Integrated System for Collecting and Reporting Crash and Citation Data

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Abstract: Currently, the collection of crash and citation data is performed by law enforcement agents without taking full advantage of existing state-of-the-art technologies. Availability of communication networks and recent developments in software technology provide opportunities to collect data in an easier, faster, and more accurate manner. Key challenges in collecting of this type of data include standardizing and capturing the right location where crashes occur as well as minimizing the exposure time of law enforcement agents at the scene. This paper describes the development of a state-of-the-art crash and citation data collection system and geospatial database, hosted by a remote server, a mobile application, and a web portal. The proposed system takes full advantage of Geographic Information and Positioning Systems to capture location data and provide tools to create scene diagrams. The proposed system was designed and implemented in cooperation with law enforcement agencies and data users to meet the needs of various stakeholders.

1 INTRODUCTION

Some of the existing software and hardware used by law enforcement agencies to collect crash data are obsolete for several reasons, ranging from budget constraints to lack of coordination across various groups. The most significant consequence of using obsolete tools are location errors, which preclude the correct use and reliability of the data. In addition, the time required for law enforcement agents to be at the scene could be lengthy, especially to collect data adequately.

Accurately locating crashes is key to geographic analyses of crash statistics and patterns as well as for the development of safety recommendations for crash 'hotspots'. Generally, an involved process is required to locate crashes and collect relevant data on public roads, using text formats and hand drawings. Many crashes cannot be located or have been incorrectly located, and the data are hard to register. The main impediments to locate crashes accurately and collect crash data are well known, and include errors in data entry, street name errors by the recording officer, the existence of alias names, and county coding errors as well as many other factors.

Crash data can be analyzed to study the incidence of the various factors in crashes; for example, information of events involving drivers under the influence of alcohol (DUI) can be used to support decision making. The methodologies for traffic safety management recommended by the *Highway Safety Manual* (AASHTO, 2010) require accurate crash and location data (Paz et al., 2015), currently collected by law enforcement agencies. This data are needed for performance-based traffic safety programs as well, and must be prepared by state agencies to address requirements from the legislators (NCHRP, 2010; FHWA, 2013).

To address data-collection issues and provide better technology for law enforcement agents, the Transportation Research Center (TRC) at the University of Nevada, Las Vegas (UNLV), has developed and implemented a system for the accurate and efficient collection of crash data, including location. The proposed solution uses a Geographic Positioning System (GPS) and a Geographic Information System (GIS) to geolocate crashes and provide a map-based data-collection environment. Compared to existing processes and technology in use, this system greatly reduces the time and resources involved in consistency checking and error correcting during data collection.

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The proposed system was developed with help from various law enforcement agencies in Nevada. Considering the challenges associated with collecting location information as well as the data need of various stakeholders, in addition to the geospatial coordinates of the crash, the proposed system includes a scene diagram that captures screenshot of the crash location, using a GIS map.

The development, implementation, and testing of the proposed system included continuous interaction between users and developers in order to take full advantage of field experience and associated needs (Racheva and Daneva, 2010). This ensured that the expectations and needs from law enforcement agencies and data users were fully addressed.

2 PROPOSED SYSTEM

The system involved a server hosting a geospatial database, a mobile application, and a web portal, as shown in Figure 1. Law enforcement agents collect crash and citations data using the mobile application. The data are send in real time to the geospatial database hosted by the server application, which makes the data available through the web portal. In addition to a website, the web portal offers a REST-API (Fielding, 2000) web-service endpoint, which allows external systems to extract raw or aggregated information. This web service endpoint was built using Open Data Protocol (OData, 2010).

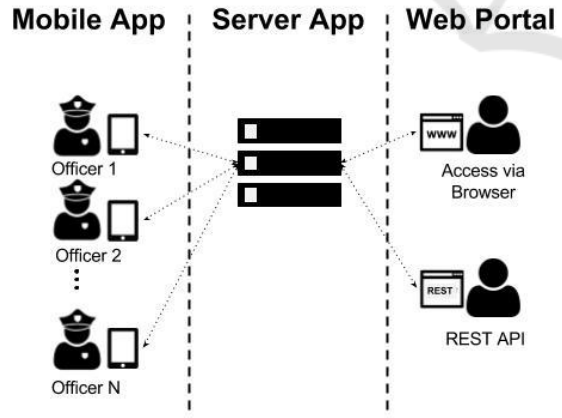

Figure 1: Conceptual illustration of the proposed system.

