Road Accident Detection and Alert System at Real-Time using Deep Learning Techniques

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***Abstract*—This paper proposes a deep learningbased road accident detection and alert system which works on the identification of accidents from CCTVs and also raising an alert to the concerned authorities. A convolutional neural network (CNN) model that has been developed using a set of videos of accidents and non-accidents to assess the incoming frames of a video in real-time. The data preprocessing, model selection and training, the model validation and performance assessment against benchmarks resulted in an efficient and accurate CNN-based accident detection system. It analyses live or recorded videos of the scene and determines whether an accident or not is present in the frame. In case of high confidence in an accident across multiple frames in succession, the system takes a picture in that frame, logs the time and location details, then sends an alert message containing the time, location coordinates, and details of the accident to a specific Telegram channel through the Telegram Bot API. This method of monitoring makes it easier to analyse the occurrence of an accident and report within a short span of time.**

Keywords—Road accident detection, alert system, deep learning, CNN, automated accident reporting.

I. Introduction

Traffic accidents rank among the top causes of mortality and loss in the quality of life in many developed and developing countries. The World Health Organization states that approximately 1.3 million people die each year due to the occurrence of road traffic crashes. This is due to the delay in getting first aid and emergency medical service. In order to address the issue and get speedy emergency medical attention, a novel method has been proposed to detect roads accidents with minimum latency using AI, computer vision and deep learning techniques. there is proposal for the development of novel road accident detection systems through artificial intelligence and computer vision most specifically Deep learning algorithms.

To overcome this challenge, we propose a novel solution using deep learning techniques. In this work, we used a subsection of the UCF crime dataset [1] that contains manually labelled image data that were obtained from the CCTV videos and the models are built and tested using this large dataset of accident images. The dataset is divided into three parts: The corpus was designed to consist of the training set which contained 791 images, the validation set with 98 images and test set with 100 images. The image size to 250 x 250 pixels and crop the face part of the image to reduce the interference of variability in sizes and intruding background that might affect the performance of the neural network. Furthermore, to achieve more data and data heterogeneity, it is also appropriate to apply more than one data augmentation technique to expand base on applicability of the model and enhance its performance.

The use of road accident detection and alert system proposed was grounded as an accurate and realistic approach to automatically detect accidents from CCTV streams. It ensured that the system employed deep learning features, especially the CNNs to achieve classification of the video frames as well as capability of ascertaining whether or not the frames include an accident. This has pretty much eliminated the need for human supervision, increased the possibility of a higher frequency of response, reducing the possibility of deaths and other effects of mishaps.

The essential element of this work lies in the CNN model where the architecture of which has been thoroughly designed and optimized with the help of a dataset containing both accident and nonaccident videos. This optimal CNN architecture has been obtained after going through several steps including data preprocessing, model training and validation, and performance evaluation. This model is the bases of Accident detection module, which process video frames at real time and sends an alert if an accident with high probability is detected.

A. The contribution of this work are as follows:

- Developed a custom sequential model tailored specifically for real-time accident detection.
- Designed and integrated an alert system module to promptly detect accidents and notify relevant

authorities through Telegram app message at realtime without any delay.

- Additionally, comparisons with pretrained models were done to gain deeper insights into its performance and applicability.

The rest of this paper are outlined as follows: Section II of this work presents literature review. Methodology is explained in Section III. Section IV shows the results of the model. Section V outlines conclusion and future work.

