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Road Accident Detection Using Machine Learning

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Abstract: Road accidents pose a significant threat to life and property, with an estimated 1.35 million people losing their lives annually, according to the World Health Organization (WHO). Prompt detection of accidents is crucial for implementing effective mitigation measures. To address this, a real-time accident detection system leveraging machine learning on video streams has been proposed. The system utilizes three convolutional neural network (CNN) models - ResNet50, VGG16, and a custom-built CNN - to extract complex features from CCTV footage frames. Training on a dataset containing labeled accident and non-accident frames from Kaggle enables the models to distinguish between the two. When given CCTV footage as input, frames are extracted, preprocessed, and fed to the models for prediction. The predictions from the three models are compared, and a final prediction is determined. This system aims to enhance emergency response and overall road safety by quickly detecting accidents, thereby reducing the toll on human lives and property. By integrating machine learning and video streams, it offers a promising solution to the issue of road accidents, with the potential to provide real-time accident detection and mitigate their impact.

Keywords: Real-time accident detection, Convolutional neural network (CNN), Machine learning, Deep Learning, Road safety

I. INTRODUCTION

Road accidents are a pressing global concern, exacting a heavy toll on human life and economic stability. According to the World Health Organization (WHO) [1], an estimated 1.35 million lives are lost annually due to road traffic accidents, with an additional 20 to 50 million people sustaining non-fatal injuries. These incidents not only result in immense human suffering but also impose significant social, economic, and healthcare burdens on communities worldwide. The impact of road accidents is particularly profound among young adults aged 15-29 years, who bear a disproportionate burden of fatalities. Moreover, low- and middle-income countries are disproportionately affected by road accidents, exacerbating existing socioeconomic disparities. In economic terms, road accidents constitute a substantial drain on resources, accounting for an estimated 1-3%, as cited in [3] of a country's gross domestic product (GDP). These costs include medical expenses, property damage, loss of productivity, legal fees, and insurance claims, imposing a significant strain on healthcare systems and hindering economic development.

Addressing the challenge of road accidents requires a multifaceted approach that leverages advanced technological solutions. In recent years, machine learning and data analytics have emerged as powerful tools for accident detection and prevention. Machine learning algorithms analyze historical traffic data to discern patterns and trends associated with accidents. By scrutinizing factors such as traffic volume, congestion, weather conditions, and temporal variations as mentioned by the authors of [4], predictive models can proactively identify potential accident hotspots and areas of heightened risk.

Real-time velocity analysis utilizing sensors and GPS data enables the detection of speeding vehicles and aggressive driving behaviors. Machine learning algorithms scrutinize vehicle speed, acceleration, and trajectory to flag anomalies indicative of potential accidents or unsafe driving practices. Surveillance cameras deployed along roadways capture live video footage, which is subjected to computer vision and image processing techniques. Machine learning algorithms analyze CCTV footage to detect objects, identify vehicles, and discern patterns associated with accidents, including sudden lane changes, collisions, or pedestrian crossings. Incorporating machine learning and data-driven approaches into road safety initiatives holds immense promise for accident prevention. Some methods include utilizing sensors and GPS data for real-time velocity analysis that enables the detection of speeding vehicles and aggressive driving behaviors, while surveillance cameras along roadways capture live video footage for analysis through computer vision and machine learning algorithms. These algorithms detect objects, identify vehicles, and recognize patterns associated with accidents, facilitating timely intervention. Automated accident detection systems, powered by machine learning, integrate data from various sources to identify and alert emergency responders promptly. Additionally, machine learning algorithms analyze vehicle data to predict and prevent mechanical failures, enhancing vehicle safety. Advanced driver assistance systems leverage machine learning to provide real-time feedback to drivers, enhancing situational awareness and enabling safer decision-making on the road. Incorporating these data-driven approaches holds great promise for accident prevention and road safety improvement.

