International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Exploring Advances in Vehicle Safety through the Integration of Artificial Intelligence Technology: A Systematic Review

Atul A. Patil[1], Lalit N. Patil*[2], Vijaykumar K. Javanjal[3], Kuldeep A. Mahajan[4], Nikhil M. Shinde[5], Sarika A. Patil[6], Ganesh E. Kondhalkar[7]

Submitted: 29/01/2024 **Revised**: 07/03/2024 **Accepted**: 15/03/2024

Abstract: Following the adoption of artificial intelligence (AI) technologies, there have been implementations that aim to apply intelligence in their respective fields. Various approaches to building a safe automobile transport system have been suggested in the past. This is a novel literary framework for mapping of artificial intelligence (AI) in vehicle safety system. This paper offers a comprehensive analysis of vehicle safety aspects, focusing on how new technologies had been employed in development of vehicle safety over the past few years. The existing literature has been extensively examined. Principal and secondary "search strings" were recognized. A search was performed on five databases, followed by screening and analysis. Thirty primary studies conducted between 2009 and 2023 were chosen from the total literature reviewed. From the comprehensive reading of this paper, the reader's interest will be enriched with: 1) Finding out the current research trends in automotive safety using artificial intelligence techniques, 2) Recognizing the upcoming challenges in vehicle safety and report whether the AI can solve the challenges?, 3) Which algorithms are preferred for artificial intelligence in vehicles? 4) Present research work going on in the field of vehicle safety and road map towards the safe drive.

Keywords: *Artificial Intelligence (AI), Smart Vehicles, Transport, Vehicle Safety*

1. Introduction

Here Artificial intelligence (AI) refers to a computer's or a robot's capacity to carry out tasks that would typically need a human's intelligence and decision-making abilities [1], [2]. The basic objective of AI, often referred to as heuristic programming, machine intelligence, or cognitive behavioural simulation, is to make it possible for computers to carry out intelligent tasks including perception, problem-solving, decision-making, and language interpretation[3]–[6]. As we go toward the usage of AI technology, we will need some system that can detect predicted actions through the training of different models. In order to enhance numerous aspects of road safety, a novel AI technique that use the predictive capability of AI to detect dangers on the road and a collision alarm system to send timely notifications to drivers is used. Fast moving cars rely on incredibly rapid data rates to have the reflexes necessary to avoid obstacles in the case of a collision. In the end, 5G and AI will be integrated to provide these automobiles a more accurate perspective of the road, enhancing their functionality and safety.

[1,2,3] *Dr. D. Y. Patil Institute of Techology, Pimpri 411018, INDIA*
ORCID ID : 0000-0002-9828-0025
[4]*M.E.S. Wadia College of Engineering, Pune, 411001, INDIA*
ORCID ID : 0000-0003-0607-3916
[5] *Vishwakarma University, Pune, 411048, INDIA*
[6] *D. Y. Patil college of Engineering , Akurdi,*
ORCID ID : 0000-0002-3843-1856
[7]*Anantrao Pawar College of Engineering & Research Pune*
** Corresponding Author Email: lnpatil_p18@me.vjti.ac.in*

India is listed as one of the 20 most polluting cities in the world, based on a latest WHO assessment (2018) [7]. Automobile exhaust, poor vehicle emission control, building construction activity, garbage burning, traffic congestion, and a number of other factors are recognized as major contributors to the ongoing rise in pollution [4], [8], [9]. The primary characteristics of electric vehicles (EVs) from urban areas place an emphasis on clean air and silent operation to protect the city's atmospheric pollution concerns[10], [11]. The automobile industry is committed to creating safer, more affordable, and more attractive vehicles[12], [13].

A common definition of an accident is an unexpected occurrence in a series of circumstances that typically results in accidental harm, death, or item damage [14], [15]. Every transit system must prioritize vehicle stability and safety, which largely depended on good braking systems. According to World Health Organization estimates from 2018, there are 1.35 million fatalities on the road each year, making them the eighth highest cause of death for persons of all ages [4], [16]. India is the country with the most yearly road deaths, surpassing China. By 2025, it is anticipated that it will surpass the threshold of 250,000 [17]. Around the world, more than 270000 pedestrians were slaughtered each year[18]. Numerous authors have expressed their perspectives and solutions for traffic accidents across the world, including blind pedestrians' decisions to cross the street[10]. This tendency is influenced by several things: Rapid urbanization, a lack of knowledge of safety rules, disobedience, driving while

intoxicated or fatigued, driving while under the influence of drugs or alcohol, speeding, and an unwillingness to use seatbelts or helmets. Because of this, several academics asserted that it is urgent to acknowledge the deterioration in the situation of traffic accidents and injuries and to take required action. Keeping this in mind, it is necessary to incorporate either driver assistance systems for collision avoidance or driver behaviour monitor systems to enhance the general safety of cars. Research on driver behaviour has been given careful consideration since driver safety is the foundation for all passenger safety. Since then, extensive research has been devoted to enhancing driver safety while taking into account a variety of factors, including eye movement detection, inebriated state detection, driver distractions, and many more. Therefore, it was intended to explore the expansion of the current study linked to the increase of safety by reviewing the previously published literature on driver safety. Figure 1 highlights the six common ADAS tasks for vehicle safety enhancement.

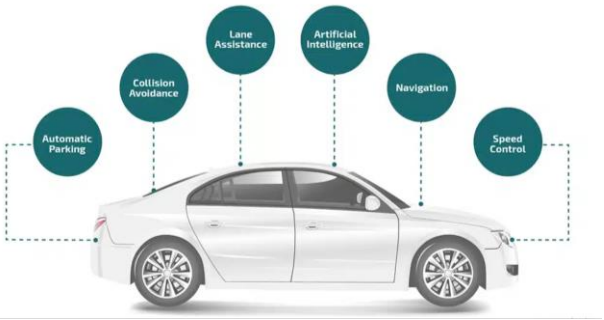

Fig. 1. Key Attributes of Intelligent Vehicle System [77]

Brakes represent one of the most important performance and safety components in automobiles. However, in addition to a robust braking system, safety also depends on a variety of other factors, including driving conduct, driver health, and traffic conditions. Drowsiness detection has been the subject of both basic and practical research with the goal of improving crash prevention. To learn more about the various approaches and their uses, the prior literature was painstakingly reviewed in this effort. Numerous unintentional incidents, notably in the area of traffic, were discovered. To address this, an IoT-based smart monitoring system was created to keep an eye on traffic infractions. Unsafe driving practices, excessive vehicle speed, driving while intoxicated, and disregarding traffic signal regulations are examples of traffic violations. A few researchers developed an alcohol detecting method with an auto-lock system to improve road safety.

