Smart Accıdent Detectıon using IoT Technology

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Abstract

Road accidents and emergency services delay are the main significant issues. To overcome these issues need to develop a system. Efficient handling of accidents through the immediate detection and provide timely aid are more crucial. Accident detection and emergency system depends on IoT (Internet of things) with minimum delay are gaining significant attention towards industry and academic literature. Several researches are investigated using IOT technology to detect accidents. In this work, we proposed an effective accident detection method by employing five sensors not only to detect accident but also to report type of accident such as collision, no accident, roll over or fall off. In addition to that, the status of the accident is communicated to the IBM Watson Cloud platform. The incoming data received in the node red platform is integrated with the Google Maps to show location and other information about the accident that can be accessed by the hospital through website and sending alert messages to victim acquaintances. In addition, two Machine Learning (ML) models based on K-Nearest Neighbor (KNN) model and the Naïve Bayes (NB) model are compared to find out the best accident detection model. It is noticed that the KNN model is the very effective ML model, which employed to know the accident status and to enhance the system by providing patient's details, a kill switch and sending messages often until acknowledgement is received.

Keywords: Internet of things; Accident detection; Machine learning; Sensors; Collision; Emergency

1. Introduction

Nowadays, more number of accidents that occurs in the world rises with the increase in population and number of vehicles. A recent World Health Organisation (WHO) estimate, 50 million people are injured and 1.35 million people die annually. Delays in receiving emergency medical aid resulted in human casualties in a traffic collision. The reduction in emergency medical care's response time may lessen the likelihood of death.

IoT is one of the main promising information and communication technology have been used to reduce the accident response time and possesses an interconnected network of various physical components and devices to track and control automobiles. Significant research has been carried out to detect accident and reduce response time after accident [1].

2. Literature Review

Kumar, N., et al. [2] developed an Internet of Things (IoT)-based automobile accident detection and categorization (ADC) system that identifies and reports the accident type via sensor fusion. Three distinct ADC models are assessed and contrasted. With an average F1-score of 0.95 among them, the NB model is found to perform better than the others do. Its highest accuracy is observed for collisions, with an F1-score of 0.97, followed by rollover, no-accident, and fall-off occurrences, in that order.

Sherif, H.M. et al. [3] reported a real time traffic accident warning system employing wireless sensor network (RTTAWS) and Radio-Frequency Identification technologies (RFID). Three algorithms are employed to detect

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accident, which includes sensor's status, RFID reader stating the location of the accident, vehicle's number, and number of passengers-gathers (and vehicle's location on predefined period).

Shaik, A., et al. [4] have an automatic notification and response to the scene using IOT. An accelerometer and GPS sensor signal is automatically transferred to the cloud, and from there, whoever is subscribed to that car receives an alarm message. The signal will identify the severity of the collision and the GPS location. The ambulance will use the GPS coordinates to rapidly arrive at the scene.

Anil, B.S., et al. [5] have a flex sensors and an accelerometer to identify the accident and send the hospital's location information nearby. The GPS module provides the location, which the GSM modem uses to send the location as a message. Additionally, it claims to broadcast live footage to convey the gravity of the issue.

Rakhonde, M.A., et al. [6] reported that along with accident detection, it also implements many other things such as accident prevention and pollution detection. The accident is found using an accelerometer sensor and it is forwarded to the node microcontroller that then checks if the driver is okay to prevent false alarm. If the driver does not answer, then using the MQTT protocol, the server receives a message with the GPS module's location and the concerned persons get the message containing the accident location.

Verma, A., et al.[7], compare the frame size and time consumption in accident detection. In addition, eliminate the unnecessary graphical content and lightened the image to make it more portable and enable for quick accident pattern detection employing canny based edge detection mechanism.

Karmokar, P., et al. [8] proposes a smart accident detection and rescue mechanism that produce exact accident location, also aids ambulance to take the shortest path to the accident spot, and thereby rescue the victims in the least possible timeframe. Besides, this proposed system achieved outcome in a cost effective way. In this system [9-10] uses a VANET (Vehicular Ad-hoc Network), where each moving vehicle acts as a node and alert messages are communicated through RF (Radio Frequency) module 11] when accident occurs.

Smartphone based systems [12] utilized an android app to identify auto crashes. The speed and tilt angle can be measured using an accelerometer sensor and a GPS unit. Further, it gives an alert upon accident detected. In this approach [13] collection of data from various sensors and feature extraction from event logs for collision detection model. To detect accident, several computational models such as nearest neighbor, neural networks and regression trees are used.

