Optimal Route Finding to Support Fire Emergency Service

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Abstract

Urban fire is one of the most ordinary problems in all nations. Fire can cause serious damages to people and properties. When the fire event occurred, it is extremely important to reach the fire vehicles to incident site as fast as possible. To reach to the incident site in short time and fast, we need to exactly identify the incident location and need to determine the suitable route. But there are some difficulties to identify the incident location and to choose optimal route. Because the road network infrastructure of Myanmar is still weak in structure. In some townships, there are narrowed roads which could not clearly see from Google Earth and not wide enough to enter the fire vehicles and closed roads which are not passed through the other streets. These roads can cause problems for drivers and delays during the emergency cases. Another difficulty is that Google Map can't give the user desired location when we used the specific address. As mention in above, some fire vehicles can't reach the incident location in time. So, we develop GIS based optimal route finding system to support fire emergency services. This system is intended to identify the fire incident location in short time, to find the nearest fire station and calculate the optimal route to travel the incident site from fire station by avoiding the closed and narrowed roads. In this paper, the optimal route is calculated by using Dijkstra's Algorithm and we also considered the traffic condition in route finding.

Keywords: Google Earth, Emergency, Dijkstra's algorithm, Optimal Route Finding System

1. Introduction

Myanmar is exposed to multiple natural hazards which include Cyclone, Storm surge, Floods, Landslide, Earthquake, Tsunami, and Fire. Myanmar suffered most from fire compared with other natural disasters [8]. Fire is the most frequent disaster in Myanmar as on average approximately 900 cases are reported every year in Myanmar and large amount of property and lives are unfortunately lost through fire. Most of the fire cases were due to negligence, while others were caused by electric short-circuit, arson and forest fire. In 2011, total of 107 fires broke out in Myanmar. The February fire in this year destroyed 592 houses and buildings, leaved 2, 343 people homeless, killed four people and injured six others. Total of 648 fires broke out across Myanmar in the first nine months (Jan.-Sept.) of 2012, suffering a loss of 210,000 U.S. dollars. Over the period, 103 fire cases occurred in August and September, killed six people, injured 19 others and destroyed 615 houses. In 2013, 2014 and 2015 the number of fire incident cases is 1673, 1629 and 1708 respectively and we had lost several millions kyats and valuable lives per year [9].

Due to the increase of buildings, population and social development, the role of the fire service becomes more demanding. In fire emergency situation, finding the suitable route to reach the incident location in time is critical concern. It is possible to reduce the fired area and prevent the remaining unfired building when the fire vehicles reach as fast as they can. There are some difficulties in verification of incident cite based on the received information. The buildings, landmarks, street networks incorporated into the developed digital map can provide to identify and confirm the location of the incident site from receiving emergency call. If the shortest path is unknown, it is quite difficult to reach the incident site and can cause delays.

Recently, much work was carried in the application of exiting studies for emergency response system to consider the shortest path analysis. N. Kumar, M. Kumar and S. Kumarsrivastva [1] develop the GIS based transport system which assist fastest, shortest and safest route to reach hospitals within Allahabad city. Although it is possible to determine the fastest and shortest route using GIS based network analysis but it not always work as link on a real road network in a city tends to possess different levels of congestion during different time periods of a day. Geographic Information System (GIS) based healthcare emergency response system had developed to identify the optimal route from the location of incident to any healthcare service providers, and the optimal route was modeled based on the distance (the shortest path) to the closest healthcare service providers. It focuses on finding a way to quickly locate an incident or case. [2].

Route Analysis for Decision Support System [3] is proposed to find shortest route between one facility to another at the time of disaster situation. The research part of this work will comprise of Geographic Information Systems (GIS) technologies, GIS Web services and how these interact with each other. This paper [4] proposed the system to produce digital route guided maps and to improve services in case of emergencies such as accidents. This had been done by utilizing the capabilities of GIS in network analysis and visualization to enhance decision making in route selection to the nearest hospital by mapping the services area based on travel time. An overview on shortest path analysis for an effective emergency response mechanism is proposed to minimize hazardous events. Both graph theory and network analysis in GIS was discussed for the purpose of modeling and analyzing traffic networks. But, the system provides the optimal route without considering road conditions and traffic congestion [5]. Public bus transportation system is developed to calculate the shortest route by using A* algorithm. This system help to show the data to the user to select the optimal route and bus number with information of public bus transport for Yangon Region [6].

The problem of identifying the shortest path along a road network is a basic problem in network analysis. In the case of any incident, it is important to respond the risk and to reach the incident site as soon as possible. So, we proposed the GIS application to identify the incident location within short time and calculate optimal to reach that location. This proposed work can provide the effectiveness and efficiency of fire emergency service in Myanmar and can reduce delays caused by closed and narrowed roads.

