DRISI

Caltrans Division of Research, Innovation and System Information

Research Notes

Software and Hardware Systems for Autonomous Smart Parking Accommodating both Traditional and Autonomous Vehicles

Develop a solution for parking congestion integrated with autonomous vehicles

Transportation Safety and Mobility

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Project Title:
Vehicle Infrastructure Integration (VII)

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WHAT IS THE NEED?

Current parking infrastructure suffers from congestion as the number of vehicles circulating in urban areas is growing and expansion is not a cost-effective solution. In parallel, developments in autonomous vehicle technology mean that driverless vehicles are predicted to be in circulation by the 2020s and makeup 40% of vehicle travel by the 2040s.

Expected benefits of autonomous vehicle travel include reduced congestion through vehicle sharing and reduced walking distance for passengers who can be dropped off chauffeur-style by autonomous vehicles. However, empty vehicle cruising, or the case in which autonomous vehicles cannot efficiently locate parking and circle instead, can potentially increase congestion. Given that this new technology has the potential to exacerbate existing congestion issues, it is necessary to develop a solution for parking congestion integrated with autonomous vehicles.

WHAT ARE WE DOING?

This project addresses this issue by providing a full-stack solution including sensors to monitor occupancy, Fog systems to perform local data pre-processing, radios to communicate with autonomous vehicles, and cloud-based software to predict occupancy. This solution is divided into 3 main subsystems which include the Parking Tracker Fog System (PTFS), a wireless sensor network and a Cloud-based server.

The PTFS refers to the local Internet of Things module and is equipped with Dedicated Short-Range Communications (DSRC) technology for Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication. It is responsible for generating useful information about occupancy and vehicle classes based on data collected from the wireless sensor network or data directly received from autonomous vehicles over DSRC.

For the wireless sensor network, a tested system of MEMSIC IRIS sensor motes equipped with Passive Infrared Sensor (PIRs) will be used because they have demonstrated compatibility with multi-hop networks that allow for sensor connections over a greater distance. To facilitate DSRC between the PTFS and autonomous vehicles, Ettus B210 Software Defined Radios (SDRs) will be used to communicate using the Vehicle-to-everything standard: IEEE 802.11p.

The study's novel contribution to the ongoing issue of parking congestion will be this DSRC solution for integrating autonomous vehicles into Intelligent Transportation Systems. A Cloud-based server is the final subsystem and will be responsible for collecting data across multiple PTFSs to be inputted into a machine learning model trained to predict occupancy in parking structures. To validate the algorithms employed, parking scenarios will be simulated and system performance evaluated in terms of response time and accuracy. DSRC solution will also be evaluated based on criteria including latency and accuracy.

For the first phase of the project focus will be on the development of three subsystems: 1) wireless sensor network, 2) PTFS, and 3) communication through DSRC with software defined radios. To summarize, the major proposed research tasks are the following:

- To develop a wireless sensor network using MEMSIC IRIS sensor motes for mounted ultrasonic sensors and PIRs that has comparable performance to established systems in.
- To develop a Fog computing system, the PTFS, that will aggregate data and use it to classify vehicles and determine occupancy in addition to communicating with autonomous vehicles over DSRC using installed radios.
- To customize the PTFS's software defined radios for connecting over DSRC with autonomous vehicles in V2V and V2I communication

WHAT IS OUR GOAL?

The goal of this project is that this system will:
1. Be scalable and include multiple lots across a metropolitan area,
2. Operate in real time, and
3. Communicate securely with autonomous vehicles over DSRC.

WHAT IS THE BENEFIT?

The results will contribute important information for the design of Autonomous Smart Parking Accommodating both Traditional and Autonomous Vehicles.

WHAT IS THE PROGRESS TO DATE?

The research team has completed the following
- Held kick-off meeting on February 25, 2020
- Conducted a literature survey on research works engaged in deploying wireless sensor networks in a star and XMesh topologies
- Ordered the photosensors to be used for the occupancy sensing application
- Started work on experimental deployment using either the MSP432 or MEMSIC IRIS boards as the sensing boards