The integration of machine learning into road accident detection, and prevention strategies represents a significant step forward in enhancing road safety. By leveraging advanced technologies to proactively identify and mitigate accident risks, stakeholders can significantly enhance road safety, mitigate human suffering, and alleviate the socioeconomic burdens associated with road traffic accidents.

II. LITERATURE SURVEY

A. *Real-Time Vehicle Accident Recognition from Traffic Video Surveillance using YOLOV8 and OpenCV (2023)*

The authors of [5] propose an ensemble model combining YOLOv8 and OpenCV for real-time vehicle accident detection from traffic video surveillance. This methodology offers real-time detection and automation but is limited by its complexity and accuracy.

B. *Detection of Road Accidents Using Synthetically Generated Multi-Perspective Accident Videos (2023)*

The authors of [6] present a deep learning framework for detecting road accidents using synthetically generated multi-perspective accident videos. While advantageous for providing multiple angles and creating diverse scenarios, this approach suffers from a limitation of limited real-world data and dependency on synthetic data.

C. *Accident detection using Automotive Smart Black-Box based Monitoring system (2023)*

The authors of [7] proposed a system which utilizes a microcontroller-based system to continuously monitor vehicle parameters and store data in digital memory cards and cloud storage. This system offers continuous monitoring and active alert systems but requires significant initial investment and raises privacy concerns due to continuous monitoring of driver parameters.

D. *A Machine Learning Framework for Automated Car Accident Detection Based on Multimodal Sensors in Cars (2022)*

The authors of [8] advocate a structure that compares different machine learning feature extraction techniques using in-car sensor data. While innovative, this approach faces challenges such as data scarcity, event complexity, and sensor limitations.

E. *A Vision-Based System Design and Implementation for Accident Detection and Analysis via Traffic Surveillance Video (2022)*

The authors of [9] suggest a framework which proposes a vision-based system combining motion interaction field, YOLO v3, hierarchical clustering, UFIR filtering, and perspective transformation for accident detection and analysis from surveillance videos. While offering automated detection and assisting traffic police in assessing accident scenarios, this approach is dependent on video quality and limited to certain vehicle types.

These studies highlight various methodologies and technologies for accident detection, each with its own advantages and disadvantages.

While some focus on real-time detection and automation, others emphasize the use of deep learning frameworks or smart black-box monitoring systems. Incorporating these approaches into comprehensive accident detection systems can enhance road safety and mitigate the impact of accidents on human life and property.

III. PROPOSED SYSTEM

The proposed Road Accident Detection System is developed and evaluated using a dataset comprising approximately 1000 frames of accidents and non-accidents sourced from Kaggle.

Preprocessing of the data involved resizing the frames to a standardized resolution and normalizing the pixel values to a common scale.

Features relevant to accident detection were extracted from the preprocessed frames to capture meaningful information. The system utilized three deep learning models: a custom-built Convolutional Neural Network (CNN), ResNet50, and VGG16, selected for their feature extraction capabilities.

Training the models involved optimizing parameters to minimize loss and enhance accuracy through multiple iterations of the labeled dataset. For Detection, A CCTV footage containing both accidents and non-accidents is given as input, frames are extracted from it, preprocessed and given to the models for prediction. The predictions of the 3 models are compared and majority prediction is taken as the final output.

