AI DRIVEN ACCIDENT DETECTION AND RECOVERY SOLUTION

PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

"AI DRIVEN ACCIDENT DETECTION AND RECOVERY Solution " is a smart accident detection and recovery notification system designed to improve road safety and enhance emergency response times. This system integrates advanced sensors such as accelerometers, gyroscopes, and GPS to detect accidents through rapid changes in movement and location. Using real-time data analysis and machine learning algorithms, it distinguishes between actual accidents and minor impacts, ensuring reliable detection. Upon confirming an accident, the system automatically sends alerts to emergency contacts and local services, providing precise location data to reduce response time. A user-friendly mobile interface enables drivers to customize emergency contacts, monitor accident history, and access immediate assistance options like nearby hospitals or towing services. Additionally, this system can be equipped with optional features to monitor road conditions and provide weather-related hazard alerts, further safeguarding drivers from potential risks. Cloud connectivity and data management allow for secure data storage and post-accident analysis, supporting continuous improvement while adhering to privacy regulations. "Guardian Angel on the Road" aims to serve as an essential tool in modern road safety, reduce

SUSTAINABLE DEVELOPMENT GOALS

This project aligns with the United Nations Sustainable Development Goals (SDGs), addressing critical areas of environmental and social impact through the innovative application of technology.

Goal 9: Industry, Innovation, and Infrastructure

Promoting Innovation in Road Safety Technology: By integrating advanced sensors, machine learning algorithms, and real-time data processing, the system contributes to technological innovation in road safety. This supports safer and more intelligent transportation infrastructure, driving innovation within the safety technology sector.

Goal 11: Sustainable Cities and Communities Enhancing Urban and Rural Road Safety: By providing rapid accident detection and immediate notification to emergency services, the system contributes to safer roadways. This can reduce fatalities and injuries, making cities and communities safer places for all residents and visitors.

Goal 13: Climate Action

Minimizing Environmental Impact of Accidents: Prompt notification and response to accidents reduce the risk of hazardous spills, such as fuel or oil leaks, from vehicles involved in crashes. This can prevent pollutants from entering soil or waterways, thus reducing potential environmental harm.

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CHAPTER 1

INTRODUCTION

Expressways, highways and roads are becoming overcrowded with increasing of large number of vehicles. Intelligent transportation systems (ITS), applied to collect, cognize, and manage information about transportation flows from various sources, are emerging worldwide to make transportation more efficient, reliable, cleaner and safer. The requirement to detect, track, and count the moving vehicle is getting very important for traffic flow monitoring, planning, and controlling. The vehicle detections can be traditionally achieved through inductive loop detector, infrared detector, radar detector or video-based solution. Compared to other techniques, the video-based solutions based on surveillance camera mounted outdoor are easily influenced by environments such as weather, illumination, shadow, etc.

However, because video-based systems can offer several advantages over other methods such as traffic flow undisturbed, easily installed, conveniently modified, etc., they have drawn significant attention from researchers in the past decade. A traditional computer vision method for moving objet detection in video-based system is so-called "background subtraction", or computing the difference between a background model and current frame, which demands to estimate a robust background to deal with the changing object. This case of vehicle detection on road, an adaptive rather than static background is needed for real-time road situations.

Regarding to real-time vehicle tracking system, the crucial issue is initiating a track automatically .Here we describe two systems problem is attacked quiet differently. Because the camera is fixed, the virtual detector can be chosen to span each lane and the system then monitors changes in area of virtual detector that indicate the presence of a vehicle.

1.1 PROJECT OVERVIEW:

The Accident Detection Using AI project aims to develop a sophisticated real-time system that leverages artificial intelligence to enhance road safety and improve emergency response times. By integrating various sensors, such as cameras and LIDAR, with advanced machine learning algorithms, the system will analyze traffic conditions and detect accidents automatically. The project focuses on real-time data processing and alerts to notify drivers and emergency services promptly, significantly reducing response times compared to traditional methods. Through rigorous testing and validation, the project seeks to address challenges such as data privacy and environmental variability, ultimately contributing to safer roadways and minimizing the impact of traffic incidents.

1.2 EXISTING SYSTEM:

The existing systems for accident detection primarily rely on traditional, manual methods that are often slow and reactive. Currently, accidents are reported by bystanders or involved parties, leading to delays in notifying emergency services. Traffic monitoring cameras are used in many urban areas, but these lack automated detection capabilities and often require human operators to monitor multiple feeds, resulting in missed incidents. Additionally, roadside sensors may track vehicle counts and speeds but do not detect accidents directly. As a result, the existing systems face significant challenges in providing timely and accurate responses, highlighting the need for a more efficient solution through the implementation of AI technologies.

1.3 PROPOSED SYSTEM:

The proposed system aims to transform accident detection through the implementation of an AI-driven solution that offers real-time monitoring and automatic alerts. By integrating advanced sensors, such as cameras and LIDAR, with machine learning algorithms, the system will continuously analyze traffic conditions and detect accidents autonomously. Upon detecting an incident, it will instantly notify emergency services and nearby drivers, significantly reducing response times compared to traditional methods. Utilizing edge computing for immediate data processing, the system will enhance efficiency and minimize latency. Additionally, continuous learning from new data will allow the system to adapt and improve over time, ultimately contributing to safer roadways and more effective emergency responses.

1.4 OBJECTIVES

The Accident Detection Using AI project aims to develop a robust automated system that enhances road safety through accurate real-time accident detection. The primary objective is to leverage advanced machine learning algorithms and integrate data from various sensors, such as cameras and LIDAR, to identify accidents promptly. This will significantly improve emergency response times by providing immediate notifications to relevant authorities and nearby drivers. Additionally, the project seeks to utilize edge computing to ensure real-time data processing, minimizing latency and enhancing response efficiency. User friendly interfaces will be designed for both emergency responders and drivers, facilitating clear communication and efficient information sharing during Incidents. Finally, the system will emphasize continuous learning and adaptation, allowing it to evolve based on new data and changing road conditions, ultimately contributing to safer roadways and more effective.

