Performance Analysis of Road Intersections under Heterogeneous Traffic Conditions: A Review

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ABSTRACT

The rapid growth of traffic in most countries exceeds the current transport system's threshold level and requires a more efficient and practical approach to be addressed. As the renovation of urban transportation infrastructure is not feasible, alternatives to the problem are urgently needed. This paper addresses the Performance Analysis of Road Intersections under Heterogeneous Traffic Conditions. At whatever point two or significantly more streets converge or cross, users of these streets should change their mobility to prevent a collision. This adjustment can take the form of a speed drop or a change in their motion pattern. In several regions of the world, traffic is a mixture of large distribution of various vehicle kinds. Hence users of a signalized crossroads in vehicles are a heterogeneous mix. The current study has involves review based on 5 selected papers analysing findings and drawing conclusion along with posing future questions.

Keywords--- Traffic, Road Intersection, UAV

I. INTRODUCTION

There are a number of links and intersections within an urban transport network. The connections are depicted by the absorption capacity of vehicles and by turning ratios on each intersection stop lines, while intersections combine with stages (or phases) built up of red and green signals with integrated traffic flows (Zhang & Su, 2021). The particular region wherein the multiple highways combine or cross, including the roadside design characteristics that permit orderly traffic movements in that area (Jensupakarn & Kanitpong, 2018). That segment of any one of the roadways radiating from an intersection that is outside of the region of the intersection proper called an intersection leg (Mussone et al., 2017). The driver of an approaching vehicle must execute particular traffic manoeuvres in the intersection area depending on the direction of the junction leg in which he or she wishes to move (Mussone et al., 2017). A mixed or heterogeneous traffic flow has a variety of vehicles, both motorized and non-motorized. It's crucial to comprehend the traffic flow itself to fully comprehend the meaning of mixed traffic (Nazia, 2019). In the field of transportation engineering, traffic system modelling is a critical subject. The macroscopic modelling, mesoscopic modelling, and microscopic modelling are 3 kinds of modelling techniques commonly used in mobility engineering based on diverse accuracies and needs. It uses fluid representation for traffic flows for macroscopic modelling, which is an aggregated technique to monitor traffic movement on a tempo spatial discretization basis. Individual vehicle models are used to depict vehicle motions in mesoscopic modelling, but traffic flow computations are used to predict traffic dynamics. It displays vehicle dynamics and traveller behaviour in detail for microscopic modelling and determines traffic complexities based on interactions and motions using individual vehicle models. Macroscopic modelling is beneficial from a strategic standpoint due to its computational efficiency (Zhang & Su, 2021). In addition to causing congestion and accidents, the existence of cracks, holes and routing also leads to reductions in vehicle speed and serious discomfort for the user. In such cases, the quality of the road surface may take precedence over time. The same applies to poor footpaths. Footbridges that are poorly maintained and long cycling times at signalled crossings lead to a pedestrian signal failure. This would cause major discomfort for motor vehicle users (Othayoth et al., 2020). No up-to-date analysis or understanding of the trends in road accidents in India as well as its regions over time and the level of those trends in achieving the SDG target is available, it is necessary to promote specific government action to reduce road accidents. To address this knowledge gap, Dandona et al. (2020) reported time trends and death differences in Indian States due to road injury from 1990 to 2017, separated By road user category, gender and age, and comparing the trend in the individual countries with the SDG target. Singh & Kumar (2020) believed side friction is one of the main traffic disruptive factors. As per them, Lateral friction means the activities like road parking, traffic jamming that can be seen on the car or in cargo, resulting in loss of efficient traffic width, which causes problems with normal traffic jams. In addition to these static activities, various events, such as bus stops, false driving and roadside pedestrians also hinder vehicles. Ultimately, all these side friction elements reduce vehicle speed, and thereby also reduce capacity and level of service (LOS). In a heterogeneous traffic condition, the situation is even worse especially in a country like India.
Ahmed et al. (2020) conducted a deep research of the videos recorded with a UAV at a selected signalised intersection in Karachi in their study of heterogeneous traffic conditions. Their paper deals with the following:

- Dynamics of traffic flow are observed in green time.
- The phenomenon of queue jumping motorcycles is detected and its impact on saturation and travel time is investigated.
- Vissim behaviour parameters are calibrated with the help of actual UAV field data.
- Vissim's weakness is highlighted in motorcycle queue jumping and its effects on simulation accuracy are quantified.

**Figure 1: Road intersection**

**II. METHODOLOGY**

To review the performance analysis of road intersections under heterogeneous traffic conditions we will be looking at some of the recent research works. First of all we will collect a few studies that are related to our field of research, there upon we will be collecting the relevant information and analyse the data which involves looking at the recent traffic trends, road infrastructure, stats of road accidents. In addition to it we will be looking at the key problems and identify possible solutions for the same. At the end of the paper conclusions and future research scopes will be discussed.

