Quality and potential analysis of traffic signal switching time prediction based on finite state theory

Master‘s Thesis of Parveen Sulthana

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Example of an intersection with countdown times in PSA web app

Personal Signal Assistant for future signal switch times

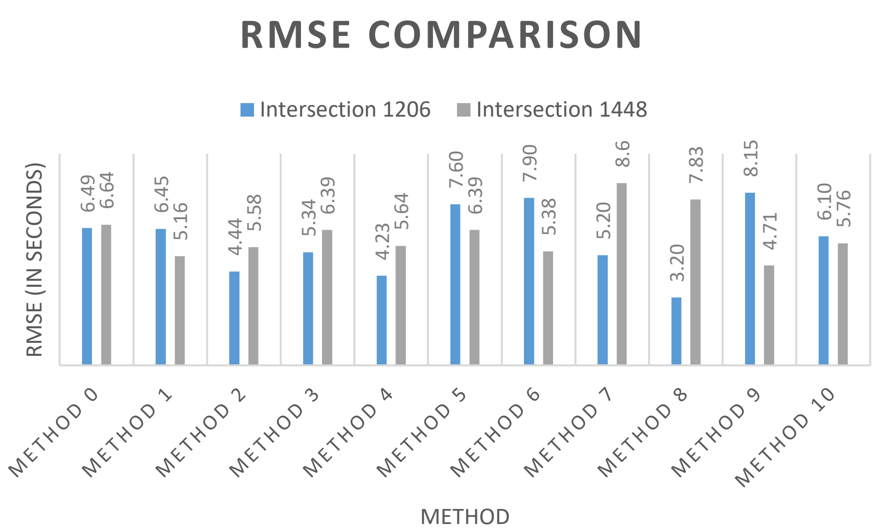
In Germany, traffic signals in urban areas are actuated and adapted to their green time per the current traffic situation. By predicting the upcoming remaining time while waiting for a red or green light in an intersection, the drivers can adapt the speed safely to speed up or slow down at an intersection. This decision-making facilitates, reducing congestion and thus emissions as well. The product from Traffic Technology Services Europe GmbH, Personal Signal Assistant (PSA) provides predictive traffic signal data with Green Light Optimized Speed Advisory (GLOSA), and red-light countdown time for intersections.

This thesis analyses the quality of these traffic signal switching times obtained from The Apha (Ampel Phasen Assistant) finite state prediction tool, which is integrated and developed with finite state theory. Previous studies on the prediction of traffic signal switching time in the usage of machine learning algorithms to limited to a certain extent. Only a few authors have contributed to research in switching time prediction using machine learning methods. The predictions of switching times already running in the real-time system are evaluated based on different training models. In finite state theory, states are defined as initial states, transition states etc. In the prediction tool, states are defined based on the factors that trigger a switching in the intersections (E.g. Cycle seconds, Signal bulb colour, Pedestrian call etc.).

Methods/Models	State vector/combinations
0	Cycle seconds
1	State (Signal image status)
2	State/Call vector (request status)
3	State/Stau vector (States of congestion)
4	State/Transit vector (Transport signal request)
5	State/Call vector/Stau vector
6	State/Call vector/Transit vector
7	State/Stau vector/Transit vector
8	State/Call vector/Stau vector/Transit vector
9	State/Call vector/Stau vector/Transit vector/ Cycle seconds
10	State/Time Last State

Analysing predicted remaining time for switching signal

The predictions will be tested against 11 methods or models which include various state combinations and try to analyze the most efficient method in quantitative analysis. In the analysis, two intersections have been chosen, one in Munich (Id: 1206) and one in Duesseldorf (Id: 1448). The intersections are chosen in such a way as to explore the possibilities of different factors affecting the triggering of switching the traffic signals and thus influencing the prediction. Intersection 1448 has transit lines and signals involved and intersection 1206 has the occupancy function involved so that all the models are influenced in predicting the remaining time of switching. As evaluation metrics regression approach is used including the calculation of Mean absolute error and Root mean squared error to comprehend the accuracy of predictions. The two intersections were set to run for different numbers of days with different time frames and for 11 methods, to generate predictions of remaining time for the switching of the signals. The evaluation focuses on individual error values formed for each signal on different models. While calculating RMSE values, the mean of predictions from all the vehicle signal types is calculated so the comparison would be to the cycle length of the intersections which generally range from 60 to 120 seconds.



The evaluation results suggest that for both intersections, the prediction quality has an overall range of Mean absolute error from 2 to 5 seconds for different signals and an RMSE value range from 3 to 8 seconds for all signals together. An average of both intersections for RMSE value gives approximately 6 seconds. The stability of predictions, on how the tool works for different signal and detector functions were also analyzed and it revealed that the signals interact marginally fair with the parameters or state vectors set for them and show the lowest values or better performance on the method with state combinations, which align with the detector function which initiates each signal that makes a switching. The lowest RMSE value for intersection 1206 is method 8 which has an occupancy function, and for intersection 1448, method 9 has the lowest RMSE value, which is a combination of all the possible states. The results show that the error in predictions for different models is reasonably fair, nonetheless, accuracy from a service perspective could be improved and will be beneficial for the future expansion of the service.