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Original Article

Monte Carlo Sumo-Based Modelling for Accident Prevention System

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Abstract - Accident prevention encompasses all actions done to preserve lives, limit property damage, avoid injury, reduce treatment and compensation costs, diminish the severity of harm, and avoid loss of productive time and morale. Road rage is a serious traffic safety issue since it can cause irrational conduct and needless risk-taking. Also, excessive acceleration and braking as a result of bad traffic flow increase fuel consumption. A novel MCS-MAPS protocol is described in this paper that overcomes these challenges. Based on safety considerations or vehicle traffic, this paper examines the effect autonomous vehicles will have on heterogeneous traffic. Accident prevention systems are used in this study to characterize the presence of many vehicle kinds; both manually operated and autonomous. The method aims to keep vehicles lowering death out of highway traffic accidents and injury rates. MATLAB is used to evaluate the accident data set and extract all essential parameters. According to these findings, automated vehicles have the ability to increase traffic flow by accelerating the mean road speed, which will shorten travel times while also reducing the frequency of accidents. Nonetheless, the average speed must be kept in check, or conflicts will rise drastically. A high vehicle flow rate causes conflicts to occur more frequently as penetration rates rise.

Keywords – Monte Carlo Sumo-based Modelling for Accident Prevention System [MCS-MAPS], Mixed traffic environment, Vehicle flow rate, Autonomous vehicles, Road Accident Sampling System of India.

1. Introduction

The Prevention via Design strategy prioritizes reducing safety threats, and the top of the control hierarchy attempts to address safe operation throughout the project design stage. Safety experts still face challenges in enhancing system safety by lowering accidents in enhancing system safety by lowering accidents [1-3]. To give a clear description of the occurrence and progression of the event, accident causation models define the cause, process, and effects of an accident.[4] The numerous accident causes and flaws in the production process can be easily identified using an accident cause model to analyze an accident. This is crucial for the establishment of post-accident accountability and the averting of additional mishaps.[5] It is crucial to clarify and elaborate on the development history of accident causation models because it is the most significant theoretical underpinning and research technique in safety science.

Throughout the last century, knowledge about various accidents and injuries has grown, and research into accident causes and preventative regulations has taken place. As a result, there has been considerable study and research on the causes, mechanisms, and prevention of accidents, and numerous theories and accident models

have been proposed. Car-following and lane-changing manoeuvres are two of the most common driving techniques that take place in traffic and, as such, should be taken into account when researching heterogeneous traffic.[6] As well as related vehicle dynamic characteristics like acceleration, speed, and location, the previous vehicles have a major impact on the driving technique of the vehicle. Traffic flow and traffic safety are also impacted by these dynamic vehicle factors [6-10]. Small gaps between vehicles and faster-moving vehicles result in a quicker response time in an emergency, which is undesirable from a safety standpoint. Yet, a close space between vehicles and a fast vehicle speed is advantageous from the traffic flow standpoint.[7]

This is done to reduce the use of road space by encouraging faster-moving cars and shorter journey times, respectively. Along with the vehicle in front of it, the vehicles in the adjacent lane also influence how a driver behaves during a lane-change movement. In order to evaluate whether a lane change is necessary, drivers frequently use the front gap to the car in front of them and the leading gap to the vehicle in the next line. According to NHTSA, accidents involving lane-changing manoeuvres result in about 60,000 yearly injuries in the USA. To overcome these challenges MCS-MAPS simulation protocol has been proposed.

The following is the proposed method's major contribution:

- In this section, a novel Monte Carlo Sumo-based Modelling for Accident Prevention System [MCS-MAPS] protocol has been proposed.
- This paper aims to inspect the effects of autonomous vehicles on accident prevention in terms of safety or vehicle traffic.
- Accident prevention is used in this study to characterize the presence of many vehicles; both manually operated and autonomous.
- The simulation findings demonstrated that when the penetration rate of autonomous vehicles increases for the same mean road speed, the number of accidents and conflicts tends to decrease.
- Also, the data demonstrated that, for a given vehicle flow rate, the mean road speed increased as the penetration rate of autonomous vehicles increased.
- When the vehicle flow rate increases, so does the difference in mean road speed. When vehicle flow rates are high, this results in an increase in the number of conflicts as the penetration rate rises.
- According to these findings, automated vehicles have the ability to increase accident flow by accelerating the mean road speed, which will shorten travel times while also reducing the frequency of accidents. Nonetheless, the average speed must be kept in check, or conflicts will rise drastically.

