Vision Systems for Analysis of Congested Traffic

Colin CAPRANI
Lecturer
Dublin Institute of Technology
Dublin, Ireland
colin.caprani@dit.ie

Colin Caprani received his structural engineering degree from the Dublin Institute of Technology in 1999. He was awarded his PhD in 2006.

Eugene OBRIEN
Professor
University College Dublin
Dublin, Ireland
eugene.obrien @ucd.ie

Eugene OBrien received his civil engineering degrees from the National University of Ireland, Galway in 1980 and 1982. He was awarded his PhD in 1985.

Serena BLACOE
PhD student
University College Dublin
Dublin, Ireland
serena.blacoe@ucdconnect.ie

Serena Blacoe received her structural engineering degree from the Dublin Institute of Technology in 2011.

Summary

For long-span bridges, congested traffic forms the governing traffic load condition. This paper reviews the current state of the art and the deficiencies in the data upon which the modelling of congestion is typically based. It is proposed that a vision system be adopted to collect statistical information for the parameters required to properly calibrate congestion models. Conventional methods for the detection of vehicle features in images are described, applied to sample images, and criticised. It is concluded that vision-based methods are a viable tool for gathering inter-vehicle gap data, but that existing methods of wheel detection are not sufficient. Therefore the development of a new technique for wheel detection is recommended and some suitable attributes identified.

Keywords: long-span bridges; congestion; microsimulation; intelligent driver model; Hough transform; template matching.

1. Introduction

Accurate evaluation of bridge safety is essential. Repair and replacement of bridges is costly and so there is scope for potentially significant financial savings if the accuracy of the safety assessment can be improved. For long-span bridges, congested traffic forms the governing traffic load condition. A sympathetic congestion model must explicitly account for the presence of cars. To date, inter-vehicle gaps have simply been assumed for the purpose of congestion modelling. It is proposed that a vision system could obtain required information on the gaps between vehicles in congested traffic. Image processing methods for extraction of vehicle features are reviewed.

2. Congestion Modelling

Some studies have considered inter-vehicle gaps in congestion models to be a single value, whilst others model the gap as a stochastic variable with a mean and standard deviation. A more complex model for modelling real traffic behaviour and interaction is traffic microsimulation. One such model, the Intelligent Driver Model [1], allows inter-vehicle gaps to vary continuously. Many studies do not illustrate the impact of the gap assumption on the calculated load effects. Caprani [2] varied the inter-vehicle gap assumption in the headway model and found that the characteristic lifetime load varied by 20% to 30%. Thus, the accuracy of congestion modelling could be improved by obtaining statistical information on true inter-vehicle gaps in congested traffic.

3. Methods for Gathering Information on Gaps

Traditional methods for obtaining headways, such as induction loops, are ineffective when vehicles are travelling at slow, varying speeds. A vision system perpendicular to the flow of the traffic could provide the locations of bumpers and axles in congested traffic. Vehicles could then be tracked through successive frames, and the inter-vehicle gap and axle-gaps found.

Wheel detection in images is a complex task. The primary methods are template matching and the Hough transform. In the template matching method, each area of an image is compared with a

https://doi.org/10.2749/222137813806501966

smaller “template” image to determine the degree of similarity. The degree of similarity can be calculated by methods such as normalized cross-correlation. The generalized Hough transform assumes each point on a colour boundary (‘edge point’) lies on a circle. The centres of all possible circles on which the edge point could lie are calculated. Each of these locations is “voted for” as a potential circle centre. The true centres are be the locations with the most ‘votes’ in the image space.

3.1 Application of Methods in the Literature

Template matching is successful in many non-traffic applications, such as fingerprint matching. The case is more complicated when applying template matching techniques to wheel detection due to the variability in the appearance of wheels. Attempts have been made to generalize the template, but detection rates in one study varied between 60% and 71% [3]. Due to the general nature of the Hough transform algorithm it is widely used. However, results in the literature were inconsistent and highly dependent on the lighting conditions. Both methods produced numerous false positives.

3.2 Application of Methods to Sample Images

The algorithms are applied to 50 images. Each of the images is of a two-axle vehicle. The accuracy of the algorithms is evaluated by determining the number of wheels correctly located (within 15 pixels of the true centre); the number of wheels not detected; the number of false positives, and the number of vehicles on which both wheels are correctly detected without the detection of any false positives. The results of this are shown below in Table 1. The template matching method showed the greatest success under the measures considered. The limited success of the Hough transform is due to noise interference from other objects in the image. Both methods require that thresholds be set for detection of peaks within the result. These thresholds have to be calibrated for each new site and different lighting conditions before they could be implemented. A preliminary investigation indicates that both algorithms are sensitive to this threshold. This is a major disadvantage. The success rates indicate that neither method is sufficiently accurate for determining gap distributions.

Table 1: Result of Application of Methods to 50 Images

Method:	Wheels Detected	Wheels Missed	False Positives	Vehicles Correct
Template Matching	70	30	15	46%
Hough Transform	48	52	62	18%

4. Discussion & Conclusions

The importance of accurately specifying the inter-vehicle gap for the analysis of load effect due to congested traffic is outlined. This paper proposes the application of image processing techniques to sequences of images of congested traffic to measure inter-vehicle gaps. The Hough transform and template matching are well-established in image processing but are found both here and in the literature to be insufficiently accurate for traffic applications. However, image analysis appears to be a viable tool for the detection of the inter-vehicle gaps and should continue to be pursued.

Acknowledgements

The authors would like to thank Science Foundation Ireland for their support of this research.

References

[1] TREIBER M., HENNECKE A., HELBING D., “Microscopic Simulation of Congested Traffic”, *Traffic and Granular Flow ’99,* Springer, Berlin, Germany, 2000, pp. 365-376.

[2] CAPRANI C. C., “ Using Microsimulation to Estimate Highway Bridge Traffic Load”, *International Conference on Bridge Maintenance, Safety and Management*, IABMAS, Philadelphia, USA, 2010.

[3] ACHLER O., TRIVEDI M. M., “Camera Based Vehicle Detection, Tracking and Wheel Baseline Estimation Approach”, *International IEEE Conference on Intelligent Transportation Systems*, IEEE, USA, 2004.