Design and Evaluation of Adaptive Traffic Control System for Heterogeneous Flow Conditions

Dr. Tom V. Mathew
Associate Professor of Transportation Systems Engineering,
Indian Institute of Technology, Bombay, India
tvm@civil.iitb.ac.in
http://www.civil.iitb.ac.in/tvm/

Traffic signals are very effective in controlling vehicles especially at congested urban intersections. Among the various control strategies; namely, fixed time, coordinated, traffic responsive, and adaptive control; adaptive control has greater potential in chaotic and heterogeneous traffic. Implementing adaptive control requires real-time traffic information and is possible due to recent advances in traffic sensors and data communication. Design of a traffic control systems in heterogeneous traffic characterised by chaotic traffic, non-lane based movement and mixed vehicle type and its evaluation by a traffic simulator which also has the ability to handle heterogeneous traffic is the goal of this presentation.

This presentation first highlights the issues of traffic modelling and traffic control under heterogeneous conditions and proposes various strategies. Three important issues that makes modelling and design under heterogeneous traffic conditions are identified. First is the presence of mixed vehicle types characterised by diverse static characteristics such as length and width and dynamic characteristics like speed and acceleration. Second is the absence of lane discipline where either the lane markings are absent or drivers especially that of the non-conventional vehicle types do not follow the lane. Finally, complex geometry of the intersection makes it difficult to estimate various design parameters.

The presentation then gives taxonomy of traffic signal systems including fixed time control, vehicle actuated control, coordinated traffic control, the concept of adaptive control, and the area traffic control systems. Two of the most popular area traffic control systems, namely SCOOT and SCAT system will be critically reviewed focusing its suitability for heterogeneous traffic conditions. An attempt will also be made to identify the requirements of a traffic control system suitable for the heterogeneous traffic conditions.

The presentation then considers a specific problem of real-time adaptive control of time-varying road traffic at isolated traffic signals junctions when only stop line departure data is available. This study proposes a mathematical model and an algorithm for adaptive traffic control system for an isolated intersection when only downstream detectors are available. The proposed algorithm aims to maximize the discharge. It defines phase terminating conditions using minimum and maximum green times and a threshold headway. These minimum and maximum green time bounds for each phase are adjusted based on the historic green utilizations and vehicle discharges, typically of the past few cycles. In this methodology the control system monitors the performance at the end of each phase and if required, the control system re-sets the green time bounds. The proposed control strategy enables one to adapt to the stochastic and dynamic behaviour of traffic flow at the intersection.

Evaluation various traffic control strategies on the field is prohibitively expensive as well as may cause severe traffic disruptions. Hence, the proposed model is evaluated using a traffic simulator. However, this traffic simulator should be able to simulate the heterogeneous traffic conditions highlighted earlier. The strategy adopted here is to identify a homogeneous traffic simulator and modifying it for heterogeneous traffic conditions. An innovative strip based model is proposed where a conventional lane is divided into number of strips and each vehicle may occupy one or more strips. The width of the strip is variable and smaller the width higher will be the precision, of course at a higher computational cost. A reasonable accuracy will be obtained if the strip width is kept same that of the smallest vehicle expected in the traffic stream. The strips concept is extended to both signalized and priority intersections. The car-following and lane changing models are modified to accommodate the strips concept.

The modified traffic simulator after calibration and validation is used in the performance evaluation of the proposed traffic control system. The results of the comparison indicate that the proposed model improves the throughput compared to the vehicle actuated system. The presentation concludes with possible extensions of the study and potential areas of collaboration.