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DRONE DELIVERY SCHEDULING IN EMERGENCIES USING SIMULATION AND HEURISTIC METHODS

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ABSTRACT

In emergency medical services, an advanced analytical tool is needed to help with the planning and scheduling of delivery tasks to deliver relief goods promptly. In this study, simulation combined with a heuristic method is proposed as an advanced analytical tool to enable quick decision making of scheduling of drone delivery tasks. In case of emergency in which general transportation is stagnated by a disaster, the proposed framework can be utilized for scheduling drone delivery tasks, and the short-term delivery performance indicators such as the starting and ending times of drone delivery tasks can be predicted and obtained.

1 INTRODUCTION

In recent years, unmanned aerial vehicles (UAVs) are already showing their prowess in various emergency environments as general logistic activities cannot function rapidly due to the overall stagnation of traffic. Especially, in the case of emergencies, medical services needs are caused by epidemics, pandemics such as the coronavirus disease-2019, or other types of disasters. In emergency medical services, an advanced analytical tool is needed to help with the planning and scheduling of drone delivery tasks to deliver relief goods promptly and bring in aid supplies to sick and wounded victims.

This study aims to develop a simulation framework combined with a heuristic algorithm which can both fast provide valuable support information of drone delivery scheduling and behave like the corresponding real drone delivery systems in dynamic emergency medical services. First, a heuristic algorithm is designed to obtain actionable sequential data based on the basic geographic information such as the longitude and latitude of each evacuation center destination and the depot area. Then, simulation models apply the actionable sequential data obtained from the designed heuristic algorithm in aid of the decision-making of scheduling of performing delivery tasks in dynamic emergency environments, considering the uncertainties in delivery activities, such as desired speed change of drones and refueling time at different shelters and so on.

2 CASE STUDY

In this section, simulation and heuristic methods are used to generate an actional schedule for drone delivery with rapid response during emergencies. The simulation models are conducted at the following six Izumi-city evacuation centers in Osaka prefecture, Japan: Kitaikeda Elementary School (B), Yokoyama Elementary School (C), Minami-Matsuo Elementary School (D), Komyodai Junior High School (E), Gosho Junior High School (F), and Kitamatsuo Elementary School (G). In this case, Momoyama University (A) is selected as the central base, wherein it should have enough space to maintain supplies from other locations and allow drones to carry production to several nearby shelters.

Besides the data of depot locations, item demands for each evacuation center, route design such as delivery times are of critical importance in aspects of forecasting drone delivery activities. Based on the

actual number of injured people in the Tohoku earthquake and the number of people accommodated, the item demands from several shelters can be predicted in this study.

A designed greedy algorithm is investigated and applied in Python, which is employed to choose the shortest number from an evacuation center of origin to next shortest number, so as to both obtain the heuristic route rapidly and ensure that shelters with delivery priorities are flown around once during and after a disaster. The designed greedy algorithm, which stands poised between actual geographic data of types of points and simulation models, is amenable to simulation models by getting a relatively suitable sequential route for emergency delivery tasks. The result of the heuristic route in this study was the following order: A-G-F-B-E-C-D. The result is then applied to simulation models, and the simulation models are performed to generate a detailed delivery schedule that fully accounts for the constraints of the system, including initial desired speed, limited payload capacity and complex material handling at base and shelters.

3 RESULTS

Simulation models can be used to provide up-front visibility into drone delivery schedules with a specific routine outputted from the designed heuristic algorithm. Figure 1 shows a part of the starting times and ending times coving drone activities at the base and each shelter. In this study, the detailed drone delivery workflow of the Gantt chart can be used to measure the quality of the resulting schedule in the form of delivery priority-base routing schema.

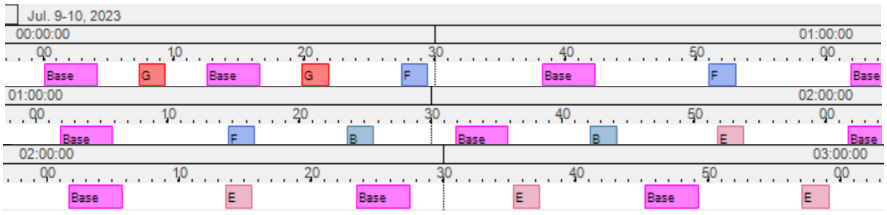

Figure 1: A Part of Starting time and ending time of drone delivery workflow.

4 CONCLUSION

This study illustrates how simulation and heuristic methods can be utilized to provide valuable support to decision-making of drone delivery scheduling. A designed greedy algorithm in Python is applied to ensure that shelters with delivery priorities are flown around once. Simulation models are performed to mimic the drone delivery routine and fast provide valuable support information of drone delivery scheduling. The integrated simulation model can function and generate schedules in near real-time means that as emergency events happen, the drone delivery schedule can be re-run quickly to re-route orders from shelters around possible constraints under complex emergency environment. In some cases, these output values may be sent back to measure the quality of the resulting schedule. As future research, the proposed procedure decision-making processes can be used in real complicated routing delivery systems to support decision making of drone delivery logistics in emergencies.

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