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Performance Evaluation of Ekantakuna Intersection

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Abstract

Majority of the intersections in Kathmandu valley are unsignalized and hence traffic management becomes one of the emerging issues for traffic police and traffic designers. The number of vehicles in Kathmandu Valley is increasing at the rate of 12% annually (Department of Transport Management, 2018). The manual traffic management is very tedious and hectic nowadays. The consequence leads to traffic congestion and sometimes crashes too. Hence, the performance evaluation of such unsignalized intersection is essential and considering the real time situations, scenario analysisis should be done. The research was carried out in Ekantakuna Intersection. The data's were collected in Ekantakuna Intersection through video-graphic surveying during weekdays: Monday to Friday both morning and evening during peak hours (9 to 11 AM in morning and 4 to 6 PM in evening).The model was developed in PTV VISSIM (Micro-simulation software) and thus the developed model was calibrated and validated using traffic volume. The relationship between field volume (actual volume) and VISSIM volume (Simulated Volume) was found with the help of R^2 Value (Coefficient of Determination) which is found to be 0.9993 which indicates that variance of VISSIM output explains 99.9 percentage of variance in field data's. Pedestrian movement was not given priority and hence pedestrian simulation is not considered. Total three scenario analysis were performed in base case scenario. Among them the best scenario analysis was found to be scenario 1 which indicates the restriction of vehicles from service lanes to main lanes and allowing the movement of vehicles from Balkhu(service) to Satdobato(service) and Jawalakhel lanes, and Satdobato(service) to Balkhu(service) and Bhaisepati lane.

Keywords: Intersection, VISSIM, Calibration, Scenario

1. Introduction

The majority of intersections in Kathmandu valley are unsignalized and hence management of traffic in such intersections has been a major problem for both traffic police and designers. The number of vehicles in Kathmandu Valley is increasing at the rate of 12% annually (Department of Transport Management, 2018).The manual traffic management is very tedious and hectic nowadays. This has emerged a bigger problem in performance of road.

The road users will experience increased travel time because of delay .The issue will only get worse without properly signalized intersections because the roads' infrastructure will not be able to meet the existing demands. The increase in traffic volume will result in congestion at intersections and characterized by slower speeds, longer travel times and a rise in vehicular queuing. Hence, performance evaluation of such intersection is essential and considering different scenario cases, suggestions in such intersections can be very useful for planners.

The study provides an overview of the existing situation of unsignalized intersections in Ekantakuna, located in the ring road in Lalitpur district. The field data were inserted in micro-simulation software known as PTV VISSIM (Planung Transport Verkehr).The data were collected through video-graphic surveying during peak hours of weekdays: Monday to Friday (9 to 11 AM in morning and 4 to 6 PM in evening).The model was then calibrated and validated using field data. The main objective of research is to evaluate the performance of Ekantakuna Intersection and suggest strategies to enhance the performance of the intersection.

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2. Literature Review

A number of research works have been done in regard to the performance evaluation of intersections. Such literatures have been studied and reviewed.

(Abhash Acharya, 2020) calibrated driving behavior parameters in VISSIM that can be used as a reference for this research work. The calibrated driving behavior is shown in Table 1.

Table 1. Calibrated Driving Parameters

SN	Parameters	Calibrated Values
1	Look ahead distance - min	30.00 m
2	Look back distance - min	5.00 m
3	Average Standstill Distance	0.30 m
4	Min headway (front / rear)	0.50 m
5	Additive part of safety distance	0.19
6	Multiplicative part of safety distance	0.71

Pradhananga et al. (2021) studied effectiveness of Reversible Lane Systems (RLS) in Kathmandu Valley taking a case study of Jadibuti – Koteswor section to improve traffic at morning and evening peak hours using travel time and queue length as indicators. A micro –simulation model was developed using VISSIM. The paper revealed that introduction of RLS at the section can reduce the queue lengths by more than 50% and improve the travel times by 11% on average during the morning and evening peak hours.

