GIS-Based Application for Emergency Preparedness and Management

Accelerating Response System through GIS

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Abstract:

Optimum utilization of the time after an incident ‘Golden hour’ serves as a measure of effectiveness of any Emergency Response Service Provider System (ERSPS). Recovery actions should be taken in time to reduce the loss of life and property. This application is mainly intended for crime and other related departments to cater the aspect of emergency response system. Due to its recent track record in crime and related incidents, Delhi fits in as an ideal study area for this project. This desktop application is broadly classified into three sections. One is to provide ground truth of locality of incident, second is to provide efficient response and third is to perform crime related analysis. Location of an incident can be known either by Location Based Services (LBS) provided by the Mobile Service Provider (MSP) or through geocoding. A detailed transportation network is also maintained which is integrated with real time traffic data provided by NAVTEQ for India. After knowing the location of incident the nearest patrolling vans are immediately notified, as they are being continuously tracked using third party software (3CX mobile device manager) which extracts the location of the user in .CSV format at regular intervals, which could be exported to ArcMap and represented as point feature layer. Once immediate response is being sent to the incident location, buffer analysis is performed and nearest police station, fire station, hospitals are highlighted on the map followed by various analysis which would include finding shortest route using OD cost matrix, network analysis, proximity analysis etc. Near real time traffic information is also used to analyses suitable routes to the incident location by avoiding the current congested roads therefore reducing the response time. After successful response, the incidents can be stored in the database along with its type, severity, cause, effect and various other basic attributes. This can be used for crime related analysis to know crime trends by generating heat maps and specifying Crime Prone Zone (CPZ) and quantifying it by using severity factor. Locational analysis is also being performed which specifies location of BPOs, Call centers, pubs/discos, market and other locations which are more crime prone and thus require strict patrolling.

About the Author:

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She is currently pursuing M.Tech in GIS from NIIT University under scholarship provided by ESRI, California. She has also presented a poster in ESRI India 13\(^{th}\) User Conference on “Analyzing Impacts of Urbanization and GDP Per Capita on Phone Usage Using GIS” using various geospatial analysis. Her area of interest is particularly in Application Development and Database Management.

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Introduction

Delhi is a metropolitan region with a population of about 22 million in 2011\(^1\); it is the world’s second most populous city and the largest city in India in terms of area. National Capital Region (NCR) and other nearby towns surrounding Delhi have nearly 22.2 million\(^2\) residents. All these facts along with other factors as well contribute to the increasing records in crime and due to this Delhi is considered to be an unsafe place. Government of India along with other associated organisations are trying hard to curb this problem in the capital city of India.

This application intends to serve the purpose of reducing crime and providing immediate response to victims in an incident by police and all crime related departments. Providing immediate response is the most crucial stage in all kinds of crimes and incidents. It relies on the preparedness of the utilities, facilities, emergency response personnel and most importantly the decision making system. This application tries to optimize the decision support system thus helps in providing quicker response for any incident or accident using Geographical Information System (GIS).

Aims and Objectives

The main objective of this application is to provide immediate response to any incident or accident. Basic idea behind developing this application is that a crime occurs at a particular location (latitude and longitude). Knowing those locations and mapping them using Geographical Information System (GIS) would greatly help in analysing and visualizing the various factors associated with the incident and thus would help in providing better decision making and quicker response.

Preparedness is the main criteria for immediate response for any emergency response provider (ERP) but decision support system also plays a crucial role. Which route to follow, which are the nearest hospitals, nearest Patrolling Control Room (PCR) vans and other related analysis can be performed using the visualization provided by Geographical Information System (GIS). All these incidents and related information can be stored in the geodatabase for future references and analysis which would help in understanding the crime trends.

Software Used

(i) ArcGIS for Desktop version 10.1 with ArcInfo license- used for digitizing, topology, joining spatial and non-spatial data and debugging python scripts and addins.
(ii) Wing IDE for Python Scripting- used for writing python script and creating addins for customizations of controls.
(iii) Third party software (3CX Mobile Device Manager) – used for tracking PCR vans which have android enabled devices using active internet connection in form of .csv format which is downloaded at regular interval.
(iv) Image Processing Software - used to apply image processing techniques on satellite imagery.
(v) Easy Google Map Downloader- used to download satellite imagery
(vi) Microsoft Office 10- used for arranging spatial data in MS Excel which is imported to ArcGIS and making reports and so on.

