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Abstract

This research is the study on the unmanned aerial vehicle routing for drugs and medical supplies transportation in flooded areas where other vehicles are difficult to access, by simulating flooded areas in Bangkok, Thailand under the loading capacity limitation of the unmanned aerial vehicle considering the weight and quantity of drugs and medical supplies for the shortest routing and timing. The researchers have chosen the vehicle routing using a saving algorithm by Clark & Wright as it is not too complicated and good enough for finding answers in a limited time based on a fast calculation and is suitable for flooded areas. The researchers have simulated a distribution center of drugs and medical supplies and 70 locations of disaster victims by using the unmanned aerial vehicle of the community in Bangkok, Thailand, as a routing model. The result revealed that routing of 70 locations was a total of 12.68 kilometers which is time effective for routing appropriately and the air force could implement it as a guideline for the unmanned aerial vehicle routing for drugs and medical supplies transportation in flooded areas or other emergencies for helping people in the future.

Keywords: Unmanned Aerial Vehicle, Geographic Information Systems, Vehicle Routing Problem, Heuristics approach

Introduction

Natural disasters in Thailand tend to be more drastic whether floods, fires, storms, mudslides, and airborne dust problems especially flood in Thailand that occur annually as the drastic environmental and climate change and the location of Thailand is influenced by monsoon from the South China Sea and Bay of Bengal. From data of The International Disaster Database, it reported 22 times of floods in Thailand during 2010-2020 (EM-DAT, 2021) that affect directly the buildings, houses, constructions, facilities, and transportation routes destroyed widely such as floods in 2018 effect 66 provinces, 1,009,289 people, 4,822 routes, and Baht 542,067,800 assets (Department of Local Administration, 2020).

In consequence, flooding is a problem that should be solved, and the academic person and relevant persons are interested in developing the process and tools for transportation and logistics in flooded areas or humanitarian logistics especially the effective last-mile distribution is an issue and challenge for the academic person and relevant persons of disaster mitigation (Jitt-Aer et al., 2022; Rabta, et al., 2018) for as the road or water routing are difficult to access. Moreover, the implementation of the developed model can help the shippers to increase their capability as well as their competitiveness (Setthachotsombut et al., 2022). Nevertheless, the disaster victims should be helped timely and righteously with requisites such as water, food, and medicine especially the medicine for waterborne disease or hantaviral disease (Witoonsasiwimon & Kanjanarat, 2017).

Drugs and medical supplies will be transported by rotary-wing aircraft of the army, air force, navy, or other public sectors to the disaster victims in flooded areas. Nevertheless, rotary-wing aircraft of the army requires a high cost, specific airport, and risk for a case of transporting with the aircrews in many flooded areas. Consequently, using the unmanned aerial vehicle to help the disaster victims cooperating with the other sectors

will enhance the capacity to access flooded areas and decrease the transportation cost as the distinctive characteristic of the unmanned aerial vehicle is its ability to fly in limited or difficult space (Bunphoei, 2019). In addition, the unmanned aerial vehicle has the agility and less limitation to fly in disaster areas, but it has a limitation of capacities (Thamwatharsaree, 2020) such as a limitation of battery power that affects the flight duration, and a limitation of payload. Consequently, unmanned aerial vehicle routing is a challenge to apply for drugs and medical supplies transportation with a small size and weight in flooded areas.

Air Force Strategy for 2018-2037 (20 years) focused on developing a capacity of air domain, cyber domain, and space domain for the completed stability, helping people, developing country, and solving problems as assigned by the government. A study of the unmanned aerial vehicle routing for drugs and medical supplies transportation in flooded areas is a response to the policy of the air force for the year 2021 on research and development the supporting software by using the unmanned aerial vehicle for helping disaster victims, planning the unmanned aerial vehicle routing, and developing a guideline for the unmanned aerial vehicle routing for the effective resource use based on the condition and limitation of capacities.

The researchers are interested in a study of the unmanned aerial vehicle routing for drugs and medical supplies transportation in flooded areas where other vehicles are difficult to access aimed to study and apply the logistics of the unmanned aerial vehicle routing for drugs and medical supplies transportation in flooded areas by using a concept of vehicle routing problem (VRP) and heuristics approach with a saving algorithm by Clarke & Wright (Moryadee et al., 2019; Sripanamvan et al., 2022; Jitt-Aer, 2017).Vehicle Routing Problem with Stochastic Demand. NKRAFA Journal, 13(13), 20-21.]. Solving the vehicle routing problem will consider the carrier or working group for economical use of resources and the disaster victims should be helped timely and righteously. This research aimed to study the heuristics approach by Clark & Wright for solving the vehicle routing problem and to apply the heuristics approach by Clark & Wright for solving the vehicle routing problem of the unmanned aerial vehicle for drugs and medical supplies transportation in flooded areas (Bodin et al., 1983).

