Microsimulation Modelling in VISSIM for Long-Term Improvements in Kuruppanthara Junction

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Abstract—: **Travel efficiency and traffic safety of non-signalized intersections are two main objectives considered in traffic management and control. Traffic analysis at non-signalized intersections has always been a difficult process to carry out with the ever-increasing volume of vehicles. Kuruppanthara junction is a four-legged intersection situated at Kottayam district in Kerala. The ineffective signaling and lack of space leads to long queues in the intersection and improper positioning of bus bays in the influence zone of the junction cause heavy traffic congestion during peak hours. The focus of the study is to investigate the current situation and to develop two models of intersections and comparing each other and choosing the most efficient intersection model. Seeking appropriate control mechanisms with the help of traffic simulation software is an effective way to solve the problem. By using VISSIM microsimulation software we created two models and ran simulations with signals fitted to each model and compared the queue length and suggested that model for long-term solution for the trip makers at Kuruppanthara junction.**

Keywords: VISSIM, Intersections, Traffic simulation, Queue length

I. INTRODUCTION

With the increase in car ownership, which causes terrible traffic jams and low transport efficiency, urban traffic is becoming more oppressive. The sudden increase in population and urbanization of the country lead to a very unauthorized and inefficient road network with poor utilization of roads and faulty designs. Very often we see traffic congestion, accidents, unauthorized parking and inadequate road widths with very low capacity. We need more efficient road designs in order to minimize traffic congestions and accidents, and ensure better flow of traffic. Traffic simulation software plays an important role in designing road models. Its output serves two purposes; to present a visual image of the predicted traffic suitable for public presentation and to provide quantitative answers to differentiate between the levels of service offered by the road design options.

Microsimulation is a relatively new technique for representing road traffic flow, in which the actions of every individual vehicle are evaluated at sub second intervals. Their journeys through the road network are derived by analyzing their interactions with the road network, the traffic control systems, and with the other vehicles on the network. The random wait for a gap in traffic, the clustering of vehicles and the variance in the length of time required to make a journey are all automatically assessed and assimilated. A microsimulation model is fundamentally quite simple. Concerning speed and lane choice each individual vehicle follows the road alignment and constantly makes decisions. It must decide which way to turn at the end of the road, and also it must wait for a suitable gap in the traffic before moving out. Such a simulation can be implemented using a simple car model and elementary physics involving equations of motion.

Traffic flow software has been available in almost its current form since the 1960s. Its function is quite simple: build a computerized model of a road system and load it with vehicles representing the demand on that system. The software then enables the user to adjust the road network description or travel demand within the model so that it represents what is observed on the road. The model is then used to predict what will happen in the future if the road network or travel demands change.

S-Paramics (2006) is one example of a number of similar microsimulation software packages. All are designed to perform a similar task. S-Paramics, Aimsun (2006) and Vissim (2006) are the most well-known. S-Paramics is based on research from Fritzsche (1994) with modifications derived from the experience of using it on many transport planning projects (Duncan and McArthur, 1997). Recent research from the USA into driver behavior is also contributing to internal behavior models (NGSim, 2006). S-Paramics is a discrete time step based simulation where the time step is commensurate with a driver's reaction time. At each time step Drivers make a set of decisions about what they will do in the future at each time step. It is the interaction between individuals that allows microsimulation to represent the flow of traffic on a road system.

This paper introduces the application of VISSIM software, in the design and testing of a model of traffic light controlled intersection. The main aim of this paper is to propose two intersection models leading to the elimination of congestion during peak hour. VISSIM is a microscopic multi-modal traffic flow simulation software developed by PTV Planung Transport Verkehr AG in Karlsruhe, Germany. VISSIM was first developed in 1992. The latest version of VISSIM is PTV VISSIM 21 released in 2021 and we have used this version in our project. VISSIM is a software that can be used to analyze private and public vehicles even under constraints such as lane configuration, vehicle composition, traffic signals etc. It is a time and behavior based simulation model developed to model urban traffic and public transport operations and flows of pedestrians. It allows you to simulate traffic patterns exactly, by comparing junction geometry, analyzing public transport priority schemes, or the effects of certain signaling. It can also be used to compare signalized and stop sign controlled intersections, roundabouts and grade separated interchanges. VISSIM allows simulating and visualizing the interactions between road traffic and pedestrians .All these features of this software makes it a useful tool for the evaluation of various alternatives based on transportation engineering.

