rede gerida pela Valorpneu,

tratando-se assim de um problema com objetivos distintos e potencialmente contrastantes.

Relevância do problema

Para a seleção de novos Centros de Recolha a Valorpneu tem definido um conjunto de critérios a que as entidades candidatas devem obedecer de forma a poderem ser acreditadas. Estes critérios incluem, entre muitos outros, aspetos que limitam distâncias entre Centros de Recolha assim como o número de centros por distrito e/ou concelho e mesmo a nível nacional. No entanto, estes critérios têm-se revelado desadequados, particularmente na região do Porto, onde se têm verificado constrangimentos na recolha dos pneus devido à distância de um dos centros de recolha às origens.

Este trabalho surge então com uma elevada relevância pois irá permitir apoiar o processo de redefinição dos critérios referidos, de forma a atingir de forma sustentável os objetivos propostos, com particular enfase nas potenciais melhorias no processo de recolha de pneus usados na região do Porto. Pretende-se assim desenvolver uma ferramenta de apoio à decisão que suporte a definição e planeamento desta rede de recolha, transporte e valorização, considerando não apenas aspetos económicos, mas também ambientais e sociais. Esta ferramenta será baseada num modelo de programação linear inteira mista, multi-objetivo, que tem como intuito minimizar os custos logísticos e impacto ambiental e maximizar o benefício social da rede. O planeamento dos fluxos entre as várias entidades da rede também irá apoiar decisões relacionadas com as capacidades dos diferentes operadores, com os níveis de inventário nos centros de recolha e com o destino final a dar aos pneus recolhidos. Para além disso, e como já referido, a relevância deste problema também se prende com a complexidade que lhe está inerente pois tanto lida com os trade-offs entre os diferentes objetivos de sustentabilidade como com a incerteza associada ao número e qualidade de produto recolhido pela rede que por sua vez, influencia diretamente o destino a dar aos pneus usados e, consequentemente, as taxas de valorização resultantes.

Metodologia

Para a resolução do problema apresentado, uma ferramenta de apoio à decisão para o projeto e planeamento da rede de logística inversa da Valorpneu é desenvolvida através de um modelo matemático de programação linear multi-objetivo que integra as três vertentes da sustentabilidade numa só solução. Os três pilares da sustentabilidade são modelados através de três funções objetivo onde se pretende minimizar os custos e impacto ambiental da rede e maximizar o seu benefício social. Para avaliar o impacto ambiental o ReCiPe 2008, método de análise de ciclo de vida é utlizado. O benefício social é calculado através de um indicador de benefício social desenvolvido por Mota et al. (2015) que prioriza a criação de emprego em regiões menos desenvolvidas. Para obter uma solução que estabelece os trade-offs entre os

vários objetivos de sustentabilidade, o método augmented ε-constraint é implementado de modo a identificar as soluções que pertencem à fronteira de pareto e, consequentemente, encontrar soluções eficientes. Tendo em conta a importância da incerteza da quantidade e qualidade de pneus usados a recolher nas decisões de planeamento e gestão da rede, programação estocástica também é explorada através de análise de cenários.

Bibliografia

ETRMA. (2018). ELT Management figures 2016. Retrieved from http://www.etrma.org/uploads/Modules/Documentsmanager/20180502—2016-elt-data_for-press-release.pdf

MAOT. (2001). Decreto-Lei no. 111/2001. Lisbon,Portugal. Retrieved from https://dre.pt/application/conteudo/362316

Mota, B., Gomes, M. I., Carvalho, A., & Barbosa-Póvoa, A. P. (2015). Towards supply chain sustainability: Economic, environmental and social design and planning. Journal of Cleaner Production, 105, 14–27. https://doi.org/10.1016/j.jclepro.2014.07.052

Valorpneu. (2017). Relatório Anual & Contas 2017. Lisbon.

Valorpneu. (2019). Valorpneu - Who We are. Retrieved March 22, 2019, from https://www.valorpneu.pt/artigo.aspx?lang=ing&id_object=49&name=Who-We-are

WBCSD. (2010). End-of-Life Tires - A framework for effective management systems. Geneva. Retrieved from https://docs.wbcsd.org/2018/02/TIP/A_Framework_For_Effective_Management_Systems.pdf

Otimização do Product Mix baseado num sistema de custeio baseado nas atividades usando programação inteira mista

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Descrição do problema

Com o crescimento da economia e aumento da globalização, o mundo empresarial revela-se cada vez mais competitivo. As empresas são forçadas a procurarem novas ferramentas de gestão e de controlo com o intuito de melhorar o funcionamento das suas atividades e a qualidade dos seus produtos e/ou serviços. De acordo com o Banco de Portugal (2018), em 2016 existiam cerca de 2100 empresas em Portugal a operar na indústria do Calçado, sendo 50% destas organizações microempresas. Segundo o AICEP (2012)1, muitas organizações de pequena dimensão só por estarem presentes no mercado, aumentam a concorrência e baixam as margens de lucro. Tal facto obriga as empresas deste setor a apostarem em novas tecnologias de gestão com o intuito de aumentarem a sua margem de lucro, mediante a diminuição do preço de custo sem alteração no preço de venda. Neste sentido, a otimização da produção desempenha um papel vital para atingir este objetivo. A nível interno surgiram novas tecnologias e diversidade na produção, de forma a colmatar as produções em grande escala. No entanto, todas estas alterações têm uma influência na estrutura de custos das empresas. Os custos são cada vez mais indiretos em detrimento dos diretos, ou seja, aumentam os custos de investigação e desenvolvimento, distribuição e logística, e diminuem os custos com a mão-de-obra (Wanderley & Cullen, 2013). Atendendo a esta realidade, a contabilidade de gestão desempenha uma função vital na sobrevivência, desenvolvimento e crescimento de uma empresa, na medida em que afeta o comportamento dos gestores e os direciona no sentido da implementação da estratégia da empresa. Tendo em conta as mudanças registadas no tecido empresarial, estimuladas pela intensificação da concorrência e pelas inovações tecnológicas a contabilidade de gestão tornou-se fulcral para o sucesso de qualquer organização (Wanderley & Cullen, 2013). A contabilidade de gestão fornece dados-chave para os gestores de planeamento e controlo, além de implementar sistemas de custeio que permitem calcular o custo total de um produto ou serviço (Horngren, Foster, & Datar, 2000). Inicialmente, surgiram os sistemas de custeio tradicionais, sendo estes desenvolvidos em ambientes

nos quais a mão-de-obra direta e as matérias-primas predominavam na construção do custo dos produtos. Tal situação originava uma sobrecarga dos custos ao nível dos departamentos eminentemente produtivos, em detrimento dos departamentos auxiliares. Assim, estes tipos de sistema de custeio tornaram-se cada vez mais obsoletos, não fornecendo informações fiáveis devido a uma elevada mudança da estrutura de custos.

Todavia, de forma a colmatar a falta de informação dos sistemas tradicionais, surgiram os sistemas de custeio contemporâneos, como é o exemplo do sistema de custeio baseado nas atividades (ABC). Trata-se de um método de custeio capaz de superar as limitações dos sistemas de custeio tradicionais face à evolução económica e tecnológica, nomeadamente, a imputação arbitrária e imprecisa dos custos indiretos. Grondskis & Sapkauskiene (2011) consideram que uma das tarefas mais importantes numa organização consiste em criar um plano de produção ótimo. Apesar de os autores identificarem a criação de plano de produção ótimo como sendo a tarefa mais conhecida na programação matemática, uma vez que esta identifica o nível de produção e o volume com o intuito da maximização do lucro, é importante a adoção de um sistema de contabilidade de custos que garanta a confiabilidade da informação para um eficaz processo de tomada de decisão.

Face, ao exposto, o objetivo principal do presente trabalho consistirá na aplicação de um sistema de custeio baseado na atividade numa empresa que ainda suporta o seu processo de tomada de decisão num sistema de custeio tradicional, e posteriormente a utilização da informação gerada pelo sistema de custeio para o desenvolvimento de modelo programação inteira mista, com o intuito de determinar o product mix ótimo no processo de produção de componentes para calçado.

Relevância do Tema

A presente investigação revela-se pertinente pelo potencial contributo para a gestão empresarial, tendo em consideração o número reduzido de estudos que relacionem modelos de otimização com a gestão de custos, assim como a escassez de estudos aplicados à indústria do calçado. A metodologia apresentada será aplicada a uma empresa do sector de componentes para o calçado e acreditamos que a investigação desenvolvida com este trabalho permitirá contribuir com uma nova metodologia a ser aplicada a um sector muito representativo da indústria nacional, o sector do calçado.

Metodologia Utilizada

De forma a implementar o método de custeio baseado nas atividades, irá ser utilizada a metodologia introduzida por Roztocki, Porter, Thomas, & Needy (2004). Os autores desenvolveram uma metodologia que permite às empresas alternarem facilmente de um sistema de custeio tradicional para um sistema de custeio baseado nas atividades. O modelo consiste em oito etapas de fácil implementação, tendo por base as duas fases identificadas por

Cooper (1987): (1) numa primeira fase os custos são atribuídos por grupos de custos dentro de um centro de atividade, com base num driver de custos, correspondendo às primeiras cinco etapas da metodologia apresentada; (2) numa segunda fase, os custos são alocados dos grupos de custos para um produto com base no consumo das atividades do produto, sendo que esta fase corresponde à sexta, sétima e oitava etapa da metodologia. Assim, o procedimento proposto por Roztocki, Porter, Thomas, & Needy (2004) consiste em investigar os custos indiretos para objetos de custos. A primeira e segunda etapas consistem em examinar as principais categorias de custo e identificar as principais atividades da empresa. Numa terceira etapa, relaciona-se as atividades que contribuem para cada despesa e desenvolve-se a matriz expense-activity-dependence (EAD), em que as categorias de custo representam as colunas, enquanto que as atividades representam as linhas. A quarta fase consiste em substituir as marcas de seleção por proporções na matriz EAD (Roztocki et al., 2004), i.e. as células selecionadas anteriormente são substituídas por uma proporção. Na etapa seguinte o valor em euros de cada atividade é obtido através do somatório do produto do valor em euros da categoria de custos e a proporção da matriz EAD. De seguida, é criada uma matriz activity-product-dependence (APD), que permite relacionar as atividades consumidas por cada produto, sendo que as atividades representam as colunas e os produtos representam as linhas. Na etapa sete é aplicado o mesmo procedimento da etapa quatro, mas neste caso à matriz APD. Por fim, na última etapa é obtido o valor em euros de cada produto, através do somatório da multiplicação do valor em euros da atividade e a proporção da matriz APD. Com a implementação destas oito etapas, espera-se com este estudo obter resultados análogos aos obtidos por Roztocki et al. (2004), ou seja, espera-se que a empresa seja capaz de identificar os clientes e produtos mais lucrativos nos quais deve concentrar uma fração do tempo maior.

Por outro lado, Gass (2006) afirma que os problemas de programação matemática estão relacionados com o uso eficiente dos recursos limitados para atender aos objetivos pretendidos. Esses problemas são caracterizados por um grande número de soluções que satisfazem as condições básicas de cada problema. A escolha de uma solução específica como a melhor solução para um problema depende do objetivo geral que esteja implícito na descrição do problema. Product mix problem é apontado por vários os autores como a metodologia mais relacionada com a contabilidade de gestão. Especificamente, Zhuang & Chang (2017) afirma que o mix de produtos é essencial para os gestores que estão sujeitos a elevadas alterações de mercado e possuem falta de capacidade de produção. Esta falta de capacidade significa que a empresa deve ser capaz de alocar os recursos utilizados para a produção dos diferentes produtos de forma a maximizar os lucros esperados. O trabalho de Zhuang & Chang (2017)tem como objetivo determinar o mix de produtos

para um processo de produção, propondo um modelo de programação inteira mista, com base na informação do sistema de custeio baseado nas atividades, introduzindo deste modo um novo conceito – o custeio baseado no tempo das atividades. Segundo o autor, o custeio baseado no tempo das atividades distribui os custos de acordo com o tempo total das atividades, baseando-se em dois parâmetros: o custo por unidade de tempo (despesa total de um departamento dividida pelo total de horas de trabalho) e a utilização de tempo para cada atividade (unidade de tempo da atividade multiplicada pelas unidades produzidas nessa atividade.

Neste momento estamos em fase de recolha e sistematização das informações da empresa que servirá de caso de estudo. Como trabalho futuro próximo será desenvolvido o modelo, efetuados testes do mesmo recorrendo a instâncias reais, assim como a sua comparação com o procedimento atual da empresa.

Referências

[1] AICEP. (2012). Síntese Setorial De Mercado. Portugal Global, 1–11.

[2] Banco de Portugal. (2018). Análise setorial da indústria do calçado 2012-2016. Eurosistema, 1–6.

[3] Cooper, R. (1987). The two-stage procedure in cost accounting-part one. Journal of Cost Management, 1(2), 43–51.

[4] Gass, S. I. (2006). Linear programming. Encyclopedia OfStatistical Sciences.

[5] Grondskis, G., & Sapkauskiene, A. (2011). Cost accounting information use for product mix design. Ekonomika Ir Vadyba, (16), 48–53.

[6] Horngren, C., Foster, G., & Datar, S. (2000). Cost Accounting - A managerial Emphasis. New Jersey, Prentice Hall.

[7] Roztocki, N., Porter, J. D., Thomas, R. M., & Needy, K. L. S. (2004). A procedure for smooth implementation of activity-based costing in small companies. EMJ - Engineering Management Journal, 16(4), 19–27. https://doi.org/10.1080/10429247.2004.11415262

[8] Wanderley, C., & Cullen, J. (2013). MANAGEMENT ACCOUNTING CHANGE :, 10(4), 294–307. https://doi.org/10.4013/base.2013.104.01

[9] Zhuang, Z.-Y., & Chang, S.-C. (2017). Deciding product mix based on time-driven activity-based costing by mixed integer programming. Journal of Intelligent Manufacturing, 959–974. https://doi.org/10.1007/s10845-014-1032-2

Integration of inventory management and distribution scheduling: An optimization model for a hospital context

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Problem description

Hospitals are responsible for a significant amount of items, of different kinds, such as administrative, laundry and apparel supplies, clinical inventory and pharmaceutical products, often with expiry dates. Inventory management is a challenging task where ordering, distribution and consumption must be achieved and coordinated between the different services and the hospital's central warehouse, maintaining obsolesce levels to a minimum. Each service is responsible for placing orders to the hospital's central warehouse according to its needs. The complexity lies on deciding when and how much to order of each medical supply, organizing and scheduling transportation and deliveries, as well as on dealing with capacity and human resource constraints, in an environment such as healthcare where stock-outs are not allowed. Moreover, the hospital demand has an uncertain behavior, which raises obstacles on inventory management and has implications on resulting inventory policies.

Problem relevancy

Healthcare costs have been gradually increasing in developed countries over the past years, leading to an emerging interest to improve logistic activities in hospitals, that constitute a large portion of the expenses, only surpassed by staff related costs. Furthermore, there is a growing pressure in improving performance and delivering healthcare more effectively and efficiently.

Although it is significantly studied in industrial environments, material logistics is less developed in the healthcare setting, and typically it is focused on predictable demand. While some items can maintain regularly a high and relatively stable demand, this is not the case for all clinical materials, that can show volatility and demand uncertainty. Moreover, hospitals are a complex setting and logistic activities tend to be performed by clinical staff without a background on logistics or inventory management, leading to experienced-based decisions as opposed to optimal and grounded solutions.

Appropriate inventory policies must be identified and applied in order to increase efficiency, decrease wastage and avoid stock-outs, allowing not only proper operation in each service within a hospital but also coordination between every service and the central warehouse, improving the functioning of the hospital as a whole. Suitable schedules of deliveries from the central warehouse to each service must in place, adapted to the necessities of each

service but focusing as well on practical schedules with a balanced workload throughout the workdays. Consequently, routes must be determined to accurately account for the travel time between the services and perform the distribution properly. Hospitals must be supported by suitable inventory management since it is crucial to have all the required supplies to provide high-quality care, enabling staff to perform their daily tasks and avoiding emergency refills and consequent staff overload. In addition, improved material management can allow cost reductions. Likewise, an improvement on the hospital's performance and service level is supported by a better inventory management.

Employed methodology

With the goal of reducing costs and decreasing the variability in the workload of deliveries, a model that allows the optimization of inventory management and deliveries scheduling is proposed.

The model incorporates several constraints, modeling the real setting of hospital services and hospital inventory management. A variability reduction in the delivery workload is achieved through minimizing the difference between the maximum and minimum time spent with deliveries per day, leading to a balanced schedule throughout the week. Multiple variables are determined, including the reorder point and order-up-to level of each item in each service following a periodic review, when each service will be replenished, consequent order sizes and respective route including the services to be visited, focusing on both inventory management and scheduling decisions.

To address demand uncertainty, complementary to a deterministic model, a stochastic approach is developed and employed. This is based on a robust optimization model following the Cardinality-Constrained Approach.

Both (deterministic and stochastic) models are then applied to the real-world case of a hospital in Portugal, where a central warehouse serves nineteen services, that receive medical supplies, with deliveries distributed along the weekdays.

Preliminary results

The deterministic model has been validated and tested using toy instances. These preliminary results show a balanced schedule and appropriate decisions on reorder point and order-up-to level. The inventory decisions show different behaviors depending on the input parameters, adapting to different demand patterns, capacity limitations and human resource restrictions. The deterministic approach has also been tested using real instances.

