Crossing Road Simulation

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***Abstract*—This work mainly focuses on baseline and multiple simulation of single-lane traffic flow, which will assist in illuminating the basic concepts of traffic flow density.In this paper Simpy library is used to simulate a 1 Km of roadway.Simulation is done to interpret the significant observations when various parameters are tweaked and analyzed.The model is then tested in various mixed traffic scenarios.While some of the parameters are changed and taken into account during the simulation, other factors, such as average travel time, maximum traveling time, average waiting time, and average queue length are derived using the results of the simulation result. This study will assist us in better comprehending how various cars behave on highways and on cross road when traffic flow is increased and maximum speed is changed.**
Keyword: **Modelling,Simpy,Simulation,traffic scenarios,traffic flow, cross road**

I. Introduction

In this project, a complete simulation model is being build, including the generation of single lane traffic scenario. This project is designed to improve the effectiveness and efficiency of the transportation system. We must comprehend the real traffic system, how to drive on the freeway, and certain rules before moving further with the simulation. Therefore, the first regulation is that the maximum speed on a highway is 120 km/h. Learner drivers, cars with a speed limit of less than 50 cc, disabled carriages, pedal bicycles, pedestrians, and animals are among the kinds of vehicles that are not permitted on highways.Except in cases of necessity, vehicles are not permitted to stop and halt on motorways or to reverse on them. When a vehicle is getting ready to merge onto a motorway, it must make absolutely sure that it yields to traffic already on the highway and uses the slip lane for as long as feasible. This provides traffic behind more time to see and also allows the car to accelerate before merging into the left lane.

On a highway, the left lane serves as the main travel lane, and the right lane is utilized for passing or allowing vehicles to join. Vehicles should keep a minimal distance between one another. The back and sides of the car need to be regularly checked by the driver. Driving on the highway demands a lot of focus. It necessitates a lot of routine mirror checks and a blind zone where the driver must move their eyes across their shoulder to view oncoming traffic. The fundamental layout of a highway and the driving regulations that must be observed when using one are as follows. A road may become congested if there are too many vehicles using it, and accidents may occur as a result of this congestion. What exactly are the causes of the congestion? We will talk about a few of the reasons listed below that cause traffic on the highway. On the highways,sudden braking increases the likelihood of traffic gridlock. On a highway, if a motorist applies the brakes for two or three seconds, the cars behind them will also do the same, starting a chain reaction that would eventually close the gap between the cars, creating traffic.

II. Literature Review

[1]In this study, it is estimated that the velocity, tire forces, and road coefficient of friction of vehicles on asphalt surfaces using extended Kalman-Bucy filtering (EKBF) and Bayesian hypothesis selection. A vehicle with eight degrees of freedom has its position and tire forces estimated by the EKBF using sensors mounted on the vehicle. No tire force model or prior knowledge of is necessary for the filter to work. The most likely value is chosen from a range of potential values by statistical comparison of the correspondence, slip, and slip angles estimates with those that come from a notional analytic tire model.The results of simulation reveal great integration and accuracy of the estimates, and they also show that it is possible to build practical tire models. The identification algorithm's resilience as well as the computing and sensor requirements are taken into account.

[2]In this study, a pedestrians model for China's micro-simulation of the traffic system is presented. Given the high percentage of signaling non-compliance, we divide pedestrians into two categories: those who follow the rules and those who take advantage of the situation. Opportunistic people make decisions about whether to run a red light during a red man based on the conditions of some external circumstances (such the presence of a police officer, the flow of traffic, and the actions of other pedestrians). The percentages of these two groups of pedestrians in various situations were calculated using questionnaires. The simulation results, however, differ somewhat from the information taken from the videotape. The parameters can be changed to improve how well the simulation results match field outcomes by assessing the occurrence of variations.The high percentage of pedestrian running red lights and the varied features of traffic patterns in Chinese cities were reflected by this model, which may also be used to micro-simulate the road network in other growing cities.

