Network Analysis Using Drone Based GIS Map for Emergency Services in Incident Location at Meiktila Region, Myanmar

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Abstract: Network Analysis aims at finding solutions to routing problems related to rate of flow, and network connectivity. It helps in identifying optimum locations for services to be provided. The special analysis of transportation network is performed for Meiktila region. Data based GIS Maps are produced with Drone aerial survey method. This method provided geo-location accuracy (x-y-z) and ground sampling distance (GSD) more accuracy and high resolution than Satellite map. Total Road length and total area is calculated using the Arc Map software, using these data and road density is calculated Network Dataset is created in Arc Catalog which provides the number of Transport lines and number of junctions. It is used to calculate the Network Connectivity Indices. The purpose system is intended to verify the incident location in short time, to find the nearest emergency services and calculate the optimal route to go to the incident site. The purpose work also considers the traffic congestion based on A* algorithm.

Keywords: Shortest Routing Problem, A* algorithm, Drone System, Public facilities, Technology Innovation, GIS

1. INTRODUCTION

The Transportation System is a critical component of urban infrastructure growth of that region. It also displays region's economic condition as well as planner dedication for their region. An efficient route planning and accessibility facilitate sustainable development. This part of the paper introduces the reader to current status of the transportation system in Meiktila region.

GIS has been used in several areas such as retail site analysis, transportation [3], emergency services, fire petrol station mapping, and health care planning for the measurement of physical accessibility etc. The shortest path problem is a problem of finding the shortest path or route from a starting point to a final destination.[3] We use graphs which are mathematical abstract objects to represent the shortest path problems. They contain sets of vertices and edges. Edges connect pairs of vertices. It is possible to walk by moving from one vertex to other vertices along the edges of a graph. The graph can be a directed graph or an undirected graph. [4]The lengths of edges are often called weights. Weights are normally used for calculating the shortest path from one point to another point. We can also use a graph to represent a map where vertices represent fire stations and edges represent routes that connect the fire stations. are more efficient. Dijkstra's algorithm determines the shortest route between the source node and any other nodes and A* algorithm is much like Dijkstra's but it relies on heuristics strategy. The remainder of the present paper is organized by sections 2, 3, 4, 5 and 6. Section 2 describes the basic representative network structure. Section 3 describes the applied

A*algorithm method and related function for this method. Section 4 briefly explains about road density and study area. Section 5 discusses about how to do experiment the proposed system on Meiktila regions. Finally, section 6 presents conclusion of the proposed system.

2. PROBLEM STATEMENT

A graph is a pair, G = (V,E),of sets satisfying E Ɛ [V]; thus, the elements of E are 2-element subsets of V. The elements of V are the nodes of the graph G, the elements of E are its links (or edges). In this case, E is a subset of the cross product V×V which is denoted by E Ɛ [V]. A connected graph is a non-empty graph G with paths from all nodes to all other nodes in the graph. An optimal path from node u to node v is the path with minimum cost, denoted by (u,v). The cost can take many forms including travel time, travel distance, or total toll.

2.1. A* algorithm

Optimum A * algorithm is used to search for the nearest public transportation route. A* algorithm is an algorithm that has been enriched with a heuristic function. The heuristic function is used as an optimization algorithm that makes this algorithm is superior when compare with other algorithm.

A* algorithm is similar to the BFS, as it will visit in depth for the selected node is considered the best. If the node was visited not lead to a solution, it will return to the previous node to destination node find other, more promising. Process back to the previous node will recur if not find the destination node that leads to the solution.

2.2. Heuristic Function

An admissible heuristic is used to estimate the cost of reaching the goal state in an informed search algorithm. In order for a heuristic to be admissible to the search problem, the estimated cost must always be lower than or equal to the actual cost of reaching the goal state. The search algorithm uses the admissible heuristic to find an estimated optimal path to the goal state from the current node. For example, A* search the evaluation function is

$$f(n) = g(n) + h(n) \quad (1)$$

where
f(n) = the evaluation function at node n
g(n) = the cost from the start node to the current node
h(n) = heuristic estimated cost from current node to goal

h(n) is calculated using as a heuristic function. h(n) is admissible if h(n) ≤ h*(n). h* (n) is the optimal cost to reach a goal from n.
With a non-admissible heuristic, the A* algorithm can still overlook the optimal solution of search problem due to an over estimation in f (n).

3. SYSETEM DESIGN AND PROPOSED WORK

The system design for optimal route is as shown in Figure 1. In this system, it is needed to enter the emergency location and system uses this location to search nearest fire station by applying Haversin function. After that the optimal route is searched using A* algorithm which is the best search algorithm.

