WebGIS-Based Road Crash Information System: A Case Study

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Abstract: Road crashes in India is showing progressive growth since COVID time, despite many road safety measures and programs the rate of crashes is not declining. Many times, road safety measures are not implemented in proper geographical locations owing to a lack of proper crash information, which includes crash information from the past. Road crash information is thus a vital support for the road safety assessment programs that eye for a reduction in road crashes. In India, as in other developing countries, very little effort is taken to provide enough road crash information conveniently and systematically. The identification of road crash locations, analysis, and treatment of road accident black spots are widely regarded as one of the most effective approaches to road accident prevention. By incorporating these approaches, a user-friendly web Geographic Information System (GIS) based Road Crash Information System (RCIS) is developed in the present study for Kerala State, India. An online platform to add, update and maintain the database of road accident black spots is offered by the system, including analysis functionalities. The database maintains a standard guideline for road crash reporting thereby reducing data redundancy. Integration of all crash data from accident locations and filtering data based on different criteria are the core objectives of this study. The study also focused on systematically sharing the accident black spot details to the public user through an online platform.

Keywords: Accident Black Spot, Road Safety, Transportation, Vehicle Crash Data, Web-based Geographic Information System

1. Introduction

World Health Organization (WHO) statistics reveal that about 1.35 million people die worldwide annually in road accidents and leaving between 20 and 50 million people with non-fatal injuries. A higher number of road traffic injuries are recorded in developing countries, with 93% of fatalities coming from low and middle-income countries. In 2018, the reported number of road traffic deaths in India was around 1.5 lakhs and it was estimated that more than 3 lakh people are killed in road traffic crashes in India every year (WHO, 2018). The diverse mix of traffic with high-speed vehicles sharing road space with vulnerable road users, unsafe road infrastructure, and poor condition of vehicles all contribute to India's high mortality rates. Accidents are a major cause of concern in Kerala as well. According to Kerala Police in 2019, a total of 41,111 accidents occurred which caused 4,440 deaths and 46,055 injuries *(https://keralapolice.gov.in)*.

It is important for traffic safety programs to identify high-risk areas. In the literature on highway traffic safety, these areas are mentioned as “black spots.” According to the Ministry of Road Transport and Highways (MoRTH), Government of India, black spots on National Highways is a road about 500m in length in which either 5 road accidents (involving fatalities/grievous injuries) occurred during the last three calendar years or 10 fatalities occurred in the last three calendar years. The identification of accident location, analysis, and treatment of road accident black spots are widely considered one of the most effective approaches to preventing road accidents.

Geographic Information System (GIS) is one of the most inseparable Geoinformatics tools which are used ubiquitously in almost all the disciples of studies, whether it is Geography, Wild Life, Engineering, etc. The useful aspect of GIS as a management tool is its ability to associate spatial objects such as street names, mileposts, route numbers, etc. with attribute information such as road crashes, causes, etc. Web-based GIS or WebGIS is a part of Internet GIS that enables accessibility of geographic or non-geographic data over the web via communication protocol e.g., WWW (World Wide Web). A web GIS-based information system for road crashes for the state will be highly beneficial for society, it will be highly beneficial for law enforcers and other road-related agencies to keep a tab on the vulnerable location and take adequate measures to prevent road crashes in the future.

2. Related Work

GIS technology is been used ubiquitously in many fields of study, and a significant number of works are carried out in road crash identification. Very few studies have attempted to understand the analysis of black spots associated with road crashes in India. Srinivasan et al. (1987), in their study to identify and improve road crash vulnerable areas on the NH in Kerala, used three methods to point out the black spots viz., Quantum of road crash method, Accident prone index method, and Accident severity index (ASI) method. The study concluded that the ASI method was the most suitable for identifying black spot. A study on the application of GIS to analyze the causes of road traffic crashes in Kenya by Mwatelha (2001) has suggested measures to alleviate the problem of road traffic crashes through the inclusion of advanced technology like GIS. Krishnamurthy et al.(2011), conducted a study on the identification, analysis, and improvement of Black Spots on three selected National

Highway stretches in Kerala. Road crash details about the study region were analyzed for the purpose. Road crash frequency and severity index methods were applied to identify road crash black spots. AutoTURN 6.1 and AUTOCAD 2008 software were used for simulations. Improvement measures were suggested to avert road crashes in the future. The road crash study of Ajmer City in India by Bhalla et al.(2014), made use of GIS technology to derive the peak time for the road crash occurrence, its position, and the reason for the crash.

