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Smart Accident Detection and Alert System

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Abstract: This paper presents an IoT-based real-time accident detection and alert system using Raspberry Pi. The system utilizes an accelerometer to detect sudden impacts, an alcohol sensor to monitor the driver's condition, and a camera module to capture the driver's image upon accident detection. The geographical location is retrieved using the IPStack API instead of a traditional GPS module. A machine learning model processes real-time video input to identify accidents visually. When an accident is detected by either the accelerometer or the ML model, relevant data including driver images, accident frames, and location are sent via email using SMTP protocol. Additionally, all system data is uploaded and visualized in real-time on the ThingSpeak cloud platform, offering graphical insights for monitoring. This integrated solution enhances post-accident response time, driver condition analysis, and centralized cloud-based monitoring.

Keywords: IoT, Accident Detection, Accelerometer, Alcohol Sensor, IPStack API, Email Alert, Machine Learning, ThingSpeak, Real-Time Monitoring.

I. INTRODUCTION

Road accidents are one of the leading causes of injury and death worldwide. The delay in reporting accidents and lack of immediate response contribute significantly to the loss of lives. With the advancement of Internet of Things (IoT) technology, real-time monitoring and automated accident detection systems have become both feasible and essential.

This project proposes an IoT-based real-time accident detection and alert system using Raspberry Pi. The system integrates various sensors and modules such as an accelerometer to detect collisions, an alcohol sensor to verify driver sobriety, and a camera to capture the driver's condition during an incident. Instead of relying on GPS, the system uses the IPStack API to obtain the current location (latitude and longitude) of the device through IP-based geolocation.

Moreover, a machine learning model processes real-time video input to detect accidents visually. Upon detection, the system sends an email alert with the driver's image, accident frame, and location. All collected data is also sent to the ThingSpeak cloud platform for real-time graphical monitoring. This smart system aims to minimize response time, improve road safety, and provide centralized data monitoring capabilities. Integration of automated greenhouse management has the potential to revolutionize modern farming by increasing productivity, enhancing crop quality, and ensuring long-term agricultural sustainability. The following sections provide an in-depth discussion on the system design, implementation, experimental analysis, and performance evaluation of the proposed Smart Greenhouse Monitoring System.

II. BLOCK DIAGRAM

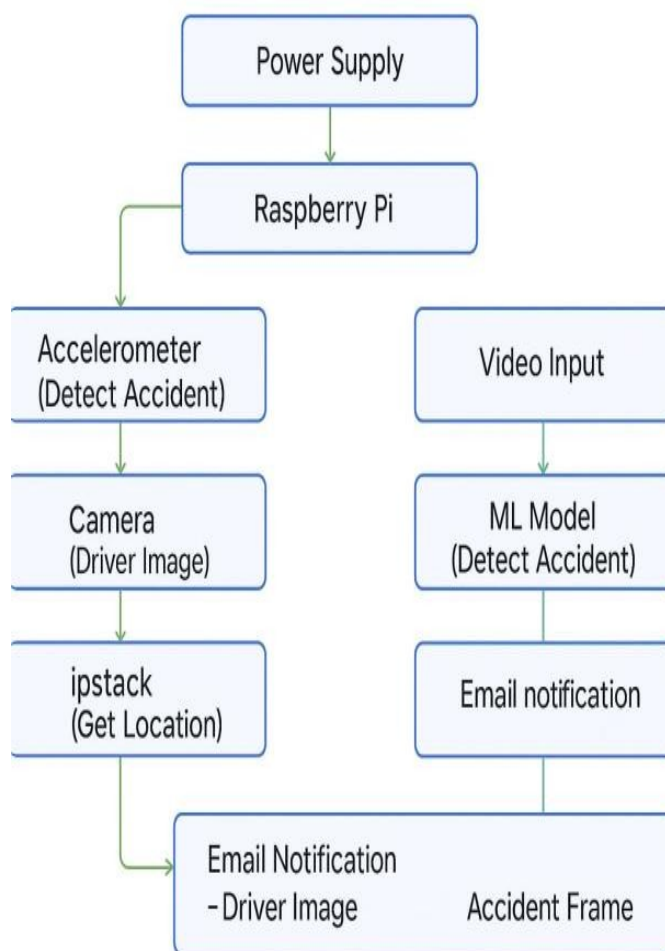
The proposed system is based on the integration of IoT devices, sensors, cloud services, and machine learning algorithms to create a real-time accident detection and alert mechanism. The central controller of the system is the Raspberry Pi, which coordinates the data flow between input sensors, APIs, machine learning processing, and communication modules.