The Problem

Nowadays, research on vehicle routing problems is very interesting and complicated. The researchers have solved the vehicle routing problem for drugs and medical supplies transportation in flooded areas by determining a distribution center of drugs and medical supplies, unmanned aerial vehicle, distance limitation, and loading capacity or capacitated vehicle routing problem (CVRP) by using a saving algorithm by Clarke & Wright, including should be developed for more effective solving the vehicle routing problem in flooded areas as the following process show in Figure 1;

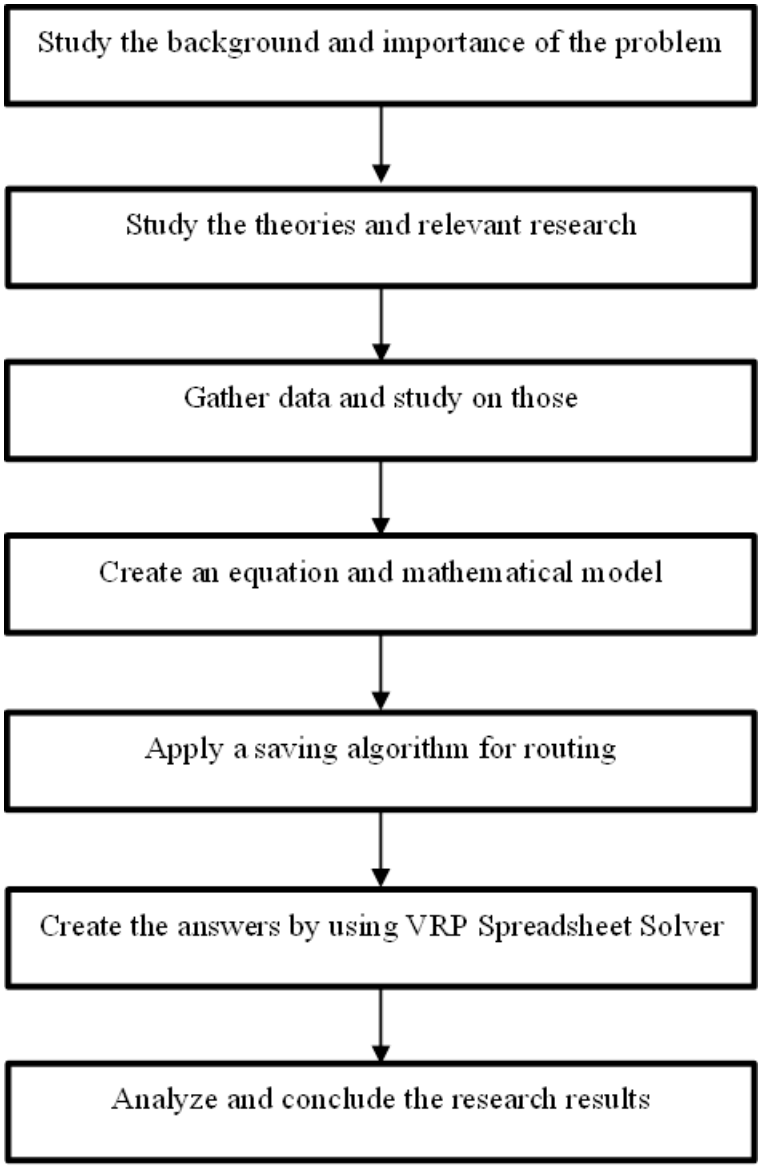

Figure 1: **Process of the research methodology**.

Location or disaster victims

The population and sample group were people living in flooded areas from the simulation in the academy. The variables for the simulation consisting;

- A distribution center of drugs and medical supplies
- 70 locations of disaster victims (in Bangkok community area)
- A product for drugs and medical supplies transportation
- A number of requirements for each point (by random method)
- An unmanned aerial vehicle (containing 4.5 kilograms with 45 minutes flight)

Location

The unmanned aerial vehicle routing for drugs and medical supplies transportation from the pick-up point to the delivery point for the disaster victims in 70 flooded areas referring to the satellite and the unmanned aerial vehicle routing to each point by a linear.

