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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 accelerometertodetectsuddenimpacts,analcoholsensortomonitorthedriver'scondition,andacameramoduletocapture 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 accidentisdetectedbyeithertheaccelerometerortheMLmodel,relevantdataincludingdriverimages,accidentframes,and locationare sentviaemailusingSMTPprotocol.Additionally,allsystemdataisuploadedandvisualizedinreal-timeonthe 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,AccidentDetection,Accelerometer, AlcoholSensor,IPStackAPI,EmailAlert,MachineLearning,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 immediateresponsecontributesignificantlytothelossoflives. With the advancement of Internet of Things (IoT) technology, real-timemonitoringandautomatedaccidentdetectionsystems 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 ThingSpeakcloudplatformforreal-timegraphicalmonitoring. 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.

Thefollowingsectionsprovideanin-depthdiscussiononthe system design, implementation, experimental analysis, and performance evaluation of the proposed Smart Greenhouse Monitoring System.

II. BLOCK DIAGRAM

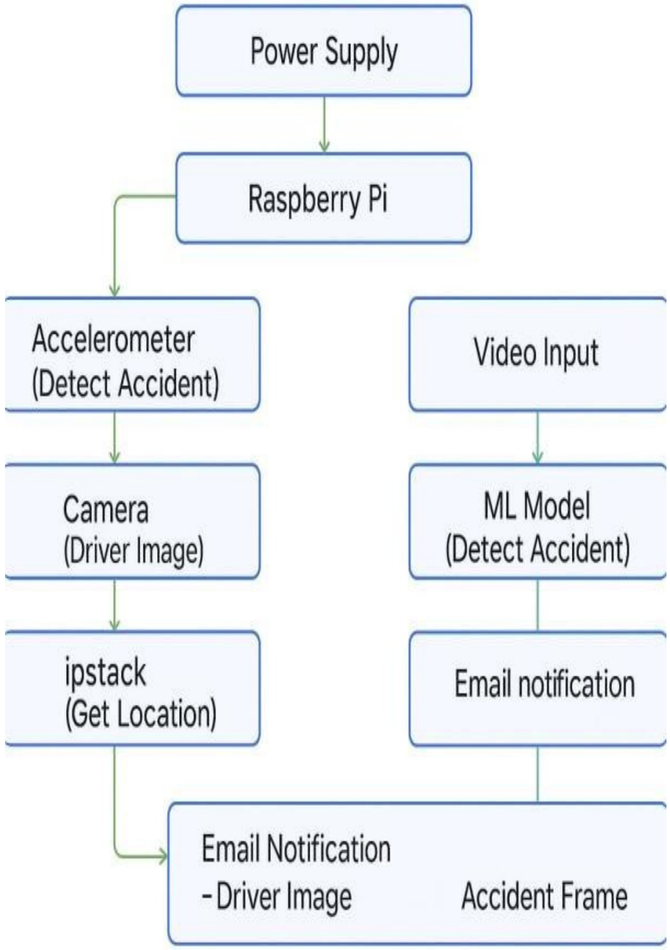
TheproposedsystemisbasedontheintegrationofIoT devices, sensors, cloud services, and machine learning algorithms to create a real-time accident detection and alert mechanism. The central controller of the system is the RaspberryPi, whichcoordinates thedataflowbetweeninput sensors, APIs, machine learning processing, and communication modules.

A. *AccidentDetectionUsingAccelerometer*

The accelerometer sensor continuously monitors the acceleration of the vehicle. Any sudden change or impact aboveapredefinedthresholdindicatesapossiblecollisionor accident. Once an accident is detected, the Raspberry Pi triggers the connected modules to initiate emergency protocols.

B. *AlcoholDetectionUsingMQ-3Sensor*

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 accidentreportstotheconcernedauthoritiesforfurtheraction.