The contribution of this entire work are,

- ✓ Receive inputs from multiple sensors respectively
- ✓ Feed the information into the selected model to examine whether an accident has happened or not.
- ✓ The location is immediately shared to the closest hospital to dispatch ambulance
- ✓ Information provided should not only to report an accident but also type of accident (i.e. crash, roll over, fall off)
- ✓ Alert loved ones who are subscribed to that vehicle
- ✓ Enable kill switch should accident not be as severe

3. Proposed Methodology

Road Transport Minister Nitin Gakdari has stated that India faces a bigger threat from road accidents than the Covid 19 Pandemic (2020) [14]. Though India only accounts for around 1 % of the world's vehicles, it makes up a whopping 11 % of global death due to road accidents according to a report by the World Bank. Out of the 450000 accidents that happen annually, 33.3% of people die. To put things in perspective, a person dies every 4 minutes from road accident as stated by the same report.

Doctors who specialize in trauma have identified a golden period in which the first 60 minutes after an accident has occurred. The care administered to the patient and the successive transport of the patient to the nearest hospital can make all the difference in finding the outcome. Not only is this a theory of experts but they have also sought out evidence that confirms RTA victims [15] have a more favourable result if the pre-hospital procedure is done efficiently. Hence, in this proposed method, we aim to minimize this gap as much as possible.

A. Detection System

The accident detection system's implementation begins with three sensors. These sensors are chosen specifically to meet the requirements. The MPU 6050 is a single sensor that can input both the current values of accelerometer and gyroscope simultaneously as shown in the figure 1. This reduces the size and cost. The vibration sensor is used on the 4 sides of the vehicle. A vibration sensor is chosen instead of a switch- crash sensor as the surface of a vehicle is huge and the vibration sensor covers a lot more region than the traditional crash sensor, which could

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miss accidents if it does not sense the impact at that particular region. Then comes the flame sensor to detect if there is a fire, as fire and accidents go hand in hand.

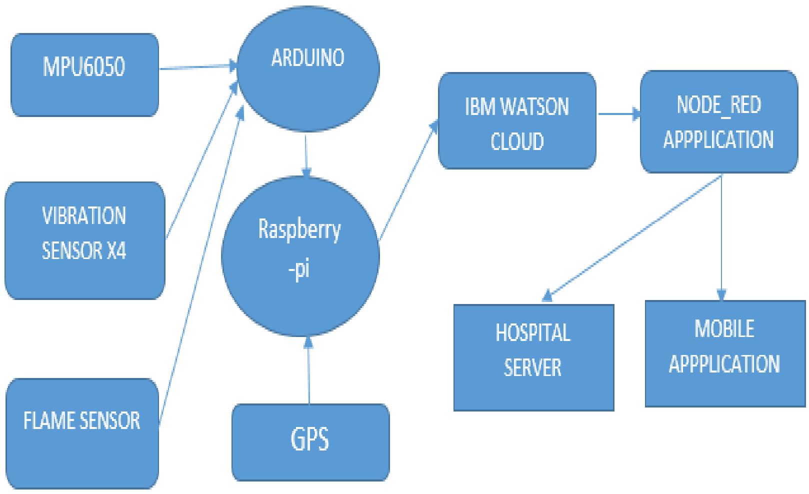

Figure 1. Accident detection system

All of these values are taken as inputs by the Arduino Uno microcontroller and are serially transmitted using the serial monitor to the Raspberry Pi 3. The Raspberry pi cannot take inputs directly as there will be overload on the device. The raspberry pi also reads the current GPS position and is ready to send the location. Only in the Raspberry pi, we perform several machine-learning models, analyze the accuracy of each model, and choose the best one that is both accurate and can classify several classes or type of accidents.

Should an accident occur, the raspberry pi detects it immediately and sends the details such as the type of accident and the location of the accident to the IBM Watson cloud? From there the information is transferred to the NODE-RED application that then alerts the concerned hospital servers and to the family members via the app created by MIT app inventor.

B. Components Descriptions

The figure 2 shows the interfacing of Arduino UNO with vibration sensor, MPU6050 Sensor and flame sensor.