Data

Planning the unmanned aerial vehicle routing for helping the disaster victims requires a study of relevant data affecting the unmanned aerial vehicle routing consisting of;

- A list of drugs and medical supplies arranged 500 grams weight for each set, and its quantity will be distributed by the requirement of each area.
- The unmanned aerial vehicle model is Octopus 02 loading 9 sets of drugs and medical supplies with 45 minutes flight.
- The requirement quantity of each area will be randomly by using a distribution center of drugs and medical supplies and 70 locations of disaster victims.
- The distance from the pick-up point to the delivery point with a total of 71 points consisting of a distribution center of drugs and medical supplies and 70 locations of disaster victims, its data were gathered by using the geographic coordinate system of WGS 1984 on a mobile application called, "GPS test".

The graph format is $G = (V, A)$ where $V = \{0, 1, 2, ..., n\}$ consisting of transportation routing points; 0 stands for a distribution center, $N = V - \{0\}$ stands for a number of recipients, $A = \{(i, j) : i, j \in V\}$ stands for a set of routing between the recipient i and the recipient j where the coefficient C_{ij} is a variable of routing cost from the recipient i and the recipient j which could be a distance or duration as the aim of solving the problem is routing by the minimum cost at the same vehicle $K = \{1, 2, ..., m\}$ with a limited loading, Q stands for a capacity of each vehicle where the demand of the recipient i is qi, and a demand of all recipients should not exceed the value of Q and the vehicle has to return to a distribution center (Jitt-Aer, 2017).

Simulations and experimental results

This research is a study of the unmanned aerial vehicle routing for drugs and medical supplies transportation in flooded areas by using a heuristics approach by simulating flooded areas in the academy with a distribution center of drugs and medical supplies and 70 delivery points aimed at the minimum cost of routing that affects the decrease of transportation cost and time, and applying VRP Spreadsheet Solver and the process of finding problem showed in Figure 2.