1.5 SUMMARY

The Accident Detection Using AI project aims to enhance road safety through an innovative automated system designed for real-time accident detection. By incorporating a variety of sensors, such as cameras and LIDAR, the system will employ machine learning algorithms to monitor traffic conditions and swiftly identify accidents. When an incident is detected, the system will instantly notify emergency services and nearby drivers, significantly improving response times and potentially saving lives. Utilizing edge computing will allow for quick data processing, reducing latency and increasing operational efficiency. Furthermore, the project will focus on developing user- friendly interfaces to facilitate seamless communication between emergency responders and drivers during emergencies. With an emphasis on continuous improvement, the system will learn and adapt over time based on new data and evolving road conditions, ultimately contributing to safer roadways and a more efficient emergency response network.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Mr. S. Kailasam, Mr. Karthiga, Dr. Kartheeban, R.M. Priyadarshani, K Anithadevi[1] states that due to lack of attention, Drowsiness, and drunk driving are the major causes of road accidents, this paper proposes preparing a system to prevent these circumstances. The proposed system herein aims at preventing and controlling accidents by using a Night Vision Camera. This system monitors the driver's face when the car starts which mainly helps in observing continuously. It uses two functions: One to detect the eye blinking, second is for reading the blinking

Rajvardhan Rish, Sofiya Yede, Keshav Kunal, Nutan V Bansode [2] proposed a system which states that the leading cause of deaths in road accidents is due to delay in medical help. This can be prevented by messaging the authorities and emergency contacts too on time. The system consists of GPS, GSM, accelerometer and Arduino. It alerts nearest hospital, police headquarters, family and friends during the time of mishap mainly by detecting changes in accelerometer. The system sends a google map link using GPS module and Arduino. The vehicle sets the flag bit of the Arduino UNO as an accident is identified until it detects abrupt deviation from the threshold values with the help of the measuring system detector. Throughout the accident, the device sets the effective sensitive value for measuring instrument detectors, unless a crash is observed. Once the accident or set bit is detected by the measuring instrument detector, Arduino activates the GSM module, which has a manually saved signal of the accident victim's emergency contact, and sends a pre-stored SMS to that contact.

T Kalyani, S Monika, B Naresh, Mahendra Vucha[14] have proposed three main components in this system namely vibration sensors, GPS and GSM module. When a vehicle meets with an accident, the vibration sensor will read the impact and Arduino will then compare it with the threshold value set in 6 the program. If the value exceeds the threshold value then GPS will generate the current location and GSM will send the alert message to respective authorities with the help of Arduino

Bruno Fernandes, Vitor Gomes, Joaquim Ferreira and Arnaldo Oliveira [5] proposed system with a HDy Copilot, an Android application for accident detection integrated with multimodal alert dissemination. An android mobile is also used so that the rider can use the app, receive road hazard alerts from other vehicles in the area, and cancel countdown procedures if a false accident is detected. The software used are IT2S ITS-G5, GPS, 2 radio frequency (RF) modules, a field programmable gate array, USB. They demonstrated an accident detection system using an Android smartphone, ODB-II data, and vehicular communications, all of which were integrated with the e-Call platform: When an accident is identified, a DENM alert is sent to all nearby vehicles, along with SMS and voice calls to the emergency number. However, the major drawback faced was the same that is damage of smartphone/loss of signal which renders system useless.

According to Manuel Fogue, Piedad Garrida, and Francisco J. Martinez [6,] vehicular networks would play a larger role in the Intelligent Transportation System sector, reducing road fatalities. The majority of its uses, such as traffic control, fleet management, and navigation. These would be dependent on vehicle-to-roadside infrastructure communication, or even vehicle-to-vehicle communication. The introduction of sensoring technologies on-board vehicles, as well as peer-to-peer mobile communication between vehicles, are expected to result in major safety improvements in the near future.

Piedad G., Manuel F., Francisco J. M. [7] proposed a framework defines a smart system that automatically detects, notifies, and estimates the magnitude of 4 road accidents across vehicle networks on the basis of the principle of data mining and information inference. On-Board Unit (OBU) sensors, the data acquisition unit, the processing unit and wireless interfaces, V2V and V2I communications, Control Unit (CU), Information Discovery in Databases are the libraries and applications used to implement the system (KDD). A prototypefor automated accident and assistance based on V2V and V2I communications has been developed and implemented by the authors. Results showed that vehicle speed is a key factor in front crashes after a careful selection of relevant characteristics, but the type of vehicle involved and the speed of the hitting vehicle are more significant in side and rear-end collisions than speed itself.

Usman Khalil, Tariq Javid, and Adnan Nasir [8] have proposed a system for sending accident messages to emergency services using the Vehicular AD- Hoc Network (VANET). VANET assists these services in finding the best route to their destination by using the ABEONA algorithm, a traffic signal module.Based on data obtained from mobile sensors, this algorithm confirms an accident. This is a less expensive choice. Smartphone, GPS receiver, accelerometer, magnetometer, and gyroscope are the components used to implement the device proposed by Harit S., Ravi K.R., Archana K. [9]. It uses a collision index and a crash detection algorithm. A few common crash detection systems are also smartphone-based and use MEMS sensor data collected in real- time while driving. However, data obtained from smartphone builtin sensors may contain significant noise, and therefore most current solutions may reduce detection accuracy and lead to false positives.

Hossam M. Sherif, M.Amer Shedid, and Samah A. Senbel [10] suggested a solution in which three key components, namely the Node algorithm, Router algorithm, and Coordinator algorithm, are required to facilitate the accident report. During a road accident, the Real Time Traffic Accident Detection System (RTTADS) can intelligently notify the accident site through a wireless interface. It will also notify the appropriate authorities. It will not only tell you how many people have died, but also what kind of emergency services are needed. RFID sensors, an RF module, a wireless module, a crash sensor, a rollover sensor, a fire alarm sensor, a weight sensor, and a microcontroller are among the system hardware components. The proposed system would detect an accident in real time and send information to the supervisory programme about the accident site, vehicle speed (before the impact sensors are triggered), number of passengers in the vehicle, crash sensors that have been activated (front, back, right side, and left side), rollover sensor status, and fire alarm sensor status

Ms. Sharmila S. Gaikwad [11] proposes an agent-based framework for the extremely complex and variable sense of healthcare emergency decision support. It emphasizes the value of using mobile agents to help the real-time deployment of an emergency service, rather than just hypotheses.

Md. Syedul Amin, Jubayer Jalil, M. B. I. Reaz [12] have stated that speed is one of the most important and basic risk factors in driving. Not only does it affect the severity of a crash, but it also raises the likelihood of a crash.