In order to calculate the distance between the emergency place location and rescues station, two geographic coordinates are needed. Both locations have their geolocation coordinates.

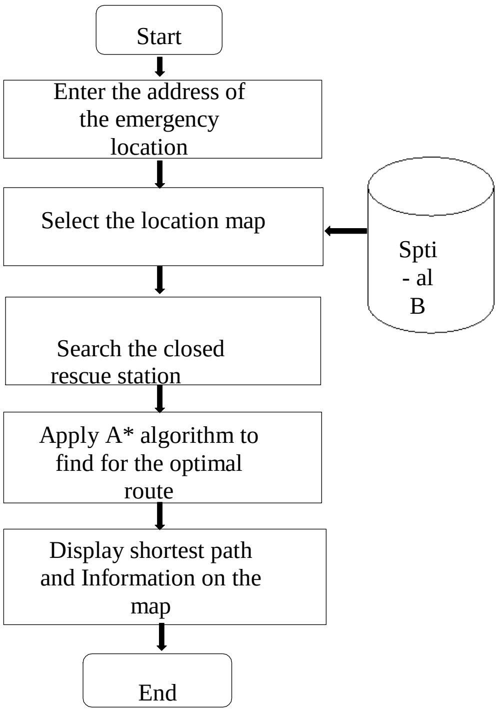

Figure 1: Flow diagram of the proposed system

The earth curvature, Haversine formula is as follow.

$$\text{haversin}\left(\frac{d}{r}\right) = haversin(\emptyset_2 - \emptyset_1) + (\emptyset_1)(\emptyset_2) haversin(\varphi_2 - \varphi_1) \quad (2)$$

where

d is the distance between two points

r is the radius of the sphere

φ_1, φ_2 are latitude of point 1 and point 2

ψ_1, ψ_2 are longitude of point 1 and point 2

haversin is the haversine function

haversin function works as follows:

$$h(\theta) = sin(\theta/2)^2 = \frac{1 - cos(\theta)}{2} \quad (3)$$

On the left side of Eqation (2), the argument to the haversine function is in radians. In degrees, haversin (d/R) in the formula would become haversine(180° d/πR).One can then solve for either by simply applying the inverse haversine (if available) or by using the arcsine (inverse sine) function:

$$d = r\, haversin^{-1}(h) = 2r arcsin(\sqrt{h}) \quad (4)$$

and $d = 2r\ arcsin$

where h is haversine(d/R)

3.1. The Path Finding Algorithm

A* algorithm is the simplest path finding algorithm, event through these days a lot of other algorithms have been developed.

A* algorithm reduces the amount of computational time and power needed to find the optimal path. The algorithm strikes a balance by calculating a path which is close to the optimal path that is computationally manageable. The algorithm breaks the network into nodes (where lines join, start or end) and the paths between such nodes are represented by lines. In addition, each line has an associated cost representing the cost (length) of each line in order to reach a node. There are many possible paths between the origin and destination, but the path calculated depends on which nodes are visited and in which order. The ideas is that, each time the node, to be visited next, is selected after a sequence of comparative iterations, during which, each candidate-node is compare with others in terms of cost.

The following is an application of the algorithm on a case of 6 nodes connected by directed lines with assigned costs, explains the number of steps between each of the iteration of the algorithm(Figure : 2). The shortest path from node 1 to the other nodes can be found by tracking back predecessors (bold arrows), while the path's cost is noted above the node.

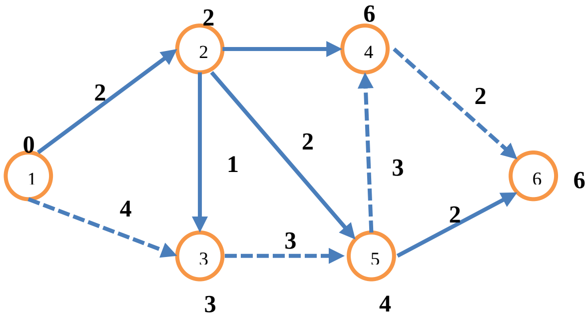

Figure 2 : An A* algorithm

3.2. Network Analysis

A network is a system of interconnected elements such as lines (edge) and connecting junction (better or points(which represent ever possible route from one junction to another junction from a feature class network dataset is create but it is restricted that form only one feature class can create only one Network Dataset. The ArcGIS network analyst extension allows to build a network dataset and perform analysis on a network dataset. GIS database building and data linking with non-spatial data were done after digitization and geo referencing. Using the database, network analysis was carried out to find out.

