Accident Prevention and Alcohol Detection using GSM Module

S.P. VIJAY VARDHAN REDDY[1], M.V.R.K. AKHIL[2], V. SAITEJA[3], Y.SUDHEER[4]

[1]Department of Electronics and Communication, Engineering, Assistant Professor, Chennai, India

[2,3,4]Department of Electronics and Communication Engineering, Chennai, India

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Abstract - *Now a days due to the growing number of 2-wheel motor vehicles, frequency of accidents is on the rise. A major portion of the accidents occur because the person was either not wearing a helmet and he could not be saved because of the delayed admittance to a hospital or because he was riding while drunk. We propose mechanisms that can detect if one is wearing the helmet, detect accidents, and detect whether the person has over-consumed alcohol. For this purpose, we use onboard sensors, flex sensor, impact sensor, accelerometer. The accelerometer measures the change in tilt, in X Y and Z axes respectively, and sends the data to a server via an online application programming interface. The breath analyzer senses the amount of alcohol present in the breath of a person wearing the helmet and reports if it is beyond the legal limit. The server also uses the data gathered from the accelerometer and the pressure sensors, to train a support vector machine. This can help optimize accident detection in the future when enough data is gathered to provide reliable accuracy. The helmet can connect to any smartphone via Bluetooth, to communicate with the online API, using the internet connection of the smartphone. This will ensure the holistic safety of the rider at all times.*

I.   INTRODUCTION

Motorcycles and bikes form an integral part of personalized transportation in India. However, unfortunately, it also involves innumerable accidents and subsequent loss of lives. Every year, about 300,000 teenagers go to the emergency department because of bike injuries, and at least 10,000 teenagers have injuries that require a few days in the hospital.. Through an ONEISS survey conducted by the Department of Health, it was found that 90% of the motorcycles rider killed in accidents were not wearing a helmet at the time of impact. This, along with drunken driving are a major reason of accidents. We aim to mitigate these problems and hence the associated casualties by ensuring that the rider will wear the helmet all the time during his/her ride, thus ensuring safety.

The helmet can detect a possible accident, using the onboard accelerometer and pressure sensor. If the values detected exceed a threshold, it is reported as an accident. Emergency contacts, specified by the rider during app setup, are informed about the possible accident, via a system generated email and text message, containing the address and GPS coordinates where the accident had been detected. The values of the accelerometer are also constantly sent to a remote server using an online application interface (API), and the server trains a support vector machine (SVM). An onboard alcohol sensor also analyzes the breath of the rider to detect if the current intoxication level is above the legal threshold. If it is so, he is first warned to not ride the motorbike. If he rides it anyway, his emergency contacts are informed, so that they may handle the situation.

II.   RELATED WORKS

In the literature, we found several smart helmet system but with different approach and proposed solution.

Wilhelm Von Rosenberg et al [1] has proposed a smart helmet with embedded sensors for cycling and moto racing to monitor both vital signs and the electroencephalogram (EEG) simultaneously. They have embedded multiple electrode within a standard helmet and a respiration belt around the thorax for validation and a reference ECG from the chest. Also a multivariate R-peak detection algorithm has been applied to get data from real life noisy environment.

Sreenithy Chandran et al [2] monitored the value received from accelerometer embedded in helmet and detects an accident by analysing those values and sends an emergency notification to contacts with Global positioning system location.

III.   MATERIALS AND METHODS

A.   Hardware Components

TABLE 1 LIST OF HARDWARE

Components	Specification
Microprocessor	Arduino NANO with Atmega 328
Flex sensor	Robodo Electronics FSENS Flex Sensor
Impact Sensor	Keyestudio Collision Crash Sensor Module
Accelerometer	ADXL355
Global Positioning System (GPS) Module	SIM 28ML module with Antenna
Breathsensor	MQ3 module
Bluetooth	BLE HM-10
Votage Regulators	9V to 5V Regulator IC L7805

B. Microcontroller (Arduino NANO with Atmega 328)

This is the core of the device, a cheap and easily available and programmable Arduino NANO clone, with Atmega 328. It provides limited processing capability, but it is enough for our purpose. It is small, and compact, which is an important factor because the entire hardware needs to be fitted inside a helmet.

When the device is started for the first time, the application prompts to calibrate the helmet. Upon calibrating, the calibrated values of the accelerometer are stored in the microcontroller's ROM. This is used to calculate the 'tilt' of the helmet while riding the motorbike. The microcontroller performs other operations as shown in the flowcharts later in this section.

C. Flex Sensor

Flex sensors are strips with metal pads. On bending, the resistance of the metal pad changes. When used with an Arduino, it can be plugged into an analog pin. The analog pin reads values between 0-1023, and the value depends on how much the strip is bent.

