Accident Detection and Alert Generation

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Abstract: *The current scenario of increasing vehicles has resulted in traffic hazards and road accidents. The continuous growth of road accidents has also caused an increase in casualties due to accidents. One of the primary reasons for the increased rate of casualties is due to lack of emergency services. The delay happens due to traffic congestion and unstable communication with medical units. The proposed system aspires to deliver a self-operating accident detection system with alert generation to provide timely aid in crucial ways. A surveillance system enriched with the concept of deep learning technique of Convolutional Neural Network built to detect real-time accidents and future communicate the details by generating an alert on a web application which will be handled by medical units and police authorities. The system also delivers the functionality to report accidents manually in remote areas. To train and evaluate the detection system we collected 120 video frames under numerous conditions. The experimental results exhibit that the proposed system can detect an accident and send an alert on the web app with a mean absolute percentage error that is less than 20%.*

Keywords: **Accident Detection, Deep learning, Convolutional Neural Network, Web application, Surveillance System**

1. Introduction

Due to the rapid increase in the world population, the demand for automobiles is increasing dramatically, and the problems of traffic congestion and casualties due to traffic accidents are also increasing. The survival rate of the injured depends largely on the time it takes for the ambulance to take the patient to the hospital after arriving at the scene of the accident. In most road accidents, the injury is not serious and can save the lives of the victims, but the delayed arrival of rescue teams can be fatal.

Today, many cities have low-cost video surveillance cameras and systems, also known as Closed Circuit Television (CCTV). They show rapid climb in current times and typically include heterogeneous cameras with varied resolution, mounting points, and frame rates. CCTV operates 24 hours a day, 7 days a week, and produces a large amount of data, called Big Data. Among other applications, this data can function as a foundation for automated accident detection through the surveillance system.

The Internet being an ever-increasing global system of interconnected computers allows people to communicate faster and has been the main source of information sharing to date. Due to the high availability of the Internet, technology has been developed to reduce time and manpower. This has encouraged automating tools and developing smart devices. The Government of India has been taking initiatives like Smart City which aims at local area development and including technology which leads to smart outcomes.

Therefore, an intelligent automatic accident detection system that helps provide timely assistance is a need for time. The main goal is to identify the accident site and send information to the rescue team in a much shorter time so that the rescue team can take the necessary steps to save the lives of the victims. The fundamental objective is to detect accidents at their exact time of occurrence and generate alerts within less time. In addition to the functionalities, the system also claims to provide manual reporting through a web application in remote areas, where the system can't be installed.

2. Challenges

High mobility of vehicles causing traffic congestion, makes the existing system difficult to distinguish between a crash and the closeness of vehicles at a place like a traffic signal or simply a traffic jam. Due to which, existing systems may generate a false alarm. The proposed system thus aims to tackle this problem to accurately distinguish between the closeness of the vehicle and crash detection.

3. Motivation

A total of 3, 54,796 road accidents were recorded across India in 2020 [1] leading to the death of 1, 33,201 people and injuries to a different 3, 35,201, consistent with the National Crime Records Bureau (NCRB), data. Among which 40% of the death rate is due to delays in medical facilities. This calls for an automated road accident detection system to provide timely assistance. However, the existing systems are based on sensors that have to be installed by the vehicle owners. Thus, a surveillance-based system to automatically detect accidents that are administered by the medical and police authorities is pursued.

4. Literature Survey

In present days, with the growing population, the demand for vehicles has increased tremendously. This has led to an increase in vehicle hazards. Thus, many solutions are proposed within the literature for automatic accident detection.

