

COMPUTER VISION BASED ACCIDENT DETECTION AND ALERT SYSTEM

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Abstract: Increasing automobile demand has increased traffic hazards, leading to more road accidents. Reducing emergency response time is essential to increase survival probability in road accidents. It remains, however, a challenging task. This paper presents a computer vision based system that automatically detects road accidents from CCTV footage using machine learning and deep learning algorithms. A supervised CNN classifier is used in our project to determine the probability of an accident in every frame. An alert message is displayed on the screen and an email is sent using the SMTP protocol whenever an accident is detected.. This method has been proven to be effective in detecting accidents quickly and accurately. As a result of our computer vision-based system, we can minimize rescue operation delays, saving many lives.

Keywords— Computer Vision, Deep Learning, Neural Network, CNN classifier, SMTP protocol

I. INTRODUCTION

Every year the lives of approximately 1.3 million people are cut short as a result of a road traffic crash. Between 20 and 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury [9]. With the increase in population and number of vehicles on the road, it has become more important than ever to develop effective methods for detecting accidents and responding to them quickly. The goal of traffic accident detection is to reduce response time and ensure that medical attention is provided to those who need it as quickly as possible.

There are several methods used for traffic accident detection. One of the most common methods is video surveillance. Video cameras can be placed at intersections or other areas with high traffic volume to detect accidents. When an accident occurs, the cameras can send an alert to emergency services or other relevant parties. This method has been proven to be effective in detecting accidents quickly and accurately.

However, despite the numerous measures being taken to upsurge road monitoring technologies such as CCTV cameras at the intersection of roads [2] and radars commonly placed on highways that capture the instances of over-speeding cars [3]–[5], many lives are lost due to lack of timely accidental reports [1] which results in delayed medical assistance given to the victims. Current traffic management technologies heavily rely on human perception of the footage that was captured. This takes a substantial amount of effort from the point of view of the human operators and does not support any real-time feedback to spontaneous events.

The field of vehicular accident detection has become one of the most prevalent uses of computer vision [7] to provide first-aid on time, without the need for a human operator to monitor an event. In India, CNN for accident detection is gaining popularity due to the increasing number of accidents on roads. The technology can be used to monitor high-traffic areas, such as intersections and highways, and quickly detect any accidents that occur. By doing so, emergency services can be dispatched to the scene faster, potentially reducing the severity of injuries and saving lives.

Generally, the research in the area of Accident Detection focuses on computer vision based and sensor based models. There are few research Publications which are discussing multimodal accident detection, but these have high computation overhead and could be damaged during the accident.

The rest of the paper is organized as: Section II portrays various methods proposed for accident detection. Section III depicts the short description of the proposed accident detection framework. Further, Section IV addresses the methods used in CNN model for activation and optimization. Analysis of the model is briefed in Section V. The results are discussed in Section VI and conclusion is elucidated in Section VII.

II. RELATED WORKS

A. IoT-based detection of vehicle accident

In 2023, Varsha Dange et al.[8] proposed a model based on Internet of Things and Cloud Connectivity which can detect an accident of the vehicle and is able to notify the nearby emergency services about the accident. This system comprises a microcontroller with Wi-Fi module, gas detection sensor, gyroscope sensor, IR sensor, etc. The alerting system is based on an application which notifies the emergency services with the live location of the accident.

B. Car crash detection using ensemble deep learning and multimodal data from dashboard cameras

In 2021, Jae Gyeong Choi et al.[10] proposed a car crash detection system, which is based on multiple classifiers that use both video and audio data from dashboard cameras, and is validated using a comparison with single classifiers that use video data or audio data only. Car accident YouTube clips are used to validate this research. The experimental results indicated that the proposed car crash detection system performs significantly better than single classifiers. It is expected that the proposed car crash detection system can be used as part of an emergency road call service that recognizes traffic accidents automatically and allows immediate rescue after transmission to emergency recovery agencies.

