ROUTE ANALYSIS FOR DECISION SUPPORT SYSTEM IN EMERGENCY MANAGEMENT THROUGH GIS TECHNOLOGIES

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ABSTRACT:
Geospatial technologies are emerging as one of the most promising frameworks for addressing emergency management. Last decades many geospatial services are used for addressing emergency situations. Geospatial technologies such as Remote Sensing, and Geographic Information Systems integrated with valuable near/real time field information can provide a comprehensive platform for emergency management.

The main goal of this work is 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. The practical part of this work will comprise of the development of software components using OpenLayers java Script framework by implementing Web Map Service(WMS) integrated in the system includes a spatial database PostGIS, pgRouting, a GIS server GeoServer and front end technology PHP and OpenLayers for finding the route and shortest distance between two locations. Following this, an exploration of the environment will take place in the form of practical hands on use of the software to build an understanding of how the research can be applied in a practical way. The source of road network which has been used here is CENSUS 2011. The entire road network has been hosted on to the GeoServer and visualized by using web application and analysis is carried out by using PostgreSQL. This study is carried out with an idea to connect the available roads networks in Puri district of Odisha to identify the shortest path. The shortest path between any two locations within the road network is determined using the tool shortest path on the map viewer.

This work carried out in National Database for Emergency Management (NDEM) project which is a national data repository to manage any emergency situation. This paper explains standards for taking decision to transfer the resource form one place to another in emergency situation.


1. INTRODUCTION

1.1 Introduction

GIS is the most powerful information system for analyzing, modelling, and displaying the disaster situations. When disaster locations can be viewed along with critical infrastructure, critical values at highest risk become apparent. Models can be processed to determine potential impacts and appropriate mitigation requirements. When events occur, response preparedness is more comprehensive. The basic foundation of developing an emergency management program is the analysis of risks and hazards to determine values at risk and operations necessary to reduce exposure, respond effectively, and recover quickly.

Emergency management systems require some of the geospatial layers such as administrative boundaries (State, District, Taluk, and Village etc.), River, Gauge Stations, Meteorological data, for better decision making. Generally, spatial database of an emergency management system [MURRAY TUROF 2004 ] is updated manually. In a disaster situation, a dynamic spatial database can help many decision makers to make better and more reliable decisions by keeping the live fields coming into the database with a suitable forecasting model.

Geographic Information System (GIS) is a powerful tool and has capability to handle and process spatial data in a large volume. GIS becomes a widespread technique that can create maps, integrate information, visualize and solve problems, and develop valuable solutions [Alain A. 2007 ]. Applying GIS for disaster management [Coppola. 2013] have been used before in developed countries. It is an effective system to monitor all the activities that occur on the roads and store the records for future development. Furthermore, to make this system easy to access, it is developed as web platform. NDEM is a Web based GIS application is an Intranet-based platform that provides client-side applications using http protocols running on the ISRO-VPN Network which can embed geographic information data as well as non-geographic data. Open source web-based GIS software is used in developing the system in order to minimize the cost of implementation and development time.
2. BACKGROUND STUDY

2.1 NDEM

National Database for Emergency Management (NDEM) is conceived as a GIS based repository of data to support disaster/emergency management in the country, in real/near real time. This database, which will leverage much on the aerospace data, will have core data, hazard-specific data, and dynamic data in spatial as well as non-spatial forms. The database should enable development of decision support system in the form of customized user interfaces. Necessary security mechanisms should also be in place, so that the database is accessible only by the authorized user. NDEM is a spatial web based portal, including Map Viewer, Content Management System and Other Modules like IDRN Database Integration, Health Database Integration, Metadata, Reports, Feedback and User Profile (On VPN). Figure 2.1, Shows the overall architecture of the NDEM VPN portal.

