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# Food Delivery System with the Utilization of Vehicle Using Geographical Information System (GIS) and A Star Algorithm

**B Siregar<sup>1</sup>, D Gunawan <sup>1</sup>, U Andayani<sup>1</sup>, Elita Sari Lubis<sup>1</sup> and F Fahmi<sup>2</sup>**

<sup>1</sup>Dept. of Information and Technology, Faculty of Computer Science and Information Technology, University of Sumatera Utara Jl. Dr. Mansur 9 Medan Indonesia

<sup>2</sup>Dept. of Electrical Engg, Faculty of Engineering, University of Sumatera Utara Jl. Dr. Mansur 9 Medan Indonesia

Email: fahmimn@usu.ac.id

**Abstract**—Food delivery system is one kind of geographical information systems (GIS) that can be applied through digitation process. The main case in food delivery system is the way to determine the shortest path and food delivery vehicle movement tracking. Therefore, to make sure that the digitation process of food delivery system can be applied efficiently, it is needed to add shortest path determination facility and food delivery vehicle tracking. This research uses A Star (A\*) algorithm for determining shortest path and location-based system (LBS) programming for moving food delivery vehicle object tracking. According to this research, it is generated the integrated system that can be used by food delivery driver, customer, and administrator in terms of simplifying the food delivery system. Through the application of shortest path and the tracking of moving vehicle, thus the application of food delivery system in the scope of geographical information system (GIS) can be executed.

## 1. Introduction

Geographical Information System (GIS) is used in terms of supporting the decision making for planning and managing the land usage [1]. Many companies use GIS to execute market analysis and to find the optimal delivery route [2]. The problem in finding the optimal delivery route has function to minimize the amount of transportation, supply, and resource costs [3]. Many problems occur when the food delivery process is held to each customer. One of them is the affair when customer who has already ordered foods cannot track food delivery vehicle. This causes deficits for the food delivery courier that has to pay punishment risk from customer, and the most serious case is losing customer [3]. Thus, the ability of customer to find out information and location of food delivery vehicle significantly impacts the delivery workload and the benefit from the restaurant side.

Furthermore, it is needed to develop the method to generate optimal vehicle route model [3]. The problem of shortest path is needed to find the least travel value of one or more initial nodes into one or more goal nodes inside the connected network. This problem is very crucial because of the broad scope



in its application seen from transportation side [4]. Using the Global Positioning System (GPS) technology and the advanced cellular network, the real-time vehicle tracking for the better transportation management has been possible [5].

A star algorithm was firstly initiated by Peter Hart, Nils Nilsson, and Bertram Raphael who proposed this algorithm in the year of 1968 [6]. The aim of this algorithm is to find the optimal path inside of graph by combining cost searching and heuristic feature. According to research done by Computer Science researcher from Stanford University, it is concluded that A star algorithm is very applicable in terms of combining the advance of heuristic approach owned by Greedy Best-First-Search and the advance of general algorithms, such as Dijkstra algorithm [7].

In this research, writer proposes A star algorithm to find the shortest path in food delivery system. In part II, it will be explained the problem identification of this research. In part III, it is described some previous researches that have been conducted for shortest path and LBS. Section III describes the proposed methods. Result from the research is depicted in Section V. Section VI consists of the research conclusion followed by advices for upcoming researches.

## 2. Material and methods

Method that is being proposed in this research consists of four phases, that are data input, data saving, shortest path finding, and real-time JSON parsing of vehicle coordinate.

Several assumptions have been made to limit the scope of workload in this research, which are: mapping route only covers some districts in the city of Medan, only simulates 12 restaurants, road calculation and usage are limited into main road merely and calculation in shortest path finding uses the vehicle with the equal and constant pace assumption. Moreover, the architecture of the system can be seen in Figure 1.

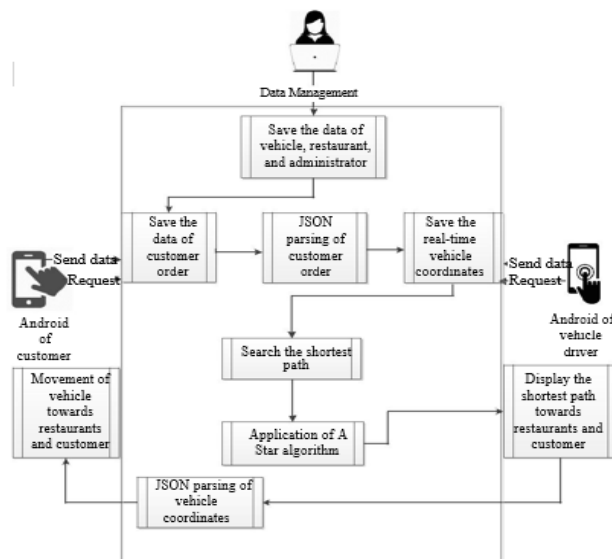


Figure 1. General Architecture

### 2.1 Data Input

In the phase of data input, there are several inputs from three elements of users, as described below: First input is conducted by admin. This aforementioned admin inputs the simulated 12 restaurant objects along with their attributes into server. Their attributes include the coordinate (latitude, longitude), restaurant address data, and others. Second input is entered by courier. This courier inputs the data and sends real-time data into server from his/her smart phone which has the built-in GPS. Third input is filled out by customers through their smart phone that has built-in GPS. This input consists of the customer log-in data, customer location, and orders.

