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Predicting and Mitigating Road Hazards with IoT & Machine learning

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Abstract:- This paper presents an extensive method for the real-time prediction and mitigation of road risks using the integration of machine learning and Internet of Things (IoT) techniques, and machine learning approaches. For both drivers and pedestrians, road hazards can cause crashes, injuries, and even fatalities. Here we offer a novel approach that uses the integration of machine learning algorithms with Internet of Things (IoT) sensors to detect and mitigate road hazards in real-time. Firstly, deployed Internet of Things (IoT) sensors along roads to collect various data points such as weather, traffic density, road surface conditions, and vehicle speed. The data from these sensors is continuously received by a centralized system for analysis. Next, applied machine learning algorithms, like support vector machines, decision trees, and neural networks, to build prediction models that anticipate potential threats based on historical data trends and real-time inputs from the Internet of Things (IoT) network.

Keywords*: Arduino, Internet of Things, Machine learning, Telegram bot.*

1. Introduction

The term "internet of things" (IoT) refers to the networking of physical objects with electronics integrated into their design that allow them to perceive and communicate with one another and the outside world. IoT-based technology is expected to provide higher quality services and fundamentally alter peoples' daily lives in the next years. IOT is an Internet of things system made up of computing devices, digital and mechanical machinery, items, and humans with unique IDs. And the capability of data transport via a network that calls for computer-to-human or human-to-human contact [1].

A network of linked devices having sensors, software, and connectivity built in to allow data collection and exchange over the internet is known as the Internet of Things [2]. In an IoT system these gadgets may interact with central systems and with one another and with common objects or industrial machinery, enable automation, monitoring, and control in a variety of sectors. Smart homes, healthcare, manufacturing, agriculture, transportation, and other industries are just a few of the industries where IoT finds use [3].

ML Integrated with IoT:

Combining two cutting-edge technologies, machine learning (ML) and the Internet of Things (IoT), can open up previously unheard-of possibilities in a variety of fields. From sensors, actuators, and other sources, IoT devices produce enormous amounts of data. Often called "big data," this information contains important insights that, with careful analysis, can lead to automated processes and wise decision-making. By extracting significant patterns, trends, and correlations from this data, machine learning algorithms are essential for making sense of it all.

ML models utilize techniques including supervised learning, unsupervised learning, and reinforcement learning to assess real-time IoT data streams, predict future occurrences, and improve system performance. A major application of machine learning on the Internet of Things is predictive maintenance. Machine learning algorithms that have previously processed sensor data from Internet of Things devices can recognize trends that indicate upcoming equipment failures or maintenance needs.

In addition to reducing maintenance costs and downtime, this proactive approach increases operating effectiveness [4,5]. ML algorithms are commonly employed for the purpose of imputed values. Being a nonparametric approach, the KNN algorithm is known to a lazy learner. Both its implementation and understanding of MLA are easy. KNN is one of the best MLAs [6], and techniques for data imputation based on it are frequently employed. SVM is one of the more sophisticated and computationally demanding supervised learning algorithms than KNN, but it is also frequently used for data imputation and effectively handles both linear and nonlinear data [7]. Multiple approaches to handling missing values using SVM are presented in different studies.

SVM might not be very accurate, though, when dealing with more than two-class situations. Leo Breiman and Adele Cutler created random forest (RF), a little younger supervised MLA than SVM based on ensemble learning. In practice, RF-based DI is frequently employed. These RF MLA-based techniques, which employ proximity from RF to impute missing data values, are described in [8].

Fig 1. Road condition

When it comes to road safety, the application of Internet of Things (IoT) technology has become a game- changer, providing creative ways to reduce and even eliminate accidents. Maintaining the road conditions are very important to maintain better and safe driving, which was shown in Fig.1. The Internet of Things (IoT) is being used in road safety in a variety of ways, from real-time data analytics platforms to sensors integrated into infrastructure and automobiles.

