10th International Workshop on Cutting, Packing and Related Topics

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Lake Constance, September 11 - 15, 2013

OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

ManSci

Contents

The conference is supported by

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General Information

Presentations

The conference room will be equipped with a video projector and a laptop computer. Speakers are asked to load their presentations on the computer during the break preceding the respective session.

40 minutes have been allocated to each presentation of which 10 minutes should be set aside for discussion.

Breakfast

For all participants staying at Hotel Seehörnle breakfast will be served from 07:30 on Thursday and Saturday, and from 8:00 on Friday and Sunday.

Coffee Breaks

Coffee, tea, soft drinks, and biscuits will be served between sessions.

Lunches

Lunches and refreshments will be served on Thursday and Saturday. On Friday, we will have lunch at Schaffhausen.

Dinner

The conference dinner on Saturday is included in the conference arrangement. Dinners on Thursday at Konstanz and on Friday during the day-out will be on a pay-yourself basis.

Internet Access

Internet access via LAN will be available in all rooms. LAN-cables will be provided at the registration desk.

In some areas of the venue, internet access through the following WLAN-networks is also available: “IR04” in the area of room Höri, “IR05” in the restaurant area, and “IR02” in the area of room Reichenau. The key for all networks is “AE10001000”.

Guest Tickets

In your conference bag you will find a guest ticket which can be used to travel on public transport for free. Please make sure to bring these tickets to the excursion to Konstanz and the day-out.

Conference Schedule

Wednesday, Sep. 11, 2013

18:00 Get Together

Thursday, Sep. 12, 2013

08:30 - 18:30 Presentations

19:00 Excursion to the City of Konstanz

Friday, Sep. 13, 2013

10:00 Boat Trip to the City of Schaffhausen (Switzerland)

16:00 Visit of the Town of Stein am Rhein (Switzerland)

Saturday, Sep. 14, 2013

08:30 – 18:30 Presentations

19:00 Workshop Dinner

Sunday, Sep. 15, 2013

8:30 - 12:00 Presentations and Final Discussion

Social Program

Get-Together, Wednesday, Sep. 11, 18:00

We will start the workshop with a very nice Mongolian Barbecue at Hotel Seehörnle. Drinks (not just beer, but also excellent wines) will be provided.

Excursion to the City of Konstanz, Thursday, Sep. 12, 19:00

Konstanz is a lively city on Lake Constance, which is known for its privileged location and relaxed atmosphere. We will go for a short tour of the city and stop by at one (well, probably not just one) of the local pubs, sidewalk cafes or restaurants.

We will meet at the parking lot in front of Hotel Seehörnle at 18:50.

Day-Out, Friday, Sep. 13, 10:00

The day out will definitely provide one of the highlights of the workshop. We will leave the hotel for a short walk to the jetty of Gaienhofen. There we will get aboard of an excursion boat which will take us down the Untersee and further on the River Rhine to the city of Schaffhausen. About two hours will be available for exploring the city before we will board the train back to the town of Stein am Rhein. The more active types, though, will get of the train at Dissenhofen already and take a hike along the river (2 hours). At Stein am Rhein, which is another very picturesque place definitely worth to be visited, they will be reunited with the less active ones for a short tour of the town and a drink at one of the cafes by the river. If you still feel energetic you may also hike up the hill to the castle of Stein. Individual return to Horn by bus.

We will meet at the parking lot in front of Hotel Seehörnle at 09:30.

Workshop Dinner, Saturday, Sep. 14, 19:00

This event concludes the workshop. At a local Gasthof we will experience excellent cuisine and wine from this part of the country. Vegetarian dishes will be available.

We will meet at the parking lot in front of Hotel Seehörnle at 18:50.

Scientific Program – Day 1: Thursday, Sep. 12, 2013

08:30 - 09:00 *Welcome*

09:00 - 10:00 Keynote Speaker:
M. Grazia Speranza, Università degli Studi di Brescia:
Inventory Routing Problems

10:00 - 10:30 *Coffee Break*

10:30 - 11:10 Tino Henke, Otto-von-Guericke-Universität Magdeburg:
A Variable Neighborhood Search Algorithm for the Multi-Compartment Vehicle Routing Problem

11:10 - 11:50 Telmo Miguel Pinto, Universidade do Minho:
Vehicle Routing Problems with Two-Dimensional Loading Constraints

11:50 - 12:30 André Scholz, Otto-von-Guericke-Universität Magdeburg:
A Comparison of Heuristics for the Order Batching and the Picker Routing Problem in Manual Order Picking Systems