C. Methodology and Mobile Application for Driver Behavior Analysis and Accident Prevention

In 2019, Alexey Kashevnik et al. [11] presented a paper on methodology and mobile application for driver monitoring, analysis, and recommendations based on detected unsafe driving behavior for accident prevention using a personal smartphone. For driver behavior monitoring, the smartphone's cameras and built-in sensors (accelerometer, gyroscope, GPS, and microphone) are used. A developed methodology includes dangerous state classification, dangerous state detection, and a reference model. The methodology supports the following driver's online dangerous states: distraction and drowsiness as well as an offline dangerous state related to a high pulse rate. We implemented the system for Android smartphones and evaluated it with ten volunteers.

D. Detection of road accidents using machine learning

In 2021, Bharath Kumar M et al.[12] proposed a system that is designed in such a case that it detects when the accident happens and it will be gone through. This proposed system will gather appropriate information from vehicles adjacent to each other and process the data with the help of machine learning tools which are used to detect possible accidents. Machine learning techniques have given success in differentiating abnormal behaviors from normal behaviors. The system's main goal is to examine the behaviour of the traffic and consider vehicles that move differently than the present traffic as a road accident.

E. Trajectory Prediction Algorithm Based on Deep Learning in Car Network Collision Detection and Early Warning System

In 2021, Rongxia Wang et al. [13] proposed Trajectory Prediction Algorithm Based on Deep Learning in Car Network Collision Detection and Early Warning System In this study, a method of early warning is presented using a fuzzy comprehensive evaluation technique, which evaluates the danger degree of the target by comprehensively analyzing the target's position, horizontal and vertical distance, speed of the vehicle, and the time of the collision. The proposed system can issue early warning prompt information to the driver in time and avoid collision accidents.

III. SHORT DESCRIPTION ON ACCIDENT DETECTION FRAMEWORK

We propose a system that uses the Convolution Neural Network (CNN) classification model for accident detection. CNN is a deep learning approach widely used to solve complex problems. It overcomes the limitations of traditional machine-learning techniques and gives more accurate results. The proposed framework comprises certain phases namely: image/video pre-processing, accident detection (CNN model) and alert system.

A. Video/ Image Pre-processing:

This phase is responsible for processing video data within the system. Its main task is to read the video data and extract individual image frames from the video. In the context of accident detection, this module plays a crucial role as it allows the subsequent modules to analyze each frame for the occurrence of an accident. Video data can be encoded in different formats or configurations, and for the system to function properly, it requires homogeneous data in a consistent format and configuration. The colour conversion module addresses this issue by converting the video data to the RGB format. RGB (Red, Green, and Blue) is a commonly used colour model in digital imaging where each pixel is represented by the intensities of these three primary colors.

B. CNN classifier Architecture

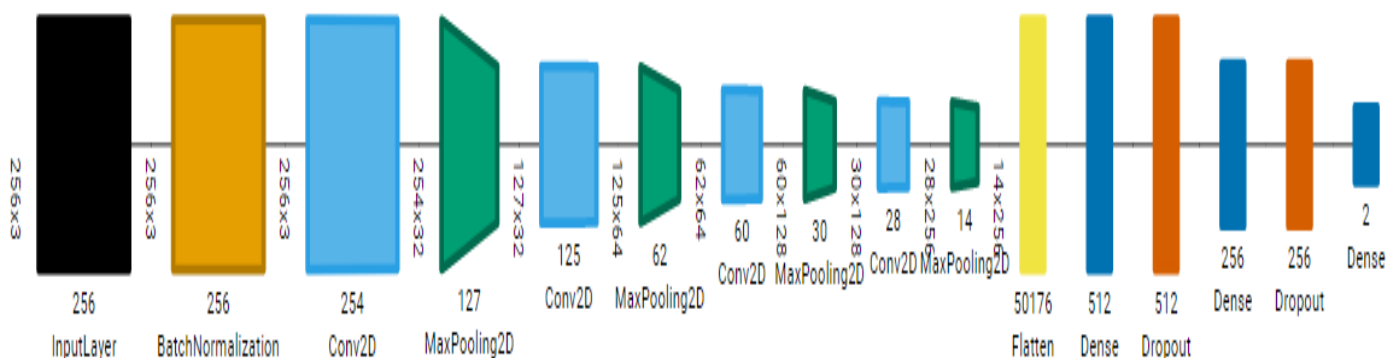


Fig 1: CNN architecture

There are various smart pre-trained CNNs, these CNNs have the capability of transfer learning as shown in fig 1. Therefore it just requires the training and testing of datasets at its input layer. The architecture of the networks differs in terms of internal layers and techniques used [15]. The proposed model has 4 convolution layers. Each layer is followed by a max pooling layer, which is connected to a flattening layer. There are then two dense layers connected by successive dropouts of 0.5 and finally a normalisation layer.