4.1 TPMS

TPMS is a system designed to regulate the pressure inside the pneumatic tires on vehicles that provide different operating conditions like lower tire pressure is desired to maximize traction, manoeuvring through challenging terrain, pulling an important load out of an incline at slow speeds, crawling out of sentimental dirt. The pressure can vary from 15 to 45 PSI. Based on the tire pressure an accident can be detected. [2]

4.2 VANET - Vehicle Ad-Hoc Network

The authors suggested that congestion problems are caused by vehicle breakdown or due to accidents in off-the-grid areas. To solve this problem the authors proposed a system based on VANET. In this system, every moving vehicle is considered a node. Alerts are sent using the RF module, and alerts are received from moving vehicles within the range of the RF

module. VANET multicast routing protocol settings may vary depending on your environment. Therefore, a single protocol may not be suitable for all types of VANET environments, as the design may change depending on the needs and capabilities of the environment. [3]

4.3 Accident Detection using Vibration Sensors

The authors of this system put forward a solution for detecting accidents using a microcontroller to control operations like vehicle detection and to report an accident. They focus on minimizing post-accident action time. The number is prefetched to the system and a notification is sent in the event of an accident. Crashes are detected by vibration sensors. Since the system relies on only a single sensor, it is more likely to produce false outputs. The downside of the system is that it produce an alert in the event of a crash, but does not share the location of the accident**.** [4]

4.4 Accident Detection using Fuzzy Logic

This system is proposed, to detect accidents within traffic lights by using fuzzy logic techniques for accident detection. This system comprises of two subsystems, Detection System and Action System. This system gathers data about different zones, such as the number of cars in a lane and the speed of cars in a particular lane. Disruption of normal traffic flow is an important indicator of an accident. The model results exhibit good accuracy in accident prediction although, factors such as streetlight and weather conditions were not taken into account in this study. [5]

4.5 Accident Detection using Distance Sensor

In this, the author proposed a system that uses a distance sensor to constantly monitor the distance between the vehicle and the obstacle in front of it. The system then sends alert to the driver to control the speed and slow down himself when the critical distance is reached. When the critical point is reached, the system will automatically adjust the speed. In case of accident the alerts are shared via Email, which is consider slow means of communication, and may take longer to provide medical assistance. [6]

4.6 Accident Prediction using Support Vector Machine (SVM)

The system focuses on detecting accidents occurring on urban roads where accidents are more likely to happen, as many disturbing entities such as bus stops and traffic lights are involved as compared to freeways where the traffic flow is unobstructed. For the further processing the traffic data is then collected by RSU (Road-Side Unit) and transmitted by On-Board Units. Three traffic variables are considered to detect an accident: vehicle speed, acceleration, and lane change status. [7]

Through this study, we have come across different aspects, the advantage over other technologies, and limitations. Though plentiful research has been done in this field of accident detection, there is still immense scope available, since none of the techniques detects accident 100% assurance to detect the accident. The sensors based systems would be somehow expensive also, in the event of an accident, these sensors and devices can be destroyed, resulting in erroneous reads and results. The accident detection using Fuzzy Logic provides more accuracy compared to other methods but hasn't considered all the factors such as road lighting and weather conditions while training the model. Thus, there is a need to enhance the existing systems and inculcate smartness into them.

5. Proposed Methodology

The goal of the proposed system is to provide real-time accident detection for areas with heavy traffic conditions commonly observed in India. This system would help the Smart City Mission of India reach its goals by serving as a mechanism that will harness the power of technology in local areas.