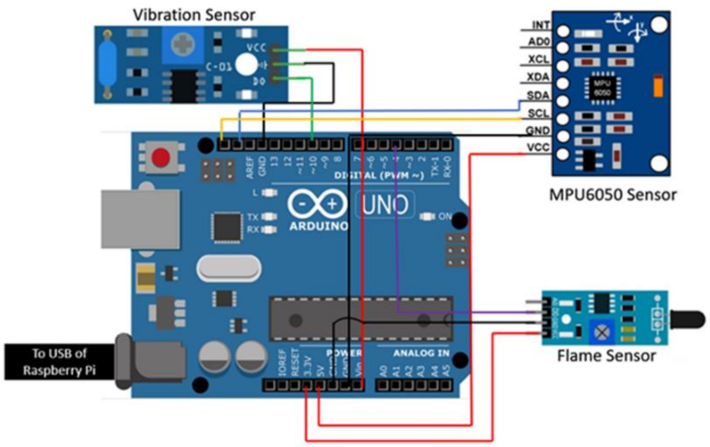

Figure 2. Arduino UNO Interface with sensors

C. MPU6050

MPU6050 sensor measures two properties. The three axes that are required for the gyroscope accelerometer are recorded. We will only need the Vcc, Gnd, Serial Clock and Serial Data pins. The connection is as follows in figure 3.

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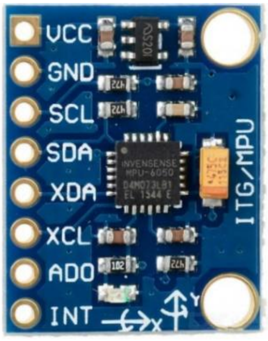

Figure 3. MPU6050 sensor

D. Accelerometer

If a car becomes unstable due to an accident, at times it will not be in a stable position. It could swerve such that the car's orientation changes. This can be picked up by the accelerometer, as it will no longer stay parallel to the gravitational axes [14]. When an accident occurs, the car will automatically decelerate, and the impact will be distributed along the three axes. The absolute linear acceleration can be calculated by finding the ALA Vector.

E. Gyroscope

By using the gyroscope, we will be getting the pitch, roll and yaw values, However, we will only be looking at the roll and pitch values in the dataset was found in [15] that when any one of the values is higher than 90 degrees, it is likely that the car experiences a rollover. The accelerometer values coupled with gyroscope values can give us the required data about the orientation of the car.

F. Vibration Sensor

The vibration sensor is shown in the figure 4 that employed to identify any impact or collision that the car experiences [16]. The sensitivity of the sensor was adjusted such that the sensor picks up a change only when the car is hit hard on a surface.

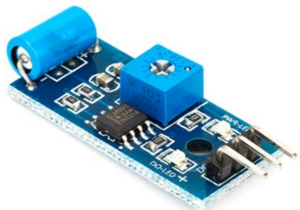

Figure 4. Vibration sensor

G. Flame Sensor

When a crash occurs, because of the presence of gas and susceptibility of sparking, fires may be anticipated. In the instance of a fire, paramedics need to be geared up to deal with the related accidents, be it when it comes to the respiration gadget or bodily burns [17]. Firefighters also can be referred if needed. The film sensor structure as shown in the figure 5.

Figure 5. Film sensor

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H. Pressure Sensor

The pressure sensor is included to calculate the change in altitude should the vehicle fall off a high cliff or bridge. With the assistance of atmospheric pressure, we are able to calculate the change in height.

I. Arduino UNO

The Arduino uno is shown in the figure 6, it is a handy microcontroller it does a perfect job in collecting all the required data and communicating these details to the raspberry pi, which would be doing the heavy lifting in terms of running these values through machine learning models [18]. The Arduino has ample Vcc pins and Digital I/O pins to accommodate all our sensors.

Figure 6. Arduino Uno

J. Raspberry PI

Raspberry Pi 3B+ is shown in figure 7, that utilized to process the sensor data as well as the GPS/GSM data as it can carry out heavy software since it is capable of handling complex software applications like machine learning. Additionally, the Raspberry Pi to the IBM Watson Cloud [19] will communicate the accidental location, driver's details, and other accident-related information. With the use of the Cloud platform's features, these details are transmitted.

Many applications are made of Raspberry Pi but it is not strongly recommended for high-end ML applications because there is no proper hardware present to carry out heavy computational processes and also RAM and processor speed is insufficient. Hence, we use the trained neural network to Raspberry-pi.

Figure 7. Raspberry Pi

K. GPS

The GPS sensor is shown in the figure 8, which gives us inputs in the form of NMEA messages. Not only do they collate information about the longitude and latitude values but also plenty of other data like as speed and altitude that we can exploit. In this instance, we will not even need the pressure sensor that we had previously planned.

