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CCTV BASED VECHILE CRASH DETECTION A TENSORFLOW FOR IMPROVED ROAD SAFETY

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ABSTRACT

Road accidents are a major public safety concern, causing significant loss of human lives, severe injuries, property damage, and traffic congestion. Rapid detection of vehicle crashes is essential for reducing emergency response time and improving road safety. Conventional accident detection methods often rely on manual CCTV monitoring, emergency calls, or vehicle-mounted sensors, which may have limitations in terms of response time, coverage, and infrastructure requirements. To address these challenges, this paper proposes a CCTV-Based Vehicle Crash Detection System using TensorFlow and Deep Learning. The proposed system utilizes existing CCTV surveillance cameras installed on roads, highways, intersections, and other accident-prone locations to continuously monitor vehicle movements. The captured video streams are processed using computer vision and deep learning techniques to detect vehicles and analyze their motion patterns. TensorFlow is employed to develop and implement the deep learning model, which identifies abnormal vehicle behavior and potential collision events. The system considers visual parameters such as vehicle position, movement direction, speed variation, sudden braking or stopping, trajectory overlap, and changes in motion patterns to distinguish normal traffic conditions from possible crashes. When a potential accident is detected, the system automatically generates an accident alert, reducing the need for continuous human supervision. Relevant video frames or footage can be stored to assist authorities in verifying the incident and analyzing its circumstances. The proposed system can further be integrated with IoT communication systems, GPS, emergency services, traffic management centers, and notification platforms to provide accident location information and facilitate faster emergency response. The effectiveness of the proposed system can be evaluated using performance measures such as accuracy, precision, recall, F1-score, false alarm rate, and detection time. Proper model training and validation can improve crash-detection reliability while reducing false alarms caused by normal traffic activities. By

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utilizing existing CCTV infrastructure, the proposed approach can be deployed in smart cities, highways, urban roads, tunnels, and busy intersections with comparatively low additional infrastructure requirements. Overall, the integration of CCTV surveillance, TensorFlow, deep learning, computer vision, and real-time alert mechanisms provides a promising approach for automated vehicle crash detection. The proposed system has the potential to improve emergency response, support intelligent traffic management, reduce the impact of road accidents, and contribute to the development of safer and more efficient intelligent transportation systems.
Keywords: Vehicle Crash Detection, Computer Vision, Real-Time Accident Detection, Video Surveillance, Emergency Notification System, Intelligent Transportation System, Smart City, Event Detection.

INTRODUCTION

Road traffic accidents are one of the major causes of death and serious injuries worldwide. According to global transportation reports, a large number of accidents occur every day due to over-speeding, careless driving, and traffic congestion. One of the main reasons for the high fatality rate in road accidents is the delay in detecting the crash and providing immediate medical assistance. In many situations, accidents are not reported on time, especially in highways, remote areas, or crowded traffic conditions. Therefore, an automatic accident detection and alert system is required to reduce response time and improve road safety.

With the advancement of computer vision and intelligent transportation systems, automatic monitoring of traffic using surveillance cameras has become possible. Video-based accident detection systems can analyze live or recorded video streams and identify abnormal vehicle behavior such as sudden collision, unusual motion, or unexpected stopping. These systems can help traffic authorities monitor roads continuously without human supervision and provide faster response in emergency situations.

Existing accident detection methods mainly depend on manual reporting, sensor-based devices, or vehicle-installed hardware modules. However, manual reporting takes time and may not always be reliable. Sensor-based systems require additional hardware installation in vehicles, which increases cost and maintenance. To overcome these limitations, a vision-based accident

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detection system using surveillance cameras can be used, which works without modifying the vehicle and can monitor multiple vehicles at the same time.

In this paper, a real-time vehicle crash detection and automated alert system is proposed using computer vision and event analysis techniques. The system processes video input from CCTV cameras or recorded footage and detects crash events based on motion analysis and abnormal behavior detection. Once an accident is identified, the system automatically sends notifications to emergency services such as hospitals, police stations, and traffic control authorities. The proposed system consists of video acquisition, vehicle detection, crash analysis, event confirmation, and alert generation modules.

The main objective of the proposed system is to reduce the delay between accident occurrence and emergency response. The system is designed to work in real time and can be integrated with smart traffic monitoring and intelligent transportation systems. Experimental results show that the proposed approach can detect crash events with good accuracy and can be effectively used to improve road safety in smart city environments.

RELATED WORK

Automatic accident detection has been an important research area in intelligent transportation systems and smart traffic monitoring. Many researchers have proposed different methods to detect vehicle crashes using sensors, mobile devices, and computer vision techniques. The main objective of these systems is to reduce the delay in accident reporting and provide quick emergency response.

Several existing systems use sensor-based approaches for accident detection. In these methods, sensors such as accelerometers, vibration sensors, and GPS modules are installed inside vehicles to detect sudden impact or abnormal movement. When a collision occurs, the sensor data is used to trigger an alert message to emergency services. Although these systems can detect accidents quickly, they require additional hardware installation in every vehicle, which increases cost and maintenance. In addition, sensor failure or hardware damage during an accident may affect the reliability of the system.