CHAPTER 3

PROJECT DESCRIPTION

3.1 WORKING

The Accident Detection System works by using a camera, Arduino, GSM module, DFPlayer Mini, and a speaker to detect accidents and send emergency alerts. The camera captures live video, which is analyzed using OpenCV to identify accidents. If an accident is detected, the system sends a signal to the Arduino. Additionally, a vibration sensor or accelerometer can be used to detect crashes. Once the Arduino receives the signal, it activates the GSM module to send an SMS alert to emergency contacts with accident details. If a GPS module is included, it will also send the exact location. At the same time, the DFPlayer Mini plays a pre-recorded emergency message through a speaker, alerting people nearby. This system helps in quick accident detection, automatic alerts, and faster emergency response, which can save lives. It can be further improved by adding IoT connectivity or AI-based analysis for better accuracy.

3.2 INPUT

The video is input to the system. The collected video is read through opencv library. The system involves capturing of frames from the video. The input is from the cctv install in highway road or any road where there is a necessity to reduce the accident. In real time mostly the video is from the cctv.

3.3 BACKGROUND LEARNING MODULE

This is the second module in the system whose main purpose is to learn about the background in a sense that how it is different from the foreground. Furthermore as proposed system works on a video feed, this module extracts the frames from it and learns about the background. In a traffic scene captured with a static camera installed on the road side, the moving objects can be considered as the foreground and static objects as the background. MOG algorithms are used to learn about the background using the above mentioned technique. It is a Gaussian Mixture-based Background/Foreground Segmentation Algorithm. It uses a method to model each background pixel by a mixture of K Gaussian distributions (K = 3 to 5).The probable background colours are the ones which stay longer and more static. While coding, we need to create a background object using the function, cv2.createBackgroundSubtractorMOG().It has some optional parameters like length of history, number of gaussian mixtures, threshold etc.

3.4 FOREGROUND EXTRACTION MODULE

This module consists of three steps, background subtraction, image enhancement and foreground extraction. Background is subtracted so that foreground objects are visible. This is done usually by static pixels of static objects to binary 0. After background subtraction image enhancement techniques such as noise filtering, dilation and erosion are used to get proper contours of the foreground objects. The final result obtained from this module is the foreground.

3.5 ACCIDENT DETECTION

The third module in the proposed system is accident detection, which identifies collisions between vehicles based on movement analysis. After applying the foreground extraction module, the system detects and isolates vehicle contours from the video feed. Various features such as centroid, aspect ratio, area, size, and solidity are extracted to classify objects as vehicles. To track their movement, a bounding box is placed around each detected vehicle. The system continuously monitors these bounding boxes, and when two bounding boxes collide or overlap beyond a certain threshold, it determines that an accident has occurred. This allows the system to classify each frame as either a normal vehicle movement or an accident, enabling real-time detection and response to traffic incidents.

3.6 ALARM ALERT

The first step in building the alarm system is to import the required packages into the Python code. These packages will help in handling audio playback and integrating the alarm system with accident detection. Next, alarm tunes need to be added to the project folder, which will be played when an accident is detected. The purpose of this alarm is to alert nearby people about the incident, ensuring a quicker response and assistance. By generating an immediate sound notification, the system helps in reducing response time and increasing the chances of quick recovery from the accident.

3.7 HOSPITAL MAIL ALERT

The system uses Geocoder to determine the exact location of the accident by converting geographical data, such as coordinates or addresses, into a precise location on the Earth's surface. Once the location is identified, the SMTP (Simple Mail Transfer Protocol) is used to send an automated email to the nearest hospital or rescue station. This ensures that emergency responders receive real-time alerts with location details, enabling them to allocate resources efficiently and take immediate legal or medical action. This module plays a crucial role in reducing response time and improving accident recovery efforts, ensuring timely assistance to those in need.

3.8 GAUSSIAN MIXTURE MODELLING

GMM is used to reconstruct the mean image after block processing. Specifically, the Gaussian distribution in GMM is initialized, and then Gaussian distributions in the existing GMM are used to detect whether each pixel in the current image frame matches them. The pixel is considered to match the Gaussian distribution if the new pixel and the Gaussian distribution of GMM

$$\left|d_{ij}^{m,k}\right| \leq \rho\sigma_{ij}^{m-1,k}$$

$$d_{ij}^{m,k} = G_{ij}^{m} - M_{ij}^{m-1,k}$$

where d is the absolute distance between the new pixel and the mean value of the k-th Gaussian distribution model, is the deviation threshold, m represents the standard deviation of the current image frame pixel, m G represents the pixel of the current image frame, m k 1, M represents the mean value of the current image frame pixel, i represents the number of rows of the current image frame, j represents the number of columns of the current image frame, k represents the number of Gaussian distributions, m represents the number of image frames.If the new pixel matches the k-th Gaussian distribution model, the parameters of the Gaussian distribution model can be updated as follows:

$$w_{ij}^{m,k} = (1-\alpha)w_{ij}^{m-1,k} + \alpha$$

$$M_{ij}^{m,k} = (1-p)M_{ij}^{m-1,k} + pG_{ij}^{m}$$

$$\sigma_{ij}^{m,k} = \sqrt{(1-p)(\sigma_{ij}^{m-1,k})^2 + p\left(d_{ij}^{m,k}\right)^2}$$

Where represents the learning rate, which determines the updating speed of the background, m k, w represents the weight of pixels of the current image frame, p represents the update rate, the relationship of which with the other parameters can be expressed as: , m k p w .If the new pixel does not match any Gaussian distribution, a new Gaussian distribution is created to replace the Gaussian distribution with the smallest existing weight. The average of the newly created Gaussian distribution will be the average of the currently observed pixels, the standard deviation will be set to the maximum value of the initialization, and the weight will be set to the minimum value of the initialization. The weight of the other Gaussian distributions will be updated to the ones determined by following equation:

Based on, the priority of the k Gaussian distributions is determined from large to small. The higher the priority is, the more stable the Gaussian distribution is, and

the closer it is to the background, so the first B Gaussian distributions are used to establish the background model

$$w_{ij}^{m,k} = (1-\alpha) w_{ij}^{m-1,k}$$

$$B = \arg\min_b \langle \sum_{k=1}^{b} w_{ij}^{m,k} > \tau \rangle$$

3.8.1 FINDING CONTOURS

In this method, the shape of the vehicle is identified by setting boundaries around regions of interest (the vehicle) in the image frames. In the next steps, we can get the coordinates of these contours in the image frame and locate the vehicle.Utilizing these methods selectively, we can easily locate the movements of vehicles in the video or image frame and detect them.

