Searching Optimal Route and Water Resources for Fire Station

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Abstract

Every day a large number of human lives and properties are lost due to emergency event. If the fire breaks out, it's important to realize that the fire truck searched the right place being on fire with the right way as soon as possible. In this proposed system the Nearest Neighbor Query (NNQ) method can be used to know the nearest fire station from the place being fire if the fire news comes to the station. After getting the using the nearest fire station, A algorithm is used to calculated the optimal route. This system also checks the way to the fire area whether it can reaches or not by using the optimal shortest path. If fire engine cannot reach destination point because of street type, the system finds water resources near the emergency place using KNN method. The fire station can get sufficient information for current emergency place by using this system.*

Keywords : Nearest Neighbor Query (NNQ), A* algorithm, optimal route, GIS, Heuristic, KNN

1. Introduction

Nowadays the traffic problems are increasing due to the population increase all over the world. Thus, the number of accidents occurring in a city is also increasing. Thus, there is need to develop and plan the roads and the routes in such a way that the accidents occurring in the city can be reduced. Also, the other solution can be that the response to the accidents should be done in a proper way. A geographic information (GIS) is a computer-based analysis tool. Using these tools the system can create, manipulate, and analyze, store and display spatial information on a map. Spatial information is information about objects which are on the earth like facilities, roads, rivers, etc. GIS is widely used in planning, administration, analyzing in different organizations. GIS is widely used in government agencies, transportation agencies and emergency system.[1] Network analysis is important function is GIS which is includes the shortest path analysis, nearest neighbor query, resource allocation and many other functions.

A shortest path is critical problem in GIS system. In many GIS applications, on the shortest path analysis of real-time requirements are also higher, such as 101, fire and medical areas.

The paper intends to develop the optimal path finding for emergency cases on mobile devices. In this proposed work, the distance between two locations is calculated by using Haversine formula. The bus route information system for public transformation calculates the shortest route by using A* algorithm. The shortest path problems are among the most studied network flow optimization problems, with interesting applications in a range of fields. The problem of finding the shortest path along a road network is a basic problem in network analysis. In case of any emergency case, it is important to respond the risk and to search the emergency site in time.[5]

A* is a modification of Dijkstra's algorithm that is optimal for a single destination. A* finds paths to one location or the nearest locations. It prioritizes path that seem to be leading closer to a goal. The remainder of the present paper is organized as follows. In section 2 of this paper, background theory and system design are described and proposed work is discussed in section 3. The experiment result analysis is described in section 4. Finally, conclusion is discussed in section 5.

2. System Methodology

In order to calculate the distance between the incident location and emergency services two geographic coordinates are needed. The length of time and distance of road between the fire station and a place catches fire are calculated by using Nearest Neighbor Query (NNQ) algorithm. Nearest Neighbor Query (NNQ) as a form of proximity search, is the optimization problem of finding the point in a given set that is closest to a given point. Closeness is typically expressed in terms of a dissimilarity function: the less similar the objects, the larger the function values. Formally, the nearest neighbor query problem is defined as follow: given a set S of points in a space M and a query point q Ɛ M, find the closest point in S to q. There are the steps of the algorithm:

1. Initialize all vertices as unvisited.
2. Select an arbitrary vertex, set it as the current vertex u. Make u as visited.
3. Find out the shortest edge connecting the current vertex u and an unvisited vertex v.
4. Set v as the current vertex u. Make v as visited.
5. Terminate, else go to step 3 if all the vertices in the domain are visited.

The two points have geolocation coordinates. The earth curvalue, Haversine formula is as follow:

$$haversin\left(\frac{d}{r}\right) = haversin(\emptyset 2 - \emptyset 1) + (\emptyset 1)(\emptyset 2)haversin(\varphi 1 - \varphi 2) \qquad (1)$$

In above equation, d is the distance between two points with longitude $\varphi 1, \varphi 2$ and latitude $\emptyset 1, \emptyset 2$ respectively and
r is the radius of the sphere. Every coordinate has latitude and longitude points. The radian coordinates have been reconverted into 'x' and 'y' coordinates using following formula

x=R*cos(latitude)*cos(longitude) (2)
y=R*cos(latitude)*sin(longitude) (3)