C. LocationDetectionUsingIPStackAPI

Instead ofusing aGPSmodule, thissystem usesthe IPStack API to fetch the geolocation (latitude and longitude) of the Raspberry Pi based on its IP address. This API provides accurateandfastlocationinformation,whichisthenincluded in the alert messages.

D. DriverImage Capture

Upon detection of an accident, the Raspberry Pi activates a cameramodulethatcapturesthedriver'simage.Thisimage helps responders assess the driver's condition remotely.

E. Video-BasedAccidentDetectionUsingML

A live video feed is analyzed using a pre-trained machine learningmodeltoidentifyaccidentsvisually.Ifanaccidentis detected in thevideo, the specific frame showing the eventis extracted and sent via email. This adds another layer of accident detection, ensuring that even non-impact-related accidents can be captured.

F. EmailNotificationviaSMTP

All important data including the driver's image, accident location,andvideoframe(ifany)aresenttopredefinedemail addressesusingSMTPprotocol.Thisimmediatealerthelps emergency services or contacts to respond quickly.

G. Real-TimeCloudMonitoringUsingThingSpeak

Allcollecteddata—suchasaccelerometerreadings,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	ImplementedMethod	Merits	Demerits
IntelligentAccident Alert System	S.S. Pethakaret al. (2012)	GSMandGPS-based crash alert system	Real-timeaccident detectionandSMS alerts	Network-dependent,no imageorvideoevidence
Arduino-based AccidentDetection	V.R.Patil and S. S. Pawar (2015)	AccelerometerwithGSM and GPS modules	Simple,low-cost,real- time alert via SMS	Lacksdatavisualization and driver condition detection
Alcohol & Crash DetectionSystem	D.M. Kotechaand A.R.Patel (2017)	Alcoholsensor and accelerometerwithGSM	Dual-function detection(alcohol&accident)	No location-based visualization,noimage capturing
RaspberryPi-based Accident Monitor	A.Singhand M.Sharma (2018)	CameraandGPSmodule integrated with RaspberryPi	Imageevidencewith crash alert	No ML detection or cloud-basedanalytics
Video-BasedAccident Detection using ML	P.Jadhavet al. (2020)	ML model to detect accidentsfromvideo input	Visualconfirmation and intelligent detection	Requirestrainingdata, 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 isdoneusingRaspberryPi,whichconnectsvariousmodules andservicestoenablereal-timemonitoring,decision-making, and alerting.

A. Sensor-BasedDetection

Anaccelerometersensorisusedtodetecthigh-impactforce 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:

- Thecameratocaptureanimageofthedriver's current condition
- TheIPStackAPItofetchcurrentlatitudeand longitude using IP-based geolocation
- Theemailalertmoduletonotifyemergency contacts with visual and location evidence

B. AlcoholDetection

An alcohol sensor monitors the driver’s breath for traces of alcohol. If alcohol is detected before or after an accident, the informationisloggedandsenttothecloud.Thishelpsidentify DUI cases and provides useful forensic data after an accident.

C. Video-BasedAccidentDetectionusingML

Parallel to sensor-based detection, a camera module continuously captures avideo stream. This stream is analyzed inreal-timeusingamachinelearningmodeltrainedtodetect framesindicatinganaccident.Whensuchaframeisdetected:

- Theaccidentframeisextracted
- Anemailissentwiththeaccidentimageattached
- Theincidentisloggedinthecloud

Thisdualdetectionapproachensuresredundancyand minimizes false positives or missed detections.

D. LocationAcquisitionviaIPStack

InsteadofusingaGPSmodule,thesystemusesthe IPStack API to retrieve the real-time location coordinates of the vehicle. This data is:

- Includedinthealertemail
- LoggedintheThingSpeakcloudfordata visualization

Thisapproachsimplifiesthehardwaredesignandmakesthe system more cost-effective.