**III. DATA ANALYSIS AND PROBLEM FINDING**

In 2017, there were 218,876 deaths in India from road injuries (95 percent UI 201,734 to 231,141), and age of 17-2 deaths (15.7 to 18.1) for every 100,000 population, which in men was considerably higher (25–7 deaths per 100 000 [23.5 to 27.4]) compared to women (8.5 deaths [7.2 to 9.1] per 100,000). Deaths from traffic accidents in India rose by 5.8% between 1990 and 2017 (43.6 to 74.7), while the age-normalized demise rate diminished marginally by 9.2% (0.6 to 18.3). In 2017, 76,729 (35.1 per cent) of all road injury deaths, 67,524 (30.9 per cent), 57,802 of motor vehicle occupants (26.4 per cent) and 15,324 of cyclists (7.0 per cent) accounted for pedestrians. India's road injury rates were higher for motorcyclists compared to the world average. The road injury was the biggest cause of mortality in India in 2017 and the second most common cause in this age group for both genders. In 2017, the overall age-standard mortality rate for road accidents was up to 2.6 times nationally. The percentage change between 1990 and 2017 in age-standardized death rates among the states was significant, trend to range from a reduction of 38.2 percent (22.3 to 51.7) in Delhi to an increase of 17.0 percent in Odisha (0.6 to 34.7). Should trends continue until 2017, no country in India or India as a whole might meet the 2020 SDG objective in 2020 or even 2030 (Dandona et al., 2020). From 1990 to 2017 the overall mortality rate for road accidents dropped substantially, but only marginally in India, with India increasing the share of world deaths due to road accidents during that period. Bikers and bikers in India are fatally fatal compared to the world average. India has seen an increased proportion of deaths from road damage and traffic accidents are the foremost reason of death in young adult men. There are significant variations in death rates for traffic accidents between India. The trends for various road users, demographic groups and sex presented here over time in India for each state can inform national road injury prevention and traffic injury monitoring policies. Dandona et al. (2020) significantly found that if there is a continued trend up to 2017, India and its States are unlikely to meet the SDG goal of halving the death rate from road injuries by...
2015-2020 or even 2030. Since LOS is a marker of customer satisfaction, it is essential for the perspectives of users. Traffic is a mixture of many different types of vehicles; hence, users of a signalised intersection are a heterogeneous mix (Othayoth et al., 2020). In his study, Othayoth et al. (2020) tried to assess the impact of the vehicle class on the perceived LoS at signalled crossings, exempting the perceptions from signalling junctions of walkers and non-motorized users. The findings show that perceived LOS quickly decreases as perceived time for waiting increases the amount of heavy vehicles, foot and obstacles. The perceived LOS is affected positively by road surface quality, clear/legible signs, road markings, traffic signals, visibility and aesthetics. The perceived LOS at the reported intersection does not affect socio-economic variables (gender, age) and frequency of journey by analysis.

According to Singh & Kumar (2020), side frictions such as on-street parking, roadside encroachment on the sides of the carriageway, and occasionally within the carriageway all result in a loss of effective carriageway width, obstructing normal traffic flow. Therefore, side frictions constitute a significant cause of reduced LOS.

Zhang & Su (2021) analysed the heterogeneous traffic network using a microscopic model as well as a signalised and non-signalised traffic network. Logical constraints involved the development of the amount of traffic on every link and the dynamics of exit at each intersection. Their study found that the development of new urban areas in the developing nations and the reconstruction of established city areas in advanced countries involved both the industrial agglomeration and urbanisation, introducing numerous unmarked intersections. As a result, we require a systematic approach to determining which intersections need signal control to guarantee better traffic guideline.

Ahmed et al. (2020) presented an in-depth microscopic analysis of heterogeneous and undisciplined traffic at the signalized traffic. In their study, they mainly focused upon the behaviour of motorbikes in comparison to other vehicles. They found that the flow of motorcycles is most significant in the first just several (1–5) secs of green time and then decreases significantly. On the other hand, the stream of vehicles and different modes is lower during the initial not many (1–5) seconds and increments fundamentally after that. The top is generally traffic stream happens toward the green time at the beginning of vehicles firmly pressed together. During the red stage, vehicles will, in the general group together to involve accessible holes and continue quickly when the sign becomes green. This outcome in an essentially expanded number of paths moving toward a signalized crossing point, bringing about an expanded stream when the line exhausts toward the beginning of the green time.

### Table 1: Summary of the selected review papers

| Author          | Year | Findings                                                                 |
|-----------------|------|--------------------------------------------------------------------------|
| Dandona et al   | 2020 | Wide variations were observed in the rate change in age-normalized demise rates for street wounds from 1990 to 2017, going from a 38·2% (22·3 to 51·7) decrease in Delhi to an increment of 17·0% (0·6 to 34·7) in Odisha. In the event that the patterns assessed to proceed until 2017, no state in India or India in general would accomplish the 2020 or 2030 SDG target. |
| Othayoth et al  | 2020 | The discoveries feature the need to remember subjective boundaries for LOS examination notwithstanding regular assistance measure (for example delay). |
| Singh & Kumar   | 2020 | Side friction, such as road parking, carriageway siding and sometimes inside the carriageway, all lead to the loss of effective carriageway width, obstructing normal traffic flow. Side frictions are a major cause of reduced LOS. |
| Zhang &Su       | 2021 | The need of signalised intersection is a must and should be planned systematically. |
| Ahmed et al     | 2020 | Motorbikes are one of the main cause of vehicle clustering during the green signal. Bikers tend to jump off the queue in order to cross traffic signal first. |
By looking at the above literature we are able to analyse the performance of road intersections under heterogeneous traffic mix. Due to unregulated traffic system and lack of proper signalled intersections, multiple problems can be faced that includes:-