To improve safety, an intelligent vehicle control system was recommended, especially for areas near hospitals and school zones. Since RF transmitters are ideally suited for such signal processing applications, they can be used in areas where drivers of motor vehicles should exercise caution. Additionally, according to some academics, there are engine braking differences between conventional and electric vehicles that need to be evaluated and resolved for extremely high levels of safety. IoT has several useful applications in the area of vehicular security. Some researchers suggested utilizing IoT to detect accidents and provide rapid medical care. Furthermore, some researchers suggest a multi-input, single-output fuzzy logic controller for anti-lock braking systems that takes slip and vehicle speed as inputs and treats them equally, which influences the controller selection.

1.1. Motivation

Tracking human emotions and behaviors has been easier and faster because to advances in science and technology. Researchers in the automotive industry are always working to create automobiles that are safer, more affordable, efficient, and aesthetically pleasing. There are several elements that might divert a driver's concentration, particularly when moving the vehicles in congested locations; nevertheless, health issues such as a Chest pain or discomfort, feeling tired, or a sudden impulsive mood are beyond the rider's control. Psychological or physical drowsiness has been identified as a leading cause of car crashes, especially in the afternoon and midnight. Driving necessitates maintaining a high degree of focus and steadiness at all times. When a driver is sleepy or under the influence of alcohol, it can have a big impact. As a result, mapping and developing a device capable of tracking and diagnosing tired or drunken driving behaviour, as well as medical emergency situations, and acting properly depending on the present scenario to operate the vehicle is essential. The different AI in automotive is shown in figure 2.

To combat the rising number of accidents, researchers are continually creating new approaches. As a result, most automobile accidents analysis percolates the objective of investigation towards the crash instances. Unintentional crashes can occur as a consequence of a delay in action, a distracted driver in traffic, a vehicle out of control owing to excessive speed, or the usage of advanced features such as a road map. Several complicated solutions have been developed to address the present difficulties, but they are only accessible in newer vehicles. As a result of budget constraints in poor nations, most automobiles on the road lacked such complex advanced technologies. Numerous modules have recommended novel ways for using ML techniques to build congestion prediction models for in CV, resulting in a variety of outputs and consequences. However, systematic and organized research on the application of ML approaches in CV vehicle safety prediction is still lacking in the current literature. Therefore, authors have thoroughly studied the past literatures to map the present artificial neural network

technologies with vehicle safety.

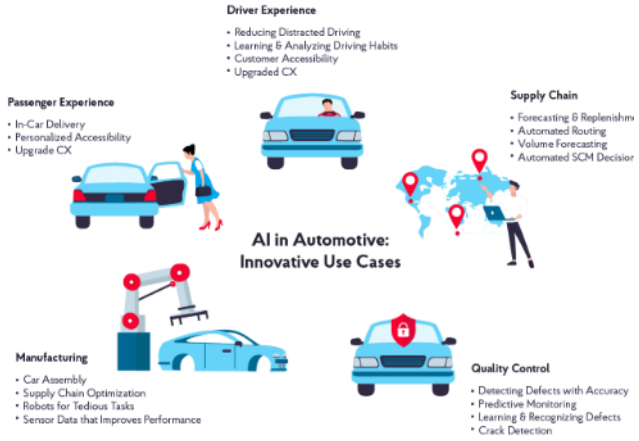

Fig. 2. Artificial Intelligence in Automotive Applications [76]

1.2. Literature Mapping

Automotive vehicle braking systems have traditionally been prioritized for safety considerations, especially active safety. Any vehicle braking system must be capable of stopping safely at the driver's command. Although a disc braking system might improve in-vehicle control in a shorter period of time, the driver's attention is also seen as an important component for a safe drive.

Numerous unintentional incidents, notably in the area of traffic, were discovered. To address this, an IoT-based smart monitoring system was created to keep an eye on traffic infractions. Unsafe driving practises, excessive vehicle speed, driving while intoxicated, and disregarding traffic signal regulations are examples of traffic violations [19]. In order to prevent major accidents caused by vehicles travelling too fast, a new RFID-based speed surveillance system featuring new capabilities was implemented [20]. Some researchers created an alcohol detecting mechanism with an auto-lock system to improve road safety [21]. To improve safety, a smart transport management system was recommended, especially for areas near hospitals and school zones. Since RF transmitters are ideally suited for these kind of signal processing applications, they can be used in areas where drivers of motor vehicles should exercise caution [22]. Several scientific research on driver behaviour have been undertaken with the goal of enhancing road safety [23]–[25]. Obstructive sleep apnea syndrome and road accidents are clearly related, with tiredness being a significant factor in increasing the chance of a crash. IoT has several useful applications in the area of automotive safety. Some researchers suggested adopting IoT to detect accidents and provide rapid medical care[26]. Interval type 2 fuzzy logic controllers are utilized a lot these days since they have a simpler computational structure than general T2FS [27]. Additionally, it was suggested to use the TSK algorithm to create a fuzzy-based automatic brake controller [28]. A substantial body of literature focuses on sophisticated neural network approaches for vehicle safety. Using driver braking behaviour, Xiong et al. devised a technique for preventing forward crashes [29]. Nauroisa et al. provided a model for predicting and detecting driver sleepiness based on two models: initially, the degree of drowsiness being identified per minute, and subsequently, the time necessary to attain the drowsiness level was calculated.

Table 1. Systematic Mapping of Past Literature

Research Area	Author	Findings and Remarks
Crash Detection using ANN	Aldona Jarašūniene & Gražvydas Jakubauskas [30]	Intelligent Vehicle Safety Systems (IVSS) ensures the required essential requirements for reducing traffic accidents
	Dewant Katare & Mohamed El-Sharkawy [31]	The collision avoidance system was given in this study utilising machine learning-based techniques.
	Xin Wang et. al [32]	The current study has been done to foresee crashes. The solution to this complex problem, which is challenging to tackle using conventional approaches, is suggested using learning-based methodologies.
	Máté Zöldy, Zsolt Szalay, Viktor Tihanyi [33]	The method focuses on securely integrating current features and prototypes into new products.
	Deyun Wang[34]	current state of research in deep learning and convolutional neural networks, in addition to their theory and technology
	Anadu Daniel et. al [35]	This study's objective was to feedback form between sensor nodes to replicate a mobile ad hoc network.
	Ba, Yutao et. al[36]	Crash detection for automotive safety applications using