The primary requirements of the proposed solution include:

1. Accuracy of the location information;
2. Efficiency to minimize the time required by the agent to be in the field;
3. Flexibility to navigate through menus;
4. Synchronization across crash and citation data, when required;
5. Capabilities to create a scene diagram, powered either by a map or using a freehand sketch view;
6. Capabilities to attach to reports all types of files, including pictures, and a screenshot of the crash location;
7. Capabilities to read information from driver licenses and vehicle registrations by using a barcode reader, and
8. Querying capabilities through the web portal to generate graphs, charts, and reports.

In addition, it is desirable that a data collection system considers real time statistics, ease of access to the data, data completeness, and safety of the data collector, among other primary issues. A description of how the proposed solution addresses these issues is provided in this paper.

The proposed system will be tested by law enforcement agencies in Nevada. Therefore, the system was implemented in compliance with the standard data dictionary for crash and citations information for the State of Nevada Citations and Accident Tracking System (NCATS) (NHTSA, 2010).

2.1 Data Accuracy

Although all collected data are important, currently, the most challenging issues focus on location and scene information. Current data collection solutions used by law enforcement agencies, require typing the location of the crash or citation. Those locations can be translated into coordinates and geographical information. However, frequent entry errors preclude the correct translation. The proposed system allows on-site location capture using GPS and maps. Figure 2 illustrates the user interface that allows location capture. The coordinates and corresponding address, if existing, for a crash or citation is provided by GPS and displayed on the screen. If the accuracy of the GPS is not sufficient or the data collection device is located away from the crash location, the agent can use the touch-screen map to set the correct location.

An additional challenge for locations on highways is when a location does not have a physical or mailing address. In these cases, police officers assume a reference point (for example, an intersection or ramp) and guess a distance to such a reference point. However, guessing is subjective, and generates accuracy issues and inconsistency in the stored data. To address this challenge, the proposed system allows the administrator to partition the highways into small regions, each with a unique geo-tag or standard

location label. This partitioning enables consistent location information and accuracy. Figure 3 illustrates this geo-tagging functionality. Using this capability, a police officer collecting data just needs to check that the software has selected the right geo-tag or geographical region.

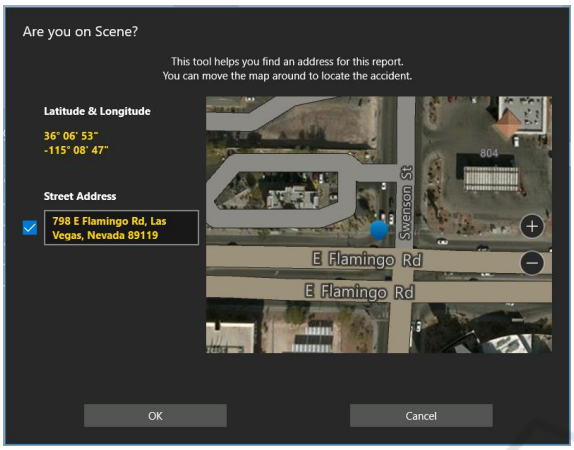

Figure 2: Capture of crash and citation location by the proposed system.

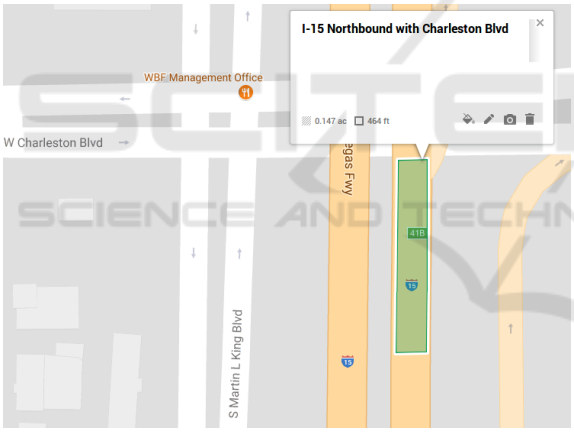

Figure 3: Definition of labeled areas for location on highways.

Figure 4 illustrates the user interface that enables the construction of a crash scene diagram. This interface shows, by default, the GPS location of the mobile device hosting the mobile app. In order create a realistic and detailed representation of crash, the interface allows the agent to drag with his or her finger all the elements involved in the crash scene. In addition, the agent can create a freehand sketch of the scene, and take an unlimited number of photos.