- Shortest path between any two destination
- Closest facility and
- Service area

3.3. Drone Based GIS Method

Drone aerial survey method is used widely all over the world. There are three process of this method included with ground survey, drone aerial survey and data processing. In ground survey section , the surveyors need to use the Real-time Kinematic (RTK) ,leveling equipment. Depend on the ground condition, the surveyors have to measure five points of the RTK GPS per one square kilometer for (X-Y geo-location accuracy).For Z geo-location accuracy, it is necessary to measure level points .After that, the target board must be placed to find clearly when the drone flying survey. Drone will capture the photo included with target board according to preflight plan automatically. After flying, the data will be collected and processing with data processing software to get output such as Orhomoasic, Digital Surface Model (DSM),Digital Terrain Model(DTM),Digital Elevation Model and Contours. This Method ,had been used in Meiktila Region to get high geo-location accuracy about 8cm (X-Y-Z) and ground sampling distance 10 cm/pixel.

3.4 The Structural Analysis of Road Network

A digital transport network with complex mathematical model is the basis for transport analysis and urban growth. The network is a representation of major routes within the routes within the area. This digital network is the input to the transport analysis and to identify urban growth, which contains vertex (Node / point / junction) and Edge (Arc / Line /Link). This is use identify the start and end point of any routes.

Every vertex(v) and Edge (E) is a record that is used to represent the characteristic of a road. In traditional GIS a Toposheet was the only medium which was available to visualize the Transport Network. Generally Transportation planning consistes of a various individual modules. These modules can be road type (width of road), pavement, traffic management and accident related data. As per the population with that area the transport network structure should be redesigned. This may be to increase road width, make one way and identify the parking area. The use of GIS technology in development of Urbanization, the transportation information system and management can provide a very strong solution. Information Desiging, Construction, Maintainance and Management of the transport system. Meiktila region transportation network consist the major road (primary road), main road (secondary road) and other road.

3.5. Emergency Service Stations' Information

The emergency services stations' information can be obtained by visiting the desired fire stations and taking the important information about the provided facilities and the specialty of fire stations etc.,. The attribute data like name of fire stations, contact number specialty etc., are need to be stored in the separate database. The data required is in the form of spatial and attribute data. Spatial data required is road network and the fire stations. Attributes taken for Fire Station such as Name, Contact number are collected by surveying of each emergency services station.

In this paper, the emergency stations information (latitude, longitude position of fire stations and hospital) for Meiktila downtown regions stored in spatial database as shown in Table 1.

Table 1: Some Emergency Services Location in Spatial – Database

No	Longitude	Latitude	Rescue Stations sName
1	95º20´52. 39"E	20º52´09.04" N	North of PyiTharyar Quarter Fire Station
2	95º18´53. 44"E	20º51´06.25" N	East of Market Fire Station
3	95º23´16. 56"E	20º52´20.55" N	AungZeyar Fire Station
4	95º20´52. 24"E	20º52´34.92" N	AungSan Fire Station
5	95º21´15. 06"E	20º52´38.15" N	Thee Gyone highway road Fire Station
6	95º20´50. 65"E	20º52´53.10" N	Big Marke Fire Station
7	95º20´41. 02"E	20º52´40.8"N	Meiktila Industrial Zone Fire Station
8	95º51´34. 16"E	20º53´11.25"N	Zaw Hospital
9	95º50´44. 66"E	20º52´33.13"N	Shin Than Chin Hospital
10	95º51´37. 06"E	20º52´42.87"N	Soe Moe Hospital
11	95º51´37. 06"E	20º52´41.71"N	ThuKaHtila Hospital
12	95º50´36. 57"E	20º52´32.68"N	Public Hospital

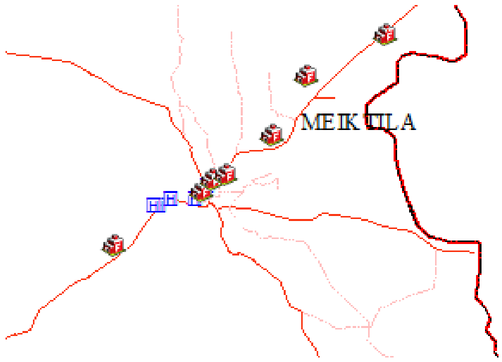

Figure 3 : Location of Emergency Services

3.6. Network Dataset

Spatial data from Geographic Information System database is used more and more in transportation due to the convenient structure they provide for entering, viewing and manipulating spatially-oriented data. Application of GIS in the traffic safety area has been limited mostly to visual representation of accident locations.