The rest of paper is organized as follows. In section 2 of this paper is described overview of system design. Optimal route finding to support fire emergency service is discussed in section 3. In section 4 explain about Dijkstra's Shortest Path Algorithm and discuss about data used in this system. In section 5 discuss the result of the

proposed system on Yangon Division and conclusion is discussed in section 6.

2. Overview of System Design

This system proposes a GIS application for finding optimal routes by using Dijkstra's Algorithm. The overview of the system is shown in Figure 1. When an emergency call is coming to the system, it takes the information of the incident site such as street name and nearest landmark or residential address. By using these address information the system identify the location of the incident site. And then it determines the nearest fire station from incident site. Finally, the optimal route for fire station to incident site is calculated and the related route information will be display on the road map.

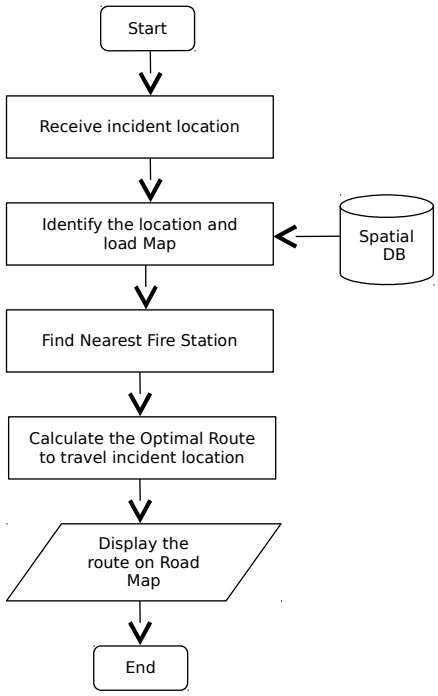


Figure 1: System Overview

3. Optimal Route Finding to Support Fire Emergency Service

Urban fire is a violent problem for both the developing and developed countries. For effective firefighting it is of crucial that to identify the fire incident and determination of optimal route to reach in the shortest time. During emergency situation, it is the most important facts to know the place where the incident occurs when we immediately receive the emergency call and to determine the optimal route to reach this location.

In this system, GIS help to determine the locations of fire station and incident site and Dijkstra's Algorithm is used to find optimal route. If the drivers mistakenly choose the closed or narrowed roads on the way to fired location, it can definitely cause delay to arrive the place in time. If we know the optimal route to reach incident location, the fire trucks can reach this location in short time if so we reduce the fired area, prevent the remaining area and save valuable human lives.

In this paper, optimal route finding to support fire emergency events has been developed for Yangon Division. This system includes a spatial-database of the fire stations and locations to identify the fire incident site. The locations of fire stations and landmarks of Yangon Region are collected from Myanmar Fire Service Department, Google Earth and GPS GARMIN etrex-10 device. The collected data are stored in Spatial-Database and used to develop this system. In Yangon Division there are 41 fire stations. In Table 1, the locations of some fire stations are described with related latitude and longitude. Figure 2 show the locations of fire stations on Google Earth.

Table 1: Sample Spatial-Database for Fire Stations in Yangon Division

No.	Name of Fire Station	Latitude	Longitude
1	Hlaing	16° 51' 01 .55"	96° 07' 28 .53"
2	Hmawbi	17° 05' 46.42"	96° 03' 25.24"

3	South Dagon	16° 51' 15 .94"	96° 13' 19 .80"
4	Mingalardon	17° 02' 31.54"	96° 08' 40. 07"
5	Shwepyithar	16° 58' 16.33"	96° 04' 36. 09"
6	Shwepyithar B	16° 57' 29.89"	96° 04' 36. 12"
7	Shwepaukkan	16° 55' 37.99"	96° 11' 04. 76"
8	North Okkalapa	16° 55' 00. 85"	96° 09' 29. 96"
9	Wabargi	16° 54' 57. 99"	96° 08' 56 .36"
10	Tarmway	16° 48' 12 .35"	96° 10' 26 .48"
11	North Dagon	16° 57' 30. 85"	96° 17' 45. 33"
12	North Dagon B	16° 52' 40 .44"	96° 12' 25 .82"
13	Sauchaung	16° 48' 14 .62"	96° 07' 58. 93"
14	Insein	16° 53' 10 .27"	96° 06' 04. 45"
15	Hlaing Thayar B	16° 52' 30. 02"	96° 04' 05. 47"
16	Hlaing Thayar	16° 52' 16. 32"	96° 02' 36 .22"
17	Mayangon	16° 52' 17. 42"	96° 09' 34 .80"
18	Thaketa	16° 47' 34 .13"	96° 12' 12 .64"
19	Bayin Naung	16° 51' 46 .94"	96° 06' 26 .49"
20	Mayangon	16° 51' 51 .44"	96° 07' 14 .07"

There are many ways for the identification of accident location by using the residential address, the nearest landmark, telephone number, etc. In this system, the accident site is identified by the street name and the nearest landmark or residential address of incident locations. The landmarks are classified into 50 categories based on their land use functions and some are shown in Table 2.