[3]In this study a simulation model of the movement of inland intermodal terminal units (ITUs) between and within them is offered. Rail corridors link the intermodal terminals

together. Each terminal uses a road network to service a user catchment region. Modeled as a series of platforms, the terminal is staffed by numerous cranes and the front lifters. The simulation model's user specifies the terminal's layout as well as the railway and truck arriving scenarios. While the schedules of trucks arriving for ITU shipment and pick-up can either be given as a predictable input or statistically simulated, train arrivals are specified in a train timetable.

[4]In this report a novel technique was used to teach road-crossing skills to five-year-old kids, enabling them to behave safely around cars on a typical road. After practicing in the simulation, five-year-olds attain a level of proficiency typically displayed by older kids, whose exposure to the road lowers their risk. This shows that the simulation would be a useful supplement to road safety programs since it enables kids to securely discover and enhance their skills more fully than while really crossing the road.

III. METHODOLOGY

The numerous phases involved in the development of the models are described and included in this section.For this simulation python version 3.9.7 with Jupyter notebook is used to execute and create the code. The simulation model has been created using python libraries such as simpy,matplotlib,math,random and pandas.

A. Visualisation

this section contains two functions which is displayMap and animate. Road network visualization is produced by displayMap function using a Network as an argument. This can be used to test a road network's design. recorder and a file-name are the two arguments required in animate function. It makes an animated gif file of the simulation after extracting the data from the recorder.

B. Roads

There are two roads in the simulation, one is National Road that runs in North-South direction another is the cross road which runs in East-West direction.The national road crosses the cross road 700m from the west towards east as can be seen in Fig. 1

C. Road Networks

This section helps in setting directions to the road networks. Some of the functions contains in this section are right,cross,left,opposite, mainDirection and look. Some of the variables are also initialized in this section like lane width(LW), length of keep clear line near crossing(SL), enlarged length of a vehicle(VL),enlarged width of a vehicle(VW), distance of stop point from side of crossing road(LD) and enlarged distance between stopped vehicles(SD). Value of these variables assumed can be seen from Fig. 2 and Fig. 3.

D. Road Segment

Road length can be specified in this section by passing required parameters in contains function where begin point and end point of road can be specified.

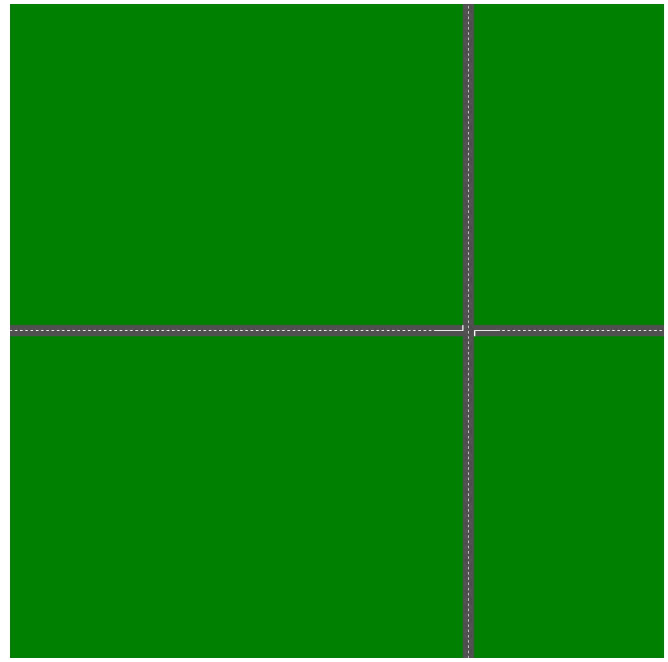


Fig. 1. Road Network

E. Intersections

This section is required to manage traffic at crossing of National road and cross road which is achieved by functions like crossRoad, crossRoadIsThroughRoad, getQueueLength, request, release, getSpotRequest, releaseSpot and stop.Some of the variables used in simulation are initialized like Lane Width(LW),Vehicle Length(VL),Stop Line Distance(LD) and Stop Distance(SD). The values used for these variables can be seen from Fig. 2 and Fig. 3.

F. Recorder

Recorder section is required to record the simulation and animation during execution.This section is also responsible in storing all the results thus obtained by executing simulations. This is achieved by using some of the functions created like run, process, startRecording, stopRecording and record.

