《研究ノート》

Smartphone based Emergency Reporting and Response System in Myanmar

Dim En Nyaung

Kazunori Yamaguchi

[Abstract]

　　　　The emergency case reporting and finding the shortest path to incident place is developed in this paper. The emergency never comes with prior information.　Therefore, how to report the authorize agency in time becomes an important factor in developing countries. And the proposed system is to overcome common problem of having manual intervention while reporting emergency case by location-based services. As a result we can maximize the ability to respond the hazard incidents. The system works on the principles of client-server system: submitting the emergency case, shortest route calculation, and reporting it to the relevant agency. The users involved in an emergency situation can also retrieve the shortest path to the agency, e.g. a hospital. The Sever is implemented as a Web Based Java Application. The shortest path is searched by the Dijkstra's Algorithm and displayed it on Google maps in appropriate scaling. Location Coordinates and messages will send on each request by Android Application. For creating the vector map for shortest route, QGIS (Quantum Geographical Information System) is used as GIS Tool. Based on the integration of Web Services, XML and PostgreSQL for Spatial Network Database (SNDB), the optimal routes from location of authorized agency to incidents site was developed. Moreover, it can support the collection and statistical presentation of emergency and accident data for further analysis.

Key words: smartphone-based emergency report, Dijkstra's algorithm, GIS

I　Introduction

　　With the development of technology, everyone can use Internet easily from mobile devices. Technology can save the daily life of citizens and the location-based information system can support many beneficial for citizens. Therefore, the emergency reporting from mobile device can be a useful application for developing countries. Recently, the mobile devices become the most powerful communication device in Myanmar. Therefore the system that can report the emergency case by smartphone and responding system becomes a challenge topic in Myanmar.

　　Emergency can cause people to the loss of life or property, to the harm of the physical integrity of individuals, or to damage of property. The emergency situation is different with disaster case. Emergency situation is a typically event that can be handled by local authorities (police, ambulances, fire departments), whereas disasters are situations, in which damage with serious consequences occur on a regional or national level and affect the population. This paper focused on emergency situations that can be handled by local authorities. To take the prompt action of the emergency case, the shortest path will be

the main part of this system. Geographic Information Systems (GIS) was designed to support geographical inquiry and spatial decision making.

Traditionally, we call to emergency dispatcher whenever there is an emergency case. And the emergency dispatcher has to take notes of the emergency location, which can be a problem because addresses may be confusing and not really well organized. Besides they need to try to understand the emergency situation. A location-based system can greatly improve mutual understanding of where the emergency happened and the shortest path on the map (e.g. Google Maps) will improve the decision making for where to go next. This will result in reducing damage to both people and property of the citizens of emergency happens.

Dijkstra's algorithm is the most powerful algorithm for determining the shortest path and it is not too complicated to implement. With the combination of Dijkstra's algorithm and GIS technology, we can provide the emergency response system so as to extend the response to hazardous occurrences. The Spatial Network Database (SNDB) in emergency response arises directly from the benefits of integrating a technology designed to support spatial decision making into a field with a strong need to address numerous critical spatial decisions. For this reason, new applications of GIS in emergency management have also flourished in recent years along with an interest in furthering this trend.

This paper aims to develop the emergency report and response system by combining the web services with GIS technology. To study how to create the vector and raster map for creating the shape file. To find the optimal shortest route by using spatial data and displaying it on the online map (e.g. Google Maps).

The remaining paper is structured as follows. Section 2 presents the Graph Theory and Dijkstra's Algorithm. Dijkstra's Algorithm is not too complicated and can find shortest path on the map or application on the network. Section 3 represents the architecture and functional detail of the proposed system. The implementation of detail system will explain on this section. Finally, section 4 concludes the paper with possible enhancements to the proposed system.

II Related Work

The recent advances in mobile communication and mobile information systems have had a significant impact on the development of Emergency Response Systems. Shortest path query is an important problem and has been well studied in static graphs.

M.H. Hsu et al., developed a GIS based decision support system to enhance the emergency operations during typhoon attacks in Taiwan. M.H. Xu et al., makes some changes in the original Dijkstra's algorithm and obtains a new improved Dijkstra's shortest path algorithm. O. Berman et al., presented a novel methodology to determine

the optimal design of a specialized team network so as to maximize its ability to respond to such incidents in a region.

V. Shekar and L. Fiondella described dynamic transportation algorithms possess applications in disaster planning an emergency response. And also described the extracting static maps from widely used open source maps file formats such as Open Street Maps (OSM). To construct the dynamic (time-varying) demand profile of a transportation network, developed a smartphone app to anonymously collect the geo-coordinates of travelers. Their proposed algorithm will allow decision support systems for dynamic defense allocation and surveillance as well as promote the coordination of orderly evacuation and response. They illustrate the tools through a series of examples on small and large maps to illustrate their potential to advance the state of the art in transportation and disaster relief planning.