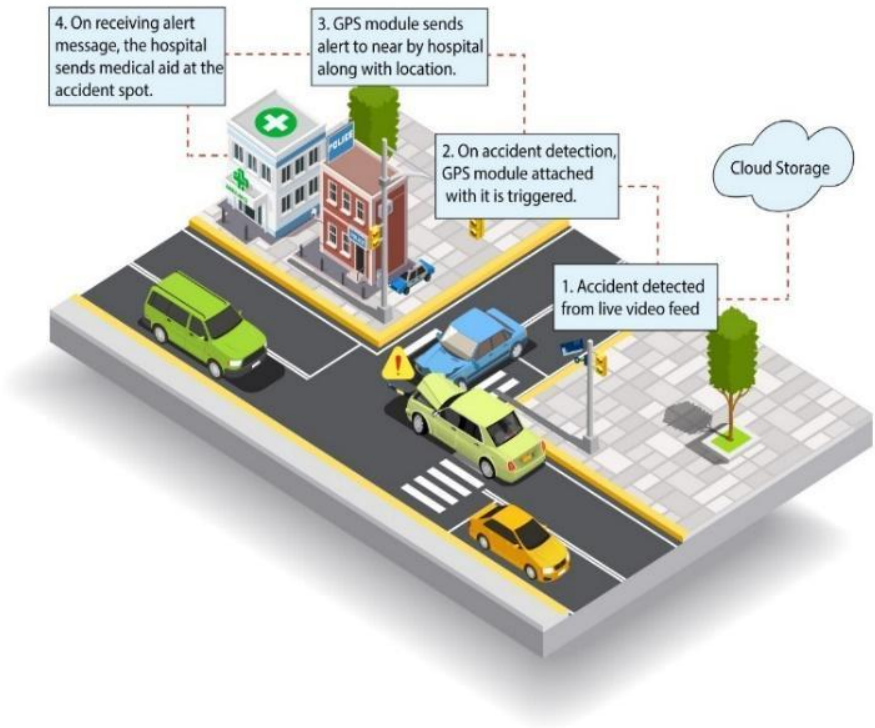

Figure 1. Surveillance system-based accident detection and alert generation

5.1 Vehicle Detection

This module is the first step of our system. The vehicle detection module directly gets input from the CCTV camera as a live video feed. In this phase, the system will focus on detecting and identifying objects such as cars, trucks and buses.

5.2 Crash Detection

The second step is to check whether there is any crash or collision being occurred between the two objects. If there is any collision, then the intensity of the collision will be compared with a threshold value to achieve accuracy.

5.3 Alert Display

This GPS module is embedded. This module notifies the hospital and police authorities once an accident is detected. This module is a simple web page handled by the authorities to know the details of the accident such as location and time. Whenever an alert is displayed it helps the authorities to take necessary actions at a crucial time.

5.4 Report Accident

This module provides a mechanism to report an accident in remote locations where CCTV cameras can't be installed such as steep areas. The user if witnesses any accident occurred and uses the web application to report it. The user simply must fill the form in the

report accident section and click on the Send button to notify the authorities. When a user reports the accident, the hospital and police authorities can view the alert on their side.

5.5 Cloud Storage

The data generated by CCTV cameras is tremendous as it is in the form of video format. This gives rise to the big data storage problem. The best option is to use cloud storage for storing the video feed automatically from IP CCTV cameras installed. No extra steps are required to carry out as IP CCTV cameras come with a cloud storage option where the data is also automatically deleted after 30 days if we archive it separately for our reference.

5.6 Dataset

We used around 150 videos for training and testing our crash detection model. The video was from different locations, shot at different times and angles, and has different feeds; some have car collisions whereas some of the videos are of crowded areas. The videos almost have 30 frames per second having around 1200 x 500 resolution. However, some videos are not perfect due to compression and blurring effects.

5.7 User Interface

The user interface is the only module through which the user gets connected to the system. It is an HTML and CSS-based interface using JavaScript. It is integrated into the system through the Node.js server.

6. Implementation

This system works by collecting live video data from the pre-installed surveillance CCTV cameras. This video data is continuously monitored and processed by the algorithm set up on Raspberry Pi module. The algorithm helps to detect crashes between two vehicles. When a crash is detected, a notification is sent via the webserver to the respective authorities on the web application. This notification consists of the location detected by the GPS module and the time when the casualty had occurred. Thus, achieves the aim to rescue a casualty and provide medical aid within time.