G. Vehicles

This section helps in initializing variables like average decelleration when using engine braking(A_COAST), max accelleration depending on car class(A_MAX), emergency brake decelleration(A_BRAKE),.Value assumed for these variables can be seen from Fig. 2 and Fig. 3

IV. THE SIMULATION MODEL

1) Baseline Simulation: In baseline simulation cars are considered to be running with fixed speed of 100 Km/hr in National road and 50 Km/hr in cross road.Inter arrival time for both National road and cross road is calculated.The assumptions of various variables described in methodology section and calculated variables for baseline simulation can be seen from the Fig. 2. North bound traffic is considered as constant as 120 veh/hr. Two simulations are executed **Case One** with 200 veh/hr and **Case Two** with 300 veh/hr and average and maximum travel times are calculated.

Baseline Simulation			
200 Vehicle/hr		300 Vehicle/hr	
Attributes	Values	Attributes	Values
IATmain_North	30seconds	IATmain_North	30seconds
IATmain_South	18seconds	IATmain_South	12seconds
IATcross	18seconds	IATcross	18seconds
VMAXmain	100Km per Hour	VMAXmain	100Km per Hour
VMAXcross	50Km per Hour	VMAXcross	50Km per Hour
Tmax	1800seconds	Tmax	1800seconds
LW	8metre	LW	8metre
VL	10metre	VL	10metre
VW	4metre	VW	4metre
LD	3metre	LD	3metre
SD	4metre	SD	4metre
SL	40metre	SL	40metre
A_BRAKE	-4m/s²	A_BRAKE	-4m/s²
A_COAST	-1.8m/s²	A_COAST	-1.8m/s²
A_MAX	2.5m/s²	A_MAX	2.5m/s²

Fig. 2. Baseline Assumptions

2) Multiple Simulation: In this simulation the velocity cars are considered to be running with 80 Km/hr in National road and 50 Km/hr in cross road.Inter arrival time is calculated for both national road and cross road. The assumed variable values and calculated variable values can be seen from Fig. 3. Three simulations are executed using these variables. **Case Three** for 300 veh/hr **Case Four** and **Case Five** for 400 veh/hr and 600 veh/hr respectively and queue length and waiting length is calculated and plotted using box plot and results are evaluated based on null and alternate hypothesis mentioned below.

- *Null Hypothesis:* By changing traffic flow from 300 veh/hr to 400 veh/hr and then to 600 veh/hr there will be significant change in queue length and and waiting time which can be inferred by looking at the p-value and box plot that is if p-value comes less than 0.01 then null hypothesis is satisfied
- *Alternative Hypothesis:* By changing traffic flow from 300 veh/hr to 400 veh/hr and then to 600 veh/hr there will be no change in queue length and waiting time which can be inferred by looking at the p-value and box plot that is if p-value comes more than 0.01 then null hypothesis is rejected and satisfies the alternate hypothesis.

V. RESULTS AND INTERPRETATION

A. Baseline Simulation

1) Case One: Case One simulation as already discussed in baseline simulation section is executed with traffic flow of 200 vehicle/hr and the parameters used can be seen from Fig. 2. Average travel time is coming around 150.69 seconds which can be seen from Fig. 4 ,which is greater than 2 minutes so the assumption is not getting satisfied. Maximum travel time is coming around 209.14 seconds which can be seen from Fig.

Multiple Simulation					
300 Vehicle/hr		400 Vehicle/hr		600 Vehicle/hr	
Attributes	Values	Attributes	Values	Attributes	Values
IATmain_North	30	IATmain_North	30	IATmain_North	30
IATmain_South	12	IATmain_South	9	IATmain_South	6
IATcross	18	IATcross	18	IATcross	18
VMAXmain	80	VMAXmain	80	VMAXmain	80
VMAXcross	50	VMAXcross	50	VMAXcross	50
Tmax	1800	Tmax	1800	Tmax	1800
LW	8	LW	8	LW	8
VL	10	VL	10	VL	10
VW	4	VW	4	VW	4
LD	3	LD	3	LD	3
SD	4	SD	4	SD	4
SL	40	SL	40	SL	40
A_BRAKE	-4	A_BRAKE	-4	A_BRAKE	-4
A_COAST	-1.8	A_COAST	-1.8	A_COAST	-1.8
A_MAX	2.5	A_MAX	2.5	A_MAX	2.5

Fig. 3. Multiple Simulation Assumptions

5, which is less than 4 minutes so this assumption is getting satisfied. Also graph from Fig. 6 and Fig. 7 it can be seen that there is no congestion in traffic flow in cross road running from West to East.

