Establishing a Simulation Package and Testbed for Traffic Congestion Reduction Using Deep Reinforcement Learning

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Tran-SET

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$ 106,000

Using deep reinforcement learning for traffic congestion reduction

Traffic congestion not just causes travel delays but also increases fuel consumption and emissions production. One of the major reasons for congestion in urban areas is traffic accidents. Currently, traffic cameras and video surveillance are some of the ways used to monitor the traffic. However, these methods are capital demanding and do not provide real-time trip information to the travelers. New technologies, such as vehicle to infrastructure (V2I) and vehicle to vehicle (V2V) communication, may be able to greatly reduce congestion. This type of communication allows real-time detection of congestion, which can result in immediate distribution of traffic affected by the congestion and therefore result in a more efficient transportation network. Advances in wireless communication technology, for instance, advanced 5G communication networks will enable this interconnection and will allow users to make better decisions regarding the use of the transportation system. In the foreseen transportation infrastructure, vehicles will communicate with other vehicles, traffic control units, and traffic management centers, to make more efficient trip decisions. All these technologies have paved a solid foundation for autonomous driving, which has been identified as a national priority for future technologies with an expected $488 billion in annual savings from reducing traffic accidents and another $158 billion in savings due to reduced fuel costs. This project aims to develop a simulation package for autonomous driving and route redirection in a designated region using reinforcement learning (RL) algorithms. The developed RL algorithms will determine the motion and routes of vehicles considering the shortest traveling path, shortest traveling time, and traffic conditions to reduce traffic congestion. We will further verify the algorithms using a hardware-in-the-loop testbed including scale-down tracks, car-like rovers, and traffic signaling systems.

Problem Statement

Traffic congestion is a major issue in urban areas, directly impacting the quality of life of individuals and economic costs of businesses, which accumulate into nationally and globally costly in terms of loss of time, fuel waste, and excess greenhouse gas emissions. The FHWAsponsored annual urban mobility reports have proven congestion as a persistently growing problem in the U.S. since 1982, with the 2019 national cost of congestion estimated at $190 billion dollars. Traffic congestion is a complex phenomenon, resulting from the interaction of many different factors in the transportation system. While high traffic density and unstable traffic flow are caused by high traffic loads or local capacity reductions, which are detectable via macroscopic traffic characteristics, disturbances caused by individual drivers also affect the traffic flow at microlevel. Given the complex, multi-scale nature of the phenomenon, reducing traffic congestion is a challenging task requiring accurate detection of congestion-causing factors, prediction of congestion occurrence, and proper decision-making for vehicle movements on both macro and micro scales. Accomplishing this task requires the integration of both road- and vehicle-level information for decision-making regarding vehicles' motion on a micro-scale and travel route on the macro-scale. Expectedly, developing such a system will include information collection, decision-making strategy design, and validation of the strategy with both computer-aided simulations and real-world implementations.

Objectives

The objective of the project is to establish a scalable traffic congestion management testbed to enable autonomous driving on the road. To fulfill the objective, the simulation package will be established with a novel reinforcement learning algorithm to design the autonomous driving strategy for individual vehicles in a hybrid environment including autonomous vehicles and human drivers to improve driving safety, reduce traffic congestion, and optimize the route for

individual vehicles for a reduced traffic time for all vehicles in a designed region.

Figure 1. traffic environment developed in CARLA showed urban setup, multiple lanes of a road, traffic signs, and multiple vehicles in motion. (Upper) A controlled vehicle changes its lane to avoid the traffic jam with information sharing. (Bottom Left) Traffic jam on the left lane without route redirection and information sharing with more vehicles taking the left lane. (Bottom right)

Intended Implementation of Research

Train future leaders in intelligent transportation, road safety, autonomous driving, and reinforcement learning. Develop workshops and training sessions in the proposed research. The findings of the study will be presented in national and international conferences and journal publications. Gather feedback from DOT and Tran-SET towards the end of the project on the potential impact of the study and how to adapt this technology to the industry. Maintain a world-wide-web page that presents our latest findings and how the research project is advancing. Disseminate the research outcome to local communities (high schools and community colleges) for a broader impact to encourage students to pursue STEM majors.

Anticipated Impacts/Benefits of Implementation

This project aims to promote and advance the research in the areas of sustainability and preserving the environment by reducing traffic congestion for better communication with travelers and lower emissions of air pollutants. This study will also increase the service life of the transportation infrastructure by decreasing the emissions as this will help decrease the climate change, which causes damage in the transportation infrastructure through higher temperatures, more severe storms and flooding, and higher storm surges, affecting the reliability and capacity of transportation systems. Therefore, with reduced emission of greenhouse gases in the transportation sector, there will be an increase in its service life.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.