The use of CNN for accident detection involves several steps. First, the algorithm is trained on a large dataset of images that represent different types of accidents, such as collisions, pedestrians being hit, or vehicles overturning. The algorithm is then able to recognize these patterns when presented with real-time footage from CCTV cameras. Each frame of the video is run through the CNN model that calculates the probability of an accident in that frame.

C. Alert System

If the probability of accident is greater than the threshold then an alert message is sent to the traffic management officers and emergency services as shown in Fig 2. The email is sent via the SMTP protocol and it contains the exact time and location of the accident.

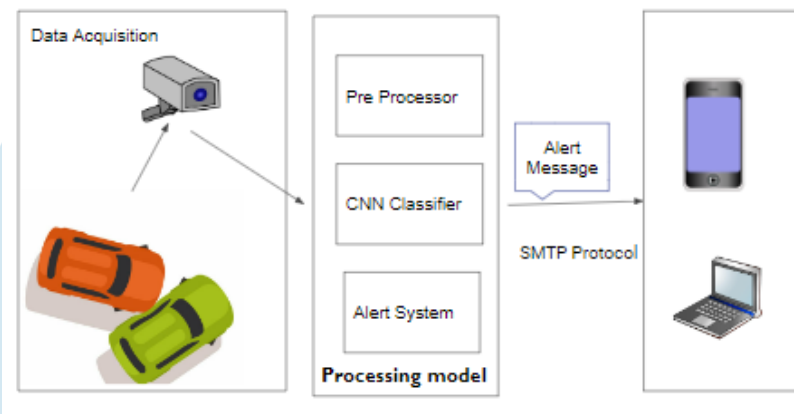


Fig 2: Working of Alert System

IV. METHODS IN CNN MODEL

A. Activation Functions

A proper activation function has a better ability to map data in dimensions [21,22]. When the network has linear properties, the linear equation of the function and its combination only have the ability of linear expression, which will make the multilayer of the network have no meaning. An activation function is used to increase the expression ability of a neural network model, which can make the deep neural network truly have the significance of artificial intelligence.

1. ReLu (Rectified Linear Unit)

The trendy activation function in neural networks is the ReLu function, which is a piecewise function. This function is used for activation in the convolution layers and the dense layers. From the curve of this function, this function will force the output to be zero if the input value is less than or equal to zero. Otherwise, it will make the output value equal to the input value. The method of directly forcing some data to be zero can create a moderate sparse characteristic to some extent. The ReLu function provides a much faster computing rate. Since ReLu is unsaturated, there is no gradient diffusion problem, unlike sigmoid and tanh functions [20]. The equation of this function is defined as:

$$f(x) = \max(0, x)$$

2. Softmax Function

The softmax is used in the output layer for the normalization. It is used to compute probability distribution from a vector of real numbers. The Softmax function produces an output which is a range of values between 0 and 1, with the sum of the probabilities being equal to 1. The Softmax function [16] is computed using the relationship:

$$\sigma(\vec{z})_i = \frac{e^{z_i}}{\sum_{j=1}^K e^{z_j}}$$

B. Adam Optimizer

The major issue that has been addressed most of the times in deep learning is the optimization of model performance along with the loss function value by tweaking the training model epochs [19]. In this model we use Adam optimizer to achieve the same. This algorithm calculates the exponential weighted moving average of gradient and then finds the square of the computed gradient [17]. The above algorithm uses two parameters of decay, momentum as well as adaptive learning rates, which regulates the rate of decay of these calibrated moving averages [18].

