INDUSTRIAL & SYSTEMS ENGINEERING
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Snow Plow Route Optimization: A Constraint Programming Approach

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Abstract

Many cities have to cope with annual snowfall, but are struggling to manage their snow plowing activities efficiently. Despite the fact that winter road maintenance has been a popular research subject for decades, very few papers propose scalable models that can incorporate side constraints encountered in real-life applications. In this talk, we explore how Constraint Programming (CP) can be used to solve a real-world Snow Plow Routing Problem. Constraint Programming is a subfield of Artificial Intelligence and Operations Research that deals with the problem of finding solutions to complex problems by expressing those problems in terms of variables and constraints. Unlike other Mathematical Programming techniques such as Integer Programming, CP relies on inference and constraint propagation techniques to derive solutions that satisfy all constraints. The Snow Plow Routing Problem (SPRP) discussed in this talk involves finding a set of vehicle routes to service a street network in a pre-defined service area, while accounting for various vehicle constraints and traffic restrictions. The fundamental mathematical problem underlying SPRP is the Capacitated Arc Routing Problem (CARP). Common Mathematical Programming (MP) approaches for CARP are typically based on: (i) a graph transformation, thereby transforming CARP into an equivalent node routing problem, or (ii) a sparse network formulation. The CP formulation in this work is based on the former graph transformation. Using geospatial data from the city of Pittsburgh, we empirically show that CP approach outperforms existing MP formulations for SPRP. For some of the larger instances, the CP model finds 26% shorter plowing schedules than alternative Integer Programming formulations. A test pilot held with actual vehicles proves the applicability of the approach in practice: the routes produced by the CP model are 3-156% more efficient than the routes generated with commercial routing software.

Bio

Dr. Joris Kinable is a Senior Applied Scientist for the Middle Mile Planning, Research & Optimization Sciences group within Amazon Transportation Services. He also holds an adjunct faculty position at the department of Industrial Engineering & Innovation Sciences, Eindhoven University of Technology. Prior to joining Amazon, Dr. Kinable was an assistant professor at the same department of Eindhoven University of Technology, and held an adjunct faculty position at the Robotics Institute of Carnegie Mellon University. Dr. Kinable obtained his PhD in Operations Research from the KU Leuven (Belgium) in 2014. Dr. Kinable is specialized in mathematical optimization techniques, with applications in transportation, logistics, planning and scheduling. His research interests include data-driven Optimization, Mathematical Programming and Machine Learning techniques to solve large-scale optimization problems. Dr. Kinable has published his research in several leading journals, including Transportation Science, European Journal of Operational Research, and Computers and Operations Research, and is a frequent member of program committees for conferences such as CPAIOR, AAAI, IJCAI and CP. In his spare time, dr. Kinable leads the development of JGraphT, the largest open source java library in graph algorithms and data structures.

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