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Effective Evacuation Route Strategy during Natural Disaster

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Abstract— **Nowadays, most of the countries around the world encounter affect of disasters. Disaster can occur anytime and anywhere, without giving any alarm or message. During the disaster, the rapid response and recovery activities are critical issues to save lives and properties. The effective response actions play vital role in the disaster situation because the large amount of properties and valuable lives are depending on it. But, the rescue teams and emergency organizations have many problems and delays to give the effective response to the victim areas. To reduce the risk and damage, identifying the best evacuation routes for the recuse teams is vital. The proposed system provides not only the recuse teams which locate near the victim area but also the best evacuation routes to move people from the hazard place to the safe places. This paper describes a web-based application for the best evacuation route assessment during natural disaster.**

***Index Terms*— Best evacuation route assessment, disaster situation, effective response.**

I. Introduction

Over the past years, almost countries around the world have suffered many disasters including flood, hurricanes, earthquakes, landslide, fire, etc. These can cause huge damage for people and loss a large amount of properties. The effective emergency response systems are essential to reduce the large amount risk by natural disaster. Today, all of the countries struggle and emphasize to recover and response the hazardous areas immediately. To give the effective response actions, emergency response system are needed to identify the risky area directly, provide the services or rescue teams located close with the victim location and the best evacuation route to go safe place.

In Myanmar, the major natural disaster such as floods, earthquakes, tsunamis, cyclones and landslides have been occurred. The impact of Cyclone Nargis that occurred in 2008 affected 2,400,000 people left 138,000 fatalities and estimated damage cost of US$4,000,000 to Myanmar. During this disaster situation, emergency rescue teams have some difficulties to give the effective operations of evacuation in time. To overcome the difficulties during natural disaster, the best evacuation route estimation is developed and tested. The main goal is to evacuate the people from the disaster area to the safe area in the situation of earthquake or flood.

In the case of any disaster, it is the most important to make respond and recovery actions and reach the victim area in time. Many researches and previous researches were carried in the application of exiting studies for route guidance systems. Urban fire is a violent problem for both the developing and developed countries. For effective firefighting, GIS based effective route discovery system for fire event is developed by using Dijkstra's Algorithm and the system is implemented base on the landmarks of the tested region [1].The bus route information system for public transportation is developed to calculate the shortest route by using A* algorithm. This system provides the shortest route and bus number with information of public bus transport for Yangon Region [4-6]. R. Fadlalla, et al. [7] proposed the system for producing the digital route guided maps and improving services in case of emergencies such as accidents. They 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.
Route Analysis for Decision Support System is suggested to find shortest route between one facility to another at the time of disaster situation [8]. The research part of this work will comprise of Geographic Information Systems (GIS) technologies, GIS Web services and how these interact with each other. The problem of finding the best evacuation route along road network is a main issue in the effective route navigation system. In this paper, best evacuation route assessment to provide effective migration processes in disaster situation is developed and tested.

II. Background Theories

In many route finding processes, the road network is considered as the graph, the locations or points of interest are nodes or vertices, the connection between the locations are the edges and the distance between nodes are regarded as weight

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value. Most of the graphs that represented the road networks consisted of millions of nodes and edges. When the size of road network is growing, the route finding processes take a large amount of time and the accuracy of algorithm becomes more difficult to measure. To solve the path finding problems, the shortest path algorithms are used and it might not be a simple task to find on large graphs. In fact, the path finding algorithm must respond the shortest path result with high accuracy. The optimal path finding algorithms are usually used in many researches and can be seen in a lot of applications used in our daily life. In this paper, modified Dijkstra's algorithm is proposed to improve the accuracy in route finding process.