WebGIS have proven to work well in addressing transportation problems, especially road safety. Hassan and Al-Amayreh (2005), in their study, have developed an algorithm for optimal path routing and a traffic control system to alert drivers about the optimal route based on high/low traffic volume road width, road crashes, snow and flooding and dynamic changes of road density (Hassan and Al-Amayreh, 2005). Evangelidis et al.(2006), proposed a WebGIS-based Traffic Accident Information System (TAIS) application by utilizing the advantages of the Database Management System (DBMS) and WWW server merged with the high capabilities provided by contemporary Internet Map Services (IMS). GIS development packages - ESRI ArcIMS and ArcSDE were used to exhibit this attempt and try to establish that proper analysis of spatial and temporal patterns, easy information retrieval, faster communication, and fast response system can only reduce the probability of road crash occurrence.

Yusoff et al. (2014), has introduced an open-source web-based GIS software to reduce development or maintenance costs by proposing an effective road management system for maintaining and controlling road conditions on the web. Accident hot spot analysis for spatial and temporal clustering of data using GIS for the city of Thiruvananthapuram was done by Prasannakumar et al, 2011. The result of the study shows temporal accident clustering near educational institutions during the monsoon season. Deepti and Ganesh (2010), developed a GIS database for the identification of accident hot spots in the Kannur district of Kerala. The “Density” function is available in the spatial analyst extension of the ArcGIS software was applied. Simple and Kernel densities were used to identify the accident patterns. In 2009, the Government of Tamil Nadu introduced a user-friendly software program called Road Accident Data Management System (RADMS) as part of the Road Safety Action Plan. The GIS-based system records the details of each accident occurring in the state, geographically locates it, identifies accident-prone locations, and displays crash trends (*https://morth-roadsafety.nic.in*)

3. Objectives

Road controlling authorities put a lot of effort and expense into collecting large amounts of data related to road asset management, including data related to road safety. Data is the basis of all road safety activities and is important for interpreting the problems of a road crash and suggesting road safety measures. Authentic and well-organized data enables road safety auditors to accurately identify issues, priority areas, and risk factors, plan effectively, set goals, and improve performance. Without data-led diagnosis and management, it will be hard to attain remarkable and sustainable scaling of crash risk or severity of crashes.

The core objective of this study is to develop an accident information system highlighting road crash black spots in the study area. The specific objectives include the development of a Road Crash Information system (RCIS) using GIS as a backend application, highlighting the road accident scenarios, and updating the accident scenario on a public website periodically.

4. Study Area

Kerala State in India is taken as the study area. Kerala falls within the graticules of 8°17'30" N and 12°47'40" N and 74°27'47" E and 77°37'12" E. The state is located between the Lakshadweep Sea to the west and Western ghats to the east (Figure 1). Topography of Kerala consist of coastal plains, midlands and high lands. The state has a good transportation network, with good air, rail, road and water connectivity. Road related crashes in the state are on the rise and proper assimilation and dissemination of information is vital to spread awareness of road safety.

Figure 1. Study Area

5. Methodology

The GIS-based road crash information system was developed for the State of Kerala. This study focused on developing a web-based road crash information system. The road accident data in Kerala was collected from the Kerala Crime Records Bureau for the years 2017, 2018, and 2019. The information system lets the users visualize the road crash black spots for all the districts in Kerala during these three years. Provisions are provided to query the road crash database based on user preferences such as district-wise, police station-wise, and based on fatalities. The information system was developed based on the database and programming. The methodology of RCIS involves the steps shown in figure 2. The whole process of web-based RCIS can be divided into three stages; Login, Insert data, and Fetch data.