Some researchers proposed smartphone-based accident detection systems where the mobile phone sensors are used to identify sudden motion changes. These systems use accelerometer

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and GPS data to detect possible crash events and send notifications to emergency contacts. However, these methods depend on the availability of the smartphone in the vehicle and may not work properly if the device is damaged or not placed correctly.

Recent studies focus on computer vision based accident detection using CCTV or surveillance cameras. In these approaches, video processing techniques are used to monitor traffic continuously and detect abnormal vehicle behavior such as sudden collision, overspeed movement, or unexpected stopping. Vision-based systems can monitor multiple vehicles at the same time and do not require any hardware installation inside the vehicle. Machine learning and image processing algorithms are commonly used to improve the accuracy of crash detection in real-time environments.

Some advanced systems use deep learning models for vehicle detection and accident classification. These methods provide better accuracy but require high computational power and large training datasets. In real-time traffic monitoring applications, lightweight and efficient algorithms are preferred to reduce processing time and improve system performance.

In this work, a real-time vehicle crash detection and automated alert system is proposed using video analysis and event detection techniques. Unlike sensor-based systems, the proposed method uses surveillance video input to detect crash events without requiring additional hardware in vehicles. The system automatically sends alerts to hospitals, police stations, and traffic authorities, which helps reduce the response time after an accident. The proposed approach is suitable for smart city and intelligent transportation applications where continuous traffic monitoring is required.

METHODOLOGY

Figure 1 represents an IoT-based smart accident detection and emergency response system**.** The system is designed to automatically detect an accident and quickly send the accident information to emergency services. When a sudden impact occurs, the force sensor detects it and sends the information to the Arduino ATmega328P**,** which processes the sensor data and activates the alarm. The ESP8266 Wi-Fi module transfers the information to the Raspberry Pi**.** The GPS module provides the exact accident location, while the camera captures images or videos of the incident and the GSM module provides communication support. The Raspberry

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Pi sends the collected information through the Internet to the Cloud, where deep learning approaches can be used to analyze the accident data. Finally, the information can be accessed by the hospital, police station, and mobile application**,** helping emergency services receive accident details and location quickly. Thus, the main purpose of this system is to detect accidents automatically, collect important information, analyze it intelligently, and support faster emergency response.

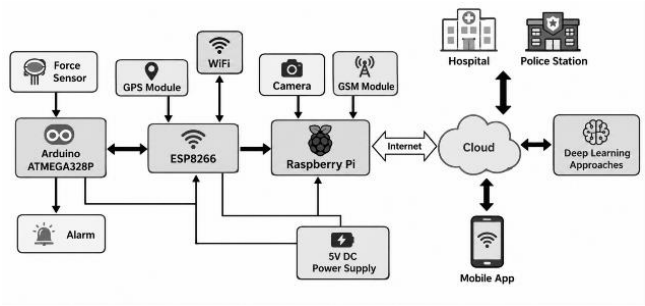


Figure 1: Work Stream of Vehicle Crash Detection

The proposed vehicle crash detection and automated alert system is developed to identify road accidents in real time using video surveillance and computer vision techniques. The system is designed to continuously monitor traffic through live CCTV cameras or recorded video streams and detect abnormal vehicle behavior that indicates a possible collision. The methodology focuses on analyzing video frames, detecting moving vehicles, tracking their motion, and identifying sudden changes that may represent an accident. The overall process is divided into multiple stages including video acquisition, object detection, crash analysis, event verification, and alert notification. The main objective of the system is to reduce the delay between accident occurrence and emergency response by automatically detecting crashes without human involvement.

In the first stage, the system captures video input from surveillance cameras installed on roads, highways, or traffic junctions. The video stream is divided into individual frames so that each frame can be processed separately. Image processing techniques are applied to enhance the quality of frames and remove noise that may affect detection accuracy. After preprocessing, the system identifies moving objects in the frame using object detection methods. Vehicles are detected based on motion, shape, and position in consecutive frames. By tracking the

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movement of vehicles over time, the system calculates direction, speed, and distance between vehicles, which helps in identifying abnormal motion patterns.

In the next stage, crash detection is performed using motion analysis and event detection techniques. When two vehicles move unusually close or collide, the system detects sudden changes in speed, direction, or position. These sudden changes are treated as possible crash events. The system compares multiple frames to ensure that the detected event is not caused by camera vibration, lighting change, or temporary obstruction. This verification step is important to avoid false detection. If the abnormal motion continues for several frames, the system confirms that a crash has occurred. This multi-frame verification improves the accuracy and reliability of the detection process.

After confirming the accident, the alert generation module is activated automatically. The system generates a notification message and sends it to emergency services such as hospitals, police stations, and traffic control authorities. The alert may include information such as the time of accident, location of camera, and captured image of the crash event. This automatic notification helps emergency responders reach the accident location quickly and provide immediate assistance. The proposed methodology works in real time and does not require any additional hardware inside the vehicle, which makes the system cost-effective and suitable for large-scale traffic monitoring. The system can be integrated with smart city and intelligent transportation systems to improve road safety and reduce accident response time.