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\(^1\ & \(^2\) - http://en.wikipedia.org/wiki/Delhi
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### Demonstration

(i) **Preparing the data**

Moderate resolution imagery of Delhi is downloaded and is digitized. High resolution imagery for Delhi would be preferred to minimize the error tolerance. Geodatabase for point location of hospitals, fire stations and police station is made alongside with other associated attributes. All database including previously occurred incidents along with other attributes are prepared. Shape file of road network of Delhi is downloaded. See Figure (1).
(ii) Creating network dataset
Road network of Delhi is used to create **Network dataset** which is used to perform network analysis like generating **service areas**, finding **optimal** route and others using network analyst extension for ArcGIS Desktop 10.1. **Network analyst extension** also has a tool- **Update Live Traffic** for integrating real time traffic information which is provided by **NAVTEQ India** which is utilized here to make the work easy for the cops to reach the incident location. See figure (2).

(iii) Knowing the location of the crime
**Location based services (LBS)** is integrated with this application to know the location of the incident if a person calls from the cell phone. The location (latitude and longitude) is received as a service from mobile service provider using GSM network. **Geocoding** is done to know the location of the particular place or address specified by the caller. See figure (4). **Third party software -3CX Mobile Device Manager** is used which helps to keep track of the Police Control Room (PCR) vans. This software is being integrated with ArcGIS for Desktop by importing **.CSV format file** which specifies the location of the PCR vans at continuous intervals (figure 5). This helps to know which PCR vans are patrolling near the site of crime when the crime has happened and thus providing immediate response. **Reverse geocoding** is performed to know the address of the site of crime when location (latitude and longitude) is known.
(iv) **Dealing with the emergency response using GIS**

Basic tool are implemented like **multiple ring buffer** to know the location of the various facilities at intervals of 1km, 2 km and 4km around the site of crime. **Intersect** is also performed to select only those facilities which lie in the multiple ring buffer around the location of crime. **Near real time traffic data** is also integrated with the network dataset to analyses which route is best out of many routes to reach location of crime depending on the flow of traffic at that particular time. A python script runs here in the backend which is available as a button to the analyst. Figure (6) shows the result after the script has performed buffer and intersect analysis on the dataset.

(v) **Customization (decision making)**

Customization is done to optimize the decision making and minimize response time. This is done using **Model Builder** which helps to integrate all the logic together in a single tool. It includes **multiple ring buffers, intersect, service area, update live traffic and find best route** as a single tool which is shown in Figure (8). This modal is converted to .py file and using the **Wing IDE for python scripting** the code is customized. A toolbar and button is made for the ArcGIS for Desktop 10.1 and the steps are performed. The directions to reach the location of crime by best route can also be printed as PDF for later references. Figure (7) shows the nearest hospital, fire station & police station for the incident location with their shortest paths highlighted with the driving directions.
(vi) **Analysis**

This is the final stage of the implementation and is used for analysis after the response to crime is sent successfully in minimum possible time. At this stage the location of the current crime is saved in the database, **severity of the crime** can be assigned which can be used to generate **heat maps**. **Crime prone zone (CPZ)** like area near call centers, night clubs or isolated place can be analyzed and preventive actions can be taken thereafter such as increasing the patrolling frequency in those zones. **Crime analysis report** for particular area can be generated and printed as PDF for further references. **Heat maps** and **hot spot maps** can also be printed as PDF.

**Conclusion:**

This desktop application would use full capability of Geographical Information System (GIS) and would work as a good decision making tool during the delicate hour of an emergency where right decision matters greatly. The application is mainly intended for crime or related departments to assist them in making a quick response to an incident. The aim is to show how GIS capabilities can be leveraged by them in making quick & accurate decision’s at all times. It would also help in analyzing the crimes and generating hot spot of those crimes along with other associated factors. This would in turn help to take long term decisions like increasing the patrolling at delicate or hot spot zones. This application will not only help the police department it would provide relief to the general public who would feel more secure.
References:

6. Christopher Frank, “from GIS to LBS, An Intelligent Mobile GIS”, Department of Geography, University of Zurich