Dijkstra's algorithm computes the shortest paths from the start node to all other nodes in the graph. The main weakness of this algorithm is that it traverses through all nodes in the graph. So, it takes much iteration and consumes a lot of time. Generally, the shortest path algorithm must produce the result as fast as possible. Dijkstra's Algorithm can find the shortest path of the road network, but does not consider the road condition. To avoid the close and one-ended road, the new variable *n_state* is added to the algorithm. To reduce the memory usage and processing time, the new condition *d[n]* == ∞ is added to original code. The proposed method is developed to reduce the visited number of nodes which are not reached from source node. It is intended to improve the performance of the algorithm and to reduce the consumption of memory space. In this work, Modified Dijkstra's is used to find the optimal route for emergency vehicles. The pseudo code of proposed algorithm is described as follow:

```
function MD(G,source,destination)
int n_state;
d[source]:=0;
q:=the set of all nodes in G;
while q is not empty:
   n := vertex in Q with minimum distance in d[ ] ;
   if n_state= =1
      remove u from q ;
   else if d[n] == ∞ || n_state == 0:
      break ;
   end if
   end if
for each neighbor v of n
   temp_d := d[n] + d_between(n, v) ;
      if temp_d < d[v]:
         d[v] := temp_d ;
         previous[v] := n ;
         decrease-key v in q;
      end if
end for
end while
return d[destination];
```

In route finding processes, the proposed method will eliminate the nodes which are not reached from the source node and the nodes with state value '0'. By applying this method in optimal route calculation, the number of iteration time will reduce and the performance of the algorithm will increase and the consumption of memory space will decrease significantly.

Computing the distance between locations is an important part of many researches which are related with geographical information system. In order to calculate the distance between two locations, two geographical coordinates are required. The appropriate method for distance calculation will depend on the objectives of the study, the nature of the data, and the type of coordinates. To calculate the distance on the spherical shape, the main issue is to account for the curvature. On the flat surface, calculating the distance between points is simple. The haversine formula is an appropriate equation to calculate distance between two points in navigation. It gives great-circle distances between two points on a sphere from their longitudes and latitudes and uses a constant *r* that represents the radius of the Earth.

The earth curvature, Haversine formula is described as follow:

$$d = 2r\arcsin\left(\sqrt{sin\left(\frac{\phi_1-\phi_2}{2}\right)^2 + cos(\phi_1)cos(\phi_2)sin\left(\frac{\lambda_1-\lambda_2}{2}\right)^2}\right) \quad (1)$$

In above formula, r is the radius of the Earth and d is the distance between two points with longitude λ_1 ,λ_2 and latitude μ_1, μ_2 respectively.

III. GENERAL ARCHITECTURE

Routing applications on urban road networks for vehicles are so useful in daily life. Effective evacuation planning and well structure road network are the essential component in disaster situation. Transportation of road network is required to search and rescue operation, to deliver the emergency supplies and services, to carry and move the victims from the collapsed shelters in case of disaster etc. Such strategies can save lives, decrease sufferings, and provide substantial savings and benefits to humanity. The general architecture of effective evacuation route response system is shown in Fig. 1. This system will provide the evacuation route not only for the people who needed to move from the risk place to safe place but also for the emergency vehicles to go the hazard place to save lives and properties in time.