The spherical coordinates system has earth's radius R approximately 6371km. A* algorithm is a graph search algorithm that find a path from a given initial node to a given goal node in a mapped area. It employs a “heuristic estimate” h(n) that gives an estimate of the best route that goes through the node. It visits the nodes in order of this heuristic estimate.[5] The heuristic used to evaluate distances in A* is:

$$f(n)=g(n)+h(n) \qquad (4)$$

where - g(n) is the cost of the path from the starting node to any node n and –h(n) is the heuristic estimated cost from any node n to the goal

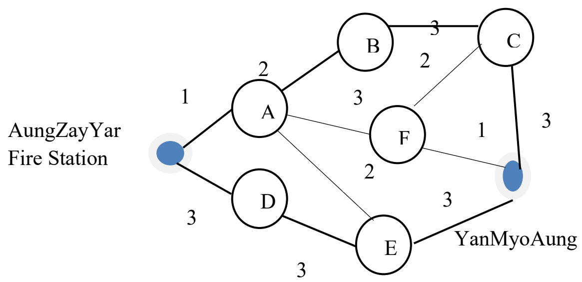

Figure 1. An example of A* algorithm

The pseudo code of A* algorithm is described as follow:

closed list=[ ] open list = [strat node]

```
do{     if open list is empty then
          return no solution    }
    n= heuristic best node
    if n==final node then { return path from start to goal
node
For each direct available node do{ if current node not in
open and not in closed list do{
        add current node to open list and calculate heuristic
         set n as his parent node}
else { check if path from start node to current node is
better;
if it is better calculate heuristic and transfer current node
from closed list to open list set n as his parent node
}
delete n from open list
add n to closed list
}
while ( open list is not empty)}
}
```

Table 1. The pseudo code of A* algorithm

If h(n) is always lower than to the cost of moving from n to the goal, then A* is guaranteed to find a shortest path. If h(n) is exactly equal to the cost of most of moving from n to the goal, then A* only follow the best path and never expand anything else, making it very fast. If h(n) is sometimes greater than the cost only h(n) of moving from n to the goal, then A* is not guaranteed to find da shortest path, but it can run faster. At the other extreme, if h(n) is very high relative to g(n), then only h(n) plays a role and A* turns into Best-First-Search.[2]

The A* algorithm was working as similar as the Dijkstra's algorithm except for its difference heuristic controls in choosing the node for every iteration. Rather than choosing the node with shortest distance path from starting node, the A* algorithm will choose the node based on its distance path from starting node with addition heuristic estimation of its proximity to the destination node.

The cost evaluations function of the A* algorithm simply adds the actual cost and the heuristic cost directly. In fact, the weights of the actual cost and the heuristic cost in the best cost evaluation function are often not equal. Therefore, setting a certain weight for the heuristic cost in different environments can improve the cost evaluation function of the A* algorithm.

3. System Design and Propose Work

In this system, it is needed to enter the emergency location and system uses this location to search the nearest fire station by applying Nerarest Neighbor Query algorithm. After that the optimal route is searched using A* algorithm which is the best search algorithm.In proposed work, it can search optimal route which bases on GIS web application for the emergency sevices. The proposed work shows in Figure.2.