The mathematical formulation is shown in Eqs.

$$v_t = \beta_1 * v_{t-1} - (1 - \beta_1) * g_t$$

$$s_t = \beta_2 * s_{t-1} - (1 - \beta_2) * g_t^2$$

$$\Delta w_t = -\eta \frac{v_t}{\sqrt{s_t + \epsilon}} * g_t$$

$$w_t + 1 = w_t + \Delta w_t$$

where

w_j : parameter,

η : initial learning rate,

g_t : gradient at time t along with w_j ,

v_t : the exponential average of gradients along w_j ,

β_1, β_2 : hyperparameters.

V. ANALYSIS OF THE ACCIDENT DETECTION MODEL

A. Accuracy Calculation

Accuracy is a metric that generally describes how the model performs across all classes. In the proposed model we have observed the highest validation accuracy as 90% as shown in fig 3. While, in order to testing the performance of the accident detection model, the accuracy formula was used as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Where True Positive (TP) denotes the number of real positives among the predicted positives, and True Negative (TN) denotes the number of real negatives of the predicted negatives. Similarly, False Negative (FN) denotes the number of real positives among predicted negatives, and False Positive (FP) denotes the number of real negatives among predicted positives. Therefore, accuracy denotes the proportion of images classified correctly by CNN among all images [23].

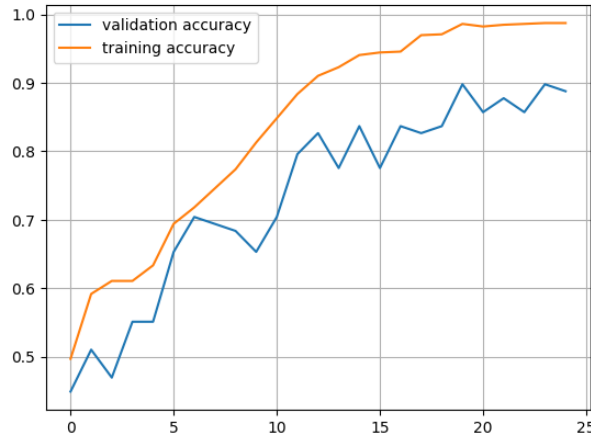


Fig 3: Training and validation accuracy

B. Loss function

In the proposed model Sparse Categorical Cross-entropy is used as a loss function. It computes the cross entropy loss between the labels and predictions. Use this cross entropy loss function when there is two or more label classes fig 4. We expect labels to be provided as integers. The mathematical formula is[24] :

$$\text{Loss} = - \sum_{i=1}^{\text{output size}} y_i \cdot \log \hat{y}_i$$

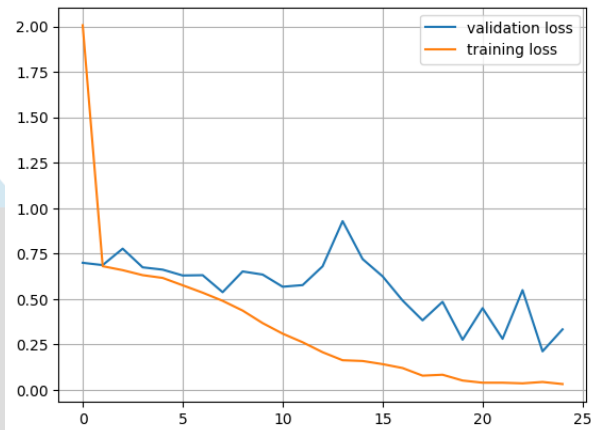


Fig 4: Training and validation loss

VI. RESULTS AND DISCUSSION

Our accident detection system has been tested on a variety of weather conditions such as sunny, cloudy, snow, etc and also on night time video footage. The results are shown in Fig. 5. As shown in Fig. 5, whenever a frame is classified as a positive case, the accident probability is calculated. The threshold value is set to 95 and when the probability of accident is more than this an alert message is sent successfully to the user in the form of an email. The model was able to identify various accidents like collision of moving vehicles, accidents of parked vehicles, accidents in street/ at intersections/ on highways, etc.