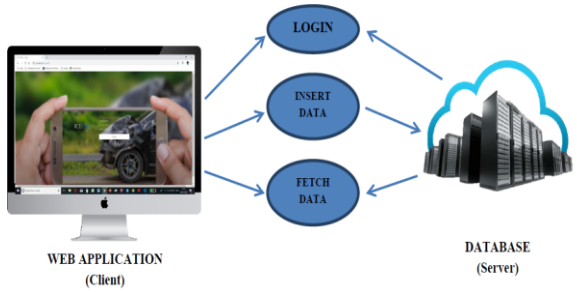

Figure 2. Methodology of RCIS

5.1 Web Application Development

The information system is developed based on client-server architecture, where the server is a Geospatial Information System database server and the client is a web browser. The web application was developed using the programming languages HTML 5, core JavaScript, Cascading Style Sheets3 (CSS3), and PHP with the help of Visual Studio Code software. HTML is the standard markup language for creating web pages and web applications. Visual Studio Code is one of the best editors for PHP development. Features like extensions, syntax highlighting, bracket matching, code completion, and out-of-the-box snippets make Visual Studio Code more efficient than simple Notepad++. The software Visual Studio Code with the latest version 1.77 was used for developing and debugging the web application.

The web application displays the location of road crash spots on a customizable map technology named Leaflet Open Street Map (OSM). Leaflet are used as it is the leading open-source JavaScript library for mobile-friendly interactive maps. It Weighs about 38 KB of JavaScript and has all the mapping attributes that the developers require. Leaflet API helps developers to integrate Leaflet OSM Maps into their web applications. It includes static map image recovery services, geocoding web services, driving direction creation, and the acquisition of elevation profiles. Using these services, the web application developed by us was integrated with the locations of the road crash black spots and displayed as markers on the map. A responsive HTML5 Charting Library named CanvasJS was used in the web application to visualize the Data as charts. CanvasJS offers 30 different types of Charts and generates across devices including iPhone, Android, Mac, and PC. Without compromising the maintenance or functionality of the web application, it allows to create rich dashboards that work across any device. Graphs include many great themes and are 10 times faster than traditional Flash / SVG-based Charting Libraries – resulting in lighter, more attractive, and more responsive dashboards.

5.2 Database of the Web Application

MySQL database was used to implement the system; it is open source and completely embedded within the PHP. WampServer software was used to create MySQL databases and tables for the system. WampServer is a software stack for the Microsoft Windows operating system, consisting of the Apache web server, OpenSSL for Secure Sockets Layer (SSL) support, MySQL database, and PHP programming language. Four tables were created in the database in which three tables are used to store the details of accident spots and the other table is used to store the login information of the user. The Spatial data and attribute data collected about the road crash spots in the study area were inserted into the corresponding table of the database (Figure 3). Spatial data including the starting and ending latitude-longitude pairs of the accident data are stored as string data in MySQL database. This data is used to represent locations of the accident hotspots by performing appropriate conversions and operations. Since only point data is represented in the web application, Geometry details in the database include only the coordinate pairs to represent points.

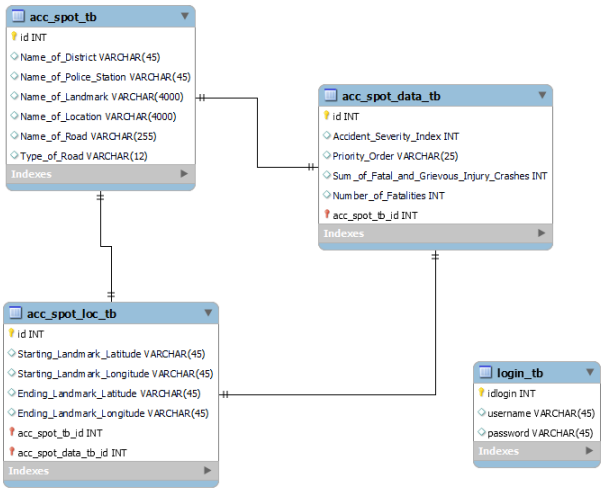

Figure 3. EER diagram of the database

6. Web-Based Road Crash Information System

The web application mainly consists of four web pages – Login page, Home page, View data page, and Insert data page.