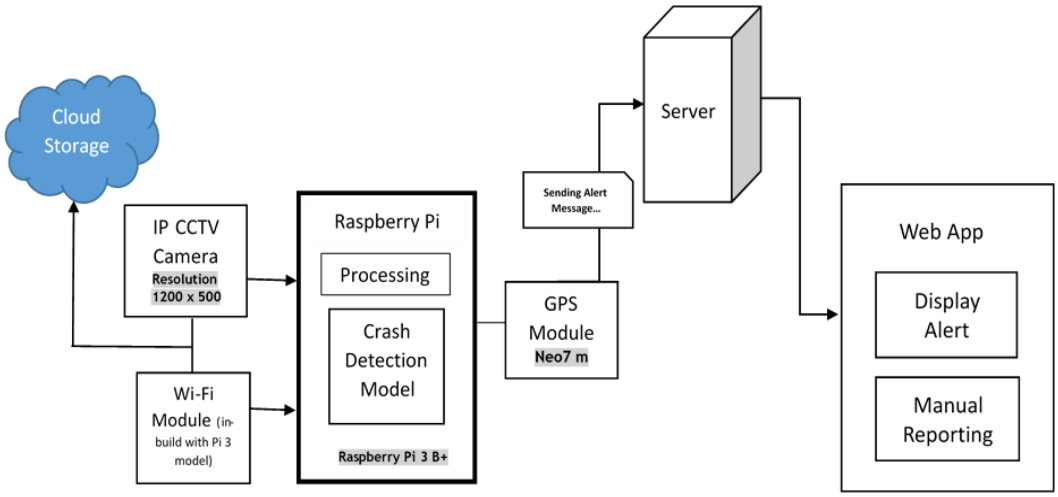

Figure 2. System Block Diagram

1. An IP CCTV camera captures the live video data. An ideal video of quality 1200 x 500 pixels with an average of 40 frames per second is required. IP CCTV cameras come with built-in cloud storage capability, this helps to store the video data feed for long-term use. This video is passed on as input to the Raspberry Pi 3 B+ module. (Refer Figure 3)

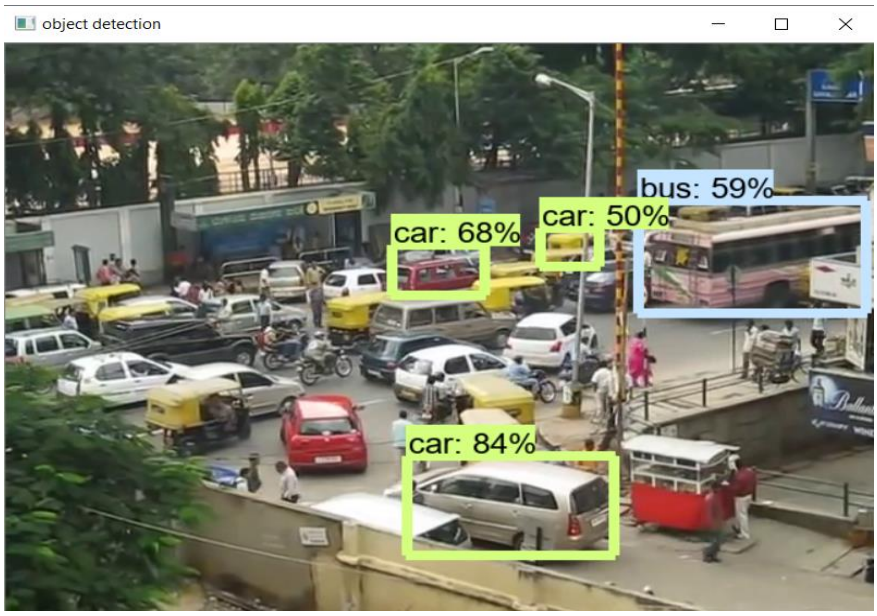

Fig. 3 Vehicle Detection

2. Raspberry Pi 3 B+ module, is configured with the code set up to monitor, detect vehicles and accidents from the video frames. It is also a medium through which alerts are sent to the web server.
   The code configured on Raspberry Pi 3 B+ module works in three stages as follows-

2.1 Vehicle Detection

We use here, machine learning module of TensorFlow object detection API to perform object detection and classification. The library Open CV is used to read the video in the form of an image frame stored in a two-dimensional array. Before storing the image in the matrix, the dimensions of the image are expanded since the object detection API expects the image to have shape. The image is then divided into boxes, each box represents a part of the image where a particular object was detected. Accordingly, the data is stored in the Score and Classes matrix. The Score matrix is used to store the resulting image, together with the Class label. The class label defines the type of object. Thus, classifying the object whether it is a vehicle. Objects such as cars, trucks, and buses are detected from the video frame. (Refer Figure 3). The boxes, scores, and classes matrix is further passed on to the crash detection module.