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Figure 8. GPS

4. Implementation of Accident Detection Depends on IoT

A. Collecting the Dataset Collection

For the gathering of dataset, we had the individual properties coming in from the various ports of the Arduino. The accelerometer values from the MPU6050 were normalized by using an equation to ensure the model still stays relevant if the data were to change with respect to the car location. The gyroscope values, which were also obtained from the MPU6050, measured the degree of pitch roll and yaw, which conveyed which way the car was swaying that helped to determine if a rollover had taken place. The vibration sensor acted as our impact sensor, hence, pointing out any kind of collision. There are currently 3 outputs for the machine learning model. The system should be able to find whether there is a collision, rollover accident or nothing at all. For the system to predict this, we need to use a machine-learning model. For that model training, we need to create a dataset imitating real world scenarios. We simulated the respective possible outputs while noting down the accident points in real time and entering them into the dataset for the subsequent supervised machine learning models. The outputs represent 0-No accident, 1-Collision, 2-Roll Off. With the usage of the Arduino, those values are sent to the serial monitor from where the data is streamed right into the excel application with the usage of the data streamer tool. They were then randomized to ensure the model is trained well. The following is a sample of the dataset that we had collected as shown in table 1 and table 2.

Table 1: Data set collection with outputs; No Accident and Collision

AX	AY	AZ	ALA	Temperature	GX	GY	GZ	Vibration	Output
-1472	564	13812	13901.66263	38.74	-468	-60	-57	0	0
-924	328	18048	18074.6138	38.69	-409	-93	24	0	0
-1032	-1016	6200	6366.88935	38.6	-596	174	-117	0	0
23220	25184	32767	47403.36006	38.6	-3624	18632	-357	896	1
3124	-29368	32767	44112.52757	38.69	11193	790	-523	895	1
-3152	-12528	1204	12974.41729	38.68	-4687	-2405	965	0	0
-3956	2256	6472	7913.675252	38.69	542	627	3563	774	1
-3176	1976	25960	26228.09852	38.65	5543	2381	4295	**697**	1
-7476	-556	21404	22678.86523	38.65	-4269	-59	3943	477	1

Table 2: Data set collection with output; Rollover

AX	AY	AZ	ALA	Temperature	GX	GY	GZ	Vibration	Output
44	-1894	-4876	19565.37799	38.93	-7082	-1081	1077	897	2
-2360	-1704	-1040	17234.0593	38.84	-8410	-1323	-2920	0	2
-1744	-1739	1828	17578.50779	38.84	-4110	-1497	7092	897	2

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-8344	-1763	-1429	24184.40357	38.88	-3917	-3940	409	897	2
-1424	-3276	-1166	34809.84344	38.84	-9774	12	-6113	897	2
-2690	32767	-3276	53583.98389	38.93	32767	1828	11387	885	2
-8	-2029	-1016	22693.41155	38.88	-32768	17559	-2243	895	2

B. Processing Data Using Machine Learning Models and Other Algorithms

First, whilst creating the dataset we see that the accelerometer values are just too random for the machine to understand and make sense out of it since it has 3 axes and it doesn't make it any easier. Therefore, we need a normalization tool. A method with which we can use the magnitude of the acceleration instead of the directions. That is how we came up with Applied Linear Acceleration. With this, it is much easier for the machine to understand when a vehicle meets with an accident, as there is definite deceleration regardless of the direction. As stated above, we have a dataset that contains the output. Hence, we look for supervised learning algorithms.

C. Sending information through cloud to hospitals using website (Node-Red)

There are two parts to this sub-chapter; one we have to collect the coordinates from the GPS and two we have to communicate this information to the cloud.

a. Connecting GPS to obtain Longitude and Latitude

After getting a fix on the GPS using the very handy U-center software. It is now connected to 7 satellites and gets accurate values each time readings are fed into the pi as shown in the image. The GPS is connected to one of the many GPIO Ports in the Pi as mentioned in the following figure 9.

