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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Guidance on RSU placement for future deployment of CAVs

Planning tool to provide Caltrans Districts Engineers guidance on RSU placement for CAV applications.

Advanced Research

NOVEMBER 2024

Project Title:
Guidance on Roadside Units (RSU) placement for future deployment of Connected and Automated Vehicle (CAV) Applications

Task Number: 4081

Start Date: June 1, 2023

Completion Date: May 31, 2025

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WHAT IS THE NEED?

To facilitate future deployment of CAV applications, it is critical to upgrade existing road infrastructure with RSU to enable V2X (Vehicle-to-Everything) communications for various CAV applications. When a freeway or an arterial network is selected, the current approach, like in the California Connected Vehicle Testbed, is to install RSUs at all road intersections. However, this approach is not cost-effective for network-level deployment due to limited budgets to install and maintain RSU facilities and low penetration rates of CAVs on surface roads. Therefore, it is crucial to develop a generalized tool that can guide Caltrans District Engineers at the planning stage to pick the right locations to install RSUs for selected CAV applications with cost effectiveness.

WHAT ARE WE DOING?

This task will take care of the following activities.

1. Conduct a literature review on existing CAV applications. Generate a list of CAV applications to be implemented in this project in consultation with the project panel.
2. Implement the selected CAV applications in the integrate microsimulation platform in Aimsun program.
3. Generate subnetworks, networks and design simulation scenarios from the I-210 corridor in consultation with the project panel.
4. Conduct simulations, summarize simulation results, and develop the sketch-level planning tool.
5. Document all findings in a final report and provide a workshop to Caltrans engineers on how to use the sketch-level planning tool.

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WHAT IS OUR GOAL?

The end goal of this task is to have a fully functional planning tool to provide Caltrans Districts Engineers guidance on RSU placement for CAV applications.

WHAT IS THE BENEFIT?

The sketch-level planning tool can help Caltrans Engineers identify best locations in a targeted project area to install RSUs so as to achieve desired performance for selected CAV applications. In the long run, this sketch-level planning tool can be further enhanced with more CAV applications, more test networks and scenarios, and more interactive features to provide Caltrans better guidance on the installation of RSUs at the network scale.

WHAT IS THE PROGRESS TO DATE?

Progress 6/1/2024 – 8/31/2024

Task 1: Project Management

- The project team submitted the Quarterly progress report – FY24/25 Q1 on 11/11/2024.

Task 2: Technical memo: literature review and a prioritized list of CV/CAV applications

- The project team submitted the technical memo for Task 2 on November 13th, 2023.

Task 3: Technical memo: subnetworks and scenario design

- The project team has implemented the architectures for Curve Speed Warning, Queue Warning, Speed Harmonization, and Eco-Approach and Departure at Signalized Intersections. The project team is currently implementing the architecture for Intersection Safety Warning and Collision Avoidance.
- While working on the application of Eco-Approach and Departure at Signalized Intersection, the project team has addressed the following technical challenges:
    - Generation of SPaT messages from intersections under Coordinated Actuated Signal Control.
        - Due to different phase settings (e.g., lead-lag phases and coordination/cycle starting point) and the existence of early return to green, it is hard to construct the element "TimeChangeDetails" in SPaT. The project team has done their best and developed algorithms to provide a reasonable estimate of the element "TimeChangeDetails".
    - Managing the SPaT and MAP messages from narrowly spaced signalized intersections equipped with RSUs.
        - When two signalized intersections are close to each other, there exists an overlap of RSU's communications range. In this case, a connected vehicle will receive SPaT and MAP messages from two or more nearby signalized intersections. The project team has developed extra functions to use a connected vehicle's current position and route information to select the right signalized intersection and the corresponding SPaT and MAP messages to use.
- To overcome the delay caused by the above technical challenges, the project team has proposed the following solutions:
    - The project team has allocated the following resources to cut the required simulation time in Task 5:
        - 4 desktops & laptops
        - 4 Aimsun licenses which can support 8 simulation runs at the same time (two simulation runs in each computer).
        - This is expected to cut a least a month for the required simulation time in Task 5.

- The project team has developed the following strategy to select the simulation scenarios proposed in Task 4:
  - Focus on the simulation scenarios with low penetration rates (e.g., <=20%) of connected vehicles.
  - Eliminate unnecessary simulation scenarios if no further benefit is achieved.
  - This can further cut the required simulation time in Task 5.
- The project team is working on the Technical Memo and will submit it on 12/06/2024.

Task 4: Technical memo: subnetworks and scenario design

- The project team submitted the technical memo for Task 4 on 08/21/2024.

Task 5: Technical memo: summary of simulation results

- The project team continues to run simulations and analyze the results for the implemented CV/ CAV applications.