드론 배달 경로를 위한 효율적인 휴리스틱 알고리즘

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Efficient Heuristic Algorithms for Drone Package Delivery Route

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Abstract

Drone package delivery routing problem is realistic problem used to find efficient route of drone package delivery service. In this paper, we present an approach for solving drone routing problem for package delivery service using two different heuristics algorithms, genetic and nearest neighbor. We implement and analyze both heuristics algorithms for solving the problem efficiently with respect to cost and time. The respective experimental results show that for the range of customers 10 to 50 nearest neighbor and genetic algorithms can reduce the tour length on average by 34% and 40% respectively comparing to FIFO algorithm.

1. Introduction

Nowadays, service providers seeks for an effective routing solution for their package delivery problem that create a competitive advantage achieved by deploying all the available resources on effective short delivery distance and time. That minimizes the inconvenience for their customers.

Drone package delivery is a big promise of the future, with small flying unmanned aerial vehicle carrying goods from warehouse or truck right to customer doorsteps. A drone carries mailbox, pizza or burgers and then releases it onto the people below. Drone package delivery can traverse very difficult terrain and restricted way of transportation infrastructure with relative ease and take a much shorter route in many cases. The routing of package delivery drones are becoming the heart of many service operations. Although these tasks may seem straightforward, there are many practical problems in routing drone package delivery.

The objective of this research is to create effective routing for drone's paths by applying genetic algorithm and nearest neighbor algorithm and compare the performance of the algorithms. This result in minimizing the distance travelled and reduces cost of operation and personnel.

2. Related Work

There are several detailed studies that have been proposed and analyzed to solve different types of routing problem. It has been used as reference for different routing solution works.

Routing problem with random customer distribution is one of the hard optimization problem. The authors in [1], suggests in the stochastic routing problem, the demands of the customers follows a certain random distribution. Location-routing Problem is a kind of hard combinatorial optimization problem arose in supply chain and logistics system has been researched sufficiently. A genetic algorithm is designed to solve the stochastic location-routing problem. In this paper simulations based on numerical examples show that the proposed algorithm is effective. On the other hand, some research focus on solving routing problem by following travel salesman problem scheme. In [3], the authors proposed an improved nearest neighbor algorithm for solving TSP in Euclidean Plane. The algorithm selects a node as next target node from its multi-orientation nearest neighbor nodes, considering their distance and orientation comprehensively, and searching process repeatedly until each segment arrives at their end nodes. Experimental results indicate that the proposed algorithm greatly improves the result of nearest neighbor algorithm.

3. Problem Formulation

Based on customer request package will be delivered to customer. In this research, one customer can request only one package at a time, which means drone can deliver one package for one customer at particular time.

Here are our lists of assumptions that shape our formulation of the drone package delivery routing model:

1. We have a single central depot
2. We have multiple distributed customers around the depot
3. We need to ensure best routes for the package delivery by finding minimum distance routes to the customers
4. Each route start travel from the depot and complete the travel by returning to the depot
5. We use two types of loading capacity for the drone to carry at a time: Drone carrying two (2) packages and drone carrying three (3) packages.

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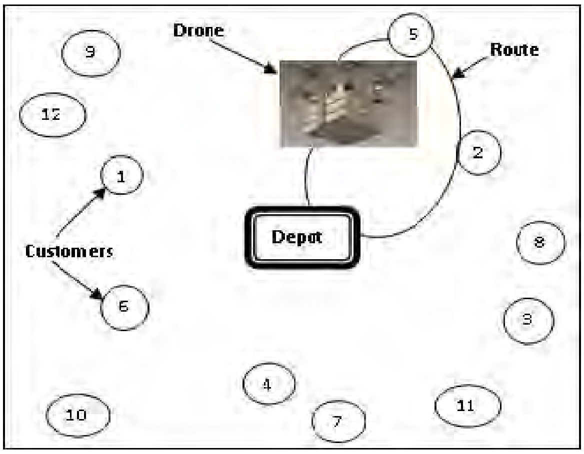


(Figure 1) Drone package delivery routing problem

4. Proposed Solution

The solution to this problem is achieved by implementing two heuristics algorithms: genetic and nearest neighbor algorithms and comparing to random FIFO algorithm.

4.1 Genetic Algorithm: Genetic algorithm is heuristic algorithms that employ the mechanics of natural selection and natural genetics to evolve solutions to problems. In our case, genetic algorithm finds a near optimal solution by searching for the shortest route, that is, the least distance needed for each drone to travel from the start location to individual customer and back to the original starting place. The proposed genetic algorithm steps are algorithmically sequenced and presented in the following way.

<Table 1> Genetic Algorithm Sequenced Steps

Input: Initial population size.
Output: The best individual in all generations.

```
Initial population individuals' selection.
Evaluate fitness of initial population.
While termination condition is false
        -Pick the best pair to reproduce
        -Perform crossover process
        -Perform mutation process
        -Insert the pair of individuals in the new population
        -New population individuals' evaluation
End while
```

4.2 Nearest Neighbor Modified Algorithm: The nearest neighbor algorithm modification for drone package delivery routing problem is formulated based original nearest neighbor algorithm. The following notations are necessary before going through the modified algorithm.

