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論文題目	A New Hybrid Framework for Preference-Aware Multi-Objective Vehicle Routing Problem with Time Windows and Demand Priority		
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論文の内容の要旨

This dissertation addresses a key gap in real-world logistics optimization by proposing the Multi-Objective Vehicle Routing Problem with Time Windows and Demand Priority (MO-VRPTWDP). Unlike traditional VRP models that focus solely on cost minimization, this new formulation incorporates customer satisfaction via a weighted waiting time mechanism, enabling more equitable and service-oriented routing, especially in domains such as healthcare logistics and premium delivery.

To address this problem across different scales and decision-making contexts, the research can be divided into 3 parts. First, a Mixed Integer Linear Programming (MILP) model is developed to validate the formulation and analyze small-scale solution behavior. It captures trade-offs between operational cost and service levels based on customer priority.

Second, a novel Multi-Thread Simulated Annealing (MTSA) algorithm is proposed to enhance scalability and exploration. MTSA introduces parallel threads and cooperation among them, significantly improving the diversity and quality of Pareto frontier approximations. Experiments show that MTSA outperforms the benchmark algorithm (MOSA).

Third, a reinforcement learning–based extension, RL-MTSA, is introduced to enable preference-aware optimization. By embedding a learning agent into the MTSA algorithm, RL-MTSA dynamically steers the search toward user-specified regions of interest. It achieves faster convergence and higher alignment with decision-maker preferences than uniform-search methods.

Overall, this research contributes a new VRPTW variant with soft-priority modeling, scalable optimization techniques, and adaptive, user-preference search strategies. The proposed methods offer practical decision support tools for the preference-aware optimization in the multi-objective vehicle routing problem.

Keywords: Vehicle Routing Problem, Multi-Objective Optimization, Simulated Annealing, Reinforcement Learning, Preference-aware Optimization

論文審査の結果の要旨

The classical Vehicle Routing Problem with Time Windows (VRPTW) ensures that all customers are served within specified time intervals, but it does not explicitly model service quality or differentiated customer priorities. This limitation is increasingly unrealistic in domains such as healthcare logistics, emergency response, and premium delivery, where responsiveness can be as critical as cost efficiency. This dissertation addresses this gap by introducing the Multi-Objective Vehicle Routing Problem with Time Windows and Demand Priority (MO-VRPTWDP) and developing a comprehensive, generalizable solution methodology. The main contributions are threefold.

First, the dissertation proposes a novel MO-VRPTWDP formulation that incorporates customer priority into the classical VRPTW via a soft-priority mechanism. Second, it develops a new metaheuristic, namely Multi-Thread Simulated Annealing (MTSA), to efficiently approximate the Pareto frontier of MO-VRPTWDP. Third, it proposes a hybrid framework that integrates reinforcement learning with MTSA (RL-MTSA), enabling preference-aware multi-objective optimization for vehicle routing. The effectiveness and applicability of the proposed methodology are demonstrated through experimental studies on real-world datasets. In particular, the dissertation systematically analyzes how priority-weight settings influence routing outcomes and provides quantitative insights into the trade-offs between total travel distance and total customer waiting time. Overall, the combined MO-VRPTWDP formulation, MTSA algorithm, and RL–MTSA framework offer both theoretical advances and practical tools for real-world deployment.

This dissertation makes significant methodological and practical contributions to multi-objective vehicle routing. The research has resulted in two journal articles and one refereed conference paper.

In summary, Mr. LEELERTKIJ Thanapat has completed all the requirements in the doctoral program of the School of Knowledge Science, JAIST and finished the examination on February 06, 2026, all committee members approved awarding him a doctoral degree in Knowledge Science.