Regarding the robust optimization model, preliminary results have been obtained employing toy instances.

Designing In-House Logistics Operations towards Industry 4.0: Volkswagen Autoeuropa Case

Sebastião Graça[*], **Susana Relvas**

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1 - Problem description

1.1 - General Context: Automotive Industry Evolution

The complexity inherent to the entire context of the automotive industry is extreme. Therefore, in order to better contextualize the problem in hand, it is crucial to return to the origins of its history. Henry Ford was responsible for a plethora of meaningful inputs and changes which contributed to the initial development of this industry and which are still widely used today. Basically, the introduction of interchangeability of components and the use of the moving assembly line laid out to the foundations for modern-day mass production techniques. This new way of producing cars is clearly in contrast with the craft production presented until then.

However, some part of this strategy was rapidly overtaken. This is because the auto industry is constantly evolving according to market changes, competitiveness and technological evolution. Thereafter, General Motors introduced a more decentralized organizational structure and offered customers the choice they wanted through a much broader product portfolio but still not totally customized (Holweg, 2008).

Over the years, due to the fast pace of development and innovation, new concepts were introduced, such as lean production, model years and several others. Nevertheless, there was a shift in the firm's mentality and customer satisfaction was fundamental in a market that was saturated. Presently, in a scenario of overcapacity, customers demanding customized products and increasing dynamic variety, the main problem is how to go beyond this new mass production system. Following the evolution, a lot of car producers decided to move from a built-to-stock oriented production of standardized cars towards a customized built-to-order production, which allows customers to customize their own vehicle. Thus, the complexity of the in-house logistic processes increased exponentially.

The mixed-model assembly lines, which relies on producing several different vehicles of the same base product with lower adjustment times and costs, rear a new challenge. The endless number of different parts that must be available on the assembly line at the right time, location and quantity, for the corresponding vehicle, makes the firm's logistical operations seen as the heart of the company.

Without an efficient logistic process, the scarcity of a specific component at the assembly line implies line stoppages with increased the production costs. On the other hand, as a trade-off, if there is a surplus of a component, it will generate idleness of these parts, and therefore the holding and handling costs increase. Basically, a well-orchestrated in-house logistic at the shop floor is fundamental to overcome such trade-offs of line stoppage and parts idleness.

Based on that, by considering the new technological paradigm in which we are subsumed and the increasing level of competitiveness through differentiation, the preponderant role that comes from introduction of automated robots in the future is reinforced. The cooperation between robots and humans in the shared shop-floor will certainly create a co-working partnership and increase the levels of productivity, flexibility and responsiveness. The use of both will allow exploring the cognitive and logical capabilities of the human being (usually associated with high value-added activities) and leaving more repetitive and ergonomically complex activities with less mental requirements for automated robots.

1.2 – Case Description: Autoeuropa & Supermarket Concept

This research will analyze a real and UpToDate case-study of one of the largest Portuguese automotive manufacturing plants, Volkswagen Autoeuropa. A future-oriented study will be carried out in order to figure out a better in-house logistics strategy to overcome some of the aforementioned problems (high level of complexity and non-use of 4.0 technologies). The concept of supermarket and picking & sequencing activities, as well as line feeding strategies are the main concepts. A supermarket corresponds to a decentralized storage area subsumed into the shop floor which are closer to the line segments. In those structures, fundamental intermediate activities such as picking and sequencing activities take place.

Hitherto, the picking process at a supermarket, in Volkswagen AE, is developed by a single operator based on a picker-to-product manual philosophy. Basically, the order picker moves along all picking locations on foot and perform everything manually. Afterwards, racks with sequenced components are placed at a specific location and await for a tow tug driver to move them directly to the assembly line. However, this setting is to be further analyzed since Autoeuropa is figuring out whether this is an efficient, sustainable and ergonomic configuration to adopt when the plant will be reconfigured to produce a new model.

2 – Relevance of the Problem

Albeit the concepts of supermarket and line feeding strategies are an extremely studied component and the current picking process is extremely used, there are several possibilities for improvement in order to follow technological development and the market itself. Thus, and based on the possibility of introducing a new car model in the factory, the restructuring of supermarkets

became a topic to review.

There are numerous points which might be improved. First and foremost, supermarket activities are developed by human operators with inherent possibilities of errors. New mechanisms might be developed in order to further minimize those human errors. Second, ergonomic problems might spring up due to the collection of a large number of heavy components and racks. Third, the efficiency of the process itself can be improved and, finally, several other measures or key performance indicators (KPI's) can be interestingly considered such as costs (with robots there is a plenty of space for human capital reduction) and 4.0 sustainability improvements. In brief, it is possible to claim that there are a broad set of possible improvement aspects.

3 - Research Methodology

The methodology will compare the as-is situation with a to-be configuration that is to be implemented when a new car model will be introduced in the plant. Different scenarios will be created and tested through a simulation software. The objective is to find out a better supermarket configuration and processes by having in mind the aforementioned KPIs and the possibility of bringing in robots (such as automated vehicles), 4.0 picking and sequencing equipment and create a human-robot partnership. The possibility of an AGV entering the supermarket area to ergonomically support the picking process will be tested, line feed will also be developed by AGVs as a way of reducing human capital (routes creation), the possibility of creating buffer areas where AGVs await with the full racks in order to avoid AGVs accumulation inside the supermarket, several variations in the number of AGVs will be duly tested in order to figure out the perfect number of AGVs per supermarket per sequence, etc. These are some of the alternative scenarios and variations which will be created and validated.

The current paradigm of supermarkets and line feeding will be directly and carefully observed in order to extract data which will be used within the model. The alternative scenarios shall be created on the basis of the observed physical constraints presented by the factory. All these possible alternative schemes will be appropriately compared. A discrete-event stochastic simulation model will be built into the simulation software Virtual Components 4.1. This model will be used as a digital twin to test new configurations of the in-house logistics operations. The study herein develop will support the design of the future operation.

Sessão M1: Transportation Management and VRP I

22 de Julho, Segunda-feira, 16:30 - 18:00
Sessão em Inglês
Sala: B253

Moderador: Gonçalo Figueira

Scenario (and solution) generation using metaheuristics for fleet management and pricing in car rentals

Beatriz B. Oliveira, Maria Antónia Carravilla, José Fernando Oliveira

Resumo. Uncertainty is a recent and critical challenge in OR. Scenarios are important tools to deal with uncertainty but the scenario generation process is often unrealistically simplified. We propose that metaheuristics, namely based on genetic algorithms, can generate relevant and complex scenarios. This is of particular interest in practical applications where there are many uncertain parameters, such as the integration of fleet management and pricing for car rental companies under demand and competitor pricing uncertainty. Considering this two-stage stochastic problem, we propose an innovative method based on a co-evolutionary metaheuristic, where solutions and scenarios are generated and evolve in parallel. The goal of the evolution of the solution population is to obtain values for the first-stage decisions that perform well when compared with the scenario population. The goal of the evolution of the scenario population is to diversify the impact of its elements on the profit of solutions. A current extension of this work is a scenario generator based on this idea of impact diversity. It is built on a BRKGA framework and can be easily adapted for different problems.

Two heuristic approaches for solving the Smart Waste Collection Routing Problem

Diana Jorge, Ana Raquel de Aguiar, Carolina Morais, Tânia Ramos, Ana Barbosa-Póvoa, António Antunes

Resumo. The Smart Waste Collection Routing Problem proposed by Ramos et. al. (2018) explores the collection of recyclable waste when real-time information on the bin's fill-level is accessible, transmitted through sen-

sors installed inside the bins. The problem was modeled as a Vehicle Routing Problem with Profits (VRPP), where dynamic routes that maximize the waste collected while minimizing the transportation cost are generated daily in the morning, depending on each bin's fill-level at that moment and on the expected waste disposal throughout the day. Nonetheless, the complexity associated to real-world cases yielded solutions characterized by both low quality (significant gaps) and low computational performances. Given this background, two heuristic approaches are now proposed to improve solution performance. The first is an optimization-based heuristic that uses the bin's fill-level criteria to decompose the problem and then the VRPP mixed integer linear program is solved for smaller instances. The second approach is a hybrid simulated-annealing/local-search. The two approaches are tested for real-world data, where the daily dynamic collection routes for 226 recyclable waste bins are designed for a 30-day period. The results obtained are compared between them and with the monolithic VRPP model.

A hybrid matheuristic for a refuse collection application

Leonor Santiago Pinto, João Janela, Maria Cândida Mourão

Resumo. We propose a Mixed Capacitated Arc Routing Problem (MCARP) to address a household waste collection system in the Portuguese municipality of Seixal. Solutions are generated through a two-phase heuristic which uses a GIS tool, available at the municipality, for the input/output. First, during the sectoring phase the tasks are assigned to sectors, one per vehicle, while secondly, in the routing phase, the vehicle trips are designed. Different stopping criteria in the first phase demand for different methods in the second phase. This last phase resorts to an adapted flow model or to a matheuristic involving a new hybrid model, depending on the percentage of tasks assigned in the first phase. The quality of the generated solutions is accessed through the total routing time, and through some attractiveness measures, including a proposed new one (the Weighted Hull Overlap - WHO), that aim to evaluate their fitness to the real case study, a crucial aspect for routes that need to be accepted by practitioners. The WHO measure is able to mix the overlapping of routes with the placement of tasks relatively to their ideal boundaries. Computational results on Seixal instances are reported.

Optimização de escalas de maquinistas com geração de colunas e pesquisa local

Jorge Roussado, Ana Wemans

Resumo. Neste trabalho apresentamos uma heurística para optimização de escalas não cíclicas de maquinistas ferroviários baseada em relaxação La-

grangiana, geração de colunas e pesquisa local com vizinhança variável. A heurística optimiza o planeamento de turnos em escalas com ou sem folgas fixas procurando maximizar o trabalho planeado e garantindo a satisfação de uma multiplicidade de regras laborais relativas a cargas horárias, folgas e períodos de repouso. A nossa abordagem divide-se em duas fases: uma construtiva e outra reparativa. Na fase construtiva, com base na solução da relaxação Lagrangiana: (i) geram-se colunas resolvendo problemas de caminho mais curto com recursos com um algoritmo de programação dinâmica e (ii) obtêm-se soluções primais com uma heurística Greedy. Na fase reparativa utiliza-se pesquisa local com vizinhança variável em que se usa o algoritmo húngaro e a heurística de Wedelin para obter estados vizinhos. Comparamos a nossa abordagem com uma heurística construtiva baseada em programação linear inteira e pesquisa local aplicando-a a problemas reais de dimensão média e elevada. Os resultados obtidos, ainda que preliminares, atestam o bom desempenho da nossa abordagem quer do ponto de vista da qualidade das soluções quer dos tempos de corrida, quer ainda da robustez em problemas de grande dimensão.

Detailed scheduling optimization of transmix oil recycling logistics

Wan Zhang, Susana Relvas, Ana Barbosa-Póvoa, Yongtu Liang

Resumo. Multiproduct pipeline is a greatly important link to connect energy production areas and the consumer market, transporting the refined oil to the sales terminal. Interface contamination of batches, called transmix, due to multiproduct pipeline operation is a standing problem in the petroleum industry. The transmix must be separated and stored in special tanks before blending with pure product oil. It also can be sent back to the refinery for reprocessing if the volume is much more than that, that can blend. A mixed integer linear programming (MILP) model is presented to optimize detailed scheduling of transmix logistics along a multiproduct pipeline in a given planning horizon. It maximizes total profit by deciding on how to process the transmix through different forms: reprocessing at refinery; blending with pure products in the depot; distillation at the termination depot; selling to fuel factories at a lower price. The designed model provides the optimal solution by defining the download station, transmix processing method and the location of processing facilities.

Operations management problems solved by decision rules: why, what and how to learn them

Gonçalo Figueira, Rui Lopes, Cristiane Ferreira, Pedro Amorim, Bernardo Almada-Lobo

Resumo. Decision rules have important advantages when compared to mathematical programming: do not require expensive commercial solvers, are more easily understood by practitioners (unlike black-box sophisticated solvers) and, most importantly, are extremely faster (enabling the optimization of large, complex and stochastic problems in real-time). Learning rules can be done analytically, empirically or automatically (i.e. via machine learning). The right approach highly depends on the problem and its features, such as its combinatorial nature, complexity and uncertainty. Machine learning is also a large field, which includes a great variety of techniques and paradigms. This work discusses the main machine learning paradigms, particularly in the context of prescriptive analytics, and how they can be combined with other learning approaches, such as guided empiricism and mathematical derivation. In addition, we discuss different learning levels (parameters vs. expressions, decisions vs. rules) and methods (metaheuristics, artificial neural networks, decision trees and genetic programming). All this discussion is conducted by instantiating and exploring fundamental operations management problems, such as vehicle routing, machine scheduling and inventory replenishment. The final approaches are able to find new elegant state-of-the-art solutions, but the path to get there is not simply by throwing variables into a black-box machine learning method.

Sessão M2: OR in Health and Life Sciences

22 de Julho, Segunda-feira, 16:30 - 18:00
Sessão em Português/Inglês
Sala: B255

Moderador: Filipe Alvelos

Health Expenditures in OECD countries: An Econometric Analysis

Sofia Cruz-Gomes, Mário Amorim-Lopes, Bernardo Almada-Lobo

Resumo. The rising health expenditures and the uncertainty about

whether there will be enough resources to deliver the demanded services in the future have been calling the attention of health researchers, managers and governments. Using a long and recent (1980-2016) panel on 34 OECD countries, this paper investigates the long-run relationship between health expenditures and its determinants. We go beyond the common single-model approach, questioning the suitability, exposing the differences and similarities and comparing the results of different econometric models. Additionally, we use projections for the main drivers to forecast health expenditures. Our results suggest that the considered drivers, both from the supply- (technology and human resources) and the demand-side (economic, demographic and health-related factors) are relevant to explain variations in health expenditures. Furthermore, we show that distinct econometric models may lead to different conclusions and that accounting for characteristics of the data - such as non-stationarity, dynamic nature, heterogeneity or cross-section dependence - is crucial for the adequate selection of the methodological approach. Furthermore, forecasts show that it is likely that health spending in OECD countries maintains its positive trend in the next years. Health expenditures planning is therefore of crucial for the sustainability of healthcare.

Avaliação de protocolos clínicos de cancro no pulmão: um caso de estudo

Bernardo Teixeira, Maria Isabel Gomes, Telma Sequeira, José Pedro Boléo-Tomé, Filipe Ferreira da Silva

Resumo. O cancro do pulmão é uma das principais causas de morte no mundo. O estudo do fluxo de doentes com suspeita de cancro do pulmão, desde a entrada no serviço especializado ao decorrer de toda a investigação clínica, é um problema emergente. Os elevados tempos de espera, a reorganização do serviço, o confronto com as fragilidades organizacionais são fatores a tomar em consideração. Durante o ano de 2018 foram recolhidos dados (2016 – 2018) relativos aos tempos e percursos efetuados pelos doentes deste a entrada no Serviço de Pneumologia do Hospital Prof. Doutor Fernando Fonseca (SPHFF) até ao momento em que iniciam o primeiro tratamento. Foram incluídos 77 doentes e analisados os tempos em cada etapa do processo de diagnóstico, estadiamento e decisão terapêutica de cancro do pulmão. O protocolo clínico seguido no SPHFF foi comparado com outros protocolos e recomendações internacionais, o que permitiu identificar os pontos críticos neste processo e propor melhorias. Um modelo de simulação de eventos discretos permitiu concluir que é possível reduzir o tempo médio até ao início da terapêutica de 74 dias para 27 dias, se alterado o protocolo atualmente seguido no SPHFF.

Reinforcement Learning for Robust Optimization: an Application in Kidney Exchange Programs

Tiago Monteiro, João Pedro Pedroso, Ana Viana, Xenia Klimentova

Resumo. Kidney Exchange Programs allow an incompatible patient-donor pair, whose donor cannot provide a kidney to the respective patient, to have a transplant exchange with another pair in a similar situation. The associated combinatorial problem of finding such exchanges can be represented by a graph: nodes represent incompatible pairs and arcs represent compatibility between donor in one pair and patient in the other. This problem has some uncertainty, which in the literature has been commonly addressed in the following ways: expected utility, fallback mechanisms and robust optimization. We propose an alternative interactive tool to support decision makers (DMs) on choosing a solution, taking into account that some pairs may become unavailable. For a solution the predicted performance is evaluated under multiple scenarios generated by Monte Carlo Tree Search (MCTS). The root node of the tree corresponds to no failures. From there, a tree of failure possibilities is generated, each of them corresponding to a different scenario. A solution is determined for every particular scenario. At the end, each solution is evaluated under each scenario. Scenarios are grouped based on the cardinality of the set of failing vertices, and average results for each cardinality are considered. Finally, Pareto dominated solutions are filtered out and the non-dominated average solutions are displayed and compared with the worst case scenario. The tool visually drives DMs in the process of choosing the best solution for their particular preferences.

Hospital-based HTA meets OR: Challenges for structured and value-driven assessment of medical devices

Edgar Mascarenhas, Mónica Oliveira, Ricardo Fernandes

Resumo. The widespread introduction of innovative medical devices (MDs) across health systems has led to an improvement of patients' health outcomes, yet it has also been a key driver of growing health expenditures in developed countries, forcing governments to reconcile access with economic sustainability. In this context, Health Technology Assessment (HTA) activities have been extended to many hospitals that, due to limited resources and increasing demands, are required to assess a broad range of MDs on multiple dimensions and on a common basis. Yet, oftentimes evaluation of MDs is based on scarce evidence, particularly for MDs in pediatric use, due to ethical, legal and safety reasons, making this appraisal largely dependent on stake-

holders' perspectives, usually relying on informal processes, which may lead to suboptimal decisions. In this study, departing from a systematic review on the literature evaluating MDs in pediatrics, we will map the challenges concerning multicriteria evaluation and stakeholder involvement that can be addressed by the Operational Research Community, so that new tools can be developed to assist hospital decision-makers in performing structured, transparent and value-driven assessments of MDs.