		behavioral and physiological characteristics
	Lalit N Patil, Hrishikesh P Khairnar [37]	To get the appropriate braking action from the suggested model, state flow algorithm and obstacle detection have been included.
	L. Ujjainiya, M. K. Chakravarthi [38]	Raspberry Pi-based car accident prevention system using Image processing
	Zhe Peng et. al [39]	Researchers go through a variety of issues and methods related to vehicle safety assessments in VANETs.
	Tingting Huang, Shuo Wang, Anuj Sharma [40]	This study investigates the viability of utilising deep learning models to forecast accident risk and identify crash incidence. Data acquired from roadside radar sensors on traffic, frequency, including sensors occupancy.
	Assi Khaled et. al [41]	Using 15 accident-related factors, this model designed machine learning (ML) algorithms to forecast collision injuries.
Pedestrian safety	Meysam Effati, Mahyar Vahedi Saheli [42]	The current study attempts to investigate pedestrian-hazardous parts in populous rural regions, with a focus on roadside land use characteristics and access road sites.
	LN Patil, HP Khairnar [14]	The current study's objective is to examine how drivers and pedestrians perceive the quietness of electric cars by analysing information gathered from questionnaire surveys and in-depth interviews performed in the Mumbai Metropolitan Region (MMR), India.
	Chien Jong-Chih et. al [43]	In this research, researchers offer a vision-based driving aids scheme which includes a pedestrian protection sub-system with a driver security sub-system.
	LN Patil, HP Khairnar [10]	Is there harm to human health since electric cars are quiet from the viewpoint of pedestrians?
Driver Safety	Koesdwiady, Arief, Ridha Soua, Fakhreddine Karray, and Mohamed S. Kamel [44]	An overview of driver safety monitoring systems is given in this study. They investigate several driver distractions while offering a thorough taxonomy.
	Liang Chen [45]	Artificial intelligence-based road vehicle detection system for safety aid driving
	LN Patil, HP Khairnar [46]	Driver sleepiness was effectively recognised for the suggested control alogorithm and established as justified with the enhancement in stopping distance, atmospheric conditions, in addition to expansion of the vehicle collision avoidance regime.
	Ngxande Mkhuseli et. al [47]	Levels of tiredness can be inferred from information found on faces. The amount of tiredness may be inferred from a variety of facial characteristics. These consist of yawning, body movements, including eye blinks.
	LN Patil, HP Khairnar [11]	A web surveillance camera was employed to observe the driver's actions. If the system detects that the driver is sleepy or fatigued, urgent safety measures will be taken, such as warning indications, automatic braking, and stopping.
	LN Patil, HP Khairnar [12]	The main goal of this effort is to create an intelligent system that will track the actions of the driver and increase overall safety for both pedestrians and passengers.
Traffic Flow Prediction	Yisheng Lv, Yanjie Duan, Wenwen Kang, Zhengxi Li, and Fei-Yue Wang [48]	For the effective implementation of intelligent transportation systems, precise and appropriate traffic flow data are necessary.
	Janković, Slađana, Dušan	The study has demonstrated that machine learning-based

	Mladenović, Snežana Mladenović, and Stefan Zdravković [49]	big data analytics may be used to accurately estimate the volume as well as structure of traffic flows.
	LN Patil, HP Khairnar [50]	The significant factors were assessed using a methodical ANOVA methodology. The findings demonstrate that the perceived danger varies depending on the category of the driver, particularly while parking the car (p=0, F=10.12 > Fcrit).
	Dogru, N., & Subasi, A. [51]	The method described in this work uses automobiles to share miniscule vehicle data, which are used to identify traffic accidents. The suggested system transmits traffic alerts to the operators based on simulated information taken from vehicular ad-hoc networks (VANETs) depending on the movements as well as coordinates of the cars.
	Ditcharoen Alyssa et. al [52]	An interesting topic of research regarding road safety is the factors that influence traffic accidents. This paper's goal is to provide an overview of the factors impacting the seriousness of traffic accidents. It also analyses the methods that have been utilized often in past research, such as logistic regression and power modelling.

2. Artificial Intelligence and Vehicle safety Background

Machine learning (ML) is frequently used in conjunction with AI; however it is a subset of AI. ML refers to AI systems that can learn based on their own algorithms. ML is a system that learns and improves over time without the need for human interaction. Deep learning (DL) is the application of machine learning (ML) to massive data sets. Deep learning has been demonstrated in computer vision and image recognition. Machine learning is a subset of this. Convolution neural networks (CNNs) are a prominent deep neural network technique in deep learning. Smart cities are one new inventive solution brought about by the Internet of Things (IoT) that allows citizens to survive more efficiently, handily, and smartly. The Intelligent Transportation System (ITS) improves commuter and transportation procedures in a number of smart city applications.

The majority of deaths in the population are caused by traffic accidents. Each year, driving while fatigued or distracted claims thousands of lives worldwide. To avoid such tragedies and preserve lives, a system that can detect both distraction and tiredness at any time of the day or night is required. In this post, some researchers introduce the convolution driving distraction and sleepiness detection model from Deep Learning. The suggested approach uses real-time video processing to track the actions of the driver while they are on the road. In the case of reckless driving or incorrect driver conduct, the model delivers warnings with a short reaction time. Datasets were created for both training and testing in order to achieve this. They utilized a CNN model to train the model[53].

Through the use of a risk detecting device called the Signal Warning Detector; the research study was carried out to prevent accidents and hazards on the direct shoulder of the highway for the safety of highway masters (SWAD). A signal was delivered to the exit through a siren device and emergency lights when a distance sensor discovered an item at a specific distance. On the vehicles used by road workers, sensors were fitted. Additionally, it transmitted signals to receivers to provide employees with early notice of any dangers found. To warn the worker, the receiver vibrated a vibration motor fastened to the worker's arm. The SWAD's primary goal was to improve safety protocols and precautions for currently employed highway maintenance employees [54].

One researcher, for example, offered an ANN-based short-term forecast of traffic levels in India and detailed the usage of ANN approaches in a study[55]. The findings and limitations showed research gaps that other researchers could fill. Another example is the researcher, who offered his quicker R-CNN detector to handle the problem of traffic estimates utilizing video data from traffic cameras.

2.1. Model Developmant

ANNs have the capability of recognizing non-linear correlations among input as well as output characteristics and can give a generic solution for forecasting safety of vehicles. A multilayer perceptron (MLP) is a type of ANN network topology that includes additional layers known as hidden layers. The nonlinear structure of the activation function between layers of processing units

allows MLP to address a wide variety of problems. The choice of activation function has a significant impact on neural network performance. At each epoch, the error is computed by comparing the computed output of each input with the predicted output. Back-propagation is a common technique for propagating errors. Each processing unit is initially given a random weight. The main goal of neural network optimization is to reduce the mean squared error during the training, cross-validation, and testing stages.