Network dataset is built mainly from two GIS data layers. They are major road networks which are captured as line features, and junctions and important landmarks that as point features. These two are playing prominent role in keeping network alive at all time. Road network is properly connected in GIS with junctions and important landmarks. Necessary attribute data such as name of roads, length of roads, name of the junctions and important landmarks have been given as input in network dataset. Exclusive module available in ArcGIS software is used to build network data from the above line and point features. While building the network dataset, proper connections between road and junctions are checked and any violations are flagged for rectification of errors. After achieving error free data, the dataset is used to find out shortest path , closest facility and service area within the Meiktila limits.

Table 2: Some Emergency Services Location in Spatial – Database

Sr.No	Major Roads
1	Meiktila -Myingyan
2	Meiktila-Thazi
3	Meiktila -Yangon
4	Meiktila -Kyaukpadaung
5	Meiktila -Mandalay

3.7. Shortest Path Analysis

A shortest path problem is finding a path with minimum travel distance from one or more origins to one or more destinations through a connected network. It is an important issue because of its wide range of applications in transportation networks. In some applications, it is also beneficial to know the second or third shortest paths between two nodes. For instance, in order to improve the effectiveness of travel information provision, there is a need to provide some rational alternative paths for road users driving in real road network. Having built the network GIS data layers, shortest path between any two destinations can be efficiently found. The shortest path takes into account road distance and not radial distance. It is also possible to find out a route which has the least travel time. In the case of travel time based shortest path, the impedance is to be given based on the road condition, vehicle type and other influencing parameters. In the present case, the best way to get from one location to another was worked out based on road distance where the destinations can be chosen by the user interactively. It has also been built in such a way that due to any reason if the road is closed, the user can introduce a barrier interactively. In such situations, the best possible alternative route is identified and made available to the user along with the distance he has to travel.

3.8. Closest Facility Analysis

Closest Facility workers on two different entities such as facility and incident. Incident is considered as place of interest from where system searches facilities within the user –specified road distance. For one incident, there may be many facilities from which, closest facility may be picked up for the purpose. At the same time, it continues to search for the next closest facility and this process is repeated and all the facilities are identified within the user-specified maximum road distance.

3.9. Service Area Analysis

One can find service area coverage around any particular location. If a hospital has certain norm of servicing only up to 1.00 km road distance the service area around selected hospital can be demarcated at all directions through road network model. The same concept can also be applied to find out the service area of schools, fair price shops, police stations, etc. based on selected norms.

3.10. The solution of Traffic Jams

To solve the problem of overloading of traffics, detour can be used. If so, it can solve traffic jam in junctions which already have been in the critical stage. The following are the suggestion for the easing of traffic jams.

(a) To eliminate and remove tea shops, venders, slow vehicles parking, temporary market, all buildings within the limit of road boundaries.
(b) To extend the limit of road boundaries for free movement, traffic pavement nets should be constructed on both sides of the road.
(c) If over bridges with a single lane can be constructed, the problem of traffic jam at junction can be solved.

4. ROAD DENSITY AND POPULATION DENSITY OF THE STUDY AREA

The road density of the study area is calculated by relating the total density to the total area. This is represented mathematically as

$$RD = L / A \quad (5)$$

where (L=total length a network, A=total area of network), 169.9 km/ 27.52 km= 6.1736 km. This analysis showed that the road density was high comparing it with the standard as highlighted in Meiktila region. This can be seemed in the road network of the study area where by the roads were even by distributed.

4.1. Connectivity

Connectivity is based on topologic distance. The relative degree of connection between all vertices is defined as the connectivity of the network. There are three types of measure that can be used. They are the Beta Index, the Alpha index and the Gamma index.

The Beta index- The simplest description of increasing complexity is to relate the number of edges and vertices in a ratio of E/V. This Beta index differentiates simple topological structures (with low beta values)from complicates structures (with high beta values.) The lower portion of the Beta scale (from zero to one) differentiates between different types of branching networks and disconnected network. Values of one and above differentiate as circuit network.

The Beta index = E/V, where E=Edges, V= Vertices

There are 279 edges and 280 vertices in this network.

Therefore the Beta index for road of wards network of Meiktila region is, E/V=279/280=0.996=99.6%

In Meiktila region , there are total 10 wards and these are named an ward 1 to 10. Among these ward 5 has a largest area. Ward 10 is second largest area, ward 9 is third largest area. Ward 7 is four largest area and Ward 1,2,3,4,6 and 8is medium and small areas. Ward 5 are very high connectivity and ward 8 has low connectivity. So ward 8 is identified as an un-development. The study reversals that the Meiktila City is medium transportation facilities.