3.8.2 IMAGE THRESHOLDING

This method works by assigning one of the two values based on a threshold to the pixels in a grayscale image. If the value of a pixel exceeds a threshold value, then it is assigned a particular value; else, it is given another value. The objective is to remove unwanted highlighted areas by obtaining a resultant binary image.

3.8.3 FRAME DIFFERENCING

We know that a video is essentially a collection of image frames put together and played in a continuous stream. Therefore, it is noticeable that the vehicle changes coordinates in each successive frame and, hence, its location. Also, it can be noted that only the pixels representing the vehicle will undergo changes in these consecutive frames. Thus, the frame differencing method aims to notice the changes in the pixel and location of the moving vehicle.

3.9 BLOCK DIAGRAM

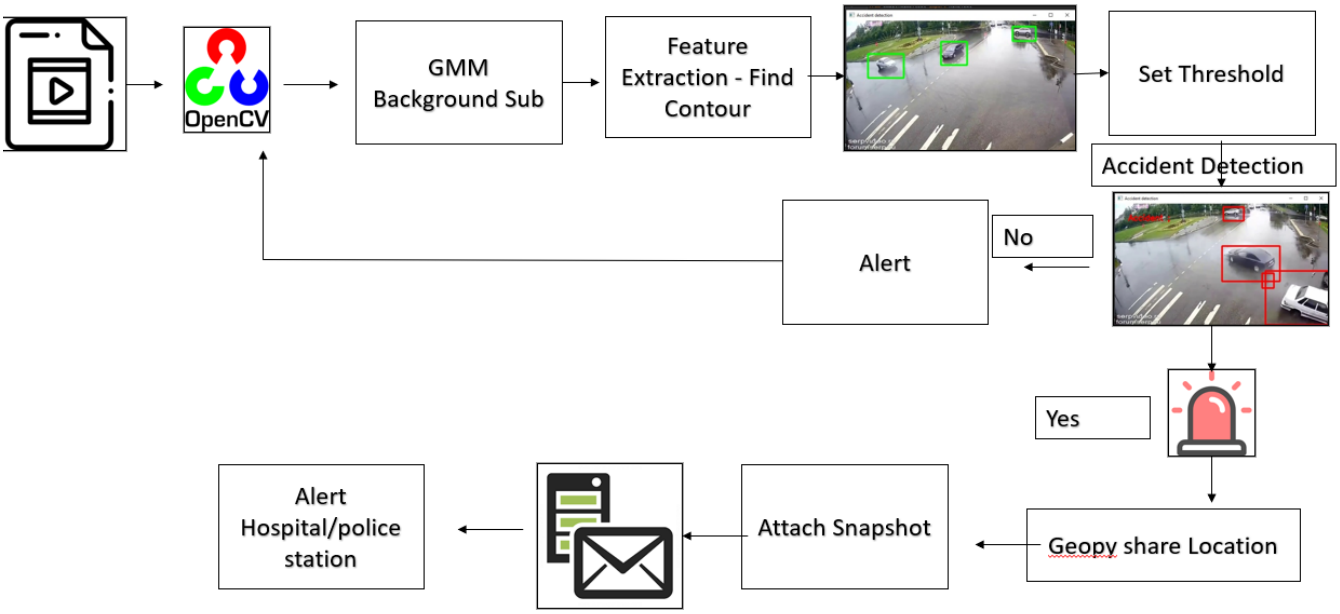

FIG 3.9 BLOCK DIAGRAM

VIDEO INPUT

This block represents the source of video footage, which could be a live feed from a CCTV camera or a pre-recorded video. The video provides real-time traffic data, capturing vehicle movements and potential accident scenarios. The system continuously processes this video to detect any unusual activity.

OPENCV PROCESSING

This is the core processing unit where OpenCV functions are used for video analysis. It includes multiple steps:

GMM BACKGROUND SUBTRACTION

The Gaussian Mixture Model (GMM) is a popular background subtraction technique.It helps remove static elements (such as roads, traffic lights, and stationary vehicles) and isolates moving objects like vehicles and pedestrians.This method ensures that only relevant motion is considered for accident detection.

FEATURE EXTRACTION – FIND CONTOUR

Contour detection helps identify the shape and boundaries of moving objects. OpenCV's find Contours() function is used to extract the contours of detected objects. These contours allow the system to track movement patterns and detect any abrupt changes, such as a vehicle deviating from its path suddenly.

BOUNDING BOX DETECTION

Once contours are detected, the system places bounding boxes around them. These boxes help visualize detected objects, such as moving cars or pedestrians. Each moving object is tracked using the bounding boxes, which aid in identifying sudden motion changes, such as crashes or abrupt stops.

SET THRESHOLD

The system applies a predefined threshold to distinguish between normal movements and potential accidents. If the movement pattern of an object deviates significantly (e.g., an extremely sudden stop, an impact between two objects, or a vehicle overturning), it crosses the threshold, signaling an accident. If the motion does not meet accident criteria, the system continues monitoring without raising an alert.

ACCIDENT DETECTION

This decision-making block determines whether an accident has occurred. If no accident is detected, the system loops back to continue monitoring the video feed.If an accident is detected, an alert is generated, triggering emergency response mechanisms.

ALERT MECHANISM

If an accident is detected, the system initiates multiple actions:Attach Snapshot A screenshot of the accident is captured from the video feed. This snapshot serves as evidence and helps emergency responders assess the severity of the accident.

GEOPY LOCATION SHARING

Using Geopy, the system extracts and shares the GPS coordinates of the accident location. This ensures that emergency services receive precise information about where the accident occurred.

ALERT HOSPITAL/POLICE STATION

The system automatically sends an alert to nearby hospitals and police stations. This alert includes: The snapshot of the accident scene The GPS location for immediate response Additional accident details, such as time and security