The number of input variables is not limited in ANN modelling. The number of input and output variables is determined by the nature of the task. There is no generic way to designing comprehensive neural network architecture in the literature. To use trial and error, the weight parameters of each neuron in the buried layer must first be randomized. Furthermore, these weights are altered by backward propagation of prediction mistakes. The quantity of contribution variables, the form of hidden layers, the activation or else transfer function, in addition to the training time all play essential roles in the design of neural network topologies.

3. Review Methodology

3.1 Challenges, Deficits, Methodologies, and Evaluation

The purpose of research and literature is to confer a particular topic or to present and suggest solutions to problems generally known as gaps. Gaps are field that can be further investigated or upgraded to better understand the discussion. Intelligent vehicle safety systems, whether vehicle-based or infrastructure related, ensure preferable safety on the road [29]. Figure 4 is emphasis on advancement in automotive.

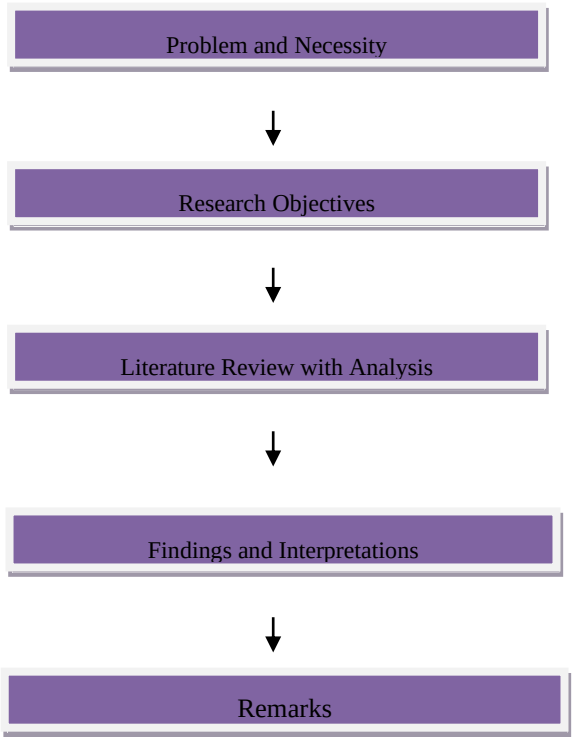

Fig. 3. The method of a Systematic Literature Review

.

Fig. 4. Development in Automotive Vehicles for intelligent control system

3.2 Machine learning approach

Most of the research articles considered in this study are the research implementations of a single machine learning approach with different approaches and

methodologies. Some researchers have proposed a model known as SG-CNN. In this model, an algorithm for grouping road segments optimizes the process of data training. By using the CNN algorithm, the proposed method yielded positive results compared with other basic models. Several authors have proposed multi-task learning-based approaches for spatial and temporal dependency extraction in multiple cities. A model called as SG-CNN has been suggested by several researchers. A technique for combining road segments optimizes the data training process in this model. The proposed technique produced positive outcomes when compared to other basic models by utilizing the CNN algorithm. Several scientists have developed multitask learning-based algorithms for extracting spatial and temporal dependencies in several cities.

4. Discussions

To improve vehicle safety and ITS in smart cities, this study aims to provide sufficient knowledge to use ML and DL techniques. Traffic safety issues are getting more and more critical as the number of automobiles grows, regardless of whether the driver is wearing a seat belt to protect their personal safety so that the issue may be resolved in the case of a traffic collision. Large-scale car component production takes place in India, and these products are shipped to major automakers all over the world to meet demand [56]. Some research uses convolutional neural networks (CNNs), common machine learning algorithms, and variants of artificial neural networks (ANNs). CNN was early introduced for image processing. It is widely used to explore patterns in spatio-temporal traffic data along with classify traffic conditions. The results reveal that a deep model outperforms state-of-the-art shallow models in terms of crash detection and prediction [40].

Some of the technologies explored under the context of ITS include connected or self-driving cars (CV). CV technology allows many types of vehicles (cars, buses, lorries, and so on) to interact with one another and share vital and crucial mobility and safety information via wirelessly connected embedded or discrete devices [57]. Models proposed by some researchers are based on forward-looking automotive radar and are based on neural networks that use supervised learning to warn drivers of detected inputs such as acceleration, velocity, along with distance [31]. Few scientists have proposed a new rear-end crash prediction mechanism using deep learning methods (RCPM) with well-established convolutional neural network models. RCPM smoothes and augments datasets based on genetic theory to mitigate class imbalance problems [32]. The numerous sensors used in automotive are shown in figure 5.

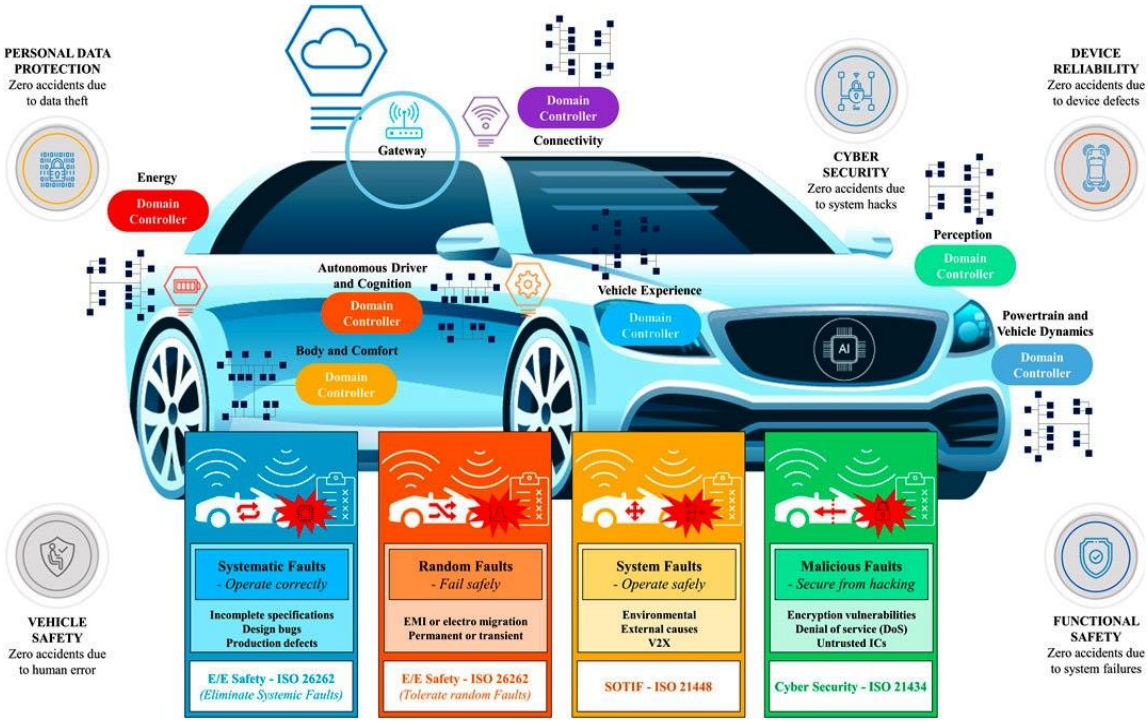

Fig. 5. The numerous fault detection techniques for safety enhancement

A vision-based driving assistance system that integrates the driver as well as pedestrian safety subsystems has been studied with fuzzy rules-based. The vehicles are subsequently detected using the area convolution neural