12:30 - 14:00 *Lunch Break*

14:00 - 14:40 Jannes Verstichel, KaHo – KU Leuven:
The Lock Scheduling Problem: Connecting Chamber Scheduling and Ship Placement through Combinatorial Benders Decomposition

14:40 - 15:20 Jorge Oliveira, Universidade de Aveiro:
Solving the Short Sea Shipping Distribution Problem Using a Linear Optimization Model

15:20 - 16:00 Yi Qu, University of Southampton:
Minimising Greenhouse Gas Emissions in Intermodal Freight Transportation Through Mathematical Modeling

16:00 - 16:30 *Coffee Break*

16:30 - 17:10 Jan Christiaens, KaHo – KU Leuven:
Optimization of Container Ship Stowage Plans

17:10 - 17:50 Sam Heshmati, INESC-TEC, Universidade do Porto:
The Train-Train Container Transshipment Problem

17:50 - 18:30 Teresa Bianchi de Aguiar, INESC-TEC, Universidade do Porto:
Optimizing Shelf Space in Supermarkets

Scientific Program – Day 2: Saturday, Sep. 14, 2013

08:30 - 09:30 Keynote Speaker:
Greet Vanden Berghe, KaHo – KU Leuven:
Nurse Rostering from Practice to Theory: Models and Algorithms

09:30 - 10:10 José Fernando Gonçalves, Universidade do Porto:
A Biased Random Key Genetic Algorithm for 2D and 3D Bin Packing Problems

10:10 - 10:30 *Coffee Break*

10:30 - 11:10 Xiaozhou "Joe" Zhao, University of Southampton:
Local Search Heuristic for the 3D Container Loading Problem

11:10 - 11:50 António Ramos, INESC-TEC, Universidade do Porto:
Static and Dynamic Stability Constraints within the Container Loading Problem

11:50 - 12:30 Maria da Graça Costa, ESCE - Instituto Politécnico de Setúbal:
A Constructive Heuristic for a Three-Dimensional Packing Problem faced by a Portuguese Company

12:30 – 14:00 *Lunch Break*

14:00 - 14:40 Célia Paquay, HEC - Université de Liège:
A Three-Dimensional Bin-Packing Model with Transportation Constraints

14:40 - 15:20 David Álvarez Martínez, Universidade Estadual Paulista:
A Randomized Constructive Algorithm for the Container Loading Problem with Multi-Drop Constraints

15:20 - 16:00 Maria Teresa Alonso, Universidad de Castilla-La Mancha:
A Inter-Depot Transportation Problem, How to Build Pallets and Load onto Trucks

16:00 - 16:30 *Coffee Break*

16:30 - 17:10 Elsa Silva, INESC-TEC:
2DCPackGen: A Problem Generator for Two-Dimensional Rectangular Cutting and Packing Problems

17:10 - 17:50 Pedro Rocha, INESC-TEC, Universidade do Porto:
Geometrical Representation of Shapes with Non-Linear Segments through Circle Covering

17:50 - 18:30 Antonio Martínez Sykora, Universitat de València:
Exact and Heuristic Procedures for Nesting Problems

Scientific Program – Day 3: Sunday, Sep. 15, 2013

08:30 - 09:10 José Fernando Oliveira, INESC-TEC, Universidade do Porto:
Nesting Problems: Where Are We? Recent Results on Benchmark Instances

09:10 - 09:50 A. Miguel Gomes, INESC-TEC, Universidade do Porto:
Exploring Graphical Processing in Irregular Packing Problems

09:50 - 10:30 José Manuel Valério de Carvalho, Universidade do Minho:
An exact/hybrid approach based on column generation for the bi-objective max-min knapsack problem

10:30 - 11:00 *Coffee Break*

11:00 - 12:00 Final discussion

Abstracts

Session 1 – Thursday, 09:00 - 10:00

Speranza, M.G.
Inventory routing problems

Abstract: The class of Inventory-Routing Problems (IRPs) includes a variety of optimization problems that consider a routing and an inventory component of an optimization problem. IRPs have received little attention, if compared to vehicle routing problems. However, as they are highly relevant in supply chain management, they are attracting an increasing number of contributions. After a review of the literature, with motivations to study this class of problems, the talk will focus on a class of discrete time IRPs that include in the objective function transportation and inventory costs. Contributions in this area will be reviewed together with their relevance in Vendor-Managed Inventory systems.