Facing dynamic demand for surgeries in a Portuguese case study

Mariana Oliveira, Inês Marques

Resumo. Operating rooms (ORs) are major cost centers of a hospital. Moreover, ORs performance have large impact in the workload variability of ORs up- and downstream units. The OR management is increasingly challenging due to population ageing, increasing demand and use of expensive technologies. While surgical demand is increasing, resources are highly restricted and thus ORs need to be efficiently managed. Based on a collaboration with a Portuguese public hospital, this paper proposes a dynamic approach for a master surgery scheduling problem to face the increasing surgical demand. Considering space and staff restrictions of the hospital, this work aims to reallocate OR time among the surgical services in order to increase surgical access through matching the available OR capacity with demand. A mathematical programming model is proposed to comply with staff preferences in the slots' allocations, to match surgical supply and demand, and to level the workforce in the up- and downstream units. The model suggests new master surgical schedules, using information and data collected in the hospital under study. Results show that the main bottlenecks are the workforce availability and the stability requirement.

Crossmatch testing in kidney exchange programs

Filipe Alvelos, Valéria Romanciuc

Resumo. In kidney exchange programs (KEP), crossmatch tests must be carried to assure the compatibility between donors and recipients. Given the large number of potential transplants, in most KEP, it is not possible to conduct all crossmatch tests. In this work, we assume an estimate of the probability of negative crossmatch, for each potential transplant, is known. Tests can be made sequentially or simultaneously in one or more rounds, as long as they comply with a given budget and a given limit date. This general modelling framework is particularly relevant when the KEP involves multiple agents (e.g. countries). The problem is to define which crossmatch tests to conduct and when in order to maximize the number of actual transplants. It

is relevant to note the dynamic aspect of the problem, as well as the uncertainty involved: the results of previous crossmatch tests influence subsequent decisions. We address the problem by using the concept of "expected number of transplants with probing" and an integer programming model that takes into account the remaining number of tests that can be made.

Sessão M3: Data mining and Data Analysis

22 de Julho, Segunda-feira, 16:30 - 18:00
Sessão em Português/Inglês
Sala: B254

Moderador: Luís Guimarães

Identification of operational demand in law enforcement agencies: an application based on a probabilistic model of topics

Marcio Basílio, Valdecy Pereira

Resumo. The aim of this study was to develop a methodology for knowledge discovery in emergency response service databases based on police occurrence reports, generating information to help law enforcement agencies plan actions to investigate and combat criminal activities. The model developed employs a methodology for knowledge discovery involving text mining techniques and uses Latent Dirichlet Allocation (LDA) with Collapsed Gibbs Sampling to obtain topics related to crime. The method used enabled identification of the most common crimes that occurred in the period from 1 January to 31 December of 2016. An analysis of the topics identified reaffirmed that crimes do not occur in a linear manner in a given locality. In this study, 40% of the crimes identified in Integrated Public Safety Area 5, or AISP-5, (the historic centre of the city of RJ) had no correlation with AISP-19 (Copacabana - RJ), and 33% of the crimes in AISP-19 were not identified in AISP-5.

Forecasting financial time series using deep learning techniques

Filipe Ramos, Anabela Costa, Diana Mendes, Vivaldo Mendes

Resumo. In this article, we propose the use of recurrent neural networks based on long short-term memory (LSTM) architecture in order to forecast financial time series. Artificial neural networks have proven to be efficient in

forecasting financial time series. In particular, recurrent neural networks have been able to store past inputs to produce the currently desired output, which justifies their application in financial time series prediction. First, we study the main features of the Standard and Poor's 500 index, S&P500, such as the linearity, stationarity, descriptive statistics, Hurst exponents, among others. Secondly, we train several types of recurrent neural networks for the S&P500 index and use the models to make short-term forecasts. Finally, we compare the out-of-sample forecast error (MAE) for the employed models, in order to conclude about the forecasting performance.

Tatical time slot management under fulfilment considerations in e-grocery

Luís Carvalho, Flávia Barbosa, Pedro Amorim, Daniel Pereira, Paulo Sousa

Resumo. E-grocery retailers are challenged with the trade-off of providing attractive delivery time slots to customers while keeping the fulfillment operations efficient. Therefore, an online grocery store needs to decide the optimal combination of available slots and delivery fees to provide to its customers. Motivated by the case of a food retailer, we extend the existing literature in the fields of static slotting and pricing using an iterative approach based on time windows configuration, consumer behavior simulation and delivery costs estimation. Each cycle starts by setting the availability of delivery slots with different lengths, time periods and prices. Afterwards, the demand is simulated using statistical distributions fitted to the historical data and customers' booking decisions are foreseen using a machine learning model. A vehicle routing problem for each delivery period is solved for the requests generated during the simulation period. The planned routes and the fulfilment operations are used to estimate the operational costs for a given time slot configuration. Moreover, different scenarios are evaluated to analyze the performance of e-grocery operations and capture changes in the demand based on the available time slots. Preliminary results of this methodology will be presented as well as its application to real environments.

Assessment of Predictive Methods for Intermittent Demand

Rui Lopes, Gonçalo Figueira, Mário A. Lopes

Resumo. Predictive analytics is a fundamental part of many operations research problems, such as inventory management, and it is critical in a variety of industrial sectors. The demand patterns found in different industries have varying characteristics and temporal frequencies. Even in a single

company, the demand patterns of thousands of products are widely different. Recent research focuses on the discussion and comparison of traditional statistical methods with ML alternatives. The most common methods used are traditional statistical algorithms (including moving averages, exponential smoothing, the Croston method and its variations, and ARIMA) and Machine Learning algorithms (mostly focused on Artificial Neural Networks and Support Vector Machines). We extend the comparisons to a new dataset with a large portion of intermittent demand, and address the gap of the algorithms by including ensemble algorithms based on Random Forests and Gradient Boosting. We analyse the forecasts using different popular error metrics, and show that it is necessary to develop better model selection in order to leverage the different methodologies and improve forecasting. Moreover, we present a preliminary analysis of the best algorithms for each demand pattern.

Market Sizing for "Reduced-Risk Products" in the Tobacco Industry

Liliana Silva, Paulo Teles, Paulo Sousa, Paulo Pereira, Pedro Campelo, Teresa Aguiar, Pedro Amorim

Resumo. Companies that launch innovative products in the marketplace face the challenge of predicting how market size will evolve. For new products, the scarcity of historical data undermines the applicability of most of the forecasting techniques available. Motivated by the launch of the novel "Reduced-Risk Products" category by the tobacco industry, we propose a market size forecast methodology composed of two main stages and based on diffusion models, adjusted via optimization and machine learning. The first stage consists in estimating historical market sizes through an iterative model that optimizes confidence-based weights assigned to each available data source. Subsequently, diffusion models, especially the Bass Diffusion Model, are used and complemented by machine learning techniques in order to anticipate the future dissemination of "Reduced-Risk Products" worldwide. A sensitivity analysis is then conducted to understand the impact of the main forecast drivers. By applying this methodology, improvements are expected in the on-going management decision-making in the countries where the category is already present and in the assessment of the investment involved in entering a given market.

A stock quantification of a Demand Planning process improvement, under a S&Op context

Diogo Sá, Andreia Cardoso, Pedro Schuller, Luís Guimarães, Sameiro Carvalho

Resumo. Companies nowadays face a continuous increase in their operations' complexity, demanding extra cohesion between their operational functions for greater value delivery. The S&Op process assumes non-negligible relevance as the accountable process to ensure such cohesion. Despite its importance, few cases are documented of transformational improvement projects originated from the process and with its benefits quantified from a holistic perspective. This thesis aims at contributing to such deficit in the topic, by quantifying qualitative S&Op benefits and gains in forecast accuracy, stock and cost reduction extracted from a Demand Planning process improvement, in a Portuguese beverage company. A S&Op assessment was proposed, measuring the efficiency and effectiveness of the process, alongside an in-depth analysis of the sales forecast accuracy and the subsequent Demand Planning department. Our methodology addressed the flaws identified, by rehashing the department's process and elaborating newer supportive interfaces, such as a statistical forecast Optimizer. The benefits of such initiatives were quantified, with a stock simulation. The initiatives that were conducted showcased significant improvements in terms of forecast accuracy, a significant reduction in terms of total stock coverage and cost and an overall increase in qualitative S&Op benefits.

Sessão M4: DEA and Performance Analysis

22 de Julho, Segunda-feira, 16:30 - 18:00
Sessão em Português/Inglês
Sala: B257

Moderadora: Ana Camanho

Pay for performance in health care: A new best practices tariff-based tool using a loglinear piecewise frontier function and a dual-primal approach for unique solutions

Diogo Ferreira, Rui Marques, Alexandre Morais Nunes

Resumo. Health care systems worldwide face a problem of resources scarcity that, in turn, should be allocated to the health care providers according to the corresponding population needs. One alternative to reach that goal

is through (prospective) payments due to the providers for their clinical procedures. The way that such payments are computed is frequently unknown and arguably far from being optimal. For instance, in Portugal, public hospitals are clustered based on criteria related to size, consumed resources, and volume of medical acts, and payments associated with the inpatient services are equal to the smallest unitary cost within each cluster. Unfortunately, this approach disregards dimensions like quality and environment, which are paramount for fair comparisons and benchmarking exercises. We propose an innovative tool to achieve best-practices tariff, which merges both quality and financial sustainability concepts, attributing a hospital-specific tariff. That payment results from the combination of costs related to a set of potential benchmarks, keeping quality as high as possible and higher than a user predefined threshold, and being able to generate considerable cost savings. To obtain those coefficients we propose and detail a log-linear piecewise frontier function as well as a dual-primal approach for unique solutions.

Evaluating the efficiency of the Portuguese National Health System: A network data envelopment analysis approach

Miguel Pereira, Diogo Ferreira, José Figueira, Rui Marques

Resumo. In contrast to conventional data envelopment analysis (DEA), where the relative efficiency of a system is measured by assuming it as a "black-box", network DEA takes into account its internal structure in order to generate more significant and enlightening results. Among the various types of models, it goes without saying that putting network DEA in practice is natural- and progressively rarer as the complexity of a system's structure increases. In particular, its employment in healthcare is not an exception. Thus, we applied a ratio-form model to measure the efficiency of the secondary healthcare providers bearing in mind their internal services. This unprecedented application to static mixed systems with a matrix-type structure, given the heterogeneity of the relationships between hospital services, allowed the evaluation of the effects that policy reforms had in the Portuguese National Health System.

Assessment of Brazilian Airport System Efficiency

João Carlos Soares de Mello, Deivison Pereira, Luana C. Brandão, Nissia Bergiante, Mariana Almeida

Resumo. In this paper we assess Brazilian airport system efficiency to evaluate benchmarks for the most central airports, using Multicriteria Data Envelopment Analysis (MCDEA), which has greater discriminatory power.

As airport environment differs significantly throughout the country, we limit our analysis to six central airports. Considering the current scenario of low airport quality in Brazil, this study aims at supporting public policies and strategies to improve productivity in the air transport sector. The airports analyzed in this paper represent half of all flights departing from Brazil. In our study, we found that only two airports in the State of São Paulo are efficient, whereas the other central airports are under-utilized. This result could aid important decisions in the airport sector. Additionally, the dual model applied in this work identifies benchmarks as reference for the inefficient airports.

Benchmarking Smart Grid Research & Development engagement by European Distribution System Operators

Micael Simões, Rogério Rocha, Ana Camanho

Resumo. Technological developments related to renewable energy led to a decrease on the prices of generation and allowed the penetration of distributed energy resources in power systems. This context, combined with other factors, such as the development of electric vehicles, enabled the rapid evolution of Smart Grids. As a consequence, Distribution System Operators (DSOs) have been investing in this field to keep up with its deployment. This work presents a case study that compares a set of European DSOs regarding their investment in Smart Grid projects. The methodology underlying this study is based on the construction of composite indicators using the Data Envelopment Analysis technique. Furthermore, we evaluate the evolution in the DSOs performance between 2013 and 2017 using a Malmquist index. The results are discussed in the light of their contribution to the definition of public policies in the energy field.

Efficiency and effectiveness improvement of wastewater treatment plants considering Emission Quotas

Flávia Barbosa, Alda Henriques, Ana Camanho, Giovanna D'Inverno

Resumo. Wastewater treatment plants (WWTPs) constitute an important part of the sewage system of the urban water cycle. They have the role of removing pollutants from wastewater to enable the safe disposal of the treated effluent on the natural environment. The purpose of this paper is to contribute to performance enhancements. The methodology is based on Data Envelopment Analysis, complemented with a robust and a conditional analysis to provide a more accurate measurement of performance. WWTP efficiency evaluates the ability to minimize energy consumption, given the effort for the removal of pollutants currently observed. WWTP effectiveness evaluates the

extent to which a plant can reduce energy consumption by meeting exactly the emission quotas specified by legislation. The empirical analysis evaluates 41 WWTP from a Portuguese water company (Águas do Centro Litoral). We explore two scenarios for performance improvement. The first assumes pollutants emission quotas fixed at each WWTP; the second assumes emission quotas fixed for the receiving waters according to the quality required for the effluents, but trade-offs in the amounts of pollutants removal are allowed. This scenario requires a system-wide analysis to identify optimal targets for pollutants removed in each WWTP, located in the frontier of the production possibility set.

Sessão M5: Discrete Optimization, Graphs and Geometry

22 de Julho, Segunda-feira, 16:30 - 18:00
Sessão em Inglês
Sala: B259

Moderador: Jorge Orestes Cerdeira

O problema da afetação com custo e amplitude mínimos

Marta Pascoal

Resumo. O problema da afetação é um problema clássico de otimização combinatória, estudado para várias funções objetivo, sendo a soma do custo dos arcos uma das mais conhecidas. Ainda que, nesse caso os custos dos diferentes arcos possam variar de forma arbitrária, pode ser relevante procurar alguma uniformidade destes valores. Neste trabalho discute-se o cálculo de afetações que minimizem simultaneamente a soma do custo total dos arcos e a amplitude dos seus custos. Com base num problema semelhante envolvendo o cálculo de caminhos tratado na literatura, apresenta-se um método para determinar afetações eficientes relativamente aos objetivos referidos. O método baseia-se na determinação de uma sequência de afetações com custo mínimo e de afetações com capacidade máxima, alternadas com atualizações do conjunto dos arcos da rede.

O problema dos k-caminhos mais curtos com dissemelhanças medidas de forma contínua

Sara Cruz, Carlos Iglésias

Resumo. O problema dos k-caminhos mais curtos com dissemelhanças é um problema de otimização em redes cujo objetivo é a determinação do conjunto de caminhos entre dois pontos incluindo: o caminho mais curto, o segundo mais curto com um grau de dissemelhança mínimo em relação ao primeiro, e por aí adiante até chegarmos ao k-ésimo mais curto com um grau de dissemelhança mínimo em relação a cada um dos k-1 anteriores. É um problema que surge, por exemplo, no contexto dos sistemas de navegação com mapas georreferenciados, em particular quando se pretende apresentar ao utilizador um conjunto de rotas alternativas entre a origem e o destino escolhidos. Na literatura, a dissemelhança entre dois caminhos é dada pela quantidade total de desvio existente entre ambos. O resultado é que caminhos considerados dissemelhantes podem ter vários desvios pequenos, não sendo considerados verdadeiramente alternativos porque nunca se afastam muito um do outro. Para contornar esta limitação, definimos dissemelhança como a quantidade mínima de desvio contínuo entre dois caminhos. Definimos também um algoritmo de programação dinâmica que resolve o problema iterativamente até à otimalidade. Apresentamos a formulação do problema como PLIM, e resultados que demonstram a eficiência da nossa abordagem face à resolução em CPLEX.

The rough interval shortest path problem

Ali Moghanni, Marta Pascoal

Resumo. The shortest path problem is one of the most popular network optimization problems and it is of great importance in areas such as transportation, network design or telecommunications. This model deals with determining a minimum weighted path between a pair of nodes of a given network. The deterministic version of the problem can be solved easily, in polynomial time, but sometimes uncertainty or vagueness is encountered. In this work we consider the rough interval shortest path problem, where each arc's weight is represented by a lower approximation interval and an upper approximation interval, which surely contains the real weight value and that may possibly contain the real weight value, respectively. A labeling algorithm is developed to find the set of efficient solutions of the problem.

The Shortest Path in Signed Graphs

Inês Serôdio Costa, Rosa Figueiredo, Cristina Requejo

Resumo. This paper addresses the shortest path problem in a signed graph. Signed graphs are suitable for representing positive/trust and negative/mistrust relationships among the various entities (vertices) of a network. The shortest path in a signed graph can be used to understand how successive relations, even if distant, affect the dynamics of the network. More precisely, the idea is to understand how the relation between any two entities is affected when connected through a signed shortest path. We describe ILP models to obtain positive and negative shortest paths in a signed graph between all pairs of vertices. We evaluate the ILP models on social network benchmark instances and present computational results. Our results highlight potential research opportunities and challenges for the social network optimization community.