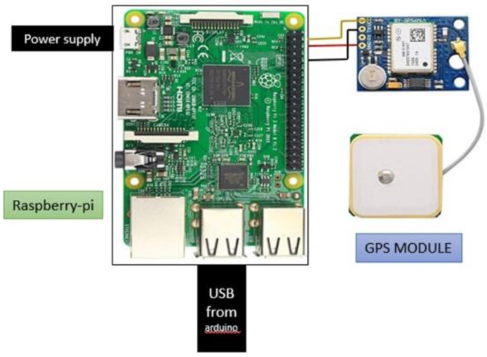

Figure 9. GPS Connection with GPIO Port

The information is serially received by the Pi but a bit of formatting, is needed to extract only the values that we need which are the latitude and longitude values. We only require the $GPGGA sentence from the many NMEA sentences. Hence, the code not only receives the information but also extracts the value we need and messaged it to the cloud along with other information such as the status of the accident and the fire presence.

b. Connecting to IBM Watson

The IBM Watson Cloud is very simple to use and has several tools that we can exploit. First, we created our free IBM Cloud account. From the Watson catalog, under the services option, we choose the cloudant database. This stores information in the JSON format, which makes it easily scalable for our needs. After giving it a suitable instance name and choosing the IAM authentication method, we create the cloudant database and deploy it.

Next, we set up the IoT platform by launching it from the resource list. In the platform, we created our device. In our case, we named it the Arduino Uno and gave our device ID to be 123. After creating our device, when we ran

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the client-server code on the pi, the sensor values were received in this platform as it can be viewed in Recent Events Shown below figure 10 and figure 11.

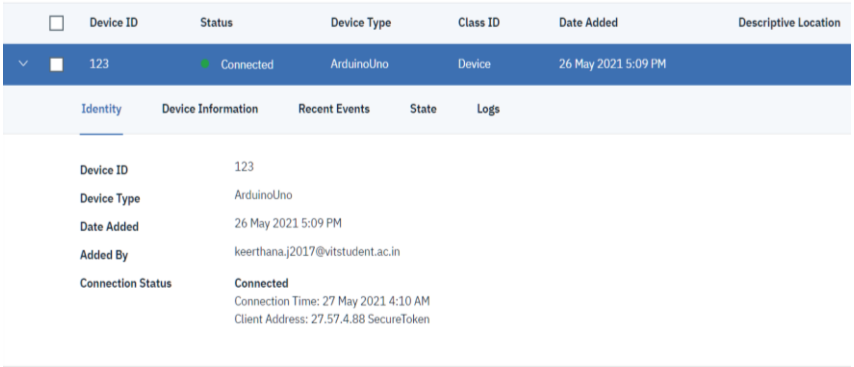
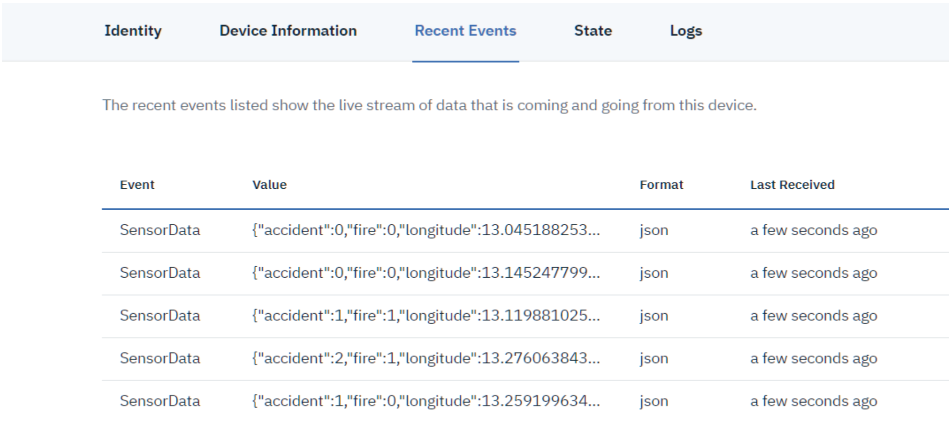


Figure 10. Connection made between Pi and Cloud



Event	Value	Format	Last Received
SensorData	{"accident":0,"fire":0,"longitude":13.045188253...	json	a few seconds ago
SensorData	{"accident":0,"fire":0,"longitude":13.145247799...	json	a few seconds ago
SensorData	{"accident":1,"fire":1,"longitude":13.119881025...	json	a few seconds ago
SensorData	{"accident":2,"fire":1,"longitude":13.276063843...	json	a few seconds ago
SensorData	{"accident":1,"fire":0,"longitude":13.259199634...	json	a few seconds ago

Figure 11. Values being received in cloud

After we know we have the values being conveyed from the device, can use this information to our advantage, we created a standard application and took down the API Key and other details. Next step we move to the creation of a very basic website using the Node-Red application in the IBM Watson Platform. After going to the Node-Red flow editor, we can create our flow and deploy it to get our website. The figure 12 shows the flow we used for our website.

