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SIGNAL PHASE TIMING IMPACT ON TRAFFIC DELAY AND QUEUE LENGTH-A INTERSECTION CASE STUDY

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ABSTRACT

Traditional intersection traffic signal control strategy is pre-determined signal with certain phase timing length for each circle. Studies focusing on adaptive traffic signal strategy have somewhat achieved the goal of reducing traffic system delay to some extent. However, few of them capture the benefit of using the queue length as the criteria under the connected vehicle environment, and this paper focuses on firstly identifying the potential saving of average system delay with agent-based simulation modeling, and secondly finding out the relationship between average system delay and average queue length for traffic approaching the signalized intersections. Through applying the agent-based simulation modeling approach in AnyLogic, findings show that average system delay could be reduced using optimized parameters (e.g. arrival rate, signal phase length, etc.), specifically, 5.29% saving of total average system time, 4%-28% traffic queue reduction for different traffic lanes, and a positive relationship between average system delay and the average traffic queue length is detected.

1 INTRODUCTION

Current situation of the traffic control strategies at the intersection has evolved and been improved through applying the advanced control technologies during the last decades, especially for signalized intersections around urban areas. Under the vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) connection environment, it is necessary to conduct an in-depth analysis about how these techniques could be applied to improve the overall efficiency and safety conditions at intersections. This study is intended to present an in-depth analysis about how to use the information from the connected vehicles to simulate the real world situation, so that an optimal traffic signal control solution can be achieved at intersections. Therfore, the research question raised in this study is whether it is more efficent to cross the intersections under connected vehicle (CV) environment in terms of system delay and traffic queue length.

2 METHODOLOGY

The data used in this study is from City of Detroit Connected vehicle data environment, which can be downloaded from Research Data Exchange website *https://www.its-rde.net/*. It was collected during a queue length estimation field test being conducted in the Southeast Michigan test bed, during the 2014 Intelligent Transportation Systems World Congress. The primary goal of this field test is to support a queue estimation algorithm while using connected vehicles in a CV environment. This Data Environment includes 4 data sets: 1) Vehicle Situation Data, 2) Intersection Situational Data, 3)Traveler Situation Data, and 4) the Queue Length Data sets. Agent-based simulation modeling is the adopted method towards studying the traffic flow at intersections. By using the performance indicators such as intersection traffic system delay, and queue length, we may have a general clue of how and to what extent the connected vehicle information will impact on the intersection operations. Statistical data descriptive analysis is another fundamental analysis method towards analyzing the basic frequentist and distribution information of the traffic flow and the output from statistical analysis will be used as the input parameters into the simulation model, which will eventually affect the outcome of the simulation results.

3 ANALYIS RESUTLS

Based on the fundamental traffic flow theory, the relationship between flow, speed and density is shown as $q = k \times v$. Where q = traffic flow, vehicle per hour per lane; k = flow density, vehicle per mile per lane; and v = speed, miles per hour. In order to determine the traffic flow rate, density and speed is needed. Statistical analysis results show that jam density is finally calculated to be 170 vehicles per mile per lane. Using Greenshields's linear model, $v = v_f(1 - k/k_j)$, where v_f denotes free-flow speed, the posted speed limit is 25mph, and k_j is jam density. Then, $q = k_j(1 - v/v_f) \times v = 170(v - v^2/25)$.

Based on available data, the speed follows the triangle distribution in AnyLogic, the arrival rate is calculated as Triangle (0, 517, 1063) representing number of vehicles coming to the intersection per hour with minimum 0, maximum 1,063 and mean 517. Signal phase and timing (SPAT) is analyzed and shown in Table 1.

Table 1: Signal phase and timing descriptive statistics.

		Time to change(s)			
Current signal state	Frequency	Min	Max	Mean	Std. Deviation
0	195788	0.1	63.7	25.291	24.2264
1 / green	969970	0.1	48	8.616	10.1704
2 / yellow	260459	0.1	75	7.638	14.0866
4 / red	1418919	0.1	93.2	15.313	15.104
16 / left arrow	25253	7	50	45.97	2.8865

The simulation is based on intersection of Shelby and Larned road. Optimization procedures are based on total system average delay, and traffic arrival rate are initially set as 15, 15, 20 and 6 vehicles/min from top, bottom, left and right entrance into the system as shown in Figure 1. Through optimization procedure with 500 runs, new values for signal phase parameters are obtained, and results shows that adaptive signal control can be further optimized with optimal control signal phase parameters, and total average time saving percentage is around 5.29%, and queue length reduction percentage ranges from 4% up to 28% under dynamic traffic flow environment.

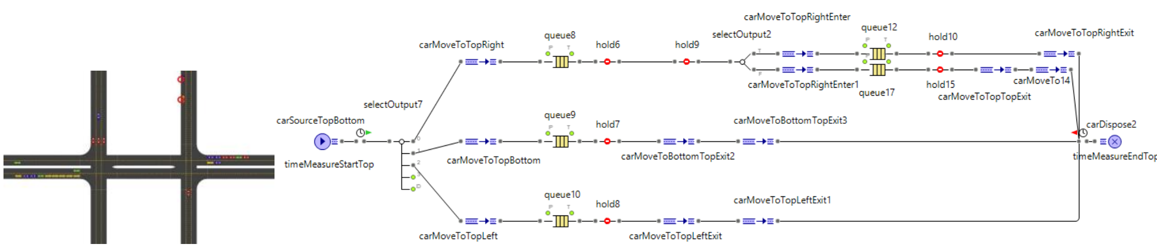

Figure 1 Traffic flow simulation logic and signal control scheme.

4 CONCLUSION

By simulating the intersection and optimizing traffic signal parameters, I found that there is still potential system average time savings and traffic queue length reduction, due to application of CV techniques.

REFERENCES

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