2.1.1 TensorFlow Object Detection API: Nowadays, many of the object detection systems are supported by the convolutional neural networks (CNN) and it segregated into two classes: single-stage detection and two-stage detection. In this system, the single-stage detection are faster and predict objects bounding boxes together with classes within one particular network pass. Object detection is intended to publish instances of semantic objects with specific class labels such as people, cars, and so on. Its wide range of applications in many computer vision tasks includes face recognition, pedestrian detection, video object segmentation, image retrieval, object tracking, and video surveillance. The system uses a single-stage SSD detector that runs faster than 30 frames per second on modern CPUs while maintaining good accuracy. The TensorFlow object detection API is based on the CNN convolutional neural network, a class of deep neural networks used to analyze visual images. We use CNN for image classification carried out by object detection in our project.

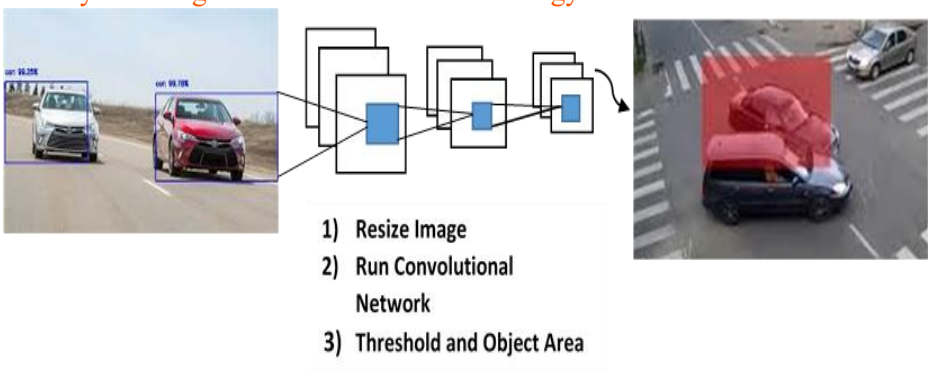

Figure 4. Conceptual diagram of the crash detection model

SSD: Single Shot Detection

a) **Bounding Boxes:** The SSD model manually defines a collection of aspect ratios (example {1, 2, 3, 1/2, and 1/3}) used for the BB bounding box at each grid cell position. (Refer Figure 4)

b) **Assigning a labelled object to a bounding box:** The SSD model attempts to directly predict the probability that a category will exist in a particular bounding box. When calculating the loss, IOU matches each ground truth box with the largest anchor box and defines that box being "responsible" for creating the prediction.

c) **Class labels:** Each bounding box is then labelled according to the classification class it occurs to be in. Classification classes are predefined in the configuration file of object detection API.

d) **Output layer:** This shows the object being detected by showing the bounding box wrapped around the object label with class i.e. the object name labelled on the corner of the box.

2.1.2 **Open CV:** Open CV is an open-source library for computer vision, machine learning, and image processing. It is used to process video to identify vehicles as the object. It is integrated with Padas, to perform calculations and train the crash detection model.

