Multi-objective algorithms for complex production scheduling problems

Dr. Jacomine Grobler, a researcher at the Council for scientific and Industrial Research (CSIR) in Pretoria, has developed a first of its kind, multi-objective algorithms for a complex real-world production scheduling problem.

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Solving industrial engineering problems

Grobler developed the production scheduling algorithms while at the University of Pretoria and finalised the hyper-heuristic algorithms after joining the CSIR. "I specifically developed these optimisation algorithms to address production scheduling challenges in the manufacturing sector," she says. "The algorithms consider how operators schedule jobs and which machines they use. This has a significant impact on the competitiveness of companies." She adds that if jobs are scheduled efficiently then companies are also better positioned to meet their delivery dates.

One of the algorithms she has developed also considers queue time - which is an indication of how long jobs wait on the production floor - with the objective of reducing inventory. "If there are large queue times it basically means that all the jobs wait too long for processing," she explains. "This queue time has financial implications as companies will need to rent storage space and pay insurance and other related costs."

The algorithms have shown to outperform existing state-of-the-art algorithms by up to 76%, resulting in a significant decrease in manufacturing costs. This work has earned her the 2015 JD Roberts Award for Emerging Researchers for her contribution to the development of optimisation algorithms for solving industrial engineering problems.

Hyper-heuristics at play

A hyper-heuristic is a heuristic search method that seeks to automate, often by the incorporation of machine learning techniques, the process of selecting, combining, generating or adapting several simpler heuristics to efficiently solve computational search problems. One of the motivations for studying hyper-heuristics is to build systems which can handle classes of problems rather than solving just one problem.

"There is a big issue in optimisation that it is very hard to match the problem with an algorithm," she says. "For instance if an optimisation expert routes a fleet of vehicles for a company in the transport sector, then that person typically has to choose from hundreds of different types of optimisation algorithms to solve the problem." This is time consuming and expensive.

"Hyper-heuristics attempts to be more self-adaptive and uses artificial intelligence to decide which algorithm to use."

Grobler developed a meta-hyper-heuristic algorithm which obtained 68% improvement over four state-of-the-art algorithms while significantly reducing algorithm development costs. The algorithm can be applied to various optimisation problems ranging from supply chain design problems and image processing applications to emergency service location problems.

At the CSIR, Grobler leads the transport and freight logistics research group which performs research in freight logistics and supply chain management. The group's research focus is on freight rail, road, and sea and air freight. "Recently we completed a project for the Gauteng Growth and Development Agency where we analysed OR Tambo International Airport and its feasibility for becoming a cargo hub in Africa," she says.

"We also assist the Aerospace Industry Support Initiative with its supplier development programmes. We go to a specific company and look at all aspects of supply chain management and see how we can best assist the company to improve its operations so that it is competitive and can provide better service to the aerospace industry."