- **India has one of the world's worst side friction roads.** Side friction results in loss of effective travel width and impacts urban arterial vehicle speed, capacity and LOS. The problem is especially in developing countries like India, where there is mixed traffic.
- **From 1990 to 2017, the overall mortality rate for road injuries decreased considerably but in India only slightly.** Motorcyclists and cyclists in India are fatally fatal compared to the world average. Road injuries are India’s leading cause of death for young adult men.
- **The flow of motorcycles is the highest in 1-5 seconds of green weather and after the first few seconds of green light it is substantial lower.** On the other hand, in the first 1-5 seconds the flow of cars as well as other modes is lower and after 5 seconds it is more important. The highest average traffic flow is observed if vehicles are queued closely together.
- **The socio-economic factors (gender, age) and travel frequency do not significantly affect users at the indicated intersection.** However, the quality of the pavement, clear/readable signposts and signs, visibility of queues and aesthetic signals are good for LOS.
- **The best performances are obtained for the non-signalled traffic network, i.e. unnecessary traffic delays may be introduced to the entire traffic system.** The introduction of traffic signals reduces traffic delays in the systems for medium and high traffic cases. If the traffic jam is not that high.

### IV. SOLUTIONS

Poor intersections and roadways, especially in the city's older neighbourhoods, can be hazardous. Travelling on roads without reflectors and markings can rapidly become dangerous, especially if the road is built without safety edges to prevent vehicles from overcorrecting the steering wheel when driving off the narrow route. Even when a motorist operates at the authorised speed limit, speed bumps can cause considerable problems for drivers in regions with no signage to inform the driver enough time to avoid a significant danger. We know a lot about the actions involved, such as the need for solid rules and guidelines and enforcement of traffic legislation, better design of roads and vehicles, and multi-sectoral approach to dealing with road injury. 1,2,8,38,73 Indian countries must promote such approaches and advance evidential interventions to improve road safety, enhance the involvement of the health system in the management of road injuries and improve the availability of actionable quality data. Dandona et al. (2020) findings give the national, state and other governmental stakeholders of the country the opportunity of planning better-targeted interventions to achieve the SDG target by 2030. The side friction is a major problem, not only causing a loss of efficient waggon width but also affecting the speed and capacity of urban arteries and LOS. One peculiar thing regarding side friction is that in developing countries such as India mainly there is mixed traffic. In order to solve the problem of the side friction, especially in city business areas, the following recommendations may be considered by the municipal authorities and practitioners. On-street parking was found in most locations to be an important issue, and the govt may be thinking of building multi-level parking lots and double-speed car parks by using vacant land in the commercial areas of cities. Effective enforcement by traffic police should not ensure illegal parking and traffic on the opposite side (Singh & Kumar, 2021). Pre-time and evolutionary traffic signals can also be designed, operated and carried out if the system receives correct info on the dynamic flow in green time. Moreover, it is necessary to monitor the behaviour of motorcyclists more effectively and not to jump quickly in the signalled traffic under heterogeneous transport conditions (Ahmed et al., 2020). However, Zhang & Su (2021) believed that the heavy traffic delay and rush can be avoided by reducing the no. of unnecessary traffic signals for low to medium traffic, though proper traffic check posts are needed to regulate heavy traffic under heterogeneous traffic conditions. According to Othayoth et al. (2020) inappropriate infrastructure potholes and cracks on the roads are leading causes of traffic disturbance. In addition to it, they believed users are an integral part of any transport system. The inclusion of user perceptions in LOS would provide a more practical and theoretical basis for designing and operating signalled intersections. An understanding of different factors and their impact on the perception of users would also enhance the probability of project success by specific tasks investment strategies.

### V. CONCLUSION AND FURTHER RESEARCH SCOPE

Road intersections under heterogeneous traffic mix are a matter of concern as rapid accidents, and road injuries are reported in India. With the help of this review paper, we came to know about the current scenario of Indian road intersections and their performance under heterogeneous traffic mix. There are several causes behind the unsatisfactory performance of these intersections: improper channelization and maintenance, lack of signalization and traffic control, less effective law enforcement, inadequate infrastructure, and side frictions are some of the leading causes behind...
the poor performance of mobility channels. However, regular maintenance and implementation of policies and road safety interventions can reduce the risk of accidents and waiting time of vehicles.

As far as further research is concerned, it may do it by combining the perceptions of walkers and non-motorized users. Or it can be based on other models, such as how intelligent vehicles can behave in mixed traffic systems or the future of driverless cars in our country’s traffic system.

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