Session 2 – Thursday, 10:30 - 12:30

Henke, T.; Speranza, M.G.; Wäscher, G.
A Variable Neighborhood Search Algorithm for the Multi-Compartment Vehicle Routing Problem

Abstract: In this presentation, a variant of the multi-compartment vehicle routing problem (MCVRP) is considered. The MCVRP arises in a variety of problem settings where several product types need to be kept separated from each other while being transported, e.g. when different kinds of petrol are to be delivered to petrol stations, when bulk or semi-bulk products are to be transported by ships or when different types of waste have to be collected from containers. We investigate a variant of this problem which occurs in the context of glass recycling.
For this problem, a heuristic solution approach has been developed and implemented, namely a variable neighborhood search with multiple starts. The metaheuristic has been evaluated in extensive numerical experiments, both on randomly generated problem instances and on real world data.

Pinto, T.M.; Alves, C.; Valério de Carvalho, J.M.
Vehicle Routing Problems with Two-Dimensional Loading Constraints

Abstract: The capacitated vehicle routing problem (CVRP) is a classical NP-hard problem which motivates several approaches in the past decades. More recently, some works in the literature in that field are not only concerned with the capacity of the vehicles but also with the loading of the vehicles. These problems are described in the literature as CVRP with loading constraints (LVRP). The LVRP is an extension of the CVRP in which the demands consist in two- or three-dimensional items. The LVRP is NP hard since it combines two NP-hard problems: the bin packing problem and the vehicle routing problem. Here we focus on LVRP where the demands consist in two-dimensional items (2L-VRP) and the loading of the vehicle must consider the sequence in which customers will be visited. These situations are usual in practice when unloading items at one customer does not require moving items of other customers.
Under the complexity level of the LVRP, the most common approaches proposed in the literature are based on heuristics. Indeed, very few authors claim to solve this problem through exact methods. However, these approaches only provide good results for small instances size.
In this talk we intent to provide important research leads to 2L-VRP and contribute with exact methods to this problem.

Scholz, A.; Wäscher, G.
A Comparison of Heuristics for the Order Batching and the Picker Routing Problem in Manual Order Picking Systems

Abstract: Order picking is a warehouse function dealing with the retrieval of articles from their storage location in order to satisfy a given demand specified by customer orders. In manual order picking systems, order pickers walk through a warehouse to collect these items. Even though there have been different attempts to automate the picking process, manual order picking systems are still prevalent in practice.
When solving the order batching problem, a given set of customer orders has to be grouped into feasible picking orders such that the total length of all picker tours is minimized. The length of each picker tour is determined by using a given routing strategy. The s-shape und the largest gap routing policy are the most frequently used strategies. However, these strategies may lead to picker tours that are far from optimal. That is why other routing policies are taken into consideration. It is investigated whether the solution quality can be improved by using more complex routing strategies. Therefore, different combinations of heuristics for the order batching problem and routing strategies are evaluated regarding solution quality and computational effort.

Session 3 – Thursday, 14:00 - 16:00

Verstichel, J.
The Lock Scheduling Problem: Connecting Chamber Scheduling and Ship Placement through Combinatorial Benders Decomposition

Abstract: Ships must often pass one or more locks when entering or leaving a tide independent port. So do barges travelling on a network of waterways. These locks control the flow and the level of inland waterways, or provide a constant water level for ships while loading or unloading at the docks.
We consider locks with a single chamber or several (possibly different) parallel chambers, that can transfer one or more ships in a single operation. The resulting lock scheduling problem consists of three strongly interconnected subproblems: scheduling the lockages, assigning ships to chambers, and positioning the ships inside the chambers. By combining the first two problems into a master problem and using the packing problem as a sub problem, a decomposition is achieved for which an efficient Combinatorial Benders approach has been developed. The master problem is solved first, thereby sequencing the ships into a number of lockages. Next, the feasibility of each lockage is verified by solving the corresponding packing subproblem, possibly returning a number of combinatorial inequalities (cuts) to the master problem.
The main focus of the talk will be on the packing sub problem and on how it interacts with the master problem through combinatorial Bender's cuts.
A decision support tool that allows lock masters to compute and compare several solutions for a set of arriving and departing ships will also be presented. Live tests have shown that this tool's flexibility and high solution quality may help the lock masters in making quick and informed decisions.