H. Hu et al., proposed an efficient index, called distance signature, for distance computation and query processing on spatial network database (SNDB). They present the optimal category partition, and the encoding and compression algorithms for the signatures to minimize the storage and search costs based on a simplified network topology. In their experiment they showed that the signature index is efficient and robust for various data distributions, query workloads, and network updates.

E.J. Manley et al., introduced a novel framework for route choice in urban to be more accurately reflect the uncertain, bounded nature of route choice decision making.　The routes dataset are constructed from GPS point data, and aligned with complete origin–destination routes. For modelling hierarchical urban space, they break down the urban environment into regions, nodes, and roads, where each feature type is encapsulated within the former as part of a hierarchy. According to the structure of the heuristic route choice model, the decision-maker moves from a course to a finely-grained route plan from source to destination. Firstly, individuals make region-based choices, forming their rough plan within which subsequent finer-grained choices are constrained. In the second tier, individuals refine their route based on the nodes within the previously chosen regions. In the lowest level, individuals select the roads that link together the chosen nodes, arriving at the final chosen route. The authors also described the validation tests the similarity between modelled and optimal routing. These tests established how closely route sets generated through the heuristic modelling framework match those generated through simple shortest distance path calculation.

III Graph Theory and Dijkstra's Algorithm

Graph theory is the study of graphs, mathematical structures used to model pairwise relations between objects from a certain collection. In computer science, graphs are used to represent networks of communication, data organization, computational devices, the

flow of computation, etc. For instance, the link structure of a website can be represented by a directed graph, in which the vertices represent web pages and directed edges represent links from one page to another. A similar approach can be taken to problems in travel, biology, computer chip design, and many other fields. The development of algorithms to handle graphs is therefore of major interest in computer science. Graphs provided a powerful tool to model objects and relationships among objects. Graphs are defined by a set of vertices and a set of edges, where each edge connects two of its vertices. Graphs are further classified into directed and undirected graphs, depending on whether the edges are directed. A graph structure can be extended by assigning a weight to each edge of the graph. Graphs with weights, or weighted graphs, are used to represent structures in which pairwise connections have some numerical values.

A network is referred to as a pure network if only its topology and connectivity are considered. If a network is characterized by its topology and flow characteristics (such as capacity constraints, path choice and link cost functions) it is referred to as a flow network. A transportation network is a flow network representing the movement of people, vehicles or goods. The approach adopted almost universally is to represent a transportation network by a set of nodes and a set of links. A transportation network can be referred to as a valued graph, or alternatively network. Directed links are referred to as arcs, while undirected links as edges. The relationship between the nodes and the arcs, referred to as the network topology, can be specified by a node-arc incidence matrix: A table of binary or ternary variables stating the presence or absence of a relationship between network elements. The node-arc incidence matrix specifies the network topology and is useful for network processing.

1.　Dijkstra's Algorithm

Dijkstra's algorithm is an algorithm used to find the shortest path. The algorithm is not too complicated and can be applied to find the shortest route on the map or the application in the network. It is also called the single-source shortest path and is referred to as the standard shortest path algorithms. It computes length of the shortest path from the source to each of the remaining vertices in the graph. It can also be used for finding costs of shortest paths from a single vertex to a single destination vertex by stopping the algorithm once the shortest path to the destination vertex has been determined.

The basic operation of Dijkstra's algorithm is edge relaxation: if there is an edge from vertex u to v, then the shortest known path from s to u (d[u]) can be extended to a path from s to v by adding edge (u, v) at the end. This path will have length d[u] + w(u, v). If this is less than the current d[v], we can replace the current value of d[v] with the new value. Edge relaxation is applied until all values d[v] represent the cost of the shortest path from s to v. The algorithm is organized so that each edge (u, v) is relaxed only once, when d[u] has reached its final value. Dijkstra's Algorithm solves the single-source shortest path problem in weighted graphs. As a simple and consequently easily

implemented algorithm, Dijkstra's algorithm depends on the data structures used to implement the graph representing the spatial network.

The shortest path is a classical and main problem in network analysis and it is mandatory for GIS. Recently, much work was carried out in the application of exiting studies for emergency response systems considering shortest path analysis.