The remainder of this research is organized as follows. Section 2 explains the literature review. Section 3 presented the proposed MCS-MAPS simulation, along with an explanation and the associated methodology. Section 4 contains the performance results and their analysis. Conclusions are included in Section 5.

2. Literature Review

In 2019 Kashevnik, A., et al. [8] developed a method for recommending and monitoring drivers using a personal smartphone based on analysis of discovered unsafe driving behavior for accident prevention by applying built-in sensors to smartphones' cameras and driver behaviour monitoring. A methodology includes detection, risky state classification, and a reference model. Tests with ten volunteers were conducted on the Android phone system developed by the company.

In 2019 Matcha, BN., et al. [9] developed a Methodology for Simulating Mixed Traffic Conditions. Traffic jams and car accidents are the two issues that are most prevalent and frequently discussed in urban areas. A nation's economy is significantly impacted when there are a lot of traffic jams and accidents on the roads. Due to this, examination of both longitudinal and continuous lateral vehicle behaviour is necessary. It might be difficult to get

sufficient amounts of field parameter data, especially for the mixed or no-lane traffic flow, enabling calibration and verification in microscopic simulation.

In 2019 Fan, J., et al [10] proposed an integrated technique to assess the influence of one-way traffic management on various vehicle exhaust emissions. Although one-way traffic management is a well-known approach for improving traffic efficiency and safety, its impacts on various traffic emissions are still unknown. The findings contribute to scientific traffic management by providing light on the secondary effects of one-way traffic management on traffic emissions at intersections, network levels, and road segments. This advances the Sustainability of the transportation system.

In 2022 Haddad, T.A., et al. [11] proposed a multi-intersection traffic light regulation using a deep reinforcement learning-based cooperative strategy. Modelling the problem as a multi-agent reinforcement learning system, where each agent learns to control a junction by choosing the optimum course of action based on data about the local lane state. Additionally, the system can continuously learn from interactions with the environment and enhance performance, particularly when traffic is congested, due to the cooperation of several trained DRL-based controllers.

In 2022 Abdeen, M.A., et al. [12] Proposed an Evaluation of the Effects of Market Penetration of Autonomous Cars during the phase of autonomous vehicle transition on a Complex Urban Highway. In order to investigate the mobility and safety implications of autonomous vehicles (AVs), this project focuses on simulation modelling and designing an al-Madinah real-world traffic microsimulation model based on traffic microsimulation for Saudi Arabia. Last but not least, we believe that successfully integrating cutting-edge and unique technology will aid decision-makers in the long run in their pursuit of sustainable development.

In 2022 Azam M. et al. [13] Proposed a Mixed-traffic Environment with Autonomous Cars; A bibliographic evaluation. Numerous scholars have been working on developing a sustainable urban transportation system that considers the safety aspects and operation of mixed traffic throughout the evolution phase. However, mapping an overview of this field of study has received relatively little scholarly attention. This article offers a wealth of future directions for those wishing to make an effort in the field of self-sufficient vehicles in mixed-traffic situations. Also, the study identified present patterns and probable upcoming hotspots in the field of self-sufficient vehicles in mixed traffic.

In 2022 Weigl K. et al. [14] proposed a mixed-methods strategy and conducted a cross-sectional survey study to gather quantitative and qualitative data. We concentrated on gathering a sample of 725 respondents, whose ages ranged from 18 to 96, which was nearly balanced in age and gender. It was discovered that at SAE levels L5 and L3, AVs are anticipated to be accepted and used in around 20 and 10 years, respectively. If the producers and decision-makers are serious about making AVs, a sociological revolution and widespread technology, they must consider these results.

In 2022 Chen Y. et al. [15] proposed a dearth of a systematic and thorough analysis of adoption attitudes towards AVs that consider several interrelated aspects, such as the transition to AVs and changes in the road traffic environment.

