Survey on Enhancing Accident Safety: Technological Solutions

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***Abstract*— Vehicle numbers are rising together with the population. Serious accidents that occur every day are rising on the road. This paper aims to bring forward an idea of where accidents can be prevented using methodologies that include IOT and deep learning concepts. Through an extensive review of the literature, it discusses a detailed comparative analysis of the current studies and research in this field. It presents a comprehensive study showcasing that the synergistic integration of IOT and deep learning can revolutionize accident prevention strategies and enhance the safety of various environments. It sheds light on the issues causing accidents. Each issue making its own subtopic aims to tackle the issues which lead to the dangers of accidents. The IOT part uses various sensors to take input and based on that provides output based on certain threshold values. The deep learning part uses algorithms and provides an output based on the model trained. Together they provide a system that helps in accident prevention and detection. This paper illuminates the transformative impact of IoT and deep learning on accident prevention and detection.**

***Keywords*— IOT, accident prevention, alcohol consumption, drowsiness detection, crash prevention.**

I. INTRODUCTION

For adolescents and young people from five to twenty-nine, fatal road accidents are the main cause of mortality. An estimated 1.3 million individuals every year pass away in automobile accidents. The frequency of accidents occurring worldwide has increased recently. Vehicle numbers are rising together with the population. There are becoming more fatal incidents on roadways each day. In more than eighty percent of scenarios, accidents result in several deaths. 93% of the world's fatalities on the roads occur in low- and middle-income countries, even though these countries have approximately 60% of the world's vehicles. Mostly, the daily traffic accidents are mostly aimed at developing nations. The majority of nations lose three percent of their annual GDP to road accidents. The main factor is a lack of infrastructure, poor traffic management, and inadequate accident handling. According to the report "Road Accidents in India 2021," there were 4,12,432 sad incidents of crashes on roads in 2021, which resulted in 1,53,972 fatalities and 3,84,448 hospitalizations. [36]

Fig. 1 The Overall Number of Deadly Accidents and Its Patterns: 2016-2021.[36]

Data Source: States/UTs (Police Departments).

The above graph visually explains the exact count of fatal accidents that occurred in the years from 2016 to 2021(the latest available). We can notice a gradual increase in the figures as the years go by. The reason the year 2020 has the lowest count is due to the restrictions on traveling due to the national covid lockdown. In the year 2021 as soon as the ban lifts we can notice a sudden spike in the annual fatal accident count making it the highest number of the decade.

The lack of quick assistance that may save someone's life in a matter of moments is the main factor in fatalities after accidents. Lots of Accidents are happening due to the driver's mistakes. Pedestrians, bicycle riders, and bikers make up over fifty percent of all vehicular fatalities. The three primary factors that contribute to auto accidents are intoxication, sleepiness, and inattentive driving. The suggested system seeks to assist in the analysis of these elements and the creation of accident prevention systems.

Whenever a driver has a BAC (blood alcohol content) of 0.08 milligrams per one-tenth of liter (g/dL) or more, are regarded to be intoxicated. Therefore, every deadly crash including a driver or passenger who has a blood alcohol content (BAC) of 0.08 g/dL or above is regarded as an alcohol-impaired driving accident, and any deaths that result from those accidents are regarded as liquor-impaired driving deaths[20]. In India, this Blood Alcohol Content (BAC) limit is extremely strict. The allowed BAC in India is 0.03% per 100 ml of blood.

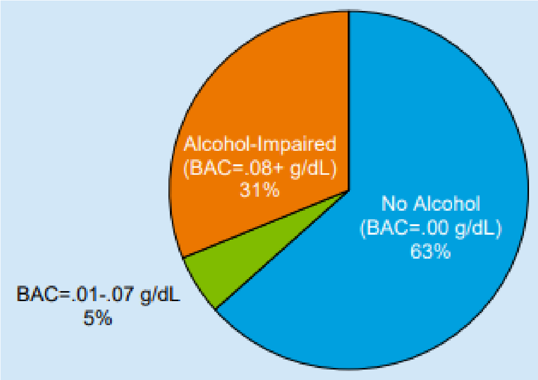

Figure 2. Percentages of Traffic Fatalities, by Highest Driver BAC in the Crash, 2021.[20]

Given the variable rounded off, numbers may not add up to 100%.

The percentage of alcohol-impaired driving fatalities where the blood alcohol content is more than or equal to 0.08 g/dL is 31% which is such a huge number. whereas the percentage count of traffic fatalities where the blood alcohol content is between 0.01 to 0.07 g/dL is 5%. Together when combined the percentage of fatalities caused due to alcohol is 36%. No other cause has single-handedly given such an impact on fatalities. If this issue is solved it will save millions of lives and reduce the overall damage caused by it.

Drowsy driving was a concern in 2.2 -- 2.6% of all fatal collisions yearly from 2005 to 2009, according to the national road visitors' protection agency. Numerous studies have shown that the hours between 2:00 and 6:00 in the morning and between 14:00 and 16:30 are when many sleep-related car accidents occur, and it is frequently noted that night shifts seem to render drivers more prone to accidents.[25] Accidents on the roads are seen to be becoming worse every year. Drivers (77%), atmospheric conditions (1%), automobile health (2%), people walking (2%), motorcyclists (1%), roadway conditions (2%), and others (14%), according to the governing body of India, are the leading causes of collisions. Due to a lack of accurate data from local authorities, it is also frequently the case that accident sufferers do not receive medical attention [18].