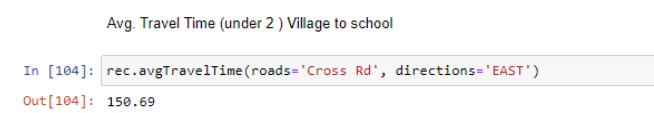


Fig. 4. Average travel time for 200 veh/hr

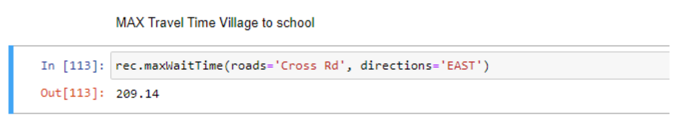


Fig. 5. Maximum travel time for 200 veh/hr

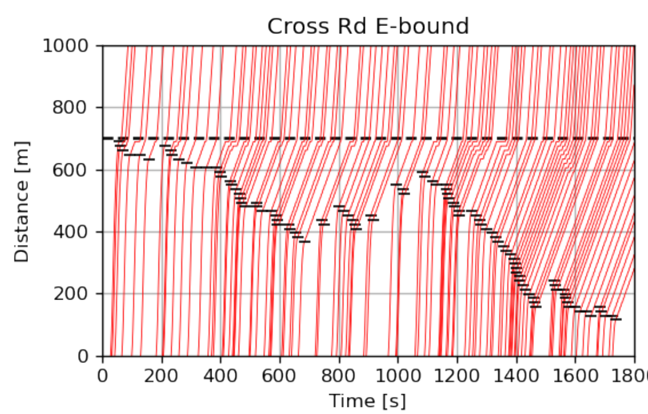


Fig. 6. Cross Road E-bound Traffic for 200 Veh/hr

2) Case Two: Case Two simulation as already discussed in baseline simulation section is executed with traffic flow of 300 vehicle/hr and the parameters used can be seen from Fig. 2. Average travel time is coming around 154.58 seconds which can be seen from Fig. 8 ,which is greater than 2 minutes.Maximum travel time is coming around 276.32 seconds

