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Research Results

Deployment and Evaluation of Targeted Warning Messaging System

Researchers integrated and tested a vehicle detection system that wirelessly sends targeted merge warnings to a portable electronic message sign board.

Maintenance

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Project Title: Deployment and Evaluation of Targeted Warning Messaging System

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WHAT WAS THE NEED?

Temporary lane closures require drivers in the affected lane to merge before reaching the work zone taper. Some drivers remain in the closing lane until the last moment, creating conflicts near maintenance workers and equipment. Static signs and arrow boards warn all motorists in the same way and cannot respond to individual vehicle behavior. Caltrans Task 3919, "Targeted Warning Messages to Protect Moving and Stationary Maintenance Lane Closures," showed that a VIDAR (video detection and ranging) camera and radar system could detect approaching vehicles, estimate speed, recognize characteristics such as color, make, and model, and generate a targeted warning. However, that proof of concept displayed messages on a computer monitor and lacked an accompanying sign and wireless connection. Caltrans needed to finish creating a portable, integrated system suitable for temporary maintenance operations that gets motorists to merge earlier and safer ahead of work zones.

WHAT WAS OUR GOAL?

The goal was to develop a deployable system that could automatically detect an approaching vehicle, select a merge message, transmit it wirelessly, and display it on a portable changeable message sign, fast enough for the driver to respond. The project also needed to confirm reliable operations before live highway testing.

WHAT DID WE DO?

Caltrans partnered with the UC Davis Advanced Highway Maintenance and Construction Technology Research Center

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(AHMCT) to complete the hardware and software integration. After reviewing commercially available signs, the researchers selected the TraffiCalm RT-6036 portable changeable message sign based on its display size, update speed, and control interface.

A Raspberry Pi computer was integrated with the sign controller and wired directly to run the display panels. The software formatted each warning across three lines, displayed it for 12 seconds, and then cleared the screen. This setting covered the approximately 9.7 seconds required for a vehicle traveling 60mph to cross the planned 850ft distance between the camera and sign.

From the camera trailer, the VIDAR camera sent information about each detected vehicle to the Raspberry Pi 5 computer. The software selected the most reliable vehicle information, created the warning, and transmitted it through two radios. The radios provided an encrypted wireless link between the camera and sign trailers. The team tested the system with four vehicles on the research center's track. Testing included repeated individual passes and two vehicles traveling closely together. Each test checked the full process from detection through message selection, wireless transmission, and display.

WHAT WAS THE OUTCOME?

The system operated automatically during every controlled test run. It detected each vehicle pass and displayed a corresponding warning, including when two vehicles followed one another closely. When the camera could not reliably identify a vehicle's make or model, the software used a simpler color-based or general message so that a warning was still displayed.

The sign updated in less than 100 milliseconds and initialized in approximately two seconds. The full system was ready roughly 30 seconds after power-up. The wireless link transmitted encrypted messages without error during track testing, and the radios have a range well beyond the planned deployment distance (850ft). The equipment was fully assembled and ready for highway deployment at project completion.

The tests confirmed that the hardware, software, and wireless communication worked together as intended. A future highway evaluation is needed to measure recognition accuracy, driver response, merge location, nighttime and poor weather performance, and longstanding reliability.

WHAT IS THE BENEFIT?

Caltrans now has a working, tested system for evaluating targeted warnings during temporary lane closures. A future highway evaluation can begin with assembled equipment, functioning software, and a recommended deployment layout. If highway testing shows that drivers respond as intended, the system could encourage earlier and smoother merges to reduce conflicts near work zone tapers. This could improve safety for maintenance workers as well as other motorists. The same design and testing approach could also help other agencies evaluate targeted work zone warnings.

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IMAGES



Image 1: The VIDAR camera identified the approaching vehicle and transmitted the detection data to the changeable message sign, calling out the color and make of the vehicle.



Image 2: The trailer-mounted VIDAR camera and pan-tilt system used to detect approaching vehicles.

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