To further understand, the study primarily looks into autonomous technology, public perceptions concerning AVs and changes in the road traffic environment, uncertainties, the impact of policies, and findings from AV adoption modelling methodologies. It highlights important issues and future approaches for the analysis of AV impacts.

3. Proposed Methodology

In this section, a novel Monte Carlo Sumo-based Modelling for Accident Prevention System [MCS-MAPS] protocol has been proposed to observe the effects that autonomous vehicles will have on heterogeneous traffic in terms of safety or vehicle traffic. The workflow summarises the calibration procedures for the lane-changing and car-following models of vehicles and trucks. Figure 1 depicts the overview of the proposed methodology.

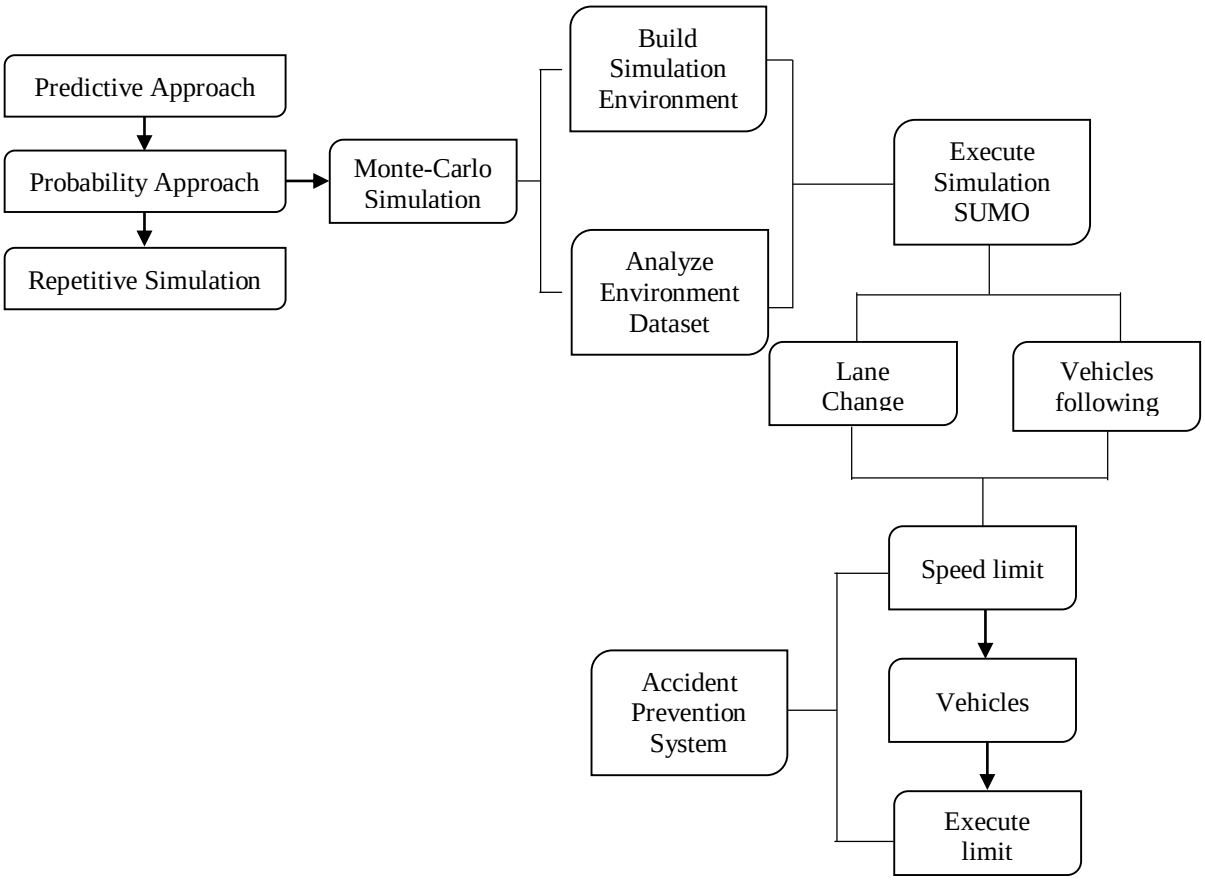

Fig. 1 Overview of proposed methodology

3.1. Accident Prevention System Based on Monte Carlo Simulation

A form of simulation called a Monte Carlo simulation computes the outcomes using repeated random sampling and statistical analysis. The random experiments, in which the precise outcome is unknown beforehand, are closely related to this simulation technique. Monte Carlo simulation can be seen as a methodical approach to performing a what-if analysis in this situation. Since this is one of the simplest methods to understand the fundamentals of Monte Carlo simulation, we will emphasize this viewpoint throughout this course.