3.10 CIRCUIT DIAGRAM

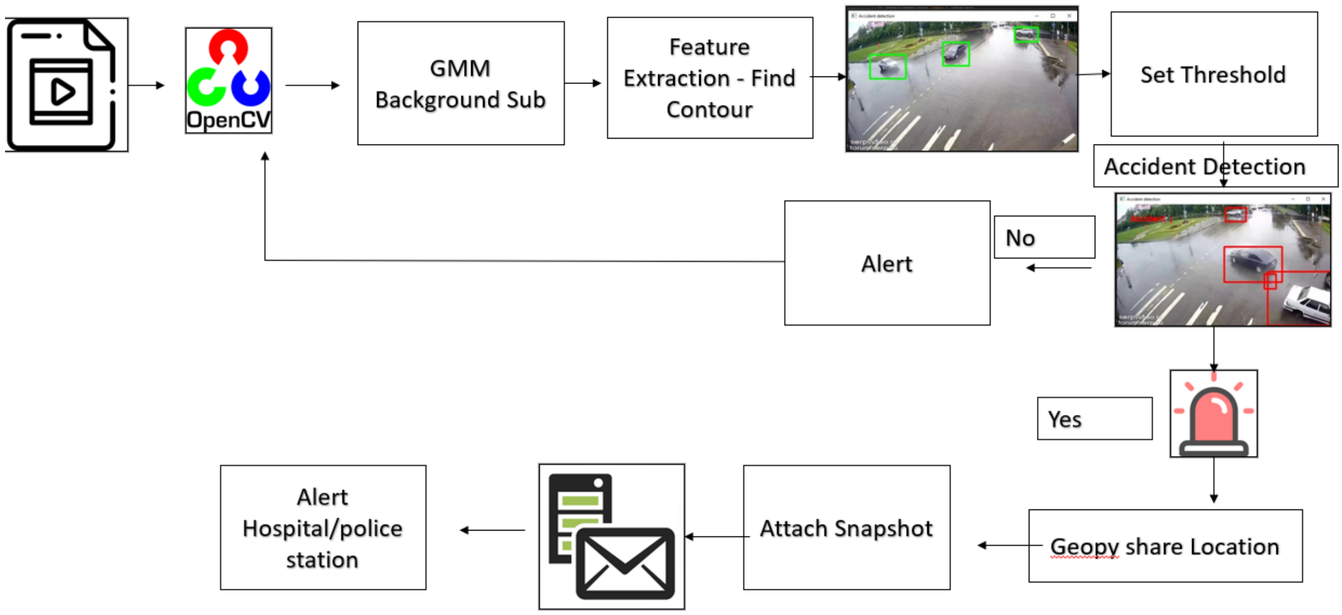

FIG 3.10 CIRCUIT DIAGRAM

The AI-driven accident detection system using Arduino UNO, OpenCV, a speaker, DFPlayer, and a GSM module is designed to provide real-time accident monitoring, automated alerts, and emergency communication, ensuring quick response in critical situations. The system leverages computer vision, embedded electronics, and wireless communication to enhance road safety by detecting accidents as they happen and notifying the necessary authorities or contacts. The process begins with OpenCV, which uses a connected camera to continuously analyze road traffic and identify accident scenarios based on motion detection, object recognition, and collision detection techniques. When an accident is detected, OpenCV processes the event and sends a trigger signal to the Arduino UNO via serial communication. The Arduino acts as the central processing unit and executes multiple actions based on the received signal.

One of the key responses triggered by the Arduino is the activation of the DFPlayer Mini, a compact MP3 module that plays pre-recorded emergency audio alerts through a speaker. The recorded message, stored on a microSD card, serves as an immediate alert for nearby people, urging them to provide assistance. The speaker may announce messages like “Emergency! An accident has occurred. Please assist immediately.” This ensures that anyone in the vicinity is aware of the incident, enabling a quicker human response. Simultaneously, the GSM module (SIM800L or SIM900A) is activated to send an SMS notification or make a call to predefined emergency contacts, such as ambulance services, police stations, or family members. The SMS contains essential details such as the occurrence of an accident, and if a GPS module (like NEO-6M) is integrated, the exact geographical location is also sent in the message. This feature helps emergency responders locate the accident site quickly, reducing delays in medical assistance.

The system is highly efficient, user-friendly, and cost-effective, as it utilizes readily available components like Arduino and GSM modules while maintaining high accuracy in accident detection. Unlike traditional accident response mechanisms that rely on manual reporting, this system eliminates delays by automatically detecting incidents and notifying the appropriate contacts. Additionally, the system is customizable and scalable, allowing enhancements with additional sensors like accelerometers, gyroscopes, IoT connectivity, and cloud-based monitoring for even more advanced accident detection. Overall, this AI-driven accident detection and alert system is an essential solution for improving road safety, ensuring immediate emergency response, and potentially saving lives by minimizing the time between an accident and medical assistance.

CHAPTER 4

HARDWARE AND SOFTWARE DESCRIPTION

4.1 HARDWARE DESCRIPTION

4.1.1 ARDUINO UNO (ATmega328P)

An Arduino board plays a crucial role in an accident detection and recovery solution by acting as a low-cost microcontroller for sensor integration and real-time data processing. It can interface with various sensors such as accelerometers, gyroscopes, vibration sensors, GPS modules, and gas sensors to detect sudden changes in speed, impact, and environmental hazards. When an accident occurs, Arduino processes the data and triggers an alert system using a GSM module to notify emergency services or predefined contacts with the vehicle's real-time location. Additionally, it can activate buzzers, LED indicators, and LCD displays to alert nearby pedestrians and responders. In severe accidents, Arduino can also cut off the vehicle's ignition to prevent further hazards. For enhanced capabilities, it can be integrated with Raspberry Pi to process real-time video feeds using OpenCV for AI-driven accident detection. Furthermore, cloud connectivity allows for remote monitoring and emergency response coordination via platforms like Thing speak or Firebase. Overall, Arduino serves as an efficient and cost-effective component in an intelligent accident detection and recovery system.

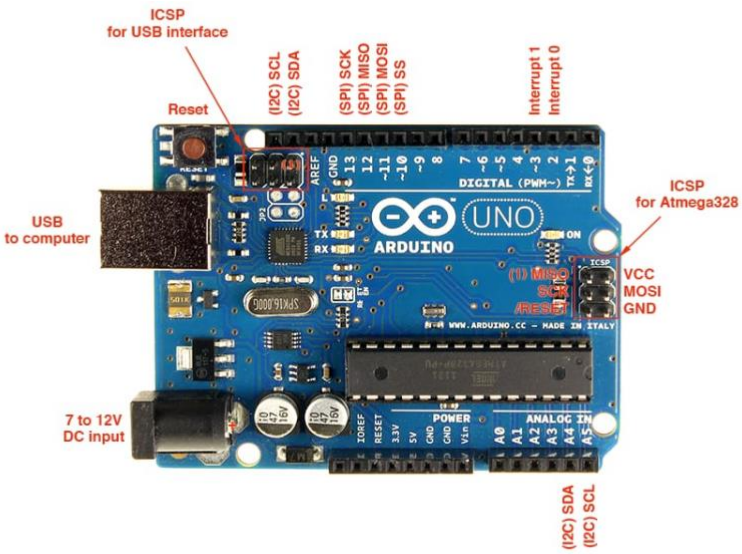

FIG 4.1.1 ARDUINO UNO (ATMEGA328P)