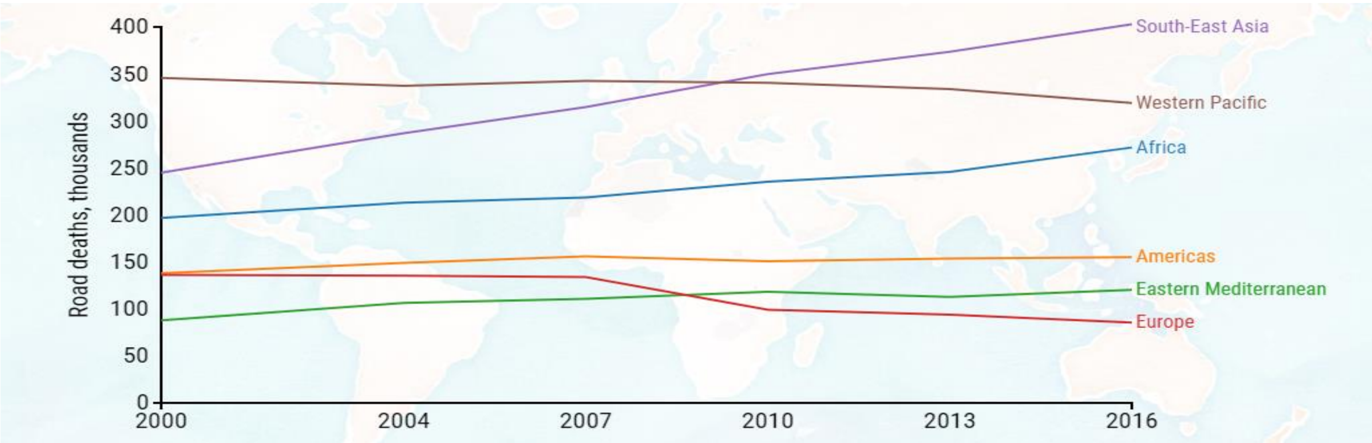

Figure 3. Road Accident deaths in different regions.

The above line graph displayed in Figure 3 with deaths caused by road accidents on Y-axis and the years from 2000-2016 on X-axis shows us the count over time. The different colors represent the various regions of the world mainly including South-East Asia, the West Pacific, Africa, America, the Eastern Mediterranean, and Europe. By glancing at the picture it is very evident that South-East Asia has an almost linear increase in road deaths. Meanwhile, Europe and the West Pacific on the opposite have a steady decline. The Eastern Mediterranean and Africa have a slow and steady increase all the while America being constant.

II. HISTORICAL BACKGROUND

Since the introduction of motor vehicles, road accidents have long been a source of concern. Various initiatives have been introduced throughout the years to improve road safety, including traffic legislation, infrastructural improvements, and car safety requirements. However, the development of IoT and Deep Learning technologies has marked a key turning point in accident prevention and detection tactics.

1. Early Efforts (Pre-Twentieth Century): There were a few ways to avoid or identify accidents in the early days of road traffic. The majority of the measures concentrated on traffic management and road signs. Police officers were stationed at key crossroads to manage traffic flow and guarantee that basic traffic regulations were followed. However, these initiatives were limited to a small geographic area and were unable to meet the rising concern about traffic accidents.

2. The Rise of Traffic Engineering (Mid-20th Century): As a response to the rising complexity of road networks, the profession of traffic engineering evolved in the mid-20th century. To improve road safety and efficiency, engineers began designing and implementing traffic management systems such as traffic lights, pedestrian crossings, and roundabouts. Although these advancements were substantial, they still depended on passive processes and lacked real-time data analyses.

3. The advent of the Internet of Things (Late 20th Century): The late twentieth century saw the advent of the Internet of Things (IoT), which added a new dimension to road safety. IoT technology allows the internet-based linking of devices, vehicles, and infrastructure, resulting in the creation of a network capable of collecting and exchanging data in real time. Early uses included traffic surveillance cameras and vehicle-to-vehicle communication, which provided the framework for more complex accident prevention and detection systems.

4. Deep Learning Revolution (Early 21st Century): The early twenty-first century saw a resurgence of interest in artificial intelligence, notably in the field of Deep Learning. Convolutional neural networks (CNNs), for example, are a type of Deep Learning algorithm that has displayed astounding ability in pattern and picture recognition. These advancements opened up new avenues for utilizing data acquired from IoT devices to more efficiently detect and prevent accidents.

5. Integration of IoT and Deep Learning (Mid-Twentieth Century): As both IoT and Deep Learning technologies advanced, researchers and industry professionals saw the potential synergy of merging these strong tools for road safety applications. By the middle of the twenty-first century, a number of pilot projects and research studies had started investigating the combination of IoT sensors, cameras, and actuators with Deep Learning algorithms for real-time accident prevention and detection.

6. Comprehensive Accident Prevention and Detection Systems (Present and Beyond): In the modern day, comprehensive accident prevention and detection systems are being implemented. These systems rely on IoT-enabled devices and cutting-edge Deep Learning algorithms. These systems have the capacity to evaluate data from several sources, such as traffic patterns, road conditions, weather, and driver behavior, in order to spot possible risks and proactively warn other road users or law enforcement. Furthermore, historical accident data and machine learning algorithms aid in the prediction of accident-prone locations as well as the optimization of road infrastructure.

Looking ahead, the future of road accident prevention and detection by combining IoT and Deep Learning offers considerable potential. Even more advanced and effective solutions will probably be created as a result of ongoing technological, data analysis, and interconnectedness developments, making our roadways safer for all users in the long run. However, concerns relating to data privacy, cybersecurity, and infrastructure development will need to be solved to ensure the effective and broad adoption of these disruptive technologies.

III. LITERATURE REVIEW

Since road accidents are a serious problem nowadays, researchers and engineers are considering advanced methods of accident detection and prevention. The Internet of Things (IoT) and deep learning are two major cutting-edge technologies that have increased the popularity of this field. The biggest reason for IoT being a huge name in this field of research is the easy integration of its components in any required system. The IoT-enabled sensors allow for the smooth capture of real-time data from the surrounding environment which feeds the entire system. The deep learning technology excels at making detections, recognitions, and making analyses based on the input. It can skillfully process real-time data to make predictions of potential hazards and unsafe behaviors. It can provide a pattern of a list of things when given historical data. The insights gained from these can be useful for decision-making scenarios. It also makes the system adaptive to changes and new learnings. This leads to improved accuracy and effectiveness.