II. LITERATURE REVIEW

Parsa, A. B et al. [2], developed a cool new method for detecting accidents in real-time on highways. They employed machine learning and different kinds of data such as traffic, network, demographic, land use, and climate datasets. To better understand the model's characteristics, they utilized SHAP. The best part is that they combined XGBoost XGBoost and the aforementioned data. Huang, X. et al. [3] proposed computer vision and AI technologies-based methods to address traffic congestion and safety issues can be addressed with data and AI technologies, particularly computer vision. In addition, they used unmanned aerial vehicles (UAV) and computer vision to monitor traffic effectively. The authors proposed the use of near-accident near detection framework that was based on the two-stream convolutional network in real-time. Srinivasan et al. [4] suggested the use of DETR algorithm in object detection and Random Forest Classifier on the accident classification in their work due to the inefficiency of previous methods. Automatic accident detection (AAD) and various limitations of data sources and the performance. Pillai, M. S. et al. [5] Machine Learning Algorithms Both: The trade-off between accurate detection and computational overhead. Zahid, A. et al. [6] shows a detection framework for real-time road accident detection and segmentation in surveillance videos using pre-trained CNNs and manually created synthetic fake accident frames. Santhi, S. et al. [7] developed a system that is designed to detect accidents on highways using a deep learning model CNN and LSTM networks. Basheer Ahmed, M. I. et al. [8] presented a comparative analysis of the different models for vehicle detection, tracking, accident severity categorization, and post-crash fire identification and observed that the YOLOv5+DeepSORT and ResNet152 have potential. Sherimon et. al [9] shows a hybrid model that specifically addresses the analysis of CCTV images of road accidents; they showed that the best performing model was the ResNet-50. Various types of deep learning techniques for road accident detection including MLP, CNN, LSTM, YOLO and RNN are explored in a literature review by Sherimon, V et al. [10] in which the authors also discuss their merits, limitations, and feasibility for real-time, end-to-end implementation. Veni et al. in [11] described a method for failure identification and severity assessment using CCTV data through evaluating the dispersion in the vehicle density gradient in the case of an accident. Chandrakala et al. [12] explained anomaly detection in surveillance videos by the use of deep learning models, GANs and Adversarial Mishra, C et al. [13] proposed a basic algorithm that is used to detect an anomaly in thermal image that captures textural, color, and shape features from the thermal image and use a model of correlation for anomaly detection for the purpose of fault detection, health monitoring as well as intrusion. Prabha. M et al. [14] proposes a mobile application that uses smartphone accelerometers to detect collisions the application then sends alert messages and locations to emergency contacts and nearby hospitals to provide timely assistance Prakash, P. et al.[15] provides the implementing cloud computing and fog computing to the video surveillance of smart city. It highlights the advantages like rapid application deployment and central management and points to the function of fog computing that can provide real-time computation and resolution at the network periphery.

The review presents a range of methodologies to detect accidents at real-time based on the features of machine learning and computer vision. This paper discussed the challenges identified by creating a new sequential model which addresses the real-time accident detection with alert system for sending the notifications and bench-marking with the pre-trained models for accuracy and applicability.

III. METHODOLOGY

A. Data Collection and Preprocessing

The data collection and preparation methods are systematically carried out in this work. The dataset used in this work is developed by collecting videos from CCTV footages which includes images classified into accident and non-accident classes, this dataset is then divided into three subsets: 791 images for training, 98 images for validation set, and 100 images for testing set. All images are then resized to 250 x 250 pixels to ensure uniform input size for neural network training purpose. To enhance model's generalizability and to prevent overfitting, data augmentation techniques are applied to it which enables the model to ensure performance on unfamiliar data. The flow diagram of this proposed model is shown in Fig.1.

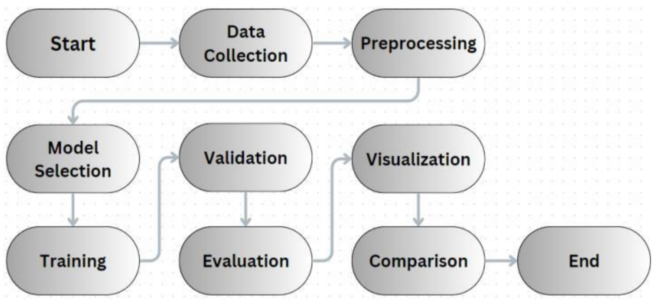

Fig. 1. Diagram of the model.

In this methodology, the first phase is identified as model and configuration. This entails identifying the number of layers to be incorporated in the CNN model, specifically, the number of convolutional layer, pooling layers as well as the dense layers. Also, relevant hyperparameters like learning rate, number of batches, and optimization algorithm are also defined. To enhance the solidity of the data and the speed of transfer learning based on large datasets of other models are used in this work. learning based on large data sets of other models.

The next step is training and validation. The video is first segmented and down sampled to a standard size of frames and the pixel values are normalized. Augmentation is used to increase the training set to improve the accuracy of the used models. Then, the prepossessed data is split into training, validation and testing datasets. Custom sequential CNN model is then used and trained on the training data and then later tested with the testing dataset. At a given interval of during the training process, the model's accuracy is evaluated using the validation dataset to assess its learning and avoid overfitting.