One such strip is attached to the interior of the helmet. This when the user wears the helmet, this head bends the strip, and the helmet is able to detect if the helmet has been worn. Our threshold value is set at 100 so that it can accurately detect the wearing of the helmet

D. Impact Sensor

We use the Keyestudio Collision Crash Sensor Module as the impact sensor. Collision Sensor can detect whether any collision movement or vibration happens. It outputs a low pulse signal when vibration is detected. To make the output signal more reliable and neat, a necessary exterior circuit is present to reduce the noise impact. Thus, normal shaking will not cause any output.

This module is attached to the exterior of the helmet. When the helmet falls down, there should be a vibration from the impact of falling down on the ground. The collision sensor detects this vibration and outputs analog output in the range 0-1023. Here too we have set a threshold of 100 so that it accurately detects the falling down of the helmet.

E. Accelerometer (ADXL355)

The accelerometer we use is a 3-axis accelerometer that measures tilt of the device with respect to the earth, in 3 axes-X, Y and Z. Since it measures the tilt with respect to the earth, we need to store the corresponding values when the helmet it normally worn. This is the calibration we require. The values are stored in the ROM, and the difference of current readings and the stored readings are used to detect a possible accident.

F. GPS module (SIM 28ML)

This module helps to get the present GPS coordinates of the device. The coordinates are required when an accident is detected or high alcohol consumption is detected. The phone GPS could be also used, but having a GPS module build in the helmet guarantees the accuracy of the reported location. The module we use follows the NMEA protocol, and thus the output coordinates need to be converted into a more usable form. Thus we use tiny GPS library to perform the necessary conversion. It is an open source library for Arduino, for NMEA GPS data.

G. Breath Analyzer (MQ3)

This module uses an Alcohol Gas sensor MQ3. It is a low-cost semiconductor sensor and can detect the presence of alcohol gases at concentrations from 0.05 mg/L to 10 mg/L. The sensitive material used in this sensor is SnO2, whose conductivity is lower in clean air. Its conductivity increases as the concentration of alcohol gases increases. It has high sensitivity to alcohol and has a good resistance to disturbances due to smoke, vapor, and gasoline. This module provides both digital and analog outputs. MQ3 alcohol sensor module can be easily interfaced with microcontrollers.

Fig 5 MQ3 Breath Analyzer

H. Bluetooth Module (BLE HM-10)

The HM-10 is a Bluetooth 4.0 Low Energy module containing the TI produced CC2540 or CC2541.It provides reliable and low power consuming Bluetooth connectivity. We use it for the communication between the device and the smartphone, and thus it is our medium of data communication. Another important reason why we use this particular Bluetooth module is that it is power efficient and low on cost.

I. Support Vector Machines (SVM)

Support Vector Machines are widely used means of supervised machine learning. These are associated with learning algorithms that analyze data and recognize patterns and are widely used for classification and regression analysis. To use an SVM, we require a set of training data, that includes positive and negative data. The SVM maps the data into space and tries to derive a hyperplane that divides the space in the best way possible, such that in one side of the plane, positive data exists, and on the other side, negative data exists. During prediction, if data lies on the positive side, it is predicted as positive, and if it lies on the negative side, it is predicted as negative.

The flex sensor accelerometer and the impact sensor outputs analog data, and are thus plugged to the analog pins of the microcontroller. The breath sensor has an analog output pin too, but we only require the digital output pin. It is thus connected to a Digital pin of the microcontroller. The GPS module and the Bluetooth module require 2 digital input pins, for their RX and TX.

The Bluetooth module sends data wirelessly to the smartphone via Bluetooth, and the smartphone calls the

J.User Interface

The rider communicates with the device through his smartphone. Thus the following features in the user interface are essential and have been implemented.
1. Screen to enter the user's details.
2. Screen to enter details of emergency contacts.
3. Prompt to calibrate helmet, when first used Warning to not drive if high alcohol consumption is detected
4. Email notification to emergency contacts in case of an accident.
5. Email notification to emergency contacts in case of drunken driving.
6. Track the rider using the application, in case any of the above notifications have been sent.

K. Proposal for Optimisation of Accident Detection

We propose an experimental mechanism to use SVM to optimize accident detection. While testing the accident detection, we noticed that the alarm was being triggered on many occasions, which might be cumbersome for riders to keep responding to while driving the motorbike. As already *M. Proposal for Optimisation of Accident Detection*

We propose an experimental mechanism to use SVM to optimize accident detection. While testing the accident detection, we noticed that the alarm was being triggered on many occasions, which might be cumbersome for riders to

Keep responding to while driving the motorbike. As already shown previously, if the alarm is rung, and the rider clicks the button, the device discards the detection and takes no action. If the button is not clicked, then the device assumes that it is a true accident, and takes action accordingly.

Every time the alarm is rung, and the button is clicked by the rider, we send the tilt data (∂x, ∂y) to the servers as negative data. If the rider does not click the button, the tilt data(∂x, ∂y) is sent to the server as positive data. This is how we propose to train the SVM.

For accident detection, the device follows the aforementioned mechanism. If the alarm is needed to be triggered, the tilt data is first sent to the server. The server checks which side of the hyperplane does the values lie and predicts if it is an accident or not.