A computational comparison of compact MILP formulations for the zero forcing number

Agostinho Agra, Jorge Orestes Cerdeira, Cristina Requejo

Resumo. Consider a graph where some of its vertices are colored. A colored vertex with a single uncolored neighbor forces that neighbor to become colored. A zero forcing set is a set of colored vertices that forces all vertices to become colored. The zero forcing number is the size of a minimum forcing set. Finding the minimum forcing set of a graph is NP-hard. We give a new compact mixed integer linear programming formulation (MILP) for this problem, and analyze this formulation and establish relation to an existing compact formulation and to two variants. In order to solve large size instances we propose a sequential search algorithm which can also be used as a heuristic to derive upper bounds for the zero forcing number. A computational study using Xpress (a MILP solver) is conducted to test the performances of the discussed compact formulations and the sequential search algorithm. We report results on cubic, Watts-Strogatz and randomly generated graphs with 10, 20 and 30 vertices.

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23 de Julho (terça-feira)

9:00 - 10:30	TA1 (sala B253): Transportation Management and VRP II** TA2 (sala B255): Energy, Environment, Nat. Resources and Climate I* TA3 (sala B254): Production and Operations Management I* TA4 (sala B257): OR in Industry* TA5 (sala B259): Scheduling*
10:30 - 11:00	*Coffee break*
11:00 - 12:30	TB1 (sala B253): Decision Support Systems* TB2 (sala B255): Energy, Environment, Nat. Resources and Climate II* TB3 (sala B254): Production and Operations Management II* TB4 (sala B257): Supply Chain Management I* TB5 (sala B259): MCDA*
12:30 - 14:00	*Almoço*
14:00 - 15:00	Sessão Plenária 2 (Auditório Pacheco de Amorim): Sofiane Oussedik
15:00 - 15:30	*Coffee break*
15:30 - 17:30	TC1 (Auditório Pacheco de Amorim): Meet the Editors TC2 (sala O101): IBM Hands On
17:30 - 18:30	Assembleia Geral da APDIO (Auditório Pacheco de Amorim)
20:00 - ...	Jantar do Congresso

*Sessões em Português/Inglês
**Sessões em Inglês

Sessão TA1: Transportation Management and VRP II

23 de Julho, Terça-feira, 9:00 - 10:30
Sessão em Inglês
Sala: B253

Moderadora: Maria Cândida Mourão

Multiple vehicle synchronisation in a full truck-load pickup and delivery problem: a case-study in the biomass supply chain

Ricardo Soares, Alexandra Marques, Pedro Amorim

Resumo. The search for efficiency and flexibility in transportation planning processes for real-life applications is rather challenging. Increasing access to sensor technologies and the advent of Industry 4.0 can highly contribute to supply chain efficiency, namely in transportation planning. In this context, the synchronisation of vehicles performing different operations at given locations can potentiate further gains in logistics costs. In this work, the full truck-load pickup and delivery problem with multiple vehicle synchronisation is presented. This problem is motivated by a real-life application in the biomass supply chain "hot-system", where it is necessary to simultaneously perform chipping and transportation operations at the forest roadside. Its purpose consists in determining the integrated routes planning for three distinct types of vehicles which need to perform interrelated operations with minimum logistics costs. We extend existing studies in synchronisation in vehicle routing problems by acknowledging multiple synchronisation aspects and present a novel mixed integer programming model (MIP) and transportation network to model the problem successfully. Furthermore, a solution method is developed for solving large-scale instances and is tested in a case-study of a biomass supplier in Finland, where significant gains in overall logistics costs can be acknowledged.

Searching for a solution method for the Smart Waste Collection Routing Problem

Ana Raquel de Aguiar, Carolina Morais, Tânia Ramos, Ana Barbosa-Póvoa

Resumo. To optimize waste collection operations, approaches to define dynamic routes based on the use of real-time information transmit- ted by

sensors are being explored - the so-called Smart Waste Collection Routing Problem (SWCRP). In a previous work, this problem was modeled as a Vehicle Routing Problem with Profits (VRPP), where the profit associated with the collection of recyclable waste is maximized. However, despite the obtained gains, the authors dealt with higher computational times and gaps. To overcome this limitation, an optimization - based heuristic is proposed to decompose the SWCRP, improving solutions' quality while reducing computational times. Through a Cluster First-Route Second methodology, the proposed approach selects a dynamic set of waste bins to be considered, and then uses this dynamic set to feed a VRPP model that decides which waste bins are worth to be collected, considering their fill-levels and locations. Computational experiments are performed and results show the potentiality of the pro- posed method.

Carsharing: a literature and a business review toward an integrated decision-making framework

Masoud Golalikhani, Beatriz B. Oliveira, Maria Antónia Carravilla, José Fernando Oliveira

Resumo. Carsharing has grown significantly over the past decades throughout the world and offers individuals a flexible and sustainable mode of mobility. The carsharing market has never been as competitive as it is now; therefore, we have witnessed a boom in the number of carsharing companies. These companies face many challenges, and their success often depends on a myriad of operational decisions that need to be supported by adequate decision-making support systems. The existing literature can be split generally into two groups. The first includes the descriptive research, which has collectively built empirical-based knowledge. The second concerns prescriptive research that usually is based on optimization approaches. Nevertheless, there are still research gaps in this area, and realistic system requirements that affect this business are often overlooked. We conducted a comprehensive literature review including descriptive and prescriptive research. Then, to gain "research insights" from current real-world operations, a business review was carried out by conceptualizing and analyzing the relevant characteristics and processes of successful carsharing companies throughout the world. The main contribution resulting from this study is a conceptual decision-making framework, useful to identify research gaps and opportunities, systematizing decisions from the company and the users, and the relevant inputs and interconnections.

Recolha e distribuição de bens alimentares em instituição de solidariedade social

Ana Maria Rodrigues, Henrique Correia, José Soeiro Ferreira, Isabel Cristina Lopes, Cristina Oliveira, Maria João Cortinhal

Resumo. Em Portugal, existem algumas instituições não governamentais que se dedicam à recolha e distribuição de bens alimentares entre doadores e populações mais necessitadas, aqui definidas como utentes. Entre estes doadores estão, por exemplo, cantinas universitárias ou hospitalares e supermercados que, não tendo como aproveitar as refeições preparadas não consumidas ou outros alimentos, acabariam por os tratar como desperdício. Este trabalho é importante por poder contribuir para a redução do desperdício alimentar e das emissões de CO2, ao mesmo tempo que se apresenta como um valioso apoio a famílias carenciadas. São considerados um conjunto de doadores, habituais ou pontuais, e várias restrições, nomeadamente, a capacidade e condições dos veículos de transporte, as necessidades dos utentes, a distância vs quantidade recolhida, a capacidade de armazenamento no ponto de receção e as rotas de recolha. Será apresentada uma proposta de medida de "distância útil de recuperação" que, perante doações pontuais, as enquadra numa setorização feita aos doadores habituais, ou seja, uma partição conveniente do espaço geográfico. Não sendo possível recolher todas as doações, esta medida permitirá escolher as doações que, de acordo com as dimensões económica, ambiental e social, apresentem uma maior vantagem global.

Parking Enforcement in Lisbon - an arc routing approach

Maria Cândida Mourão, Reinaldo Ferreira, Margarida Moz, Leonor Santiago Pinto, Vasco Móra, João Ribeiro

Resumo. This work aims to present a new problem to generate daily pedestrian routes for parking enforcement officers, named as the Parking Enforcement Routing Problem (PERP). Parking Enforcement Officers (PEO) must ensure that the users comply to all parking rules and, when applicable, pay the correspondent fee. The duration of the routes is limited by the PEO daily working schedules. Moreover, a street is supervised by only one PEO and could not be supervised more than once on consecutive hours. In Lisbon, the enforcement of on-street parking is delegated to the municipal company EMEL, requiring a frequent supervision by PEOs walking through a wide area of Lisbon. The problem is tackled as a mixed capacitated arc routing problem with profits over a specific network. Having one or two-way streets with up to four different parking sides, the underlined network has some specificities usually not found. Arcs are scored according to recent events, namely

issued fines, as well as the number of days unattended / without supervision. This work aims to obtain the maximum score per route while fulfilling time/staff/geographical constraints. We present heuristics and a mathematical model for the problem. Solutions to real instances obtained by all methods are analysed.

Sessão TA2: Energy, Environment, Nat. Resources and Climate I

23 de Julho, terça-feira, 9:00 - 10:30
Sessão em Português/Inglês
Sala: B255

Moderador: Manuel Matos

Uma abordagem com branch-and-cut e branch-and-bound sequenciais para o problema de gestão florestal com múltiplos cortes rasos

Isabel Martins, Susete Marques, Marlene Marques, Marco Marto

Resumo. O problema de gestão florestal com múltiplos cortes rasos sujeitos a restrições espaciais sobre a área das clareiras é abordado geralmente com heurísticas que não medem a qualidade das soluções obtidas. Neste trabalho, propomos um branch-and-cut e um branch-and-bound sequenciais para este tipo de problemas que mede a qualidade das soluções. Para testar esta abordagem foram usados dois conjuntos de dados reais com 1137 e 789 povoamentos, em que cada povoamento tem, em média, cerca de 55 e 33 prescrições alternativas, respetivamente, e cada prescrição mais de quatro cortes rasos. O horizonte de planeamento é de 100 anos e encontra-se dividido em períodos de 10 anos. Resultados computacionais são apresentados.

Estudo comparativo de abordagens para reconfiguração de redes de distribuição de energia elétrica

Juliana Salvadorinho, Bárbara Soares, Joana Cordeiro, Ana Moura

Resumo. Num mundo onde a eletricidade faz parte do nosso dia-a-dia, esta é tida pelos consumidores, como um dado adquirido, isto é, está sempre disponível quando solicitada. Contudo, são inúmeras as situações em que

efetivamente isto não acontece, devido à necessidade da sua interrupção no sistema de distribuição. Esta suspensão pode ocorrer na decorrência do disparo de um dispositivo de proteção devido a um defeito, ou também devido a obras e/ou manutenção no sistema. Para que todo este processo seja executado com o mínimo de interferências, é indispensável restringir a área a desenergizar, havendo necessidade de dispor de um plano de manobras de reconfiguração, no sentido de que os consumidores a jusante não sofram consequências deste efeito. Assim, neste trabalho, foram analisados artigos que abordam o problema de reconfiguração de redes, onde o principal objetivo é reduzir as perdas reais de energia no sistema, enquanto são satisfeitas todas as restrições de distribuição. Com base nesta análise, esta revisão da literatura, resume as abordagens mais recentes de planeamento de sistemas de distribuição, cujas abordagens desenvolvidas foram testadas em redes 33-bus. As metodologias e abordagens propostas nesses trabalhos são analisadas e categorizadas, sendo o principal foco a análise das perdas de energia.

Reliability Assessment of Distribution Lines

Alexandra Oliveira, Luís Guimarães, Armando Leitão, Leonel Carvalho, Luís Dias, Miguel Ribeiro

Resumo. Energy distribution systems are essential for the daily living being projected to transform, transmit and deliver electric energy to every customer. Nowadays, the world without electricity is inconceivable and therefore, is of great responsibility to guarantee the continuous operation of the constituent assets of these systems. Distribution lines, intended to transmit and deliver electricity, have paramount importance on energy distribution systems. Yet, these assets are subjected to numerous factors which are behind the causes of their failures, as well as degradation over time. In order to prevent power outages to occur and to ensure electricity delivery, an energy distribution company strive to minimize the risk of failure by correctly estimating failure probability. Based on a real-world challenge, this work presents a reliability study of distribution lines which aims at predicting future failures and assessing the health condition of each individual line. The methodology encompasses clustering techniques to group lines sharing similar characteristics, the identification of the most significant factors on lines' lifetime and a prediction algorithm which leverages the historical records to deliver accurate estimations. The obtained results will be exposed along with the respective conclusions and future work.

Otimização em dois níveis para a definição de tarifas com períodos e preços variáveis – uma aplicação no setor elétrico

Inês Soares, Maria João Alves, Carlos Henggeler Antunes

Resumo. É expetável que estruturas tarifárias com preços diferenciados no tempo se tornem comuns nas redes elétricas inteligentes. Estas tarifas dinâmicas podem trazer benefícios para os operadores de rede, comercializadores e consumidores. A interação entre comercializador e consumidor pode ser modelada através da programação em dois níveis (bilevel). O comercializador (líder) define primeiro os preços em cada período e o consumidor (seguidor) reage, definindo os setpoints de cargas termostáticas e reagendando a operação de equipamentos, face aos preços e requisitos de conforto. Foram desenvolvidos diferentes modelos de definição de tarifas dinâmicas, considerando: períodos fixos à-priori e preços variáveis; períodos variáveis com um número máximo de preços diferentes; períodos e preços variáveis. Estes dois últimos modelos, mais gerais, nos quais se pretende determinar os períodos tarifários e os respetivos preços, apresentam elevada dificuldade de resolução, devido à dimensão do espaço de pesquisa do problema de nível superior. Esta comunicação descreve o desenvolvimento de abordagens híbridas consistindo numa meta-heurística populacional para o problema do comercializador e um solver de programação linear inteira-mista para resolver o problema do consumidor. A capacidade de exploração do espaço de pesquisa do problema de nível superior é essencial para obter boas soluções com um esforço computacional aceitável.

Escalonamento de grupos de produção de eletricidade considerando cargas difusas

José Fidalgo, Manuel Matos

Resumo. Na sua versão determinística, o SCUC (Security Constrained Unit Commitment) encontra a solução mais económica para a escala de serviço dos grupos produtores de eletricidade, que simultaneamente respeita as restrições técnicas e mantém uma reserva adequada. Embora se possa considerar que a reserva, para além de compensar a saída de serviço intempestiva de grupos produtores, pode ser usada para corrigir a incerteza da carga líquida (consumos – produção local), o exercício beneficia de um tratamento explícito da incerteza da carga. Nesta comunicação descreve-se uma abordagem híbrida onde a incerteza na carga é modelizada com recurso a números difusos. Numa primeira fase, resolve-se um SCUC determinístico, com recurso ao Enxame de Partículas Evolucionário (EPSO), seguindo-se a execução de um trânsito de potência difuso DC, que permite identificar e quantificar situações de risco de sobrecarga nos ramos do sistema ou de insuficiência de produção. Numa

terceira fase, ativada se o risco for superior a um limiar pré-estabelecido, utilizam-se metodologias de redespacho ou mesmo reescalonamento para aumentar a robustez da solução. Também podem ser utilizadas heurísticas específicas. A comunicação inclui dois casos de estudo, um para validação da metodologia usada no UC (sem consideração de rede), outro para ilustração do modelo completo.

Sessão TA3: Production and Operations Management I

22 de Julho, Terça-feira, 9:00 - 10:30
Sessão em Português/Inglês
Sala: B254

Moderadora: Helena Alvelos

Extending the Resource Task Network for scheduling collaborative robots in assembly lines

Vanessa Sousa, Samuel Moniz, Cristóvão Silva, Pedro Neto

Resumo. The need for achieving superior levels of efficiency and reducing operational costs are pressuring the manufacturing industry to design novel assembly lines that favour the utilization of collaborative and mobile robotic technologies. In this work, a mixed integer linear programming (MILP) model is developed for the optimal scheduling of collaborative robots in assembly production lines. The model is based on the resource-task network (RTN) formulation and extensions. The RTN is a generalized MILP model used in scheduling optimization problems. Here, we present modifications to the conventional RTN model to explore additional degrees of freedom, particularly in the interaction of the mobile robotic resources with other resources such as workstations and human workers. The proposed extensions allow for modelling complete assembly lines in great detail. In the case study, we demonstrate the advantages of the extended formulation in periodic scheduling.

A CVRP Model for an In-plant Milk Run System

Maria Teresa Pereira, Isabel Cristina Lopes, Luís Pinto Ferreira, Silvana Oliveira

Resumo. Automotive industry is very competitive and efficiency is needed

in key processes such as logistics in all companies at the supply chain. Using optimization models to increment the efficiency of inbound logistics, such as the in-plant transportation systems, can bring competitive advantages to these companies. This work presents a Vehicle Routing Problem (VRP) model to support and optimize the in-plant transportation system routing, Milk-Run, at the worldwide manufacturing plant of manual assembly in an automotive company, where the routing was planned manually, and too much time and resources were used on this task. At the present, 4 or 5 routes were necessary to supply and collect both raw material and finished items in the plant with 21 workstations. A VRP model was developed into a decision support tool using Integer Programming. The IBM ILOG CPLEX 12.0.8 was used to run the developed model using the production plan of two months of 2018. The results point out an optimal number of 2 milk-runs, a reduction of circa 50%, allowing the freed resources to be used in other production areas of the plant.

In-house logistics operations enhancement in the automobile industry using simulation

Rodrigo Macedo, Fábio Coelho, Susana Relvas, Ana Barbosa-Póvoa

Resumo. In a fast-paced and synchronised context for manufacturing industries, an efficient material handling of parts is crucial. Therefore, this industry requires reliable and efficient internal logistics operations that enable efficient production strategies, such as an assembly line powered by a decentralized storage support area – logistics supermarket. Agile and flexible decision-making raises the need to plan all plant operations as well as to control them. To support such planning this work proposes a simulation-based decision support tool for the operation of a manufacturing supermarket. It analyses the activity of order picking and line feeding in the logistics supermarket where factors such as the speed of the pickers or the number of AGV's are explored. This is done using the Simio – simulation modelling framework based on intelligent objects. The model was validated using a real case study.