The transmitter of this technique divides the understandable light pulses produced by a laser diode into strong local oscillator pulses and weak signal pulses. After being loaded with important information using an amplitude modulator and a phase modulator, the coherent state's X and P quadratures trace a centred Gaussian distribution with VA as their respective variances. A delay line delays the local oscillator pulses so that they can be transmitted with the signal pulses via temporal multiplexing.

Bob randomly selects one of the signals states to be detected by homodyne detection. It uses the local oscillator as a phase reference at the receiving end after first using a beam splitter to separate the local oscillator and signal pulses. Bob's phasing modulator chooses the quadrature randomly by introducing an x/2 phase shift to the local oscillator. The pulses propagating in seawater are influenced by two key elements throughout this process: absorption and scattering. The type of particles present in the water and its turbidity play a significant role in sorption and scattering. To describe the combined effects of these two processes, one can use the beam extinction coefficient, or c, which is defined as q () = a () + b (), where w is the wavelength of the light, a () is the absorption coefficient, and b () is the scattering coefficient. To determine the values of a () and b () based on the proposed bio-optical models, chlorophyll concentration C (in mg/m3) is often employed as the free parameter. It is possible to write the radiative transfer equation (RTE) as

$$pf(x, \emptyset, \varphi, \lambda) = q(\lambda)F(x, \emptyset, \varphi, \lambda) + F^{c} + F^{L} \quad (1)$$

However, because this method presumes that every photon that experiences dispersion is lost, the optical power collected may be greatly understated. It is possible to capture scattered photons, especially if the water is heavily scattered.

3.2. Accident Prevention System

Accident prevention refers to the concepts, methods of advance planning, and protective measures implemented to prevent accidents. Accident prevention refers to an organization's efforts to limit the likelihood of accidents, save lives, and lower the risks of injury or lessen their severity. Direct causes, such as poor working conditions, may exist, as well as indirect ones brought on by managerial practices and cultural considerations. Accidental causes: making work environments safe, particularly by designing and assessing the physical variables involved in work tasks, is one way to reduce accidents.

4. Result and Discussion

MATLAB is used to evaluate the accident data set and extract all essential parameters. The retrieved parameters will be compared to the simulation result from SUMO and utilized as beginning states for the running simulation models in SUMO. The development of an accident prevention model is enabled by examining the elements (traffic danger) influencing the likelihood of accidents and techniques for controlling those factors. The comparative analysis of road accidents, death and injuries is shown in Figure 2.

