Geospatial Big Data Analytics for Road Network Safety Management

Wei Liu
GHD
Level 1, 103 Tristram Street, Hamilton, New Zealand 3204
wei.liu@ghd.com

ABSTRACT
Reliable and accurate data are needed in each stage of road safety management in order to correctly identify problems and risk factors and priority treatments, and to formulate strategy, set targets and monitor performance. Ongoing, data-led diagnosis and management of the leading road safety problems enables appropriate action and resource allocation. Data relevant to road safety are collected every day, but for these data to be useful for informing road safety practice, they must be properly coded and visualized, processed and analysed in a systematic way. In this paper, the development of an integrated road safety data management system is introduced. The road safety data management system consists of a geospatial database for storing, querying and analysing road safety related data including crash records, road safety deficiency records, carriageway, surfacing, geometry, skid resistance, signs and road marking etc, and a GIS mapping platform for visualizing and integrating different data sets. Data from New Zealand State Highway network is used to demonstrate the potential application areas of the information system developed, such as identification of crash hot-spots, development of safety intervention and safety management strategies, planning of minor safety improvement programme, and investigation of severe and fatal crashes.

KEYWORDS: Road Safety, GIS, Big Data, Data Integration, Risk Profiling, Clustering, Web Mapping

1 INTRODUCTION

Road controlling authorities put great effort and expense into collecting large quantities of data related to road asset management, including road safety related data. Data is the cornerstone of all road safety activity and is essential for the diagnosis of the road crash problem and for monitoring road safety efforts (WHO 2010). Reliable and detailed data help road safety practitioners accurately identify problems, risk factors and priority areas, and to formulate strategy, set targets and monitor performance as shown in Figure 1. Without ongoing, data-led diagnosis and management of the leading road injury problems, it is difficult to achieve significant and sustainable reductions of crash risk or the severity of crashes.

In New Zealand, crash and other related road safety data have been collected for several decades. Crash Analysis System (CAS) has been used to record and analyze road crashes since 1990s (LTNZ, now NZTA, 2005). The CAS is an integrated computer system that provides tools to collect, map, query, and report on road crash and related data. It contains data from all traffic crashes reported by police.

Safer Journeys, New Zealand’s Road Safety Strategy 2010-20, has a vision to provide a safe road system increasingly free of death and serious injury. It adopts a safe system approach to road safety focused on creating safe roads, safe speeds, safe vehicles and safe road use (MoT, New Zealand, 2010). These four safe system pillars need to come together if the Government’s vision for road safety is to be achieved. This approach represents a fundamental shift in the way we think about road
safety therefore there is the additional challenge and demand for integrated and more effective use of various types of road safety data.

Figure 1 Data Flow in Road Safety Management

2 USE OF GIS FOR ENHANCING ROAD SAFETY ANALYSIS

The use of Geographic Information Systems (GIS) in road safety analysis has increased rapidly in recent years. A major reason for this growing interest is the fact that spatial factors such as land use, population density, population distribution, socio-economic factors as well as environmental factors have strong influences on crash occurrence in addition to the commonly known geometric design elements of roadways.

GIS has been widely used for the geocoding of accident locations and developing maps of crashes. Not only for visual representation, GIS has also been used to enhance data integration and efficient handling of information from various sources in some studies. For example, spatial statistical techniques were used to identify clusters of road segment crashes in Belgium (Flahaut et al. 2003), to locate snow related crash locations (Qin 2007), and to locate road segments and intersections with high pedestrian and bicycle related crashes (Bejleri et al. 2007). CAS (LNTZ, now NZTA, 2005) utilises mapping data supplied by Critchlow Associates Ltd (www.critchlow.co.nz), including state highways, motorways, arterial roads, all roads, railways and railway stations, rivers and lakes, built-up areas, cities, towns, places of interest, territorial authority boundaries, regional government boundaries, census meshblocks and area units, Transit New Zealand boundaries, and police station, area and district boundaries. Between 2004 and 2006, Transit NZ (one of NZTA's predecessors) put in place a strategy to articulate and implement a vision for the use of geospatial information. As a result of this a Spatial Viewer (SV) application was developed to integrate all available data. The Spatial Viewer has improved data representation and created significant potential to undertake more advanced spatial analysis into the future. Access to data has improved, including to staff in the field, and the technology can assist senior managers in their decision making including the road safety improvement. KiwiRAP, the New Zealand Road Assessment Programme, has produced risk maps (KiwiRAP 2008) and star rating maps (KiwiRAP 2010) for the whole state highway network of New Zealand since 2008. Based on KiwiRAP and two of NZTA’s recent publications, High-risk rural roads guide (NZTA, 2011) and High-risk intersections guide (NZTA, 2012), SafetyNET is a road safety tool developed by Abley Transportation Consultants (Durdin and Janssen, 2012) for NZTA.
SafetyNET is a nationwide State Highway GIS application that displays crash data and a number of attributes for each section of each State Highway. Enabling the display of this information in a spatial manner allows users of SafetyNET and funding agencies to effortlessly identify those high risk parts of the State Highway network that warrant attention, and then target their investigations and investments.

