BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF INFORMATION TECHNOLOGY

Excel@FIT 2023
http://excel.fit.vutbr.cz

Automated Logistic Plan Optimization

Bc. David Sedlák

Abstract
Logistic planning is, in some cases, still done mostly manually, mainly due to the high complexity of real-world constraints. Classical solutions fail to keep up with real-world demands. In this study, we investigate whether handmade logistic plans used by a particular Czech logistic company can be automatically improved while considering all the real-world constraints. We based our solution on stochastic optimization methods and achieved average improvements of 7.6 % on data sets with historic plans provided by the logistic company. The use of improved logistic plans can reduce the traveled distance and lower the cost of transportation, implying a competitive advantage for a logistics company, lower prices for the end consumer, and even less pollution for the environment.

*xsedla1d@stud.fit.vutbr.cz, *Faculty of Information Technology, Brno University of Technology*

1. Introduction

[Motivation] Logistic planning is, in some cases, still done mostly manually, even in logistic companies with large transportation volumes. Mainly due to the high complexity of real-world requirements. Classical solutions fail to keep up with real-world demands. With increasing needs for freight transportation, improved logistic plans can reduce the traveled distance and lower the cost of transportation, implying a competitive advantage for a logistics company, lower prices for the end consumer, and even less pollution for the environment.

[Problem definition] The task is to determine the mapping between pallets from orders and available vehicles to specify routes for those vehicles such that all orders are satisfied, all limiting conditions and rules are met, and the total distance traveled by cars is minimized.

This problem belongs to the category of Vehicle Routing Problems (VRPs) [1], which were extensively studied in past decades. Specifically, it is an instance of so-called Rich Vehicle Routing Problem (RVRP). The RVRPs focus on complicated constraints arising from real-world planning [2].

Conditions considered in our work include: heterogeneous vehicle fleet, weight capacity limits, pallet capacity limits, delivery time windows, temperature classes, restrictions on delivery points (truck size limitations, ramp requirement), different route lengths for different vehicle types. . .

The logistics company serves more than 5 000 delivery and pickup points and daily delivers on average more than 2 000 orders totaling more than 17 000 pallets per day.

[Initial goal] In this study, we investigate whether handmade logistic plans can be automatically improved while considering all the real-world constraints.

[Methodology] Historical data sets provided by a particular Czech logistic company were used. Data sets include information about the vehicle fleet, orders for delivery, used distribution network with distances and travel times between individual pickup and delivery points, and hand-made plans used during January 2020.

[Our solution] We designed and implemented problem representation suitable for the application of stochastic optimization methods and created various optimizers based on Markov chain Monte Carlo (MCMC) sampling techniques, Evolutionary Strategies, and other evolutionary optimization approaches.

[Existing solutions] Various solutions were proposed for the classical VRP variants achieving great results, in some cases even by application of exact methods leading to optimal solutions for reasonable problem sizes [3].

Research around RVRPs is quite active [4]. But

the studies are typically focused on RVRPs with their specific conditions and requirements, such as focusing on 3D pallet dimensions in [5] and perishable food distribution in [6].

Individual RVRP variants are quite unique due to broad generality in the possible conditions and requirements. Slightly changing the requirements can drastically change the whole problem. Hence the studied variants are a great inspiration but are not really usable in our case; I wasn't able to find research on RVRP with the same requirements and conditions as our logistic partner has.

2. Results

Figure 1 shows the difference in the traveled distance between the original, purely handcrafted plans and our optimized plans for individual days.

We were able to automatically optimize provided historic plans from January 2020 by 7.6 % on average. In total, adding up to 54 000 optimized kilometers in a single month.

Achieved optimizations were, in general, more significant on days with greater transported volume. And not only in total but also proportionally. The biggest relative improvements, between 10 % and 12 %, were achieved on days 28, 15, and 14, which are all days with above-average transported volumes.

Optimized distances presented in Figure 1 were obtained from the optimizer based on the MCMC sampling techniques, but in recent experiments, the approaches based on evolutionary optimization techniques (mainly Evolutionary Strategy) showed to be promising in surpassing the ones obtained with previous methods.

3. Conclusions

Considering the complexity of real-world logistic planning, where a lot of contradictory conditions have to be met, the stochastic optimization approach showed to be a promising alternative addition to manual time-consuming planning. The proposed methods demonstrated the capabilities of further improvements of various manually-designed plans. Further tuning and generalization represent the next goals of our research. We are optimistic about the ability to achieve further improvements by further fine-tuning of used approaches.

The current solution could be already used by the logistic company in cooperation with the operators handcrafting the plans to achieve noteworthy savings. Nonetheless, this is only the first step in our research, and the ultimate goal is to completely eliminate or at least reduce the need for human operators to handcraft the plans while being able to produce plans with better properties than the ones used today.

The achieved results are a promising demonstration of the feasibility of our research.

Acknowledgements

I would like to thank my supervisor Ing. Michal Bidlo Ph.D. as well as my consultant Mgr. Miloš Červenka for their help and their patience.

References

[1] G. B. Dantzig and J. H. Ramser. The truck dispatching problem. *Management Science*, 6(1):80–91, 1959.

[2] Min Wen. *Rich Vehicle Routing Problems and Applications*. PhD thesis, March 2010.

[3] Grigorios D. Konstantakopoulos, Sotiris P. Gayialis, and Evripidis P. Kechagias. Vehicle routing problem and related algorithms for logistics distribution: a literature review and classification. *Operational Research*, 22(3):2033–2062, Jul 2022.

[4] Jose Caceres Cruz, Pol Arias, Daniel Guimarans, Daniel Riera, and Angel Juan. Rich vehicle routing problem: Survey. *ACM Computing Surveys*, 47:1–28, 12 2014.

[5] Emmanouil E. Zachariadis, Christos D. Tarantilis, and Chris T. Kiranoudis. The pallet-packing vehicle routing problem. *Transportation Science*, 46(3):341–358, 2012.

[6] Pedro Amorim, Sophie N. Parragh, Fabrício Sperandio, and Bernardo Almada-Lobo. A rich vehicle routing problem dealing with perishable food: a case study. *TOP*, 22(2):489–508, 2014.