II. RESEARCH PROBLEM DEFINITION

The traffic section we will deal with is a traffic-light controlled intersection in Kuruppanthara junction, Kottayam district. It is a crossroad of streets Kottayam to Ernakulam and Pala to Kallara, which is located on the main road of the city .The problem of the intersection is the occurrence of traffic congestions, especially in the peak hours, mostly in one direction of the intersection. This congestion is caused by a few factors, such as the presence of a railroad crossing a few kilometers back from the intersection. There are a lot of Heavy goods vehicles (HGV) passing through this intersection each day. The presence of railways affects the queueing of vehicles. Another problem is that the bus stops, and auto rickshaw stands are in the zone of influence. It takes up the space of the road. In this project we have made use of the VISSIM software to model an intersection in Kuruppanthara. We have used the software to design a new model to that intersection. The current intersection has a lack of space and with that much vehicle passing through that intersection, providing a signal leads to more vehicle queues. So it is better, if any extension work is allowed in that intersection, a new model designs along with the addition of signals to make it more efficient.

A. AREA OF STUDY

Kuruppanthara is situated in the district of Kottayam, Kerala. For the research purpose, we are focusing on the 4-legged intersection in that area. This intersection is currently operated by traffic police. One road is in the direction towards Ernakulam (Entrance A) and the opposite to Kottayam (Entrance C) and the third one is towards Pala (Entrance B) and its opposite to Alappuzha (Entrance D) as shown in fig-2. All the entrances to the intersection are two-lane.

Fig. 1. Satellite view of the intersection (Source; Google Earth).

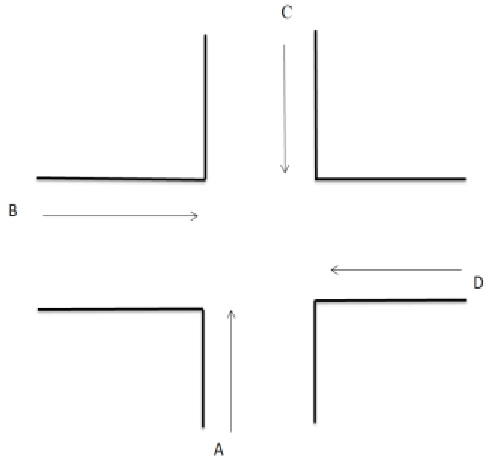


Fig. 2. Entrances to the intersection

B. TRAFFIC SURVEY

The traffic survey was conducted on April 21, 2021. We analyzed the traffic flow in the peak hours, i.e., 9:30-10:30 and 16:30-17:30. The flow of each vehicle through the intersection is taken. The Passenger Car Unit (PCU) through each route is shown in Table-1.

TABLE I. PCU/HR. THROUGH EACH ROUTE.

Routes	PCU/hr.
Kottayam-Pala	150
Kottayam-Ernakulam	761
Kottayam-Alappuzha	209

Alappuzha-Kottayam	224
Alappuzha-Pala	309
Alappuzha-Ernakulam	138
Ernakulam-Alappuzha	85
Ernakulam-Kottayam	721
Ernakulam-Pala	181
Pala-Ernakulam	184
Pala-Alappuzha	226
Pala-Kottayam	126