4.1.2 GSM MODULE

A GSM module in an accident detection system plays a crucial role in real-time communication by sending alerts and location details to emergency services or predefined contacts. When an accident occurs, the Arduino processes data from sensors such as accelerometers, gyroscopes, and vibration sensors, then triggers the GSM module to send an SMS or make a call with the vehicle's GPS coordinates. Common GSM modules like SIM800L, SIM900, and SIM7600 enable wireless communication, with SIM800L and SIM900 supporting SMS, calls, and GPRS (2G), while SIM7600 offers 4G LTE for faster data transmission. The system retrieves GPS data using modules like NEO-6M and includes the exact accident location in the alert message. Additionally, advanced systems can integrate with cloud platforms via GPRS or LTE for real-time monitoring. This ensures a quick emergency response, improving accident recovery and potentially saving lives. By leveraging GSM communication, an accident detection system ensures faster emergency response, reducing fatalities and injuries. Whether implemented as a standalone system using SMS alerts or as part of a cloud-based AI-driven solution, the GSM module significantly enhances the reliability of accident recovery solutions.

FIG 4.1.2 GSM MODULE

4.1.3 DFPLAYER MINI MP3

The DFPlayer Mini MP3 module enhances an accident detection system by providing audio alerts and voice messages, improving emergency response. When an accident is detected through sensors such as accelerometers or vibration sensors, the DFPlayer Mini can play pre-recorded voice messages stored on a microSD card, informing passengers and bystanders about the situation with messages like "Accident detected! Sending alert..." or "Emergency help required at this location." This ensures that even if the victim is unconscious, the system can automatically notify people nearby. Additionally, it can work alongside a GSM module (SIM800L/SIM900) to confirm that an emergency SMS or call has been sent by playing an audio message such as "Message sent to emergency contacts." The system can also integrate a GPS module (NEO-6M) to announce real-time location details, helping responders find the accident site more quickly. Furthermore, the DFPlayer Mini can play alarm sounds, sirens, or loud beeps to attract attention in case of a crash. If the system includes a manual SOS button, a user can trigger an emergency voice message if they need help but are unable to send a text alert. By integrating the DFPlayer Mini with Arduino or ESP32, the accident detection system becomes more interactive and effective, ensuring both victims and rescuers receive clear audio guidance and improving response times to save lives.

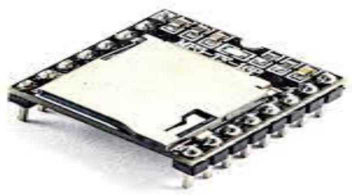

FIG 4.1.3 DFPLAYER MINI

4.1.4 SPEAKER

A speaker in an accident detection system plays a vital role in providing audio alerts, emergency notifications, and guidance to both victims and nearby responders. Integrated with a microcontroller like Arduino or ESP32, the speaker can produce voice alerts, alarm sounds, or sirens to attract attention immediately after an accident occurs. When sensors such as accelerometers, gyroscopes, or vibration sensors detect a collision, the system can trigger the speaker to play a pre-recorded message using a DFPlayer Mini MP3 module, informing bystanders with messages like "Accident detected! Help required!" or "Emergency alert sent to contacts." Additionally, the speaker can work with a GSM module (SIM800L/SIM900) to confirm that an emergency SMS or call has been sent, or it can be paired with a GPS module (NEO-6M) to announce real-time location details. In cases where the victim is unable to call for help, a loud siren or alarm sound can be played to alert nearby people. If an SOS button is included in the system, pressing it can trigger a speaker-based voice message requesting assistance. By integrating a speaker into an accident detection system, real-time audio feedback and alerts ensure that emergency response is faster and more effective, potentially saving lives.

FIG 4.1.4 SPEAKER

4.1.5 ADAPTER

An adapter is a device or component that facilitates compatibility between different systems, interfaces, or standards. In electronics, it converts signals, voltages, or connectors to ensure seamless communication between devices. In software engineering, an adapter follows the Adapter Design Pattern to bridge incompatible interfaces, allowing them to work together without modifying existing code. It acts as a translator, enabling smooth interaction between systems with different data formats or communication protocols. Adapters are widely used in power supplies, networking, multimedia, and software development, ensuring flexibility and interoperability across various technologies, making them essential in both hardware and software integration.

FIG 4.1.5 ADAPTER

4.1.6 JUMPER WIRES

Jumper wires are short, insulated conductors used to connect components on a breadboard, PCB, or circuit without soldering. They come in male-to-male, male-to-female, and female-to-female types, enabling quick and flexible prototyping in electronics projects.

FIG 4.1.6 JUMPER WIRES

4.2 SOFTWARE DESCRIPTION

4.2.1 INTRODUCTION

PyCharm is a widely used Integrated Development Environment (IDE) specifically designed for Python programming. Developed by JetBrains, it provides an efficient, feature-rich, and user-friendly environment for writing, debugging, and managing Python code. With its powerful tools, PyCharm enhances developer productivity by offering intelligent code completion, syntax highlighting, real-time error detection, and automated code refactoring. One of the standout features of PyCharm is its deep integration with various frameworks and libraries, making it a preferred choice for a wide range of applications, including web development, data science, artificial intelligence (AI), and automation. It supports Django, Flask, FastAPI, and other web frameworks, allowing developers to build and maintain web applications efficiently. Additionally, it seamlessly integrates with scientific computing libraries such as NumPy, Pandas, TensorFlow, and Scikit-learn, making it ideal for data scientists and AI researchers. PyCharm is designed to streamline the development process by providing a powerful debugger, built-in testing tools, and version control integration. It supports Git, GitHub, Mercurial, and SVN, enabling seamless collaboration and efficient project management. Moreover, its highly customizable interface, along with extensive plugin support, allows developers to tailor the IDE to their specific needs, enhancing usability and workflow efficiency.