Large volumes of data regarding vehicle dynamics, road conditions, and driver behaviour may be gathered thanks to these sensors, which are frequently outfitted with sophisticated features like GPS, accelerometers, and cameras. Through real-time data utilization, IoT enables prompt alerts and actions by enabling early identification of possible risks including abrupt braking, lane deviation, or unfavorable weather conditions [9]

The introduction of this article covered the Internet of Things and machine learning. Machine Learning techniques are used to measure the severity of the accident. We covered both the overview of the internet of things and traffic accidents in this introduction. The remaining of the paper is arranged as follows: In Section 2 covers the review of prior studies and research on the topic of IoT and machine learning techniques, Section 3 discuss the road accident detection mechanism and also discuss the proposed methodology, block diagram of the working system, Section 4 describes the proposed methodology used for accident detection through IoT and Machine learning, Section 5 discuss about the experimental setup, working scenario, & results, and rest of the Section covers the conclusion and future work and also references.

2. Literature Review

Predicting and Mitigating Road Hazards with IoT & Machine Learning" would benefit from a thorough literature analysis that looks at previous studies and research on the subject of machine learning approaches for hazard prediction as well as IoT applications in transportation.

Marzana Khatun et.al proposed [10] Machine learning and data analysis techniques identify the root causes of auto accidents and offer solutions for their prevention. However, big data solutions must be utilized here because to the amount and speed at which data regarding traffic accidents is being gathered. This study looks at pertinent data factors to find patterns in road car accident data and to propose a predictive model, such as accident severity, number of victims, and number of cars.

Philippe Sivla et.al, article [11] shows an effective tactic for encouraging safe mobility is road safety modelling, which makes it possible to create crash prediction models (CPM) and look into the variables that influence the likelihood of crashes. Although the drawbacks of this type of approach (particular assumptions and prior design of the link functions) have been acknowledged, statistical techniques have been employed in this modeming traditionally.

3. Road Accident Detection Mechanism

The process of "Predicting and Mitigating Road Hazards with IoT & Machine Learning" starts with identifying stakeholders, including transportation authorities and technology experts, and setting clear objectives. In the following phase, many data sources will be gathered and pre-processed, such as past accident data, meteorological data, and real-time sensor data from IoT devices placed beside roadsides and in cars [12].

After that, useful features are retrieved from the data to aid in hazard prediction a process known as feature engineering. Next, using the provided dataset, machine learning models are created and trained, with an emphasis on methods appropriate for tasks involving regression or classification. In order tocontinually ingest and process sensor data, real-time data integration must be implemented using data pipelines. Alerts are provided to inform stakeholders about potential risks, and predictions of hazards are made using the deployed machine learning algorithms. Based on anticipated hazards, mitigation techniques are advised, such as changing speed restrictions or diverting traffic [13].

4. Proposed method for Road Accident Detection Mechanism through IoT

To ensure that the system is effective in anticipating and reducing road dangers, evaluation and monitoring are continuous procedures. As a means of enhancing road safety and transportation efficiency over time, the methodology is continuously improved and iterated based on feedback from stakeholders and users. IoT-based road accident detection systems leverage real-time data analytics and sensor technology to improve traffic safety [14, 15].

Typically, these systems use a network of Internet of Things (IoT) sensors to monitor various aspects of driving conditions, vehicle behavior, and environmental factors both inside and outside of cars. Road surface conditions, surrounding traffic density, vehicle speed, acceleration, braking patterns, and lane deviations are all continuously recorded by sensors like accelerometers, gyroscopes, GPS trackers, and cameras which was shown in Fig 2.

