Automatic collection of safety related road and roadside data

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ABSTRACT

In order to address risk, it is important to have up-to-date information on the state of a road network, including both road and roadside elements. Accurate collection of this information can be time consuming, and the task often involves subjective assessment of risk. This paper explores current technologies that are available for the automatic collection and processing of safety related road and roadside data as well as highlighting the results from a trial to collect information on roadside hazards.

WHY DO WE NEED TO COLLECT ROAD AND ROADSIDE DATA?

The traditional approach in road safety has been to use crash history as the basis for assessing risk. This approach has been highly successful in Australia and elsewhere (e.g. benefit-cost ratios of 14 from the federally funded black spot program - BTE 2001). However, recently there has been a move towards an additional risk assessment approach based on the risk inherent in road and roadside features. This approach has grown from the safety audit process (particularly audit of existing roads) and the movement has occurred for a number of reasons. Firstly, Australia has adopted the 'Safe System' approach which includes the need to address all locations where fatal or serious crashes may occur, not just those where crashes have previously occurred. Secondly, there are legal liability issues (stemming from the removal of non-feasance) with a need for road authorities to know where risks lie on their roads. Thirdly, there are decreasing treatable crash blackspots, especially in rural areas. As an example, based on New Zealand and Victorian crash data, only a third of fatals occur in locations defined as blackspots, and from New Zealand data, over half the fatals occurred at locations with no other crashes in the five years leading up to that event. This shows that by just treating black spots, a large proportion of crashes are being neglected. Finally, based on research over the last few decades, far more is now known about the road elements that influence the level of risk, and this information is able to be used to estimate which sites are likely to be of higher risk.

A number of systems have been produced that allow an objective assessment of the road network to determine the level of risk based on road and roadside features (e.g. RISA, AusRAP and NetRisk – see Appleton et al. 2006; Daly et al. 2006; McInerney & Doyle 2006). However, in order to accurately estimate the level of risk on the road network, there is a need to collect a wide variety of information. This includes elements such as road surface condition, horizontal alignment, lane and shoulder width, delineation and a variety of other measures.

Accurate collection of this information can be a time consuming task, and one that often involves subjective assessment of risk. Methods include driving the network and visually inspecting the road features, or videoing the network for later office-based visual assessment. Collection of road and roadside information has traditionally been the domain of asset managers, with little attention applied to the collection of information specifically for road safety purposes.

With recent technology, it may be possible to automate much of the data collection and processing required for road safety purposes. It may even be possible in the near future to automatically collect enough data to provide a reasonable picture of safety of the network. This would dramatically reduce the resources required to assess network safety, and increase the accuracy of the assessments that are made.

However, at present it appears that in most cases the collection and processing of safety related data is completed manually. Whilst the video images can be used to objectively measure parameters (e.g. measure widths with calibrated video images), the main interest for this project lies in the automatic collection *and* processing of road and roadside information (i.e. processing without manual involvement).

This project aims to explore the current technologies that are available for the automatic collection and processing of safety related road and roadside data. This involves the identification of features that are of importance; an understanding of the data that is currently available for collection; and an assessment of what road features need be collected in future.

The focus for this project is primarily on midblock rural road environments, although information gathered will also be of relevance to urban data collection and processing.

WHAT INFORMATION DO WE NEED TO COLLECT?

Earlier research conducted by ARRB on behalf of Austroads has identified the road and roadside features which contribute significantly to road safety risk (see Turner & Tziotis 2006; McLean & Veith in press). These features include:

- horizontal alignment
- vertical alignment
- superelevation

- speed environment
- lane and shoulder width
- clear zone width
- road surface condition (skid resistance)
- separation of opposing traffic flow
- delineation
- overtaking opportunities/facilities
- street lighting
- access points
- sight distance.

WHAT INFORMATION CAN WE CURRENTLY COLLECT?

A literature and internet review was conducted to determine available technology to collect the road and roadside information identified above. The information that was identified was of two types: commercially available applications of technology, and academic research which takes a theoretical or experimental approach to the automatic capture and processing of information.

A number of examples were identified where current technology existed that enables the automatic collection and processing of road and roadside data (mainly identified through internet websites).

A number of organisations are capable of automatic data collection of horizontal alignment using technology such as GPS and GIS. Some are also able to provide data on the gradient and superelevation of a road. Most of the organisations listed provide data collection services for automatically determining the road surface condition including rutting and roughness properties, with many also being able to determine the pavement’s skid resistance properties.

The operating speed of the data collection vehicle can be used as a proxy for the speed environment, and technology exists to identify the posted speed limit automatically. In some cases, delineation devices are able to be identified but this appears to be limited to signs and luminance of markings.