network. Some researchers provide a brand-new evolutionary computation-based hyper-parameters optimization technique that may be utilized to adjust deep learning framework parameters[58]. One of the main elements that contributes to drivers ignoring possible traffic dangers and ultimately causing accidents is distracted driving. Deep learning (DL) algorithms, which identify distracted behaviours by evaluating static properties of pictures, are the basic foundation for current distracted behaviour detection attempts. The DL approaches based on convolutional neural networks (CNN)[59], [60] do not, however, have the ability to infer the causes of behaviour patterns [61]. The purpose of neural network technology is to resolve complex problems using similar condition diagnostic characteristics of a vehicle. This is brought on by the fact that researchers frequently have to deal with a variety of data that are not yet included in any mathematical model [62], [63]. Traffic accidents caused by fatigue have a high fatality rate and have a large impact on the environment. Convolutional neural network (CNN)-based approach for real-time detection of driver drowsiness is proposed as a means of ensuring driving safety. Two CNN-based stages, including a detection phase and a classification phase, are cascaded in the proposed approach to driver drowsiness detection [64], [65]. As a result, it is crucial to observe and assess the behaviour of the driver while they are on the road in order to spot distractions and reduce the frequency of accidents. Machine learning and deep learning can play a big part in the detection of numerous types of behaviour, such as using a mobile phone, conversing with people, eating, napping, or not paying attention while driving. To train the model using a large amount of training data, this method may require substantial processing power. In this study, researchers tried to build a CNN-based approach to determine the origin of distractions like chatting, sleeping, or eating by using facial and hand localization[66]. Artificial intelligence (AI)[67] is a representation of human intellectual processes such as self-correction, training, and understanding. Figure 6 throws focus on numerous fault detection techniques for safety enhancement. It makes thinking and learning easier for machines or computer programmes. Computer systems can now execute functions including visual insight, decision-making, adaptability, sensory comprehension, and communication due to advances in technology [68]–[70]. New prediction methods have emerged as a result of the quick development of artificial neural network-based technology. By using neural network-based approaches to anticipate data pertaining to transportation parameters, several studies investigated the use of artificial intelligence in transportation[71]. Some studies describes an optimization technique that helps neural networks handle limited training data, which are often available during the development of new products, and ultimately achieve acceptable low-error prediction performance [72]. IOT is playing a role in addition to trained neural networks for efficient results [73]–[75]. Thus, the application of artificial neural network highlights gigantic role in the field of automobile 75,76). The advanced driving features of heavy passenger vehicle (HPV) drivers were used in the some research to present a framework for identifying aggressive driving tendencies in longitudinal control [78].

5. Conclusion

A systematic literature mapping was conducted to explore the use of artificial intelligence in the field of vehicle safety. Although the usage of artificial neural network techniques is gaining lot of attention yet it is essential to assess the suitability of such models for real time use and applications. The systematic scientific approach has been adopted to address all research questions thoroughly. The use of machine learning techniques, in particular CNN, LSTM, etc., to predict traffic flows shows promising results in enhancing the performance of the suggested approaches, such as C-LSTM, STRCN, and MTN. The principles behind the suggested model were further strengthened by a comparison with current base models like ARIMA and HA, as the comparative findings revealed favorable and better outcomes. This study adds to the growth of research in the area of ML and DL-based accidents preventions and prediction. By acting as a resource for other academics, practitioners, and researchers, it contributes to the body of literature and further study. This research offers a systematic and thorough evaluation of contemporary ML and DL research.

Author contributions

Atul Patil: Conceptualization, Methodology, Software, Field study **Lalit Patil:** Data curation, Writing-Original draft preparation, Software, Validation., Field study **Vijaykumar K. Javanjal:** Visualization, Investigation, Writing-Reviewing and Editing **Kuldeep A. Mahajan:** Visualization, Investigation **, Nikhil M. Shinde:** Methodology, Software **,Sarika A. Patil:** Data curation**, Ganesh E. Kondhalkar:** Final Approval

Conflicts of interest

The authors declare no conflicts of interest.

References

[1] S. Tripathi, “Artificial intelligence: A brief review,” Analyzing Future Applications of AI, Sensors, and Robotics in Society, pp. 1–16, 2021.

[2] M. Alotaibi and B. Alotaibi, "Distracted driver classification using deep learning," SIViP, vol. 14, no. 3, pp. 617–624, Apr. 2020, doi: 10.1007/s11760-019-01589-z.

[3] P. K. Garg, "Overview of Artificial Intelligence," in Artificial Intelligence, Chapman and Hall/CRC, 2021, pp. 3–18.

[4] Lalit N. Patil et al., "An Experimental Investigation of Wear Particles Emission and Noise Level from Smart Braking System," Evergreen, vol. 9, no. 3, pp. 711–720, Sep. 2022, doi: 10.5109/4843103.

[5] T. N. Dief and S. Yoshida, "System Identification for Quad-rotor Parameters Using Neural Network," Evergreen, vol. 3, no. 1, pp. 6–11, Mar. 2016, doi: 10.5109/1657380.

[6] Gde Dharma Nugraha, B. Sudiarto, and K. Ramli, "Machine Learning-based Energy Management System for Prosumer," Evergreen, vol. 7, no. 2, pp. 309–313, Jun. 2020, doi: 10.5109/4055238.

[7] W. H. Organization, "Ambient air pollution: A global assessment of exposure and burden of disease," 2016.

[8] S. Bharadwaj, S. Ballare, Rohit, and M. K. Chandel, "Impact of congestion on greenhouse gas emissions for road transport in Mumbai metropolitan region," Transportation Research Procedia, vol. 25, pp. 3538–3551, 2017, doi: 10.1016/j.trpro.2017.05.282.

[9] S. K. Guttikunda, R. Goel, and P. Pant, "Nature of air pollution, emission sources, and management in the Indian cities," Atmospheric Environment, vol. 95, pp. 501–510, Oct. 2014, doi: 10.1016/j.atmosenv.2014.07.006.