RESULTS AND DISCUSSION

The proposed vehicle crash detection and automated alert system was tested using recorded traffic videos and live camera input to evaluate its performance in real-time accident detection. The system was implemented using video processing and motion analysis techniques to identify collision events and generate automatic alerts. Different test cases were conducted with various traffic scenarios including normal vehicle movement, sudden stopping, and collision situations. The objective of the testing process was to verify whether the system can correctly detect crash events and send notifications without delay.

During the experiment, the system successfully detected vehicle movement in each frame and tracked the motion of multiple vehicles at the same time. When a collision occurred in the

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video, the crash detection module identified sudden changes in speed and direction, which were treated as abnormal behavior. The event verification module checked multiple consecutive frames before confirming the crash, which helped to reduce false detection caused by noise or camera movement. The system showed reliable performance in detecting accidents in clear video conditions and was able to identify crash events within a short time after the collision occurred.

After confirming the accident, the alert module generated a notification message and sent it to the predefined emergency contacts. The alert system worked correctly during testing and successfully triggered notifications without manual intervention. The time required to detect the crash and send the alert was very small, which proves that the system can be used in real-time traffic monitoring applications. The results also showed that the system can monitor multiple vehicles simultaneously, which makes it suitable for highways, city roads, and crowded traffic areas. Compared to sensor-based accident detection systems, the proposed method does not require additional hardware installation inside vehicles, which reduces cost and maintenance.

Although the system performed well in most test cases, some limitations were observed during the experiment. Detection accuracy depends on the quality of the video and camera position. Poor lighting conditions, low-resolution video, or obstruction in the camera view may reduce the accuracy of crash detection. In addition, very small collisions or partial occlusion between vehicles may not be detected correctly. These limitations can be improved in future work by using advanced machine learning or deep learning algorithms for better object detection and event classification. Overall, the experimental results show that the proposed system is capable of detecting vehicle crashes in real time with good accuracy and can be effectively used in intelligent transportation systems and smart city applications to improve road safety and emergency response time.

CONCLUSION

In this paper, a real-time vehicle crash detection and automated alert system was proposed to improve road safety and reduce the delay in emergency response after an accident. The system uses video surveillance and computer vision techniques to monitor traffic continuously and detect crash events automatically without human involvement. The proposed method analyzes

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live or recorded video streams, tracks vehicle movement, and identifies abnormal behavior such as sudden collision or unexpected stopping. Once a crash is detected, the system verifies the event and automatically sends notification messages to emergency services including hospitals, police stations, and traffic authorities. This helps in providing immediate assistance and reduces the time required to report accidents manually.

The implementation results show that the system can successfully detect vehicle crash events in real time with good accuracy under normal video conditions. The system was able to monitor multiple vehicles simultaneously and generate alerts without delay. Compared to sensor-based accident detection systems, the proposed approach does not require any hardware installation inside the vehicle, which makes it more cost-effective and easier to deploy in large-scale traffic monitoring environments. The system can be installed with existing CCTV cameras, making it suitable for highways, city roads, and smart traffic control systems.

Although the proposed system performs well in most situations, the accuracy of detection depends on video quality, camera position, and lighting conditions. In some cases, small collisions or unclear video frames may reduce detection performance. These limitations can be improved by using advanced machine learning and deep learning algorithms for more accurate vehicle detection and event classification. Future work can also include integration with cloud-based monitoring systems, GPS location tracking, and automatic emergency service communication for faster response.

FUTURE WORK

The proposed vehicle crash detection and automated alert system can be further enhanced by improving the accuracy and efficiency of the detection process using advanced machine learning and deep learning techniques. In the current system, crash detection is based on motion analysis and abnormal behavior identification from video frames, which works well in normal conditions but may fail in complex traffic situations. In future work, deep learning models such as convolutional neural networks can be used for better vehicle detection and collision classification. These methods can help the system identify different types of accidents more accurately and reduce false detection caused by noise, lighting changes, or camera movement. The use of trained datasets and real-time object detection algorithms can significantly improve the performance of the system in real-world environments.

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Another important improvement is the integration of the system with cloud computing and Internet of Things technology for large-scale monitoring. In the current implementation, the system works locally with a single camera input, but in future it can be connected to a cloud server to monitor multiple cameras from different locations at the same time. This will allow traffic control authorities to manage accident detection from a centralized monitoring system. Cloud storage can also be used to store crash event data, video clips, and alert history for future analysis. This information can help in identifying accident-prone areas and improving traffic management strategies. With cloud integration, the system can become scalable and suitable for smart city applications.

Future development can also include automatic location tracking and mobile notification support to improve emergency response speed. When an accident is detected, the system can use GPS or map-based services to identify the exact location of the crash and include it in the alert message sent to hospitals, police stations, and rescue teams. A mobile application can also be developed to receive real-time alerts and display accident details instantly. In addition, the system can be integrated with intelligent transportation systems to provide fully automated traffic monitoring. With the use of high-quality cameras, improved video processing, and real-time communication technology, the proposed system can be developed into a reliable and efficient solution for reducing accident response time and improving road safety in smart city environments.

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