![Figure 2.1 Architecture of NDEM VPN Portal](image)

2.2 GIS

Geographic Information System is neither a single thing nor a single analysis (ISS, 2006), the primary thing that makes GIS difference is location, the place where almost everything that happens, happens somewhere (Longley et al. 2010). Whether it's the regular delivery of morning newspaper, the synchronization of traffic lights on way to work, or the convenient location of favorite park, GIS make these things happen (ESRI, 2011a), so “GIS is a computerized tool for solving geographic problems” (Longley et al. 2010, p.16). In today’s 21st century organizations all over the world are using GIS to manage the environment, work more efficiently, provide better customer service and save money. A Geographic Information System (GIS) is the integration of hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information (GIS.com, 2011). Many historians and historical geographers regard GIS as primarily being concerned with mapping. Although mapping is one of the key abilities of GIS is a specialized form of database because each item of data, be it a row of statistics, a string of text, an image, or a movie, is linked to a coordinate-based representation of the location that the data refer to (Geogray & Healy, 2007). Thus GIS combines spatial data in the form of points, lines, polygons, or grid cells, with the attribute data held in conventional database form. This provides a structure that is able to answer queries not only about what features are in the database, but also about where they are located.

According to Ullman (1954) transportation is defined as a measure of relations between areas and therefore is an essential part of geography. GIS can be a useful tool in the planning of road networks in new developments. Gopala Raju et al. (2012) have studied the road network in Visakhapatnam city using geographical information systems. Shortest path algorithm such as Dijkstra is the most common algorithm used in finding shortest path which has a lower computational complexity, determined the shortest path distance from each residential point to the nearest clinic which is measured on the actual road network using ArcView. Now-a-days there is a rapid development of information technology which can be used to support the mobility of people, vehicles and goods. According to Dueker and Tu Ton (2000), often rely on data integrators to provide transportation data in the form of maps and network for location, path analysis and routing. In addition to shortest path, path queries processing over transportation has also been studied by Yun-Wu Huang et al (2000). Route planning for transportation road networks has been studied intensively by Yu-Li Chou et al (1998) GIS consists of data, software, hardware, personnel and arrangements for collecting, storing, analyzing and disseminating information’s about areas of the Earth. Network analysis is one the function in GIS to identify the road direction either shortest or fastest path. Therefore this study is mainly focused on the shortest path where the criteria taken under consideration are the length and path.
2.3 OpenLayers

OpenLayers is an open source client-side JavaScript/AJAX framework for overlaying various mapping services. It supports various mapping APIs such as GeoRSS, KML (Keyhole Markup Language), Geography Mark-up Language (GML), GeoJSON, Text layers, and Markers to name a few. The nice thing about it being a pure client-side implementation is that you can drive it with any server language such as ASP.NET, PHP, PERL and for simple maps, embed directly into a plain HTML file. There is minimal requirement from the web server if you are using publicly available or subscription layers.

2.4 PgRouting

PgRouting plugin supports the route finding mechanism for geospatial data. PostgreSQL/PostGIS doesn’t automatically provides the routing functionality so PgRouting plugins has to be installed for that. PgRouting is an extension of PostgreSQL and PostGIS. It adds a geospatial routing functionality to PostGIS (FOSS4G, 2011). PgRouting is open source available under GPL license and it includes three types of shortest path search algorithm (FOSS4G, 2011):

• Dijkstra,
• A-Star,
• Shooting Star

As per the previous knowledge of shortest path queries and non-negative arc length manipulations in Dijkstra shortest path algorithm, it was chosen among those three algorithms. It provides a comprehensive system that can monitor and manage resource transaction which is very helpful at the time of disaster situation.

Therefore, the main objective of this study is:

• To propose an effective network analysis tool using openLayers which can be used as Decision Support System (DSS)
• To find the shortest path and distance between facility/resource and disaster event location.

3. PROPOSED SOLUTION

In emergency situation, disaster manager requires the available facility for rescue operation in minimum time. For that shortest distance between disaster event and facility location has to be known at near real time. Many algorithms have been already implemented for finding shortest path between two locations. In this paper, Author focuses on implementing Dijkstra algorithm to find the shortest distance between event location and resource location for Disaster management. The process of implementing this algorithm to achieve the objective is explained in following sections.