Oliveira, J.; Moura, A.
Solving the Short Sea Shipping Distribution Problem Using a Linear Optimization Model

Abstract: Short sea shipping is a means of transportation for the movement of cargo between seaports geographically located in a relative small area. The trend towards consolidation of containers loading on the vessel fleets and their related routes, led to the use of decision support systems in order to solve this complex problem. Very few works consider the integration of loading and routing when dealing with both terrestrial and maritime distribution. Bearing this in mind, the main contribution of this work is not only the integration of these two problems but also the consideration of pickups and deliveries in the visited ports. A linear mathematical model that integrates the Vehicle Routing Problem with Simultaneous Pickup-and-Delivery and the Container Stowage Problem, named: Container Stowage Ship Routing Problem with Simultaneous Pickup and Delivery is presented. In order to apply the model to real case scenarios, the model was tested with real data collected from European ports. We prove that it is possible to obtain optimal solutions to short sea shipping problems.

Qu, Y.; Bektaş, T.; Bennell, J.A.
Minimising Greenhouse Gas Emissions in Intermodal Freight Transportation Through Mathematical Modeling

Abstract: Intermodal freight transportation is concerned with shipping of commodities from their origin to destination using combinations of transport modes. Traditional logistics models have concentrated on minimizing transportation costs by appropriately determining the service network and the transportation routing. This paper considers an intermodal transportation problem with an explicit consideration of greenhouse gas emissions and intermodal transfers. A model is described which is in the form of a non-linear integer programming formulation, which is then linearized. A hypothetical but realistic case study of the UK including eleven locations forms the test instances for our investigation, where uni-modal with multi-modal transportation options are compared using a range of fixed costs.

Session 4 – Thursday, 16:30 - 18:30

Christiaens, J.
Optimization of Container Ship Stowage Plans

Abstract: The container ship stowage planning problem was introduced to the research group by the container transport company Euroports. The goal of this so called Master Bay Plan Problem (MBPP) is to minimize the total stowage time to transport a given set of cargo. Although the MBPP is a general definition of the problem, it differs in two aspects. First, the MBPP takes into account an individual loading time for each container and aims to minimize the total loading time. Second, containers are located into fixed slots in the cargo space. Our approach aims to minimize the total container operations or shifts consisting of unloading and reloading operations caused by blocking containers. In the first stage an alternative model is developed: the Sliced Bar Packing Model (SBPM). Bars represent containers from the pick up till the destination terminal. These bars can be cut into multiple parts and are packed in a given space, while the total number of cuts should be minimized. In the second stage, a heuristic solves stowage problems represented by the SBPM. The performance of the SBPM heuristic is compared to the Suspensory Heuristic (SH) introduced by Avriel et al. Results show that the SBPM outperforms the SH. In addition, while the SH is limited to a homogeneous set of containers and cannot take into account stability constraints, the SBPM accommodates these needs.

Heshmati, S.; Carravilla, M.A.; Oliveira, J.F.
The Train-Train Container Transshipment Problem

Abstract: To achieve a higher share of freight traffic on rail road, there is a need for a higher efficiency in freight handling in train terminals. Therefore, it requires technical innovation as well as the development of suited decision support systems.
In this study we are aiming at reviewing container transshipment processes in train terminals from an operational research point of view. Basic decision problems for the modern train-train transshipment terminals are analyzed and existing literature is reviewed. Finally, the current state of our research and some improvement ideas for possible future works are presented.

Bianchi de Aguiar, T.; Caravilla, M.A.; Oliveira, J.F.
Optimizing Shelf Space in Supermarkets

Abstract: While shopping, customer choices are highly influence by in-store factors such as promotions, pricing or even space organization. Therefore, more than just displaying the merchandise available, a clever arrangement of the products in the shelves can boost products demand and ultimately the stores' financial performance. With the increasing number of products available, this task has becoming increasingly challenging and an active field of research in both marketing and operations research literature.
In this talk we present an optimization method for managing shelf space at a Portuguese supermarket chain. The method has a modular structure and hierarchically applies MIP models, combined with heuristics, to derive the right allocation of products in the shelves. Besides deciding for each product the number of items to be displayed (facings), the method further extends this traditional approach by including the sequencing and positioning of the products in the shelves, respecting real word constraints such as the grouping of product families. A new feature additionally connects assortment with space management by identifying possible benefits from reducing the assortment planned for a given store by trading off substitution effects with space elasticity.
Benefits from its implementation in the company include: trade-off analysis between solutions biased towards profit maximization or towards company's rules, adequacy of the assortment variety to the space, image standardization and finally, reductions in the execution times.