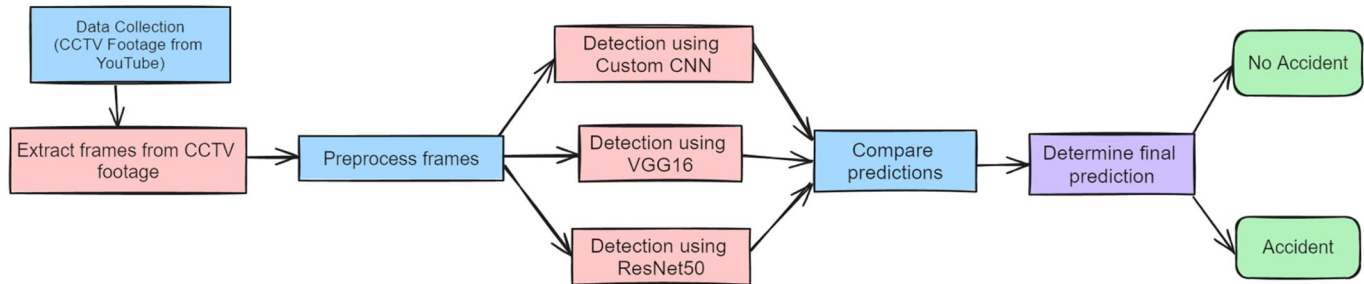


Figure 1: Proposed System

IV. METHODOLOGY

A. Data Collection

The first step in our research involved collecting datasets containing extracted frames from CCTV footages. We sourced these datasets from Kaggle, a well-known platform for machine learning datasets. Additionally, we collected CCTV footages from social media platforms, ensuring the inclusion of both accident and non-accident videos for detection purposes.

B. Data Preprocessing

Following data collection, we performed preprocessing steps to prepare the extracted frames for training. This involved converting the frames into a format compatible with our machine learning models and resizing them to a standardized resolution. Furthermore, we normalized the pixel values of the resized frames to a common scale, ranging from 0 to 1. Additionally, we extracted relevant features from the frames to capture meaningful information for accident detection.

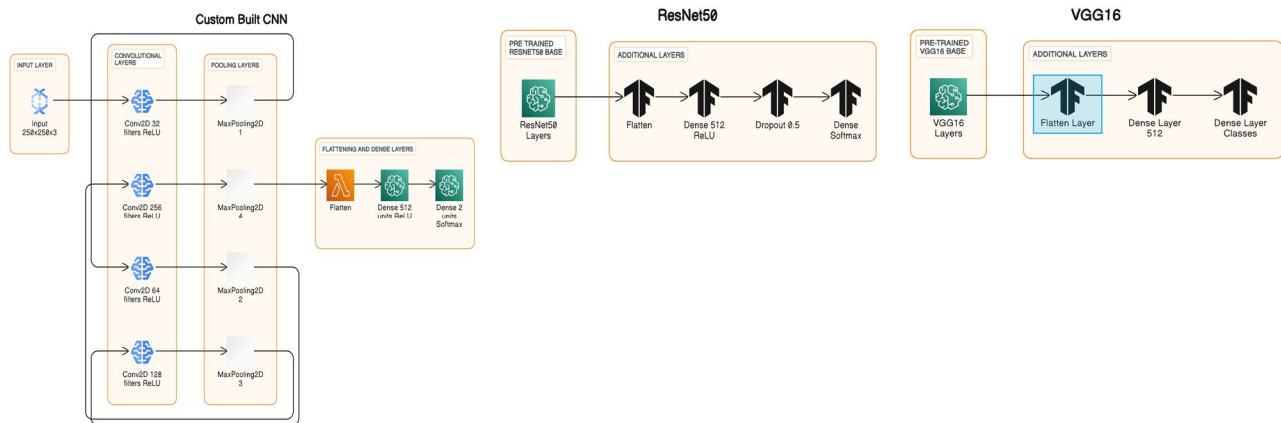


Figure 2: Model Architecture

C. Feature Extraction

In the feature extraction phase, we extracted relevant features from the preprocessed data. It was essential to ensure that all features were on a similar scale to prevent certain features from dominating others during model training. Finally, the extracted features were validated using appropriate evaluation metrics and techniques to ensure their effectiveness in accident detection.

D. Machine Learning Models

We selected and implemented various machine learning models for road accident detection. These models included a custom-built CNN model, as well as pre-trained models such as ResNet50 and VGG16, known for their effectiveness in image classification tasks. Each model was evaluated for its performance in accident detection.