Analysis and Optimisation of a Production Line Using Discrete Simulation

Fabiane K. Setti, Carla A. S. Geraldes, João P. Almeida, Marcelo G. Trentin

Resumo. This study presents a simulation-based procedure to analyse a production line of a metalworking company. We use a simulation tool,

ProModel® software, to reproduce the existing production line layout of the company best-selling product which represents about 70% of the total sales. Our purpose is to get information about the existing system behaviour, and to find strategies to increase actual production level to meet the market's demand. Based on an initial simulation model, different production scenarios were proposed and results have shown that it is possible to increase the production level allowing to meet the increasing demand for the product. The following changes in the production system were considered: (i) the use of intermediate stock of work-in-process items, (ii) the introduction of new equipment, and (iii) a mixed strategy where the introduction of new equipment is combined with the use of intermediate stock of work-in-process items. In summary, this research exhibits the flexibility of the simulation technique to address manufacturing problems throughout the creation of different scenarios providing some of the behaviour of the systems allowing the anticipation of final outputs.

Improving the performance of the internal supply chain: the case of a cork company

Idália Oliveira, Helena Alvelos

Resumo. Nowadays, and when considering a supply chain, it is increasingly important that suppliers and customers are aligned. In this work a case study carried out in a Portuguese company in the cork sector is presented. Its purpose was to increase the level of service of the internal customer. The production process consists of several stages: crushing, drying, agglomeration, transformation and customization. In this particular process, the aim was to increase the level of service of the agglomeration stage. In order to understand if the drying capacity was being used in full, the production in the previous 9 months of drying and agglomeration was compared to their productive capacities and it was concluded that the drying capacity was underutilized. Thus, in order to reduce the number of stops of the agglomeration line due to lack of cork raw material, a buffer was created. Additionally, in order to make the analysis of the supervisor much simpler, an algorithm was developed. This algorithm automatically calculates the amount of granulate that must be dried, to ensure that the plan is fulfilled and to supply the buffer, taking into account the position of the silos and the expected granulate needs for the agglomeration.

Sessão TA4: OR in Industry

23 de Julho, Terça-feira, 9:00 - 10:30
Sessão em Português/Inglês
Sala: B257

Moderadora: Sara Martins

Design and scheduling of multipurpose plants under demand uncertainty: A model-based decision support system

Miguel Vieira, Helena Paulo, Tânia Pinto-Varela, Ana Barbosa-Póvoa

Resumo. The increasing market dynamics in most industrial sectors is compelling companies to increase their effectiveness of design and scheduling decisions through the assessment of optimization solutions. With Industry 4.0 digital transformation, technology has provided greater relevance on model-based decision-support systems, in order to potentiate production competitiveness under operational uncertainty. The aim of this work is to provide an integrated decision-support approach for the design and scheduling of multipurpose plants under demand uncertainty, while considering the optimal solution assessment for alternative risk management profiles. The mathematical model proposes a bi-objective two-stage stochastic mixed-integer linear programming with the goal to maximize annualized profit and minimize financial risk using the Conditional Value at Risk (CVaR). The topology and design characterization, capacity utilization, process schedule decisions and storage profiles are presented over a Pareto optimal curve that illustrates the different trade-off solutions. The integrated approach considers multiple decisional elements pairing the expected profit and the associated financial risk, while evaluating the borderline risk of high losses or high returns, the evaluation of service level performance, the influence of confidence level in CVaR calculations, and the impact on a retrofit design scenario.

Leveraging Simulation-Optimization to Determine Fashion Delivery Patterns

Daniela Pinho, Raquel Vieira, Diogo Miranda, Daniel Pereira, Pedro Amorim, José Fernando Oliveira

Resumo. Fashion retailers must decide on the best strategy to deliver products from warehouses to stores, maximizing the fulfilment of demand and keeping costs low, while simultaneously dealing with short life cycle products,

a high risk of lost sales caused by stock-outs and backrooms with limited capacity. This industry's specific challenges have not yet been fully researched regarding the definition of an ideal delivery pattern, which is capable of quickly replenishing sales and deliver new products to the stores, filling up shelves after the weekend demand peak. The simulation-optimization method proposed leans on simulation to detach the sales and shipping data from reality, providing unbiased inputs for optimization and estimating relationships between variables. The linear programming problem is designed to maximize the individual store profits while assuring the holistic integration needed for processing in the warehouse with the associated constraints. The best alternative is then tested on the simulator, in hand with experimenting with variable condition-based lead times, and a detailed solution is obtained for each store. The resulting model is expected to generate the delivery pattern that maximizes the balance between service level and logistic costs. Preliminary results for a case study on an Iberian apparel retailer will be presented.

Optimized conditions to industrial aluminium extrusion

Filipe Ferrás, Aldina Correia, Eliana Costa e Silva, Fátima de Almeida

Resumo. Environmental concerns in industrial companies are increasingly imperative, not only due to national and international norms, but also because companies' image in current demanding markets. Aluminium industry is not an exception. Although aluminium is a recyclable material, minimizing the scrap production is the best way to avoid excessive costs and preserve the environment. The amount of scrap production depends on several processing conditions, concerning with pre-extrusion, extrusion and post-extrusion processes. In a previous work, we consider several extrusion variables in order to analyse their effects on the amount of scrap produced in an industrial aluminium extrusion company. Variables concerning with temperature, time, speed, pressure and geometry were considered and a multivariate linear model was computed to estimate the scrap production. Considering a huge database on the company's six-month production, the limits for the studied variables are known. Thus, in this work we intend to determine the best values for these variables in order to minimize the scrap production, and consequently to avoid excessive costs and to promote the environmental sustainability. For that, a linear minimization problem with simple bounds is formulated and solved.

Strategic decision-making in the development of pharmaceutical products

Catarina Marques, Samuel Moniz, Jorge Pinho de Sousa

Resumo. Strategic decision-making during the product development process is critical for the competitiveness of the pharmaceutical industry. During this phase, efficient process design and capacity planning decisions usually entail considerable challenges. The main hurdles are related to the long development cycles and to the stochastic nature of the process. In fact, not only product demand variability, but also the technical uncertainty associated with the clinical trials outcomes, can have a significant impact on the global system's performance, thus affecting decision-making. Moreover, current approaches to tackle uncertainty seldom consider the decision-maker preferences in an explicit way. In this study, we address these issues by developing a new Multi-Objective Integer Programming (MOIP) model to optimize process productivity, while considering the decision-maker risk attitude. This approach proved to be quite effective in improving strategies for process design, to maximize productivity, and in achieving a good balance between investment and capacity allocation decisions. Results also show the unquestionable influence of the decision-maker in the construction of the final solution, thus highlighting his importance in strategic decision-making for strongly stochastic environments.

Food Supply Chains: thoughts on strategies to mitigate food waste

Sara Martins, Ana Sofia Figueiredo, José Cunha, Pedro Amorim, Luís Guimarães, Bernardo Almada-Lobo

Resumo. Thousands of food kilograms are wasted every day while there are people starving. This fact places food waste as one of the central societal topics in discussion today. Food supply chains have the challenge to match supply and demand, while dealing with perishable products that can not be stored for long. To address this issue, there are many researches that try to support a better planning for procurement, production, and sales. However, as the planning is still mainly focused on the economic aspect of the problem, the final decision still produces more waste than that of a sustainable planning that also considers the social and environmental impact. Nevertheless, even if the supply chain is very efficient, there will always be spoilage that can not be avoided. In this study, we present two lines of work that can contribute to food waste reduction and at the same time towards more sustainable supply chains: (1) challenging retailers-producers contract agreements with very

strict minimum life on receipt (MLOR) of the products; and (2) innovating retailers valorization strategies for aged fruits and vegetables.

Sessão TA5: Scheduling

23 de Julho, Terça-feira, 9:00 - 10:30
Sessão em Português/Inglês
Sala: B259

Moderadora: Tânia Pinto-Varela

Otimização de rotações de material circulante em ordem ao lucro: um caso de estudo na América do Norte

Rita M. Portugal, Luís M. Albino, Ricardo L. Saldanha

Resumo. A otimização de rotações de material circulante é normalmente tratada na literatura como um problema de minimização de custos sujeito a restrições (rígidas ou flexíveis) que estabelecem mínimos para o número de passageiros que é possível transportar em cada viagem. Apesar da minimização de custos operacionais e financeiros (manutenção, aquisição ou aluguer de veículos, consumo de energia, etc.) ser de extrema importância, o aumento de receitas com a venda de bilhetes não pode ser descurado. Nesta comunicação apresentamos um caso de estudo de um transportador da América do Norte que opera comboios de médio e longo curso, garantindo lugares sentados para todos os passageiros. Utilizando o FLEET (sistema de apoio à decisão para planeamento de material circulante desenvolvido pela SISCOG), principalmente os respetivos otimizadores, é possível produzir rotações do material circulante que permitem aumentar as receitas e baixar os custos através de um dimensionamento mais eficiente da capacidade de transporte face ao número de passageiros esperado em cada viagem operada pelo transportador. A comunicação inclui a apresentação do problema, de alguns detalhes dos métodos de resolução utilizados bem como dos resultados obtidos na prática pelo transportador ferroviário.

A Metaheuristic Approach for Staff Scheduling at Emergency Medical Services

Mariana Cunha, Inês Marques, Ana Barbosa-Póvoa

Resumo. Staff scheduling and rostering are complex tasks required for many industries. In the health care sector due to the large number of personnel, high variety of required skills and the nonstop service, scheduling

problems become even harder to solve. This work presents an approach for staff scheduling at emergency medical services. The problem considers both legal constraints, such as work hour regulations, as well as equity enhancing constraints, such as balanced work schedules among team members in terms of overtime/undertime and shift type. Furthermore, problem specific characteristics are modeled, namely work teams and fixed shifts. The objective is to maximize service level by meeting demand as much as possible. Staff's fairness perception is considered by ensuring that: each staff member is assigned to all types of shifts (night, morning and afternoon) and has a minimum number of full weekends off; and overtime and undertime (with respect to contractual working hours) is minimized for all staff. This work adapts a nature-inspired population-based metaheuristic, Cuckoo Search, for staff scheduling. This methodology is applied to the Portuguese emergency medical service case.

A Meta-Heuristics Approach for Production Scheduling - A Real Case Study

João Sacramento, Tânia Pinto-Varela, Nelson Chibeles-Martins

Resumo. The increasingly competitive corporate environment is driving companies toward a greater focus on efficiency. To this end, many companies are guiding efforts to increase productivity in their operations and the manufacturing industry is no exception. To achieve these goals, one of the most useful tools available to managers is Operations Research, which allow the creation of models to aid in system optimization. This work focuses on a Portuguese plastic container manufacturer, which produces many products, with different characteristics, using several production strategies, triggering many changeovers, long setup times, reducing its overall efficiency. As such, there is a need for development of scheduling decision support tool at its facility. In production scheduling literature, this problem is referred to as a Flexible Job Shop Scheduling Problem with Sequence Dependent Setup Times (FJSSP-SDST). In a FJSSP-SDST, the jobs productions may follow different paths, sharing the equipment available to perform a given operation. This problem is known to be NP-hard and many authors have developed algorithms attempting to solve it to optimality. Exact approaches have shown to be insufficient and thus, most of the research adopts meta-heuristic approaches, with the most prevalent and successful method being the Tabu Search (TS). The aim of this work is to develop a TS based algorithm for production scheduling on a weekly basis. The facility has to produce 62 jobs in 5 different types of machines, making a total of 10 machines available. The setup times for each batch depend on the previous combinations of three possible changeover operations: "Changing Mold", "Changing Dye" and "Changing Label".

A TS approach will be developed the support decision tool, due to its ability to explore any region of the search space very efficiently coupled with simple mechanisms to diversify the search and avoid getting trapped in local minimum. First, data is gathered regarding the production process. Then, the mathematical model describing the process is built, followed by a fitting representation scheme for solutions. After the representation is chosen, the algorithm's structure is outlined and its specific mechanisms and parameters further detailed. The model takes as input the process characteristics such as: resource requirements, process durations, precedence restrictions, as well as information on orders placed and stock levels. The model output is the best schedule found during each run. The schedule's fitness is determined by the completion time of all jobs, with the best schedule being the one with the shortest makespan. The previous algorithm is extended considering two folders: the former to develop multi-objective approach, considering the makespan and the tardiness minimization; followed by the Pareto front characterization, as a decision support tool, to support the decision maker. Several problem instances will be generated. The algorithm's parameters will be empirically tuned for each instance to improve its performance. Finally, an overview of the algorithm and its performance is done, and conclusions are drawn regarding the algorithm's behavior when faced with specific problem characteristics.

Lot-sizing and scheduling problem with resource allocation: a rolling-horizon approach

Rafael Carvalho, José Queiroga, João Alves, Pedro Schuller, Teresa Bianchi-Aguiar, Luís Guimarães, Bernardo Almada-Lobo, José Fernando Oliveira

Resumo. Defining the optimal lot sizes with the objective of minimizing inventory and production cost is of utmost importance to several manufacturing industries. However, the literature on lot-sizing and scheduling with sequence-dependent setups is scarce when concerning flexible industrial environments, with production lines sharing stages, machines or workforce. Under these circumstances, the chosen resource setting influences the overall capacity, and consequently, it is necessary to decide lot-sizing and scheduling and resource allocation concurrently to correctly estimate it. Motivated by a case study in the beverages industry, we propose a rolling horizon model to integrate the lot-sizing and scheduling problem with resource allocation. In this specific case, the combination of active production lines influences the production rate and has non-linear workforce needs, by taking advantage of layout efficiencies. Focusing on tactical planning, groups of similar products are sequenced and detailed scheduling is relaxed in later periods, estimat-

ing capacity in the mid-term and achieving an improved performance of the mixed-integer programming model. In this talk, we present the insights obtained from applying this methodology to the case study and discuss the main challenges.

Practical production planning and scheduling optimization

Daniel Carvalho, Eduardo Curcio, Pedro Amorim

Resumo. This work proposes an iterative solution method to address the integration of the tactical (lot-sizing) and operational (scheduling) levels in production planning with sequence dependent setups. This method breaks the integrated lot-sizing and scheduling problem into two. In the first subproblem, the production planning is optimized with production setups disregarded. The production scheduling solution is then defined using local search strategies that will also construct rules for the tactical level. After that, the tactical level is optimized again, considering the rules defined from the operational level. The algorithm continues iteratively until objective functions from both levels converge. In this work, two computational experiments are proposed. The first is performed to compare the solution method proposed with mixed-integer programming models and meta-heuristics from the literature. Then the research will focus on an animal-feed industry case, in which production setup is sequence dependent and usually presents non-triangular setups, so products can avoid cleaning setups if produced between two products that otherwise would require a setup. The purpose of the second experiment is to evaluate the potential gains to a hierarchical approach usually used in this industry.

Sessão TB1: Decision Support Systems

23 de Julho, Terça-feira, 11:00 - 12:30
Sessão em Português/Inglês
Sala: B253

Moderador: Jorge Pinho de Sousa

Waste and by-products Mapping: A tool to foster Supply Chain Sustainability

Mafalda Ivo de Carvalho, Ana Barbosa-Póvoa, Susana Relvas

Resumo. In a global and highly competitive market, companies are beginning to differentiate themselves by engaging in collaborative relationships,

at chain level, in order to achieve a long-term sustainable and competitive advantage. Given its weight in the GDP of European countries; his inherent fragmentation, with a high number of different stakeholders along the chain; and at the same time concentration, with most of the agro-explorations in a region belonging to the some cluster of stakeholders, the Agri-food Supply Chain (SC) is the selected case study to explore the possible impact of a collaborative SC management in the chain's sustainability. To do so, the SC waste and by-products mapping emerges as a solution to promote more Sustainable SC, concerning the three pillars of sustainability, economic, environmental and social. This research focuses on the topic of food waste and develops a generic and operational tool able to map where, why and in which amount the waste and by-products are generated. By analyzing the scientific literature published, this research aims to develop a Decision Support System (DSS) to assist companies in optimizing their waste treatment strategies. In order to validate the tool, agro-food players would use it as a DSS.

Embedding behavioural OR within Delphi knowledge construction processes in health settings

Liliana Freitas, Ana Vieira, Mónica Oliveira, Carlos Bana e Costa

Resumo. Stakeholder involvement is crucial for developing operational research tools to assist health policy- and decision-makers. The Delphi process is widely used for involving large and geographically dispersed groups, with its recent use being enhanced by new web platforms. However, stakeholders' interaction within Delphi processes may be influenced by their characteristics and advice-taking attitude. Such aspects are critical for interpretation and use of the information generated. This study designs features to be embedded within web platforms enabling behavioural research within Delphi. Namely, we build an experimental design to be included in a Delphi to explore if health stakeholders' willingness to take advice is influenced by their knowledge about the stakeholder group who gives the advice, with social network analysis used to draw the stakeholders' advice network; and we use metrics to understand if the Delphi knowledge construction process is influenced by group characteristics and cognitive diversity search. This will be tested within the MEDI-VALUE research project, in which a Delphi process will be used to gather consensual dimensions for Medical Devices evaluation.