After evaluation and visualization step is performed. Evaluation metrics like accuracy, precision, recall, and F1-score are used to calculate and check model's performance on validation data. Performance metrics, including plots of loss and accuracy over training epochs, are visualized. Sample predictions made by model shows its ability to classify images to show whether it is an accident or non-accident situation. If applicable, ensemble methods can be implemented by combining the predictions of multiple models to potentially improve overall accuracy.

After a model has been trained, properly assessed, and fine-tuned, it can be incorporated into the accident detection and alert system. The prepossessed frames from the CCTV camera feeds are these fed to the trained CNN model that categorize each input video frame as an accident or non-accident. When an accident is identified, an alarm is initiated which calls the emergency services, traffic control room and police. Location of the accident, as well as the calculated severity level according to the analysis of the video feed, etc., are mentioned in the alert.

In addition, a vehicle tracking system is included to analyse movements and trajectories of vehicles which might possibly lead to the accident, helping in reconstruction and analysis of how accidents occur.

B. Comparison with Other Model

The models proposed in this work has been compared with other models viz., GoogLeNet, ResNet50, MobileNetV2, and Vision Transformers [16]. All these models pass through same training and evaluating pattern so that the comparison is just. The results obtained from evaluating these models are then compared to determine the architecture most suited for accident detection. This comparative analysis also helps to make sure that the selected model can not only handle high accuracy tests independently but also outperform other models in terms of time, accuracy and generalization.

C. Alert module

The system's alert module will send notifications of the detected accidents to the authorities or the special response units involved in the accidents. Fig.2 shows the architecture diagram of alert system. This figure demonstrates the placement of the alert catastrophe system. Whenever an accident is detected, the system places a fixed counter variable to 1 and then looks for further occurrence of an accident for the next 50 frames. It has a frequency counter for each frame in case an accident is found in the frame. If a frame is not defining an accident, a counter is reset to the value equal to 0 and the system will choose the next frame. If an accident signal is found in any of the last 50 frames the system records the current time stamp using a python function or instruction and sends an alert message to a Telegram group to be created for this purpose preferably with top officials Fig 3. Additional information of the alert message are the images of the accident that happened at the time the message is generated along with the date and the location of the camera that captured the accident. By providing this information to the concerned authorities in the shortest span, suitable measures can be taken to protect the victims of the accidents. The actions may include arrival of ambulance, fire extinguisher and police by providing this information to the appropriate authorities within the shortest time possible, appropriate measures can be taken in a bid to safeguard against future safety compromise within the institution regarding the accident.

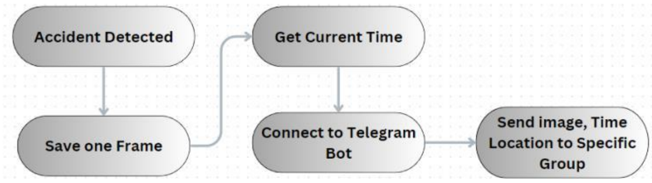

Fig. 2. Architecture diagram of the alert system.

D. Alert Model Testing

The proposed method uses deep learning strategy to detect car accidents in the video feed. Firstly, an in-built CNN model trained previously for detecting accidents in frames of a video is imported into the system. In this system, video files in the form of either real time video stream from surveillance cameras or recorded videos are taken as input.

The video is then processed in individual frames using OpenCV's VideoCapture object. Each frame then follows several preprocessing steps, such as resizing the image to 128 x 128 pixels and normalizing pixel intensity values from 0 to 1. These directly prepossessed frames are then passed into the loaded CNN model to make the necessary predictions. CNN's last layer gives out the probability score that has a possibility of an accident occurring in that particular frame. If the probability score is higher than 0. 5 then the frame is automatically labeled as an accident. To achieve this another method is used which employs a look ahead queue of recent frames (upto 50 frames) and calculate the average probability score of frames.

The binary classification of the accident status (True = Accident, False = No Accident) is placed over the video frames using the putText function of OpenCV and the frames with the results are illustrated in the Matplotlib's imshow function. In case an accident is detected, then the use of OpenCV 's VideoWriter object ensures the activation of video recording.

After identifying a potential accident across a sequence of up to 50 frames, the system captures a snapshot from the video stream and extracts the current timestamp and the camera's location. An alert message is then automatically generated, including details about the detected accident such as the captured image, timestamp, and location.