This survey of the literature on the application of IoT and Deep Learning to improve traffic safety and lower accident rates seeks to give readers an overview of the current state of this field's research.

1. *Alcohol detection:*

Driving under the influence of alcohol is one of the biggest causes of road fatalities. Therefore making it one of the most important issues to overcome. Alcohol detection comprises a system that makes use of the Internet of Things (IoT) to track and find the amount of alcohol present in a particular environment, such as the car's cabin or any other place. This method focuses on real-time monitoring and alerting based on predetermined specific threshold values rather than deep learning methods.

Using a hardware platform made up of an Alcohol sensor MQ3, an Arduino board, a GSM module, and a Global Positioning System module, an efficient method is presented for developing an intelligent system for vehicles that will monitor the driver's alcohol consumption concentration and send this data to the base unit. Alcohol Detection and Accident Prevention of Vehicle [17], this system used an alcohol-detecting sensor in vehicles that detects alcohol gases and sends messages with their location to their relatives. This process is useful for special purposes, not for overall accident detection and prevention.

In order to track and curb driving under the influence, this paper [26] develops a vehicle-based liquor identification system that uses Internet of Things innovation. The STC12C5A60S2 single-chip microprocessor serves as the technique's influence core. The MQ-3 liquor sensor collects information regarding the air level of alcohol, as well as the GU900E GPRS component is used for wireless interaction. The LCD panel shows the amount of alcohol value that has been detected. The established intoxication threshold is compared to produce the necessary control actions, including managing the relay to prevent the automobile from being driven, alarming with a light and noise alert device, and executing base station placing and placing a brief message transfer with the GU900E.

A gas detector system is part of a liquor tracking system that tracks the operator of a vehicle and measures their blood alcohol content. If the quantity of liquor found in the driver exceeds a predefined threshold, a speedometer is available to regulate the car's top speed to a preset level. If the level of liquor found in the driver exceeds the set limit, the smartphone is programmed to immediately summon a distant call center. Additionally, a positioning system is set up to inform the distant contact center about the vehicle's whereabouts. In the faraway contact center, a location-based system is set up to show the closest places for the automobile to rest, directing the person in charge to take the vehicle to any of those places.[38]

A compact alcohol identification system is shown in [39] and consists of an inhalation sensing device, a cell phone that operates a sensor and transmits data, and an information cloud platform [40]. You may utilize the detecting system to maintain a watch on the vehicle's operator from a distance. The respiration sensing unit is made up of four distinct sensors. The first check is to see if the gas that's being released is breath from humans or not using a liquid vapor detector. The remaining ones are semiconductors sensors for gases that can pick up on alcohol, a compound called hydrogen. The findings of the driver's breathalyzer test are sent to a data database to be immediately processed, which may be problematic if a link were to break.

A breathalyzer detector, which is often used to measure the amount of liquor in the lungs of the individual who is operating the car, may identify whether an operator is intoxicated. It operates similarly to a typical breathalyzer. Due to its low cost and simplicity of integration into systems, the MQ-3 sensor is a popular option for alcohol detection. It may respond quickly and is extremely responsive. The detector produces an analog signal according to the level of liquor in the air. The most sensitive substance, SnO_2, is used in this detector. In pure air, SnO_2 has reduced resistivity.[3] Alcohol vapors create a change in the detecting element's electrical conductivity when the sensor is exposed to the air. Alcohol vapor interacts with the SnO_2 sensing substance and lowers its resistance when it is present. The sensor's circuit subsequently measures this change in resistance. The change in resistance is proportional to the quantity of alcohol vapor present, allowing the sensor to estimate the ambient alcohol concentration.

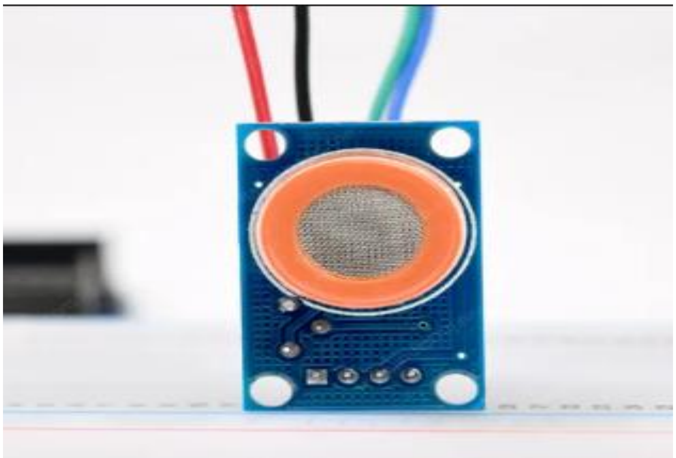

Fig. 4. MQ-3 Senor

Given below table 1 discusses alternatives to the MQ-3 server available in the market. There are other five sensors that can replace MQ-3 but may not be that widely used due to reasons listed in the table. We have discussed the advantages and disadvantages of these sensors. It's critical to take into account the gases you need to detect, the concentration range you want to measure, the climatic conditions, and the overall sensitivity and accuracy needed for your application when selecting an alternative sensor. As with any sensor, accurate and trustworthy findings depend on thorough calibration and testing in your application context.

