Abstract

The vehicle routing problem (VRP) is a well-known combinatorial optimization problem that is used in the logistics industry for the efficient delivery of parcels to multiple customers. In the vehicle routing problem, vehicles start from a depot and return to the same depot. The goal of the vehicle routing problem is to find optimal routes for vehicles to deliver goods to a given set of customers and then return to the start point. Since the vehicle routing problem is NP-hard, finding an optimal solution requires an exponential running time (unless P=NP). In real-world applications, a heuristic algorithm is widely used to solve VRP. From a practical point of view, it is important to find an approximate solution quickly because a long-running time is not practical for a daily delivery operations. Local search and some augmented local search algorithms are mostly used to solve VRP. However, the running time will be too long even when using these heuristic algorithms. This is specifically problematic when considering large instances if the business operation requires real-time delivery (e.g. same-day delivery). VRP has various types of constraints such as a demand capacity constraint and a time window constraint etc.

Some recent works attempt to solve the routing problem by applying machine learning techniques, specifically reinforcement learning. In recent years, a network architecture called *attention network* is gaining popularity in the NLP field because it shows a good performance on various NLP related tasks, and it is applied to other fields such as the graph theory and the image recognition. Attention networks achieve good performance on VRP with capacity constraints. Since it has an end-to-end architecture, it can be used without being combined with other heuristic algorithms. In our study, we focus on the development of an extension of the attention network that is able to take a time window constraint into consideration. Furthermore, recent works assume the distance between nodes is Euclidean, and encode nodes' XY coordinates. This is a problematic assumption for real-world business operations because the distance between nodes is actually non-Euclidean. To overcome this drawback, we propose a network architecture that accepts distances as input.

We evaluate the model on the Solomon dataset, which is a well-known dataset for VRP with a time window constraint. We show the following. First, the attention network with a simple extension to VRP with a time window constraint shows similar performance to Google ORtools on both small size and large size instances. Second, the proposed modification to the

attention network is able to take the distance matrix into consideration, so it is possible to assume that the distance between nodes is non-Euclidean.

Keyword: Vehicle Routing Problem, Deep learning, Reinforcement learning, Combinatorial optimization, Machine learning