RESEARCH NOTES

October 2006

Caltrans

Automated Collection, Comparison and Fusion of Data from All Vehicle Presence Detectors in I-405 Detector Test Bed

Why We Pursued This Research

The Traffic Operations division of the California Department of Transportation is expanding its vehicle detector infrastructure to provide more traffic information to its TMCs (traffic management centers). Recently, the market has seen an increasing number of "out of pavement" detection systems, which have an advantage over conventional inductive loop detectors because they do not require lane closures for installation and subsequent maintenance. These systems use various non-intrusive sensing methods, and there is evidence from pilot installations, however anecdotal, that these detectors have different detection characteristics and yield different accuracies than inductive loop systems. Knowledge is needed about how these various types of detection systems perform in different situations in order to design installations and specify equipment for various detection environments.

With these and other concerns in mind, Caltrans DRI (Division of Research and Innovation) established the ATMS Detector Testbed on Route 405 in the city of Irvine. The Sand Canyon overpass site of the testbed has been instrumented with a machine vision video detection system, a row of ultrasonic detectors and three side fire microwave radar detection systems. In addition, the site has dual loop detectors dedicated to testing purposes (Figures 1 & 2).

These various out of pavement detection systems, along with the inductive loop system, generate event records for each northbound vehicle that passes by. However, due to their different sensing mechanisms and occurrences of occlusion, lane changing, vehicles with trailers and other situations, the detectors will occasionally miss or double count different vehicles. There was previously no way to compile and compare these anomalies without manually reviewing each individual event record for each data collection session, which is practically impossible. Hence, it is difficult to gain insight into which types of situations cause difficulty for each detector under test. The goal of this project is to determine, for a given test period, on which specific vehicle passage events the various detectors disagree and under which circumstances those disagreements occur.

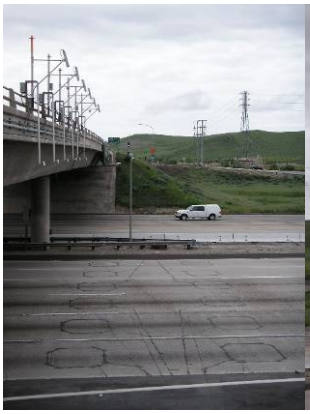

Figure 1

Figure 2

What We Did

To meet the previously stated goal, a video based system for automatic ground truth event verification has been developed. The Video Vehicle Detector Verification System (V2DVS) is physically comprised of a cluster of rack-mount Linux computers, one per lane, and a LAN connected central database server. In addition, a PC-based client program facilitates remote monitoring and control of all field machines and manual ground truth verification. Each field machine interfaces to a video camera positioned on the over-crossing bridge above an assigned traffic lane (Figure 1). The outputs of the detectors under test are wired to the parallel ports of the Linux computers, and each reported vehicle detection generates a record consisting of a JPEG compressed image and the time of arrival of the vehicle. A maximum of eight contact closures, or DC logic level inputs, are accepted for each lane. Figure 3 shows a diagram of the system.

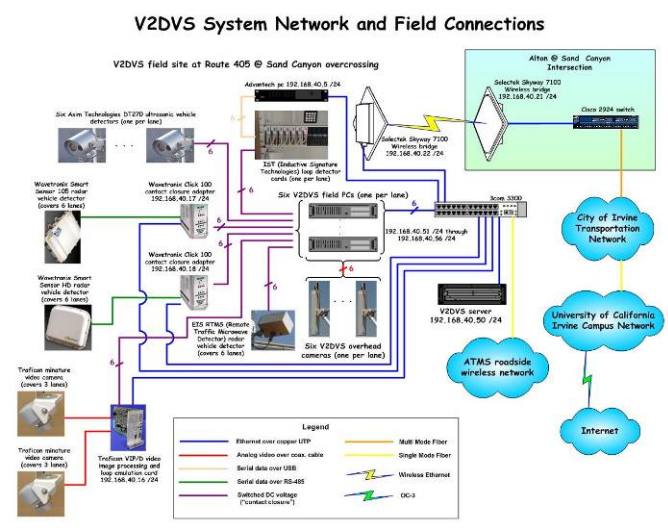

Figure 3

The down-looking high-resolution NTSC video cameras placed 10 meters above each traffic lane have manual electronic shutters set at 1/4000 of a second to prevent image blur from moving vehicles. The field of view of each camera extends from immediately below the over-crossing bridge to approximately 25 meters down-road, to contain most of the zones of detection used by different detectors. An exception is the video-based detection system which uses far-field departing traffic views. Signaling may be real-time in which a record is acquired immediately, or delayed up to 5 seconds after the actual time of detection to accommodate the video system and the processing and/or communications delays of some of the other detectors. The image acquisition function maintains a 5 second circular buffer of the most recent 300 video images (fields) acquired at 60 video fields per second for this purpose.

The field machines for each lane acquire their own detection records, in addition to the records for each detector under test, by processing the video streams and acquiring images for each vehicle arriving at the baseline positions in the field of views of each camera. These serve as reference images and provide vehicle speed data needed for proper correlation between detectors with different detection zones.

Much attention was given to the ability of the software to distinguish shadows from actual vehicles and to detect vehicles imbedded in, or connected to, shadows cast by other vehicles. One approach involves tests of texture and contrast, but the primary method relies on detecting the continuity of a shadow originating from an adjacent lane.

After a data collection session, the software derives an initial composite ground truth dataset. It automatically identifies records of the same vehicle reported by different detectors having different detection zones and processing delays. Adjusted detection times are calculated from the distance, or offset, of each detection zone from the system's baseline position using the assumption of constant vehicle speed over the offset interval. A reported detection is considered valid if it occurs within a user-defined admissible time/distance aperture.

After a ground truth data set has been automatically generated, manual verification is usually necessary for a small percentage of ambiguous cases, i.e. detections occurring outside of an aperture, or multiple detections inside the same non-overlapping aperture. Figure 4 shows the results of successful automatic correlation as blue dots, with false detections in red. Mouse-click selection of any dot brings up the corresponding image acquired at the time of that detection, which makes it clear if the detection was correct, or in what way incorrect. The status of any detection, shown as colored dots, including those that may have been incorrectly grouped by the automated process, can be changed by clicking on the toolbar buttons in the inset window.

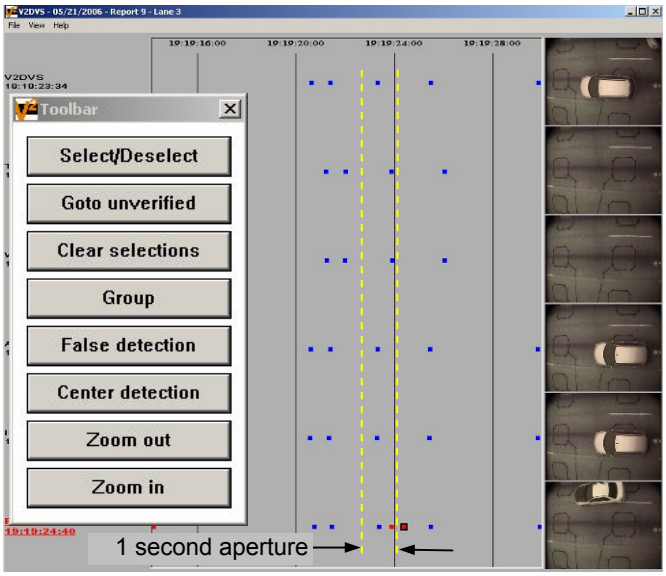

Figure 4

Once manual verification has been completed, the software automatically generates statistical accuracy results for all detectors under test.

For More Information About This Research

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