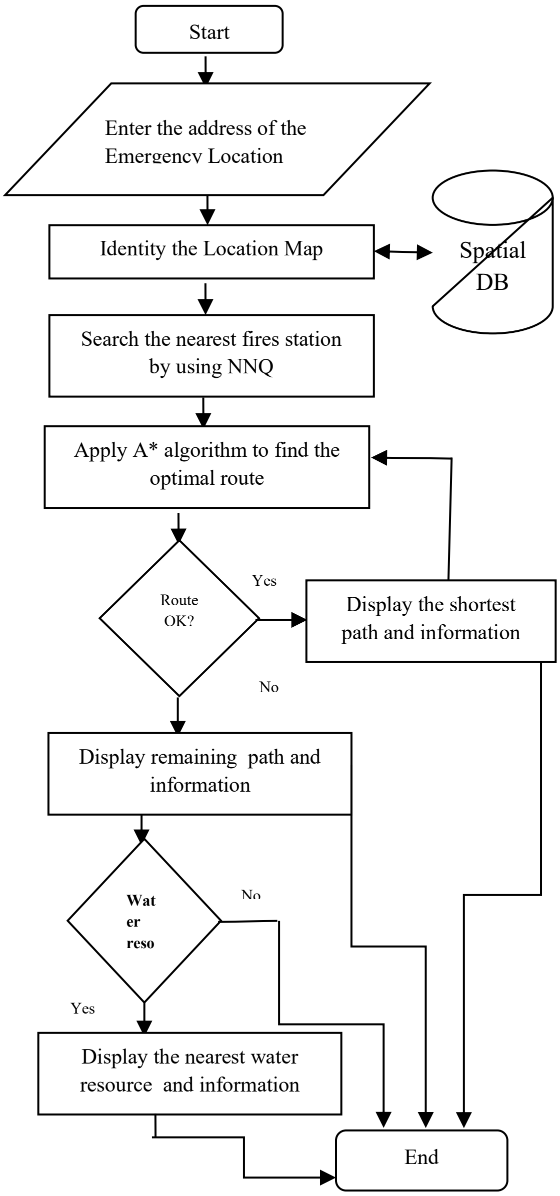

Figure 2. Flow diagram of the proposed system

When a news that the houses are on fire enters to the fire station, the station will ask which ward or which road is catched fire definitely. After inquring, it can search on map using NNQ algorithm. This map can show the nearest fire station where the places catch fire by calculating latitude and longitude from spatial database. After knowing the nearest place, it can search the nearest path by using A* algorithm in order to reach the fire place. It also calculates time for searching the shortest path. Heverisine formula is used for searching the paths between nodes. A* algorithm includes types of road. It can describe four types of road in the system. There are (A) District road,(B) Neighbourhood street, (C) Residential street and (D) Residential path.[3] The name of wards and the name and types of roads are stored in the spatial database. The table 3 shows the special type of road classification in Meiktila city.

In finding the optimal shortest path, the system checks whether the road allows the fire engine to get in or not. If the fire engine gets in the road, the system shows the path from start to goal and calculates the distance. If the road is narrow, the system expresses how many distance left between the road and goal. That will be the distance needs to connect the pipes from fire engine to the destination. If other water resources have near the emergency place, the system calculate the distance between emergency place and water resources. If resource is more than one, the system find the nearest resource using KNN methods.

The pseudo code of KNN algorithm is described as follow:

Pseudocode KNN

- Step 1:Determine parameter K = number of nearest neighbors
- Step 2 : Calculate the distance between the query-instance and all the training examples
- Step 3: Sort the distance and determine the nearest neighbors based on the k-th minimum distance
- Step 4: Gather the category Y of the nearest neighbors
- Step 5 :Use simple majority of the category of the nearest neighbors as the prediction value of the query instance

The data in this system work for Meiktila region (20º52´09.04" N 95º20´52. 39"E) which is situated in the Mandalay Division of Myanmar. It is necessary for reaching an incident place immediately for an emergency case.

Table 3. Special type of road classification

Street Type	Road class	Crossing distance (km)	Speeds)km/hr)	Width (m)
A	District road	1	30	3.67
B	Neighbourhood street	0.3	20	10.66
C	Residential street	0.1	10	9.8
D	Residential path	0.03	5	8.2
E	Other			

If so, it can protect and save the property of the public. If the fire men want to reach the emergency place quickly, they have to search the shortest path. In order to find the shortest path, they can use a system that is based on GIS and A* algorithm. Those database collected by using GPS status and a detail survey of road types and road marks. In Meiktila city such as name of 7 fire stations, 16 quarters and 1200 streets, latitude and longtitude position are stored in spatial database. Meiktila city has five main roads. They are Meiktila-Myingyan, Meiktila-Thazi, Meiktila-Yangon, Meiktila-kyaukpadaung and Meiktila-Mandalay. [3] The table 4 shows the road address and road type stores in spatial database .

