Assessing the Severity at Unsignalized Intersection under Heterogeneous Traffic Conditions

[1]Anamika Yadav, [1]*Ankit Kathuria
*Anamika Yadav
[1]anamika251295@gmail.com-mail, Indian Institute of Technology Jammu, India
[2] Indian Institute of Technology Jammu, India

Introduction

Road safety poses a significant global challenge, particularly in developing and under-developed countries, due to its non-lane-based and intricate heterogeneous traffic conditions. According to World Health Organization, 90% of the total road accidents occur in developing and underdeveloped nations (WHO, 2018). In India, almost 20.6% of total accidents where people are killed or injured occur at intersection (MORTH, 2021). Therefore, it is important to evaluate the safety of unsignalized intersections so that measures can be taken to improve their safety.

Intersections are critical road geometry; unsignalized intersections experience a higher frequency of accidents compared to their controlled counterparts (MORTH, 2021). A large number of studies on vehicle-vehicle (V-V) interaction have identified the factors influencing the safety and risks at unsignalized intersections (Adavikottu and Velaga, 2023; Paul et al., 2022). This heightened risk can be attributed to the inherent nature of intersections, where traffic converges, and the absence of control measures leaves unsignalized intersections more vulnerable to collisions. The factors influencing the risk can be improved by understanding the vehicle-vehicle interaction and the various conflicts generated on the unsignalized intersection. To understand the interaction of vehicles, SSMs like time to collision (TTC) are employed, which provides an overview of the risk associated with the interacting vehicle. The speed of vehicles at the intersection is a crucial factor taken into account, as it has been identified as the primary cause behind crashes resulting in fatalities and severe injuries, underscoring the critical role of speed management in ensuring intersection safety (MORTH, 2021).

Considering the above, the present study aims to investigate the safety at three-arm unsignalized intersections under non-lane based heterogeneous traffic conditions. TTC is employed to analyse different V-V interactions, and the maximum speed of the interacting vehicle (Vmax) is utilized to understand the severity of interactions. The study investigates the most severe conflicts generated at unsignalized intersections. To do so, different interactions using TTC and speed are classified into three classes (severe, mild and safe interaction). The tool used for classifying the interaction is relevance vector machine (RVM). In order to comprehensively examine safety, the study aims to achieve the following objectives:

- Firstly, the study first compares the speeds of different vehicles at unsignalized intersection
- Secondly, the study examines the various V-V interactions and the types of conflicts generated at the intersection
- Finally, severity dimensions are proposed to compare the severity of each type of conflict

The findings of the present study will be helpful for the researchers and the policymakers to understand the severity and risks of different conflicts at unsignalized intersections. Further, the findings of the present study can be used for developing strategies and implementing policies to improve safety at unsignalized intersections.

Methodology

To examine the safety at three-arm unsignalized intersections, the present study follows a detailed methodology as shown in the Figure 1 below.