## 2.2 Data Storage

The second phase is data storage. The process of data storage done as follows: First process covers the attribute storage of simulated 12 restaurants which have data and coordinates. These restaurant coordinates have function to simplify the ways of customer to notify the restaurant location of their choosing. These 12 restaurants eventually will have legend or restaurant badges, thus the different 12 restaurants can be easily notified by the customer. Second process is the real-time data storage and courier coordinates. Third process is data and customer coordinate storage.

## 2.3 Shortest Path Searching

The third phase is the shortest path searching by applying A star algorithm. This A star algorithm process that eventually generates shortest path as follows: Initialization of initial node and goal node. There are two paths that can be taken and marked using node. Each node will have each function  $f(x)$ ,  $g(x)$ , and  $h(x)$ .

It will be shown in each node and indicated the next node that will be visited according to cost of shortest path using formula  $f(x) = g(x) + h(x)$ , where:

- $G(x)$  is the total distance from the initial position into current location.
- $H(x)$  is the heuristic function used to estimate the distance from current location into the destination location.

A star algorithm uses the shortest path into destined node that makes it the best first search using the formula  $f(x) = g(x) + h(x)$ . As mentioned beforehand, the A star will choose the lowest  $f(x)$ . When the destined node is popped up in priority list, then the search is terminated.

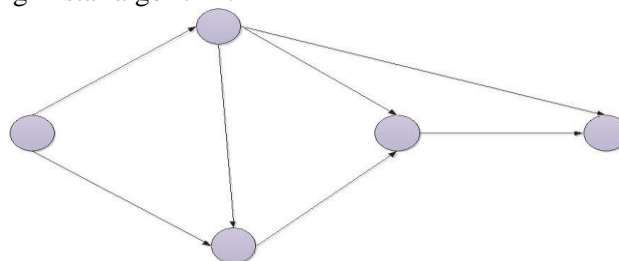
**2.3.1 Pseudo-Code of A starAlgorithm.** Pseudo code of A star algorithm used to solve this system can be seen in Figure 2.

```

Function A*(start,goal)
1   closed = empty set
2   q = makequeue(path(start))
3   while q is not empty do
4       p = removefirst(q)
5       x = lastnode(p)
6       if x in closed then
7           end if
8       if x = goal then
9           return p
10      end if
11      add x to closed
12      for y successor(x) do
13          enqueue(q, p, y)
14      end for
15      return Failure
16  end while
17 end function
    
```

**Figure 2.** Pseudo-Code of A Star Algorithm

**2.3.2 Implementation of A Star Algorithm on System.** The picture below is one of graph samples for the shortest path searching using A star algorithm.



**Figure 3.** Sample of Graph for Shortest Path Searching

The explanation of the picture above can be seen in Table 1.

**Table 1.** Explanation of Shortest Path Element

No.	Node	Coordinate	Name
1	S	1,1	Pempek Palembang Setiabudi
2	A	3,1	Intersection of Dr. Sumarsono Street
3	B	2,6	Intersection of Politeknik/ Tri Dharma Street
4	C	6,1	Intersection of Gate3, University of North Sumatera (USU)
5	G	6,5	Faculty of Medicine, University of North Sumatera (USU)

The calculation of shortest path for this case is started with the initial node of node S or Pempek Palembang Setiabudi to the goal node of node G or Faculty of Medicine, North Sumatera University (USU). Relation and distance among nodes on database can be seen on Table 2.

**Table 2** Relation and Distance among Nodes

No.	Node Relation	Distance in Kilometers (km)
1	S-A	1
2	S-B	4
3	A-B	2
4	A-C	5
5	A-G	12
6	B-C	2
7	C-G	3

#### 2.3.2.1 Heuristic Calculation

Process of heuristic calculation using A star algorithm is done with the equation below:

$$d(x,y) = |\sqrt{(x_1-y_1)^2 + (x_2-y_2)^2 + \dots + (x_n-y_n)^2}| \quad (1)$$

By applying the aforementioned equation, the heuristic result generated as follows:

A. Heuristic  $S(1,1) \rightarrow G(6,5)$   $d(x,y) =$

$$\begin{aligned} d(S,G) &= \sqrt{(x_1-y_1)^2 + (x_2-y_2)^2} \\ &= \sqrt{(1-6)^2 + (1-5)^2} \\ &= \sqrt{(-5)^2 + (-4)^2} \\ &= \sqrt{25 + 16} \\ &= \sqrt{41} \\ &= 6.4031 \end{aligned}$$

