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Optimal Driving Strategy at Signalized Intersections for Improving Traffic Flow and Congestion Mitigation

Kenta Nakakura, Magzhan Atykhan, Md Abdus Samad Kamal and Kou Yamada
Graduate School of Science and Technology
Gunma University, Gunma, Japan
t231b063@gunma-u.ac.jp, magzhan.atykhan@gmail.com, maskamal@gunma-u.ac.jp

Abstract

In recent years, the continuing development of automobiles and road transportation systems have changed to more sophisticated ones incorporating inter-vehicular communication and automated driving technology. However, many problems still need to be solved in the road traffic system. One of them is the deterioration of traffic flow at signalized intersections. Deterioration of traffic flow at signalized intersections affects the smoothness of traffic and the fuel consumed by vehicles. One of the leading causes of poor traffic flow is that intersections confine the traffic volumes. The need for appropriate signal cycles and traffic demand also leads to traffic congestion. Over the last few decades, there has been much research on improving traffic flow at signalized intersections to achieve smooth traffic flow. Among them, the idea of adjusting the signal cycle according to the traffic volume of each intersecting road is a major one. Additionally, the traditional approach in signalized intersections is adjusting the signal cycle according to the time of day in actual road traffic. However, changing the signal cycle to a suitable depending on the current traffic load is not expected to improve the traffic capacity in the intersections. Observation reveals that shorter signal cycles result in a better flow of under-saturated traffic. However, more frequent signal switching increases the intersection loss time, reducing the effective green time needed by traffic, i.e., reducing traffic capacity and worsening traffic flow. To solve these problems, a control method that reduces the time wasted during signal switching is considered effective. Therefore, this paper proposes an optimal control method in which an automatic vehicle decides on appropriate pre-start before a signal changeover at a signal intersection from a far distance that is determined optimally. In this model, by receiving the signal cycle information, the first vehicle starts a few seconds before the signal changeover, arriving at the intersection at the green time with a higher speed. Thus, drivers can cross the intersection at an increased rate and faster than conventional human traffic. In this study, the automated vehicle is controlled using model predictive control (MPC). The model was evaluated by simulating ten vehicles and one signal intersection. The described model, where only the lead vehicle used automatic driving control and the trailing vehicles used a conventional motion model, was compared to the traditional motion model with all ten vehicles using a human following motion model. The results demonstrate that the proposed model improves the crossing time for the ten vehicles by 9.5% compared to existing traffic, which is expected to increase the road traffic similarly to mitigate congestion.

Keywords
Intelligent Transportation Systems, Automated Driving, Optimization, Model Predictive Control

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