[10] Lalit N. Patil and Hrishikesh P. Khairnar, "Investigation of Human Safety Based on Pedestrian Perceptions Associated to Silent Nature of Electric Vehicle," Evergreen, vol. 8, no. 2, pp. 280–289, Jun. 2021, doi: 10.5109/4480704.

[11] L. Patil and H. Khairnar, "Python Inspired Smart Braking System to Improve Active Safety for Electric Vehicles," IJAME, vol. 19, no. 1, pp. 9447–9459, Mar. 2022, doi: 10.15282/ijame.19.1.2022.08.0727.

[12] L. Patil and H. Khairnar, "Enhancing Safety of Electric Vehicle Drivers through Vision Oriented Monitoring System: Vision Oriented Monitoring System," in Advances in Robotics - 5th International Conference of The Robotics Society, Kanpur India: ACM, Jun. 2021, pp. 1–5. doi: 10.1145/3478586.3478590.

[13] S. M. Ali and A. Chakraborty, "Performance Study of Adsorption Cooling Cycle for Automotive Air-conditioning," Evergreen, vol. 2, no. 1, pp. 12–22, Mar. 2015, doi: 10.5109/1500423.

[14] L. N. Patil, "Assessment of Risk Associated with the Quiet Nature of Electric Vehicle: A Perception of EV Drivers and Pedestrians at Mumbai Metropolitan Region-India," European Transport/Trasporti Europei, no. ET.2021, pp. 1–19, Sep. 2021, doi: 10.48295/ET.2021.83.1.

[15] P. Tungjiratthitikan, "Accidents of Thai Industry between 2001 and 2017," Evergreen, vol. 5, no. 2, pp. 86–92, Jun. 2018, doi: 10.5109/1936221.

[16] W. H. Organization, "European regional status report on road safety 2019," 2020.

[17] S. K. Singh, "Road Traffic Accidents in India: Issues and Challenges," Transportation Research Procedia, vol. 25, pp. 4708–4719, 2017, doi: 10.1016/j.trpro.2017.05.484.

[18] W. H. Organization, "Pedestrian safety: a road safety manual for decision-makers and practitioners," 2013.

[19] C. M. Jacob, N. George, A. Lal, R. J. George, M. Antony, and J. Joseph, "An IoT based Smart Monitoring System for Vehicles," in 2020 4th International Conference on Trends in Electronics and Informatics (ICOEI)(48184), Tirunelveli, India: IEEE, Jun. 2020, pp. 396–401. doi: 10.1109/ICOEI48184.2020.9142936.

[20] M. A. M. Sarbini, S. B. Hassan, T. S. Jiann, and P. N. P. Ahmad, "Design of a RFID-based speed monitoring system for road vehicles in Brunei Darussalam," in 2014 International Conference on Computer, Communications, and Control Technology (I4CT), Langkawi, Malaysia: IEEE, Sep. 2014, pp. 219–223. doi: 10.1109/I4CT.2014.6914178.

[21] S. Al-Youif, M. A. M. Ali, and M. N. Mohammed, "Alcohol detection for car locking system," in 2018 IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), Penang: IEEE, Apr. 2018, pp. 230–233. doi: 10.1109/ISCAIE.2018.8405475.

[22] Kranthi Sai Reddy Vanukuru, "Intelligent Smart Zone Based Vehicle Speed Control System Using RF," 2018, doi: 10.13140/RG.2.2.32852.86408.

[23] M. Gromer, D. Salb, T. Walzer, N. M. Madrid, and R. Seepold, "ECG sensor for detection of driver's drowsiness," Procedia Computer Science, vol. 159,

pp. 1938–1946, 2019, doi: 10.1016/j.procs.2019.09.366.

[24] C. J. de Naurois, C. Bourdin, C. Bougard, and J.-L. Vercher, "Adapting artificial neural networks to a specific driver enhances detection and prediction of drowsiness," Accident Analysis & Prevention, vol. 121, pp. 118–128, 2018.

[25] M. Patel, S. K. L. Lal, D. Kavanagh, and P. Rossiter, "Applying neural network analysis on heart rate variability data to assess driver fatigue," Expert Systems with Applications, vol. 38, no. 6, pp. 7235–7242, Jun. 2011, doi: 10.1016/j.eswa.2010.12.028.

[26] Department of CSE VLITS Guntur, India and S. K. R. Mallidi, "IOT BASED SMART VEHICLE MONITORING SYSTEM," ijarcs, vol. 9, no. 2, pp. 738–741, Feb. 2018, doi: 10.26483/ijarcs.v9i2.5870.

[27] D. Setiady, O. Wahyunggoro, and P. Nugroho, "Design of Automatic Braking System Using Interval Type-2 Fuzzy Logic System," Journal of Electronic Systems, vol. 9, no. 2, p. 35, Jun. 2019, doi: 10.6025/jes/2019/9/2/35-43.

[28] R. Mittal and M. Kaur, "Implementation of fuzzy automated brake controller using TSK algorithm," in AIP Conference Proceedings, American Institute of Physics, 2010, pp. 1–3.

[29] X. Xiong, M. Wang, Y. Cai, L. Chen, H. Farah, and M. Hagenzieker, "A forward collision avoidance algorithm based on driver braking behavior," Accident Analysis & Prevention, vol. 129, pp. 30–43, Aug. 2019, doi: 10.1016/j.aap.2019.05.004.

[30] A. Jarašūnienė and G. Jakubauskas, "IMPROVEMENT OF ROAD SAFETY USING PASSIVE AND ACTIVE INTELLIGENT VEHICLE SAFETY SYSTEMS," TRANSPORT, vol. 22, no. 4, pp. 284–289, Dec. 2007, doi: 10.3846/16484142.2007.9638143.

[31] D. Katare and M. El-Sharkawy, "Embedded System Enabled Vehicle Collision Detection: An ANN Classifier," in 2019 IEEE 9th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, NV, USA: IEEE, Jan. 2019, pp. 0284–0289. doi: 10.1109/CCWC.2019.8666562.

[32] X. Wang, J. Liu, T. Qiu, C. Mu, C. Chen, and P. Zhou, "A Real-Time Collision Prediction Mechanism With Deep Learning for Intelligent Transportation System," IEEE Trans. Veh. Technol., vol. 69, no. 9, pp. 9497–9508, Sep. 2020, doi:

[33] M. Zöldy, Z. Szalay, and V. Tihanyi, "CHALLENGES IN HOMOLOGATION PROCESS OF VEHICLES WITH ARTIFICIAL INTELLIGENCE," Transport, vol. 35, no. 4, pp. 435–446, Nov. 2020, doi: 10.3846/transport.2020.12904.