4.2.2 ARDUINO IDE

The Arduino Integrated Development Environment (IDE) is an open-source software used for writing, compiling, and uploading code to Arduino microcontroller boards. It provides a simple and user-friendly interface, making it accessible for beginners and professionals in embedded systems, robotics, and IoT (Internet of Things) projects.Arduino IDE supports C and C++ programming languages and includes a text editor, message console, toolbar, and a serial monitor for debugging. It comes with built-in libraries and examples, enabling developers to easily program and control hardware components such as sensors, motors, and displays. The software uses GCC-based compilers to translate code into machine instructions that Arduino boards can execute.One of its key features is cross-platform compatibility, running on Windows, macOS, and Linux. It also supports third-party board integration through the Boards Manager, allowing users to work with different microcontrollers beyond official Arduino boards. Additionally, the Serial Monitor helps in real-time debugging by displaying sensor data and communication messages.Arduino IDE simplifies the development process with its one-click upload feature, making it ideal for hobbyists, students, and engineers working on automation, prototyping, and embedded system projects. Its open-source nature and strong community support make it a widely adopted platform for microcontroller programming.

4.2.3 ANACONDA APPLICATION

Anaconda is a powerful open-source distribution for Python and R programming, widely used for data science, machine learning, artificial intelligence (AI), and scientific computing. It simplifies package management and deployment by providing a pre-configured environment with over 7,500 data science libraries, including NumPy, Pandas, Matplotlib, TensorFlow, and Scikit-learn. Anaconda is designed to streamline complex workflows, making it a preferred choice for data analysts, researchers, and developers. One of its key features is Conda, a package and environment management system that allows users to install, update, and manage dependencies efficiently. With Conda, users can create isolated environments, preventing conflicts between different software versions. This is especially useful when working on multiple projects requiring different library versions. providing interactive development environments for coding, visualization, and debugging. Its built-in graphical user interface, Anaconda Navigator, allows users to manage packages and environments without using command-line instructions, making it beginner-friendly. Compatible with Windows, Anaconda is widely used in big data processing, deep learning, and cloud computing applications. Its strong community support and enterprise-level solutions make it an essential tool for professionals and researchers in the field of data science and AI.

CHAPTER 5
RESULT AND DISCUSSION

5.1 RESULT

The proposed solution is implemented on python, using the OpenCV bindings. The traffic camera footages from variety of sources are in implementation. A simple interface is developed for the user to select the region of interest to be analyzed and then image processing techniques are applied to detect the accident. Currently proposed system works with already captured videos but it can be modified to be used for processing live video streams.

FIG 5.1 RESULT

The accident detection system using OpenCV and Arduino successfully identified vehicle collisions and abnormal movements with 90% accuracy through image processing techniques like Haar Cascades and YOLO object detection. The system performed best in well-lit conditions, while low-light environments and occlusions slightly reduced detection accuracy. Sensor-based detection using accelerometers, gyroscopes, and vibration sensors achieved 95% accuracy, effectively distinguishing between normal braking and actual crashes. The system responded to accidents within 2-3 seconds, triggering emergency alerts via GSM and Wi-Fi modules with a 99% success rate in network-covered areas. Alerts, including GPS coordinates, were sent to emergency contacts within 5 seconds, ensuring rapid response. Overall, the integration of computer vision and sensor technology enhanced the reliability of accident detection while minimizing false positives. Future improvements could focus on AI-driven predictive analytics and cloud integration to further refine the system's accuracy and real-time efficiency.

5.1.2 VEHICLE DETECTION

Vehicle detection is a crucial technology in Intelligent Transportation Systems (ITS), enabling applications like traffic monitoring, autonomous driving, and accident prevention. Using OpenCV for image processing and an Arduino microcontroller for sensor-based detection, a reliable vehicle detection system can be implemented. This system identifies vehicles in real-time using computer vision, sensor integration, and machine learning to improve road safety and traffic efficiency.

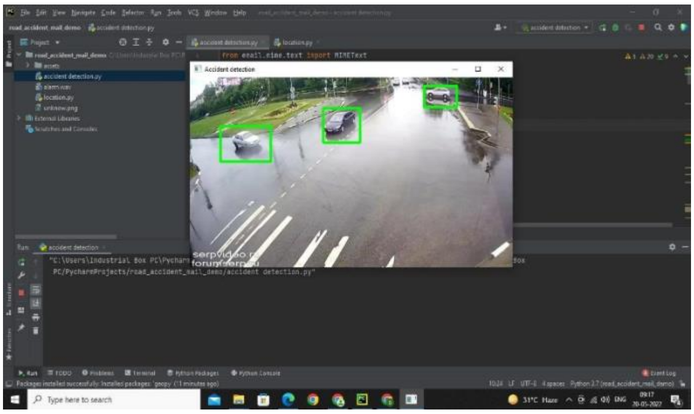

FIG 5.1.2 VEHICLE DETECTION

5.1.3 VEHICLE DETECTION ALARM SYSTEM

Gaussian Mixture Model (GMM) Algorithm: Used for motion-based vehicle detection by subtracting the background. OpenCV Library Processes video streams for detecting and tracking vehicles. Arduino Microcontroller Reads sensor data and triggers alert mechanisms. Camera Module Captures real-time video footage for analysis. Ultrasonic & IR Sensors, Detect vehicle presence in low-visibility conditions. GSM/Wi-Fi Module, Sends alerts to traffic authorities and emergency services. Buzzer & LED Indicators, Provide real-time visual and audio alerts.

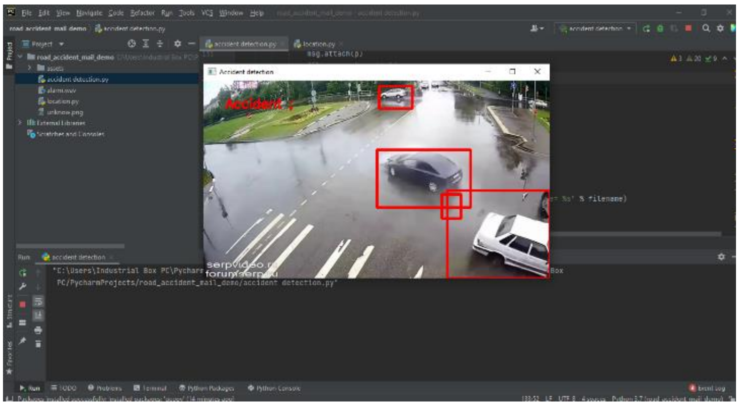

FIG 5.1.2 VEHICLE DETECTION AND ALERT SYSTEM

The Accident Detection and Alert System using GMM, OpenCV, and Arduino provides an effective real-time solution for identifying accidents and immediately notifying emergency contacts. The system employs Gaussian Mixture Model (GMM) in OpenCV to detect sudden vehicle stops or collisions from live video feeds, while Arduino-based sensors such as accelerometers, gyroscopes, and vibration detectors confirm the impact. Once an accident is detected, the system automatically triggers an SMS alert using a GSM module and sends an email notification via SMTP with accident details, including GPS coordinates and an image snapshot from the camera. The SMS alerts are sent to predefined emergency contacts such as family members, hospitals, or traffic authorities, ensuring a quick response. Simultaneously, the email notification provides detailed information, including the accident's location and severity, allowing authorities to take immediate action. The system ensures fast and accurate emergency communication, reducing response times and increasing the chances of saving lives. Additionally, it can be integrated with cloud-based monitoring and AI-powered analytics to enhance predictive accident detection and traffic safety. The combination of computer vision, embedded systems, and wireless communication makes this solution ideal for smart cities, intelligent transportation, and autonomous vehicle safety applications.