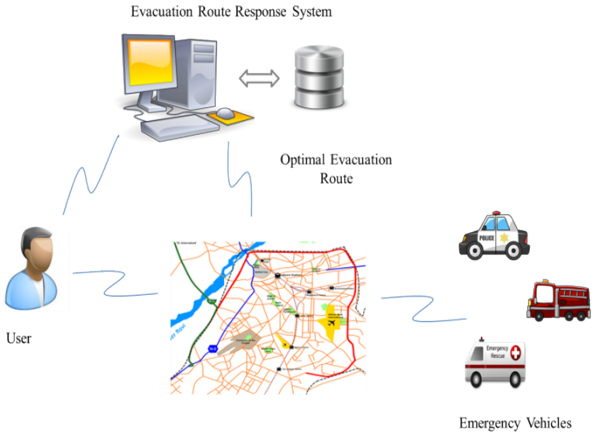

Fig.1. General Architecture

IV. System Design and Data Creation

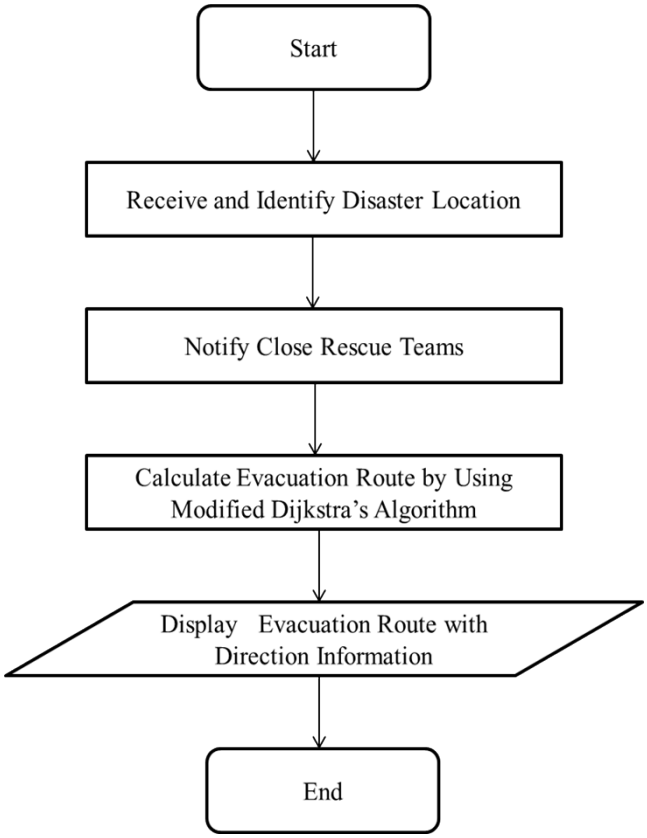

Fig.2. System Overview

The proposed system is intended to provide the best evacuation route for people and emergency vehicles during disaster situation. According to the complex structure road network and absence of best evacuation route guiding system, there are many difficulties in many developing countries. Road network transportation is important for evacuation processes, to provide the emergency facilities, to bring and transport the people from the disaster affected area to the safe places. To save valuable lives and properties, the emergency vehicles are needed to reach to the hazard area as fast as possible. Effective respond actions and evacuation processes are a vital role during natural disaster. The proposed system will provide the hazard location and close services discovery components and the best evacuation route calculation by using our proposed modified method. Overview of proposed system is described in Fig.2.

The data of road network, emergency services locations and damaged locations are prepared and stored in the database. The data used in this system are collected from related emergency service departments of Yangon Region, Google Map and GPS GARMIN etrex-10 device. The number of 41 fire stations, 47 police stations and 80 medical services are collected and used for emergency services location points. The sample data of emergency services are describes as sample in Table 1 with related geolocation. Table 2 shows the example data for incident location identification. In this work, the street names are used as address. The road network table is created to calculate the optimal route. Sample data creation of road network is shown in Table 3.

Table 1. Emergency Services Location

Emergency Service Name	Latitude	Longitude
Dagon Seikkan Fire Station	16.845701	96.265748
Hlaingtharyar_B Fire Station	16.875918	96.068839
Mingalardon Fire Station	17.046965	96.140114
South Dagon Fire Station	16.854688	96.223212
North Dagon Fire Station	16.959331	96.295907
Shwepyithar Fire Station	16.97397	96.076451
Thaketa_B Fire Station	16.807593	96.21824
Shwpaukkan Fire Station	16.928111	96.184485
Rose Hill Hospital	16.809522	96.155364
Thaketa Hospital	16.805619	96.217417
La Gabar Hospital	16.901581	96.160019
Min Ga Lar Don Hospital	16.921114	96.133447
Kan Thar Yar Hospital	16.841681	96.203544
Yangon General Hospital	16.778903	96.148975
Orthopedic Hospital	16.819436	96.122583
Workers' Hospital	16.797989	96.172372
Yangon University Hospital	16.825747	96.134581
Yangon Children Hospital	16.788158	96.136464
Bayint Naung Police Station	16.864288	96.101723
Pazundaung Police Station	16.7786903	96.1719782
Pabedan Police Station	16.7753184	96.154622
Thingangyun Police Station	16.830411	96.186589
Thuwunna Police Station	16.847473	96.186586
Botahtaung Police Station	16.7715459	96.1726236
Mingalar Taung Nyunt Police Station	16.796389	96.152754

Table 2. Location Identification Sample Data

Id	Street Name	Latitude	Longitude
1	Myanandar 1st	16.847820	96.11723
2	Myanandar 5th	16.852990	96.11611
3	Myanandar 6th	16.852390	96.11975
4	Myanandar 7th	16.852165	96.12692