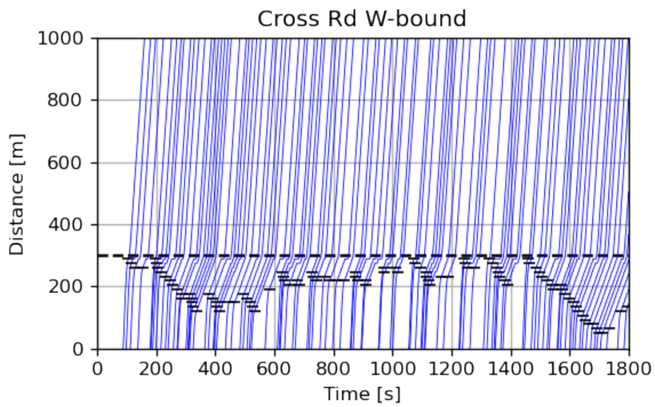


Fig. 7. Cross Road W-bound Traffic for 200 Veh/hr

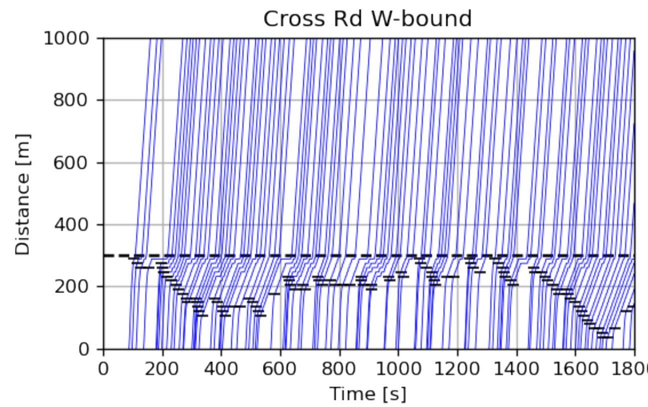


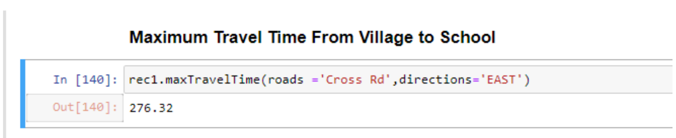
Fig. 11. Cross Road E-bound Traffic for 300 Veh/hr

which can be seen from Fig. 9, which is more than 4 minutes so assumptions are not getting satisfied.Also graph from Fig. 10 and Fig. 11 it can be seen that there is no congestion in traffic flow in cross road running from West to East.


Average Travelling Time in sec from village to school

```
In [131]: rec1.avgTravelTime(roads='Cross Rd', directions='EAST')
Out[131]: 154.58
```

Fig. 8. Average travel time for 300 veh/hr


Maximum Travel Time From Village to School

```
In [140]: rec1.maxTravelTime(roads ='Cross Rd',directions='EAST')
Out[140]: 276.32
```

Fig. 9. Maximum travel time for 300 veh/hr

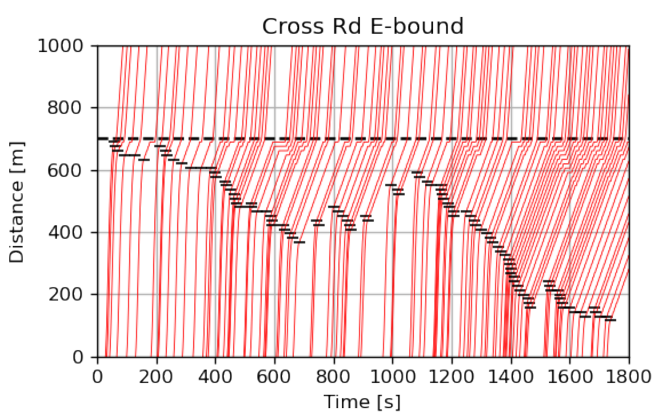


Fig. 10. Cross Road E-bound Traffic for 300 Veh/hr

3) Baseline Conclusion: From above observation from simulation case one and case two it is observed that there is not traffic congestions or sudden brakes condition due to increase in traffic flow from 200 veh/hr to 300 veh/hr on the national road but average travel time is increased from 150.69 seconds to 154.58 seconds and also maximum travel time is also increased from 209.14 seconds to 276.32 seconds.

B. Multiple Simulation

1) Case Three: Case Three simulation as already discussed in multiple simulation section is executed with traffic flow of 300 vehicle/hr with 80 km/hr maximum speed in National road and other parameters used can be seen from Fig. 3. Queue length is seen to be increasing with time in East bound as seen in Fig. 12.