6.1 Login and Home Page

The web application at the initialization leads the user to the Login page. Authorized persons with valid usernames and passwords are allowed to access the system. The login page prompts the user to enter the login credentials - username and password. A signup section is also available on the login page for new users to register in the web application. New users can register by entering their name, email/username, and password. While registering for the administrative privilege user needs to enter the one-time password (OTP) that will be sent to the registered Email address. After successful registration, the user can login to the system. Based on the privileges of the user the web application redirects them to the corresponding Home page of the web application. The user with administrative privilege will be redirected to the Home page with options to view and insert data. The user without administrative privilege can only view the system. The home page of the web application consists of a customized Leaflet OSM highlighting the Kerala state and a control panel as shown in figure 4.

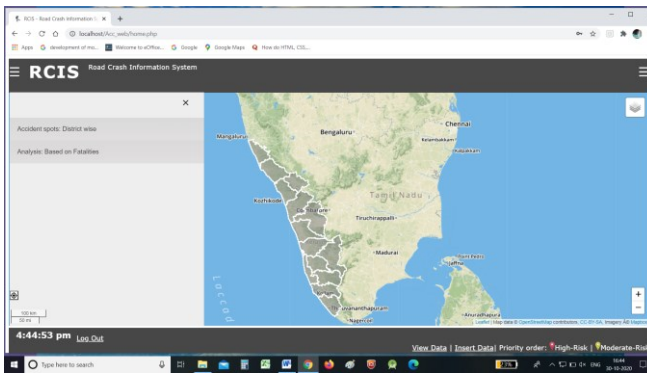

Figure 4. Home page of web application

Geographic locations of road crash black spots were geocoded on the map with the help of a database and Leaflet API. The control panel on the left side of the map consists of different options to filter the result from the database. The first section in the control panel displays the district-wise road crash spots in Kerala. A dropdown list of districts in Kerala is provided from which users need to select the district and click on the 'View Road crash Spots' button to view the road crash spots in the district. A dropdown list of police stations within the district is available in the panel. The user needs to select the district and the corresponding police station to see the hotspots matching the user-defined criteria in the selected area. ASI is calculated for each accident data based on the number of fatal and grievous injury crashes. Based on the ASI, road crash spots are classified into High-Risk, Moderate-Risk, and Low-Risk priority orders. Road crash spots are displayed as markers on the map with two different colors indicating the priority order. The marker with red color indicates the road crash spots having the High-Risk priority order and yellow indicates Moderate-Risk. On clicking the marker, a pop-up window consisting of information such as Name of Location, Name of Landmark, and ASI values is displayed. Pie charts are provided for a graphical representation of several road crashes based on the type of road – NH, State Highway (SH), and Other roads (OR). Figure 5 shows the Home page of the Web Application displaying the road crash spots in the Kollam district along with the pie chart based on the type of road.

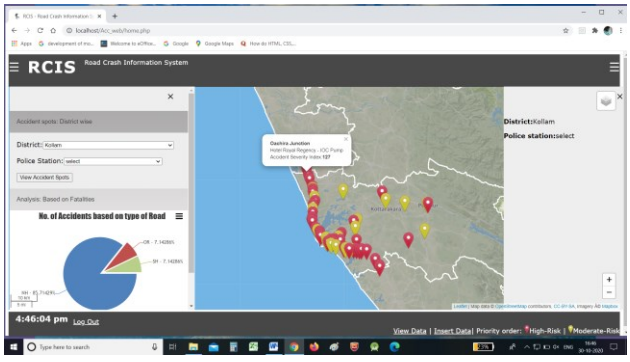

Figure 5. Home Page Displaying Road Crash Spots in Kollam District

The second section in the control panel is used to display the analysis based on the number of fatalities in road crashes in Districts of Kerala. To view the analysis based on the Sum of Fatal and Grievous Injury Crashes, the user needs to click on the 'Sum of Fatal and Grievous Injury Crashes in Kerala' button. A column chart showing the analysis based on the Sum of Fatal and Grievous Injury Crashes will be displayed in the control panel. To view the analysis based on the number of fatalities in road crashes in the study area, the user needs to click on the 'Number of Fatalities' button. A column chart showing the analysis based on the Number of Fatalities will be displayed in the control panel. A live clock is also provided in the footer section of the Home page along with the Logout option.

