07112 Abstracts Collection
Cutting, Packing, Layout and Space Allocation
— Dagstuhl Seminar —

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Abstract. From 13.03. to 16.03.2007, the Dagstuhl Seminar 07112 "Cutting, Packing, Layout and Space Allocation" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

Keywords. Cutting and Packing, Nesting, Space Allocation, Layout, Optimisation

07112 Summary – Cutting, Packing, Layout and Space Allocation

Dagstuhl Seminar 07112 took place from Wednesday, 14th March, 2007 to Friday, 16th March. There were 17 participants from a total of 9 different countries. The seminar was led by Graham Kendall and Karen Daniels. Jan van der Veen was designated to collate the proceedings.

Keywords: Cutting and Packing, Nesting, Space Allocation, Layout, Optimisation

Joint work of: Burke, Edmund; Daniels, Karen M.; Kendall, Graham

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2007/1280

An exact algorithm for the Strip Packing Problem

Ramon Alvarez-Valdes (Univ. de Valencia, E)

We propose a new branch and bound algorithm for the two dimensional strip packing problem, in which a given set of rectangular pieces have to be packed into a strip of given width and infinite length so as to minimize the required height of the packing. We develop lower bounds based on relaxations of the integer formulation of the problem as well as new bounds based on geometric considerations, and reduce the tree search with some dominance criteria. An extensive computational study shows the relative efficiency of the bounds and the good performance of the exact algorithm.

Keywords: Strip packing, Non-guillotine cutting, Branch and Bound, Lower bounds

Joint work of: Alvarez-Valdes, Ramon; Parreño, Francisco; Tamarit, Jose Manuel

Optimising Retail Shelf Space Allocation

Ruibin Bai (University of Nottingham, GB)

In times of severe competition, retailers recognize the importance of controlling their operational costs. In this talk, We will introduce the shelf space allocation problem and its relationship with classic knapsack problem. We propose a two-dimensional shelf space allocation model. The second dimension stems from the height of the shelf. This results in an integer nonlinear programming model with a complex form of objective function. We propose a multiple neighborhood approach which is a hybridization of a simulated annealing algorithm with a hyper-heuristic learning mechanism. Experiments based on empirical data from a retail chain show that the shelf space utilization and the resulting sales can be greatly improved. Sensitivity analysis on the input parameters and the shelf space show the benefits of the proposed algorithm both in sales and in robustness.

Keywords: Shelf space allowation meta-heuristics hyper-heuristics planogram

Bin-packing with Divisible Sizes

Moshe Dror (University of Arizona, USA)

We examine the likelihood that two shelves of integer length L can be packed with items whose individual lengths are divisors of L, given that the individual items sum-up to 2L.

The main thrust of this study is computational. That is, we explicitly compute the answer for this question for all integers L, $1 \leq L \leq 1000$. We conclude that an instance of this packing problem in which we cannot pack the two shelves is very rare. Existence of packing failures is tied to the number of divisors of L. That is, we prove that the number of divisors has to be at least 8 for a packing failure to exist.

Keywords: Bin-packing, rare events, divisible items

See also: Dror, M, J.B. Orlin, and M.Zhu

A Hybrid Multi-Stage Approach to the Irregular Strip Packing Problem

Miguel Gomes (Universidade do Porto, P)

The Irregular Strip Packing Problem is a Cutting and Packing Problem where a set of pieces with irregular shapes need to be cut from a rectangular strip with fixed height and infinite length. The irregular pieces need to be totally positioned inside the strip, without any overlap and the required strip length need to be minimised. We propose a hybrid multi-stage approach to tackle real world Irregular Strip Packing Problems. Typically, these real world problems have a big number of pieces to place and a very big diversity on the sizes of the pieces. It turns up that in this type of problems the layout length is totally or almost totally determined by the positioning of the big pieces, while the smaller ones are easily packed into the gaps among the bigger pieces. The proposed multi-stage approach takes advantage of this situation, reducing the computational effort without compromising the layout quality.

Joint work of: Gomes, A. Miguel; Oliveira, José F.

Bottom left heuristics for strip packing problem

Shinji Imahori (University of Tokyo, J)

We treat heuristic algorithms for strip packing problem with rectangular items, which place rectangles at bottom-left stable positions. There are some variants of this type algorithm, and their effectiveness was shown in the literature. We will propose efficient implementation of bottom left heuristics.

Keywords: Rectangle packing, bottom left heuristics, time complexity

Joint work of: Imahori, Shinji; Yagiura, Mutsunori

A maximal-space GRASP algorithm for the container loading problem

Jose Fernando Oliveira (Universidade do Porto, P)

In this paper a greedy randomized adaptive search procedure (GRASP) for the container loading problem is presented. This approach is based on a constructive block heuristic that builds upon the concept of maximal-space, a non-disjoint representation of the free space in a container.