S. Luitel et al. evaluated two possible scenarios for the intersection: left turn control optimum cycle and optimization of cycle length. The obtained results were compared and evaluated in both peak hours of the day based on Delay time, level of service and queue length. The proposed scenarios were found to improve LOS (Level of Service), decrease in delay t and queue length. But among them by incorporating left turn maneuvers into Signal-controlled intersections rather than allowing free turns, it was more effective to significantly reduce the average delay, the queue length and improve LOS. Based on LOS, Average Delay, and Back of Queue, performance variances were compared.

Shrestha and Marsani conducted an evaluation of the New Baneshwor Intersection using VISSIM. They found that the Level of Service (LOS) was F during morning as well as evening peak hours.They proposed five different alternatives for reducing congestion. Based on the travel time and delay reduction with 5 comparative modeling it shows that the three phases signal planning with flyover by providing U-Turn effectively decreases delay and travel time by 81.92% and 80.1% in morning and evening peak time respectively maintaining Level of Service C, in addition, Maitighar, Tinkune, Old Baneshwor as well as Sankhamul lane is found to have decreased by minimum 60% in the morning and evening which was found to be the most technically efficient to be applied.

For calibration of developed model, GEH (Geoffrey E. Havers) statistics is used. The GEH formula (Wisconsin Department of Transportation, 2002) for hourly flows is

$$GEH = \sqrt{\frac{2(m-c)^2}{m+c}} \qquad \text{(Equation 1)}$$

where,

m = output traffic volume from the simulation model (Vehicle per hour)

and c = input traffic volume (Vehicle per hour)

Table 2. Protocol for VISSIM Simulation, ODOT, 2011

GEH Value	Remarks
<5	Acceptable fit
5 to 10	Model error or poor data
>10	Unacceptable

3. Research Methodology

The research methodology section describes all procedures and strategies applied to our research work. The overall methodological framework for research is presented in figure 1.

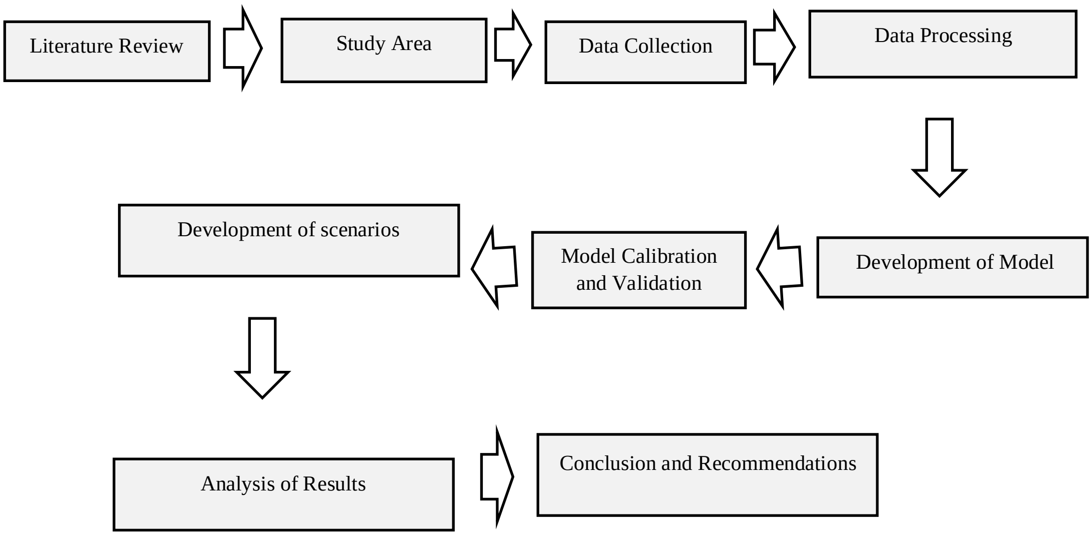

Figure 1. Framework of Research Methodology

3.1 Literature Review

Various papers were studied thoroughly and the information's related to our research work has been taken.

3.2 Study Area

Several literatures have been studied regarding performance evaluation and Ekantakuna intersection has been selected as the study area for the research. The general layout of Ekantakuna intersection is shown in Figure 2.

