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Smart Pollution Monitoring, Alert and Control System using IoT

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Abstract*: One of the most important issues relating to the environment is Air Pollution. This is because it does not solely harm the environment in various ways such as ozone layer depletion, global warming but additionally affects the living beings adversely inflicting various health-related problems. The major contributors to Air Pollution apart from industries are vehicles. So, to observe and scale back air pollutants emitted from vehicles this paper proposes a design to develop a smart pollution monitoring system using IoT for detecting the over polluting vehicles. A semi-conductor sensor known as mq2 sensor is integrated with Arduino Uno and it is placed at the emission outlet of vehicle from where the smoke is emitted. The mq2 senor senses the different pollutants emitted from the vehicle and takes the reading of it. It is then compared with the pre-specified threshold value which is already programmed in Arduino Uno. Once the pollution level shoots on the far side beyond the set threshold level, various sorts of warnings such as textual warnings such as messages and, visual warning using LED are fabricated to point that the limit has been breached. Apart from it, if the owner of the vehicle is not taking necessary precaution then a message will be delivered to the traffic control office using GSM along with the GPS location including latitude and longitude values of the vehicle and will impose a fine on the owner of the vehicle as per traffic norms and may also cease the vehicle. This paper, when implemented in real time will be beneficial for the society as it is very economical and yields good result for measuring the air pollution mostly in urban areas.

Keywords: Air pollution, buzzer, led light, GPS, GSM, Sensor.

I. INTRODUCTION

The beginning of the twenty-first century was the time when the concern for Environmental awareness was instigated. Air pollution has always been a major concern with regard to environmental sustainability. It contributes to the greenhouse gases, which causes the greenhouse effect, whose side effects are well known to all after the findings of the hole in the ozone layer. It isn't solely harmful to the environment but also to all the living beings on this earth.

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The pollutants that are inhaled have a serious impact on human health affecting the lungs and the respiratory system; they are also taken up by the blood and pumped all around the body. These pollutants are also deposited on soil, plants, and in the water, further contributing to human exposure and also affecting sea life. The pollutants released from the vehicles are affecting the ozone layer in space due to which harmful rays are bypassing onto the earth resulting in various types of problem for human beings. So controlling the emission of these toxic gases from the vehicles has to be controlled.

At present, the normal practice which is being carried out currently in the country in order to verify pollution which is caused due to vehicles is by manual checking where the driver is supposed to carry a PUC (pollution under control) certificate which ensures that the vehicle is not polluting the environment. There is no automatic monitoring of pollution check in the existed traffic system [1]. This manual checking may not be efficient always as the user may not carry the certificate always and also the certificate may not be trustworthy.

In a paper entitled, automated control system for Air Pollution detection in vehicles [2], the author has proposed that by placing semi-conductor sensors at the emission outlets of vehicles, the level of pollutants present in the gas emitted by the vehicle will be detected. When the level of pollution exceeds the already set threshold, there will be a buzzer in the vehicle that will ring to indicate the driver that the limit has been breached and the vehicle will stop after some time. The GPS will help in finding the nearest service station so that the driver can tow the vehicle to it. But doing so will control the vehicle but not the gases emitted from the vehicle. Moreover, if the vehicle stops suddenly in heavy traffic roads it may prone to accidents.

Piyush R. Tapar, Prof. A. K. Pathrikar has implemented a project for detecting the over polluting vehicles and bringing it to rest state using the fuel-cut mechanism and sending the location of the vehicle to the owner of the vehicle [3].

V. Prathyush et al were able to detect the CO gas from the vehicles remotely. In this, the system detects the pollution and then the information regarding it is sent to the server for storage from where the analysis is done and based on that the message is delivered to the owner of the vehicle [4].

In another implementation, the authors have developed an embedded system using wireless sensor networks for collecting data from the sensors using IoT. They have utilized RFID (Radio Frequency Identification) tags to monitor the pollution from the vehicle and updating the data in the server [5].

However, using RFID tags seems to be a bit expensive and might have an impact on the signals generated by these tags when they come in contact with metal-related materials.

Prof. D. D. Mondal et al proposed a paper for detecting pollution in the vehicle using sensors such as MQ7 which detects the level of concentration of carbon monoxide.

If the reading exceeds the threshold value the microcontroller will trigger signal to the motor to disconnect the fuel which results in the vehicle coming to a halt state. [7].

This paper aims to develop a smart, sensible and secured smoke restrictive system for vehicles. With this implementation in situ, the cities and metros will become a higher comfortable place to drive and live in. The system should be precise enough to detect smoke emission from vehicles and alert the driver regarding the emission levels. Operating the vehicle through a smart system should provide better smoke control but at the same time should be inexpensive, so here the proposed system will provide a smart and inexpensive way to regulate smoke emission in vehicles.

This paper implements an IoT based system which provides a framework for collecting the data from MQ-2 sensor which is mounted in vehicle for monitoring the pollution from the vehicles to determine whether they are in the threshold values or not. Based on the values received and processed, necessary actions can be taken up to control the pollution from the vehicle. The paper is divided into six sections. Section II covers the design of the proposed system. In section III the specifications for the proposed system are represented. In section IV and V we have represented the implementation of the proposed system and Results drawn from it. Finally, the conclusion is placed in section VI.

II. DESIGN OF THE PROPOSED SYSTEM

In the proposed system we place the MQ-2 sensor at the fuel gas outlet of the vehicle. It monitors the Carbon monoxide and other toxic gases emission from the vehicle. If the emission of gases is higher than the mentioned levels as per the norms, it activates an alarm with the help of the buzzer on the vehicle, indicating the driver that the threshold value has been breached. At the same time a message will be delivered to the registered mobile number of the owner. If the owner of the vehicle does not take any necessary precaution and the emission of the toxic gases reaches the maximum threshold value then a message will be delivered to the traffic control office consisting of the location of the vehicle. The traffic control authorities can immediately take necessary action against the owner of the vehicle such as seizing the vehicle or by imposing heavy charges. Thus the pollution rates can be reduced and at the same time immediate action can be taken against the users of the vehicle who are polluting the environment.

In an optimized way the steps are implemented as follows:

1. Analysis and calibration of the MQ2 smoke detector.
2. