Deep Learning-based Human-Driven Vehicle Trajectory Prediction and its Application for Platoon Control of Connected and Autonomous Vehicles

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Abstract

The advent of connected and autonomous vehicles (CAVs) will change driving behavior and the travel environment, providing opportunities for safer, smoother, and smarter road transportation. During the transition from the current human-driven vehicles (HDVs) to a fully CAV traffic environment, the road traffic will consist of a "mixed" traffic flow of HDVs and CAVs. Equipped with multiple sensors and vehicle-to-vehicle communications, a CAV can track the trajectories of other CAVs in its vicinity, and ideally, all CAVs in communication range. Such CAV trajectory data can be leveraged with advances in computing and machine learning algorithms to potentially predict trajectory data of HDVs, such as acceleration and speed. Based on these predictions, CAVs can react accordingly to avoid or mitigate traffic flow oscillations and accidents. In this study, we seek to predict a HDV's trajectory based on two types of deep learning models: (i) the Long Short-Term Memory (LSTM) model, which is efficient for temporal trajectory prediction because its neural network architecture is designed to utilize inputs from previous time steps and (ii) a model that combines two deep learning architectures, the LSTM and the Convolutional Neural Network (CNN) model. CNN provides the capability to feed more information into the LSTM using images. The images are converted from time series trajectory data, road geometry data and relative vehicle positions. As a case study, these two deep learning models will be used to predict the leading HDV trajectory for platoon control of CAVs; that is, in this scenario a HDV is the leading vehicle for a group of CAVs to platoon. To dampen traffic flow oscillations, model predictive control (MPC), which can fully leverage deep learning-based predictions, is implemented to generate the control law for each CAV in the platoon. The performance of the MPC platoon control with trajectory predictions using the two deep learning models will be compared to that of CAV platoon control based on a traditional trajectory prediction model.

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