Device	Description	Advantages	Disadvantages
MQ-2 Sensor	Semi-conductor gas sensing principle. Sensitive to flammable gases and smoke.	Sensitive to a wide range of gases like methane, butane, propane, alcohol, and hydrogen as well as smoke.	Does not provide highly precise measurements of gas concentration. Calibration and sensor drift affects accuracy over time.
MQ-9 Sensor	Made of tin dioxide and heat coil.	The small form allows easy integration.	Not suitable for detecting trace amounts but rather for high

	Sensitive to a range of flammable gases.	Heavy industrial usage for multiple gases detection.	concentrations. Cross sensitivity may lead to false readings.
MQ-135 Sensor	Sensitive to harmful gases and pollutants like ammonia, benzene, and carbon dioxide.	Useful for indoor and outdoor air quality. Exhibits fast response time.	The sensor's performance can be influenced by humidity and temperature.
Infrared (IR) Gas Sensors	Based on the principle of infrared absorption. Measuring the absorption of infrared radiation at characteristic wavelengths which is unique to each gas.	Low cross sensitivity as compared to other sensors. Longer life span than other sensors leading to fewer replacements. They are not affected by dust, humidity, or oxygen levels.	Effective range is limited and thus doesn't work well with low concentration. Designed to detect only specific gases. Requires warm-up time to stabilize and provide an accurate reading.
PID (Photoionization Detector) Sensor	Performs detections by using ultraviolet light to ionize the gas molecules. Measures volatile organic compounds.	Highly sensitive and can detect a wide range of VOCs. Provides immediate feedback on changing gas levels.	More expensive than some other gas detection technologies making it not very budget-friendly. Typically requires a high-power source to operate the UV lamp, which limits their use in battery-operated devices.
MQ-3	Alcohol-sensitive semi-conductor-based sensor. In a controlled environment, it can detect vapors up to one to three meters from the source.	The MQ-3 sensor's ability to precisely identify alcohol vapors is its main benefit. It is sensitive to a wide range of alcohol concentrations and was created particularly for alcohol detection.	Although the MQ-3 sensor is unique to alcohol, because of its sensitivity to alcohol vapors, it might not be able to distinguish between different forms of alcohol (such as ethanol and methanol).

Table 1. Different gas sensors can be used for alcohol detection.

From the comparison done in the above table, they can conclude that MQ-3 is the best alcohol gas sensor making it so widely used in almost all papers. It is compact budget-friendly and perfect to use for small spaces like driver space in a vehicle.

2. Crash detection

Every single day, automobile crashes result in a significant number of fatalities and injuries, some of which are due to delayed medical care and subsequent mishaps. Automated automobile recognition can, in some cases, reduce the amount of time it takes for cars and rescuing agencies to arrive at the scene of a crash, thus increasing the effectiveness of rescue efforts and the degree of roadway safety. A strategy for automatically detecting auto accidents based on image processing and cooperative vehicle infrastructure systems (CVIS) was suggested in this study by [49]. In order to increase the precision of identifying accidents using smart highway equipment in CVIS, a unique picture database called CAD-CVIS is produced. To increase the self-adaptability of incident identification techniques in diverse traffic scenarios, CAD-CVIS has included a variety of collision categories, climate variables, and collision sites. To identify crashes, they create the YOLO-CA deep neural network structure employing CAD-CVIS along with deep learning techniques. To improve the efficiency of identifying tiny items, they use Multi-Scale Feature Fusion (MSFF) and the function of loss with variable values in their model. Last but not least, our test research assesses the effectiveness of YOLO-CA in identifying car crashes. The findings demonstrate that our suggested approach can do so in 0.0461 seconds (21.6FPS) with a mean accuracy (AP) of 90.02%. Additionally, they evaluate YOLO-CA to other object identification models, and the outcomes show a thorough increase in precision and actual time compared to different models.

This paper[42] demonstrated an IoT-based collision identification and categorization system that works well with any type of vehicle. By getting in touch with the appropriate parties, it produces a rapid response to incidents. Additionally, details about the accident are given, such as its location, its extent, the velocity of the vehicle at the moment of the collision, and its sides. The paper's primary achievements include An effective Internet of Things solution is used by the technology to immediately report incidents and classify them using the knowledge that is most important to the investigation. To gather information on accidents, a vehicle contains a number of sensors. Utilizing an algorithm for categorization, the information is handled in a tiny computer and categorized according to the intensity degree. The microcontroller uses a global positioning system (GSM) transceiver to send a distress signal if a crash is discovered. The technology may be utilized without an expensive vehicle or mobile. a comparison of different classifiers based on machine learning using various automotive motion metrics to see which one provides the best precise estimate of the seriousness of accident levels. The Gaussian Mixture Model (GMM), the Naive-Bayes Tree (NB), the Decision Tree (DT), and the Classification and Regression Trees (CART) were four categories that were evaluated. The categorization factors that were taken into consideration were speed, collision place, & intensity, spin & height, and amounts of burn and haze. a model of the suggested system. The first version was created and put through testing using a respectable amount of crash incidents.

	Detection Accuracy	Accident Classification	Smart-Phone Based	Reporting to Emergency Centers	Communication Technology	Fire Detection
Dashora, C., et al., 2020 [6]	Low	No	No	Manual	Wi-Fi	No
Sharma, S., et al., 2019 [7]	Low	No	No	Automatic	4G/LTE	No
Ali, H. M., et al., 2017 [8]	Low	No	Yes	Automatic	4G/LTE	No
Kumar, N., et al., 2020 [9]	High	Accident type	Yes	Automatic	4G/LTE	No
Shetgaonkar, P., et al., 2015 [10]	Low	Injury's existence	No	Automatic	Wi-Fi	No
Kumar, N., et al., 2020 [11]	High	Accident type	Yes	Automatic	4G/LTE	No
Proposed System	High	Severity Level	No	Automatic	4G/LTE	Yes

Figure 5. Shows a summary of [42] proposed model compared with the other reviewed model where [6][7][8][9][10][11] refers to [43][44][45][46][47][48] respectively.

The data needed to identify a serious crash is picked up by an accelerometer. According to this study,[41] the motion detector will transmit a signal through the ATMEGA 8A processor when the car is involved in a collision or rolls over. The emergency department or the lifesaving squad gets notifications from the embedded system through GSM. Following the receipt of the data, authorities may now link the position to the GPS. The relevant measure will then be conducted after complying with the spot in question. The person who drove can turn off the alarm signal during the collision if nobody was seriously hurt or if there was no immediate danger to anyone's safety, so as not to squander the relief team's resources. Through the usage of a motion detector, an incident is discovered using this.