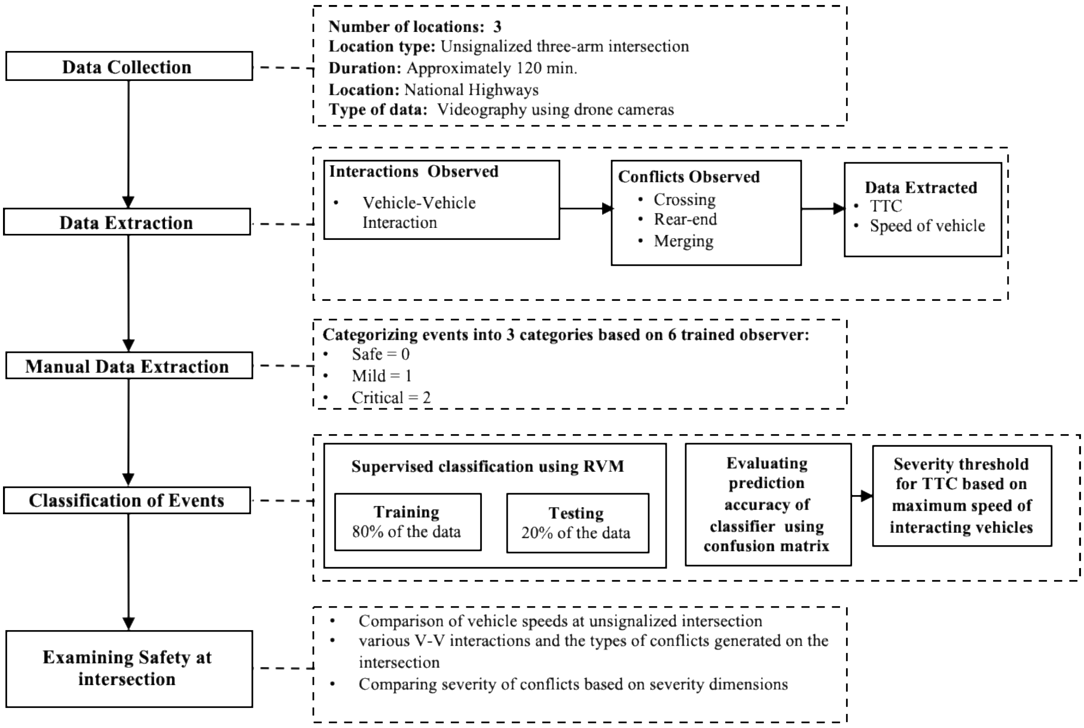

Figure 1: Methodology adopted in the present study

Results

Vehicle speeds at three-arm unsignalized intersection

For the safety analysis of three-arm unsignalized intersection, the focus is on determining the varying speeds at which different vehicles traverse the intersection. As depicted in Figure 2, a comparison of speeds for different vehicle categories is shown. One-way ANOVA test was performed to check if there exists a significant difference between the speed of other different vehicle categories. One-way ANOVA test reveals that there exists a significant difference in the speed of other vehicle categories ($F=484.04$, $p<0.001$). It can be inferred from the graph that the cars (M= 18.02, S.D =4.37) maintain higher speed as compared to buses (M=15.67, S.D =5.06), HCV (M= 12.66, S.D = 4.03), PTW (M= 11.49, S.D = 3.66), and 3-W (M= 10.11, 3.17).

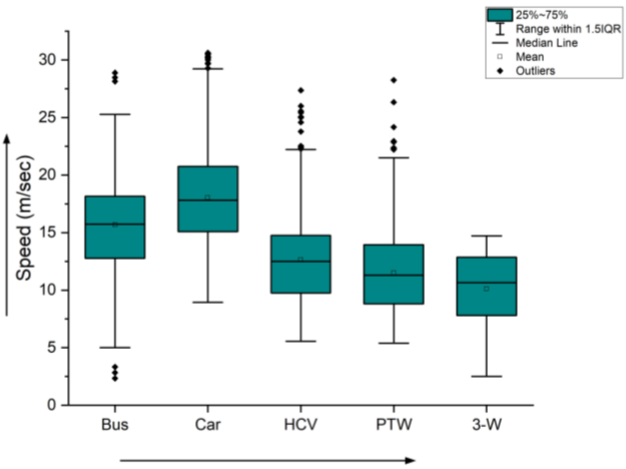

Figure 2: Vehicle speed profiles at three-arm unsignalized intersection

Indicator-Based Severity Classification

The current study investigates the use of the RVM classification model to classify severity levels as shown in Figure 3(a), Figure 3(b) and Figure 3(c). The developed model considers two dependent variables, namely maximum speed and TTC, while the independent variable is the manual ratings provided by trained observers. The entire dataset was divided into random subsets where 20% dataset was used for testing the model fit, and 80% dataset was used to train the model. Overall the RVM classification model correctly predicted 85.04% and 87.34%, and 88.62% of the data for crossing, merging and rear-end classification, respectively.

When considering the crossing conflict, critical conflicts were 44.88%, mild conflicts were 28.74%, and safe conflicts were 26.3%, whereas for merging conflicts, critical conflicts were 55.11%, mild conflicts were 26.67%, and safe conflicts were 18.22%. Further, in the case of rear-end conflicts, critical conflicts were 19.43%, mild conflicts were 70.2%, and safe conflicts were 10.37%.

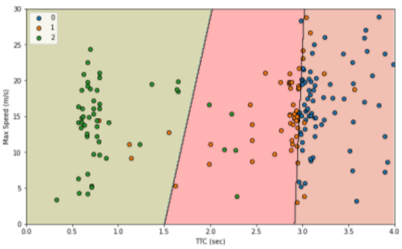

Figure 3(a): Crossing conflicts

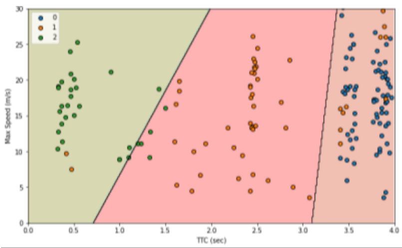

Figure 3(b): Merging conflicts

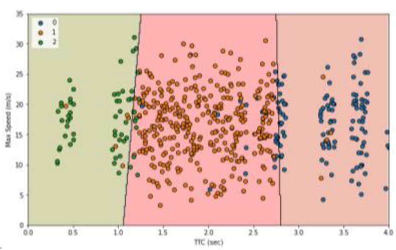

Figure 3(c): Rear-end conflicts

Conclusion

The results of the study indicate that the majority of the conflicts observed at the intersections are rear-end conflicts, accounting for 61.92% of the total conflicts; crossing conflicts represent 20.12% of the conflicts, while merging conflicts constitute 17.96% of the total conflicts. However, the present study highlights that more frequency of conflict does not directly correlate with more critical conflicts observed at the intersection. The results of classification highlight that crossing conflict has a higher severity dimension for TTC (1.5 sec to 2 sec for speeds ranging from 0 to 30 m/sec) as compared to rear-end or merging conflicts resulting in more severe conflicts at higher threshold.