For other types of safety related risk factors it appears that some form of manual processing is required (typically through video footage, sometimes using subjective estimation, and sometimes using calibrated measurement). Lane and shoulder widths can be accurately calculated using calibrated video footage, as can the width of clear zones. Objects within the clear zone require manual examination of video footage, as does presence of lane separation (median barriers), delineation, overtaking opportunities, street lighting, access points and sight distance.

A number of new technologies were identified through the literature review. The majority of research appears to be on road sign recognition (e.g. Fang et al. 2004; Gao et al. 2002; Janssen et al. 1993; Priese et al. 1993; Shaposhnikov et al. 2002; Shneier 2005; Tao 2001; Wu et al. 2005). Various techniques to detect road signs have been developed, with most focusing on detection using colours and shapes of signs to determine the sign type.

No organisations were found to be using this technology yet, with Tao (2001) suggesting the main reason for lack of commercial use is that the type of technology is very complex and still quite expensive so not financially viable.

Toth et al. (2001) discussed a technology able to automatically recognise delineation (centrelines and edgelines) using a series of algorithms to interpret data collected by a digital camera.

Nehate & Rys (2006) have created a method for the calculation of stopping sight distance (SSD) using all three dimensions of GPS data. Parametric equations are used to represent the roadway and sight obstructions, including grades, horizontal and vertical curves. The available sight distance is calculated by examining the intersection between the sight line and the elements representing the roadway and sight obstructions.

A study by Ng et el. (2006) developed a technique to detect guide posts, with the research team successfully able to detect around 85% of guide posts on two study routes.

Cuskelly & McDonald (2006) identified options to scan and locate the position of roadside objects (trees) for a road widening project. They selected a technology, previously used in rail and mounted on rail trolleys, and adapted it for use on roads. Although very accurate, the ideal scanning speed was found to be only 3.6 km/h.

Finally, an automatic data collection system called the Digital Highway Measurement (DHM) system is currently under development at the Turner-Fairbanks Highway Research Centre in the US. The DHM system is claimed to be able to measure horizontal and vertical alignment as well as obtain various pavement surface characteristics (edgeline, centreline etc.). It is understood that the system is not yet in commercial use, and unfortunately no further information was available on the system at the time of this review.

In summary, technology currently exists to collect information on the following features:

- horizontal alignment
- vertical alignment
- superelevation
- speed environment
- road surface condition.

The accuracy of this information in most cases appears adequate for an assessment of road safety risk. New technologies are currently being developed for other road features, but are not yet advanced enough for commercial application.

WHAT ARE WE NOT ABLE TO COLLECT?

Features for which there appears to be no ability to automatically process data are as follows:

- lane and shoulder width
- width of clear zone
- type of object within clear zone
- whether opposing traffic flows are separated
- delineation devices present
- overtaking opportunities/facilities
- presence of street lighting
- access points
- sight distance.

Based on an assessment of each feature's importance to road safety, and the ease with which new technology could be developed, it was recommended that technology to assess the width of clear zones be developed as a high priority.

DEVELOPMENT OF CLEAR ZONE DETECTION TECHNOLOGY

A trial was undertaken to assess whether technology existed to allow the detection of roadside objects, and the distance to that object. A digital scanning laser manufactured by SICK (the LMS 221-S16), was selected for the trial. The scanner scans at 180 degrees by deflecting an internally rotating mirror. A light impulse is emitted every 1 degree for the whole 180 degrees. The scanning rate of the laser is 75 Hz (75 scans per second) and has a typical range of 30 metres.

Two trials were conducted to test whether this equipment could be used to detect roadside objects. The first trial took place on an urban stretch of road 100 metres long. The roadway contained several trees, a parked car and a number of driveways. Test runs were undertaken travelling at 60 km/h and 30 km/h with the scanner in various configurations. Operating at the same time, a video camera recorded the roadside as the vehicle drove the test route. The scanner was mounted onto a beam on the tow bar of one of the ARRB data collection vehicles at an angle of 30 degrees to the horizontal and 0.5 metres off the ground.

A typical 60 km/h trial on the 100 metre long section resulted in approximately 85,000 data points being recorded. The format of recording allowed the data points to be easily transferred into Microsoft Excel. This allowed plotting of the distances to objects against the route length.

As expected, not all of the data can be used. Given the scanner was placed at a 30 degree angle, some of the laser beams will be infinitely long as they will be pointing at the sky. Similarly, given a 180 degree sweep is taken, the laser will also emit beams onto the ground almost directly below the scanner.