E. Real-TimeAlertSystem

Once an accident is detected (either via sensor or ML), a structuredemailalertissentusingSMTPprotocol.Thealert includes:

- Driverimage(sensor-triggered)
- Accidentframe(ML-triggered)
- Latitudeandlongitude(viaIPStack)

Thisensurestimelycommunicationwithemergencyservices or family members.

F. DataVisualizationusingThingSpeak

All sensor data including alcohol detection status, accident logs, and location coordinates are sent to the ThingSpeak platform.Thisdataisdisplayedingraphicalformat,enabling:

- Real-timemonitoring
- Historicaldataanalysis
- Remoteaccessviacloud

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 monitoringandfastalertgenerationintheeventofavehicular accident. Thedataflowarchitectureisdesignedtohandlereal- time data acquisition, processing, decision-making, andremote visualization through the following stages:

A. InitializationandMonitoring

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 collectionfromsensorsandbeginvideoinputanalysisusinga pre-trainedmachinelearningmodel.Simultaneously,network servicesareverifiedtoensureconnectivitywithexternalAPIs such as IPStack, SMTP servers, and the ThingSpeak cloud platform.

B. Dual-ModeAccident Detection

Thesystemoperatesinparallelacrosstwodetectionpipelines:

1) Sensor-BasedDetection

The accelerometer continuously captures real-time motiondataacrossx,y,andzaxes.Acrasheventis inferred when the sensed acceleration exceeds a predefinedthreshold,indicatingapossiblecollision. Inparallel,theMQ3alcoholsensorperformsbreath analysis to assess the presence of alcohol in the driver's breath, generating a digital signal proportional to alcohol concentration.

2) Vision-BasedDetectionUsingMachineLearning

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. EventTriggerand Response

Upondetectionofanaccidentbyeithermethod,thefollowing sequence is executed:

- Thecameracapturesanimmediateimageofthe driver’s condition.
- TheIPStackAPIisinvokedusingtheRaspberryPi’s IP address to obtain geolocation information, including latitude and longitude.
- Thedriver’salcoholstatusandotherrelevantsensor data are recorded.
- Allcollectedinformation—driverimage,location data, accident frame (if applicable), and alcohol status—are compiled into an alert message.
- Anemailnotificationissenttopredefinedemergency contacts using the SMTP protocol.

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D. CloudData Visualization

Toenablecontinuousremotemonitoring,thesystemtransmits real-time data to the ThingSpeak IoT platform. Parameters such as acceleration, alcohol level, and timestamp are periodically uploaded. ThingSpeak processes this data and presentsitthroughdynamicgraphicalvisualizations,allowing stakeholders to track and analyze incident patterns, environmental behavior, and sensor data over time.

E. LoggingandStorage

Eacheventisrecordedinlocalorcloud-basedlogs,containing images,sensorreadings,andtimestamps.Thisarchivalfeature 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 modulesandsoftwarecomponentstodetectaccidents,gather relevant data, and alert emergency responders via email.

Additionally,real-timedataisvisualizedontheThingSpeak cloud platform.

A. HardwareImplementation

Thefollowingcomponentswereconnectedandconfigured:

- Raspberry Pi 4: Acts as the main controller, managingsensordataprocessing,MLinference, location extraction, and email alerts.
- MPU6050Accelerometer:Detectssuddenchanges in acceleration that indicate a collision. Threshold values were calibrated during testing for accuracy.
- CameraModule:Capturesimagesofthedriverupon accident detection and streams video for ML-based analysis.
- MQ3AlcoholSensor:Analyzesbreathtodetectthe presence of alcohol, outputting a voltage signal corresponding to alcohol concentration.
- IPStackAPI:IntegratedusingHTTPrequeststo retrieve latitude and longitude from the device's public IP address.
- SMTP Protocol: Configured to send emails containingaccidentdata,driverconditionimage, accident frame, and location.
- ThingSpeak Platform: Sensor data such as acceleration,alcohollevel,andtimestampsare uploaded in realtimeanddisplayed asgraphs.