Session 5 – Saturday, 08:30 - 10:10

Vanden Berghe, G.
Nurse Rostering from Practice to Theory: Models and Algorithms

Abstract: Health care is under high pressure to improve efficiency, given increasing requirements and decreasing resources. Among the activities to optimise, nurse rostering is one of the most relevant to address. The problem is computationally complex and has potential for improvement through automated decision support. Personnel rosters also have a considerable socio-economic impact.
This optimisation problem has yielded ample practice-oriented operational research approaches. Despite the vast amount of academic research results, it remains hard for novice developers to profit from general insights or re-usable approaches. This `cold start' issue can be partially explained by complicated regulations typical for personnel environments with 24/7 duties and different in almost every organisation. The very same issue also persists due to the lack of a theoretical framework for nurse rostering.
From an academic point of view, interesting models have been developed for varying nurse rostering problems. The approaches range from self-rostering and manual problem decompositions to different levels of automated decision support.
The talk will focus on the relevance of academic results and on the interplay between practical and theoretical nurse rostering contributions.

Gonçalves, J.F.

A Biased Random Key Genetic Algorithm for 2D and 3D Bin Packing Problems

Abstract: In this paper we present a novel biased random-key genetic algorithm (BRKGA) for 2D and 3D bin packing problems. The approach uses a maximal-space representation to manage the free spaces in the bins. The proposed algorithm hybridizes a novel placement procedure with a genetic algorithm based on random keys. The BRKGA is used to evolve the order in which the boxes are packed into the bins and the parameters used by the placement procedure.
Two new placement heuristics are used to determine the bin and the free maximal space where each box is placed. A novel fitness function that improves significantly the solution quality is also developed. The new approach is extensively tested on 858 problem instances and compared with other approaches published in the literature.
The computational experiments results demonstrate that the new approach consistently equals or outperforms the other approaches and the statistical analysis confirms that the approach is significantly better than all the other approaches. Supported by Fundação para a Ciência e Tecnologia (FCT) project PTDC/EGE-GES/117692/2010.

Session 6 – Saturday, 10:30 - 12:30

Zhao, X.; Bennell, J.A.; Dowsland, K.; Bektaş, T.

Local Search Heuristic for the 3D Container Loading Problem

Abstract: The paper arises from an ongoing research project with Gower Optimal Algorithms Ltd (GOAL), focusing on their container packing problem. The overall aim is to develop effective heuristics for 3D regular packing problem where there are multiple identical or non-identical large items. In this presentation we investigate problems with weakly heterogeneous small items and one or more identical large item. Specifically we consider the Single Large Object Placement Problem, with the aim of output maximisation, and the Single Stock Size Cutting Stock Problem, with the aim of input minimisation. GOAL's core algorithm utilises a number of heuristic strategies for determining the placement of boxes, which can be used individually or combined as a user defined subset. Since the output must be usable in practice, placements must obey all additional practical constraints such as orientation, stability, weight limits, weight distribution, stacking and bearing strength. Priorities can be assigned to boxes according to customer requirements. Our research firstly investigates the impact of priority orders. Different existing box sorting strategies in the literature are combined into sets with a third-tier tie breaker and tested on benchmark data. Results under different sorting rules when the rule can be relaxed if the next item can not put into the open container are compared with the literature. In a similar manner, we test different sets of heuristics for their impact on the various problem instances. Finally our main research focus is on applying local search to the sorted lists to improve the packing efficiency exploring a number of neighborhood types. Extensive numerical results on benchmark problem instances will be presented.

Ramos, A.G.; Oliveira, J.F.; Gonçalves, J.F.; Lopes, M.P.

Static and Dynamic Stability Constraints within the Container Loading Problem

Abstract: The container loading problem, a NP-hard, real-world driven, combinatorial optimization problem, addresses the optimization of the spatial arrangement of cargo inside transportation vehicles or containers for maximizing the containers space utilization.
The Container Loading Problem approaches are of limited applicability in real world scenarios if they do not effectively tackle real-world constraints. Of these constraints, cargo stability is considered in the literature as one of the most important. The impact of stability isn't confined to the cargo as it can also have an influence on workers safety during loading operations and on other persons or vehicles during transportation.
The way that the stability constraint has been previously treated in the literature usually relates stability with a box base support and imposes the full base support or partial base support as the stability constraint. Other authors add another constraint such as the three side's lateral support, and therefore introducing a distinction between static (vertical) and horizontal (dynamic) stability. While being relatively easy to implement, these constraints have a few disadvantages. On one hand they are excessively restrictive to the container space utilization, and on the other, when considering all the forces that act on the cargo during loading and transportation, don't provide a real world stable solution. This fact can lead authors to develop loading strategies in their algorithms that despite respecting the constraints don't provide usable cargo arrangements.
In this work the approach to the stability constraint starts by addressing separately static and dynamic stability, i.e., the stability of the cargo during the loading process into the container and the stability of the cargo during transportation. The static stability constraint approach is based on the static mechanical equilibrium conditions applied to rigid bodies and the dynamic stability constraint by the equations of motion of a rigid body system derived from Newton's laws of motion. Due to the complex nature of the dynamic stability analysis of a system of boxes, it is considered by the authors to be more effective to use a simulation tool, such as a physics engine, in the development of the container loading problem optimization algorithm. As such a simulation-optimization framework based on a physics engine and a biased random-key genetic algorithm is presented.