E. Training and Evaluation

The selected models were trained using both training and validation datasets to optimize their performance. We implemented optimization techniques to achieve the best possible results with the trained models, considering factors such as Accuracy.

F. Model Integration and Deployment

To detect accidents or no accidents in CCTV footage, we combined the predictions of ResNet50, VGG16, and the custom CNN models. We considered the majority prediction among the three models as the final result to ensure robustness and reliability. Additionally, we overlaid the final output, indicating whether an accident or no accident was detected, as text onto the video frames.

V. EXPERIMENTAL RESULTS

The custom-built CNN model achieved a training accuracy of 98.24% (Figure 3a) and a validation accuracy of 89.80% (figure 3b). ResNet50 exhibited a training accuracy of 98.88% (figure 3c) and a validation accuracy of 92.86% (figure 3d), while VGG16 demonstrated a training accuracy of 99.13% (figure 3e) and a validation accuracy of 91.84% (figure 3f). Real-world testing involved inputting a single CCTV footage containing both accidents and non-accidents, with the models generating predictions indicating the presence or absence of accidents. These results underscore the efficacy of the proposed system in accurately detecting accidents from CCTV footage and contributing to enhanced road safety measures.

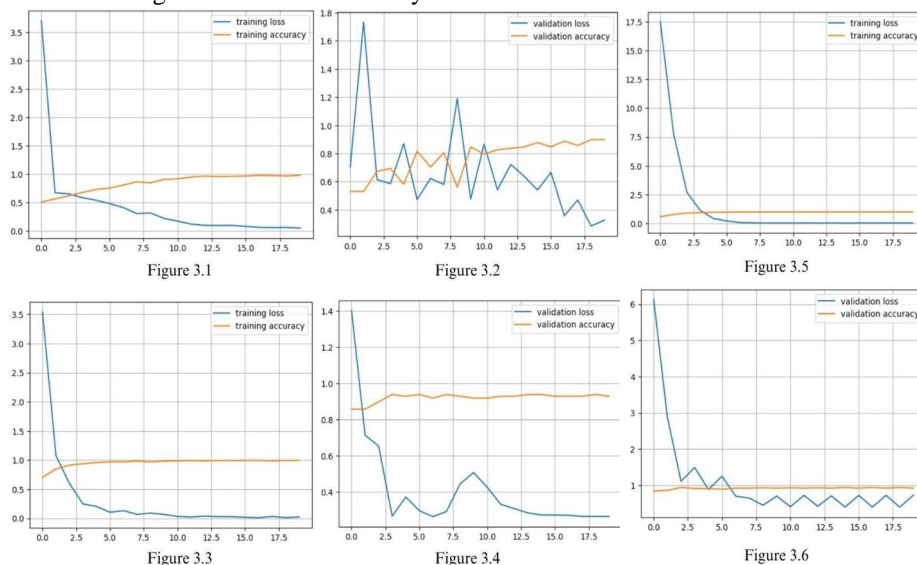


Figure 3: Performance Evaluation

VI. FUTURE SCOPE

The project holds promising potential for integration with AI-powered cameras to enable rapid response in emergency situations. By incorporating AI cameras into the accident detection system, we can enhance the effectiveness of emergency response systems by providing real-time alerts to police stations and hospitals. Additionally, there is an opportunity to develop severity detection algorithms to prioritize responses based on the severity of accidents. These advancements align with the overarching goal of leveraging technology to improve road safety and minimize the impact of accidents on society.

VII. CONCLUSION

This project demonstrates the effectiveness of machine learning in accident detection, providing valuable insights and paving the way for future advancements. By summarizing key findings and addressing challenges, we've laid a strong foundation for enhancing existing systems and exploring new possibilities. The success of this project underscores the importance of ongoing research and implementation efforts in improving road safety. Moving forward, further refinements and interdisciplinary collaborations will be crucial for maximizing the potential of machine learning in accident prevention and saving lives on the road.

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