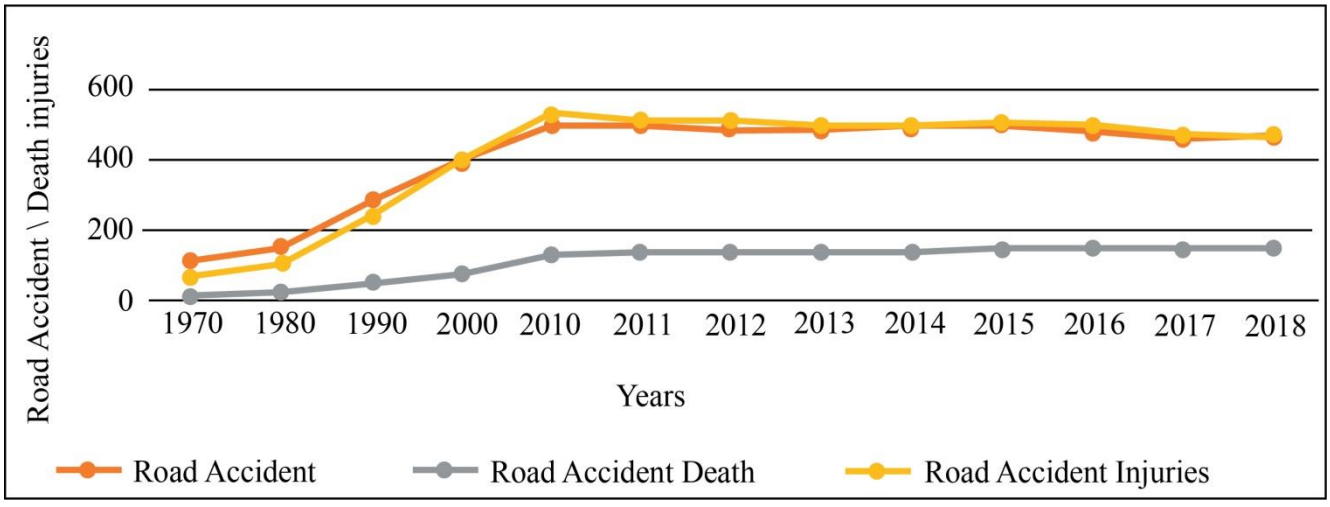

Fig. 2 A comparative analysis of road accidents, death and injuries

The above graph shows a steady rise in road accidents, deaths from accidents, and injuries from accidents until 2018, when all three categories of deaths, accidents, and injuries stabilized with slight adjustments.

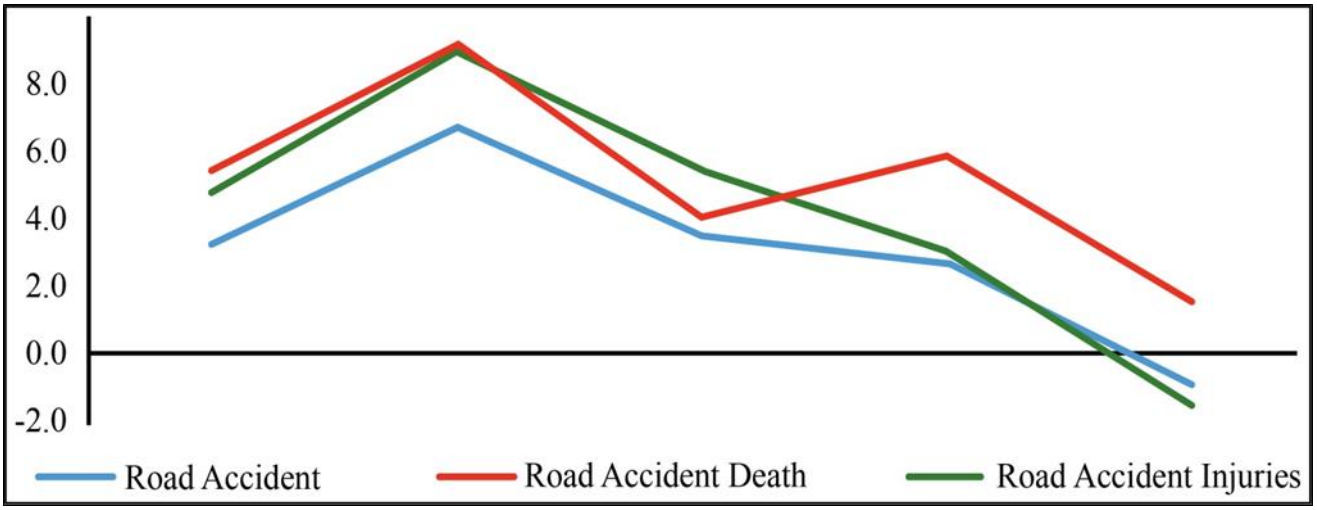

Fig. 3 CACR Of road accidents, death and injuries

The 1980–1990 era is found to have this category having the highest CAGR for accidents, deaths, and injuries. As a result, all categories of deaths, except accident-related deaths, decrease. The CAGR for the period 2010–2018 for all categories of accidents, deaths, and injuries is noteworthy because it is the lowest compared to the previous 40 years, as shown in Figure 3.

Despite the fact that between 2010 and 2017, the province's total number of registered motor vehicles increased at a compound annual growth rate (CAGR) of 10.3%, resulting in an increase in the vehicle density per kilometre from 28 in 2007 to 42.95 in 2017.