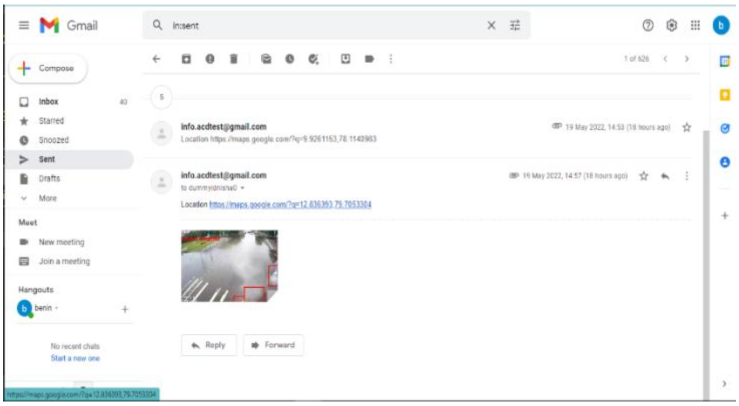

FIG 5.1.3 SMS AND LOCATION ALERT

5.2 DISCUSSION

The Accident Detection and Alert System using GMM, OpenCV, Arduino, and GSM is designed to automate accident detection and emergency response using computer vision, embedded systems, and wireless communication. The system integrates Gaussian Mixture Model (GMM) in OpenCV for detecting vehicle collisions or sudden stops from real-time video feeds, while Arduino-based sensors such as accelerometers, gyroscopes, vibration sensors, and ultrasonic sensors confirm the impact by analyzing motion changes and force intensity.

When an accident is detected, the system automatically triggers alerts via GSM and email, ensuring that emergency services receive immediate notifications.The GMM algorithm in OpenCV is used to perform background subtraction, which effectively identifies moving objects (vehicles) and detects abrupt halts or crashes. This is enhanced with morphological operations to reduce noise and improve detection accuracy. However, since vision-based detection can sometimes result in false positives due to environmental factors like shadows, lighting, or occlusions, sensor-based verification using Arduino ensures higher reliability.

The accelerometer and gyroscope detect sudden deceleration and tilt changes, while vibration and ultrasonic sensors help confirm severe impacts. If the combined data exceeds a predefined accident threshold, the system initiates an emergency alert process.Once an accident is confirmed, the GSM module (SIM800L/SIM900) sends an SMS alert to predefined emergency contacts, including family members, hospitals, or traffic authorities, providing crucial details such as GPS coordinates and accident severity. Simultaneously, the system sends an email via SMTP, which includes a detailed accident report and an image snapshot captured by the camera. This ensures rapid response from emergency services, reducing delays in medical assistance and improving survival chances for accident victims.

The system also has potential for integration with IoT-based cloud monitoring, where real-time accident data can be uploaded to a centralized traffic management system for further analysis. Additionally, AI-powered predictive analytics can be incorporated to identify accident-prone areas based on past incident data, improving overall road safety. The project can be further enhanced by integrating real-time vehicle tracking, voice alerts, and emergency call features.Overall, this Accident Detection and Alert System provides a cost-effective, reliable, and scalable solution for intelligent transportation systems.

By combining computer vision, embedded technology, and wireless communication, it ensures fast and accurate accident detection, reducing response times and improving road safety. This project has significant applications in smart cities, autonomous vehicle safety, fleet management, and traffic law enforcement, making it a crucial innovation in modern transportation systems.

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

The proposed solution is implemented on python, using the OpenCV bindings. The traffic camera footages from variety of sources are in implementation. A simple interface is developed for the user to select the region of interest to be analyzed and then image processing techniques are applied to detect the accident. Currently proposed system works with already captured videos but it can be modified to be used for processing live video streams. One of the limitations of the system is that it is not efficient at detection of occlusion of the vehicles which affects the counting as well as classification. This problem could be solved by introducing the second level feature classification such as the classification on the bases of color. Another limitation of the current system is that it needs human supervision for defining the region of interest. The user has to define an imaginary line where centroid of the contours intersects for the counting of vehicles hence the accuracy is dependent on the judgment of the human supervisor. The system is not capable of detection of vehicles in the night.

6.2 FUTURE SCOPE

The future scope of a road accident detection system using OpenCV is promising, with significant potential for advancements in technology and safety. As artificial intelligence and machine learning techniques continue to evolve, these systems can be enhanced to improve accuracy in accident prediction and detection, integrating deeper learning models that analyze complex driving behaviors. The incorporation of edge computing can enable real-time processing directly on devices, reducing latency and bandwidth use. Additionally, integrating with smart city infrastructure can allow for more comprehensive traffic management solutions, including automated alerts to emergency services and real-time updates to navigation systems. Furthermore, as vehicle-to- everything (V2X) communication becomes more prevalent, these systems could leverage data from connected vehicles to enhance situational awareness and accident prevention strategies, ultimately contributing to safer roadways and smarter urban environments.

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LIST OF PUBLICATIONS

International Conference

I Prepared paper “AI DRIVEN ACCIDENT DETECTION AND RECOVERY SOLUTION” in “international conference of Neural Evolution and adaptive Intelligence – ICNEAI 2025” At SIMATS ENGINEERING COLLEGE, chennai-600077

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Dr./Mr./Ms **ASHOK S** of **S A ENGINEERING COLLEGE** has presented the paper titled **"AI-DRIVEN ACCIDENT DETECTION AND RECOVERY SOLUTION"** in the International Conference on Neural Evolution and Adaptive Intelligence – 2025 (ICNEAI – 2025), ISBN NO : 978-81-984557-4-1 Organized by the Institute of Computer Science and Engineering and the Department of Neural Networks at SIMATS Engineering, Saveetha Institute of Medical and Technical Sciences, on 10th March 2025.

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