4.2. Population Density

Meiktila, situated in Mandalay Division has 475.34 m^2. It is about 30 miles from East to West and 22 miles South to North. The city is about 11.08 m^2. There are four main roads. Not only citizens but other travelers use these roads everydays. Then, it is a simply crossing point between Yangon, Mandalay, Bagan and Inle lake. Moreover, it is also a significant trade centre. So, there are so much traffic especially at junctions.

Need to find the shortest path for emergency case at downtown. Need to choose type of road to pass through depending on cases. E.g Fire case or accidence

Because of population density and road density, the user needs to use this system to overcome the bad result. If there are schools, universities, banks, markets on the main road, traffic jam occurs more and need to use other paths to reach destination. Traffic lights on the roads are also needed to be considered especially the length of time. The equation of population density is:

Population Density=

Total number of people / Total land area (km^2) (6)

Table 3: Population density of 3 Quarter in Meiktila region

SrNo	Quarter	Population	Width (km^2)	Population Density
1	MyoMa	3305	0.259	331
2	Yadamaanaung	6603	0.337	508
3	Aungzayyar	10979	0.984	289

5. EXPERIMENTAL RESULTS

In this paper, the proposed system is tested on Meiktila downtown regions, road network. After the data collection it is important to locate in the map. After Fire Station location is marked it is important to draw a road map. The Figure(3) shows the Toposheet of the Meiktila region.

Figure (4) shows Quarters that may take place incident. When creating a network routing system, specific spatial data were collected for the accurate completion of the network. For a complete road network, where 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 AungZayar fire station to the destination point YanMyoAung quarter in Figure (6). The solution has been tested with simulated road conditions and has performed exceptionally well, i.e. the A* Search algorithm worked every time and was able to find the optimal path.

A menu driven interface has been designed and implemented to simulate the road blockage condition which can be due to heavy traffic, road construction, or bad weather condition. The calculated optimal path is then displayed on the console, giving step by step directions from the start to the destination. Only if all roads are active, the program successfully finds the optimal and shortest path.

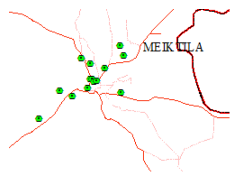

Figure 4 : Location of 14 Quarters

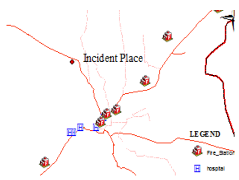

Figure 5 : The closest emergency services

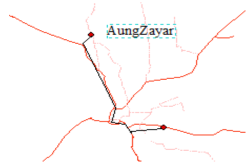

Figure 6 : Optimal route between Incident Location and AungZayar Fire Station

6. CONCLUSION

The developed system is tested on the Road Map of Meiktila region. The propose system will provide the location of incident place or the user location, the appropriate service location based on the user requested and the closest emergency service within the shortest time. It also provides to compute the optimal ways to go to the incident place with the route direction information. Thus the user should use this system to find the shortest path in many emergency cases. Because it is very useful and can give advantages for the user.

7. REFERENCES

1. Amrapali C. Dabhade, Dr. K. V. Kale, "GIS Based Health Care Information System for Aurangabad City", International Journal of Engineering and Innovative Technology (IJEIT) Volume 4, Issue 1, July 2014

2. D Eunice Jayashree, J. Jeffi Rose , Dr.M.Stalin, "Geo Spatial Distribution and Medical Information System for Central Government Scheme", Volume 54, Number 1 December 2017

3. Ajay D. Nagne, Dr. BhartiW.Gawali, "Transportation Network Analysis By Using Remote Sensing And Gis A Review", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622, Vol. 3, Issue 3, PP.070-076, May, 2013

4. Usman Ado Kibon and M. Ahmed "Distribution of Primary Health Care Facilities in Kano Metropolis Using GIS (Geographic Information System)", Research Journal of Environmental and Earth Sciences, Volume 5 Issue 4,PP.167-176, 2013

5. M.MuthulakshmandM.M.Shanmugrapriya, "Shortest Path Algorithm and its Implementation", International Journal of MathematicsTrends and Technology ,Volume 36, August 2016

6. Aljoufie, mohammed. " Development of a GIS Based Public Transport Composite Social Need Index in Jeddah." Journal of Geographic Information System 8,no.04,2016,pp.470.

7. Roozbeh Shad, Hamid Ebadi, Mohsen Ghods. "Evaluation of Route Finding Methods in GIS Application", International Journal of Computer Applications (0975 – 8887) Volume 53– No.10, September 2012.

8. Tao Peng and Xiaowen Wang, "A Mobile-based Navigation Web Application: Finding the Shortest-time Path based on Factor Analysis", June 2012