ABSTRACT

Road networks are significantly affected by traffic signal operations, which contribute from 5% to 10% of all traffic delay in the United States. It is therefore important for agencies to systematically monitor signal performance to identify locations where operations do not function as desired and where mobility could be improved.

Currently, most signal performance evaluations are derived from infrastructure-based Automated Traffic Signal Performance Measures (ATSPMs). These performance measures rely on high-resolution detector and phase information that is collected at 10 Hz and reported via TCP/IP connections. Even though ATSPMs have proven to be a valid approach to estimate signal performance, significant initial capital investment required for infrastructure deployment can represent an obstacle for agencies attempting to scale these techniques. Further, fixed vehicle detection zones can create challenges in the accuracy and extent of the calculated performance measures.

High-resolution connected vehicle (CV) trajectory data has recently become commercially available. With over 500 billion vehicle position records generated each month in the United States, this data set provides unique opportunities to derive accurate signal performance measures without the need for infrastructure upgrades. This dissertation provides a comprehensive suite of CV-based techniques to generate actionable and scalable traffic signal performance measures.

Turning movements of vehicles at intersections are automatically identified from attributes included in the commercial CV data set to facilitate movement-level analyses. Then, a trajectory-based visualization from which relevant performance measures can be extracted is presented. Subsequently, methodologies to identify signal retiming opportunities are discussed. An approach to evaluate closely-coupled intersections, which is particularly challenging with detector-based techniques, is then presented. Finally, a data-driven methodology to enhance the scalability of trajectory-based traffic signal performance estimations by automatically mapping relevant intersection geometry components is provided.

The trajectory data processing procedures provided in this dissertation can aid agencies make data-driven decisions on resource allocation and signal system modifications. The presented techniques are transferable to any location where CV data is available, and the scope of analysis can be easily varied from the movement to intersection, corridor, region, and state level.