Initially it was decided to look at just one laser beam to get an idea of the scanner’s output; the beam emitted at 90 degrees. The plot of the 90 degree beam is shown in Figure 1.

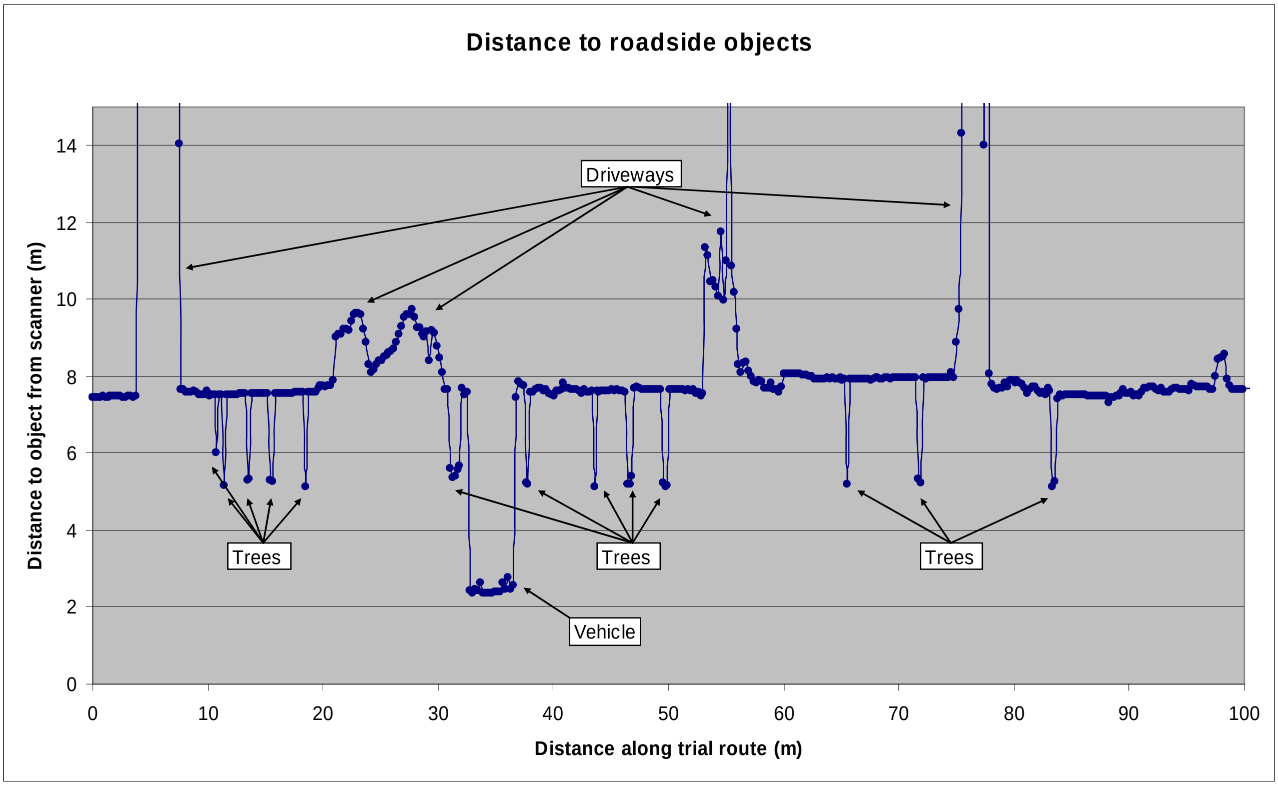

Figure 1: Results from trial 1 – distance to roadside objects

This shows the scanner detecting a number of objects. The next step was to look at the video camera footage to determine how well the location of the objects detected by the scanner correlated with the video footage and to then determine what the objects actually were. The video footage showed the scanner had detected 5 driveways, 13 trees and a car parked on the side of the road. The location of these objects as detected by the scanner, in terms of their position along the roadway, was verified based on a review of the camera footage. The footage showed that the scanner had picked up objects in the correct position along the roadway with a relatively accurate measurement of distance to that object.

A second trial was conducted in a rural environment, and an assessment made to determine the accuracy of the data that was collected. The route (approximately 2 kilometres in length) consisted of typical semi-rural type terrain (trees, dense scrub, occasional driveways and fenced paddocks). Along with the sensor, a camera was again used to record the roadside, however, in this trial the camera was calibrated to allow manual measurement of the distance to objects (essentially through the counting of pixels). Results from this trial are shown in Figure 2.