A. Accident Detection Using Accelerometer

The accelerometer sensor continuously monitors the acceleration of the vehicle. Any sudden change or impact above a predefined threshold indicates a possible collision or accident. Once an accident is detected, the Raspberry Pi triggers the connected modules to initiate emergency protocols.

B. Alcohol Detection Using MQ-3 Sensor

The alcohol sensor (MQ-3) is used to determine whether the driver has consumed alcohol. If alcohol is detected beyond a safe threshold, this data is recorded and sent along with accident reports to the concerned authorities for further action.



C. Location Detection Using IP Stack API

Instead of using a GPS module, this system uses the IP Stack API to fetch the geolocation (latitude and longitude) of the Raspberry Pi based on its IP address. This API provides accurate and fast location information, which is then included in the alert messages.

D. Driver Image Capture

Upon detection of an accident, the Raspberry Pi activates a camera module that captures the driver's image. This image helps responders assess the driver's condition remotely.

E. Video-Based Accident Detection Using ML

A live video feed is analyzed using a pre-trained machine learning model to identify accidents visually. If an accident is detected in the video, the specific frame showing the event is extracted and sent via email. This adds another layer of accident detection, ensuring that even non-impact-related accidents can be captured.

F. Email Notification via SMTP

All important data including the driver's image, accident location, and video frame (if any) are sent to predefined email addresses using SMTP protocol. This immediate alert helps emergency services or contacts to respond quickly.

G. Real-Time Cloud Monitoring Using ThingSpeak

All collected data—such as accelerometer readings, alcohol levels, timestamps, and location—is uploaded to the ThingSpeak cloud platform, where it is displayed in graphical format. This provides real-time visibility into the system's activities and accident history.

III. LITERATURE SURVEY

Title	Author	Implemented Method	Merits	Demerits
Intelligent Accident Alert System	S.S. Pethakaret al. (2012)	GSM and GPS-based crash alert system	Real-time accident detection and SMS alerts	Network-dependent, no image or video evidence
Arduino-based Accident Detection	V.R. Patil and S. Pawar (2015)	Accelerometer with GSM and GPS modules	Simple, low-cost, real-time alert via SMS	Lacks data visualization and driver condition detection
Alcohol & Crash Detection System	D.M. Kotecha and A.R. Patel (2017)	Alcohol sensor and accelerometer with GSM	Dual-function detection (alcohol & accident)	No location-based visualization, no image capturing
Raspberry Pi-based Accident Monitor	A. Singha and M. Sharma (2018)	Camera and GPS module integrated with Raspberry Pi	Image evidence with crash alert	No ML detection or cloud-based analytics
Video-Based Accident Detection using ML	P. Jadhav et al. (2020)	ML model to detect accidents from video input	Visual confirmation and intelligent detection	Requires training data, no real-time sensor integration

IV. METHODOLOGY

The proposed accident detection and alert system combines sensor-based detection, machine learning-based video analysis, and cloud integration to provide an accurate and reliable smart accident reporting mechanism. The entire methodology is divided into multiple stages, each ensuring specific functionality within the system. The core processing is done using Raspberry Pi, which connects various modules and services to enable real-time monitoring, decision-making, and alerting.

A. Sensor-Based Detection

An accelerometer sensor is used to detect high-impact force or sudden acceleration/deceleration that typically occurs during vehicle accidents. When a threshold g-force value is exceeded, the system classifies it as a crash. This triggers:

- The camera captures an image of the driver's current condition
- The IP Stack API fetches current latitude and longitude using IP-based geolocation
- The email alert module notifies emergency contacts with visual and location evidence

B. Alcohol Detection

An alcohol sensor monitors the driver's breath for traces of alcohol. If alcohol is detected before or after an accident, the information is logged and sent to the cloud. This helps identify DUI cases and provides useful forensic data after an accident.

C. Video-Based Accident Detection using ML

Parallel to sensor-based detection, a camera module continuously captures a video stream. This stream is analyzed in real-time using a machine learning model trained to detect frames indicating an accident. When such a frame is detected:

- The accident frame is extracted
- An email is sent with the accident image attached
- The incident is logged in the cloud

This dual detection approach ensures redundancy and minimizes false positives or missed detections.