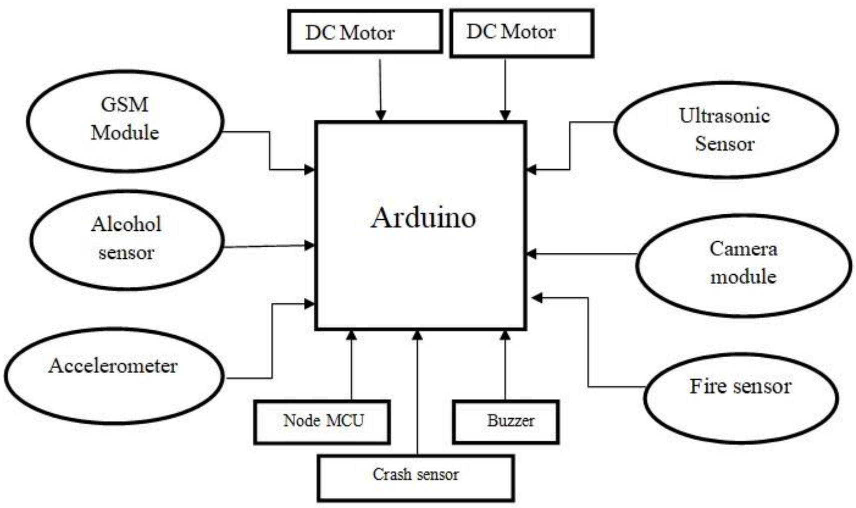


Fig 2: Block Diagram of proposed model

Various sensors are utilized in this block diagram to recognize accidents and gather accident-related data, including locations, force, alcohol detections, distance, obstacles, and fire. The following are these sensors specifics [16, 17]:

Arduino: Hardware and software components are both included in the open-source Arduino electronics platform. Arduino's brainchild is the microcontroller board, which is effectively a tiny computer on an integrated circuit [18]. Code written in the Arduino programming language (based on Wiring) can be transferred to this board via a USB connection to program it to do a number of tasks

LCD Display: LCDs operate on the basis of the characteristics of liquid crystals, which are materials that, when exposed to an electric current, can alter their molecular structure. Electronic gadgets like digital watches, calculators, computer monitors, and consumer electronics frequently employ liquid crystal displays (LCDs), a form of flat-panel display.

Ultrasonic Sensor: Ultrasonic sensors are widely employed to identify things or measure distance. Based on the echolocation principle, which is essentially how bats find their way in the dark these sensors release ultrasonic sound waves that are usually above the human hearing range and spread outward in a cone- shaped pattern through the atmosphere.

IR Sensor: A device that detects infrared radiation emitted or reflected by nearby objects is known as an infrared (IR) sensor. All objects with a temperature higher than absolute zero produce infrared radiation, which is the basis for the operation of R sensors.

GPS Module: A GPS (Global Positioning System) module used for navigation is called the NEO-6MV2. The module only determines its position on Earth and outputs the position's longitude and latitude.

Node MCU: An open-source development board called Node MCU is built around the ESP8266 microprocessor. Because it combines a microcontroller and Wi-Fi connectivity, it is perfect for Internet of Things (IoT) projects and experimentation. The Node MCU board includes GPIO ports for attaching external sensors and actuators, a USB interface for programming and power supply, and integrated Wi-Fi.

Alarm (Buzzer): A clock that is intended to notify a person or group of people at a specific time is called an alarm clock or alarm. These clocks' main purpose is to wake people up from naps or night time sleep; occasionally, they can also serve as other reminders. Alarm clocks typically emit sounds, though some also vibrate or light up.

DC Motor: Because they allow for automation, remote control, and monitoring, DC motors are essential to the Internet of Things (IoT). Users can use PCs or cellphones to operate wireless modules like Bluetooth or Wi-Fi from any location.

The proposed system uses a combination of the Internet of Things and machine learning.

IoT module for Accident detection**:** The designed hardware device contains sensors and actuators to detect an accident and its intensity. A pressure sensor is used to identify the accident which is mounted on the vehicle chassis. The pressure sensor is connected to the ATMEGA328 microcontroller to detect accidents and raise the alarm system. If the speed and vibration’s values exceed a predefined threshold, an accident will occur. When the accident is detected, it will first activate the alarm for 15 s. If there is no accident or the accident is average or negligible. Node MCU will send the information nearby Police stations, hospitals. The ESP8266 module will activate the camera and send photos, GPS data, and other items to the Arduino Uno. The GPS data are also sent to the LCD display to show GPS information captured by the GPS module [19].