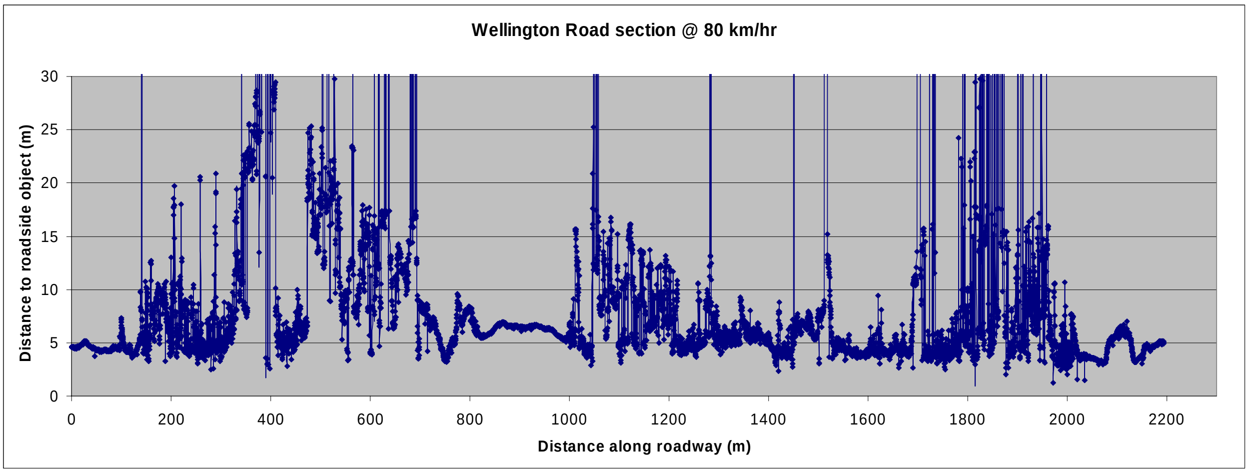

Figure 2: Results from trial 2 – distance to roadside objects

Spot checks were undertaken to compare the results of the scanning laser to the calibrated camera. In all cases the distance measured by the scanning laser equalled that measured using the calibrated measuring tool.

Although further work is required to verify the accuracy of the data, it appears that the equipment provides the potential to collect information on roadside hazards. With further development it would be possible to use more of the collected data, allowing detection of very narrow objects, or even allowing the production of 3-D images of the road environment with data collected at normal driving speeds. Given similar technology developed at ARRB, it should be possible to generate a map of a road network, and to highlight on this all locations where roadside objects exist. These tools would allow filtering so that the threshold at which objects are included can be changed (e.g. showing only objects within 5 m, or 9 m of the vehicle).

Combined with other objective road based data (such as horizontal alignment, speed environment and road surface conditions) it is now possible to make predictions about the probability of a crash occurring and the consequences of this in terms of severity. This would allow cost effective targeting of resources to address high risk locations.

CONCLUSIONS AND RECOMMENDATIONS

Collecting information on the road and roadside is becoming increasingly important for assessments of road safety risk. Currently, collection of information on key risk factors can be a time consuming task and contain some degree of subjective assessment. Collection of data in an automatic way would improve the rate of data collection and the degree of accuracy.

It is already possible to collect some of this information in an automated way. However, for many features no adequate technology existed. In terms of highest priority, information on the distance to the nearest roadside object, and the type of object were thought to be most important. A simple trial showed that it should be possible to at least identify the distance to roadside objects. However, it is recommended that further work be conducted to improve this data collection technology, including analysis tools to assist in the interpretation of these data (e.g. a map based tool).

Further automatic data collection techniques are also required, much of this involving some form of object recognition. This would include the ability to recognise roadside signs, as well as road markings (particularly edge and centrelines). Further investment is required to develop this technology, and this may be costly. However, it is likely that the information will be of use not only to safety practitioners, but also to asset managers, so it is likely that the benefits of such a system would outweigh the costs.

Based on the simple trial highlighted here, it is likely that it will be possible to develop tools which will automatically assess enough factors to determine the risk associated with run-off-road crashes. By combining information on the speed environment, horizontal alignment, road surface condition and distance to roadside objects, it should be possible to identify a relatively accurate level of risk associated with running off the road (along with the expected degree of severity). Such tools would be highly useful in identifying the current level of risk associated with road and roadside features.

With further development, it may be possible to collect enough information on all of the key risk factors to identify a relatively accurate estimate of overall risk for all crash types. If this could be done quickly and in an objective manner, this would greatly assist road authorities in assessing the level of risk on their networks. It is recommended that work continue to achieve this goal.

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