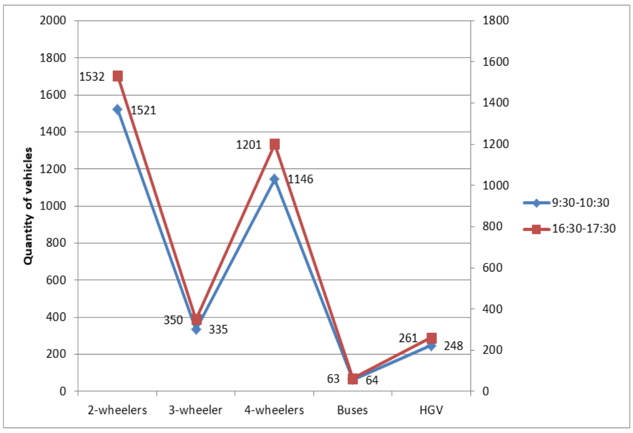


Fig. 3. Graphical representation of the type of vehicles passing through the intersection during peak hours.

III. SIMULATION

A. *DESIGN OF INTERSECTION MODEL*

VISSIM has various features, such as traffic flow, modeling, traffic light engineering, vehicle queue length analysis, pedestrian simulation, and also script-based modeling. Simulation provides us the advantage of being able to study how the created model behaves dynamically over time or after a certain span of time. A traffic characteristic on roads as a system varies with time and with a considerable amount of randomness and simultaneous interactions. There are five basic components for the signalized intersection modeling in microscopic simulation modeling. Some of the five components represent the signal control objects that we can find in the field and some represent the behavior of the drivers at the signalized intersections. The five basic components are:

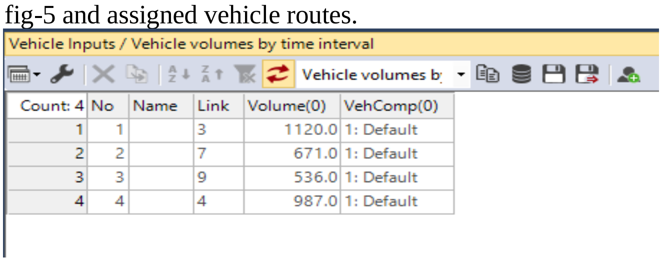
- Signal Controller
- Signal Timing Plan
- Signal Head
- Priority Control for Permissive Movements
- Detector

The components listed above generally need to be created in successive order because most components are associated with each other and affect the simulation model collectively.

At first we have to make the intersection model as a satellite image of the selected section of roads. On the basis of scale in the image, the map is scaled to match the model's measurements to the actual intersection measurements. The modeling procedure begins by sketching straight roads and joining them directly to the intersection map. In places where roads crossing conflict areas appear where the priority of vehicles in the event of an uncontrolled intersection needs to be defined.

Fig. 4. The conflict zones in the model

After the model has been made, all the components have been added to the model. First is vehicle inputting, which is adding the vehicle volume to the model. The total vehicle flow through each entrance is added to the table shown in the fig-5 and assigned vehicle routes.



Count: 4	No	Name	Link	Volume(0)	VehComp(0)
1	1		3	1120.0	1: Default
2	2		7	671.0	1: Default
3	3		9	536.0	1: Default
4	4		4	987.0	1: Default

Fig. 5. Screenshot of vehicle input.

Detectors and signal heads are added to the model. The signal programming is assigned to the signal heads and the detectors are added in order to get the result about the queue length of the vehicles after adding signals.

B. *SIMULATION RESULT*

The simulation is basically a real-time traffic flow according to the inputted data. The simulation was run in 3600 seconds and we got good results. At some point the vehicles had to be stopped due to the conflict zones. The signal timing also affected the queueing of the vehicles. After performing the simulation we get a set of results which includes:

- Queue length
- Vehicle delay
- Stops

We compared the queueing length of vehicles after adding signal to the existing model with the new model with signal. There is a major change in the results.

