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NTIGen: a software for generating Nissan based instances for time and space assembly line balancing

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TIME AND SPACE ASSEMBLY LINE BALANCING

An industrial process is divided into a set V of n tasks. Each task j requires an operation time t_j and has a set of direct predecessors (problem precedence constraints). The SALBP consists of grouping these tasks into m workstations minimising the cycle time C or the number of stations m.

The area is a really important factor in the assembly line balancing. The time and space assembly line balancing problem (TSALBP) is a SALBP extension which includes:

- The area of each task (a_j)
- The available area for the stations (A)

As many real-world problems, TSALBP has a multi-criteria nature. It has four different multiobjective variants given by its three possible objectives to be minimised:

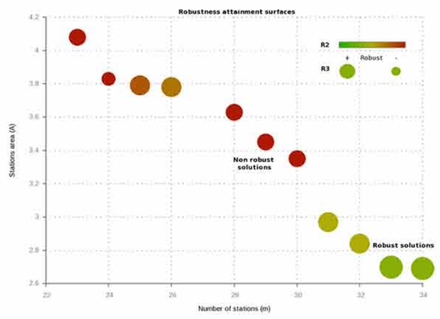
- The cycle time of the plant (c)
- The number of stations (m)
- The available area (A)

DEMAND CHANGES AND ROBUSTNESS

Recently, we have proposed novel robustness functions to be used when a set of mixed products is variable and uncertain [R²]. They measure how robust the line configuration is when production plans demand changes.

These functions are based on the station overload under future demand conditions and are used as additional ***a posteriori*** information for the non-dominated solutions found by any multiobjective method.

The values of the robustness functions were put together with a novel graphical representation to form a generic model that aims to offer a better picture of the robustness of the set of Pareto-optimal solutions.



R²: Chica et al. A robustness information and visualization model for time and space assembly line balancing under uncertain demand. IJPE, 2013 (in press)

METAHEURISTICS APPLIED TO THE TALBP-m/A

The TSALBP-m/A is the most realistic variant in the automotive industry. It consists of minimising the number of stations m and the station area A, given a fixed value of the cycle time c.

$$\text{Minimize} \qquad f^s(x) = m = \sum_{k=1}^{M} \max_{j=1,2,\ldots,n} x_{jk}$$

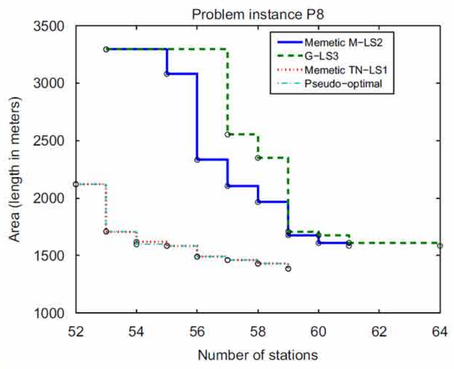
$$f^a(x) = A = \max_{k=1,2,\ldots,M} \sum_{j=1}^{n} a_j x_{jk}$$

The TSALBP-m/A is a hard multiobjective combinatorial optimization problem having many constraints. Therefore, different multiobjective metaheuristics have been applied to it [R¹]:

MACS: a multiobjective ant colony optimization algorithm. It was the first method designed for the TSALBP-1/3 because of its constructive nature and constraints handling. It also uses a multi-colony approach to diversify its search for the best configurations of the line.

Advanced NSGA-II: a genetic algorithm for multiobjective problems with an advanced variable-length representation by using separator genes and problem-specific crossover and mutation operators. In addition, it makes use of a diversity preservation mechanism.

Memetic Algorithms: the Memetic Algorithms achieved the best results to the TSALBP-1/3 up to now by using the afore-mentioned algorithms as global search methods and by including local search operators.



R¹: Chica et al. Multiobjective memetic algorithms for time and space assembly line balancing. Eng.App.AI, 2012

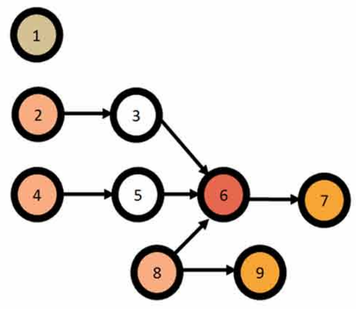
NTIGen: AN INSTANCE GENERATOR

We noticed the absence of an available dataset with real-like instances for the TSALBP. And what is more, there is not any instance generator for including mixed product plans when the demand is uncertain.

The main goal of the NTIGen software is generating real-like TSALBP instances with different features to serve as a benchmark for any future research work. It is based on the context of a Nissan plant of Barcelona.

The developed NTIGen software includes the following features:

- Checkpoints
- Tasks without precedence
- Final tasks
- Isolated tasks
- Operations aggregation and breaking up
- Chains of tasks



The user can set all the desired features by changing the parameters of an XML file. The most important input parameters are the following:

- Number of tasks (n)
- Processing times (t_j)
- Production plans
- Cycle time (c)
- Required operation area (a_j)

NTIGen also generates the precedence graph of the instance. The complexity of the precedence graph is also a user parameter and it is measured by the order strength (OS) of the graph.

By using NTIGen a set of instances were created in this work.
The NTIGen software and these TSALBP instances are publicly available:

http://www.prothius.com/TSALBP

PROTHIUS
Cátedra Organización Industrial

UVa Universidad de Valladolid
ABEPRO Associação Brasileira de Engenharia de Produção
ADINGOR Asociación para el Desarrollo de la Ingeniería de Organización
INSISOC Social Systems Engineering Centre