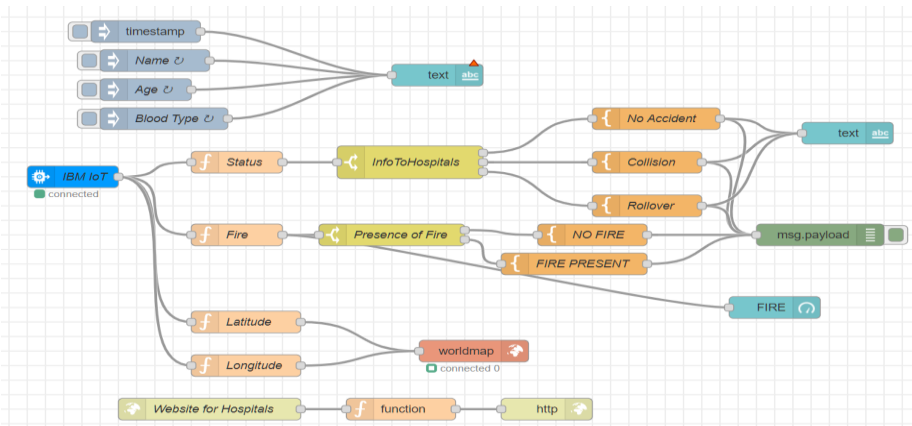


Figure 12. Node red flow for use of data and sending to server of hospital

The values received in json format are extracted to each individual property and compared with thresholds. Then, the respective message goes out to the hospital and the loved ones. The Details can be viewed in this page and the

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position on the map is shown thanks to the various ui features and the world map feature as shown in the figure 13.

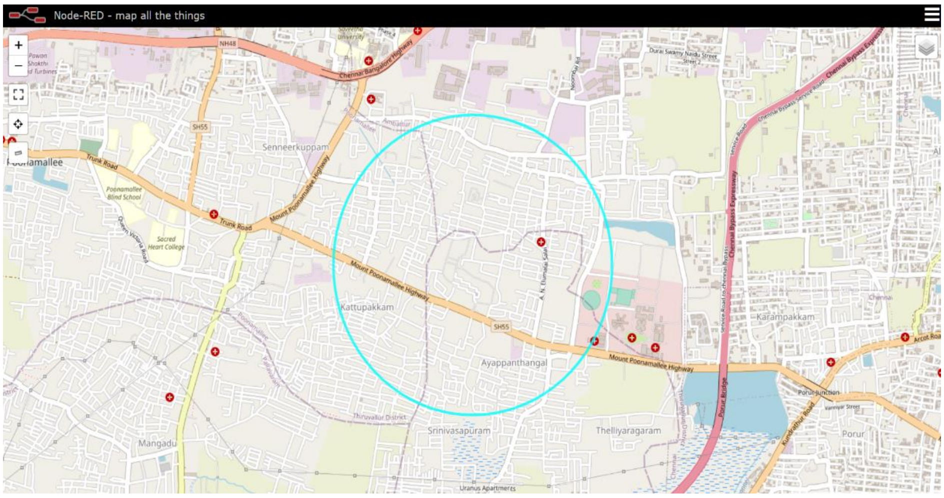

Figure 13. Node Red map image

Fast2SMS is a SMS service provider to be employed for sending our emergency messages depends on the output of whether the accident happened or not. We activate it using a simple authorization key and token to get the messages on our phone as show in the figure 14 below,