5	Myanandar8th	16.851607	96.12282
6	Gantgaw 2nd	16.842031	96.12482
7	Gantgaw 3rd	16.842573	96.12632
8	Gantgaw 4th	16.842783	96.12641
9	Gantgaw 5th	16.843318	96.12559
10	Gantgaw 7th	16.844727	96.12531
11	Gonnisetyone	16.851136	96.12499
12	Hlaing Buter Yone	16.837112	96.12665
13	Hlaing Sabal	16.849316	96.11772
14	HlaingYandanar Mon	16.853857	96.11433
15	Htantapin	16.833965	96.11413
16	Kan	16.838037	96.11939
17	Kha Poung	16.838654	96.11588
18	KhaYae	16.846591	96.12651
19	KhaYae 3rd	16.846747	96.12648
20	Khine Shwe War	16.832765	96.11248
21	Padauk Shwe War 1	16.837185	96.12227
22	Padauk Shwe War 2	16.837070	96.12197
23	Padauk Shwe War 3	16.837026	96.12164
24	Padauk Shwe War 4	16.83735209	96.12113
25	Paday Tha Yazar	16.87641512	96.17377

Table 3. Sample Data for Route Calculation

From_Node	To_Node	Distance
21	23	8
21	17	32
22	25	85
23	21	8
23	22	35
24	34	40
24	23	140
25	19	42
26	25	34
27	82	114
28	39	29
29	33	74
30	22	8
31	33	83
32	33	41
34	32	96
35	13	49
37	38	256
38	36	42
40	41	116
41	37	44
42	754	81
43	367	123
44	28	152
45	44	42

V. SYSTEM IMPLEMENTATION

The research work is implemented and tested on the Yangon Region.