2.2 Crash Detection

In this module, we receive - boxes, scores, and classes' matrix from the vehicle detection model. We consider only 60% of the image viewable objects. Here, we enumerate only through the boxes which are classified to have vehicle objects i.e., car, bus, or truck. If two vehicles are detected, we calculate the area of the object considering the bounding box. Further based on the vehicle area we calculate the threshold. When we calculate the area of the vehicle, we check where the bounding boxes of both the boxes overlap, if they are overlapping, we calculate the combined area. (Refer Figure 4)

Formula to calculate overlapping of the bounding boxes,

$$dx = \min(a.xmax, b.xmax) - \max(a.xmin, b.xmin) \quad (1)$$

$$dy = \min(a.ymax, b.ymax) - \max(a.ymin, b.ymin) \quad (2)$$

$$\text{Vehicle Area} = dx*dy \quad (3)$$

Formula to calculate threshold based on equation 3,

$$\text{Threshold} = 0.6*(\text{vehicles area2})$$

Then, we compare the areas of the two vehicles and the threshold. If the threshold exceeds, it means an accident is detected and the current frame breaks. Thus, the request is sent to the alert module.

Figure 5. Crash Detection

The collision of two vehicles is detected from the video frame. (Refer Figure 5)

3. Send a request to the web server - The request is sent to the web server after the crash is detected with the help of a built-in Wi-Fi module on the Raspberry Pi 3 B+ module. (Refer Figure 6)

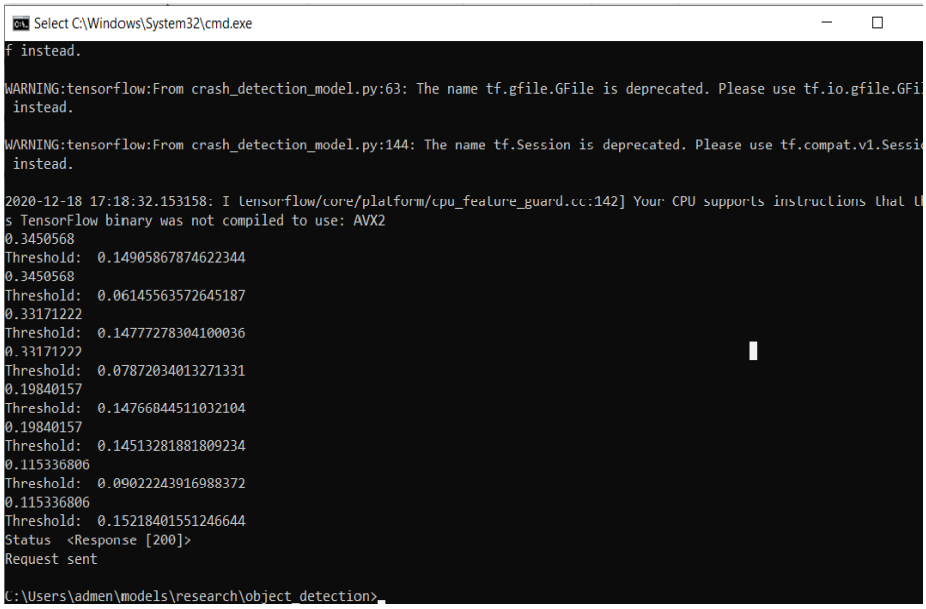

Figure 6. Request Sent to the web server

4. The request sent by the webserver is then navigated to a web application used by police and hospital authorities. The message displayed on the web application consists of location details captured by the GPS Neo7m module. (Refer Figure 7)