[34] D. Wang, "Intelligent Detection of Vehicle Driving Safety Based on Deep Learning," Wireless Communications and Mobile Computing, vol. 2022, pp. 1–11, Jun. 2022, doi: 10.1155/2022/1095524.

[35] D. Anadu, C. Mushagalusa, N. Alsbou, and A. S. A. Abuabed, "Internet of Things: Vehicle collision detection and avoidance in a VANET environment," in 2018 IEEE International Instrumentation and Measurement Technology Conference (I2MTC), Houston, TX: IEEE, May 2018, pp. 1–6. doi: 10.1109/I2MTC.2018.8409861.

[36] Y. Ba, W. Zhang, Q. Wang, R. Zhou, and C. Ren, "Crash prediction with behavioral and physiological features for advanced vehicle collision avoidance system," Transportation Research Part C: Emerging Technologies, vol. 74, pp. 22–33, Jan. 2017, doi: 10.1016/j.trc.2016.11.009.

[37] L. N. Patil and H. P. Khairnar, "Assessing Impact of Smart Brake Blending to Improve Active Safety Control by Using Simulink," Applied Engineering Letters, vol. 6, no. 1, pp. 29–38, 2021, doi: 10.18485/aeletters.2021.6.1.4.

[38] L. Ujjainiya and M. K. Chakravarthi, "RASPBERRY – PI BASED COST EFFECTIVE VEHICLE COLLISION AVOIDANCE SYSTEM USING IMAGE PROCESSING," vol. 10, no. 7, p. 6, 2015.

[39] Z. Peng, S. Gao, Z. Li, B. Xiao, and Y. Qian, "Vehicle Safety Improvement through Deep Learning and Mobile Sensing," IEEE Network, vol. 32, no. 4, pp. 28–33, Jul. 2018, doi: 10.1109/MNET.2018.1700389.

[40] T. Huang, S. Wang, and A. Sharma, "Highway crash detection and risk estimation using deep learning," Accident Analysis & Prevention, vol. 135, p. 105392, Feb. 2020, doi: 10.1016/j.aap.2019.105392.

[41] K. Assi, S. M. Rahman, U. Mansoor, and N. Ratrout, "Predicting Crash Injury Severity with Machine Learning Algorithm Synergized with Clustering Technique: A Promising Protocol," IJERPH, vol. 17, no. 15, p. 5497, Jul. 2020, doi: 10.3390/ijerph17155497.

[42] M. Effati and M. Vahedi Saheli, "Examining the influence of rural land uses and accessibility-related factors to estimate pedestrian safety: The use of GIS and machine learning techniques," International Journal of Transportation Science and Technology, vol. 11, no. 1, pp. 144–157, Mar. 2022, doi: 10.1016/j.ijtst.2021.03.005.

[43] J.-C. Chien, J.-D. Lee, C.-M. Chen, M.-W. Fan, Y.-H. Chen, and L.-C. Liu, "An integrated driver warning system for driver and pedestrian safety," Applied Soft Computing, vol. 13, no. 11, pp. 4413–4427, Nov. 2013, doi: 10.1016/j.asoc.2013.06.008.

[44] A. Koesdwiady, R. Soua, F. Karray, and M. S. Kamel, "Recent Trends in Driver Safety Monitoring Systems: State of the Art and Challenges," IEEE Trans. Veh. Technol., vol. 66, no. 6, pp. 4550–4563, Jun. 2017, doi: 10.1109/TVT.2016.2631604.

[45] L. Chen, "Road vehicle recognition algorithm in safety assistant driving based on artificial intelligence," Soft Comput, Jul. 2021, doi: 10.1007/s00500-021-06011-w.

[46] L. N. Patil, H. P. Khairnar, and S. G. Bhirud, "An intelligent contactless brake blending system with advanced driver assistance technique for electric vehicles," WJE, Sep. 2022, doi: 10.1108/WJE-11-2021-0643.

[47] M. Ngxande, J.-R. Tapamo, and M. Burke, "Driver drowsiness detection using behavioral measures and machine learning techniques: A review of state-of-art techniques," in 2017 Pattern Recognition Association of South Africa and Robotics and Mechatronics (PRASA-RobMech), Bloemfontein, South Africa: IEEE, Nov. 2017, pp. 156–161. doi: 10.1109/RoboMech.2017.8261140.

[48] Y. Lv, Y. Duan, W. Kang, Z. Li, and F.-Y. Wang, "Traffic Flow Prediction With Big Data: A Deep Learning Approach," IEEE Trans. Intell. Transport. Syst., pp. 1–9, 2014, doi: 10.1109/TITS.2014.2345663.

[49] S. Janković, D. Mladenović, S. Mladenović, and S. Zdravković, "Traffic Flow Prediction Using Machine Learning," in Third International Conference "Transport for Today's Society ", Faculty of Technical Sciences Bitola, Dec. 2021. doi: 10.20544/TTS2021.1.1.21.p46.

[50] L. N. Patil and H. P. Khairnar, "Investigation of Perceived Risk Encountered by Electric Vehicle Drivers in Distinct Contexts," Applied Engineering Letters, vol. 6, no. 2, pp. 69–79, 2021, doi: 10.18485/aeletters.2021.6.2.4.

[51] N. Dogru and A. Subasi, "Traffic accident detection using random forest classifier," in 2018 15th Learning and Technology Conference (L&T), Jeddah: IEEE, Feb. 2018, pp. 40–45. doi: 10.1109/LT.2018.8368509.

[52] A. Ditcharoen, B. Chhour, T. Traikunwaranon, N. Aphivongpanya, K. Maneerat, and V. Ammarapala, "Road traffic accidents severity factors: A review paper," in 2018 5th International Conference on Business and Industrial Research (ICBIR), Bangkok: IEEE, May 2018, pp. 339–343. doi: 10.1109/ICBIR.2018.8391218.

[53] P. Panwar, P. Roshan, R. Singh, M. Rai, Asha Rani Mishra, and Sansar Singh Chauhan, "DDNet- A Deep Learning Approach to Detect Driver Distraction and Drowsiness," Evergreen, vol. 9, no. 3, pp. 881–892, Sep. 2022, doi: 10.5109/4843120.

[54] S. Hassan et al., "Safety Working Environment at Highway: Safety Warning Detector (SWAD) System," Evergreen, vol. 8, no. 3, pp. 517–523, Sep. 2021, doi: 10.5109/4491637.