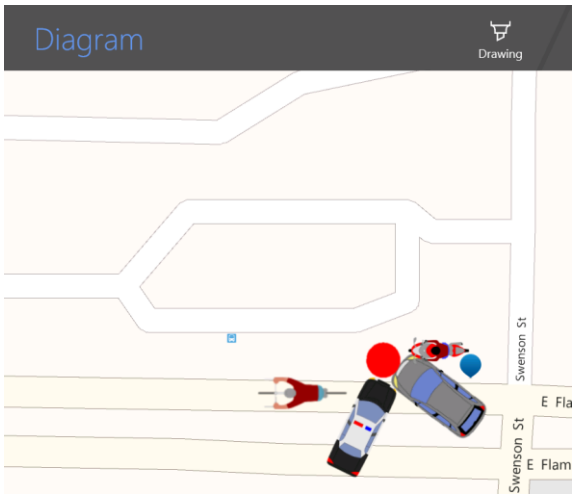

Figure 4: Crash scene diagram.

2.2 Real-Time Collection and Reporting

The data collected are automatically sent to the server in real-time on a regular basis by means of the cellular network. This was designed to minimize the risk of losing data because of a special event, such as the loss or damage of the mobile device. If network connection is not available, the data are stored in the mobile device until the connection is reestablished and the data are completely received by the server.

Once in the server, the data can be aggregated and filtered in real time to generate reports. Among two important applications. Figure 5 shows how the system provides color-coded locations and the status of crashes, based on how old they are, and/or an applied filter. This type of information could be important for real-time operations and tactical decisions by managers and supervisors. Figure 6 illustrates how a heat map is used that allows the user to zoom into specific zones and apply filters to analyze crash patterns in detail.

Figure 7 illustrates the density of crashes by day of the week and time of the day for a selected year. By default, this summary includes the entire number of crashes in the system but it can be filtered by the severity of the crash (injuries, fatalities, property damage). Other available filters and diagrams include severity of crashes, involvement of drugs, and gender or age.

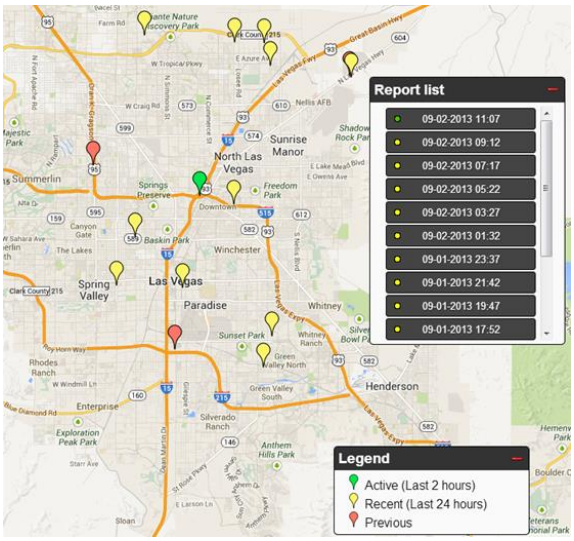

Figure 5: Crash location and status.

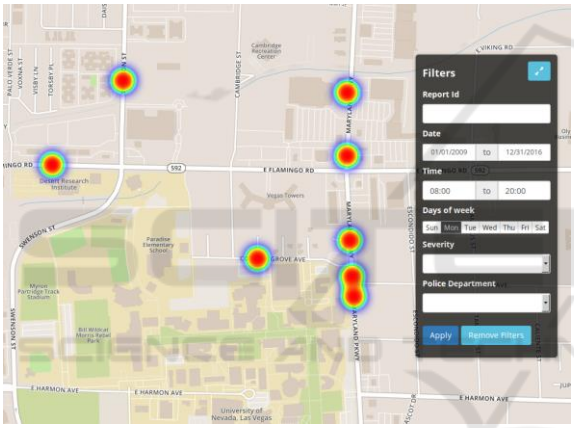

Figure 6: Heat map of crash densities.

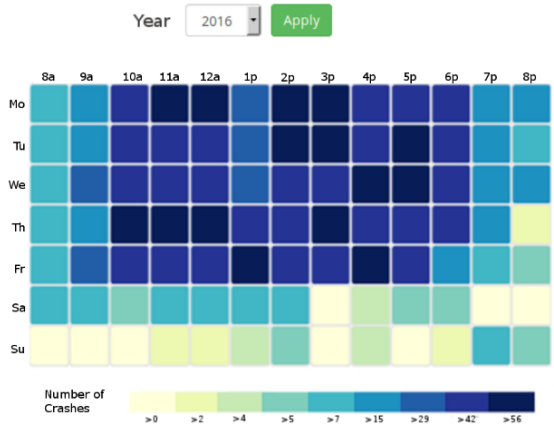

Figure 7: Crash density by day of week and time of the day.

