Maintenance

MARCH 2024

Project Title:
Targeted Warning Messages to Protect Moving and Stationary Maintenance Lane Closures

Task Number: 3919

Start Date: January 1, 2021

Completion Date: March 31, 2024

Task Manager:
Eemon Amini
Research Project Manager
Eemon.Amini@dot.ca.gov

Targeted Warning Messages to Protect Lane Closures

The research developed an innovative component in a traffic management system aimed at enhancing safety in work zones through targeted warning messages.

WHAT WAS THE NEED?

The California Department of Transportation (Caltrans) uses truck-mounted attenuators (TMAs) to establish moving or stationary temporary highway lane closures. These closures require approaching vehicles to merge out of the lane into adjacent lanes before reaching the TMA. A closed lane typically disrupts traffic flow by slowing traffic in the through lanes as motorists in the merging lane merge over. Some motorists will take advantage of the thinning traffic in the merging lane to leapfrog ahead of traffic.

These drivers often go as far as possible in the merging lane to find a space to quickly merge over immediately before reaching the physical barrier. This behavior increases the risk of their vehicle colliding with the TMA truck. Conventional arrow boards and signboards are placed ahead of the closure on the shoulder and on the in-lane TMA truck to passively inform drivers of the approaching lane closure. Since conventional boards are common and generic, motorists often disregard these safety tools.

Caltrans needs message boards that are more effective in alerting drivers and creating a sense of urgency that consistently enforces timely merging of vehicles into the adjacent lanes.

WHAT WAS OUR GOAL?

The goal of the research was to develop a prototype intelligent TMA truck messaging system based on artificial intelligence that monitors vehicles approaching highway lane closures, recognizes unsafe driving patterns, and generates vehicle-specific warning messages. In addition, the research aimed to increase the safety of both highway maintenance workers and traveling motorists

through the development of such an intelligent message board system.

WHAT DID WE DO?

In the collaborative study with the Advanced Highway Maintenance and Construction Technology Research Center (AHMCT), they developed an advanced targeted warning system to enhance safety and traffic flow near work zones. This system uses real-time vehicle-specific data to generate personalized messages, prompting drivers to merge safely and efficiently. The core of this system lies in automated vehicle detection and Vehicle Make and Model Recognition (VMMR), achieved through both a cost-effective solution with the Milesight brand camera and a more robust, higher-end Vidar brand system. The latter offers built-in VMMR capabilities along with continuous updates and support, making it suitable for large-scale.

Field tests conducted primarily during daylight have validated the reliability of both systems in vehicle detection and attribute extraction. Simulation studies using VISSIM (a traffic simulation software) further supported the potential of targeted warning messages to improve safety, particularly by reducing late merges near work zone tapers. Optimal placement of cameras and message boards was also explored, with simulation results suggesting that positioning these elements far from the lane closure maximizes driver response time and safety. The proposed placements integrate seamlessly with existing Caltrans infrastructure, enhancing the practicality of implementation.

WHAT WAS THE OUTCOME?

The comprehensive research and extensive field testing have demonstrated the effectiveness of both a custom-developed AI-based Vehicle Make and Model Recognition (VMMR) system, used in conjunction with a low-cost camera, and the more advanced, commercially available Vidar

system. Both systems proved highly capable in accurately detecting vehicles, estimating their speed, and identifying their color, make, and model during daytime conditions. Our traffic simulations underscored the importance of driver compliance in enhancing safety and traffic flow near work zones. These results also indicate that placement of the warning message board far from the lane closure improves traffic flow and safety. Consequently, the recommendation to place message boards at strategic locations far from lane closures will allow drivers sufficient time to respond to warnings.

As we move to the next phase of this study in Task 4294, Deployment and Evaluation of Targeted Warning Messaging System, we will focus on field implementation to directly observe the system's effect on traffic behavior and safety, refining the approach based on real-world data.

WHAT IS THE BENEFIT?

The research yielded promising results that have important implications for traffic management in work zones. The two systems evaluated, Milesight and VIDAR, demonstrated distinct strengths in their respective areas of application.

The benefits of both systems include high accuracy in their respective functionalities during daylight field tests. The recommended VIDAR system is anchored in its more robust design and the comprehensive nature of its capabilities. This system offers an all-encompassing solution that seamlessly integrates vehicle detection, license plate recognition, speed measurement, and the identification of specific vehicle attributes like make, model, and color.

Furthermore, VISSIM simulation studies played an important role in understanding the dynamics of traffic flow and safety in work zones. These simulations illuminated the importance of driver compliance and timely merging in ensuring efficient traffic movement and reducing safety

risks near lane closures. We observed that driver response to merge warnings significantly impacts the occurrence of unsafe conditions, such as late merges at the taper, which can lead to near-miss incidents or collisions. By providing personalized, relevant information to drivers through this system, we anticipate an improvement in driver compliance with the warning signs. Such an enhancement in driver compliance is expected to contribute to smoother traffic flow and heightened safety in work zones. Therefore, the targeted warning system, as suggested by research, could be an effective tool in improving current work zone traffic management practices.

LEARN MORE

To view the evaluations, contact the task manager: Eemon.Amini@dot.ca.gov

IMAGES

Image 1: Radar AI LPR 4x/12x Pro Bullet Plus Network Camera from Milesight

Image 2: The true CMFs vs the predictions from the piecewise MLR model (a) and the general prediction model (b) on the test set for the shoulder width category