[55] B. Sharma, S. Kumar, P. Tiwari, P. Yadav, and M. I. Nezhurina, "ANN based short-term traffic flow forecasting in undivided two lane highway," J Big Data, vol. 5, no. 1, p. 48, Dec. 2018, doi: 10.1186/s40537-018-0157-0.

[56] A. Kumar, R. Giri, S. Mishra, and N. Gupta, "Productivity Improvement of HLLS Using Lean Technique in Assembly Line of an Automotive Industry," Evergreen, vol. 9, no. 2, pp. 356–366, Jun. 2022, doi: 10.5109/4794160.

[57] X. Chang, H. Li, J. Rong, Z. Huang, X. Chen, and Y. Zhang, "Effects of on-Board Unit on Driving Behavior in Connected Vehicle Traffic Flow," Journal of Advanced Transportation, vol. 2019, pp. 1–12, Feb. 2019, doi: 10.1155/2019/8591623.

[58] Y. Djenouri, A. Belhadi, G. Srivastava, D. Djenouri, and J. Chun-Wei Lin, "Vehicle detection using improved region convolution neural network for accident prevention in smart roads," Pattern Recognition Letters, vol. 158, pp. 42–47, Jun. 2022, doi: 10.1016/j.patrec.2022.04.012.

[59] J. Cui et al., "A compact and interpretable convolutional neural network for cross-subject driver drowsiness detection from single-channel EEG," Methods, vol. 202, pp. 173–184, Jun. 2022, doi: 10.1016/j.ymeth.2021.04.017.

[60] M. Shahverdy, M. Fathy, R. Berangi, and M. Sabokrou, "Driver behavior detection and classification using deep convolutional neural networks," Expert Systems with Applications, vol.

149, p. 113240, Jul. 2020, doi: 10.1016/j.eswa.2020.113240.

[61] P. Ping, C. Huang, W. Ding, Y. Liu, M. Chiyomi, and T. Kazuya, "Distracted driving detection based on the fusion of deep learning and causal reasoning," Information Fusion, vol. 89, pp. 121–142, Jan. 2023, doi: 10.1016/j.inffus.2022.08.009.

[62] K. Yurii and G. Liudmila, "Application of Artificial Neural Networks in Vehicles' Design Self-Diagnostic Systems for Safety Reasons," Transportation Research Procedia, vol. 20, pp. 283–287, 2017, doi: 10.1016/j.trpro.2017.01.024.

[63] H. Srivastava, A. Kaushal, H. Kumar, A. Tripathi, and Anuj Kumar Sharma, "A Design and Development of Baggage Sorting Robotic System at the Airport," Evergreen, vol. 9, no. 1, pp. 86–92, Mar. 2022, doi: 10.5109/4774219.

[64] H. He et al., "A Real-time Driver Fatigue Detection Method Based on Two-Stage Convolutional Neural Network," IFAC-PapersOnLine, vol. 53, no. 2, pp. 15374–15379, 2020, doi: 10.1016/j.ifacol.2020.12.2357.

[65] J. Min, C. Xiong, Y. Zhang, and M. Cai, "Driver fatigue detection based on prefrontal EEG using multi-entropy measures and hybrid model," Biomedical Signal Processing and Control, vol. 69, p. 102857, Aug. 2021, doi: 10.1016/j.bspc.2021.102857.

[66] Md. U. Hossain, Md. A. Rahman, Md. M. Islam, A. Akhter, Md. A. Uddin, and B. K. Paul, "Automatic driver distraction detection using deep convolutional neural networks," Intelligent Systems with Applications, vol. 14, p. 200075, May 2022, doi: 10.1016/j.iswa.2022.200075.

[67] Z. Halim, R. Kalsoom, S. Bashir, and G. Abbas, "Artificial intelligence techniques for driving safety and vehicle crash prediction," Artif Intell Rev, vol. 46, no. 3, pp. 351–387, Oct. 2016, doi: 10.1007/s10462-016-9467-9.

[68] V. Parekh, D. Shah, and M. Shah, "Fatigue Detection Using Artificial Intelligence Framework," Augment Hum Res, vol. 5, no. 1, p. 5, Dec. 2020, doi: 10.1007/s41133-019-0023-4.

[69] W. Tong, A. Hussain, W. X. Bo, and S. Maharjan, "Artificial Intelligence for Vehicle-to-Everything: A Survey," IEEE Access, vol. 7, pp. 10823–10843, 2019, doi: 10.1109/ACCESS.2019.2891073.

[70] Y.-C. Chiou, "An artificial neural network-based expert system for the appraisal of two-car crash accidents," Accident Analysis & Prevention, vol. 38, no. 4, pp. 777–785, Jul. 2006, doi: 10.1016/j.aap.2006.02.006.

[71] G. N. Kouziokas, "Neural Network-Based Road Accident Forecasting in Transportation and Public Management," in Data Analytics: Paving the Way to Sustainable Urban Mobility, vol. 879, E. G. Nathanail and I. D. Karakikes, Eds., in Advances in Intelligent Systems and Computing, vol. 879. , Cham: Springer International Publishing, 2019, pp. 98–103. doi: 10.1007/978-3-030-02305-8_12.

[72] S. Lolas and O. Olatunbosun, "Prediction of vehicle reliability performance using artificial neural networks," Expert Systems with Applications, vol. 34, no. 4, pp. 2360–2369, May 2008, doi: 10.1016/j.eswa.2007.03.014.

[73] School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia et al., "Smart Vehicle Monitoring and Analysis System with IOT Technology," IJIE, vol. 11, no. 4, Sep. 2019, doi: 10.30880/ijie.2019.11.04.016.

[74] S. L. Ullo and G. R. Sinha, "Advances in Smart Environment Monitoring Systems Using IoT and Sensors," Sensors, vol. 20, no. 11, p. 3113, May 2020, doi: 10.3390/s20113113.

[75] Tejas G. Patil and Sanjay P. Shekhawat, "Artificial Neural Based Quality Assessment of Guava Fruit," Evergreen, vol. 9, no. 2, pp. 389–395, Jun. 2022, doi: 10.5109/4794164.

[76] M. Hofmann, F. Neukart, and T. Bäck, "Artificial Intelligence and Data Science in the Automotive Industry," p. 22.

[77] Dr. S. Shakya, "Analysis of Artificial Intelligence based Image Classification Techniques," JIIP, vol. 2, no. 1, pp. 44–54, Mar. 2020, doi: 10.36548/jiip.2020.1.005.

[78] J. Yarlagadda, P. Jain, and D. S. Pawar, "Assessing safety critical driving patterns of heavy passenger vehicle drivers using instrumented vehicle data – An unsupervised approach," Accident Analysis & Prevention, vol. 163, p. 106464, Dec. 2021, doi: 10.1016/j.aap.2021.106464.