Towards an integrated decision-support framework for the new generation of manufacturing systems

Miguel Vieira, Fábio Coelho, Cátia da Silva, Bruna Mota, Joana Guapo, Rodrigo Macedo, Bruno Gonçalves, Samuel Moniz, Tânia Pinto-Varela, Ana Carvalho, Susana Relvas, Ana Barbosa-Póvoa

Resumo. The global innovation paradigm for industry is setting new research challenges for the management of manufacturing systems. With Industry 4.0 transformation across multiple enterprise levels, advanced automation gained a greater relevance to business intelligence models, as it aims to leverage integrated approaches to improve competitiveness and responsiveness under operational and market uncertainty. In this work, an integrated framework is discussed to develop management solutions for the next generation of industrial manufacturing systems. The underlying idea is to discuss existing challenges for designing and implementing effective decision-support systems. Both modeling and decision-support perspectives are provided so as to develop a framework capable to address reactive production planning and scheduling problems supported by efficient in-house logistics systems, while pursuing operational sustainability targets.

A mathematical model for the ambulance dispatching and relocation problems to optimize system's preparedness

Maria Eugénia Captivo, Ana Sofia Carvalho, Inês Marques

Resumo. In the Emergency Medical Service (EMS) environment, the decision-making process plays a very important role at strategic, tactical and operational levels. This work focuses on the operational level by solving the ambulance dispatching and relocation problems to urgent emergency requests. Ambulance dispatching decisions assign ambulances to emergencies and the relocation problem decides to which base available ambulances should be (re)assigned. A mathematical model for an integrated optimization approach is proposed considering a time-preparedness measure which is calculated for a fleet of available ambulances at each time period. The main goal is to ensure the sustainability of the system, i.e. an appropriate response for emergencies on the current period and a good system's preparedness for the future. This model highly penalizes uncovered emergencies and emergencies that are not served within the maximum response time. Experiments are performed using EMS data from Lisbon where solving these problems is still a handmade task. Results highlight the potential of this model to be applied in real-time contexts. The strategy based on preparedness improves system's

performance when compared to the current strategy which dispatches the closest available ambulance for each emergency and relocates ambulances to their home bases.

Robust Supply Chain Design of Aerospace Supply Chains under Probabilistic Bounds for Constraint Violation

Nuno Falcão e Cunha, Eduardo Curcio, Pedro Amorim, Bernardo Almada-Lobo

Resumo. Recent disruptions to the aerospace sector have led original equipment manufacturers (OEMs) to hire super tier-1 risk-sharing partners. These suppliers are responsible for designing and integrating large modules and delivering them to the final assembly line. The added engineering and management responsibilities for suppliers led to delays in both development and delivery of aircraft. As a result, OEMs have begun to assess integration risk values for suppliers integrating multiple parts. To mitigate the impact on aerospace supply chains, a mathematical programming model for supply chain design (SDC) was developed and tested using robust optimization. The model makes trade-off decisions on supply chain modularity and sourcing flexibility. However, robust optimization uses uncertain parameters and may yield overly optimistic or even infeasible nominal solutions upon the realization of those parameters. As such, a priori probabilistic bounds for constraint violation are imposed on the robust counterparts for the constraints dealing with risk. This approach provides decision makers with a decision support tool for SCD based on their risk aversion profile. A further study was made to improve these bounds for robust optimization problems by employing other analytical tools, such as chance-constraint optimization, to reduce their conservatism.

Sistemas de Apoio à Decisão em Mobilidade Urbana

Jorge Pinho de Sousa

Resumo. Os sistemas de mobilidade urbana são hoje indiscutivelmente uma parte importante do nosso quotidiano e da atividade económica em geral. A tendência para uma maior inter-modalidade e a dependência crescente da "informação" tornam a mobilidade de pessoas mais eficiente e mais sustentável, mas implicam uma significativa "complexificação", constituindo frequentemente um fator de exclusão social. De facto, estes sistemas, envolvem múltiplos stakeholders (passageiros, operadores de transportes, municípios, o governo), recursos elevados, com investimentos significativos e importantes custos de operação, havendo um enorme espaço para otimização e ganhos de eficiência. Os problemas associados têm uma natureza multi-critério, sendo

natural o recurso a Sistemas de Apoio à Decisão (SAD) onde os dados e os algoritmos são fundamentais mas a interação com os agentes de decisão é importante, como forma de ter em conta os aspetos não estruturados de sistemas socio-técnicos complexos e de grande dimensão. E num quadro de fortíssima digitalização e de crescimento da economia da partilha, torna-se ainda mais indispensável (co-) criar soluções e serviços de mobilidade muito mais inteligentes e sustentáveis. Assim, é com esta preocupação que, neste trabalho, são discutidas algumas destas tendências e apresentadas ideias para o desenvolvimento de SADs inovadores no contexto da mobilidade urbana.

Sessão TB2: Energy, Environment, Nat. Resources and Climate II

23 de Julho, Terça-feira, 11:00 - 12:30
Sessão em Português/Inglês
Sala: B255

Moderador: Reinaldo Gomes

Strategic and Tactical Planning of the Downstream Petroleum Supply Chain

Carolina Diniz Melo, Susana Relvas, Ana Barbosa-Póvoa

Resumo. The aim of this work is to develop a mixed integer linear programming (MILP) mathematical model that will support the definition of a distribution strategy for supplying markets that may span over more than one country. The model is based on that developed by Kazemi & Szmerekovsky (2015), which addresses strategic and tactical decisions (such as determining optimal location and capacities for distribution centers, selection of transportation modes, determining flow allocation, etc.) considering multiple products while minimize the fixed and distributing costs. The model proposed in this work extends the previous work and adds terms in objective function and constraints related to imports and exports between countries, not yet considered. In order to test and validate the model developed, the Portuguese oil supply chain and its operation in Iberia will be considered to illustrate the solution approach selected, considering one of the market players present in both countries. The model will be implemented in GAMS programming language and solved using the solver CPLEX. The results will analyze not only the current network and how it can be optimized in terms of resource usage,

but also foresee which network adjustments would be more advantageous in the case study selected.

The ϵ-constraint method to solve a bi-objective problem of sustainable cultivation

Angelo Aliano Filho, Helenice Florentino Silva

Resumo. This study presents a nonlinear bi-objective 0-1 optimization model for sustainable cultivation and proposes an exact method to solve it. In this formulation, among a set of cultures, a predefined number of cultivable plots and planning horizon, it is intended to decide which crops, periods and plots should be cultivated. Two conflicting objectives are considered: (i) minimize the proliferation of pests and (ii) maximize the profit of the planting schedule in all planning horizon. The mathematical formulation was solved by the classical ϵ-constrained method. We linearized the original model and obtained an alternative linear version of our problem. Then, we compare the performance of ϵ-constrained method in this two formulation to determine some Pareto optimal solutions in 27 instances generated by a semi-random procedure of real dimension. The experiments showed that mathematical models along with the proposed method may be powerful tools in the complex decision-making in this field.

An approach to address road network design, machinery location and routing problems in forest management planning

Marta Mesquita, Susete Marques, Marlene Marques, Marco Marto, Miguel Constantino, José G. Borges

Resumo. We address an integrated forest management road design, machinery location and routing problem in Zona de Intervenção Florestal de Paiva (ZIF_Paiva). In a harvest scheduling plan, covering a nine 10-years periods planning horizon, one has to decide which roads to build and/or to maintain in each period of the planning horizon to provide access to the stands by the machinery needed for harvesting and to allow timber transportation from the stands being harvested to the municipality roads. Geographical and topographical information that characterizes the stands and the existing roads is processed by GIS routines to identify the potential road network and machinery location sites. A MILP model is developed to minimize a linear combination of road building, road maintenance, machinery location and timber transportation costs. A three steps solution approach is proposed. First, a preprocessing procedure based on the computation of shortest paths and the contraction of subsets of vertices is developed and implemented to reduce

the cardinality of the vertex and edge sets. Afterwards, branch-and-bound techniques are used to solve the integrated problem in the resulting network. Lastly, a greedy heuristic is applied to improve the machinery location subproblem solution. Results are discussed for an application to ZIF_Paiva.

Integrated Biorefinery Supply Chains Design: Modelling Technological Uncertainty Using Learning Curves

Helena Paulo, Ana Barbosa-Póvoa, Susana Relvas

Resumo. The design and planning of lignocellulosic biomass based supply chains to produce bioenergy and biomaterials is a major challenge. Amongst many other aspects this challenge is related to the uncertainty associated with the low maturity of technological development on the processing technologies. To deal with such uncertainty the present work identifies and describes a framework capable of modelling the technological development uncertainty based on the learning curve concept to be used in the stochastic mixed integer programming model. The relation mathematically expressed in the form of learning curves reflects the technical and economic performance of a technology increase as producers and consumers gain experience with a new technology. We assume that technological change is reflected in the technological conversion factor uncertain parameter that is modeled through discretization of the learning curves over time for different learning rates. A case study based on the Portuguese integrated biorefineries supply chain is used to illustrate the application of the proposed methodology. The results highlight by one hand the advantages and major drawbacks of using learning curves to technological uncertainty modeling by the other hand the influence of technological development in the supply chain design as well as implications for investments in technology.

Biomass supply network design through facility location and equipment assignment: linking strategic and tactical decisions

Reinaldo Gomes, Ricardo Soares, Alexandra Marques

Resumo. The biomass supply chain is a complex system and deals with several constraints specific to its geographical location and harvest season. The profitability of companies in this sector is closely related to minimizing the costs associated with transportation and its operations. In order to find a model that provides a logistics optimization plan, it was developed a multiperiod capacitated facility location problem, in which two different approaches were incorporated in the model and tested. At first the raw material is chipped directly at harvest residue piles and goes to the final biomass consumers, in the

second approach there is the selection of terminals to where the raw material of specific piles will be transported, after which it is chipped in these same terminals and is transported to the final consumers. The proposed Mixed Integer Programming (MIP) incorporates these two approaches and provides the optimal network design with a flow scheme between the different locations, the number and capacity of each terminal, the number and productivity of each chipper, stocks and number of trucks. Provide managerial insights on specific biomass supply chain aspects and infer from the obtained results.

Sessão TB3: Production and Operations Management II

23 de Julho, terça-feira, 11:00 - 12:30
Sessão em Português/Inglês
Sala: B254

Moderador: Agostinho Agra

Dimensionamento e escalonamento de lotes de produção numa unidade fabril de injeção de plásticos

Mariana Amaral, Rui Trindade, Samuel Moniz, Cristóvão Silva, Jorge Pinho de Sousa

Resumo. Motivado por um caso real, este trabalho apresenta a aplicação de modelos de otimização para o dimensionamento e escalonamento de lotes de produção numa unidade fabril de injeção de plásticos. Este problema é especialmente relevante porque influencia a capacidade efetiva de moldes e máquinas. Assim, em vez de seguir uma abordagem sequencial de dimensionamento dos lotes e escalonamento da produção, sugere-se a resolução em simultâneo dos dois processos de tomada de decisão. As características específicas do sistema produtivo em estudo, como máquinas em paralelo, compatibilidade molde-máquina e setups motivaram a construção dos modelos que visam a redução dos custos de stock e de setup, bem como a minimização do tempo total gasto em tarefas de setup. Exploram-se ainda algumas extensões do problema, com o objetivo de propor estratégias de dimensionamento e escalonamento de lotes alternativas. São ainda apresentados alguns desafios de desenvolvimento e implementação de métodos de otimização na indústria e são apontadas algumas diretrizes para atenuar as dificuldades de modelação de problemas reais.

The constrained three-dimensional guillotine cutting problem: ILP formulations and a bottom-up algorithm

Mateus Martin, José Fernando Oliveira, Elsa Silva, Reinaldo Morabito, Pedro Munari

Resumo. We address the Constrained Three-dimensional Guillotine Single Large Placement Problem (C3GSLOPP). This problem involves cutting a larger box (object) to produce smaller boxes (items) from orthogonal guillotine cuts, i.e., cuts that are parallel to the object's edges and always generate two sub-boxes. In addition, there is an upper limit on the maximum number of copies that can be produced of each item type. This problem arises in manufacturing industrial settings, such as in the cutting of steel and foam mattresses. To model this problem, we propose a new compact integer nonlinear programming (INLP) formulation and its integer linear programming (ILP) version, by extending a previous formulation for the two-dimensional case. Additionally, we propose a new model for a particular case of the problem, which consider only 3-staged patterns. Finally, as solution method for the C3GSLOPP, we extend the algorithm of Wang (1983) to the three-dimensional case in the context of heuristic solutions. All proposed approaches are evaluated through computational experiments using benchmark instances and compared with other approaches available in the literature. The results show that the approaches are effective on different types of instances.

Adaptive Sequence-based Heuristic for Two-Dimensional Non-Guillotine Packing Problems

Óscar Oliveira, Dorabela Gamboa, Elsa Silva

Resumo. We present heuristics for two related two-dimensional non-guillotine packing problems. The first problem aims to pack a set of items into the minimum number of larger identical bins, while the second aims to pack the items that generates most value into one bin. Our approach successively creates sequences of items that defines a packing order considering knowledge obtained from sequences previously generated. Computational experiments demonstrated that the proposed heuristics are very effective in terms of solution quality with small computing times.

Product line selection in the fast-moving consumer goods industry: literature review and opportunities for research

Xavier Andrade, Luís Guimarães, Gonçalo Figueira

Resumo. Product line selection (PLS) is a high-level problem that heavily determines lower-level decisions such as lot-sizing and, in turn, is influenced by them. We survey the literature on this problem and contextualize it in the marketing-operations interface. We distinguish the decision from closely related problems such as the product-line design and the assortment problem. We track the evolution of the literature can focus on the development and inclusion into PLS models of sophisticated consumer choice models, or on more modeling production more accurately. Furthermore, we analyze notable contributions and discuss research opportunities. This work provides the much needed definition and placement of the PLS line of research, enabling researchers to contribute to the topic with ease.

Robust inventory theory with perishable products

Marcio Costa Santos, Agostinho Agra, Michael Poss

Resumo. We consider a robust inventory problem where products are perishable with a given shelf life and demands are assumed uncertain and can take any value in a given polytope. Interestingly, considering uncertain demands leads to part of the production being spoiled, a phenomenon that does not appear in the deterministic context. Based on a deterministic model we propose a robust model where the production decisions are first-stage variables and the inventory levels and the spoiled production are recourse variables that can be adjusted to the demand scenario following a FIFO policy. To handle the non-anticipativity constraints related to the FIFO policy, we propose a non-linear reformulation for the robust problem, which is then linearized using classical techniques. We propose a row-and-column generation algorithm to solve the reformulated model to optimality using a decomposition algorithm. Computational tests show that the decomposition approach can solve a set of instances representing different practical situations within reasonable amount of time. Moreover, the robust solutions obtained ensure low losses of production when the worst-case scenarios are materialized.

Sessão TB4: Supply Chain Management I

23 de Julho, Terça-feira, 11:00 - 12:30
Sessão em Português/Inglês
Sala: B257

Moderadora: Bruna Mota

Sewage sludge management optimization with energy recovery: a supply chain design approach

Alda Henriques, Milton Fontes, Ana Camanho, Jaime Gabriel Silva, Pedro Amorim

Resumo. Wastewater treatment plants (WWTPs) undertake an energy intensive productive activity. However, there is potential for energy efficiency improvements and the target of energy self-sustainability is presently feasible, though it may require a wide range of technical and technological initiatives along with good management practices. This study adopts a system-wide perspective of a set of WWTPs that use different technologies for sludge stabilization to develop a new management strategy for sludge treatment optimization, which does not require technological investments to allow energy sustainability improvements. The approach developed consists in a logistics network to leverage sludge flows between WWTPs with different methods for sludge stabilization, which are the aerobic stabilization that requires high amounts of electricity consumption and the anaerobic digestion that produces biogas. These can be interconnected by reducing the aeration period such that the sludge retains its biogas potential without compromising the quality of the effluent discharged, and then be transported to the plants with available capacity in the anaerobic digesters. To tackle this problem, a mixed integer linear programming (MILP) model is developed that maximizes the economic benefit accrued through the energetic balance under the logistics approach. A Portuguese case study is used to demonstrate the model applicability.

A multi-objective and multi-period model to the design and operation of a hydrogen supply chain: an applied case in Portugal

Diego Câmara, Tânia Pinto-Varela, Ana Barbosa-Póvoa

Resumo. Hydrogen has been listed as one of the main energy alternatives to integrate the world energy matrix, with great relevance in the automotive sector. This integration aims to contribute for the reduction of global potential warming through global supply chains (SC) that support industrial processes using renewable energy sources. Hydrogen is an option with a high potential to mitigate environmental impacts caused by the current fossil fuels. Although it has benefits in environmental terms, there are no current infrastructures and does the design of such network requires high capital investment, being this the main barrier to the hydrogen economy development. It is then crucial to define a future hydrogen SC in an optimized way. Following this need, we propose a multi-objective, multi-period mathematical formulation for the design and planning of a hydrogen SC. A Mixed Integer Linear Programming (MILP) model is developed to determine the Hydrogen SC planning and operational decisions. The formulation minimizes cost and environmental impacts of the network. A case study in Portugal was explored.

A Multiperiod Model for Supply Chain Management in the Retail Sector

Ana Teixeira, Eliana Costa e Silva, Isabel Cristina Lopes

Resumo. In this work a case study on the purchasing management department of a Portuguese retail company is presented. More specifically, a multiperiod nonlinear mixed integer model aiming at optimizing the decision-making of the company's purchasing managers, was developed with the objective to minimize the ratio between operational costs and the merchandise costs. Different storage models and periodicity are considered, as well as the service level of each supplier. Afterwards, real instances regarding the demand for one year are tested for once and twice a week. The results show that the model can reduce, on both periodicity scenarios, the ratio between operational costs and merchandise costs, for the majority of the products.