3.1 Algorithm

1. Create a Database for routing
2. Load road Shape-file in database
3. Make the road dataset routing enabled
4. Publish the routing enabled network in Geo-Server as WMS.
5. Select the event location point and resource location point on the map to find shortest route
6. Compute the all possible network segments between these two point geometries of WMS layers using PostGIS function
7. Determine shortest route network segments by using Dijkstra algorithm
8. Shortest route and corresponding distance will be calculated between these two locations

3.2 Data Flow

For finding the shortest path between two facilities or path between disaster event location and resource location, the data flow is described in figure 3.1. This figure shows the process wise data flow for network analysis and the detail dataflow is explain in 3.1.1 and 3.1.2.
3.1.1 Create Routable Network

Routing Enabled Database
PostgreSQL with PostGIS must be installed in the windows system. Routing binaries (.dll) of pgRouting has to be copied in postgis lib folder of the system. A new database has to be created based on PostGIS template in PostgreSQL. This database will be made routing enabled by executing three routing .sql files (routing_core.sql, routing_core_wrapper.sql, routing_topology.sql) for adding routing functions to the database.

Building routable road network
First and foremost condition to perform pgRouting is, the road shape-file on which pgRouting has to be performed should be continuous without any breakage. If the road shape-file is not continuous then snapping has to be performed on the road shape-file. The shape-file has to be stored in the routing enabled database by using PostGIS. This table will contain line geometries and road type attributes which will be needed to perform queries. Now start and end point geometries are to be calculated for each line of the road layer by using PostGIS functions integrated with this database. Corresponds to these point geometries, unique id's have to be generated to identify the line segments. All this attributes will make new road network table which is routable. This road network is published in Geo-server for visualising purpose in openLayers.

3.1.2 Perform Network Analysis

At the time of disaster, if Manager wants to get the minimum distance path between event location and facility location, network analysis operation has to be performed. User has to select Source and Target location near the road network by clicking on the map and set them as Source & Target locations respectively. The geometries of selected locations will be fetched from the GeoServer and passed to OpenLayers functions. The nearest road segments to these locations will be calculated and passed to the Postgresql table to find the respective nodes over the road network. Then by using Dijkstra algorithm of PostGIS, shortest route between these two nodes will be calculated and accordingly shortest route between those two locations will be drawn on the map in GeoJSON format. The corresponding shortest distance will be also displayed with the route details.

4. EXPERIMENTAL RESULTS

To explain the work in systematic manner, Odisha flood 2014 is used for experimental purpose. In this flood the main affected district are Puri, Jagatsinghpur and Balashwer. To, perform the network analysis, we are using Puri District 10K road layer, Odisha state 50K admin layers, 50K hospital layer and flood layer of 15 September 2014 of Odisha Flood 2014. Due to high flood in Govindpur village, if Puri district disaster manager wants to evacuate the people from Govindpur village to Kunjar Hospital, Govindpur (Relief Shelter), then he has to find out the shortest path between a location on Govindpur village to Kunjar Hospital,. The detailed results are shown in figure 4.1(a-d). In this experiment shows that disaster manager selects a location of Govindpur village as a source location and Kunjar Hospital as destination location on the map and perform the network analysis. As the result, the shortest distance is calculated from Govindpur village to Kunjar Hospital and the path details to travel is also shown in table as well as on the geospatial map.

Figure 3.1 Network routing data flow
Finding the shortest path is often a central task in disaster management for shifting people and material. It is the most valuable research work carried out in disaster management. Considerable research has been done to develop the faster algorithms for solving this problem and of course, there have been numerous algorithms like Bellman-Ford-Moore algorithm, Dijkstra algorithm etc. have been implemented. Moreover, some important evaluations have been made to test the efficiency of these algorithms. The choice of Dijkstra algorithm is due to its characteristic of running just on non-negative arc length, solving all the subtypes of single-source shortest path problem and taking any of the nodes as source.

Finally the results of our study might be a guideline not only for network analysis in disaster situation but also used for finding the route between two places, facilities and point of interests.

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