Machine Learning Module: Reduced false alarms are the primary objective of this module. Vehicle speeding is one of the primary causes of traffic accidents. The technology recognizes an accident when the vehicle's speed abruptly changes and goes above the set threshold. NodeMCU will turn on the camera and send an activation signal to Arduino as soon as the device detects an accident [20]. Some pictures captured by the camera will be uploaded to the Telegram Bot. In Fig 4, the mechanism of the IoT and machine learning module is shown.

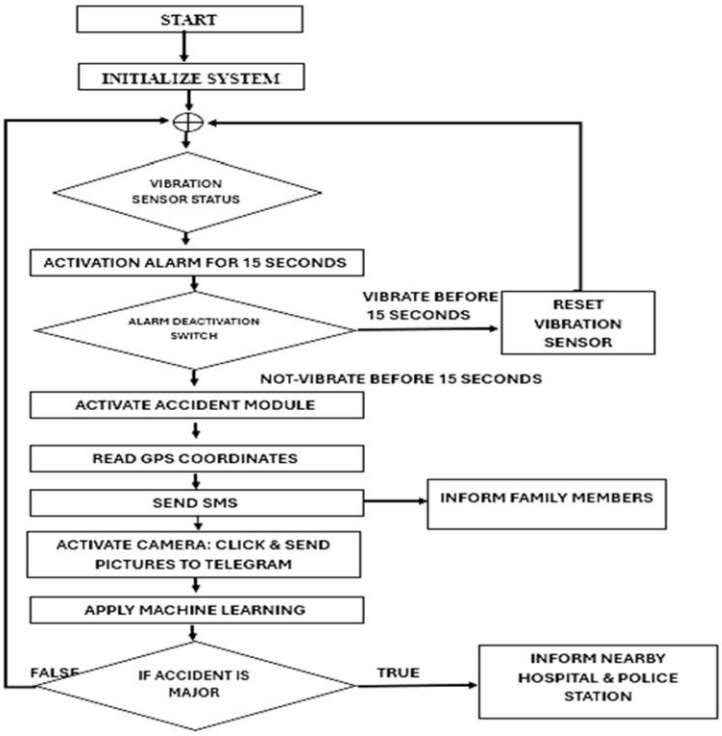


Fig 3: Step by step Procedure

5. Experiment Setup

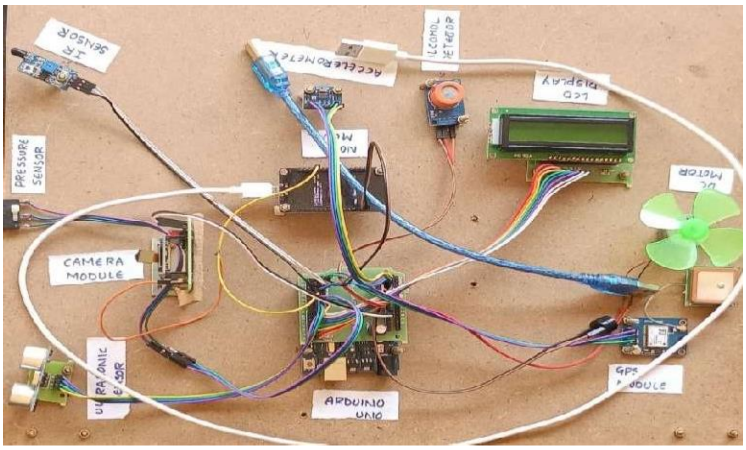


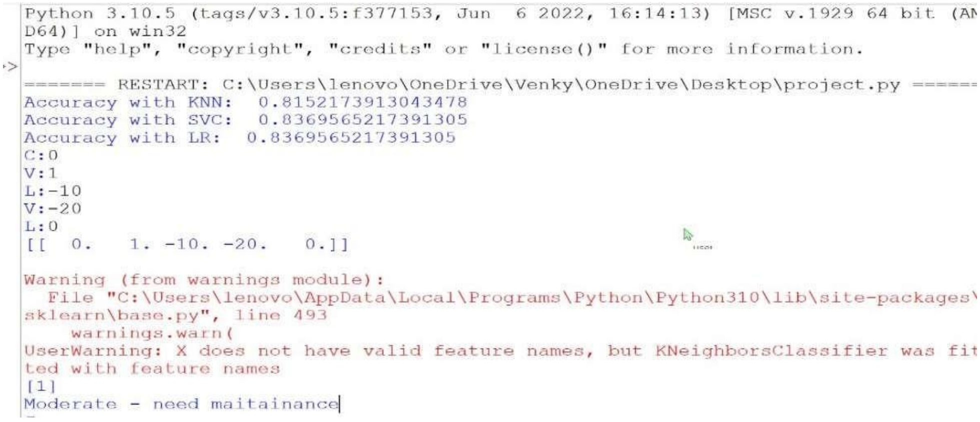
Fig 4: Working of the system

In this project an Arduino UNO is used. An ON LED indicates that electricity is being delivered to the circuit when the system is turned on. Data is sent to the LCD display for display purposes whenever the vibration sensor detects an obstruction. The ultrasonic sensor will provide sensor data to the LCD screen based on variation in the distance between two objects. The experimental setup of the proposed model was mentioned in Fig 4. After receiving the location of the car involved in an accident, the GPS returns the information. A Telegram Bot message will be used to provide this information to a mobile number. The internet that is connected to the circuit will be used to receive this message.