The revised limited Boltzmann model was put forward in content [42] for detecting crashes in this work. The following are the phases of our suggested technique. They used a combination of unintentionally taken and intentionally taken images as the basis for their work. In the following stage, they applied a deep-learning method they created called the altered limited Boltzmann model. In the third step, where mass speed and variable adjustments are conducted as an expansion procedure, we evaluate the outcome of the framework after employing different steps. Consequently, several photographs of cars are categorized as hazardous and nonaccidental. The data collection was subjected to the suggested approach, and its contents were divided into different training and testing proportions. For both incidental and unintentional vehicle images, the proposed MRBM system achieves an identification precision of 98%.

The Internet of Things and the cloud's capabilities are used to suggest an emergency alert system in this paper [45]. The use of the XBee WiFi module, XBee Shield, GPS module, Seeeduino, and accident sensors to create the suggested system is covered. The main concept is to use crash sensors to pinpoint the exact site of an accident, identify it when it occurs, and then send the area's information to the closest facility via XBee WiFi and the cloud.

In this work [46], a gadget is created that, in the event of an accident where the motorist is unable to summon an ambulance, can prompt an instant reaction from the hospital. Building a tool that can improve driver and rider security is the goal of this endeavor. IoT technology aids us in achieving this goal of effectively creating the gadget. The time it takes for the hospital to learn about an accident from when it happens will be shortened by this effort.

Table 2 given in the following pages gives a comparative study of similar papers [2][8][9][13][14] in a tabular format. These papers heavily focus on detecting accidents using different ways. Papers [8][13][14] make use of IOT-based devices to make detections. Paper [2][9] makes use of scientific algorithms to create a system that detects accidents.

Research paper number	Proposed system	Disadvantages	Enhancements	Technology and Components
[8]	Accident detection and data transmission to the server are both done using vibration sensors and MEMS sensors. The alarm message is sent by the Arduino Mega Controller via GSM and GPS. After collecting the data, a GPS MODEM is utilized to determine the victim's current location.	Inaccurate accident detection or measurements that might result from any sensor malfunction or calibration problem. The system's effectiveness mainly depends on GSM and GPS connection. Sending accident alerts may experience delays or difficulties in places with low network connectivity.	To cross-validate data, use redundant sensors or several different sensor technologies. Use various sensor technologies or redundant sensors to cross-validate data.	Vibration sensor Crash Sensor Ultrasonic sensor GPS GSM Heartbeat sensor MEMS Gas Sensor Arduino Mega LCD DC Motor
[2]	EXAMINE unit collects the data from CRASH MAPS and classifies road based on the probability of accident using the ML algorithm. DETECTION unit where sensors in the vehicle become active and warns the driver to be cautious based on the classification. The EMERGENCY unit will contact nearby hospitals and emergency contacts with accidents.	Accuracy and reliability depending on data from CRASH MAPS lead to incorrect risk assessments and unreliable warnings if data is incomplete, outdated, or biased. False positive and negative prediction fails to detect actual risks.	Eliminating bias and incomplete information by data verification and filtering processes along with regular updates and maintenance of CRASH MAPS ensures accuracy.	Raspberry Pi 4 Accelerometer Long-range ultrasonic sensors ML clustering algorithm (K-means)
[9]	Applying YOLOv4, following the tracked road traffic movements using the Kalman filter method, and keeping an eye on their trajectories allow for the analysis of their motion patterns and the detection of dangerous irregularities that might cause minor or major collisions.	In dense traffic or crowded scenarios, the Kalman filter will struggle with occlusions, where road users temporarily disappear from view or overlap with each other leading to inaccurate tracking and potentially missing hazardous behaviors. Real-time processing for tracking and trajectory analysis will introduce latency-reducing the system's effectiveness.	Advanced multi-object tracking algorithms beyond the Kalman filter, such as the DeepSORT (Deep Learning + SORT) algorithm for improved tracking accuracy and handling occlusions. Offloading some processing tasks from the central system to edge devices or sensors can reduce latency and enhance real-time performance.	YOLOv4 MS COCO dataset The Hungarian algorithm Haversine formula Google Maps
[13]	uses a GPS receiver's capacity to track a vehicle's speed, identify accidents based on that speed, and report the position as well as the moment of the accident to the Warning Service Facility using GPS data handled by a tiny computer via the GSM network.	A steady and precise GPS signal is crucial to the system's operation. The accuracy of speed tracking and accident detection may be hampered in places with low GPS signal reception, including tunnels, urban canyons, or heavily wooded areas.	Utilize techniques to fuse data from GPS and other vehicle sensors (e.g., accelerometer) for more robust and accurate speed estimation, especially in scenarios where GPS signals might be noisy or intermittent.	GPS Receiver GSM/GPRS Modem Microcontroller Unit
[14]	The sensor monitors the angle of the vehicle and indicates when any deviation is found in all three axes of the vehicle at the same time. Accelerometer sensor	Electromagnetic Interference (EMI) can disrupt the communication channels between different components of the accident	Protect important electronic components from external EMI sources by using electromagnetic	Arduino UNO Gyroscope Module(MEMS) NodeMCU ESP8266 GSM/GPS Module

	checks for any vibration or deviation in the acceleration of the vehicle in the axes(x,y,z).	detection system, including the GPS/GSM module, NodeMCU, and cloud connectivity. EMI can corrupt data during transmission or storage and weaken or block the GPS signals received by the GPS module.	shielding. Metal enclosures and other conductive materials can be used for shielding.	Crash Sensor

Table 2. Comparative study of papers suggesting accident prevention.