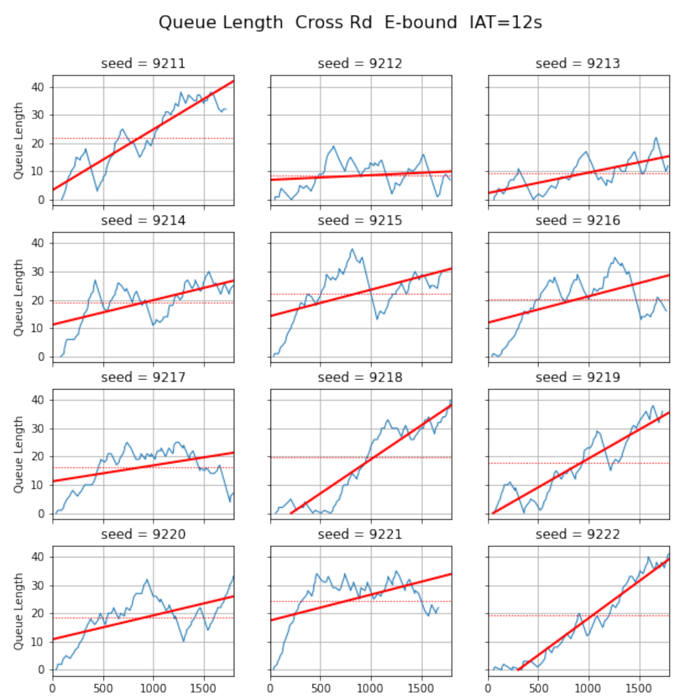


Fig. 12. Queue Length Cross Rd E-bound IAT 12s

2) Case Four: Case Four simulation as already discussed in multiple simulation section is executed with traffic flow of 400 vehicle/hr with 80 km/hr maximum speed in National road and other parameters used can be seen from Fig. 3. Queue length is seen to be increasing with time in East bound as seen in Fig. 13.

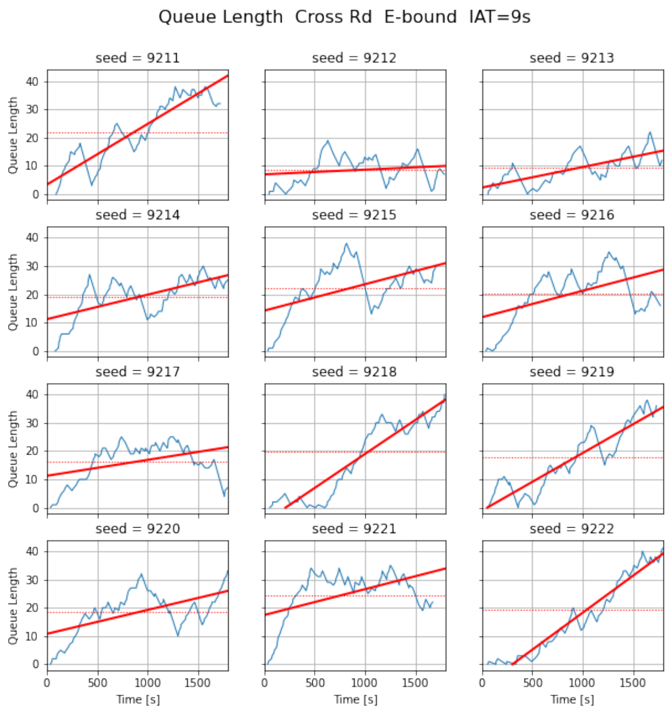


Fig. 13. Queue Length Cross Rd E-bound IAT 9s

```
In [48]: AQL = avgQueueLength(RECS)

In [49]: t_test_less(AQL[0], AQL[1])
Out[49]: 0.5
```

Fig. 14. Average Queue Length T-test

```
In [52]: AWT=avgWaitTime(RECS)

In [53]: t_test_less(AWT[0], AWT[1])
Out[53]: 0.5
```

Fig. 15. Average Waiting Length T-test

3) Case Five: Case Five simulation as already discussed in multiple simulation section is executed with traffic flow of 600 vehicle/hr with 80 km/hr maximum speed in National road and other parameters used can be seen from Fig. 3.Queue length is seen to be increasing with time in East bound as seen in Fig. 16.

