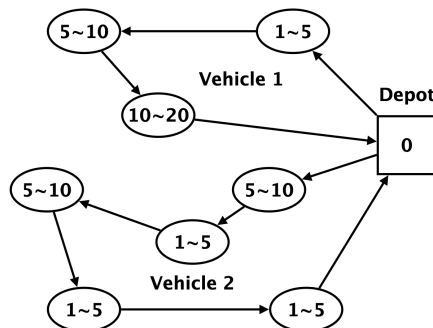# Solving the Vehicle Routing Problem with Time Window and Fluctuating Demand by Using Simple Heuristics

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The shortage of truck drivers is a serious problem all over the world. To deal with this problem, a modal shift is underway, in which items previously transposed by truck are transposed by other means of transportation such as trains and ships. However, in the case of agricultural products, there is a problem that the amount of cargo is not known until the cargo is loaded. Therefore, it is difficult to replace it with other means of transportation. From this viewpoint, an algorithm that creates a robust delivery plan under the fluctuation of the amount of cargo with a small number of track drivers is desired.

The problem of creating a delivery plan is called the vehicle routing problem (VRP). In particular, a variation of the VRP that visits customers within predefined time windows is called a VRP with a time window (VRPTW) [1]. The VRPTW is an $\mathcal{NP}$-hard combinatorial optimization problem. Many metaheuristics are used to solve the VRPTW, such as the tabu search [2], simulated annealing [3], and genetic algorithm [4]. In addition, a variation of VRPTW that the amount of demand is depending on the day has also been proposed [5] and we call it VRPTW and fluctuating demand (VRPTWFD) in this paper. An image of VRPTWFD is shown in Fig. 1. The purpose of VRPTWFD is to find a solution that always shows stable performance for the fluctuating quantity of demands. The multi-stage genetic algorithm shows good performance for this problem [5]. However, it has a demerit: the calculation time is too long.

For solving the traveling salesman problem, POPMUSIC [6] has been proposed as a method for obtaining a good solution in a short calculation time. POPMUSIC finds a solution with two steps: extraction of candidate solutions and application of improvement methods. Extracting candidate solutions is done by applying high-speed construction methods multiple times. In particular, it is possible to find a good solution at high speed for a large-scale traveling salesman problem. This method is also considered to be effective for VRPTWFD. First, input multiple instances that have different demands, and create multiple solutions by the construction method. Next, the paths that appear in multiple solutions are processed by the improvement method. From these steps, it is expected that a solution showing stable performance for a fluctuating amount of demands will be obtained. It is also expected to shorten the calculation time. We plan to evaluate the performance of this method through numerical experiments.

## Acknowledgments

## References

[1] M.M. Solomon, "Algorithms for the Vehicle Routing and Scheduling Problems with Time Window Constraints," *Oper. Res.*, vol. 35, no. 2, pp. 254-265, 1987.

[2] J.Y. Potvin, T. Kervahut, B.L. Garcia, and J.M. Rousseau, "The Vehicle Routing Problem with Time Windows Part I: Tabu Search," *INFORMS J. Comput.*, vol. 8, no. 2, pp. 158-164, 1996.

[3] W.C. Chiang and R.A. Russell, "Simulated annealing metaheuristics for the vehicle routing problem with time windows," *Ann. Oper. Res.*, vol. 63, no. 1, pp. 3-27, 1996.

[4] J.Y. Potvin and S. Bengio, "The Vehicle Routing Problem with Time Windows Part II: Genetic Search," *INFORMS J. Comput.*, vol. 8, no. 2, pp. 165-172, 1996.

[5] T. Onoyama, T. Maekawa, S. Kubota, S. Tsuruta, and N. Komoda, "Vehicle routing problem solving method for a coorperative logistics network by using multi-stage GA," *IEEJ Trans. EIS*, vol. 127, no. 9, pp. 1460–1467, 2007.

[6] É.D. Taillard and K. Helsgaun, "POPMUSIC for the travelling salesman problem," *Eur. J. Oper. Res.*, vol. 272, no. 2, pp. 420-429, 2019.

**Figure 1:** The vehicle routing problem with time window and fluctuating demand (VRPTWFD).

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