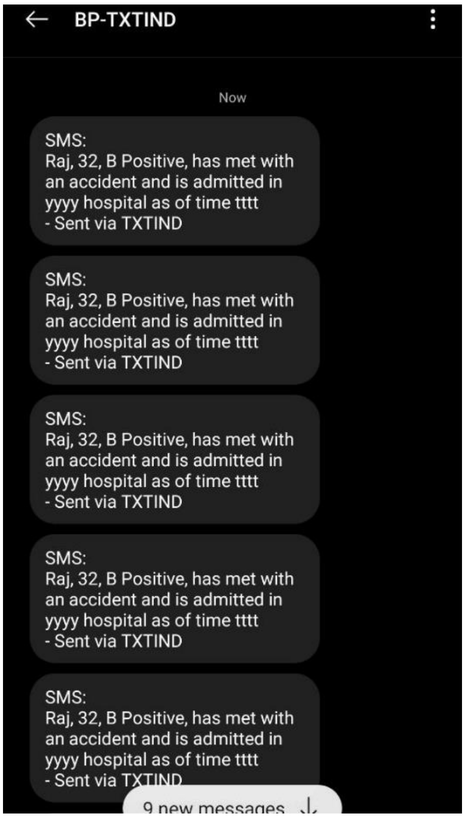

Figure 14. Emergency message to mobile phone

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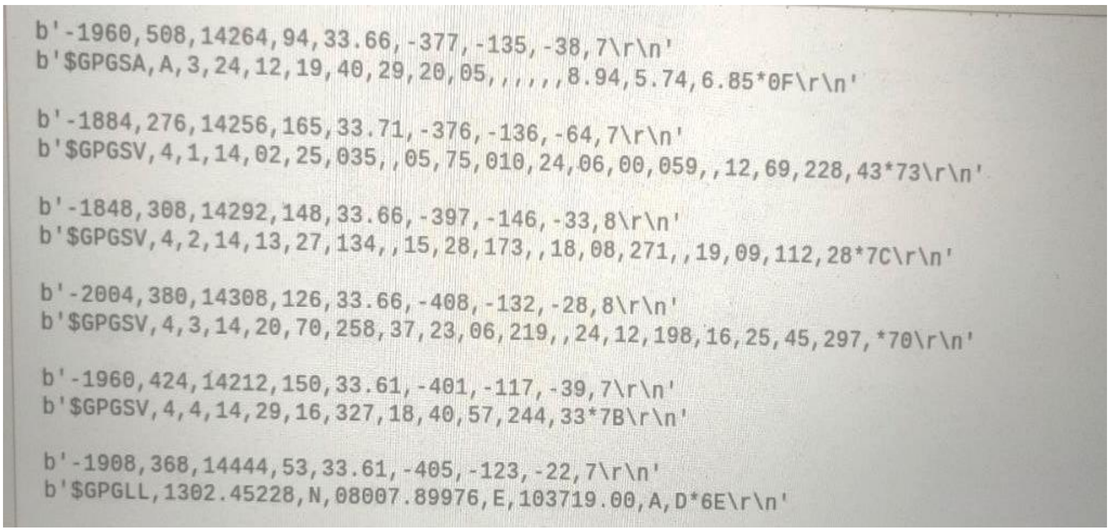
5. Results and Discussion

The below figure 15 and table 3 shows the Output of Arduino, transferring the sensor values to the raspberry pi and dataset collected using data streamer in excel.

Table 3: The dataset collected using data streamer in excel

AX	AY	AZ	ALA	Temperature	GX	GY	GZ	Vibration	Output
1472	564	13812	13901.66263	38.74	-468	-60	-57	0	0
-924	328	18048	18074.6138	38.69	-409	-93	24	0	0
-1032	-1016	6200	6366.88935	38.6	-596	174	-1179	0	0
23220	25184	32767	47403.36006	38.6	-3624	18632	-3571	896	1
3124	-2936	32767	44112.52757	38.69	11193	790	-5235	895	1
-3152	-1252	1204	12974.41729	38.69	-4687	-2405	965	0	0
-3956	2256	6472	7913.675252	38.69	542	627	3563	774	1
-3176	1976	525960	26228.09852	38.65	5543	2381	4295	**697**	1
-7476	-556	21404	22678.86523	38.65	-4269	-59	3943	477	1
-3812	6412	-512	7477.113882	38.74	-1969	-25	3978	0	0
-828	2088	12860	13054.68989	38.69	-2978	1524	1266	0	0
-3936	4360	9824	11446.07671	38.74	-3340	809	2293	0	0



```
b'-1960,508,14264,94,33.66,-377,-135,-38,7\r\n'
b'$GPGSA,A,3,24,12,19,40,29,20,05,,,,,,8.94,5.74,6.85*0F\r\n'

b'-1884,276,14256,165,33.71,-376,-136,-64,7\r\n'
b'$GPGSV,4,1,14,02,25,035,,05,75,010,24,06,00,059,,12,69,228,43*73\r\n'

b'-1848,308,14292,148,33.66,-397,-146,-33,8\r\n'
b'$GPGSV,4,2,14,13,27,134,,15,28,173,,18,08,271,,19,09,112,28*7C\r\n'

b'-2004,380,14308,126,33.66,-408,-132,-28,8\r\n'
b'$GPGSV,4,3,14,20,70,258,37,23,06,219,,24,12,198,16,25,45,297,*70\r\n'

b'-1960,424,14212,150,33.61,-401,-117,-39,7\r\n'
b'$GPGSV,4,4,14,29,16,327,18,40,57,244,33*7B\r\n'

b'-1908,368,14444,53,33.61,-405,-123,-22,7\r\n'
b'$GPGLL,1302.45228,N,08007.89976,E,103719.00,A,D*6E\r\n'
```

Figure 15. Output of Arduino, transferring the sensor values to the raspberry pi

When the car is idle or moving without an accident as shown in the figure 16.

