THEA AI Queue Length Detection
Innovative applications to enhance safety for Connected Vehicles

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Background

In 2015, Tampa Hillsborough Expressway Authority (THEA) selected Siemens as a turnkey system provider to supply Connected Vehicle (CV) roadside infrastructure and systems as part of the US Department of Transportation (USDOT) to test CV technology. This system is operational in Tampa, enabling communication with 1,500 vehicles equipped with CV technology. More than 40 Roadside Units (RSUs) are located at key points throughout downtown Tampa, interacting with a system of physical roadside detectors to collect information to prevent collisions between cars and vulnerable road users such as pedestrians and cyclists. The RSUs also relay the information to the CVs using direct short-range communication or DSRC.

THEA owns and operates the Selmon Reversible Express Lanes (REL), a unique facility that helps address congestion in downtown Tampa. With the advanced nature of REL, wrong-way entry is possible. CV technology thus helps THEA relieve congestion caused by peak times and reduce collisions by preventing wrong-way entry at REL exits.

Challenges

Unpredictable congestion resulting in road safety issues

Several roadway segments within THEA's Expressway experience morning peak congestion because of commuter traffic into downtown Tampa.

As vehicles exit the inbound Selmon Expressway REL and make right turns onto East Twiggs Street towards downtown Tampa, the right-turn lane backs up due to congestion, causing the queues to backup up onto the REL at the end of the queue. The impact of such queues generates a safety hazard with the potential of causing vehicles to brake quickly, attempt a rapid lane change or crash.

Inability to quickly respond to changes in traffic demand

Another challenge faced by THEA relates to dealing with the impact of congestion in REL, having to rely on fixed detection infrastructure or other systems to allow messages to be sent to drivers of potential safety issues to avoid crashes from happening.

Solution

New approach using AI/ML to detect queue lengths using CV data

To address safety issues associated with in Tampa's REL, the Siemens ITS Digital Lab data scientists and software engineers have developed an **industry-first** queue length detection approach that utilizes Basic Safety Message (BSMs) from CVs in Tampa and automatically detects the end of a queue without the need for additional detection infrastructure. The solution, born out of the THEA's unique needs and ecosystem, was enabled by artificial intelligence (AI) and

machine learning (ML) brought by the ITS Digital Lab team, leveraging vast amounts of CV existing data to create new applications to fit with the ecosystem already in place in Florida. In this case, the ML model running in the Siemens RSUs can automatically detect, in real-time, anomalies in traffic patterns that relate to queues, using an AI-based method to compute the length and location of the longest queue present in the Expressway.

Automatic generation of driver advisory safety messages

Once the queue is detected, the AI-based system within the Siemens RSU automatically creates a Traveler Information Message (TIM), taking the end of the queue location to generate an advisory safety message. Each TIM contains the recommended speed for each zone based on safe stopping distances in accordance with Florida's driver manual for CVs in range. As the driver approaches the end of the queue, the recommended speed drops in the TIM to ensure safe stopping distance.
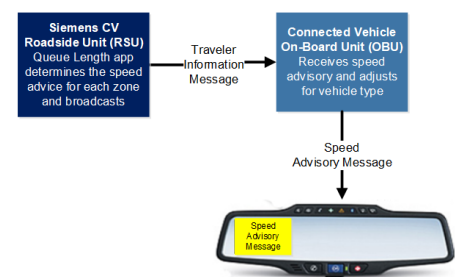
Data-driven applications using AI/ML technologies powered by the Siemens ITS Digital Lab

Results and benefits

Increased safety for connected vehicles in downtown Tampa

The unique approach developed by the Siemens ITS Digital Lab complements the multiple CV use cases and applications already adopted and demonstrated in Tampa. By creating a new automated application for flagging safety hazards, THEA is helping to enhance driver safety by reducing harsh braking and mitigating potential crashes in peak times in THEA's Expressway REL when unpredictable congestion happens.

Making use of existing data with state-of-the-art AI/ML technology

The innovative Siemens ITS Digital Lab brought their expertise in data science, analytics, AI/ML to solve a unique problem for THEA. By collecting and analyzing the data obtained by CVs, the team was able to create a new approach for detecting and raising safety advisory messages to drivers in an automated way.

No need for additional hardware

The method developed has been encapsulated as an add-on application to the existing Siemens CV RSU hardware, enabling THEA to serve a new use case to improve safety while leveraging past infrastructure investments. The system developed simply uses the data obtained by CVs in the region and does not require any detection or other roadside infrastructure for detecting queue lengths. This reduces reliance on other systems while enabling a new safety use case.

Queue length insights for signal phase and time optimization

Queue length detection information can also serve as insight for traffic management. In Tampa – in addition to providing real-time speed advisory messages to avoid crashes – the queue length detection data generated by the Siemens system is used as an input to THEA's Intelligent Traffic Signal System (I-SIG) for the optimization of phase time allocation. This assists in the reduction of congestion and performance of signal timing plans.

About the ITS Digital Lab

Based in the heart of Austin, TX, the Siemens ITS Digital Lab works with cities and transportation agencies to create software tools that enable cities to improve safety, efficiency, and performance of their mobility ecosystems.
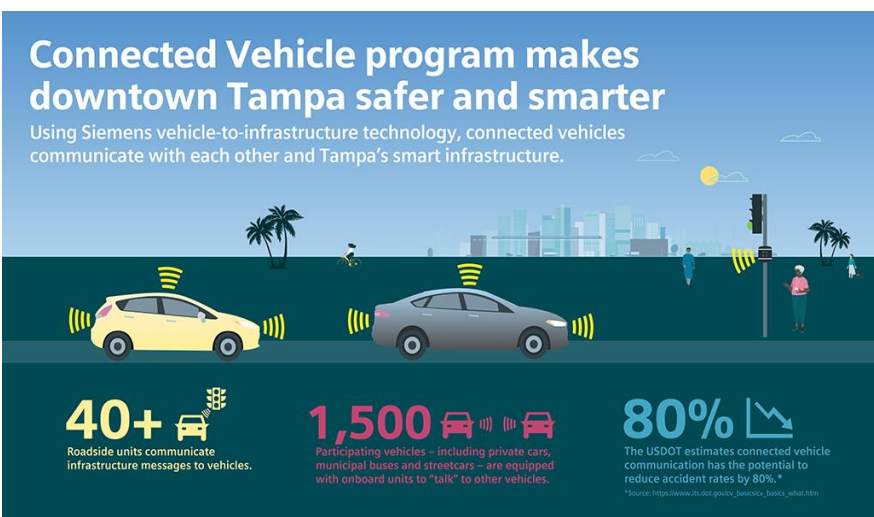
Comprised of data scientists, data engineers and software developers, the team specializes in consulting with cities and collaborating with them to jointly unlock the sometimes hidden or unknown power of their data. Additionally, the team is passionate about working with industry partners and academia to create new use cases that help enhance and generate value from data.

Shaped by innovation, the Digital Lab is passionate about collaborating with traffic managers, engineers, and transit operators with an agile, rapid innovation process to bring the best solution to new challenges using AI and ML techniques

Connected Vehicle program makes downtown Tampa safer and smarter

Using Siemens vehicle-to-infrastructure technology, connected vehicles communicate with each other and Tampa's smart infrastructure.

40+ Roadside units communicate infrastructure messages to vehicles.

1,500 Participating vehicles – including private cars, municipal buses and streetcars – are equipped with onboard units to "talk" to other vehicles.

80% The USDOT estimates connected vehicle communication has the potential to reduce accident rates by 80%.*
*Source: https://www.its.dot.gov/cv_basics/cv_basics_what.htm