3 DEVELOPMENT OF INTEGRATED ROAD SAFETY INFORMATION PORTAL

Road safety management has been identified as one of key areas in New Zealand State Highway maintenance. To improve the safety performance of the State Highway network and to assist in the management of the road safety work on the network, an integrated road safety information portal, consisting of a road safety database and associated mapping tools, have been developed. The system combines and integrates road safety related data from various sources including RAMM, CAS, State Highway Safety Deficiency Database (SDD), Road Safety Audit (RSA), Safety Reduction Studies (SRS), and safety studies (road safety inspections, driver behavior studies, safety risk profiling analysis, and safety hot spot clustering analysis etc.). The structure of the integrated road safety information portal is shown Figure 2.

Figure 2 Structure of Integrated Road Safety Data Management System

The core component of the integrated road safety information is a road safety geospatial with all relevant data modelled as spatial objects (point and line) and encoded in geospatial format and stores all safety related data in a centralized location. It provides functionalities to perform spatial query and spatial analysis and integration with other spatial database. It also provides tools to convert
locations between linear referencing system and spatial referencing system. Figure 3 shows a screenshot of the safety database.

The data in the road safety database are visualized through the mapping tool. Functionalities of converting data from road safety database into geospatial layers (such as ESER shape file and Keyhole Markup Language (KML) file) have been included in the mapping tool developed for the road safety database. Google Earth is the primary platform for visualization of the data in the road safety database. Google Earth combines the power of Google Search with satellite imagery, Google 360 panorama streetview images, maps, terrain and 3D buildings to put the world’s geographic information in a single platform. No other GIS has available the background images that Google Earth does so for visualizing data, and it has a user-friendly interface and is free to public use.

APPLICATIONS OF INTEGRATED ROAD SAFETY INFORMATION PORTAL

There are many applications of the integrated road safety data management system developed for PSMC007 (West Waikato) in both network and project level. Some of its typical applications are presented below.

1) Identify high risk areas in the network: high risk areas are hot spots in the network with concentrations of crashes. Geospatial clustering analysis and crash risk profiling analysis have been used to identify hot spots in this study. Figure 4 below shows an example of hot spot analysis results.
2) Integrated data analysis: data from various sources can be integrated in the road safety database and displayed all together in Google Earth. This makes it easier to find out the contributing factors that influences the safety performance of the road. Figure 5 below shows an example of integrated use of surface, skid resistance, road sign and crash data in a safety study.
3) Provides input for road safety audit: the combined use of the road safety database and its mapping tool in Google Earth is able to provide the input for road safety audit such as crash history, existing road characteristics, and safety deficiency data. Figure 6 below shows the data in Google Earth for the road safety audit of a pavement rehabilitation treatment section.
4) Visualization of data from driver behavior studies: data, including driving speed and accelerations, from driver behavior studies are stored in the road safety database and visualized in Google Earth for identification of areas of inconsistent driving occurred in the network. Figure 7 shows some screenshots for the mapping of driver behavior data.
5 SUMMARY AND CONCLUSIONS

Effective use of data is a challenge in road safety management under the safe system approach. The integrated road safety data management system developed for New Zealand State Highway network has the potential to make the most of data and to apply it in the areas of road safety studies. By applying the tools developed, more informed decisions on road safety improvements can be achieved.

REFERENCES


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