The latitude and longitude values are provided in this message. Making use of these values, it is possible to approximate the vehicle's position. The Arduino receives the received data. In response, it sends a Telegram message to the mobile device acknowledging receipt of the message. The circuit's LED indicates when messages are received. Select lines that are internally incorporated into the internet are used to activate the devices, which are interfaced by the Arduino to the GPS modem through it.

Results

The accident detection and prevention system in the IDLE environment is likely to be operated by Python code that contains functions like tracking driver behaviour, identifying fatigue indicators, and sending out timely messages to keep drivers alert and awake.



```
Python 3.10.5 (tags/v3.10.5:f377153, Jun  6 2022, 16:14:13) [MSC v.1929 64 bit (AM
D64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>
======= RESTART: C:\Users\lenovo\OneDrive\Venky\OneDrive\Desktop\project.py ======
Accuracy with KNN:  0.8152173913043478
Accuracy with SVC:  0.8369565217391305
Accuracy with LR:  0.8369565217391305
C:0
V:1
L:-10
V:-20
L:0
[[  0.   1. -10. -20.   0.]]

Warning (from warnings module):
  File "C:\Users\lenovo\AppData\Local\Programs\Python\Python310\lib\site-packages\
sklearn\base.py", line 493
    warnings.warn(
UserWarning: X does not have valid feature names, but KNeighborsClassifier was fit
ted with feature names
[1]
Moderate - need maitainance
```