Figure 2. General layout of Ekantakuna Intersection

3.3 Data Collection

Video cameras were installed to record the footage of traffic flow in Ekantakuna Intersection. For videographic surveying, the pilot survey was carried out during weekdays (Monday to Thursday) and the peak flow was noticed. The time corresponding to peak flow was considered as favorable time for videographic surveying. The video was taken for morning and evening time for four days (Monday, Tuesday, Wednesday and Thursday). 21 The video was taken at two different times in a day – 9 AM to 11 AM in the morning and 4 PM to 6 PM in the evening.

Figure 3. Videographic Surveying using Go-Pro

3.4 Data Processing

The video was played to conduct classified count of vehicles. The vehicle types were considered as per the Nepal Road Standard 2070. The non-motorized carts, rickshaw and tractor have not been considered during classified count of total vehicles since their frequency is relatively low compared to other vehicle types. The traffic volume count at the intersection with respect to Balkhu (Main) is from 9:00 AM to 11:00 AM on Monday is represented in table 3.

Table 3. Traffic volume count of Monday Morning (9 to 11 AM)

Time	Bicycle/ Motorcycle	Car/SUV/Light Van/Pickup, Jeep	Tempo	Mini Truck	Truck, Bus, Minibus
9:00 - 9:15	156	106	0	10	17
9:15 - 9:30	228	121	0	15	9
9:30 - 9:45	243	120	2	19	13
9:45 - 10:00	232	125	0	14	20
10:00 - 10:15	225	134	0	7	19
10:15 - 10:30	261	130	1	11	18
10:30 - 10:45	228	103	0	13	17
10:45 - 11:00	241	112	0	4	7
Total	1814	951	3	93	120

3.5 Development of Model

PTV VISSIM was used for the development of the model. The data used as input for VISSIM for generating simulation model were as follows:

- Vehicle Types
- Classified Vehicle Count
- Directional movement of vehicles
- Relative flows for vehicle routing
- Stop time for vehicles

The vehicle input in VISSIM is given as vehicle per hour (vph).The model developed in VISSIM is shown in figure 4.

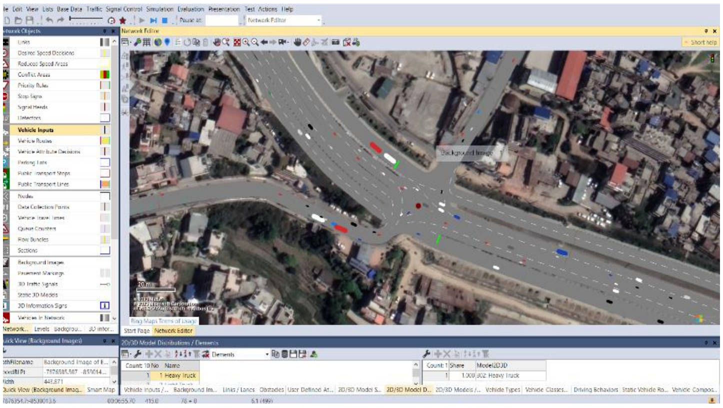

Figure 4. Development of model in VISSIM

3.5 Model Calibration and Validation

Calibration is the process of comparing output of PTV VISSIM with the real-world data by changing traffic flow parameters inside the model in such a way that the model realistically represents the real field. For calibration of model using traffic volumes, average data's of Monday and Tuesday was used. The relationship between simulated volume and field volume is represented in figure 5. For calibration of model, Traffic volume data of Monday and Tuesday was used. The GEH value was calculated using equation 1 and the values obtained was obtained less than five.