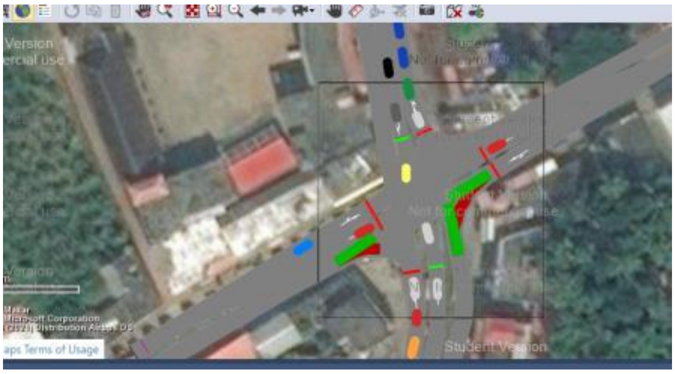


Fig. 6. Simulation run of the model.

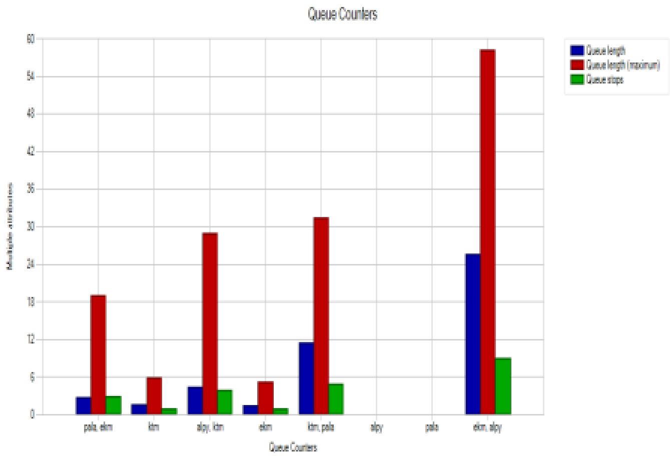


Fig. 7. Final result of the simulation (Queue length and Queue stop).

C. DESIGN AND VERIFICATION OF NEW MODELS

The existing traffic in Kuruppanthara consists of a two lane road model. Our purpose was to add a signal to that model and we got results which are shown in fig-9. Also we created a second model for better efficiency.

Fig. 8. Simulation of first model.

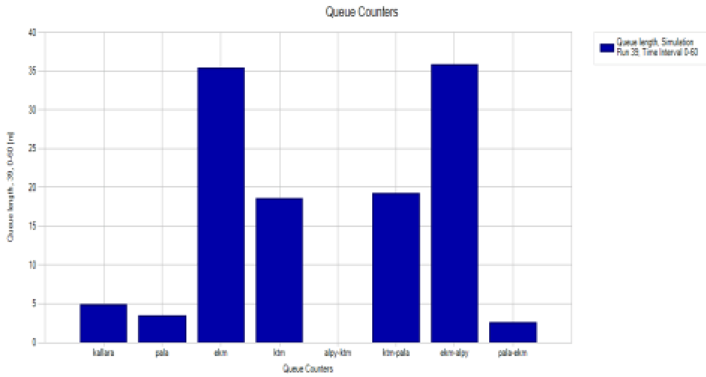


Fig. 9. Queue length of the existing model.

The second model is basically a 3-lane road which has a dedicated signalized right turn (fig-11) for uninterrupted flow of traffic. The straight is also signalized and free left turns are possible. The signal programming is added to the model. The signal timing is calculated by Webster's method. The signal parameters are added to the model such as signal heads, cycle time and signal programs as shown in fig-10. After all the components are added the results from two models are observed.

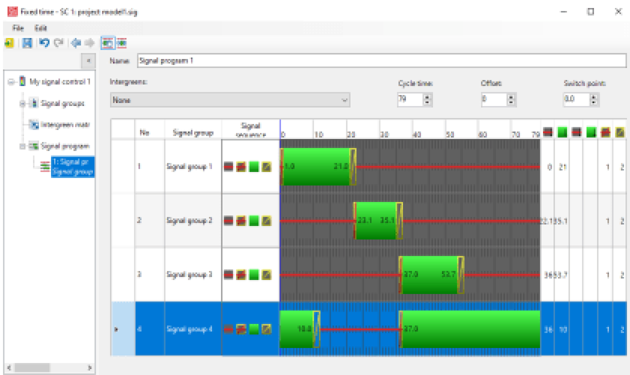


Fig. 10. Setting cycle time in signal program.