Costa, M.G.; Captivo, M.E.

A Constructive Heuristic for a Three-Dimensional Packing Problem Faced by a Portuguese Company

Abstract: Packing problems are a well known combinatorial problem with many variants and practical applications. In this work we will describe a real three-dimensional packing problem faced by a Portuguese company, and present the heuristic developed to solve it.
Every day this company needs to establish a plan to pack a set of boxes onto a truck. The cargo consists of rectangular boxes with different sizes and weight, and the vehicle is a single truck. The company wishes to optimize the packing operations so as to minimize the number of travels the truck has to do to transport all the requests for the day.
We will propose a constructive heuristic that is based in a layer arrangement with a corner selection. This heuristic is developed to account for the particularities of the company's data and takes in consideration all the constraints that have to be verified when building an admissible solution to implement in real life, such as box orientation constraints, full support of the cargo, weight limit of the truck and the distribution of the weight inside the truck.
The results obtained from the application of this heuristic to the company's operations will be presented and discussed.

Session 7 – Saturday, 14:00 - 16:00

Paquay, C.; Schyns, M.; Limbourg, S.
A Three-Dimensional Bin-Packing Model with Transportation Constraints

Abstract: Nowadays, packing items into containers is a daily process in many fields such as truck or air transport. This process has to be conducted as fast and profitable as possible. These problems belong to the cutting and packing problems which are key topics in operations research (Wäscher et al. (2007)). They don't only concern the transport; it can be applied in many different fields. In this paper, 3D-BPP is considered in the particular case of air cargo. In this specific situation, containers are called unit load devices (ULD). A ULD is an assembly of components consisting of a container or of a pallet covered with a net, whose purpose is to provide standardized size units for individual pieces of baggage or cargo, and to enable rapid loading and unloading (Limbourg et al. (2011)). Note that the ULDs may differ in size, shape and maximum weight (BA Cargo (2012)). Our aim is to pack a given set of items, which are rectangular boxes, of many different sizes into ULDs of different shapes minimizing the unused volume. In this purpose, an exact linear model has been developed taking into account several types of constraints: the geometric constraints (e.g. no overlap), the orientation constraints, the fragility and the stability of the cargo, the even distribution of the weight inside a ULD and the particular shape of some ULDs. This model has been implemented in Java using the CPLEX library. A specific interface based on Java 3D has also been developed to visualize the results. To speed up the process, the next step will be to develop a relax-and-x heuristic (Pochet and Wolsey (2006)) to determine a better initial solution.

Álvarez Martínez, D.; Parreño Torres, F.; Álvarez-Valdés, R.
A Randomized Constructive Algorithm for the Container Loading Problem with Multi-Drop Constraints

Abstract: The container loading problem is a classic problem in operation research and has a big importance and application in the industry, despite that is not common to find studies including all the characteristics that represent practical constraints for this problem, such as: box rotations, load-bearing strength, weight limits, full support and multi-drop constraints.
In this paper, we consider the container loading problem with all the constraints previously mentioned. Formally, this problem is known as three-dimensional multi-drop Single Large Object Placement Problem (3DSLOPP) or Single Knapsack Problem (3DSKP). The aim is maximize the loading value, but guaranteeing that all the constraints are satisfied. Specifically, the multi-drop constraint refers to the fact that subsets of items go to different costumers and the position of these subsets inside the container has to allow to unload the items of a costumer without moving the items of other costumers.
A randomized constructive algorithm based on maximal-spaces has been developed (which builds totally feasible solutions) as well as a local search phase with several improvement moves. These two phases were combined in a GRASP metaheuristic scheme.