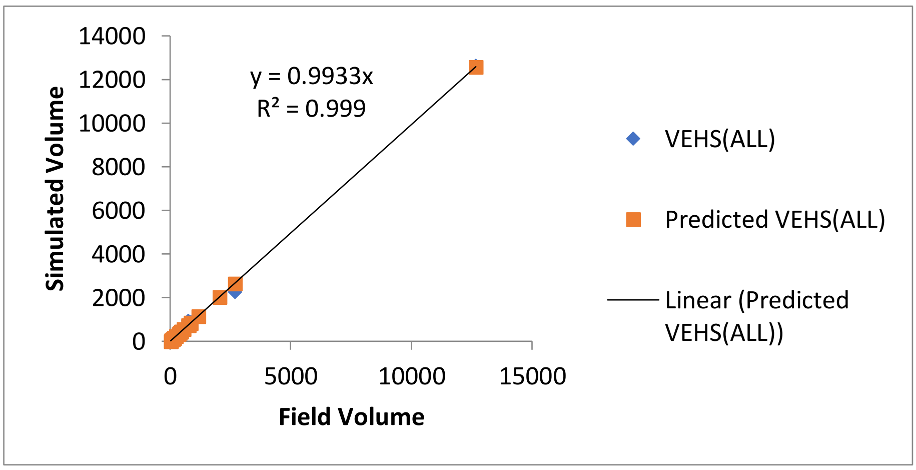

Figure 5. Calibration of VISSIM Model

The figure 5 shows that the simulated volume in VISSIM equals to 0.9933 times the field volume. Hence, once the field volume is known, simulated VISSIM volume can be easily determined. Moreover, The R^2 value was found to be 0.999 which indicates 99.9 percent of variance of the field data is explained by the variance of the VISSIM output.

Validation is the process of determination that a model is an accurate representation of the real system. For validation of model the traffic volume data of Wednesday was used.

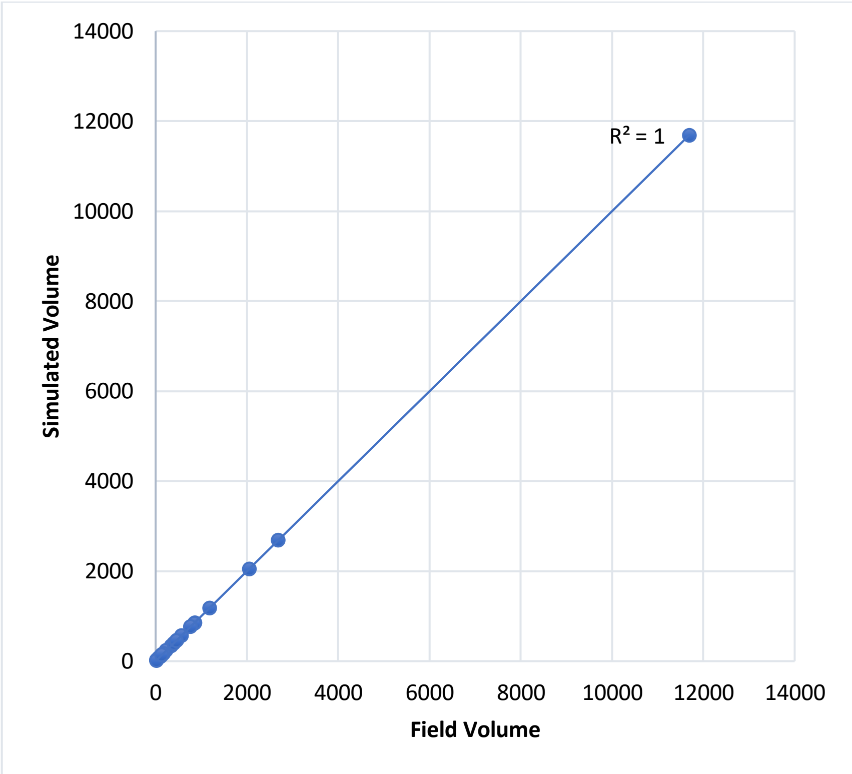

Figure 6. Validation of VISSIM Model

The figure 6 shows that R^2 value in validation was obtained to be one which indicates strong correlation between field volume and simulated volume.

The overall strategy chosen to integrate the different elements in VISSIM is shown in figure 7.