We propose to train the SVM using a real-time simulation of accidents. The data set should be unique for every physical device, as the values will vary depending on physical design.

IV.RESULTS AND DISCUSSION

A prototype has been developed using the materials mentioned earlier. It has been calibrated and then tested in several test cases. The data for the following metrics are calculated.

A. Accuracy

where, TP - True Positive, TN - True Negative, P - Positive instances, N - Negative instances

We consider a situation to be a true positive or negative if the detection matches the expectation. Suppose our test case was intended to be an accident, and our detection correctly detected it as an accident, it is reported as a true positive. Similarly, if our intention was not an accident, and the system does not report an accident, it is a true negative.

B. Precision

Precision is the ratio of the correct True instances, to the total number of True instances reported by the detection system.

where, TP - True Positive, FP - False Positive

C. Recall

Recall is the fraction of True instances, as reported by the detection system.

where, TP - True Positive, FN - False Negative

D. F1 score

F1 score is the harmonic mean between precision and recall.

$$= \frac{2}{2 + + }$$

where, TP - True Positive, FP - False Positive, FN- False Negative

Tests were performed for each of the three detection systems we propose. Each situation has been performed and observed in sets of 10, so that accurate results can be obtained. The results of the mean of the 10 sets are tabulated below.

E. Analysis of Tests for Helmet Wear Detection

TABLE 1.   HELMET WEAR DETECTION TEST RESULTS

Situation	Flex Sensor value	Expected Result	Reported Result
Helmet is worn	331	True	True (all 10 cases)
Helmet in hand	49	False	False (all 10 cases)
Helmet hung in bike steering	87	False	False (8 cases of 10)

The following table summarizes the values of the parameters for the above test results.

TABLE 2. ANALYSIS OF DETECTION WITHOUT BUTTON RESPONSE

Accuracy	Precision	Recall	F1 Score
0.7615	0.5737	0.875	0.693

However, the alarm was rung for many cases as shown above, and the subsequent click of the button regarded the reported detection as FALSE. Thus, taking into the rider's response, the values of the parameters are:-

TABLE 3. ANALYSIS OF DETECTION WITH APPROPRIATE BUTTON RESPONSE

Accuracy	Precision	Recall	F1 Score
0.9615	1.0	0.875	0.933

Fig 7 Comparison of Accident Detection between Using and Without Using Button Response by the Rider

The above chart to compare the parameters of analysis for accident detection, with and without the use of an alarm shows the necessity of the alarm in our mechanism.

TABLE 4.   ANALYSIS OF ALCOHOL DETECTION

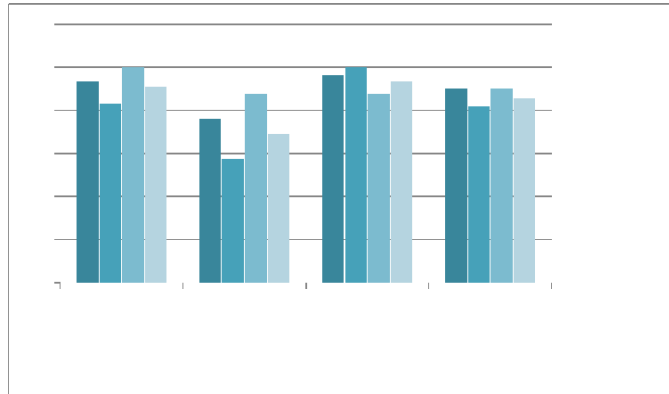| Accuracy	Precision	Recall	F1 Score
0.9	0.8181	0.9	0.857
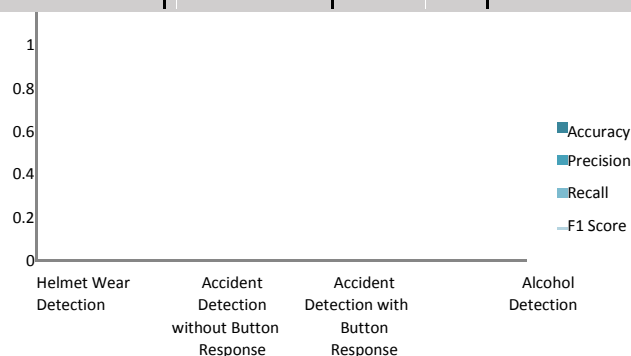
Fig 8 Comparison of Parameters between All Functionalities

V. CONCLUSION

The prototype developed yielded satisfactory results. The accuracy and precision are high, which shows that our proposed mechanism is accurate in detecting an accident and high alcohol consumption.

However, during accident detection, there have been many cases, where the alarm has been rung. The comparison of the parameters for accident detection, with and without the use of the alarm, shows how important the use of an alarm is, to report false accident detection. However, repeated unwanted need to respond to the alarm while driving can cause discomfort and distraction. Therefore, this is not safe either. Thus, we are currently trying to use Support Vector Machines to predict if the values of the sensors correspond to an accident or not, by training the device using real-time simulation, as mentioned earlier.

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