Algorithm　　：DIJKSTRA

Input　　　　：A weighted directed graph G = (V, E), where V = {1, 2, …, n}

Output　　　 ：The distance from vertex 1 to every other vertex in G

1.　　X = {1}; Y ← V – {1}; λ[1] ← 0
2.　　for y ← 2 to n
3.　　　　if y is adjacent to 1 then λ[y] ← length [1, y]
4.　　　　　　else λ[y] ← ∞
5.　　　　end if
6.　　end for
7.　　for j ← 1 to n-1
8.　　　　Let　y ∈ Y　be such that λ[y] is minimum
9.　　　　X ← X ∪ { y }　　{ add vertex y to X }
10.　　　Y← Y – { y }　　 { delete vertex y from Y }
11.　　　for each edge (y, w)
12.　　　　　if　w ∈ Y　and λ[y] + length[y, w] < λ[w] then
13.　　　　　　 λ[w] ← λ[y] + length [y, w]
14.　　　end for
15.　　end for

Figure 1: Dijkstra's Algorithm

IV GIS Tools

This section describes the GIS tool that is used in the proposed system. Open Street Map (OSM) is used as map extraction tool and Quantum GIS (QGIS) is used for creating the vector map of the road network.

1. Open Street Map (OSM)

Open Street Map (OSM) is an open source and collaborative project to create free and editable map which can be shared through XML (Extensible Markup Language). An OSM file contains four core elements:

1. **Nodes** are points with geographic locations stored as latitude and longitude. They are used to represent map features with no size such as points of interest or mountain peaks.

2. **Ways** are an ordered list of nodes representing a line or a polygon. They are used to represent features such as roads, streets, rivers, or areas such as parking lots, and forests.

3. **Relations** are ordered lists of nodes and ways collectively known as members, where each member can be assigned a role. Examples of relations are turn restrictions on roads, and routes spanning existing ways.

4. **Tags** are key-value pairs which are used to store metadata related to a node, way or relation. For example, in this project, nodes and ways with tags related to roads are extracted.

　　Within the OSM database, the attributes for nodes, ways and relations are stored.

Key	Description
id	Used for identifying the node.
user	The display name of the user who last modified the object.
uid	The numeric identifier of the user who last modified the object.
timestamp	Time of the last modification.
visible	Whether the object is deleted or not in the database, if visible= "false" then the object should only be returned by history calls.
version	The edit version of the object.
changeset	The changeset number in which the object was created or updated.

Table 1: common attributes of OSM database

　　Figure 2 shows the some part of Yangon on Open Street Map. Figure 4(a) shows the raw OSM map, whereas Figure 4(b) shows the road network with simple nodes and edges. An OSM map may contain many intermediate nodes that are not intersections.

(a) Extracted Map of Yangon　　　　　　(b) Road Network of Yangon

Figure 2: Open Street Map of Yangon

2. Quantum GIS

The developed system use Quantum Geographical Information System (also called QGIS) for creating shape file of road network. For the analysis of geospatial data, QGIS is cross-platform free and open-source desktop geographic information system (GIS) application and it supports viewing, editing geospatial information. The version of QGIS Desktop 2.18 is applied to develop the system in this paper. QGIS supports both raster and vector layers; vector data is stored as either point, line, or polygon features. Multiple formats of raster images are also supported.

QGIS can support the shapefiles, coverages, personal geodatabases, MapInfo, PostGIS, and other formats. Web services, including Web Map Service and Web Feature Service, are also supported to allow use of data from external sources. And it can integrate with other open-source GIS packages, including PostGIS, GRASS GIS, and MapServer.

PostGIS allows to convert the shape file to database. PostGIS is a spatial database extender for PostgreSQL object-relational database. Therefore, the developed system applied PostgreSQL version 9.6 for query processing. PostgreSQL is used for querying geospatial data (such as storing and retrieving) by Geometry function. GIS database includes data about the spatial locations and shapes of geographic features recorded as points, lines, areas, pixels, grid cells, as well as their attributes. A well designed and comprehensive database is the prime requirement for a good network analysis.

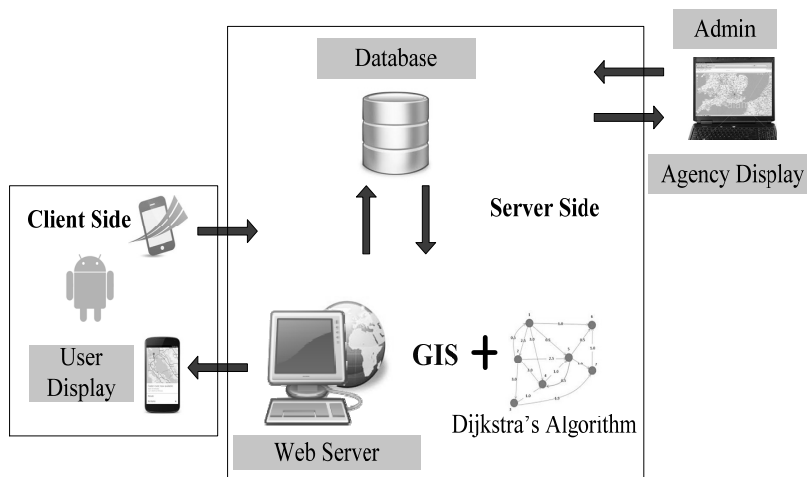## V　System Design and Implementation

Figure 3: System Architecture

This paper developed the client- and server-side data processing, and data

visualization on Google Maps. Therefore, the system includes two parts of application: client side application for emergency reporting and server side application for emergency response. The following figure shows the architecture of the proposed system.