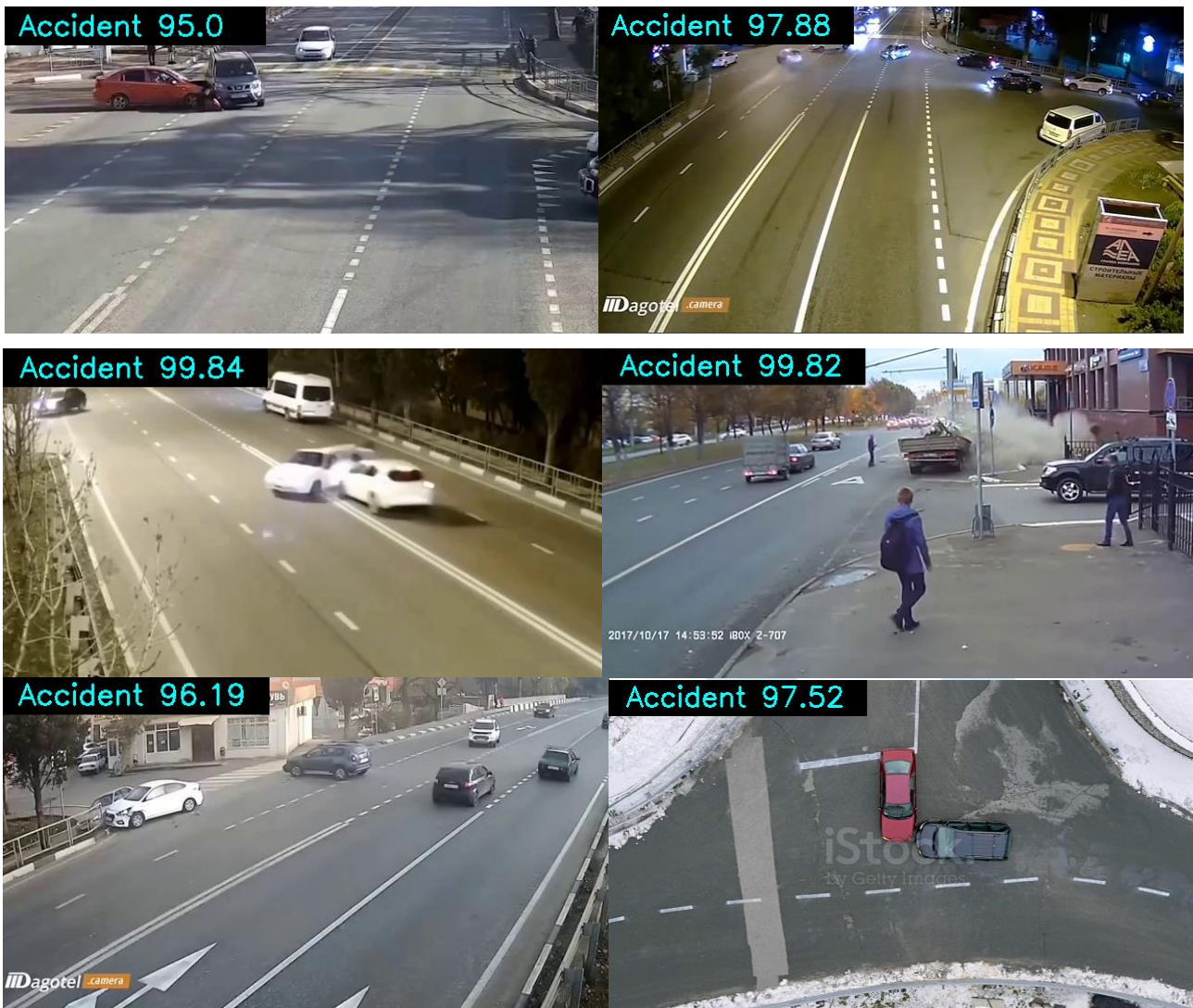


Fig 5: Sample videos are tested using the model

VII. CONCLUSION

This paper was developed to accurately detect the accidents from CCTV footage quickly. One important consideration in an accident detection project is the trade-off between accuracy and speed. While a highly accurate CNN model may detect accidents more reliably, it may also require more computational resources and take longer to process input data. Therefore, it is important to balance accuracy and speed based on the specific needs of the paper. Overall, the proposed CNN classification model for accident detection has the potential to improve road safety and reduce the human and economic costs of traffic accidents by automating the detection of accidents and enabling faster emergency response. To further this model can be enhanced in future for identifying how many people were in the accident.

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