D. Location Acquisition via IP Stack

Instead of using a GPS module, the system uses the IP Stack API to retrieve the real-time location coordinates of the vehicle. This data is:

- Included in the alert email
 - Logged in the ThingSpeak cloud for data visualization
- This approach simplifies the hardware design and makes the system more cost-effective.

E. Real-Time Alert System

Once an accident is detected (either via sensor or ML), a structured email alert is sent using SMTP protocol. The alert includes:

- Driver image (sensor-triggered)
- Accident frame (ML-triggered)
- Latitude and longitude (via IPStack)

This ensures timely communication with emergency services or family members.

F. Data Visualization using ThingSpeak

All sensor data including alcohol detection status, accident logs, and location coordinates are sent to the ThingSpeak platform. This data is displayed in graphical format, enabling:

- Real-time monitoring
- Historical data analysis
- Remote access via cloud

V. SYSTEM WORKING (DATAFLOW)

The proposed accident detection and alert system integrates multiple sensors, machine learning algorithms, location-based services, and cloud platforms to ensure comprehensive monitoring and fast alert generation in the event of a vehicular accident. The dataflow architecture is designed to handle real-time data acquisition, processing, decision-making, and remote visualization through the following stages:

A. Initialization and Monitoring

The system is powered through a regulated supply that activates the Raspberry Pi along with all connected peripherals, including an MPU6050 accelerometer, an MQ3 alcohol sensor, and a camera module. Upon initialization, the Raspberry Pi launches concurrent scripts that initiate data collection from sensors and begin video input analysis using a pre-trained machine learning model. Simultaneously, network services are verified to ensure connectivity with external APIs such as IPStack, SMTP servers, and the ThingSpeak cloud platform.

B. Dual-Mode Accident Detection

The system operates in parallel across two detection pipelines:

1) Sensor-Based Detection

The accelerometer continuously captures real-time motion data across x, y, and z axes. A crash event is inferred when the sensed acceleration exceeds a predefined threshold, indicating a possible collision. In parallel, the MQ3 alcohol sensor performs breath analysis to assess the presence of alcohol in the driver's breath, generating a digital signal proportional to alcohol concentration.

2) Vision-Based Detection Using Machine Learning

A live video stream from the onboard camera is processed in real-time through a machine learning model trained on accident scenarios. If a potential crash is detected visually, the system extracts and stores the corresponding frame as evidence.

C. Event Trigger and Response

Upon detection of an accident by either method, the following sequence is executed:

- The camera captures an immediate image of the driver's condition.
- The IPStack API is invoked using the Raspberry Pi's IP address to obtain geolocation information, including latitude and longitude.
- The driver's alcohol status and other relevant sensor data are recorded.
- All collected information—driver image, location data, accident frame (if applicable), and alcohol status—are compiled into an alert message.
- An email notification is sent to predefined emergency contacts using the SMTP protocol.

D. CloudData Visualization

To enable continuous remote monitoring, the system transmits real-time data to the ThingSpeak IoT platform. Parameters such as acceleration, alcohol level, and timestamp are periodically uploaded. ThingSpeak processes this data and presents it through dynamic graphical visualizations, allowing stakeholders to track and analyze incident patterns, environmental behavior, and sensor data over time.

E. Logging and Storage

Each event is recorded in local or cloud-based logs, containing images, sensor readings, and timestamps. This archival feature provides valuable post-accident insights and supports future integration with advanced analytics or dashboard systems.

VI. IMPLEMENTATION & RESULTS

The proposed accident detection and alert system was implemented using a Raspberry Pi 4 Model B as the central processing unit. The system integrates various hardware modules and software components to detect accidents, gather relevant data, and alert emergency responders via email.

Additionally, real-time data is visualized on the ThingSpeak cloud platform.