Table 4.Road address and type

YanMyoAung Quarter					
No	Street Name	Junction street	Latitude	Longitude	St Type
1	YanMyoAung Street(Y)		20.887	95.867	B
2	Zizawar(Y1)		20.887	95.867	B
3		Saba(Y2)	20.887	95.865	C
4		Saba(Y2)	20.886	95.886	C
5	Ngwe Kyal(Y1)		20.888	95.9	B
6		(Y2)	20.888	95.866	C
7		SweThaw(Y2)	20.888	95.865	C
8		SweThaw(Y2)	20.888	95.865	C
9	Mingalar(Y1)		20.889	95.866	B
10		SweThaw(Y2)	20.888	95.865	C
11		SweThaw(Y2)	20.888	95.865	C

4. Experiment Implementation

4.1 Experimental 1

In this paper, the proposed system is tested on Meiktila regions, road network. After the data collection process, it is important to locate it in the map. After fire station location is marked, it is important to draw a road map. When creating a network routing system, specific spatial data were collected for the accurate completion of the network. For a complex road network, when all the roads within the network are connected, network routing is significant because it allows connection throughout the system. The program successfully finds the optimal path from the start point Aung Zay Yar fire station to the destination point Yan Myo Aung quarter. The solution has been tested with simulated road conditions and has performed exceptionally well, i.e. the A* search algorithm work every time and was able to find the optiaml path. During the emergency case, it is important to know the suitable route to travel the incident location within short time. The proposed system will provide to know the optimal route and to give the immediate response.The Figure. 3 shows the path from start to goal and calculates the distance and the sample of route information is shown in Figure. 4.

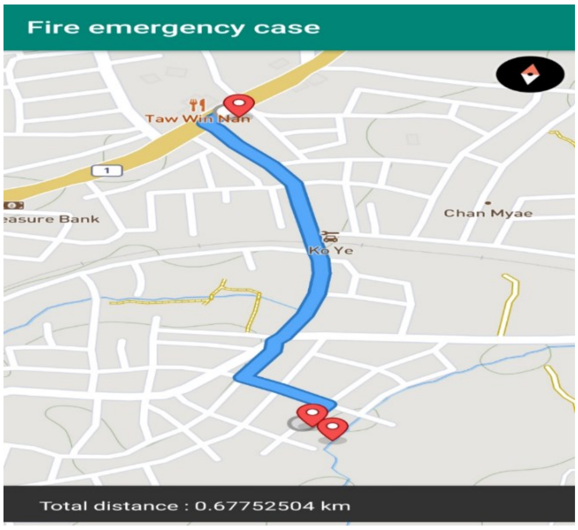

Figure 3. Shortest path two location

SrNo	From	To	Distance(m)
1	Aung San	Education College	2679.65
2	Education College	Nandaw Gone	1192.60
3	Nandaw Gone	Zay Ashae Pyin	452.96
4	Nandaw Gone	Kang Pat Street	625.92
5	Kang Pat Street	Pauk Chaung	696.04
6	Zay Ashae Pyin	Yan Myo Aung	1404.88
7	Yan Myo Aung	Wun Zin	7007.18
8	Nandaw Gone	Wun Zin	1174.83
9	Yan Myo Aung	Zaw Hospital	7007.18
10	Wun Zin	Technology University	685.55
11	Zay Ashae Pyin	Meiktila Hotel	1071.4
12	Zay Ashae Pyin	Kyee Daw Gone	213.17
13	Zay Ashae Pyin	Myo Ma	797.25
14	YanMyoAung	MAEU	1014.1
15	Myo Ma	Aung Zayar	1302.59

16	Aung Zayar	Chi Sat	707.04
18	Chi Sat	Maharsi	731.88
19	Maharsi	Computer University	2220.19
20	Computer University	Military Textile and Garment Factory	7001.8

Figure 4. Sample of route information

The System will generate the shortest path between two locations by calculating the distance based on road length. This will help the user to reduce the traveling time to reach a particular fire station. Figure .5 shows how many distance left between the road and goal if the street type is narrow. The distinction between Aung Zay Yar fire station and the fire area at Yan Myo Aung Quarter Mingalar road is 0.67752504 km far. The fire engine is taken 0.67752504/30 hours to reach there because the limitation of driving the fire engine is 30 km per 1 hour.[4]

4.2 Experimental 2

The experiment has been conducted using a special application developed in java. The sample data that used to test the shortest path algorithm is the existing bus route of Meiktila City area. This experiment simulates the navigation system to find the shortest path from the origin to the destination using the proposed algorithm.