2.3 Ease Access to Data

The data collected are available online and can be accessed easily through the web portal or the REST-API. For the web portal, an account is required to register, modify, or aggregate the data. A reporting feature has been included in the proposed system to allow exporting aggregated or disaggregated reports in 1) common formats for data interchange, such as XML, CSV, and JSON; and (ii) common document formats, such as PDF, DOC and XLS. If desired, some of this information can be made available for public access, including special statistics.

If required by government agencies or interconnected systems, this proposed system offers a REST-API with OData protocol implementation. The use of an OData implementation makes information retrieval of linked entities easier (Carey, 2012). The access to the REST-API is available only for authenticated users.

2.4 Data Completeness

Law enforcement agencies have requirements concerning the collected information. Data dictionaries are designed to standardize the structure and codification of the information. For illustration purposes, the proposed solution for this system implements all the required fields that are specified in the NCATS data dictionary, version 2010.

Implementations using a different data dictionary requires changes to the system, which could be minor or large, depending on the differences with NCATS. However, all important and significant capabilities, such as the collection of location information and scene diagram, require no changes to the system unless special needs or upgrades are demanded.

In order to minimize the risk of mistyped information, and reduce the effort required to manually type in the data, such features as barcode readers for driver license and vehicle registrations were implemented in this proposed system.

2.5 Safety of the Agent

It is very important to minimize the time that the agents are exposed to traffic and danger. The proposed system was designed to minimize the time required by an agent to collect field data. In critical or urgent situations, an agent can collect on-site critical information rapidly by using a minimum number of touches to the screen on the GPS device, the camera, and the barcode reader. Later, when in a less risky environment, the agent can complete the rest of the

data collection by using the mobile application or the web portal.

Table 1 shows an estimated time to collect critical information about a typical crash scenario with two cars and two occupants. This estimation assumes that the agent has access to the drivers' licenses and vehicle registrations.

Table 1: Estimate time to collect critical crash data.

Information Item	Time (sec)
Location	5
Vehicles	12
Drivers	12
Pictures	10
Total	**39**

3 RESULTS

Multiple meetings with law enforcement agencies in the State of Nevada have been conducted to review the design and implementation of the proposed system. Law enforcement agents have acknowledged that the mobile application provides enough accuracy to capture location information. They agreed that the crash-scene diagram tool provides all the necessary elements to create a reliable representation of the scene. In addition, they have suggested usability improvements, such as pre-filled values and favorite lists for commonly used fields.

Administrative staff has validated compliance of the collected information with the NCATS data dictionary. It has been confirmed that the reports and statistics generated in the web portal contain the required information. Additional statistics and reports have been suggested by administrative staff to increase the benefits of the reporting tool. Feedback has been collected from multiple agencies, and new features have been added to the proposed solution based on their suggestions.

To validate the proposed system in a real-life environment, a field test was completed with the Nevada Highway Patrol (NHP) Southern Command. The field test was designed to collect feedback from four police officers having distinct roles in the data collection process. One agent was the system manager, and had a high-level knowledge of the technical features of the system. The other three agents were troopers who collected daily information on crashes and citations on the highways. Two of them collected information using a tablet device and the other with a handheld device. The requirement was that all four police officers collected at least three crash reports and three citations. In total, 12 crash reports and 15 citations were collected.

Results from the field test were used to improve the system. Several enhancements related to usability were implemented. The field test participants highlighted the (i) significant reduction in time required for data collection and (ii) ease of interaction with the system.

4 CONCLUSIONS

The developed system is able to collect crash data *in situ* and store it in a geodatabase. Data that is collected is characterized and processed in real-time to generate reports, maps, charts, and statistics. The proposed data collection system facilitates the data collection while saving time, reducing errors, and enabling the collection of the more valuable information from crashes, such as the scene diagram. The proposed system is the result of a combine effort involving law enforcement agencies, the Nevada Department of Transportation, and the University of Nevada, Las Vegas.

Future work includes the development of additional performance measures. A key capability required by law enforcement is the ability of multiple officers to be able to work on the same report at the same time. In addition, such capabilities as the ability to generate collision diagrams and visuals are desirable that can report various statistics, including expected crash frequencies and the rankings of sites based on them (Paz et al., 2014). The field test provided a great opportunity for NHP to propose valuable capabilities, such as:

- Geo-tagging or highway regions to improve location accuracy.
- A tool to compute the distance from a crash location to a reference point defined by the agents.
- Towing sheets to register and print information of vehicles that were towed after a crash or citation.
- Social media notifications for crashes classified as severe.

These are very desirable features that were devised only because of suggestions and ideas generated during the field test. These capabilities are currently under development for planned field testing.

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