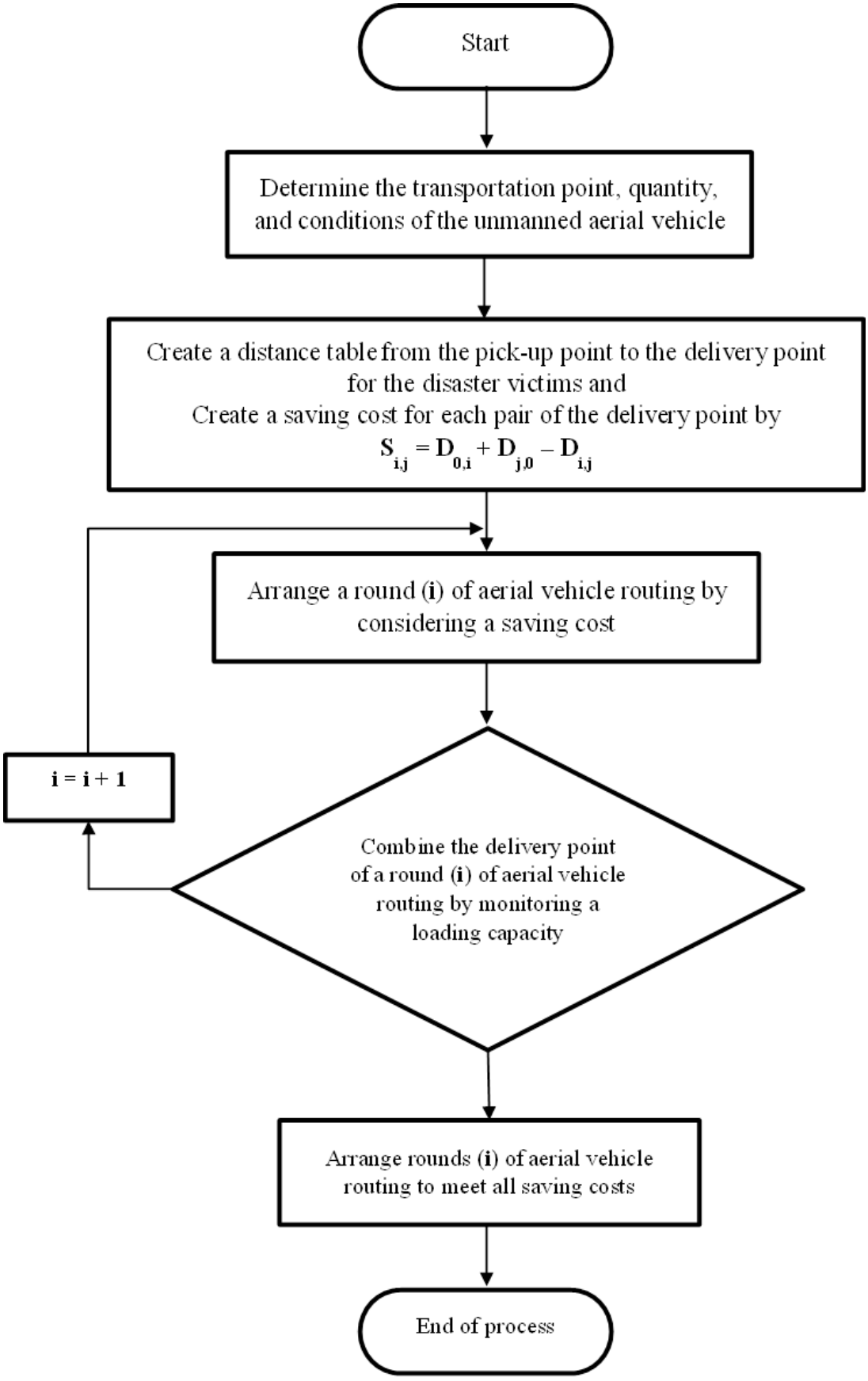

Figure 2: **Process of finding answers by a saving algorithm**.

This research has chosen the vehicle routing using a saving algorithm for finding answers by VRP Spreadsheet Solver and Add-in Microsoft Excel using Intel Core i3-7130U Processor as hardware for finding answers and routing. The findings by objectives revealed as follows;

Objective 1: to study the heuristics approach by Clark & Wright for solving vehicle routing problems. A study of a saving algorithm theory by Clark & Wright or the heuristics approach which is widely used and popular as its easy approach, even if it is probably not the best answer but applying a saving algorithm takes an appropriate time for finding answers in a limited time and suitable for flooded areas, especially in small areas. A distribution center of drugs and medical supplies, and 70 deliveries points at the community area in Bangkok, Thailand are simulated by applying the mathematical model (Moryadee et al., 2019; Bodin et al., 1983; Chiang et al., 2019). The heuristics approach by Clark & Wright and VRP Spreadsheet Solver for decreasing the unmanned aerial vehicle routing for drugs and medical supplies transportation are used for solving the problem (Sripanamvan et al., 2022).

Objective 2: to apply the heuristics approach by Clark & Wright for solving the vehicle routing problem of the unmanned aerial vehicle for drugs and medical supplies transportation in flooded areas (Chiang et al., 2019; Saengnoy & Srinual, 2018).

Conclusion

This research is a study of unmanned aerial vehicle routing for drugs and medical supplies transportation in flooded areas by using a heuristics approach by simulating flooded areas in the academy and checking the validation. The findings could be concluded as follows; applying VRP Spreadsheet Solver under the use of a saving algorithm, the routing of 70 locations was a total of 12.68 kilometers which indicated that the more time of processing, the less total routing but there were few differences of the findings, and it could be concluded that time of processing affects the findings. In consequence, creating the answers by using a saving algorithm is good for finding answers in a limited time, and applying VRP Spreadsheet Solver could be a guideline for the unmanned aerial vehicle routing, and decreasing the total routing and time appropriate with helping the disaster victims such as flooded areas. Nevertheless, this research has considered the direct variables, flight distance, and speed of the unmanned aerial vehicle excluding the consideration of loading on the unmanned aerial vehicle and unloading at the delivery point for the disaster victims.

Suggestions

Vehicle routing by using a saving algorithm is a basic of solving the vehicle routing problem which is probably not the best answer but it could be a similar answer and adaptable. To apply the other algorithms such as Tabu Search, Genetic Algorithm, or Ant Colony Algorithm, for adapting the answer after using a saving algorithm for a more effective answer. But writing a computer program for more efficiency of the unmanned aerial vehicle routing is too complicated as it needs more capacity in developing more variables of the unmanned aerial vehicle routing such as wind speed, altitude, and aerodynamics which has to calculate a total routing of 3 axes and its complication. In addition, future research should calculate the total time of the whole routing, for example, installing the equipment on the unmanned aerial vehicle, timing from the pick-up point to the delivery point, and duration at the pick-up point.

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