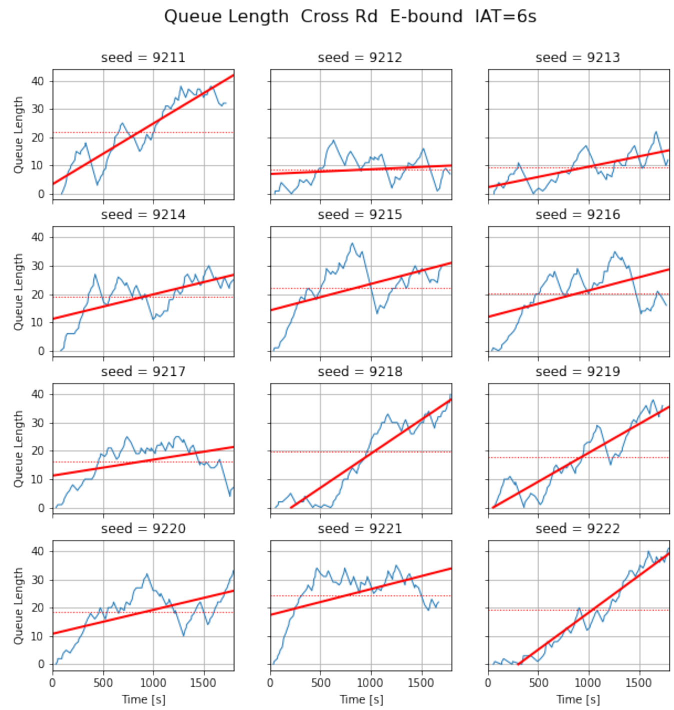


Fig. 16. Queue Length Cross Rd E-bound IAT 6s

4) Multiple Simulation Conclusion: As seen from Fig. 14 and Fig. 15 the p-value of t-test for average queue length and average waiting time is coming as 0.5 which is greater than 0.01 so rejecting the null hypothesis as discussed in Multiple Simulation section. Thus accepting the alternate hypothesis which states that there is no change in average queue length and average waiting time due to change in traffic flow from 300 veh/hr to 400 veh/hr and then to 600 veh/hr and also there is no change in average queue length and average waiting time due to change in maximum speed in national road from 100 km/hr to 80 km/hr. This inferences can also be verified from box plot as seen in fig. 17 and Fig. 18.

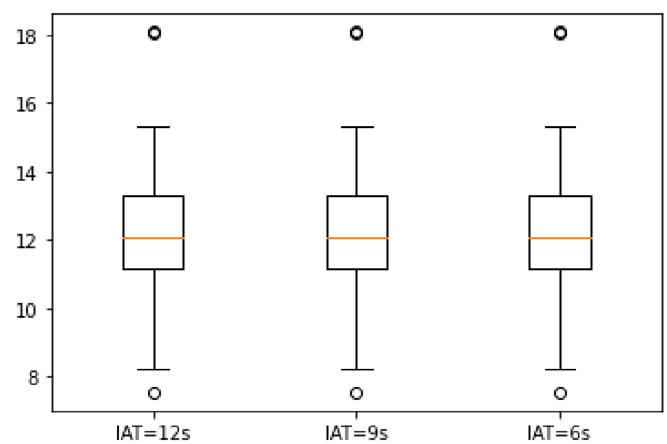


Fig. 17. AQL box plot

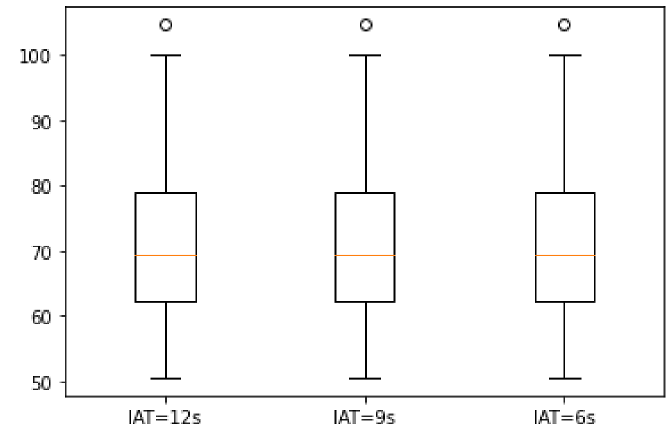


Fig. 18. AWT Box plot

VI. REFLECTIONS AND FUTURE WORK

For baseline simulation with traffic flow 200 veh/hr and 300 veh/hr the average travel time is not coming less than 2 minutes which is dependent on seed value and the maximum travel time is not under 4 minutes so the assumptions are not getting satisfied. For multiple simulation null hypothesis got rejected as p-value is coming more than 0.01 which shows that there is no significant change in average queue length and average waiting time in cross road due to increase in traffic flow and change in speed in national road. For future work we can include traffic lights as well to control the traffic in intersections and also to prevent any sudden brake or accidents during crossing.

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