Project Summary

Texas Department of Transportation

0-5774: Improve Current Design of Video Imaging Detection Systems Used for Dilemma Zone Protection

Background

The Texas Department of Transportation (TxDOT) has been using video imaging vehicle detection systems (VIVDS) for signalized intersection control for a number of years, in most cases replacing inductive loops. Even though the accuracy of VIVDS for any presence detection is known to be inferior to inductive loops, and even more so during inclement weather, in changing light conditions, and during nighttime, agencies have continued to install VIVDS due to their positive aspects. Advantages might include lower cost, less traffic interference and motorist delay, reduced public employee exposure to traffic, flexibility in changing detector locations, reduced damage to pavements, and ability to transmit an image of the roadway to a remote location. However, a thorough and focused investigation of the use of VIVDS on high-speed intersection approaches for dilemma zone detection had not been done. Previous research had focused on stop line detection.

What the Researchers Did

Texas Transportation Institute (TTI) conducted a literature search and contacted agencies to determine the state-of-the-practice with respect to using VIVDS for dilemma zone protection. Researchers then developed an experimental design to conduct field studies for speeds from 50 mph to 70 mph at live intersections where camera mounting locations could replicate TxDOT practice. As the study began, TxDOT was installing VIVDS cameras on high-speed approaches at one of three locations:

1) on the signal head mast arm on the far side of the intersection supported by a 5-ft riser,
2) on a signal or luminaire pole within the intersection often near the stop line, or
3) two cameras per approach with one camera mounted within the intersection (i.e., #1 or #2) and the other usually mounted upstream on a dedicated pole.

A variation of the third method was to place both cameras on the mast arm at the same height but with one covering the stop line area and the other the setback detection area. TTI collected data for several days at three locations: Elgin (50 mph), College Station (60 mph), and Cedar Park (65 mph) after installing all three of the major VIVDS products currently used by TxDOT.

Research Performed by:

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What They Found

Even using the latest equipment from the three manufacturers, TTI found greater than desired variability in the setback detection activation and termination points in good weather and lighting conditions. Detection deteriorated even more at night and during inclement weather. Many agencies, TxDOT included, commonly exceed the maximum aspect ratio (defined as the ratio of the horizontal distance to a detection zone to the mounting height of the camera) of 10:1 recommended by the VIVDS industry. Hasty setups of VIVDS detection zones also contributed to errors, with violators including the vendors themselves. Lack of maintenance such as lens cleaning probably compromises performance as well, but this research did not formally include maintenance.

The most common problem identified with VIVDS for dilemma zone protection was its inability to find gaps in the traffic stream, a phenomenon that only worsens as traffic volume increases. Even at a 10:1 aspect ratio, the camera's flat horizontal angle causes blending of vehicles front-to-back such that the camera sees a string of vehicles as one vehicle. This phenomenon is especially pronounced with large numbers of commercial vehicles. A VIVDS camera often cannot see a gap behind vehicles, frequently extending the green indication to max-out instead of ending the green safely and providing the critically needed dilemma zone protection.

What This Means

Findings of this research have implications for both safety and efficiency at signalized intersections. When a max-out occurs, there is no dilemma zone protection. When VIVDS cannot find an acceptable gap to terminate the green phase, there are also efficiency losses due to excessive delay to the minor street and possibly large gaps in the traffic stream where a phase termination should have occurred. Certain weather and lighting conditions exacerbate the frequency and unpredictability of these errors. Detection at night usually occurs at the leading edge of the headlight beams ("headlight bloom") rather than at the front of the vehicle. Street lighting appears to reduce the problem but not eliminate it. Detections occur earlier and remain longer at night, but again, with less predictability compared to daytime.

Based on project findings, TxDOT should emphasize the use of VIVDS as a stop line detector, add dedicated poles upstream of the intersection for setback detection needs, or investigate other technologies that serve dilemma zone detection needs more consistently and reliably than VIVDS.

For More Information:
0-5774-1 Improvements to Video Imaging Detection for Dilemma Zone Protection

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