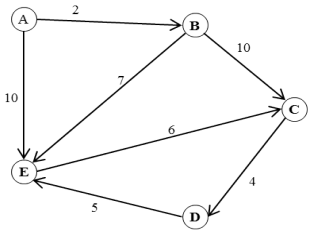
Table 2 .Sample Data for Incident Location

No	Categories	Number of Landmark
1	Bank	35
2	Church	36
3	Cinema	23
4	Collage	25
5	Gas Station	70
6	Guest House	50
7	Hospital	79
8	Hotel	77
9	Market	40
10	Monastery	30
1	Factory	60
12	Museum	7
13	Government Office	37
14	Oil Station	20
15	Shopping Center	21
16	Post Office	42
17	Restaurant	50
18	School	55
19	Store	35
20	University	27

Figure 2: Locations of Fire Stations in Yangon Division

4. Example calculation of shortest path between two nodes

When fire incident occurred, it is important to choose suitable route to travel the incident location in short time. So, optimal route finding is necessary to response the risks as fast as possible. In this paper, the optimal route between the fire station and incident sites is calculated by using Dijkstra's Algorithm that is used to find the shortest path from one node to another node in a graph [7]. Example of Dijkstra's Algorithm is described as follow.



These are the iteration steps of Dijkstra's Algorithm.

Vertices	A	B	C	D	E
Initialization	0	∞	∞	∞	∞
Step 1	0	2	∞	∞	10
Step 2	0	2	5	∞	9
Step 3	0	2	5	9	9
Step 4	0	2	5	9	9

After calculating, the shortest paths from source vertex A to all other vertices are

A to B A → B with distance 2
A to C A → B → C with distance 5
A to D A → B → C → D with distance 9
A to E A → B → E with distance 9

If source vertex is A and destination vertex is C, there will be three possible paths between these two vertices.

A → B → C
A → E → C
A → B → E → C

By using Dijkstra's algorithm, the shortest path from A to B is A → B → C with total distance 5.

5. Result of proposed system

In this paper, the efficiency of proposed system is tested on the Road Map of Yangon Division. When an incident occurs, the location information of emergency call could not determine accurately the incident location. This system will help to match address information with coordinate information to determine the place of fire incident location in short time. It will make the address query to find the accident location on the road map by using the residential address or street name and nearest landmark information. After identifying the incident site, the system finds the nearest fire station and then calculates the optimal route between the fire station and the fire incident site. After finding the optimal route, it will display the directions to travel, route information and the shortest path on road map. Figure 3 illustrates three possible routes from South Okkalapa Fire Station to Incident Site with black, green and blue lines. In this figure, the source is the South Okkalapa Fire Station and the destination is the Incident Site. By calculating with Dijkstra's Algorithm, the result of optimal route to reach fire location is shown in figure 4 with blue color.

Figure 3: Three possible routes from South Okkalapa Fire Station to Incident Site

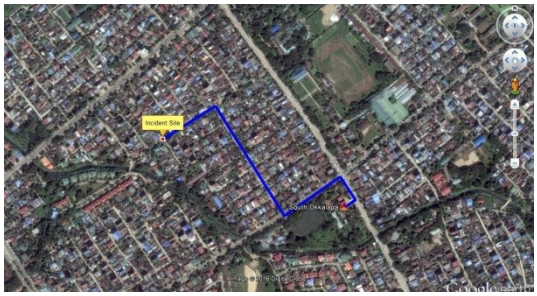


Figure 4: Optimal route between Fire Station and Incident Site

6. Conclusion

Population and the vehicles are increasing at the same time causing congestion on road networks. Besides, the closed and narrowed roads can cause delay for emergency vehicles to reach the incident location in time. The proposed system is especially designed for the problems faced by the emergency service vehicles while travelling on the road network. Our proposed system significantly solves the problem like location finding and calculate optimal route for fire emergency vehicles. This system was aimed to increase the effectiveness and efficiency of emergency services in Myanmar. The main advantages of this system is that it will make the work of the drivers much easier and make sure they get to the fire accident location within short time and we can save valuable human lives and properties.

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