6.2 View and Insert data page

The user with administrative privilege can view and insert data in the database using the 'View Data' and 'Insert Data' options in the footer of the Home page. When the user clicks on the View Data option, the web application redirects to the web page that shows the list of accident hotspots in the study area. The options to filter the data based on the district and the corresponding police station are available for the administrator along with data Edit and Delete options (Figure 6).

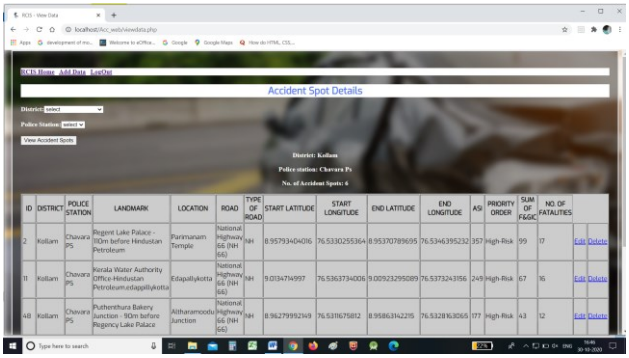

Figure 6. View Data page of the Web Application displaying the list of road crash spots in the Kollam district

Insert Data option redirects the web application to the web page to add details of new accident hotspots in Kerala. The user needs to enter details in the corresponding fields on the Insert Data page. After entering data, the user needs to click on the Save Data button at the bottom of the form (Figure 7). Validation rules such as required field validation, number format validation, dropdown list validation, digit validation, etc. are incorporated in the client side of the web page to check the validity of data entered by the user. PHP form validation rules such as required field validation, number format validation, digit validation, etc. are included on the server side and not null, primary key validations are set in MySQL database to avoid duplication of data. The user with administrative privilege can enter the details of new accident hotspots using this web page. Newly inserted data will be readily available to the public through the web application.

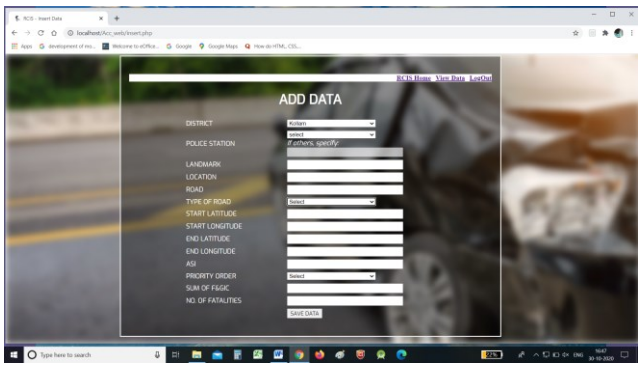

Figure 7. Insert Data page of the Web Application

7. Conclusion

Reliable and precise data are required in each phase of road safety management to properly identify problems, risk factors, and priority treatments, formulate strategy, set goals, and monitor performance. Road safety information, especially road crash data is collected every day. This data should be useful for road safety practices only if it is properly coded, visualized, processed, and analyzed systematically. The analyzed data provide meaningful results, especially the road crash black spots. The vulnerable locations thus identified the need to display to a wider audience rather limited to the researchers and bureaucrats. The present study was an attempt in this direction. The study developed a Road Crash Information System (RCIS); the web application shows the first and second-order road crash black spots within the State of Kerala. Tools and graphical interfaces are given to the application to facilitate facile analysis and visualization of the road crash details by a common man. The web application can provide a common online platform for reporting accidents to selected organizations such as the Regional Transport Offices (RTO), the Police Department, and the Motor Vehicle Department (MVD). This common platform can overcome any shortcomings such as loss of data, repetitive data collection, and inconsistencies in results and leads to high reliability in data collection and accident management systems. In addition, such a system would provide road users with valuable information on the location of accident black spots all over the area and the trends of road crashes. The developed system will be hosted publicly soon. For recording the road black spots details, a map-based interface for capturing the location coordinates can be provided instead of manual entry, and bulk data uploading utility could be included in the future. A mobile and desktop application for the system can be developed in the future.

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