A comprehensive supply chain planning: pharmaceutical alliances for sustainable services

Ana Amaro,

Resumo. Great challenges are being perceived in management as a result of the new opportunities introduced by international business and trade re-

lations. The assurance of service levels to global customers strongly impacts companies' performance. The unpredictable variability observed in demands, prices and customer expectations introduced risk and uncertainty. These had a particular effect in the pharma industry where hard compliance and regulatory conditions have to be fulfilled. Besides that, pharmaceutical expenditure of generic drugs grew within a cost-containment scenario. So, important learning from processes is required to ensure customers' expectations while maintaining a healthy and sustainable position. Strong enterprise alliances have started in pharma companies, to manage risk (e.g. drug shortage). In this contribution the optimal planning of industrial pharmaceutical Supply Chains (SC) is addressed. A broad MILP decision model based on Events Replication is proposed to support planning decisions. A sustainable economic objective is coupled with customer compliance and service levels criteria, while accounting for comprehensive planning conditions and process requirements. Also, decisions' costs and process indicators are tested for different customers' expectations, in a risky situation. The proposal and the planning methodology are illustrated through the solution of a case-study discussed for different decision scenarios.

Evaluating the impact of different approaches in LCA in its application to supply chain design and planning optimization models

Bruna Mota, Ana Carvalho, Maria Isabel Gomes, Ana Barbosa-Póvoa

Resumo. Life cycle Assessment (LCA) is increasingly being applied as a decision variable in supply chain design and planning models. However, the absence of standardized guidelines in this type of application brings up issues regarding the value and legitimacy of the results obtained. This work addresses the impact of different decisions or approaches taken when applying LCA to supply chain design and planning optimization models. Specifically, the Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA) steps are targeted. A multi-objective, mixed integer linear programming supply chain design and planning model is applied to a representative case study of an office paper producer and distributor. Environmental and economic objectives functions are implemented, and its trade-offs are assessed using the augmented epsilon-constraint method. This work evidences how different LCIA methods can significantly affect the obtained solutions. Furthermore, the normalization step of LCIA is identified as one the most impacting factors affecting the results. Important managerial insights are obtained regarding the impact of non-standardized analysis of the application of LCA in supply chain design and planning. Attention is brought to the importance of operations research methods to improve LCA-based studies.

Sessão TB5: MCDA

23 de Julho, Terça-feira, 11:00 - 12:30
Sessão em Português/Inglês
Sala: 259

Moderador: Luís Dias

Sectorization for managing maintenance technicians

Isabel Cristina Lopes, Ana Maria Rodrigues, Cristina Oliveira, José Soeiro Ferreira, Maria João Cortinhal

Resumo. Sectorization problems consist in dividing a large region into smaller regions, in order to have a better organization of the region, or to simplify a large problem into smaller sub-problems, or to obtain groups with similar characteristics. To evaluate the quality of the solutions, three criteria are commonly used: Equilibrium (the sectors should be identical portions of the whole), Compactness (regular forms like circles are preferred, avoiding sectors shaped with 'tentacles'), and Contiguity (avoid sectors divided into portions). Depending on the application, other criteria can also be considered, therefore multicriteria approaches should be used. Sectorization problems can arise when designing political districts, defining sales territories, managing routes for distribution of goods or collecting municipal waste, assigning neighborhoods to schools, locating health care services, police stations, or fire brigades. This talk will address the sectorization in an elevator maintenance company, where the definition of the zones assigned to each technician have an impact on the company's efficiency and quality of service. In order to define the best sectorization, not only the maintenance plan should be considered, but also the unplanned interventions. We will discuss the different solution methods that can be applied to this case.

Building a multiple criteria nominal classification model: Application to the Portuguese Army Special Forces recruitment process

Ana Sara Costa, José Rui Figueira, José Borbinha

Resumo. This work presents a case study developed in collaboration with the Portuguese Army through the Centro de Psicologia Aplicada do Exército (CPAE). It is related to the assessment and classification of military candidates into Special Forces categories (Commando, Paratroopers, Special

Operations and Snipers). To address that, we have applied a multiple criteria nominal classification method, CAT-SD (CATegorization by Similarity-Dissimilarity), following a constructive approach through an interactive process between the analyst and the experts. For that, a set of interaction protocols were used to elicit the preference parameters of the method according to the experts' judgments. The DecSpace web-based platform has been used to obtain the candidates assignment to the considered categories, according to the constructed CAT-SD model. The application of the method allowed to identify the most adequate category (or categories) to each candidate profile. The constructed model and the results constitute therefore a relevant contribution to the research on the recruitment process of the Portuguese Army Special Forces.

Gestão de portefólios considerando o compromisso dos agentes

Jorge Noro, Luís C Dias

Resumo. Este estudo propõe uma metodologia que prevê novas restrições na área da análise de decisão da gestão por portefólios para a afetação de diferentes tipos de projetos, sejam de modernização administrativa, de investigação e inovação, de investimento ou outros. As propostas de novas restrições para esta análise assentam no limite da disponibilidade individual, no compromisso das pessoas com o serviço e no benefício individual dado pelo reconhecimento e oportunidades de desenvolvimento de competências. Neste estudo, a afetação de projetos por portefólios tem em vista a maximização de duas funções objetivo, para o valor do portefólio e para o valor desse reconhecimento. A afetação de projetos pelo staff está sujeita ao limite de disponibilidade/carga semanal pré-definida e ao compromisso com o serviço, que atende às dimensões do Vigor, Absorção e Dedicação da escala de UWES (Utrecht Work Engagement Scale), na sua forma reduzida (9 questões-chave).

Aplicação de método multicritério para modelagem de processo de avaliação e desempenho: Um estudo de caso em uma agência de governo

Max Oliveira, Marcio Basílio, Valdecy Pereira, Fabrício Moça

Resumo. A pesquisa objetivou desenvolver um modelo baseado em multicritério para avaliação de desempenho em recursos humanos. O modelo desenvolvido foi dividido em dois módulos. O primeiro foi responsável pela geração da ordenação parcial, onde foi utilizado o método TOPSIS. O segundo módulo, alimentado pelos dados de saída do primeiro módulo, produz a ordenação final do processo de avaliação de desempenho. Neste módulo foi

utilizado o método ELECTRE III. A comparação entre o modelo proposto e modelo vigente na agência de governo analisada permitiu a constatação que o resultado final do modelo proposto produziu alterações em 76,92% das posições geradas na ordenação do modelo vigente. As alterações afetaram o primeiro terço superior da classificação final implicando na promoção de servidores com competências inferiores as desejadas na alta administração da instituição estudada. Outro achado foi a constatação de que os critérios avaliados pelas comissões de avaliações de oficiais que geraram o grau GCP não distinguiam os avaliados no modelo vigente. Por fim, por meio da análise de sensibilidade constatou-se que houve uma inversão na sensibilidade do módulo CPO e GCP entre os modelos vigentes e o proposto.

A multicriteria framework to assist HTA agencies on the evaluation of new drugs on a common basis

Mónica Oliveira, Ana Vieira Vieira, Aris Angelis, Panos Kanavos, Carlos Bana e Costa

Resumo. Multicriteria decision analysis (MCDA) is being increasingly explored to inform Health Technology Assessment (HTA). Nevertheless, literature in the area has not delivered MCDA modelling approaches that enable the evaluation of drugs across disease areas on a common basis, that help evaluation committees to perform structured evaluations while considering qualitative knowledge, and that are informed by the views of a large number of HTA stakeholders. Within the scope of the IMPACT HTA H2020 project, in this study we describe the development of a multicriteria value framework to assist HTA agencies on the evaluation of drugs on a common basis and that addresses these challenges. Technically, the framework is based upon adaptable and flexible multi-criteria models that make use of novel features, including equivalent across-areas attribute-references and interval-weights. Socially, the framework is developed through a collaborative modelling approach in which a large number of HTA stakeholders are involved in a sequence of Delphi and decision conferencing processes and provide insights to build a framework with potential to be used in practical settings.

Sessão Plenária 2

23 de Julho, Terça-feira, 14:00 - 15:00
Sala: Auditório Pacheco de Amorim

Moderador: João Patrício

Operations Research and Machine Learning use cases

Sofiane Oussedik *IBM*

Resumo. Combining Machine Learning and Operations Research is a growing area. The techniques have been combined since a long time and at different levels, and the complementarity is gaining much more traction nowadays due to the great value it provides. We'll go thru use cases including optimizing electricity generation, optimizing a bike sharing system, better planning of the production, and go thru modern applications development best practices that eases the development of operational applications required by the line-of-business stakeholders.

24 de Julho (quarta-feira)

9:00 - 10:30	W1 (sala B253): Transportation Management and VRP III** W2 (sala B255): Other OR Applications* W3 (sala B254): Production and Operations Management III* W4 (sala B257): Supply Chain Management II** W5 (sala B259): Invited Session and Continuous Optimization**
10:30 - 11:00	*Coffee break*
11:00 - 12:00	Sessão Plenária 3 (Aud. Pacheco de Amorim): José Valério de Carvalho
12:00 - 12:30	Entrega de Prémios e Sessão de Encerramento (Aud. Pacheco de Amorim)
12:30 - 14:00	*Almoço*

*Sessões em Português/Inglês
**Sessões em Inglês

Sessão W1: Transportation Management and VRP III

24 de Julho, Quarta-feira, 9:00 - 10:30
Sessão em Inglês
Sala: B253

Moderadora: Cristina Requejo

A bilevel optimization model for the collaborative transportation planning

Maria Santos, Pedro Amorim, Eduardo Curcio, Margarida Carvalho, Alexandra Marques

Resumo. This work addresses a collaborative transportation planning problem between a manufacturer and a carrier. The manufacturer outsources the carrier to deliver all requests to its customers for which it pays a fixed price per unit of distance. The manufacturer must also receive a minimum amount of raw-materials from its suppliers, for which it pays an incentive to the carrier to perform pickups after deliveries. The problem is modeled as a bilevel Vehicle Routing Problem with Selective Backhauls (VRPSB), where the upper level describes the problem of the manufacturer, aiming to minimize the total costs, and the lower level describes the problem of the carrier, aiming to maximize the total profits. The bilevel VRPSB can be reduced to a single-level VRPSB using a Big M reformulation technique and can be further solved using both exact and heuristic algorithms, respectively a cutting plane and an Adaptive Large Neighborhood Search (ALNS). The goal of this work is to evaluate the benefits of our approach compared with the traditional transportation planning. The results suggest that substantial savings (synergy value) can be obtained with the collaboration and the bargaining power of the carrier may play an important role.

Recent trends on dynamic vehicle routing problems

Eduardo Curcio, Maria João Santos, Pedro Amorim, Brenner Ojeda Rios, Eduardo Xavier, Flávio Miyazawa

Resumo. Logistics planning has been improved over the years due to significant advances in information technology such as global position systems, mobile data and more recently internet of things. These advances allowed to

make real-time decisions and impacted several segments such as ridesharing, emergency, routing, delivery and picking services. These applications usually require algorithms that are capable to efficiently process the data and return an optimized planning. In the scientific literature, these applications are related to the dynamic vehicle routing problem (DVRP), in which information are revealed over time and routes can be readjusted. In this work, we intend to explore the main optimization methods and applications related to the DVRP. This is done through a literature review that consists of classifying the works in terms of problem characteristics, solution methods, metrics, application and uncertainty sources. Finally, we also analyze the interface of the DVRP with stochastic optimization methods and expose research opportunities in the field.

Comparing techniques for modelling uncertainty in a maritime inventory routing problem

Filipe Rodrigues, Agostinho Agra, Marielle Christiansen, Lars Magnus Hvattum, Cristina Requejo

Resumo. Uncertainty is inherent in many planning situations, namely in maritime transportation, where weather conditions and port occupancy are typically characterized by high levels of uncertainty. We consider a maritime inventory routing problem (MIRP) where travel times are uncertain. Delays in the travel times may result in inventory surplus or shortages at the storages located at ports. Several techniques to deal with uncertainty, namely deterministic models with inventory buffers; robust optimization; stochastic programming and models incorporating conditional value-at-risk measures, are considered. The different techniques are tested for their ability to deal with uncertain travel times for a single product MIRP with constant production and consumption rates, a fleet of heterogeneous vessels and multiple ports. We assume two-stages of decisions, where the routing, the visit order of the ports and the quantities to load/unload are first-stage decisions, while the visit time and the inventory levels at ports are second-stage decisions. Several solution approaches resulting from the proposed techniques are considered and a computational comparison of them is performed to compare the routing costs, the amount of inventory bounds deviation, the total quantities loaded and unloaded, and the running times. This computational experiment is reported for a set of 21 maritime instances.

Online packing heuristics for the container loading problem

Sara Ali, José Fernando Oliveira, Maria Antónia Carravilla, António Ramos

Resumo. The container loading problem (CLP) is a real-world driven combinatorial optimization problem, that addresses the optimization of spatial arrangement of boxes inside containers so that the utilization of the containers' space is maximized. Most existing works focus on the static (offline) CLP, that all boxes are available beforehand, and the optimization algorithm can freely choose any box to be loaded. However, real-world CLP problems are subject to uncertainty, and one of the most common uncertainties is the characteristic of upcoming boxes, that arises whenever boxes are not available to the optimization algorithm in advance and must be loaded right after they became known. This is referred to as the dynamic (online) CLP. The previous research about online CLP mainly developed an online packing heuristic method and used lower bounds to give information on the solution quality or test the algorithm's performance against other algorithms. This work presents an online problem generator to produce instances with specific properties, including the availability sequence of boxes. The main contribution of this paper is to develop a new well-trained algorithm that could be able to switch among different existing placement heuristics and find the best rule for the boxes as they arrive.

Otimização de horários periódicos de transportes públicos com IA e IO

Luís M. Albino, Gonçalo P. Matos,

Resumo. Neste trabalho estudamos o problema de otimização de horários periódicos em transportes públicos, minimizando o tempo de viagem dos passageiros. Para tal, utilizamos uma abordagem híbrida que inclui aprendizagem por reforço num sistema multi-agente, satisfação booleana e programação linear inteira, entre outras. Estas técnicas são executadas de forma concorrente e colaborativa, permitindo que várias resoluções em simultâneo, utilizando diferentes abordagens, contribuam mutuamente através da partilha de informação e das soluções obtidas. A complexidade do problema e a dimensão do espaço de estados tornam inviável a utilização de abordagens exactas, nomeadamente baseadas unicamente em programação linear inteira. A aprendizagem por reforço aliada à satisfação booleana permite obter muito rapidamente soluções admissíveis e aprender quais são as zonas mais promissoras do espaço de procura, produzindo soluções otimizadas que podem posteriormente ser ainda refinadas pelos métodos de programação linear. Comparamos

a nossa abordagem híbrida com o estado-da-arte aplicando-a a um conjunto de problemas de referência (PESPLib) e a outros problemas do mundo real. Esta abordagem permitiu-nos obter os melhores resultados de sempre para alguns dos problemas de referência, superando todos os outros métodos conhecidos na literatura, bem como registar melhorias significativas face à nossa abordagem anterior nos resultados dos restantes problemas.

Sessão W2: Other OR Applications

24 de Julho, Quarta-feira, 9:00 - 10:30
Sessão em Português/Inglês
Sala: B255

Moderador: João P. Almeida

Analysis of the results of the 2018 FIFA World Football Cup using graph centralities

Paula Felippe, Maria Mello

Resumo. Graph theory allows several possibilities of analysis and, in this paper, it is used the centrality measures to do so. We used data from the 2018 FIFA World Cup to study the behaviour of the teams and its results along the competition. The main conclusions are that Panama has the worst results, using indegree centrality, France has the best autovector centrality and Belgium, the best outdegree centrality. Other conclusions may be taken by these measures.

Utilização de Grafos para análise dos gols realizados nos países sede das copas do mundo de futebol - FIFA

Carlos Augusto Teixeira Coelho, João Vítor Araújo Garcês, Nathalia Soares Bento da Silva, Maria Mello

Resumo. Os grafos possuem importância significativa tanto para estudos simples como para complexos. A aplicação da teoria dos grafos pode envolver diversos temas, como: distribuição de lojas, aeroportos, e até mesmo, envolvendo partidas de futebol, como é o caso desse estudo. Neste trabalho, realizou-se a aplicação de grafos para análise dos gols realizados nos países sedes das Copas do Mundo, com auxílio do software UCINET. Dessa forma, foi possível analisar os resultados das métricas de centralidades de grau, proximidade, betweeness e de autovetor. Foi possível analisar tanto em relação

aos países sedes como em relação aos países participantes. Os dados extraídos confirmaram que a Alemanha, por exemplo, é o país sede com maior centralidade de grau.

The Investigation of penalty/interior points method and the solution of Discret Reactive Optimal Power Flow

Jéssica António Delgado, Edméa Cássia Baptista

Resumo. The optimal power flow problem is a non-linear, non-convex, constrained and large-scale optimization problem. As a tool is used for determining the best operating point of the electric power system. A particular case is the reactive optimal power flow, where the objective function minimizes the active losses in the transmission. Thus, considering the relevance of problem, this work proposes an approach that uses a union of methods penalty and Interior Points for solving it reactive optimal power flow with discrete control variables. For handling the discrete variables it is adopted a strategy that transform the discrete problem in a continuous problem using a Penalty function which forces the variables to assume discrete values. Numerical tests carried out with the IEEE 14, 30, and 118 bus electrical systems indicate that the proposed approach is efficient in the solution of the reactive optimal power flow with discrete control variables.

