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A Study on Vehicle Routing Problems Considering IoT based Real Time Information

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Abstract. With the recent increasing demand of freight, parcel delivery service, and product distribution, the quantity of supply that a company needs to handle is also increasing. The travel time between the demand points in the city is greatly affected by the complicated road conditions and the changing external environment in real time. In the previous researches, the vehicle routing problem is to define a route based on the distance between the demand points, the travel time, and the determined demand. This study propose a vehicle routing problem considering the vehicle location, vehicle condition information and dynamic demand forecasting by the Internet of Things (IoT) equipment attached to the vehicle.

Keywords: Internet of Things, Vehicle Routing Problem, Fleet Management

1 Introduction

With the recent increasing demand of freight, parcel delivery service, and product distribution, the quantity of supply that a company needs to handle is also increasing. Due to the external environment factors such as the complicated road conditions and the increased vehicles, it is getting harder to deliver products to the demand points within the desired time. Companies have built and utilized logistics systems in order to keep appointments with customers and reduce logistics cost logistics system. However, the most of them have been planning of vehicle routing based on their heuristic know-hows and historical data of the past. Because of the dynamic tidal flow of traffic such as downtown traffic, depending on the existing heuristic know-hows can not only increase the logistics cost but also lose customer confidence.

Currently, the IoT technology has been being applied to diverse industries, the things come with communication module that can realize network communication in real time. If applying the IoT technology that generates data in real time, effective

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management can be achieved with not only information integration but also minimization of the gap of information flow [1]. The IoT based real time information ensures traceability and visibility of product that can reduce logistics cost and promote customer confidence [2].

This study proposes a vehicle routing problem considering traffic conditions, real time information about vehicle location and vehicle condition which have achieved from the IoT devices attached to the vehicle, and the dynamic forecasting demand of the demand points.

2 Previous Researches

Dantzig and Ramser [3] defined Vehicle Routing Problem (VRP) as a problem of determining the route of the vehicle to minimize distance, cost, and number of vehicle for the vehicles departing from the depot to visit the customers and return to the depot again. It is also known as NP-hard problem.

There are diverse types of VRP studies such as capacitated VRP (CVRP) that vehicle with limited capacity, VRP with time windows (VRPTW) that the visiting time is limited, VRP Multi Trips (VRPMT) that multiple visiting available, Multi Depots VRP (MDVRP) that there are many depots, Heterogeneous VRP (HVRP) that vehicles have different capacities. VRP with Pickup and Delivery (VRPPD) that there is product exchange between the demand points, VRP with Backhauls (VRPB) that there are collecting supplies, and Stochastic VRP (SVRP) that considers a probabilistic environment [4][5].

There are several studies on the impacts of speed change to the VRP, considering traffic conditions. Hill and Benton [6] proposed a model to forecast average vehicle speed at a location of customer in a specific time of the day. Malandraki and Daskin [7] have estimated a total travel time by using the nearest neighbor search (NNS) and the cutting plane method in applying the service based- and time based-vehicle average speed after dividing 2 or 3 service times considering traffic conditions. Tillman [8] proposed a VRP considering probabilistic demands for the first time. Haughton and Stenger [9] proposed a vehicle routing decision model considering the vehicle demands follows a Poisson distribution.

3 A Mathematical Model

The problem to be addressed in this study is to understand real time traffic conditions and real time information about vehicle location and vehicle condition that are collected from the IoT devices attached to the vehicle, as well as, to generate vehicle routings that can minimize the total required time considering the limited load capacity of the vehicle under the situation that the estimated demand in the demand points is changing.

This study establishes a model assumed that there is a total of N demand points and a limited number of vehicles around a single depot, and the required service time in

each demand point and the load capacity of the vehicle are constant, as well as, the locations of vehicle and the quantities of the demand in the demand points are known.

The hypotheses of the model are described in below.

H1: The starting and ending of the vehicle is done only in the depot.

H2: The sum of the demands in the demand points included in the route of each vehicle cannot exceed the load capacity.

H3: Traffic conditions in each route are known.

H4: The location and condition information of the vehicle can be known in real time.

4 Conclusion

This study proposed a mathematical VRP model and hypotheses considering real time traffic conditions and information about vehicle location and vehicle condition that collected from the IoT devices in real time. For the future study, it is necessary to establish a mathematical model and algorithm based on the proposed mathematical VRP model and hypotheses, and to conduct a comparative analysis with the previous researches on VRP.

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