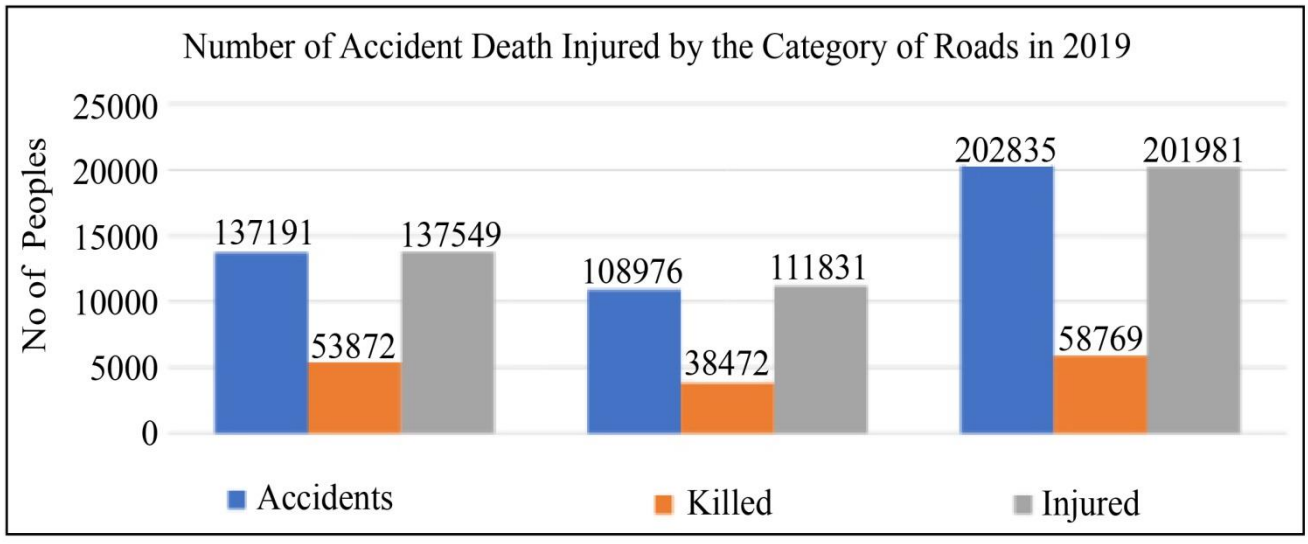

Fig. 4 Accident death and injury by the category of roads

Road accidents will economically impact both the victim and the community. The victim won't be able to keep working to make money, and because they don't contribute to the GDP of their nation, it has a detrimental effect on that nation's financial situation.

Here Only 1% of all automobiles are in India, but it accounts for 11% of all road accident fatalities worldwide. In 2019, more than 781,668 vehicles were engaged in road accidents, according to survey and data analytics conducted by the Road Accident Sampling System of India (RASSI). The damage caused by these disasters also ranged from $0.57 to $1.81 billion. The study's findings indicate that these victims' or patients' cumulative medical costs range from $0.82 to $1.92 billion. Studies from 2019 indicate that the number of accidents (202835), fatalities (58769), and injuries are highest on routes other than national or state highways (201981), are showed in Figure 4.

5. Conclusion

In this paper, a novel MCS-MAPS protocol has been proposed to overcome several challenges in the accident prevention system. The purpose of this paper is to inspect the effects that autonomous vehicles will have on heterogeneous traffic in terms of safety or vehicle traffic it may cause accidents. An accident prevention system has been used in this study to characterize the presence of many vehicle kinds, both manually operated and autonomous. The simulation findings demonstrated that the number of traffic conflicts tends to decrease when the penetration rate of autonomous vehicles increases for the same mean road speed. The method aims to keep vehicles lowering death out of highway traffic accidents and injury rates. When vehicle flow rates are high, this results in an increase in the number of conflicts as the penetration rate rises. MATLAB is used to evaluate the accident data set and extract all essential parameters. According to these findings, automated vehicles have the ability to increase traffic flow by accelerating the mean road speed, which will shorten travel times while also reducing the frequency of accidents. Nonetheless, the average speed must be kept in check, or conflicts will rise drastically. A high vehicle flow rate causes conflicts to occur more frequently as penetration rates rise.

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