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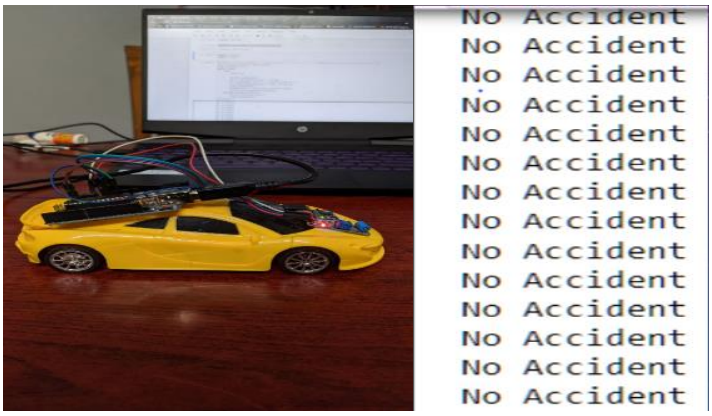
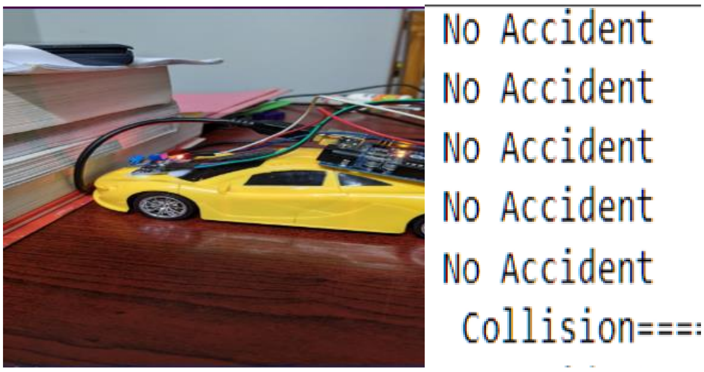


Figure 16. Car is idle or moving without an accident

When the car goes through a collision while moving as shown in the figure 17.



F
igure 17. Car goes through a collision while moving

When the car has rolled over due to an accident while moving as shown in the figure 18.

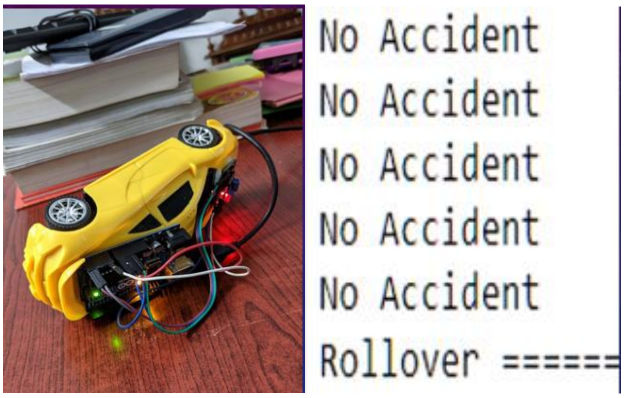


Figure 18. Car has rolled over due to an accident

6. Conclusion and Future Scope

From the system and real life testing, we are able to observe that the accuracy of detecting accidents is high for KNN algorithm. The algorithm is effectively able to classify the type of accident within an instant. The system can run constantly and reliably connecting to the cloud service where it is ready to send the details of the accident in an instant should the rider meet with an accident. The system will be cost efficient and compact such that it can even fit inside a motorcycles' seat, thus making it more accessible to many people. With this system working as intended, it is believed that the time taken for the person to get to the hospital from the time of crash will be drastically cut down and increases the chance of survival rate of those who meet with accidents.

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Future study will focus on determining the most appropriate version of our ADC system's categorization, enforcing validation techniques such K-fold cross-validation, and analyzing the time required by employing an algorithm. Moreover, that there is potential for the number of incidents to increase in the up comings. So that first responders can respond more effectively and anticipate the situations, they will find themselves in by having rapid access to facts about the event.

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