Alonso, M.T.; Álvarez-Valdés, R.; Gromicho, J.; Parreño, F.; Post, G.; Tamarit, J.M.
A Inter-Depot Transportation Problem, How to Build Pallets and Load onto Trucks

Abstract: A distribution company has to decide how to put goods onto pallets according to the customers' orders and, then, how to efficiently distribute these pallets among the trucks so as to reduce the trucks needed to supply the customers. We consider the inter-depot transportation problem. The company supplies a group of depots spread around the country. At each depot a daily decision has to be taken about which trucks will be sent to any of the other depots to distribute the goods. Each depot sends a weekly list of products they want to receive and these products are classified by days, so we have a list of the products they want to receive the first day, then a list for the second day and so on. The main depot has to put the products onto pallets and load the pallets onto the trucks for distribution, respecting as far as possible the priority and trying to operate with as few trucks as possible each day. Therefore, the objective here is to minimize the number of trucks needed to transport all the products while fulfilling a set of constraints, (priorities, stackability, total weight and volume, axle weight, center of gravity,…)
The problem can be solved in two phases, one for building the pallets and the other for loading the pallets into the truck, but our proposal is to solve the problem in one phase building and placing pallets at the same time. For each place into the truck a pallet is built tailored for that the position according to the constraints (priority, axle weight, and so on). We have developed a metaheuristic in two phases, one for building a feasible solution and the other for improving the solution trying to reduce the number of trucks that we have to send to the depot.
Keywords:

Session 8 – Saturday, 16:30 - 18:30

Silva, E.; Oliveira, J.F.; Wäscher, G.
2DCPackGen: A Problem Generator for Two-Dimensional Rectangular Cutting and Packing Problems

Abstract: Cutting and packing problems have been extensively studied in the literature in the last decades, mainly due to its computational complexity (almost all NP-hard) and due to its numerous real-world applications.
Different variants and objectives may be considered depending on the applications where the problem appeared. However, all the problems have in common the existence of a geometric sub-problem, originated by the natural item non-overlapping constraints.
In order to provide an organization in categories of the cutting and packing problems and of the literature on this topic, a relevant recent contribute was given by Wäscher (2007) with an improved typology on cutting and packing problems. In addition to the unification of definitions and notations, the recent typology facilitated also the access to the relevant literature to each cutting and packing problem category.
Nevertheless, a limitation is felt by researchers in cutting and packing problems field, the absence of appropriate test problems and problem generators which are widely and commonly used by all researchers in their computational experiments.
Regarding the one-dimensional problems, a problem generator is available in the literature. However, for the two-dimensional problem the computational experiments are conducted over classical sets, usually without any critical analysis of their nowadays difficulty, adding a few of self-generated instances.
Computational experiments are used to demonstrate the superiority of an algorithm regarding the quality of the solutions, the computational times and the identification of its limits and behaviour. Therefore, when the right instances are not used to test the algorithms, the published foundations for the superiority of an algorithm over others may be rather weak.
The lack of appropriate test problems for each type of cutting and packing problem, led also to the adaptation of existing instances to solve problems for which they were not designed.

To overcome the drawback of the lack of general two-dimensional cutting and packing problem generators, this work proposes a problem generator for each type of 2D rectangular cutting and packing problem (2DCPackGen).
The problem generator will strongly contribute for the quality of the computational experiments run with cutting and packing problems and will allow the generation of a large number of problems instances under controlled conditions with specific desired properties, which provides the ground for systematic testing and variation of problem parameters.
The 2DCPackGen is not build on sampling uniform distributions and will contribute for a faster access to the problem tests, for every type of two-dimensional rectangular cutting and packing problems.

Rocha, P.; Rodrigues, R.; Gomes, A.M.
Geometrical Representation of Shapes with Non-Linear Segments through Circle Covering

Abstract: Nesting problems are two-dimensional Cutting and Packing problems where the pieces are irregularly-shaped. They are both geometrical and combinatorial optimization problems, where the aim is to tackle the positioning of pieces, or empty spaces, into a given region, without overlap, while minimizing wasted space. The geometrical representation plays a significant role into determining the efficiency of the approach, together with the method chosen to find the piece placement positions.
When dealing with Nesting problems, the ability to deal with continuous rotations is an important feature.
Circle Covering uses circles to represent a piece, which are simple to rotate, and can compute overlaps without much computational cost. When described by non-linear equations that represent overlap, structural integrity of the pieces and containment, the problem is defined through a Non-Linear Programming model. In order to achieve a good approximation of the pieces through Circle Covering, one possibility is to use a topological skeleton, the Medial Axis, to assist in determining the position of the circles. However, this method is more oriented to pieces described by linear segments. The easiest way to deal with non-linear segments is to approximate them by linear segments, and then apply the Circle Covering algorithm.
Our current focus consists on how to represent pieces (through Circle Covering) described by non-linear segments, such as circular and parabolic arcs, and also splines, within the same controlled approximation error as the pieces that use only linear segments. In order to illustrate the advantages of using Circle Covering of pieces with non-linear segments, and their application to the Nesting problem, several examples will be presented.