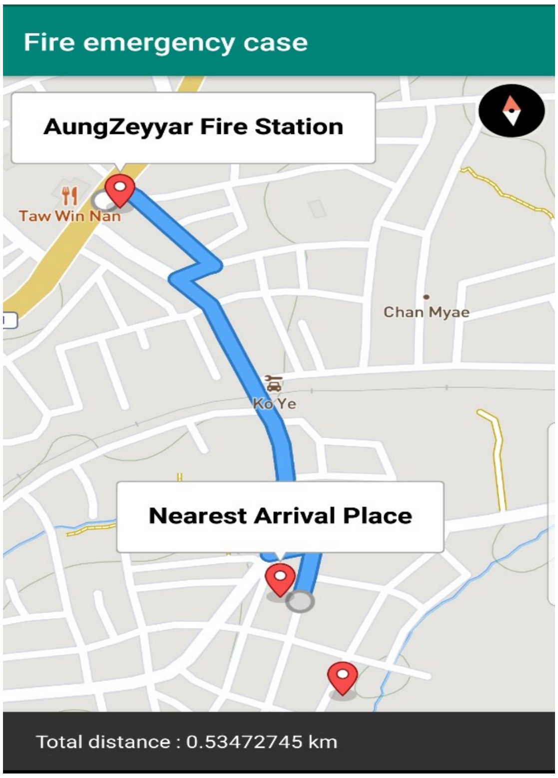

Figure 5. Distance left between the road and goal

Especially if there is a fire where the street is not accessible for fire trunk. At this time the system calculates where water resources are available and how much water pipe would be required for current fire case. This system also checks the way to the fire area whether it can be reached or not by using the optimal shortest path. If it would reaches to that area, the start and destination are shown on this system. And then the distance between the source and target area computes for displaying the information. If the way is blocks, the system computes left distance as shows as Figure. 5 the information of the length of the pipe line for firefighters. And then, it looks for water sources within 100 yards of the inaccessible places. After that, the distance to the site of the fire is calculated. The system tends to the fire truck to enter the fire, the position of the road may cause the fire to go out or retract, the fire truck is parked only where the fire exits, and the system calculates how much water there is and how much water is left. Since the firefighters had to go to the source of water and return to the fire site, the system was designed to provide firefighters, tubes, and water to prepare. It helps to find directions, place to get water.[8] The Figure. 6 shows the path of nearest water resource. This system is proposed a valid routing to a fire area in Meiktila City. If there is no routing to fire area, it can also be ckecked at least three positions where can get water to put the fire out. It can also be shown the distance between a fire area and water position throughout the putting fire out.

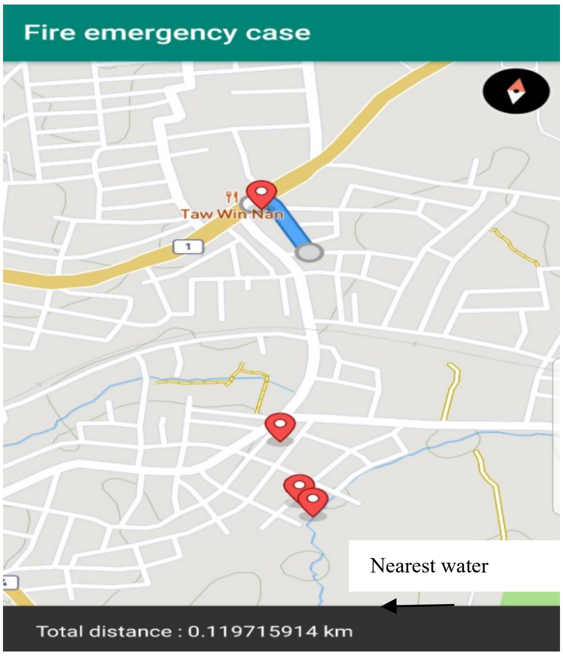

Figure 6. Show the path of nearest water resource

5. Conclusion

The propose system will provide the location of incident place or the users location, the appropriate service location based on the user request and the nearest emergency service within the shortest time. It also provides to compute the optimal ways to go to the incident place with the route distance information. This system can provide the optimal path and road information fully for the firefighters. Moreover, it also searches water resources nearby when the road cannot be gone across. Therefore, using this system will not only help in the event of a fire in the short-term, but it can also protect the lives of people by quickly extinguishing the property.

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