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Advancements in Smart Transportation: The Evolution of MUST Sensor Technology

In recent years, innovations in transportation technology have reshaped the landscape of mobility and safety. A team of researchers from the Pacific Northwest Transportation Consortium (PacTrans) Smart Transportation Application and Research (STAR) Lab at the University of Washington (UW) developed the Mobility Unit for Sensing Traffic (MUST) technology to aid in such efforts.

MUST is a multisource roadside sensor that integrates computer vision, sensor fusion, vehicle-to-everything (V2X) communications, and other Machine Learning (ML) technologies into an edge computing platform. It offers multiple functions with the same device: traffic sensing, road surface conditions, weather, and visibility data collection; data fusion and computation; and communication with traffic management center and road users. It provides a powerful yet cost-effective solution to the traffic data challenges and benefits all stakeholders in the road transportation ecosystem.

The journey of MUST began in 2008 with its first iteration, designed to capture the hardware Media Access Control (MAC) address of Wi-Fi and Bluetooth devices in its vicinity. This initial version paved the way for identifying spatial-temporal movement characteristics of both motorized (e.g. cars and trucks) and non-motorized traffic (e.g. pedestrians and bicyclists), crucial for extracting necessary traffic parameters such as travel time, traffic speed, and traffic volume.

Building upon this foundation, the second iteration of MUST emerged with enhanced capabilities. New sensing modules were integrated such as a PTZ camera, environmental sensors, a temperature control unit, a communication module, a power supply board, and an edge computing board. The edge computing board features a powerful CPU and GPU designed specifically for comprehensive traffic sensing and computing applications.

Figure 1. The most recent MUST sensor with aluminum casing (Source: UW STAR Lab).

The physical design also improved, the casing was upgraded to an aluminum shell rendering it both water- and dust-resistant. This enhancement ensures the sensor's reliable operation even in harsh environmental conditions. All of these additions gave MUST the capability to fuse data from various sensors, conduct in-device analysis, and facilitate communication (e.g., Cellular, Wi-Fi, LoRa) functions all in one unit.

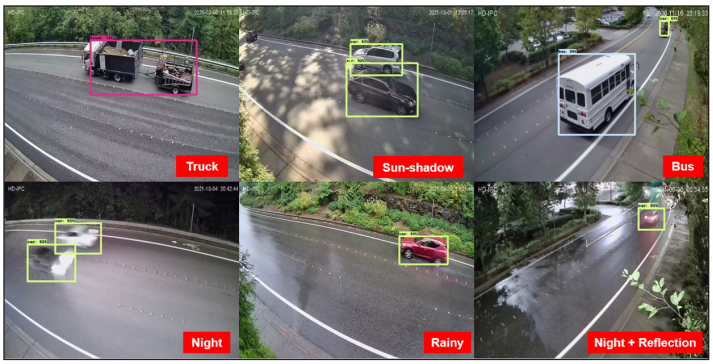

Figure 2. Photos taken by the MUST sensor showcasing its detection capabilities (Source: UW STAR Lab).

During an academic exchange event, the Norwegian Public Roads Administration (NPRA) expressed interest

in supporting the development of MUST technology to withstand extreme weather conditions, such as -40ºF. They aimed to utilize MUST for monitoring the E-8 corridor, a critical freight route, to ensure reliable travel time by assessing road and traffic conditions. Thus, an automated heating module was added to the MUST technology and tested in Norway. The test demonstrated the MUST sensor's capability of working under extreme cold weather climates.

MUST technology has been implemented in several locations for a variety of purposes:

1. **Larue Road Intersection, Toppenish, Washington:** Deployed at one of the most dangerous intersections in Yakama Nation, the sensor monitors real-time traffic and road conditions, detects hazardous events, and sends out warning messages directly to the traffic center to improve safety. This project recently earned the prestigious 2023 Innovative Project Award and Best-All Round Award from the Federal Highway Administration's (FHWA) Build a Better Mousetrap program, which serves as a testament to its effectiveness and innovation.

2. **Cities of Bellevue and Lynnwood, Washington:** Funded by the Washington State Transportation Innovation Council (STIC), MUST devices have been deployed along high-risk corridors in the cities of Bellevue and Lynnwood to monitor traffic, roadway surface, and environmental conditions, detect warning events, and communicate with traffic operations centers as well as broadcast useful information to road users when needed. Furthermore, the MUST technology was also evaluated through the City of Bellevue Curbside Management Pilot Program and outperformed all other systems that participated in this program.

3. **Tucson, Arizona:** Working with the Department of Transportation & Mobility (DTM) in Tucson, Arizona, the MUST devices are deployed at Alvernon & 22nd St for intersection safety applications, including collision/near-miss events detection and dynamic dilemma zone monitoring.

4. **Interstate 5 Traffic Data Collection, Washington:** Currently deployed by the Washington State Department of Transportation (WSDOT) at I-5 for accurate traffic data collection, especially for FHWA 13-Category classification.

5. **Sound Transit Light Rail Station Parking Facility Monitoring, Washington:** At two Sound Transit Light Rail Station parking lots, MUST devices are deployed for parking data collection and real-time parking occupancy monitoring.

Figure 3. MUST sensor installed in Toppenish, November 2022 (Source: Photo taken by Garrett Ambrose, Yakama Power).

These projects highlight the sensor's ability to collect complex data and apply it across diverse transportation scenarios and conditions. Leveraging the MUST technology, researchers can now make more informed infrastructure decisions, leading to improved mobility and safety for all users. The research team holds two issued patents related to this technology, Video-Based Vehicle Detection and Tracking Using Spatial-Temporal Maps (US20110170744A1), and Travel pattern discovery using mobile device sensors (US9374661B2). Two more relevant patents are currently under review.

In 2022, PacTrans STAR Lab at UW launched a spin-off company, AIWaysion, Inc., with an angel investment fund. Utilizing MUST, the company provides smart mobility solutions using Artificial Intelligence (AI), computer vision, and edge computing technologies for safer and more efficient transportation. Over the past year, the company has won two U.S. Department of Transportation Small Business Innovation and Research Awards, to work on the Edge Server-Based AI Application for Dilemma Zone and Traffic Conflict Events Detection (Phase II project), and Edge Computing and Sensor Fusion System for Comprehensive Monitoring of Traffic and Road Conditions (Phase I project). Also, the company was selected as one of the top five startup companies for the International Roadway Federation's startup label.

About This Project

The University of Washington Smart Transportation Applications and Research Laboratory (STAR Lab) is directed by Dr. Yinhai Wang. The University of Washington is a member of the Region 10 Pacific Northwest Transportation Consortium. The first version of the MUST sensor was developed in 2008, and since then the STAR Lab team has been actively enhancing the MUST sensors through a variety of research and technology transfer projects, several of which were PacTrans-funded.

This newsletter highlights some recent accomplishments and products from one University Transportation Center. The views presented are those of the authors and not necessarily the views of the Office of the Assistant Secretary for Research and Technology or the U.S. Department of Transportation.

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