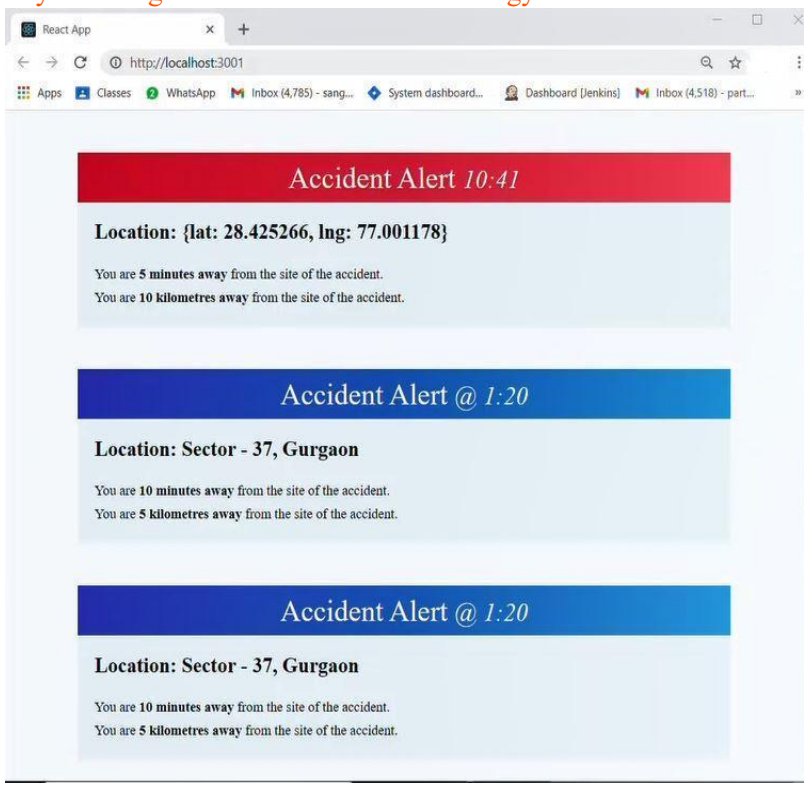

Figure 7. Notification displayed on web application

5. A feature is provided to help residents manually report accidents. It is also useful in remote areas where the system can't be installed. This report is displayed in the same way as a web application alert. (Refer Figure 8)

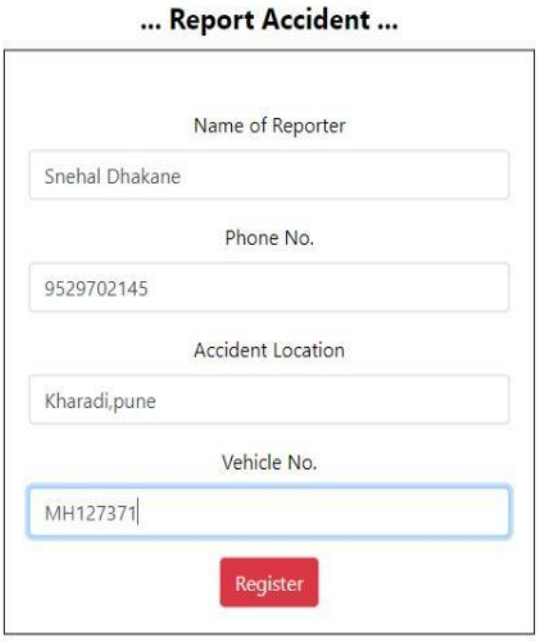

Figure 8. Report accident manually

7. Conclusion

As the number of accidents increases, it is important to have an automated system that can send assistance to the accident site as soon as possible. The proposed system deals with accident detection. As soon as the accident is recognized, the information is sent to the ambulance crew and police are informed, who can assist at the right time.

The proposed system offers benefits such as reducing the subsequent impact of a road collision, pinpointing the exact location of the accident, and facilitating all rescue operations. Users can manually report an accident by submitting a report via a web application, even in remote areas where the system is unavailable. This system ensures that the accident is recognized more quickly and reported to the emergency unit with details such as time and place.

Therefore, the proposed system indulges the detection of collisions between two vehicles by applying an approach adapted to collision detection based on image classification and object detection supported by convolutional neural networks. This bespoke approach allows you to accurately distinguish between the proximity and collision of two vehicles, even in heavy traffic conditions.

8. Future Scope

The feature of crash detection can be further enhanced to detect accidents between vehicles and other objects such as road dividers, electricity poles, and pedestrians. The web application can be augmented by providing a tracking mechanism for the medical units, which will track the ambulance to the location of the accident. Furthermore, the information about the victims will be recorded to help the police with the accident verification

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