Fig. 11. Simulation of second model.

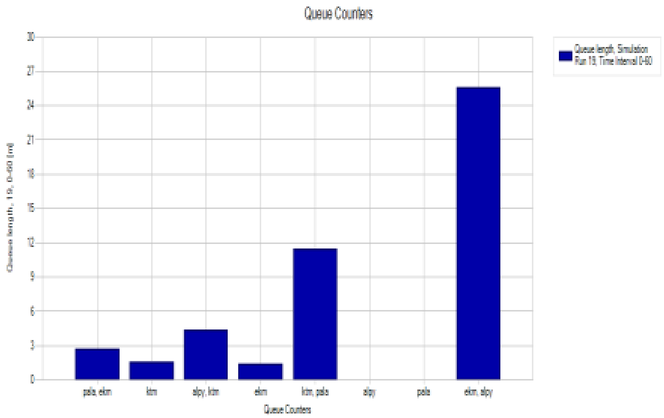


Fig. 12. Queue length of the second model.

From fig-9 and fig-12 it is evident that the more efficient model is the 3-lane design. There is a significant difference in the queue length. Finally we selected the second model as the final result.

IV. CONCLUSION

The present study focuses on suggesting short-term and long-term improvements at Kuruppanthara junction. A traffic survey is conducted and determines the vehicle flow through each entrance. Optimum signal cycle time corresponding to minimum total delay to all the vehicles at the approach roads of the intersection is determined and a signal is designed using Webster's method and by taking these values two microsimulation models are developed using VISSIM .

A visual inspection of the simulation performed in VISSIM indicates that the above mentioned reduction in the stopped delays due to a adding an exclusive lane for the existing carriageway has resulted in vehicles utilizing the available extra space to move forward. This consequently cleared the road spaces for other vehicles such as buses, cars, and HGVs to flow more freely resulting in an increase in the overall simulated volumes considering all vehicle types. The above simulation results show us that the proper utilization of road lanes could increase the efficiency of that intersection. The first model is basically a two-lane road with free left turns. The second model is a three-lane concept which follows the lane property very well, which has a dedicated right turn lane in the middle for reducing the queue length. After creating these models, traffic signals are added to each lane and compared the queue length. By comparing the two models we found that by providing an exclusive lane for right turners, which do not interrupt the straight flowing vehicles and resulting in lesser queue length.

Three-lane concept is better when it comes to 4 legged intersections which have less space for a round-about or any other type of intersections. This utilizes the space more efficiently. The high increase in vehicular flow is also due to the reason that 2% of buses pass through this intersection and stops are in the influence zone, 8% is HGVs, and the rest 90% is other vehicles such as rickshaws, bikes and cars. The rickshaw stand is also in the influence zone. If the bus stop and rickshaw stand are moved from the influence zone, there will be more space for the traffic flow.

By comparing the two models (fig-8 and fig-11) we observed that the second model is more efficient. The queue length varies significantly from the existing model. The simulation had run several times to see if the result varies.