3. *Crash Prevention*

Convolutional neural networks (CNNs) in particular have dramatically revolutionized computer vision and are now a powerful tool for monitoring accidents. Convolutional Neural Networks (CNNs) are a particular kind of deep learning neural network that is frequently used for computer vision applications, natural language processing, and image and video recognition. Input data is used to train CNNs to automatically and adaptively learn spatial hierarchies of features. The raw data, which is often a picture or a series of images, is delivered to the input layer. Each input picture is represented as a matrix of pixels, where the value of each pixel represents the information about color or intensity. The fundamental component of CNNs is the convolutional layer. This layer's function is to identify various characteristics contained in the input data, such as edges, textures, and patterns. The feature maps' spatial dimensions are down-sampled while still preserving the most crucial data using the pooling layer. The computational complexity is decreased, and the model is strengthened against changes in the input data. Each neuron in the fully connected layer of a conventional neural network is coupled to every other neuron in the layer above.

The convolutional and pooling layer high-level features are processed and mapped to the output classes. The probability distribution over the potential classes is generally produced by the output layer using the softmax activation function. The architecture of CNNs can vary based on the specific task and complexity of the model.

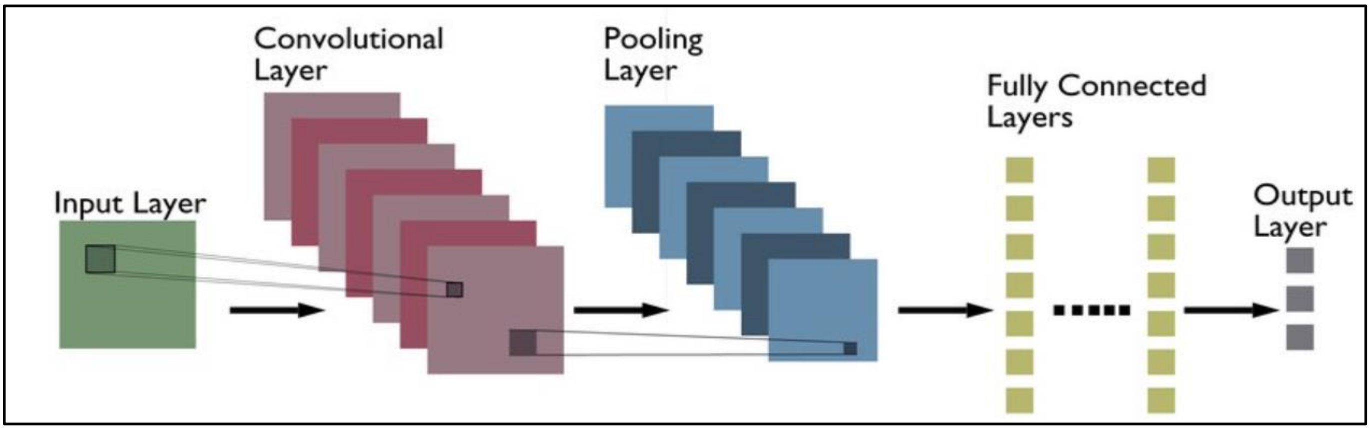

Fig. 6. The architecture of the CNN model

The most popular deep learning framework for processing images is CNN, as shown in Fig. 3. This design incorporates pre-processing as a transformations layer to provide a feature map, which is then concatenated to produce a data vector for the last layer that is completely connected that performs the classification.[6] With the technological advancements the architecture of Video feeds from traffic cameras has been analyzed using deep learning algorithms to detect and predict potentially dangerous situations. Handling large amounts of data from IoT devices is one of the biggest barriers to real-time accident prevention. Edge computing, which enables data processing at the network's edge, has become a useful way to reduce latency and response time.[4][7][9]

It is essential that technologies employed for detection provide high sensitivity and accuracy in critical circumstances like accidents. Popular instantaneous object recognition methods like YOLO are helpful in instances where immediate accuracy is essential because of their speed and precision. The YOLO method has a number of benefits, including the fact that it moves exceedingly quickly (between 45 and 150 frames per second). It learns applicable descriptions of things since it views the complete image as opposed to area proposal-based techniques, which are useful for storing contextual information. [23] The YOLO method makes predictions about both the categorization and location of objects in photos (expressed as a bounding box). In an image, YOLO seeks to identify the following elements: (bx, by) denotes the location of an item's center; (bw, bh) its width and height; c, the object's class; and Pc, the likelihood that a component of class c is present in the box. The picture is frequently divided by YOLO into a 19x19 image, with 5 bounding boxes predicted for each cell of the following shape: y = (Pc, bx, by, bw, bh, c). This results in 19x19x5 = 1805 distinct bounding boxes for each image. Non-max suppression is the process of eliminating the low Pc boxes, as seen in Figure 6.[24]

Fig. 7. The YOLO technique's non-max reduction function only retains best-fit bounds. [24]

YOLO predicts numerous bounding boxes for each item during the object identification phase, where each bounding box indicates a probable position and size of the object. These many bounding boxes may cover or partially enclose the same item. Non-maximum suppression is used to stop reporting repeated detections for the same item.

The contrast between YOLOv4 alongside different architectures' performance is presented in Figure 6, where it is clear that YOLOv4 performs better than the majority of neural network designs in terms of overall accuracy and does so at a rate of execution which is over two times as fast. YOLOv4 stands out from the other techniques due to its ability to classify objects in real-time with accuracy that is comparable to that of a person. In this case, CNN can tell the difference between vehicles traveling on a highway—cars, bicyclists, and trucks. YOLO is extensively used and a success due to its quick speed and unexpectedly remarkable accuracy.[24]

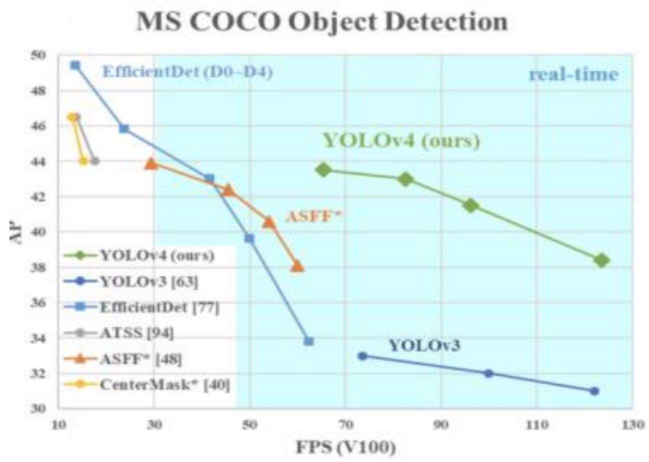

Fig. 8. Comparison between YOLOv4 vs other algorithms. v4 performs about as well as EfficientDet while running twice as quickly. FPS refers to frames per second, while AP is for average precision.