1. Client Side Application

The client side application is used to send the incident situation to the web server for emergency report. It is developed by Android Studio. The user can report the detail of the emergency case and the location is used by Location Manager of GPS function. Therefore, the web server can know the incident place of longitude and latitude correctly. The following figure shows the interface design of the client side application.
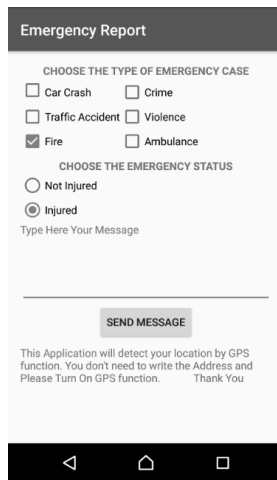

Figure 4: Interface design for client side application

2. Server Side Application

In this section, the process of the server side application explained in step by step. The server side application is developed by using Apache Tomcat Web Services.

(1) Preprocessing

The preprocessing step generates a modeling graph from an input spatial network. Considering the road network in section 3, the graph nodes generated by this process are: (i) the network junctions, (ii) the starting/ending point of a road segment. The graph edges preserve the connectivity in the original network. PostGIS allows to convert the shape file to database. And then the graph will apply in Dijkstra's Algorithm for the shortest path analysis. This algorithm needs to compute the distance between two vertices of user and agency. In this paper, Haversine distance formula is used for finding the nearest one.

(2) Finding the Nearest one

The system finds the nearest authorized agency based on the location and type of emergency reported by client side application. The distance between them are measured by Haversine Distance formula that can determines the great-circle distance between two points on a sphere given their longitudes and latitudes.

$$hav\left(\frac{d}{r}\right) = hav(\alpha_2 - \alpha_1) + \cos(\alpha_1)\cos(\alpha_2)\,hav(\lambda_2 - \lambda_1) \qquad \text{Eq: 1}$$

where α_1, α_2, and λ_1, λ_2　are the latitude and longitude of user and agency side respectively. The radius of earth R is used for sphere. The Haversine formula remains particularly well-conditioned for numerical computation even at small distances – unlike calculations based on the spherical law of cosines. The agency with minimum distance is used to find the shortest path between these two locations.

(3) The Shortest Route

This step will find the shortest path between the incident location and nearest agency by using the Dijkstra's Algorithm for emergency response. The incident location will be the location send by the client side application. The location searched by the equation 1 will be the nearest agency location. And then we will transformed it to the vertex of the graph. These will become the start and end node of shortest path on the road network. There are many extensions to the basic GIS data model needed to support shortest path analysis. We defined the length of the road to calculate the shortest path from one node to the target node in a map, and then select the optimal path among the road based on the minimum weight. The nature of the Dijkstra's Algorithm is already described in Section 3. The shortest route is displayed on the Google Map and send it to the relevant agency web.
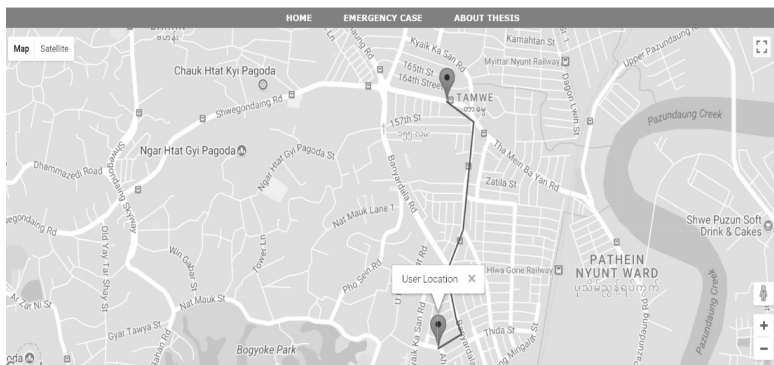
3.　Agency Side Application

Figure 5: The shortest route shows in Agency site

　　The agency side is only for receiving for the shortest route from the server side. And use it to take the prompt action on it. In this system, the agency has only permission for adding their own locations and types of emergency. Furthermore, agency can print the shortest routes and edit/delete locations whenever agencies have moved.

VI　Conclusion

　　By applying the GIS technology with Web Services, the emergency case can be reported with accurate data in time. It is the ongoing research work and finding shortest path is not a solution all the time because there are several factors affecting travel time. It can extend many research work based on the road condition and previous data of traffic condition. Currently, the application provides the optimal route without considering road conditions and traffic congestion. Further research is focused on integrating this system with real time on-road traffic count to display more dynamic, reliable and accurate routes to emergency managers.

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