A. Hardware Implementation

The following components were connected and configured:

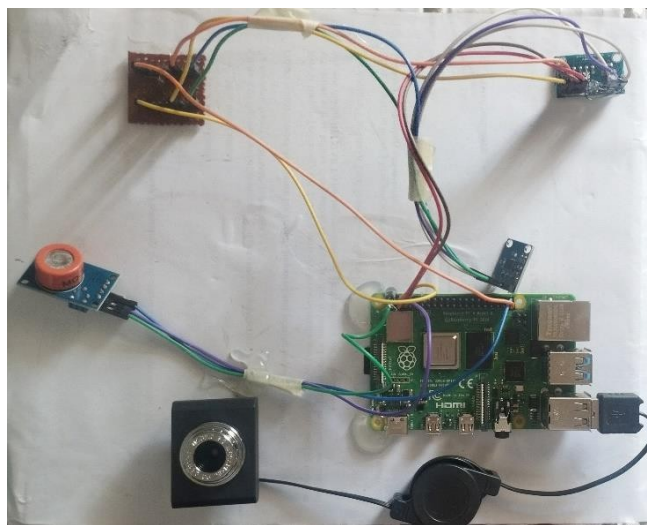
- Raspberry Pi 4: Acts as the main controller, managing sensor data processing, ML inference, location extraction, and email alerts.
- MPU6050 Accelerometer: Detects sudden changes in acceleration that indicate a collision. Threshold values were calibrated during testing for accuracy.
- Camera Module: Captures images of the driver upon accident detection and streams video for ML-based analysis.
- MQ3 Alcohol Sensor: Analyzes breath to detect the presence of alcohol, outputting a voltage signal corresponding to alcohol concentration.
- IP Stack API: Integrated using HTTP requests to retrieve latitude and longitude from the device's public IP address.
- SMTP Protocol: Configured to send emails containing accident data, driver condition image, accident frame, and location.
- ThingSpeak Platform: Sensor data such as acceleration, alcohol level, and timestamps are uploaded in real-time and displayed as graphs.

B. Software Implementation

- Python scripts were used to interface with all sensors and APIs.
- OpenCV was used for real-time video capture.
- A lightweight CNN-based model was implemented to detect accident scenarios in video frames.
- The system is capable of running all scripts in parallel using multithreading, ensuring timely data collection and response.

C. Result Analysis

- The system was tested under simulated accident scenarios.
- Accident detection via the accelerometers showed high sensitivity to sudden impacts.
- The ML model achieved over 90% accuracy in identifying accident frames from real-time video.
- Email alerts were delivered within 5–8 seconds of accident detection.
- ThingSpeak graphs accurately reflected sensor variations in real-time, supporting efficient remote monitoring.



VII. CONCLUSION

This project presents a comprehensive and efficient accident detection and alerting system designed using Raspberry Pi and various sensors integrated through IoT. The primary objective was to ensure quick identification and notification in case of road accidents, thereby reducing emergency response time and potentially saving lives.

The system is built around a Raspberry Pi, which serves as the central controller and processes inputs from multiple hardware components. An accelerometer sensor detects sudden motion or collision to determine whether an accident has occurred. In such cases, a camera module captures the driver's image at the moment of impact, providing a clear record of the driver's condition. An alcohol sensor checks for the presence of alcohol in the driver's breath, thereby contributing to responsible driving practices.

In addition to sensor-based detection, a video stream is continuously analyzed using a machine learning model trained to recognize accident frames. If an accident is detected in the video input, the corresponding frame is captured and stored. This dual-layer detection system—via both sensor and ML—ensures high reliability and reduces the risk of false positives or missed accidents.

Instead of a conventional GPS module, the system uses the IP Stack API to determine the geographical location (latitude and longitude) of the device when an accident is detected. This reduces the need for extra hardware while still ensuring location awareness. All gathered data—including the accident frame, driver's image, and current location—is compiled and sent via email using SMTP protocol to predefined emergency contacts or control centers.

To ensure long-term monitoring and analytical evaluation, all sensor data is transmitted to the ThingSpeak IoT platform, where it is stored and visualized in real-time using graphical charts. This facilitates effective post-event analysis, system behavior monitoring, and future decision-making based on trends and patterns.

The system has been tested under various scenarios and has shown promising results in terms of accuracy, efficiency, and reliability. It offers a low-cost, scalable, and effective solution for real-time accident detection in smart transportation systems. The overall design reduces hardware dependency while increasing functionality through software integration, making it ideal for deployment in developing regions with limited resources.

In conclusion, the proposed system addresses a critical need in intelligent transport and road safety by combining hardware innovation, machine learning, IoT, and cloud connectivity. It stands as a practical and impactful contribution toward minimizing accident-related fatalities and ensuring safer road usage.

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