Martínez Sykora, A.; Álvarez-Valdés, R.; Tamarit, J.M.; Oliveira, J.F.; Carravilla, M.A.; Gomes, A.M.
Exact and Heuristic Procedures for Nesting Problems

Abstract: We have developed a Branch and Cut procedure for solving Nesting problems. This procedure uses a Mixed Integer Programming (MIP) model and both branching and Cutting procedures have been studied. We were able to solve instances up to 16 pieces to optimality.
On the other hand we have developed an Iterated Greedy Algorithm for solving Nesting problems, that is, strip packing problems with non-rectangular pieces. The IGA combines a constructive algorithm (CA) based on the insertion of the pieces one at a time, a destructive phase and a local search phase. Since for each insertion a Mixed Integer Programming (MIP) model is solved to optimality, some parameters of the CA are changed along the process in order to adjust the complexity of the MIP model. Computational results show that IGA is competitive and improves the best known solution on several instances.

Session 9 – Sunday, 08:30 - 10:30

Oliveira, J.F.
Nesting Problems: Where Are We? Recent Results on Benchmark Instances

Abstract: In the last 5 years the number of publications on nesting problems (aka irregular packing problems) have significantly increased, with more research groups in the world looking at these problems and proposing new solution approaches. Not only new heuristic algorithms have been published, but also exact techniques, based on Mixed Integer Problems models have been developed, aiming the resolution until optimality of nesting problems or the integration of these models with heuristics, under what is currently known as a matheuristics framework. This attention of the scientific community led to a significantly improvement on the quality of the best solutions known for what has been until now a rather stable set of benchmark instances. A characterisation of these instances will be provided, together with the best results known and respective solution approach, aiming to identify the real challenges for future research.

Sampaio, S.; Gomes, A.M.; Rodrigues, R.
Exploring Graphical Processing in Irregular Packing Problems

Abstract: Nesting problems are problems whose goal is to optimize the usage of a certain space. This dissertation deals with two-dimensional cutting problems. One possible application of these algorithms is the textile manufacturing, where it is necessary to pack pieces of clothing tightly in a stock sheet in a way that minimizes the waste of cloth. A certain distribution of the pieces inside the limits of the stock sheet is called layout or cutting pattern. Some algorithms build partial solutions iteratively until they reach a final complete solution; and others take a complete solution and make successive improvements to it (by changing the positions of one or more pieces). There are two possible representations for the geometry in the context of nesting problems: raster representation (a grid of pixels) and polygonal representation. The search for better solutions is limited by the algorithms' performance. Hence, there is a need to constrain the possible moves and/or the pieces to move in order to reduce the computational cost. The main bottlenecks of these algorithms are related to the geometry processing which is necessary to produce feasible solutions, this is, patterns without overlapping. Polygonal representations have a greater computational cost when solving problems with complex shapes that imply repetitive and slow trigonometric calculations.
It is proposed to transfer the geometry processing to the GPU, using a raster representation of the cutting pattern, in order to reduce run time. The layout was rendered in the graphical device and the image produced was processed. An image-processing step detects the feasible placements for a piece, called the configuration space. This analysis identifies the possible placements of a piece in a more efficient way, which is also independent from the geometry.
The time it takes to build a complete layout - nesting time - in the graphical implementation was compared to the nesting times of other polygonal approaches referred on the bibliography. We noticed a significant reduction in the positioning algorithm run time for problems with complex shapes.

Mansi, R.; Alves, C.; Pinto, T.M.; Valério de Carvalho, J.M.

An exact/hybrid approach based on column generation for the bi-objective max-min knapsack problem

Abstract: In this work, we address the max-min knapsack problem (MNK), which is an extension of the standard knapsack problem where the profit of the items changes according to the scenario (each scenario is characterized by a specific objective function). The objective of the MNK is to achieve the best solution in the worst possible case without exceeding the capacity of the knapsack, i.e. it consists in maximizing the worst total profit of the selected items. Since it is an extension of the standard knapsack problem, the MNK is NP-hard for a limited number of scenarios and strongly NP-hard when the number of scenarios is unbounded.

We propose an original approach based on column generation to compute strong lower and upper bounds for the MNK. We describe the details of the underlying Dantzig-Wolfe decomposition, and present the associated column generation algorithm. The method was implemented and tested on large scale instances of the MNK. The results achieved with the method attest the performance of the approach.