Hotelling game on networks

João P. Almeida, Alberto Pinto

Resumo. We develop a theoretical framework to study the location-price competition in a Hotelling-type network game, extending the Hotelling model with linear transportation costs from a line (city) to a network (town). We show the existence of a pure Nash equilibrium price if, and only if, some explicit conditions on the production costs and on the network structure hold. Furthermore, we prove that the local optimal localization of the firms are at the cross-roads of the town.

Sessão W3: Production and Operations Management III

24 de Julho, Quarta-feira, 9:00 - 10:30
Sessão em Português/Inglês
Sala: B254

Moderadora: Ana Raquel Xambre

Leveraging the reconfigurability of assembly lines through mobile collaborative robots

Isabela Maganha, Cristóvão Silva, Samuel Moniz

Resumo. Disruptive technologies promoted by the Industry 4.0 paradigm, such as mobile collaborative robotics, might support the ready reconfiguration of manufacturing systems and contribute to adaptive operational conditions. The objective of this study is to analyse multi-model assembly lines, where mobile collaborative robotics was introduced to leverage the reconfigurability. For this purpose, a meta-heuristic approach was applied to determine the sequence of assembly, the tasks assignment to robots and the assignment of robots to the workstations that minimise the number of robots required to achieve the assembly line cycle time. The results are discussed, emphasising the operational aspects of the introduction of mobile robots in multi-model assembly lines. The findings support that i) the sequence of assembly of products impacts on the number of robots required; ii) the addition of as many robots as needed to achieve the cycle time might imply low utilisation rates of the robots; and iii) the tasks assignment and robots' displacement among workstations indicate a cyclic pattern that may facilitate the introduction and the use of mobile collaborative robots in multi-model assembly lines.

A Multi-objective Metaheuristic Approach for the Planning in Flexible Assembly Lines

Joana Guapo, Tânia Pinto-Varela, Miguel Vieira, Nelson Chibeles-Martins

Resumo. Nowadays, the industrial sector faces a new challenge, triggering the optimization of manufacturing processes. With the advent of Industry 4.0 digital revolution, facilities are more able to respond to market variability and mitigate operational uncertainty, to leverage competitiveness over its

competitors. Whereas, advanced technological systems are being considered at all decisional levels, with major importance at the operational level. Particular attention has been given to the implementation of collaborative robotic solutions, optimizing the efforts of humans and advanced robotic technologies in production systems. Therefore, novel production planning methodologies have been integrated in model-based management systems, often in real time, to enable increased efficiency of flexible manufacturing operations. The aim of this work is the development of a Multi-objective Particle Swarm algorithm (MOPSO) to cope with the planning of a flexible assembly production, by exploring the assignment of human-robot collaboration (Cobot) while considering the impact of production maximization and minimization of production costs, inventory and the number of robots required. The performance of the MOPSO is illustrated through a case study and the results are compared with the exact MO methodology using the ?-constraint method. Some indicators are defined to quantify the solution quality.

Mathematical Optimization Approaches for Facility Layout on Several Rows

Manuel V.C. Vieira, Miguel F. Anjos

Resumo. Multi-row layout are facility layout problems in which departments are to be placed optimally in two or more rows. We propose a new mixed integer linear optimization model that uses continuous values for both the row assigned to each department and the position of departments within a row. We prove that there is at least one optimal solution with integer values for the row assignments, even though they are represented by continuous variables. We also propose a two-stage optimization framework based on the combination of two mathematical optimization models. The first model is a nonlinear approximation of the problem that establishes the relative position of the departments, and the second model is an exact linear optimization formulation of the problem that determines the final layout.

Using discrete-event simulation to model chemical processes

José Suspiro, Samuel Moniz, Cristóvão Silva, Carlos Henggeler Antunes, Tânia Pinto-Varela, Ana Barbosa-Póvoa

Resumo. In this work, we propose the use of a discrete-event simulation model to study the dynamics of a chemical process. The modelling approach includes several structural aspects of the facility, as well as process characteristics, such as materials transfers, start-up and shut-down effects, setups, and process uncertainties (e.g., processing times and breakdowns) that are more

difficult to capture when using optimization methods. The flexibility provided by the simulation modelling framework allows the study of several designing alternatives and scheduling operating policies. These are demonstrated using several illustrative scenarios.

Improvement actions in a manufacturing cell: a simulation study

João Tomás Álvaro, Ana Raquel Xambre

Resumo. Organizations are faced with a constantly changing environment and with fluctuating customer's demand. The use of cellular manufacturing systems has been pointed out as a strategy that contributes to higher levels of flexibility of production systems. This work was developed in a company that produces car components and that has a manufacturing system organized into manufacturing cells. The forecast regarding the demand of a certain part family shows a shift to another type of component. The increase in demand for that type of part, as well as its more complex production process, made it necessary to improve the output of the cell while reducing its inefficiencies. In order to analyze the potential impact of the different possible improvement actions, a simulation study was performed using a Discrete Event Simulation software (Flexsim). The initial situation was simulated, as well as an upgraded version of that scenario that has since been implemented because it did not involve an investment. Other five scenarios were analyzed that simulated different actions, or combinations of those actions, in order to understand their potential impact, mainly in terms of output, which helped the company understand if the cell was able to face the foreseen increase in demand.

Sessão W4: Supply Chain Management II

24 de Julho, Quarta-feira, 9:00 - 10:30
Sessão em Inglês
Sala: B257

Moderador: Telmo Pinto

Design and Planning of Green Supply Chains with Risk Concerns

Cátia da Silva, Ana Barbosa-Póvoa, Ana Carvalho

Resumo. Currently, legislative and social pressures led companies to widen their main goals and have been now considering not only economical

but also environmental goals into their supply chain activities. In addition, the uncertainty associated with supply chains activities and the need to obtain more realistic values led to the need of addressing the associated financial risk. This paper explores this tendency and presents a mixed integer linear programming model for the design and planning of green supply chains that account for the economic and environmental concerns in the same objective function by monetizing environmental impacts. Also, the goal of minimizing the associated financial risk is considered. To deal with these two goals an augmented ?-constraint method is used to generate a pareto-optimal curve to determine the trade-off between the two objective functions. In this way, the present work contributes to the literature by providing a new model that considers the environmental impacts' monetization as well as models risk considering both economic and environmental performances of the supply chain. A case study is explored.

Flexible design of a heliports network used in forest fire suppression applied to the case of Sardinia

Hugo Torres, Abílio Pereira Pacheco, João Claro, Michele Salis, Matthew P. Thompson, Crystal S. Stonesifer, Gavino Diana, Silvio Cocco

Resumo. Helicopters play a central role in the Sardinia suppression system. They are allocated at the beginning of the fire season, to eleven helipad operational bases, with the objective of fighting fires located in each base's coverage area. Analyzing fire occurrence and helicopter flight data from 2006 to 2010, we found spatiotemporal asymmetries in the fire patterns along the island, and thus, the existence of opportunities to benefit from demand pooling. Cost-effective strategic management of aerial forest fire suppression resources involves decisions about fleet location, to efficiently match supply and demand. We explore the flexible design of such a system, pooling the demand of several bases into a "zone," and analyzing alternative partitions of the territory into zones. Feasible partitions consider an upper limit on the distance between bases, and require their adjacency, within the same zone. Then, we classify the feasible partitions according to a set of six criteria and explore the non-dominated partitions. Finally, we select the preferred partition, with the support of several experts, by applying the AHP method. Comparing the results with the current design, in which each zone has only one base, we identify efficiency gains, potential fire management implications, limitations, and opportunities for additional research.

Merging Resilience and Sustainability in Supply Chain Design

João Pires Ribeiro, Bruna Mota, Ana Barbosa-Póvoa

Resumo. In this work, the growing concern with the resilience of organisations and particularly of supply chains (SC) is coupled with the already fundamental environmental factors when designing and planning a SC. A mixed integer linear programming model (MILP) is developed to support strategic/tactical decision making where the cost of emissions is considered in a set of disruptive scenarios under uncertainty. The results contribute to understand the relationship between the two concepts and sustain that coupling these two concepts does not endanger the financial sustainability of the company while increasing resilience and sustainability performance, thus providing a true competitive advantage for those who embrace it appropriately.

Considering Inventory and Transportation in Supplier Selection Decisions: A Simulation-Optimization Approach

Thomy Saputro, Gonçalo Figueira, Bernardo Almada-Lobo

Resumo. Supplier selection has a great impact on the operations of a company, particularly in what concerns inbound inventory and transportation. Inbound transportation can be managed by considering either less than truckload (LTL) or truckload (TL) policies. TL transportation is common in practice, as it assumes that a vehicle has a capacitated load, and thus it should be used efficiently. However, most of the supplier selection studies do not consider TL to address inventory control. Disruptions at a supplier channel affect the continuity of supply at the buyer's end thus causing delivery delays. Taking into account disruptions in supplier selection is essential to protect a buyer from shortages. This study focuses on the supplier selection with multi-sourcing under supply disruptions, considering order allocation, inventory management and transportation costs. Due to the complexity of the problem, a simulation-optimization approach is developed by employing discrete-event simulation and a genetic algorithm (GA). The simulation-optimization (S-O) procedure follows an evaluation function framework which iteratively evaluates a cost function of a GA solution. Additionally, a refinement process is implemented in the S-O procedure to incorporate the change of supplier's lead time due to disruptions.

Sustainable supply chain design and planning and strategic ramp-up: the case of the aerospace industry in the adoption of advanced materials technologies

Telmo Pinto, Carlos Malarranha, Bruna Mota, Ana Carvalho, Cláudio Alves, José Manuel Valério de Carvalho, Ana Barbosa-Póvoa

Resumo. The aerospace industry is nowadays characterized by the introduction of advanced materials technologies and inherent innovative processes. Their related strategic decisions need to be considered accounting for their impact in the overall supply chain and its sustainability, which raises the need for strategic ramp-up planning ensuring, for instance, the selection of appropriate technologies and suppliers. This work contributes to the development of a decision support tool using a multi-objective mixed integer linear programming model which includes strategic and tactical decisions such as location-allocation, suppliers and technologies selection, evolution of installed production capacity, the network planning and inventory management. A framework to design the ramp-up curves is proposed which considers significant criteria within aerospace advanced materials and technologies are systematically analyzed and compared. The three pillars of sustainability - economic, environmental and social - are embedded in the decision support tool towards the definition of sustainable supply chain strategies. This decision support tool is applied to a representative case study in the aerospace supply chain aiming to introduce new lightweight carbon fibre composites and their manufacturing technologies. Important managerial insights are derived from this work that can be suitable for new product development processes.

Sessão W5: Invited Session and Continuous Optimization

24 de Julho, Quarta-feira, 9:00 - 10:30
Sessão em Inglês
Sala: B259

Moderadora: Tatiana Tchemisova

Immobile indices in linear Semi-infinite and Copositive Programming

Tatiana Tchemisova, Olga Kostyukova

Resumo. Semi Infinite Programming (SIP) deals with problems of minimization of a cost function in a finite dimensional space subject to an infinite number of constraints. The notion of immobile indices was first introduced in SIP to denote the indices of the constraint that stay active for all feasible solutions. It is a known fact that the immobile indices play an important role in study of properties of the feasible sets and permit to deduce efficient optimality conditions which do need use any Constrain Qualifications (CQs). A linear problem of Copositive Programming consists in minimization of a linear function subject to linear constraints defined in a conic (infinite) index set. Using the equivalent formulation of the linear copositive problem in the form of a convex SIP problem and basing on the immobile indices of constraints of the last, we obtain new optimality conditions that do not need any additional conditions for constraints or CQs.

Synthesis of the Optimal Control by Queueing System with Service Quality and Rate Depending on the Amount of the Harvested Energy

Alexander Dudin, Sergey Dudin, Olga Dudina

Resumo. We briefly analyse a single server queueing system with energy harvesting and multi-threshold control by the service modes as the model of operation of the node of wireless sensor network. The available service modes are distinguished by the provided service rate, the number of required for customer service energy units and the probability of error occurrence during service. The account of a possibility of errors occurrence is very important in modelling wireless sensor networks. The use of a larger number of energy

units corresponds in real-life wireless communication systems to the ability to send a stronger signal what implies the faster service rate and a lower probability of incorrect transmission. Incorrect transmission implies the necessity of repeated transmission and additional consumption of energy. This model generalizes a previously considered in the literature by suggestions that the buffer for customers has an infinite capacity and the accumulated energy can leak from the storage. Under the fixed thresholds defining the control strategy, behavior of the system is described by multi-dimensional Markov chain what allows to formulate and solve various optimization problems.

Optimização Angular no planeamento de tratamentos de radioterapia: a importância da escolha da função objectivo

Joana Dias, Humberto Rocha, Tiago Ventura, Brígida Ferreira, Maria do Carmo Lopes

Resumo. A radioterapia é uma tecnologia usada para tratamento do cancro. Existem diferentes modalidades de tratamento, mas todas elas obrigam a um processo de tentativa e erro para que seja possível chegar a um plano de tratamento que cumpra o mais possível a prescrição médica. A optimização aparece como uma importante ferramenta no planeamento dos tratamentos, permitindo não só melhorar a qualidade dos tratamentos mas também automatizar uma parte deste processo. Nesta apresentação iremos apresentar o problema de optimização angular em tratamentos de intensidade modulada (IMRT), explorando o impacto que a utilização de diferentes funções objectivo poderão ter na procura da solução óptima, sendo que esta solução será avaliada, em última análise, pelos seus resultados clínicos. Sendo a função objectivo usada nestes problemas muito exigente em termos computacionais, irse-ão apresentar resultados que suportam a discussão acerca do compromisso existente entre a melhoria dos resultados clínicos e os tempos computacionais necessários ao cálculo da solução. Também se irá discutir a aplicabilidade de heurísticas baseadas em populações neste tipo de problemas.

Asset management decisions optimization on a multi-dependent portfolio

Luís Dias, Luís Guimarães, Armando Leitão

Resumo. In many industries, a large share of the productive assets is reaching or have surpassed their design life. Thus, unplanned maintenance is increasing leading to rising operation and maintenance (O&M) costs and/or incipient service levels. Carefully planning their replacement and selecting an adequate maintenance policy is of utmost importance. Furthermore, with the

advances in information systems, years of operation have generated a substantial amount of data ready to be analyzed and used to diagnose and predict asset condition. Most approaches found in the literature optimize the aforementioned decisions sequentially and for a single asset by using condition-based maintenance. By focusing on a single asset or asset type, these approaches are unfit for asset portfolio management due to asset inter-dependency. The sequential approach is also prune to yield suboptimal plans. Thus, recent works started to adopt a portfolio perspective. In this line of research, we propose a novel mixed-integer optimization model integrating asset inter-dependency with O&M decisions. In this formulation, a non-linear Wiener process is used to model each asset degradation where maintenance interventions improve the asset condition. Due to the problem complexity, decomposition methods are used to isolate the inter-dependencies, aiming at achieving high-quality solutions under a reasonable computational time.

Cálculo de soluções extremas e moderadas para problemas de otimização em dois níveis multiobjetivo

Maria João Alves, Carlos Henggeler Antunes

Resumo. Nos problemas de otimização em dois níveis (bilevel), o líder toma uma decisão primeiro. O seguidor reage escolhendo uma solução que otimiza a sua função objetivo na região admissível restringida pela decisão do líder. No entanto, o líder deve antecipar a reação do seguidor dado que esta afeta o valor da sua função objetivo. A existência de múltiplas funções objetivo no problema de nível inferior conduz a que o seguidor tenha à sua escolha, para cada decisão do líder, um conjunto de soluções eficientes que representam diferentes compromissos para os seus objetivos. A incerteza quanto à escolha do seguidor dificulta o processo de decisão do líder. O cálculo de diferentes tipos de soluções, extremas e moderadas, para este problema pode apoiar o líder nas suas decisões, fornecendo-lhe informação sobre o risco vs. oportunidade que incorre numa dada decisão. As soluções extremas resultam de uma perspetiva otimista (abordagem de maior risco) ou pessimista (abordagem mais conservadora) das escolhas do decisor. Podem ainda ser calculadas soluções moderadas como resultado de um índice de risco que o líder está disposto a aceitar. Nesta comunicação, serão introduzidos estes conceitos e apresentado um algoritmo baseado em evolução diferencial para calcular soluções extremas e moderadas.

Sessão Plenária 3

24 de Julho, Quarta-feira, 11:00 - 12:00
Sala: Auditório Pacheco de Amorim

Moderadora: Maria Antónia Carravilla

Pseudo-polynomial models in optimization: an overview

José Valério de Carvalho *Departamento de Produção e Sistemas, Universidade do Minho, Braga, Portugal*

Resumo. Many structured combinatorial optimization problems can be modeled as flows in graphs with extra side constraints. Among those, there are models in which the size of the graph depends on additional dimensions, as, for instance, size or time, and are coined as pseudo-polynomial models. They have been used in areas such as cutting and packing, scheduling and routing.

At the expense of a larger number of variables and constraints, their LP relaxations provide a nicely close description of the space of feasible solutions and have other properties that make them very efficient computationally. Therefore they are able to solve significantly large problems. In many application areas, where the raw materials or the transportation costs are relevant, being able to get optimal solutions may represent substantial savings and more environment-friendly solutions.

In this talk, we illustrate the use of pseudo-polynomial models in several different applications, and compare the quality of the models and their performance with other modeling alternatives. We also provide insight into structural properties and overview practical enhancements that can further improve computing times.

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