IoT-based traffic monitoring systems have been suggested in several studies recently and are now in use to reduce accidents. These systems gather real-time information on traffic, road conditions, and driver behavior using sensors, cameras, and connected devices mounted on roads and in vehicles. Fig 7 shows us how using vehicle-to-vehicle (V2V) communication in IoT systems we can warn drivers of impending crashes and enable preventative steps. It measures the distance between two cars and based on the result classifies the situation into categories. The ultrasonic sensors are used to measure the distance. This measurement gets updated each second.[1] The action is taken based on the category and thus can be used for preventing accidents. Hypothetically, if an accident happens, the system will send an email as an alert with car details to the authority for the rescue.

One practical way to improve vehicle safety is through the use of stabilization technology to avoid accidents that can detect nearby objects. The system uses ultrasonic sensors and IoT technology to provide the driver with instant warnings of impending accidents involving objects, moving vehicles, or people. By delivering ultrasonic pulses and timing how long it takes for the pulses to bounce back after striking an object, ultrasonic sensors can measure distances.

The goal of the car Safety notification and Monitoring System [18] is to notify of a crash and car theft. Accident sites can be provided using this method. It lacks any safeguards against mishaps. The ultrasonic and brake failure detectors are utilized in the study [25] to stop vehicle collisions that may happen as a result of the driver's negligence. To measure the separation between the front and rear cars, ultrasound sensors are also used. The driver will receive a warning to slow down the car if the distance appears to be very short. If the driver doesn't slow down, an autonomous braking system will kick in to bring the car to a halt.

Crash prevention using object detection is a crucial application of computer vision and deep learning technologies to enhance road safety. By leveraging object detection techniques, vehicles can identify and track potential hazards in real time, allowing for timely warnings to drivers or even autonomous intervention to avoid collisions.

Some of the key object-detecting technologies are described in Table 3.

Name	Description
Region-based Convolutional Neural Network	R-CNN-based approaches typically consist of the following steps: Region Proposal, Feature Extraction, Region Classification and Bounding Box Refinement.
RetinaNet	RetinaNet is a state-of-the-art object detection model that can be utilized for crash prevention in autonomous vehicles or advanced driver assistance systems (ADAS). RetinaNet is known for its accuracy in detecting objects of varying scales and has been proven effective in complex real-world scenarios.
You Only Look Once (YOLO)	YOLO is known for its fast inference speed and high accuracy, making it suitable for real-time applications like crash detection. YOLO-based object detection can be integrated with other sensor data, such as radar and lidar, to improve object tracking and increase the system's robustness.
Single Shot Multibox Detector (SSD)	SSD employs a single-shot approach, where it predicts object bounding boxes and class probabilities directly from a fixed set of default bounding boxes across multiple feature maps. SSD serves as a powerful and efficient object detection component within such a comprehensive system, helping to identify potential crash-related objects in real time and enabling timely warnings and interventions to enhance road safety.

Table 3. Sophisticated deep learning-based object detection models

4. Drowsiness detection subsystem

Whilst the word "drowsiness" is frequently used, "fatigue" is also used. Nevertheless, their distinctions, exhaustion, and sleepiness are sometimes used synonymously [28]. Doing the same work for an extended amount of time or via physical or mental exhaustion may end up in fatigue [29]. However, the definition of tiredness or drowsiness is the desire to sleep. Drowsiness essentially results from a compelling biological urge for sleep [29]. Numerous factors, including medications, lengthy workdays, sleep problems, insufficient or low-quality sleep, and prolonged periods of awake time, can cause fatigue [29]. As a result, it is clear that they are related since weariness directly causes sleepiness.[27]

Deep learning techniques can be used to automatically recognize tired faces by monitoring closed eyes, yawns, or facial expression changes. In this research [3], ocular winks are measured utilizing an IR sensor component. Infrared radiation is sent by the infrared (IR) transmitter and returned to the detecting element by the infrared receiver. For people with prescribed spectacles, it is impractical to wear two eye gears. Wearing a gadget like an eye blink sensor at all times can be uncomfortable for people who work as full-time drivers. Convolutional neural networks (CNNs) especially excel in this because they can extract hierarchical features from discrete video image frames.

This technology, which is addressed in the publication [50], is primarily designed to monitor the driver's facial expressions and gaze. The system will provide an alert message if it detects that the driver has become sleepy. The sound of a buzzer alerts the driver when sleepiness is identified. The pulse, blood alcohol content, and eye blinking rates are measured utilizing sensors that monitor heart rate, blood alcohol content, and eye blink rates, accordingly, in the driver. There are several items available that assess the amount of driver weariness and are used in numerous automobiles. A similar capability is offered by the driver sleepiness identification and wellness surveillance system but with superior outcomes and further advantages. Additionally, it warns the user when the sleepiness gauge reaches a particular point of saturation.