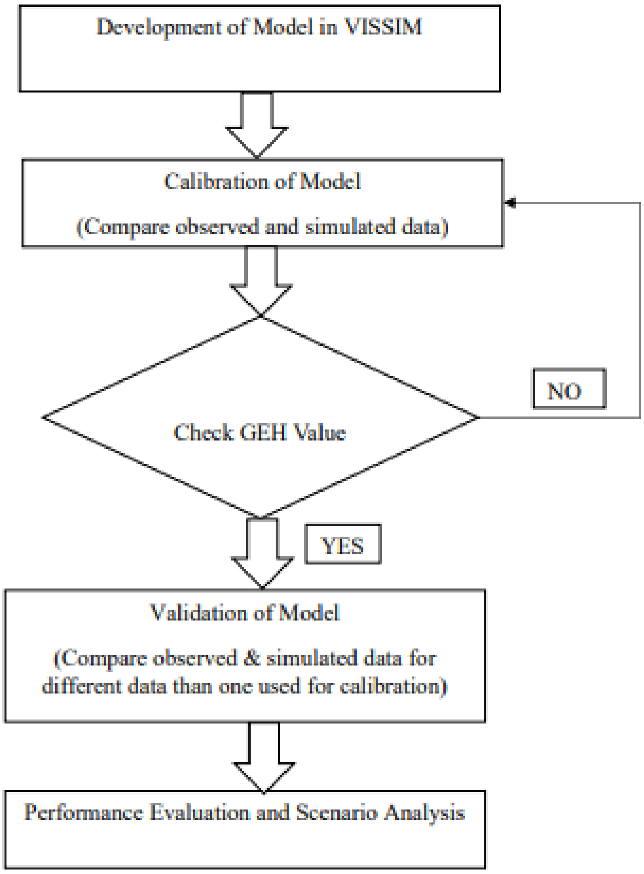

Figure 7. Strategy Process in VISSIM

3.6 Development of Scenarios

3.6.1 Scenario 1

This scenario includes the restriction of vehicles from service lanes to main lanes. Thus this allows the movement from

- Balkhu(service) to Satdobato(service) and Jawalakhel lanes
- Satdobato(service) to Balkhu(service) and Bhaisepati lanes

3.6.2 Scenario 2

This scenario analysis includes the restriction of right turning vehicles from main lanes. This restricts the motion of vehicles from

- Balkhu(Main) to Bhaisepati
- Satdobato(Main) to Jawalakhel

3.6.3 Scenario 3

This scenario analysis includes the dedicated motorcycle and cars in main lanes and dedicated service lanes to other vehicles.

3.7 Analysis of Results

The comparative analysis of different scenarios in terms of delay and queue length is represented in following graphs.