B. Software Implementation

- Pythonscriptswereusedtointerfacewithallsensors and APIs.
- OpenCVwasusedforreal-timevideocapture.
- AlightweightCNN-basedmodelwasimplementedto detect accident scenarios in video frames.
- The system is capable of running all scripts in parallelusingmultithreading,ensuringtimelydata collection and response.

C. Result Analysis

- Thesystemwastestedundersimulatedaccident scenarios.
- Accidentdetectionviatheaccelerometershowed high sensitivity to sudden impacts.
- The ML model achieved over 90% accuracy in identifyingaccidentframesfromreal-timevideo.
- Emailalertsweredeliveredwithin5–8secondsof accident detection.
- ThinkSpeak graphs accurately reflected sensor variationsinreal-time,supportingefficientremote monitoring.

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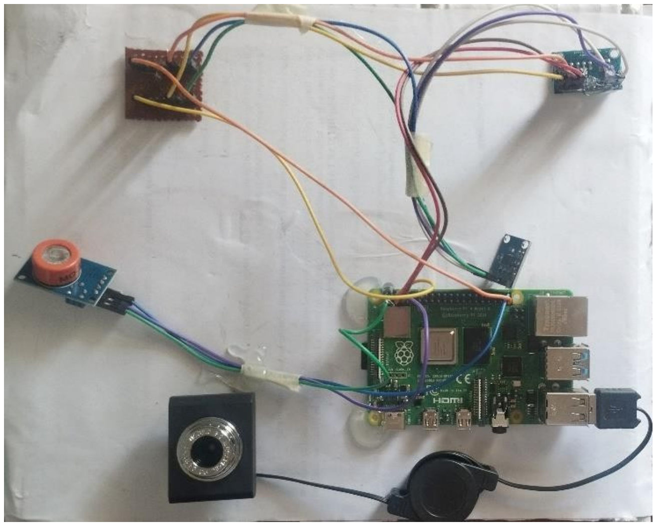

VII. CONCLUSION

This project presents a comprehensive and efficient accident detectionandalertingsystem designedusing RaspberryPiand various sensors integrated through IoT. The primary objective wastoensurequickidentificationandnotificationincaseofroad accidents, thereby reducing emergency response time and potentially saving lives.

The system isbuiltaround a Raspberry Pi, which serves as the centralcontrollerandprocessesinputsfrommultiplehardware components.Anaccelerometersensordetectssuddenmotionor collisiontodeterminewhetheranaccidenthasoccurred.Insuch cases, a camera module captures the driver's image at the moment of impact, providing a clear record of the driver's condition.Analcoholsensorchecksforthepresenceofalcohol inthedriver'sbreath,therebycontributingtoresponsibledriving practices.

In addition to sensor-based detection, a video stream is continuouslyanalyzedusingamachinelearningmodeltrainedto recognizeaccidentframes.Ifanaccidentisdetectedinthevideo input,thecorrespondingframeiscapturedandstored.Thisdual-layerdetectionsystem—viabothsensorandML—ensureshigh reliability and reduces the risk of false positives or missed accidents.

Instead of a conventional GPS module, the system uses the IPStack APIto determine the geographicallocation (latitude and longitude) of the device when an accident is detected. This reducestheneedforextrahardwarewhilestillensuringlocation awareness. All gathered data—including the accident frame, driver's image, and current location—is compiled and sent via emailusingSMTPprotocolstopredefinedemergencycontacts or control centers.

To ensure long-term monitoring and analytical evaluation, all sensor data is transmitted to the ThingSpeak IoT platform, whereitisstoredandvisualizedinreal-timeusinggraphical 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.Itoffersalow-cost,scalable,andeffectivesolutionfor real-timeaccidentdetectioninsmarttransportationsystems.The overall design reduces hardware dependency while increasing functionality through software integration, making it ideal for deployment in developing regions with limited resources.

Inconclusion,the proposedsystemaddressesacritical 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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