The approach that is being proposed here [51] is intended to reduce the number of accidents that occur as a result of sleepy driving. The Raspberry Pi and Internet of Things (IoT) technologies are used to build a system that can track driver sleepiness and the potential consequences of collisions. An in-car Pi camera may be used to detect the driver's tiredness or exhaustion. For sensing the extreme of an impact, the vehicle also needs to be properly installed with a collision sensor and an FSR monitor. An audio speaker alerts the driver and the proprietor of the car by mailing when sleepiness is noticed. Similarly, imagine that a sudden accident occurs as a result of being sleepy. In such instances, the closest hospitals to the accident site are notified through a Google Maps link using the data gathered by the detectors and the notification of the alert.

Wavelet connectivity was used by Jemai et al. [32] to develop a method for a drowsiness warning system. With the aid of classification techniques like Wavelet Network Classifier (WNC), which especially depends on Fast Wavelet Transform (FWT), that network watches eyeballs by making binary judgments (aware or not). The physiological factors include heart rate and ECG, which are repeatedly retrieved using Babaeian et al.'s [33] wavelet conversion with regression approach for tiredness diagnosis. This theory was applied to the categorization of heart rate data using a wavelet network, which may provide an average method for a sleepiness alert system.[34]

In the review, we could see that the proposed systems do have the power to reduce the problem or the damage caused by it significantly. The systems may not be fully enhanced or optimized but they are proactive, intelligent, and effective in reducing the problem to some extent.

IV. FUTURE DIRECTION

There is immense potential for transformative advancements in the contributions made in this field as deep learning and IoT are two major promising areas of research.

1. Edge Computing and IoT: Improving the usage of edge computing to process data closer to the source. This will help in generating responses faster and improve results. Combining cutting-edge technologies with IoT to develop a robust system to tackle the issues.

2. Federated Learning: Federated Learning enables the cooperative training of DL models across several edge devices without the need to share raw data. In sensitive sectors like healthcare and finance, where data security and privacy are crucial, this privacy-preserving strategy will be essential.

3. AIoT (Artificial Intelligence of Things): More autonomous and intelligent systems will be created as a result of the combination of AI with IoT, or AIoT. AIoT devices will be able to self-optimize, self-heal, and make adaptive decisions based on ongoing environmental learning.

4. 5G Connectivity: The widespread use of 5G technology will have a big influence on Internet of Things applications. 5G will make it possible to deploy more advanced IoT systems because of its faster data rates, reduced latency, and improved device capacity.

5. Custom Hardware Acceleration: Custom hardware accelerators, such as neuromorphic chips and specialized AI processors, will proliferate to match the computational demands of DL models, enhancing the effectiveness and speed of DL calculations.

6. Sustainable IoT: IoT systems will be designed to be more environmentally friendly and energy-efficient. The environmental effect of IoT deployments will be diminished through the creation of low-power sensors and renewable energy options.

7. Ethical AI and Responsible Deployment: Addressing ethical issues and ensuring responsible AI-driven system deployment will be essential to prevent unexpected biases and potential societal repercussions as IoT and DL grow more pervasive in our lives.

In order to address real-world problems and enhance the quality of life, the synergy between IoT and DL will continue to spur innovation, enhance automation, and produce more intelligent and connected systems. Road safety may be considerably improved by combining the Internet of Things (IoT) with Deep Learning (DL) technology for accident detection and prevention.

Deploying IoT sensors by carefully planning and considering factors like sensor type, location, connectivity, and range in an environment to form a network of multiple sensors used to monitor various parameters.

One of the most important steps in harnessing the potential of Deep Learning (DL) algorithms is to gather real-time data from the Internet of Things sensor network and feed it into a centralized data processing system. The DL algorithms will use this data as input so they can assess it and choose the best course of action. When a substantial change in the parameter is noticed, the sensors may be set up to provide data immediately or at predetermined intervals. The DL algorithms' judgments may result in immediate responses or actions. Real-time data analysis using simple computation making it faster to compute results. Using this we can drastically improve the prevention and detection capabilities. Determine any unusual trends that could point to an impending collision or dangerous driving conditions. Utilize DL models to predict possible accident hotspots using both real-time and historical data.

Allow automobiles to connect with one another using V2V (Vehicle-to-Vehicle) protocols. By exchanging vital safety information, this communication can improve situational awareness and lower the chance of accidents.

Increase public awareness of the need of driving safely as well as the advantages of IoT and DL-based accident prevention technologies. Inform drivers, pedestrians, and other road users about safe driving habits and the value of obeying the law. Make sure the IoT and DL system upholds data security and privacy. Protect sensitive data from unwanted access by implementing encryption and authentication procedures. Accurate capacities for accident prevention and detection will result from ongoing progress.

V. CONCLUSION

Finally, this paper investigated the intriguing confluence of accident prevention and detection using Internet of Things (IoT) technologies and deep learning algorithms. The creation of sophisticated systems to reduce accidents becomes crucial given the rising number of cars on the road and the priority that road safety is receiving. IoT devices and deep learning algorithms have emerged as a viable solutions to addressing this difficulty. We looked at a variety of academic articles and real-world applications that demonstrated the potential of IoT-enabled sensors and deep-learning models for accident prevention and detection. These systems showed the capacity to record real-time data, examine it for possible dangers, and take prompt preventative action.

Let us highlight the key findings:

- IOT components: The integration of IoT gadgets like cameras, GPS, gas sensors, and ultrasonic sensors made it possible to collect rich, real-time data from automobiles and the infrastructure of roads. This information is helpful in analyzing driving patterns, conditions in the environment, and potential risks.
- Deep learning algorithms: DL algorithms in particular CNN are super effective in analyzing data from IOT devices.
- Systems to assist drivers: The combination of IoT and deep learning has led to the development of advanced systems that assist the driver in a safer ride by providing real-time feedback.
- Emergency responses: The automated emergency responses triggered during risky situations help in facilitating quicker response and potentially saving a life.

As these technologies continue to advance, the potential to create smarter, safer roadways becomes increasingly feasible, saving lives and improving overall road safety. However, ongoing research, testing, and collaboration between researchers, policymakers, and industries are essential to fully realize the transformative impact of IoT and Deep Learning in accident prevention.

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