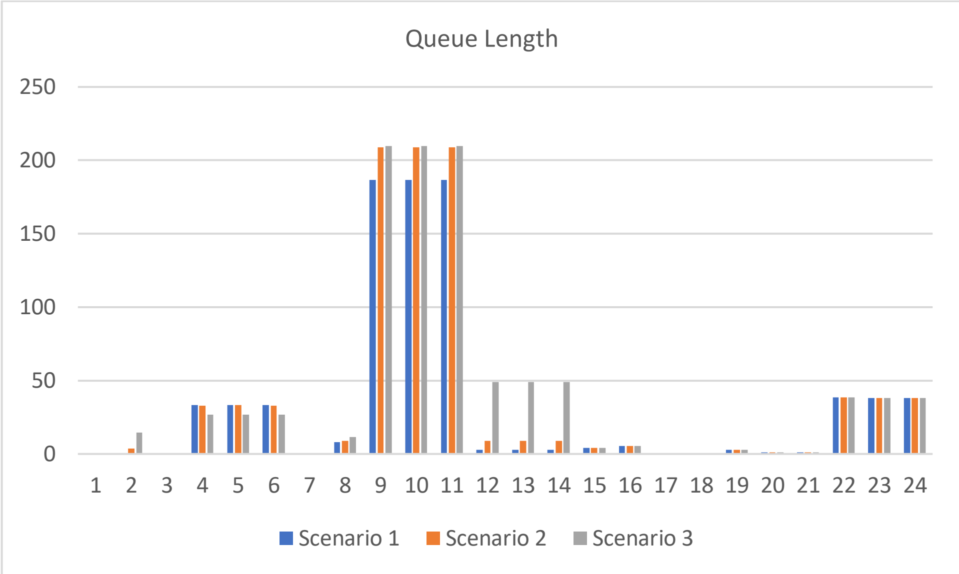

Figure 8. Comparative analysis of Queue Length in different scenarios

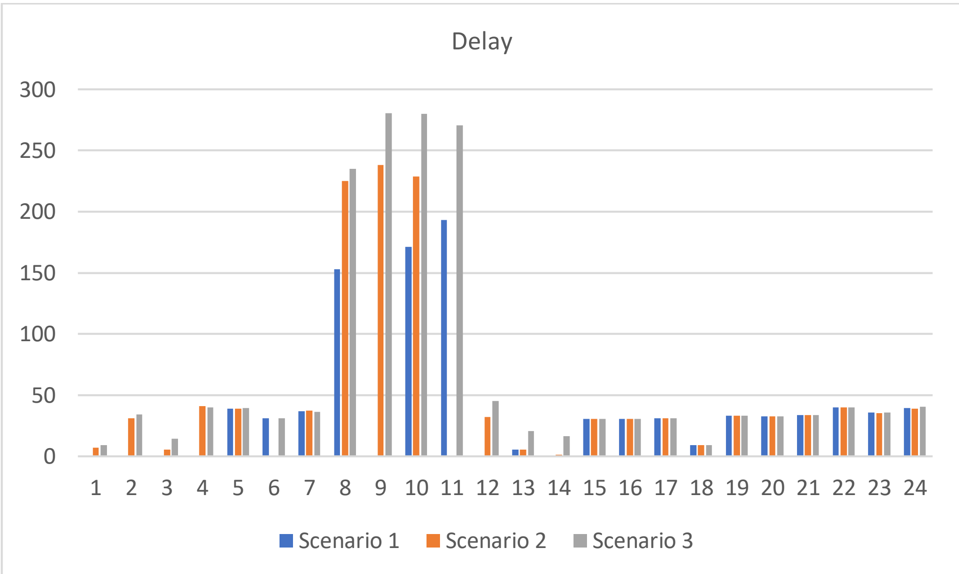

Figure 9. Comparative analysis of Vehicular Delay in different scenarios

The movement of traffic is assigned as shown in table 4.

Table 4. Traffic Movement and Route Name

Movement of Traffic	Route Name
Route 1	Balkhu(Service) Satdobato (Service)
Route 2	Balkhu(Service) to Satdobato (Main)
Route 3	Balkhu(Service) to Jawalakhel
Route 4	Balkhu (Main) to Satdobato (Service)

Route 5	Balkhu (Main) to Satdobato (Main)
Route 6	Balkhu (Main) to Bhaisepati
Route 7	Balkhu (Main) to Jawalakhel
Route 8	Satdobato(Main) to Balkhu(Main)
Route 9	Satdobato(Main) to Balkhu (Service)
Route 10	Satdobato(Main) to Bhaisepati
Route 11	Satdobato(Main) to Jawalakhel
Route 12	Satdobato (Service) to Balkhu(Main)
Route 13	Satdobato (Service) to Balkhu(Service)
Route 14	Satdobato (Service) to Bhaisepati
Route 15	Bhaisepati to Satdobato (Service)
Route 16	Bhaisepati to Satdobato (Main)
Route 17	Bhaisepati to Balkhu(Main)
Route 18	Bhaisepati to Balkhu(Service)
Route 19	Bhaisepati to Jawalakhel
Route 20	Jawalakhel to Satdobato (Service)
Route 21	Jawalakhel to Satdobato (Main)
Route 22	Jawalakhel to Balkhu(Main)
Route 23	Jawalakhel to Balkhu(Service)
Route 24	Jawalakhel to Bhaisepati

3.8 Conclusion and Recommendations

The analysis shows that the queue length and delay with cycle time 150 seconds imposed in scenario 1 decreases with respect to base case by 67.883% and 77.12% respectively. The scenario 3 was found to be ineffective in intersection as it has no significant impact in queue length and delay. However, the cycle length must be changed for other days and more scenario analysis should be done in order to suggest improvements in that intersection. Following tasks are recommended for further studies:

- Study of pedestrian-vehicle interaction taking pedestrian modelling into account.
- It is suggested to forecast the future traffic volumes since the vehicular volumes considered in study were based on the present data.

4. Limitations

The limitations of research has been presented as follows:

- The study does not account for pedestrians, only vehicles were considered.
- The interaction between vehicle and pedestrian has not been considered.

5. Acknowledgements

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