• Depot - refers to the central warehouse (in this case, the first randomly chosen customer) and it is the start and end point of all routes generated by the algorithm

• Count - refers to the number (count) of visited customer in each iteration

• Visit Capacity (N) - the number of customer that a drone can visit at a time (in other word, it is the package loading capacity of a drone)

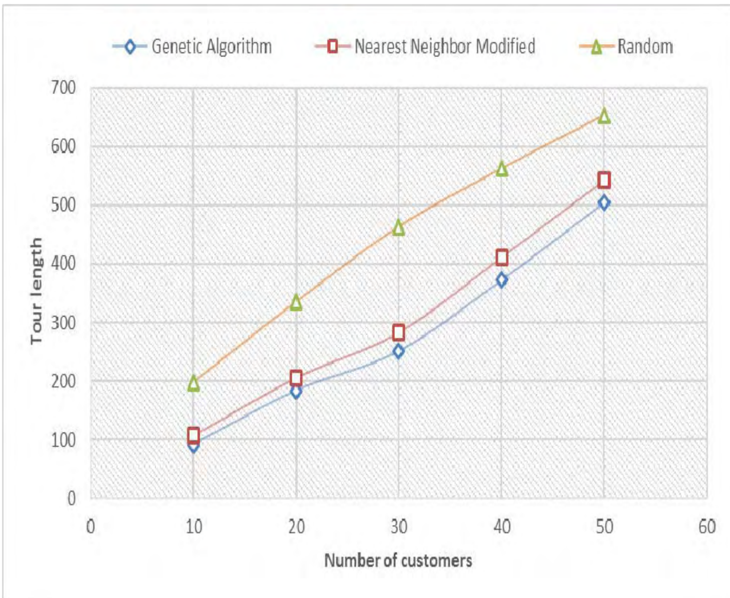
<Table 2> Nearest Neighbor Modified Algorithm

Input: Customers, visit capacity → N.
Output: Efficient delivery routes.

```
Count ← 0
Visit capacity ← N
While (unvisited customer exist)
{
 Do
   {
     -Select a first customer as depot
     -Set the depot as current customer
     -Find out the shortest edge connecting the
       current customer and an unvisited customer
     -Set the new customer as current customer
     -Mark the previous current customer as visited
     -Count ← Count + 1
     If Count equal to N then
       -Set the depot as current customer
       -Count ← 0
     End If
   }
}
Return to the depot and terminate.
```

5. Experiment and Result

This experiment involves three algorithms: Genetic Algorithm, Nearest Neighbor Modified and Random FIFO. We use five different instances of customers and two package loading capacity instances. We perform simulation using MATLAB software, version R2013a and measure average tour length of each algorithm for each instance. In the first part where package loading capacity is two, we can observe from Figure 2, genetic algorithm gives more efficient result and nearest neighbor also shows good performance but relatively less than genetic algorithm. On other side, random FIFO shows inefficient performance when compared to genetic and nearest neighbor algorithms.



(Figure 2) The algorithms comparison result of drone package delivery routing with a capacity of 2

In the second part where package loading capacity is three, genetic and nearest neighbor algorithms shows near similar performance but still genetic algorithm show more efficiency. And we observe from this result when the loading capacity of drone increases, the efficiency of these two algorithms increases. On other side, random FIFO again shows inefficient performance when compared to the genetic and nearest neighbor algorithms.

6. Conclusion

In this paper, we present an approach for solving drone routing problem for package delivery service using two different heuristics, genetic and nearest neighbor algorithms. We use different instances of customers and package loading capacity and measure average tour length of each algorithm for each instance. The result shows us genetic algorithm gives more efficient solution than nearest neighbor modified. This is due to the ability of genetic algorithm working on a population of candidate solutions instead of just a single solution and applying different fitness evaluation of the individuals result. On the other hand, random FIFO shows inefficient performance on every instance. This solution used to choose the best route of drones for delivery service. This result in reducing the total distance covered by drones which finally reduces travelling and operational cost and time of the delivery services.

References

[1] YE Wei-long and LI Qing. "Solving the Stochastic Location-Routing Problem with Genetic Algorithm," International Conference on Management Science & Engineering (14th) August, 2007 Harbin, P.R.China.

[2] Salman Yussof, Rina Azlin Razali, Ong Hang See, Azimah Abdul Ghapar and Marina Md Din. "A Course-Grained Parallel Genetic Algorithm with Migration for Shortest Path Routing Problem," (11th) IEEE International Conference on High Performance Computing and Communications, 2009.

[3] Xiang Zuo-Yong, Gao Xing-Yu, Chen Zhen-Yu, Ouyang Liu-Bo and Chen Duan-Lai. "Solving TSP Based on Multi-Segment Multi-Orientation Nearest Neighbor Algorithm," in IEEE international conference 978-1-4244-6585-9/10 in 2010 IEEE.

[4] David Pisinger and Stefan Ropke. "A General Heuristic For Vehicle Routing Problems," in Department of Computer Science, University of Copenhagen, 25th February 2005.

[5] Arunya Boonkleaw, Nanthi Suthikarnnarunai, PhD., and Rawinkhan Srinon. "Strategic Planning and Vehicle Routing Algorithm for Newspaper Delivery Problem: Case study of Morning Newspaper, Bangkok, Thailand," Proceedings of the World Congress on Engineering and Computer Science, October, 2009, San Francisco, USA.