This new algorithm is extensively tested over the complete Bischoff and Ratcliff's set of problems, ranging from weakly heterogeneous to strongly heterogeneous cargo and outperforms all the known non-parallel approaches that, partially or completely, have used this set of test problems. When comparing against parallel algorithms, it is better in average but it is not better for every class of problems. In terms of efficiency, this approach runs in a fraction of the time required by the parallel methods. In what concerns stability issues, although not explicitly taken into account in the algorithm design, when using standard measures of stability its performance is similar to the best approaches. Thorough computational experiments concerning the evaluation of the impact of algorithm design choices and internal parameters in the overall efficacy of this new approach are also presented.

Keywords: Container loading; 3D packing; GRASP

Joint work of: Oliveira, Jose Fernando; Parreño, Francisco; Alvarez-Valdes, Ramon; Tamarit, Jose Maria

Space Planning in Universities

Andrew Parkes (University of Nottingham, GB)

Teaching Space in Universities is generally inefficiently used. Rooms are often only used half the time, and half empty when in use. I report on progress of our project (http://www.asap.cs.nott.ac.uk/projects/amoh/) towards understanding the underlying causes of the poor utilisation. The goal is to provide a scientific basis for better decision support systems for space planning. In particular, for tasks such as the planning of new teaching space and the re-modelling of existing space.

Keywords: Course timetabling, space management

PHI-FUNCTION TECHNIQUE IN MATHEMATICAL MODELING OF ARBITRARY OBJECT PACKING PROBLEMS

Tatiana Romanova (Ukrainian Acad. of Sciences, RUA)

Phi-function technique is considered as a constructive tool for modeling optimization packing problems as mathematical programming ones. Properties of Phi-functions are given. A strategy for constructing Phi-functions for basic and, so-called, composed objects is introduced. A number of Phi-function examples for 2D and 3D objects are given. Resources of the technique to deal with multi-connected (objects with holes), rotating objects and describe in an analytical form non-overlapping, containment restrictions, prohibited areas, minimal and maximal admissible distances between geometric objects are discussed.

Keywords: Mathematical modeling, Optimization, Packing, Phi-function, Geometric object

Joint work of: Romanova, Tatiana; Stoyan, Yuriy; Bennell, Julia; Scheithauer, Guntram

A SOLUTION STRATEGY OF ARBITRARY OBJECT PACKING PROBLEMS

Yurij Stoyan (Ukrainian Acad. of Sciences, RUA)

The report considers an optimization packing problem of arbitrary space form geometric objects. For constructing a mathematical model of the problem phi-functions are utilized. Peculiarities of the mathematical model are investigated. On the ground of the peculiarities a general solution strategy of the problem is developed. The strategy uses a combination of optimization method on group of variables, a modification of simplex method, the Zountendijk feasible directions method, branch-and-bound algorithm, decremental neighborhood algorithm. A number of numerical examples are given.

Keywords: Mathematical modeling, Optimization, Packing, Phi-function, Geometric object

A metaheuristic approach based on overlap minimization for the irregular packing problem

Shunji Umetani (Univ. of Electro-Communications - Tokyo, J)

The irregular strip packing problem asks to place a set of polygons within a rectangular strip of fixed height without any overlap, so as to minimize the strip width required.

We consider an overlap minimization problem which minimizes the amount of overlap penalty for all pairs of polygons within a given bound of strip width.

We propose a local search algorithm which translates a polygon in horizontal and vertical directions iteratively, and incorporate it in metaheuristic approaches called the iterated local search and the guided local search.

Computational results show that our algorithm is competitive with other existing algorithms.

Keywords: Irregular strip packing, overlap minimization, local search, metaheuristics

Joint work of: Umetani, Shunji; Mutsunori, Yagiura; Takashi, Imamichi; Shinji, Imahori; Koji, Nonobe; Toshihide, Ibaraki

Remarks on 1DBPP with various bin costs and sizes

Rafal Walkowiak (Poznan University of Technology, PL)

The problem consists in packing a set of items into a set of containers. There are types of containers characterized by the size and the cost. There is no constrain on the number of containers of any type. The goal is to minimize the total cost of the containers used while all items are assigned. The problem has practical meaning and originates from logistic.

The IP formulation for the problem is followed by lower bounds. Subsequently the heuristic approach and two-phase exact method are described. Finally the concept of parallel metaheuristic approaches for the problem is presented. Introductory results for parallel methods inform about the flow of ongoing work.