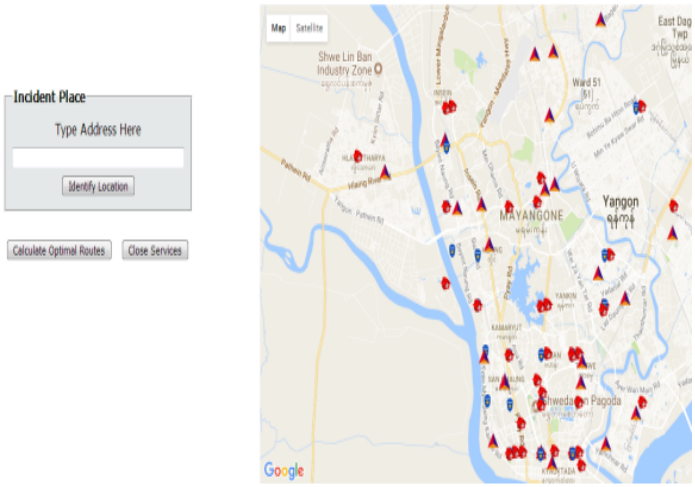

Fig.3. Emergency Services Locations in Tested Region

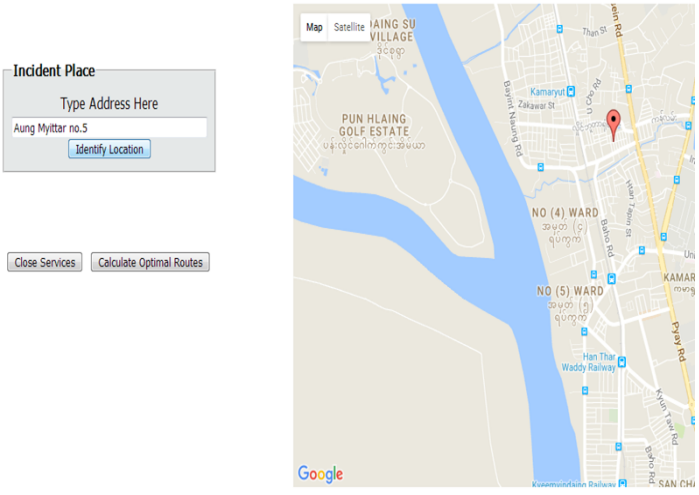

Fig.4. Damage Location Identification

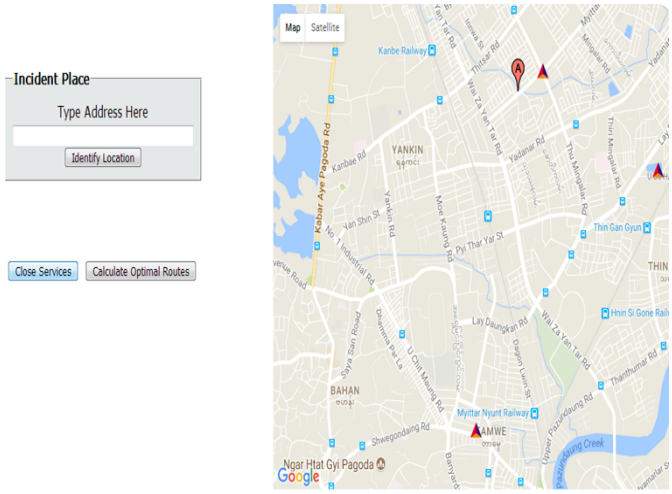

Fig.5. Defining the Close Emergency Services

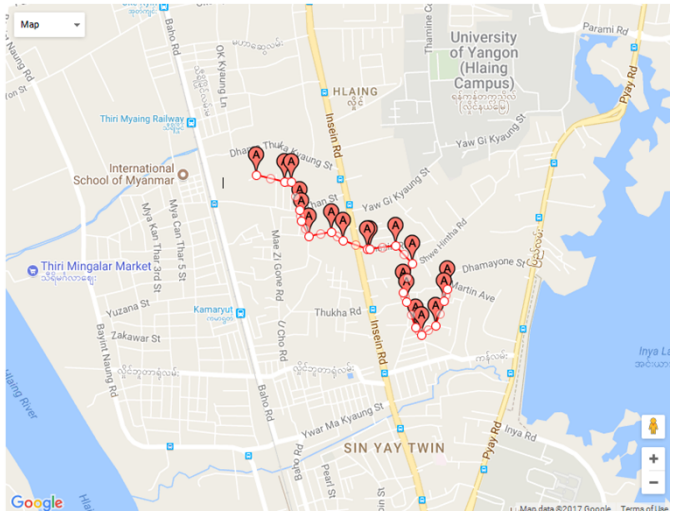

Fig.6. Showing Best Evacuation Route

The road network of Yangon Region consisted of the number of edges 87038 and the number nodes 27852. Fig.3 shows the emergency service locations in the tested region. The location identification of victim area is shown in Fig. 4 and the close services which locate near the victim area is illustrated in Fig. 5. The evacuation route to move people from disaster to go safe place or the optimal route to save people by rescue team is show in Fig. 6.

VI. SYSTEM EXPERIMENT

The effectiveness of the proposed work is tested by calculating on the road network of Yangon region with the number of edges 87100 and the number nodes 27900. The performance of the proposed method is compared with traditional Dijkstra's algorithm to prove the improved efficiency of its. The performance evaluation of the two algorithms is calculated by comparing processing time as shown in Fig. 7 and the number of visited nodes as described in Table 8.

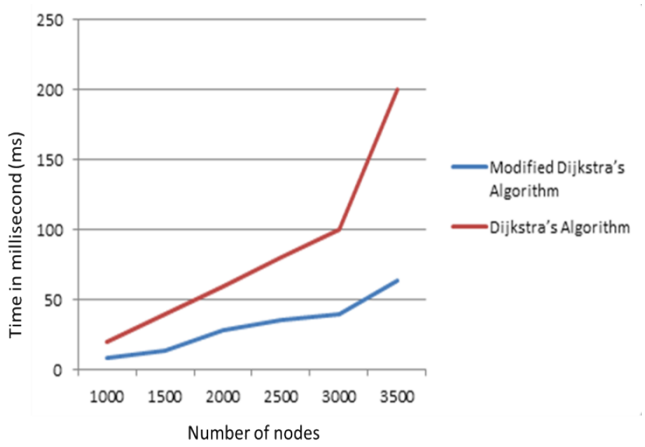

Fig. 6. Comparison of two methods in processing time

Table 4: Comparison of two algorithms in visited nodes

Proposed Algorithm	Dijkstra's Algorithm
10	25
20	36
30	45
40	61
50	92
100	137

VII. CONCLUSION

The proposed work is discussed and developed to solve the problems faced by the emergency rescue teams during natural disaster. It provides to verify the precise location of disaster area, to know the emergency rescue teams which located near the victim area and the optimal evacuation routes to transport people from the hazard location to the safe places. This system can give the significant help to the emergency rescue teams by supporting the best route to go the disaster location in time. It must improve the evacuation processes and recovery actions with effectively and efficiently. As future plan, the proposed work is advanced as mobile application according to be used in the world wide.

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