Fig 5: Output for python programming by using KNN, SVC, LR

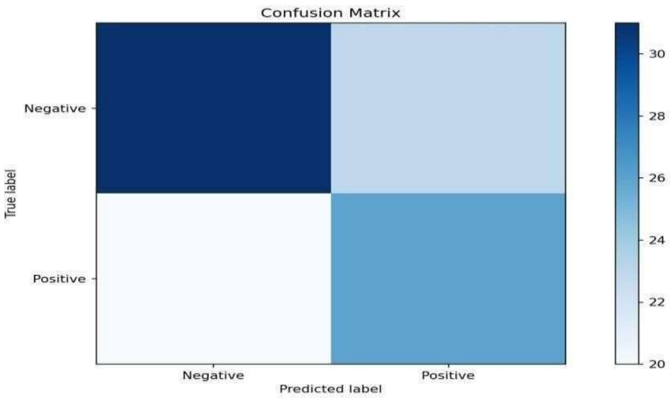


Fig 6: Confusion matrix output

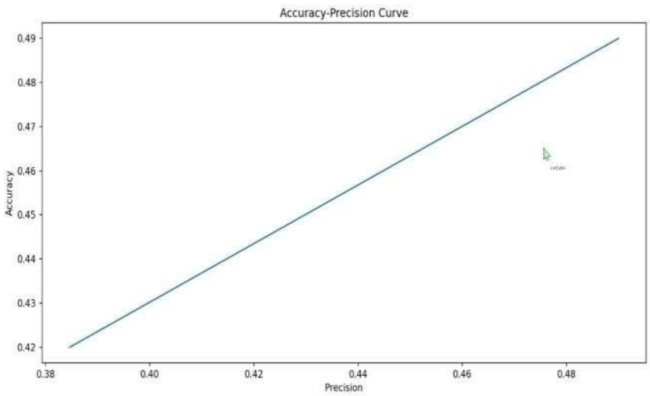


Fig 7: Accuracy in graphical Representation

Fig 5,6 & 7 are the outputs of machine learning algorithm. In this algorithm we use the data set for analyzing the code. In this data set virtually applied the values. If the output is 0 it shows that the vehicle is in good condition, the output is 1 it indicates the vehicle is in moderate condition and displays need maintenance, and the output is 2 the vehicle is in majorly damaged and it indicates immediate action is required.

Fig 8: Sending accident info

Fig 9: Location & sensors values

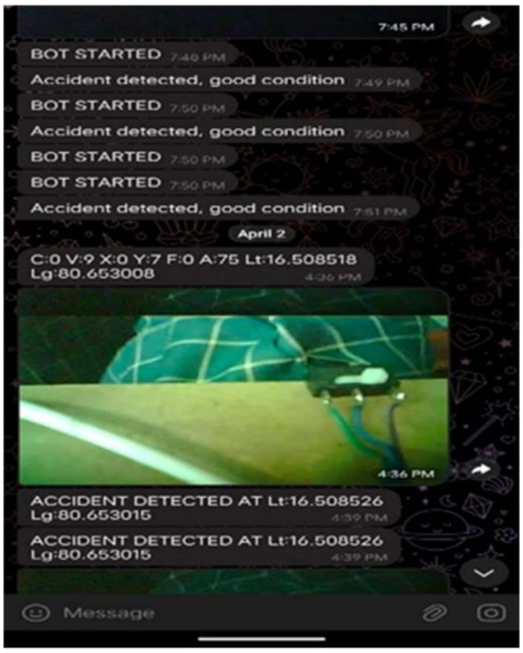


Fig 10: Receiving Accident alerts with location and photo in telegram Bot

The above-mentioned Fig 10 shows how the code runs and the camera begins to monitor. The console will display a notification indicating that the Telegram Bot is ready. If the system determines that the accident occurred after a threshold has been exceeded, both the alarm and the current position are shown on the console. Additionally, an image is sent to the specified chat ID.

That same graphic above illustrates how the phone gets a "Bot started" signal as soon as the console indicates that the "Telegram bot is ready." When the driver alert is activated, the console shows the currentposition and informs that a photo is being sent to the chat ID. Using machine learning and IoT (Internet ofThings) to predict and mitigate road dangers has various benefits with Increased Security, Effective Resource Distribution and Financial Savings.

Conclusion & Future work

Road safety may be increased and the frequency and severity of accidents can be decreased by utilizing the combination of IoT and machine learning technologies, which provides a workable method for predicting and reducing traffic hazards. Interested parties may be able to create intelligent systems with the capacity to quickly identify possible dangers, keep an eye on road conditions, and proactively reduce risks by integrating these two technologies. Using sensors data, machine learning models can be taught to predict a wide range of road hazards, Vehicle conditions, Accident severity, including crashes. By giving early warnings and notifications to drivers, emergency responders, and transportation authorities, these models enable proactive efforts to reduce the likelihood of accidents and their effects.

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