Subsequently, a notification message containing this information is promptly sent to a designated Telegram channel using the Telegram Bot API Fig.3, ensuring that relevant authorities receive timely updates for swift emergency response and enhanced public safety measures. this

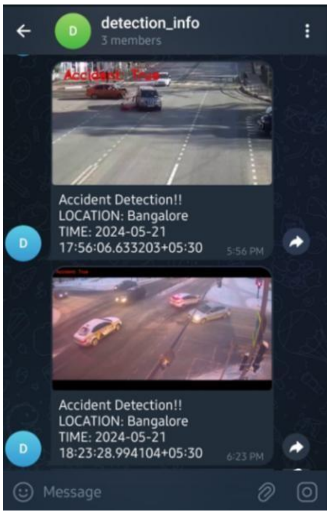

Fig. 3. Screenshot of Alert Message.

After processing the video, the system releases used resources by VideoCapture and VideoWriter objects' termination. False Positives testing consisted of three scenarios with different video files paths (V_path) which were evaluated using the print_results function in the program. A trained model file is also necessary as it serves as an important script file for the system to process video files and detect accidents

IV. RESULTS

The proposed road accident detection and alert system model shows promising performance in identifying accidents from CCTV video feeds. After data preprocessing, model training, validation, the sequential model was then evaluated and compared against the state-of-the-art models such as GoogleNet, ResNet50, MobileNetV2 and Vision Transformers. This implemented custom sequential model has achieved higher accuracy in classifying video frames if the content is relevant to accident or not. As shown in Table 1 this sequential model outperformed other pretrained models. The results showed that the model achieved an accuracy of 95%, precision of 92%, recall of 95%, and F1-score of 96% on the test dataset.

TABLE I. PERFORMANCE OF DIFFERENT MODELS

Model	*Accuracy*	*Precision*	*F1-Score*	*Recall*
EfficientNetB0	0.94	0.94	0.93	0.94
GoogleNet	0.94	0.94	0.94	0.94
ResNet50	0.93	0.93	0.92	0.93
MovileNetV2	0.94	0.93	0.93	0.93
Vision Transformers	0.91	0.91	0.91	0.91
Sequential	0.95	0.92	0.95	0.98

Fig. 4. Predicted and Actual Results from the Accident Detection System.

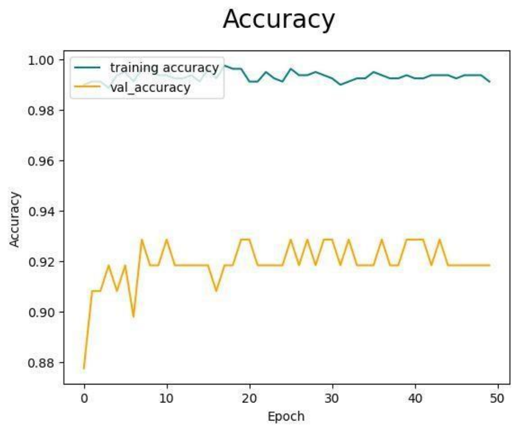

Fig. 5. *Shows the Training accuracy and val_accuracy.*

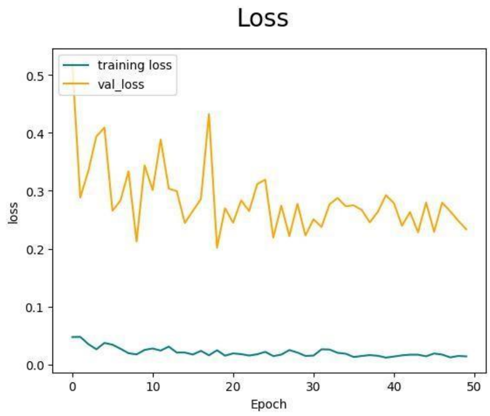

Fig. 6. *Shows the Training loss and val_loss.*

This automated process enables faster reporting compared to traditional methods, significantly reducing emergency response times and mitigates the impact of accidents and response times for better public safety.

V. CONCLUSION

In this work, a method for detecting road traffic accidents and an alert system in real-time from Camera footages has been proposed. This model uses custom sequential CNNs to train. The trained model shows enhanced effectiveness in accident detection as compared to the existing state-of-art models. It also has an alerting system, through which message containing details of the accident like the image, time stamp, location of cameras among others relating to an accident are sent and Future work will be focused on continuous monitoring and evaluation of the system's performance in real-world scenarios and periodic retraining of the models with newly acquired data will be crucial to adapt to changing road conditions, vehicle types, and other factors that may affect the system's generalizability and performance to ensure the longterm accuracy and reliability of the Accident Detection and Alert System.

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