REFERENCES

[1] Microscopic Traffic simulation using Vissim and traffic management measures at Kalady; Risni Salim, Leena Samuel, Laya Francis, Muhazina M, P. H. Haris(2019)
[2] Analysis of Speed profiles at speed hump under various dimensions & simulating their LOS using VISSIM; Korra Ravi Kiran, Kumar Molugaram, Manthirikul Sandeep
[3] Designing a Vissim model for a motorway network with systematic calibration on the basis of travel time measurements;Ioannis Karakikes, Matthias Spangler, Martin Margreiter
[4] Design of city logistics simulation model using PTV VISSIM softwareS;Tomas kucera,jan chocholac (2020)
[5] Calibration of VISSIM for Indian heterogeneous traffic conditions;S.M.P Siddharth,Gitakrishan Ramadurai(2013)
[6] Kuwahara M, Horiguchi R, Hanabusa H. Traffic Simulation with AVENUE. In: Fundamentals of Traffic Simulation. 2010, pp. 95–129. [25]
[7]]Fedorko G, Rosová A, Molnár V. The application of computer simulation in solving traffic problems in the urban traffic management in Slovakia. Theor Empir Res Urban Manag; 9: 5–17
[8] Nyame-Baafi E, Adams CA, Osei KK. Volume warrants for major and minor roads left-turning traffic lanes at unsignalized Intersections: A case study using VISSIM modelling. J Traflc Transp Eng (English Ed; 5: 417–428
[9] Neradilová H, Fedorko G. The Use of Computer Simulation Methods to Reach Data for Economic Analysis of Automated Logistic Systems. Open Eng; 6: 700–710.
[10] Chen M. Modeling and Simulation Analysis of Road Network Based on VISSIM. In: 2019 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS). IEEE, 2019, pp. 32–35.
[11] Fellendorf M, Vortisch P. Microscopic Traffic Flow Simulation VISSIM. In: Fundamentals of Traffic Simulation. Springer, New York, NY, 2010, pp. 63–93
[12] .Hambor L. Analysis of the traffic situation on the selected transport section in Spišská Nová Ves using simulations. Technical University of Kosice, 2018.
[13] Jang, Seung-Ju (2018) “Design of Traffic Flow Simulation System to Minimize Intersection Waiting Time” International Journal of Advanced Computer Science and Applications, Vol. 9, No. 5
[14] G. Kotusevski and K.A. Hawick (2009) “A Review of Traffic Simulation Software” Sci., Vol. 13, pg. 35- 54
[15] Song X, Xie Z, Xu Y, et al. Supporting real-world network-oriented mesoscopic traflc simulation on GPU. Simul Model Pract Theory; 74: 46–63
[16] E Joelianto, H.Y. Sutarto, D.G. Airulla, and M.Zaky, "Design and Simulation of Traffic Light Control System at Two Intersections Using Max-Plus Model Predictive Control," To Appear International Journal of Artificial Intelligence (2019)
[17] PTV, “PTV Vissim 8 User Manual,” PTV Planung Transport Verkehr AG, Karlsruhe: PTV Planung Transport Verkehr AG., 2016.
[18] Fan Wei. Application of PTV Vissim in intersection optimization simulation [J]. Master's thesis of Capital University of Economics and Business, 2014; 6:8-9
[19] Zhou Haijuan. Research on Traffic Organization Optimization of Urban Signalized Intersection Based on PTV Vissim Simulation[J]. Chang'an University Master's Thesis, 2015.06: 5-6
[20] Zou Liang, Pan Zhou, Chen Wei. Signal Control Optimization of Intersection Based on PTV Vissim
[21] Modern Transportation Technology, 2014.04, 11 Modeling Reservation Based Autonomous Intersection Control in Vissim M. Li ZChittui MV, Zheng

[22] Wu et al., 2018 Wu J., Radwan E., Abou-Senna H. Determination if VISSIM and SSAM could estimate pedestrian-vehicle conflicts at signalized intersections Journal of Transportation Safety & Security, 10.6 (2018), pp. 572

[23] Abou-Senna et al., 2013 Abou-Senna H., Radwan E., Westerlund K., Cooper C.D. Using a traffic simulation model (VISSIM) with an emissions model (MOVES) to predict emissions from vehicles on a limited-access highway

[24] Journal of the Air & Waste Management Association, 63.7 (2013) Prajapati, V. N., and Gundaliya, P. J. (2010), "Simulation of heterogeneous traffic intersection using VISSIM

[25] Mathew, T. V., and Radhakrishnan, K. (2010). "Calibration of microsimulation models for nonlane-based heterogeneous traffic at signalized intersections." Journal of Urban Planning and Development, 2010.136:59-66.