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Investigating various solution techniques for real-world vehicle routing problems

Operations research (OR) is a field of study that employs analytical techniques to improve decision-making. The field of OR can help you make better decisions in a variety of fields, including manufacturing, transportation, project management, supply chain management, etc. Vehicle Routing Problem (VRP) is a well-studied application within the field of OR. The primary goals of the vehicle routing problem are to find the optimal route plan to minimize distribution costs and travel times while maximizing customer satisfaction and fleet capacity utilization [1] (Figure 1). Researchers have used VRP in a variety of fascinating applications, including green vehicle routing, electric vehicle routing, unmanned aerial vehicle routing [1], etc.

Presently, the Center for Supply Chain, Operations and Logistics Optimization, University of Moratuwa is attempting to develop a vehicle routing model to optimize the distribution processes of a supermarket chain operating in Sri Lanka. The model is comprised of real-world constraints, and the model's goal is to minimize total distribution cost while ensuring timely delivery of goods to supermarket outlets. The application contains 250 supermarkets, 2 distribution centers, and a heterogenous truck fleet of 70 trucks, making the problem considerably large. It is highlighted that we used OSRM (Open Source Routing Machine) API to estimate the distance matrix for the routing model using a real-world road network [2].

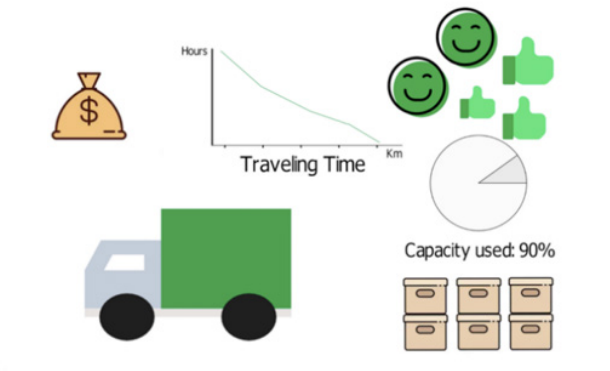

Figure 1: Fundamental objectives of vehicle routing problem

Existing literature used various solution techniques to solve different types of route optimization problems. Exact methods, heuristic methods, metaheuristic methods, and hybrid methods were identified as solution techniques [3]. Using the existing research published in peer-reviewed journals, we conducted a comparison of the pros and cons of the available solution techniques (Figure 2). Additionally, our literature analysis revealed how existing research has employed different solution techniques to solve the application-oriented vehicle routing problems. Although hybrid methods are relatively good for solving application-oriented VRP models, as illustrated in Figure 3, researchers have paid little attention to this. Two solution techniques are combined in hybrid methods to avoid limitations such as low solution quality, impracticable computation time, and optimal solutions trapped in local minima [3]. To achieve better results, researchers used combined exact-metaheuristic, heuristic-metaheuristic, and metaheuristic-metaheuristic methods[3].

> “Currently, the global demand for REEs is skyrocketing, owing to their immense consumption in the advancement of modern high-tech and green technologies.”

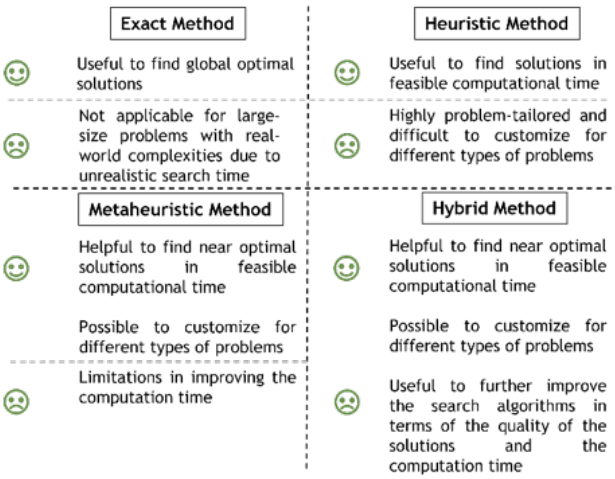

Figure 2: Pros and cons of solution techniques

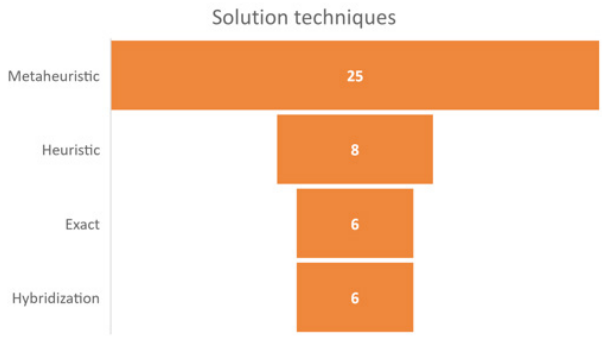

Figure 3: Utilization of different solution techniques

This research combined heuristic and metaheuristic methods. To obtain Initial Basic Feasible Solutions (IBFS) for the proposed model, heuristic techniques were used. Following that, meta-heuristic techniques were used to improve the solution until getting near-optimal. We conducted numerical experiments to measure the performance of the suggested hybrid solution technique against the well-known metaheuristic methods using a real-world application. We developed all the algorithms using OR-Tools version 7.2 with Python version 3.9.6 in Visual Studio Code version 1.60. The proposed model and the solution technique save 16 % of daily distribution costs. It represents a 24% reduction in fuel costs and a 7% reduction in fixed costs. Further, the model ensures 95% of on-time deliveries to supermarket outlets. Our suggested hybrid solution technique contributes to solving application-oriented VRP models effectively and thereby can minimize the transport inefficiencies occurring in supermarket distribution.

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