B. Heuristic  $A(3,1) \rightarrow G(6,5)$   $d(x,y) =$

$$d(A,G) = \sqrt{(x_1-y_1)^2 + (x_2-y_2)^2} = 2,24$$

C. Heuristic  $B(2,6) \rightarrow G(6,5)$   $d(x,y) =$

$$\begin{aligned} d(B,G) &= \sqrt{(x_1-y_1)^2 + (x_2-y_2)^2} \\ &= \sqrt{(2-6)^2 + (6-5)^2} \\ &= \sqrt{(-4)^2 + (1)^2} \\ &= \sqrt{16 + 1} \\ &= \sqrt{17} \\ &= 4.1231 \end{aligned}$$

$$\begin{aligned}
 d(B,G) &= \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2} \\
 &= \sqrt{(2 - 6)^2 + (6 - 5)^2} \\
 &= \sqrt{(-4)^2 + (1)^2} \\
 &= \sqrt{17} \\
 &= 4,12
 \end{aligned}$$

D. Heuristic  $C(6,1) \square G(6,5) d(x,y) =$

$$\begin{aligned}
 d(C,G) &= \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2} \\
 &= \sqrt{(6 - 1)^2 + (6 - 5)^2} \\
 &= \sqrt{(5)^2 + (1)^2} \\
 &= \sqrt{26} \\
 &= 5,1
 \end{aligned}$$

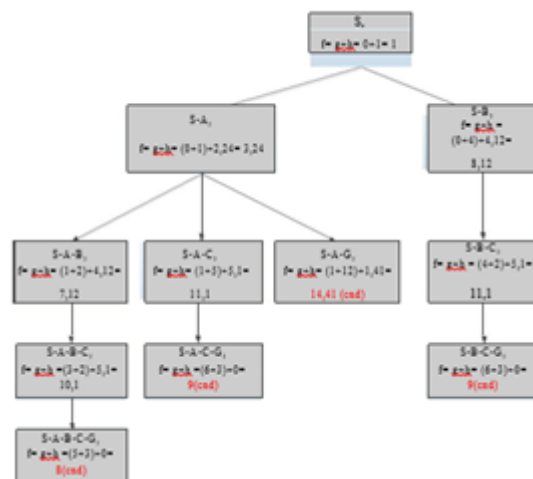
E. Heuristic  $G(6,1) \square G(6,5)$   
 $d(x,y) = 0$

**Table 3.** The Heuristic List of Each Node

No.	Node	Heuristic
1	S	1
2	A	2,24
3	B	4,12
4	C	5,1
5	G	0

### 2.3.2.2 The Calculation of Shortest Path Using A Star

After generating the heuristic through process above, The next phase is the calculation of shortest path using A star algorithm executed using the equation:  $f = g + h$ , where:  $g$  = distance and  $h$  = heuristic



**Figure 4.** The Process of Shortest Path Calculation

From the searching above, we can conclude that the shortest path from node S into node G using A star algorithm is through S-A-B-C-G with the distance weight of 8 kilometers.

### 2.3.2.3. Real-Time JSON Parsing of Vehicle Coordinate

The last phase is the real-time JSON parsing of vehicle coordinate that is helpful to track the motion of vehicle. By using this feature, thus the food delivery customer can track the movement of vehicle, the vehicle arrival time, and the distance from vehicle towards the customer location.

## 3. Results

The implementation is done using Android smart phone with Samsung Core Duos type. Implementation is done according to the interface architecture designed in both mobile and web-based application.

### 3.1 Display of Shortest Path

After user who is the vehicle driver pushes the button Find Shortest Path on layout in Figure 4.2, next thing popped up is the automatic form contains customer and destined restaurant location, as follows:



**Figure 5.** Display of Customer Location and Restaurant Name

The interface for destination with maximum number of 3 restaurants is below :



**Figure 6.** Result of Shortest Path with Destination 3 Restaurants

From the aforementioned system trial result, it can be seen that the shortest path calculation and time to display the movement of food delivery vehicle tracking really depends on the internet data transfer speed used by user. The faster the internet connection, then the faster process and the display of shortest path and the vehicle movement displayed in smart phone screen.

#### 4. Discussions

After doing all the implementation phase and trial towards the system, thus there are some conclusions generated in this research, which are: by applying the A star algorithm application to solve the shortest path case, Ojek Food Delivery system operated by user that is vehicle driver can be executed, calculation of shortest path is done with the purpose of finding the shortest path from vehicle location into restaurant and customer location in the area of North Sumatera University (USU) listed as Ojek Food Delivery customer. The second purpose is to simplify the customer way in order to choose wanted restaurant, to track the location, distance, and arrival time of food delivery vehicle, by applying the tracking application with the Java Android, PHP, and MySQL functions to implement tracking, thus system of Ojek Food Delivery can operate.

#### 5. Conclusion

Considering traffic jam element and other traffic elements in terms of determining the shortest path, system that has been designed has the purpose to simplify and to help the digitation process of food delivery system with the assistance of freelance vehicle firstly.

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