Traffic Measurement and Control Methods using Autonomous Learning

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Abstract

Traffic management is an essential part of intelligent transportation systems (ITS). It monitors and controls traffic in order to reduce congestion and to improve traffic flow. In order to implement appropriate traffic control, it is necessary to understand the traffic volume at more locations in real time, and to control the signal for efficient traffic scheduling. To improve traffic control, traffic control based on accurate traffic information and global traffic information is necessary. Therefore, in this thesis, we address these two challenges.

To address the first challenge, we propose PAVEMENT, a novel autonomous-learning traffic-census sensor system using a piezoelectric vibration sensor and a video camera. PAVEMENT consists of two models: the video-based model which detects vehicles by using bounding boxes (detected by YOLOv3 and DeepSORT) and the vibration-based model which uses road vibrations to detect passing vehicles. To reduce the burden of collecting ground truth labels, we apply supervised learning to train the vibration-based model by using the result of the video-based model as ground truth. Once the vibration-based model is trained, it can be used for traffic census on roads without the video camera for various conditions. We collected the video and vibration data of more than 4,000 passing vehicles on roads in different places and applied our method to the data. As a result, PAVEMENT achieved over 98% accuracy and 92% f1-score in detecting passing vehicles.

To address the second challenge, we propose an adaptive traffic control algorithm based on backpressure and Q-learning. Adaptive traffic control is a strategy to control traffic signals based on actual traffic information. To improve adaptive traffic control, our approach uses Back-pressure routing which was originally developed for routing packets based on queue length differentials (also called pressure gradients) in wireless communication networks. We apply Back pressure routing to signal control at junctions regarding vehicles as packets. We also use Q-Learning to predict real-time traffic information at junctions and global traffic information that are input to our algorithm. We evaluated the proposed algorithm through computer simulations and confirmed that our algorithm reduces average vehicle traveling time from 17% to 38% compared with a state-of-the-art algorithm in some test scenarios.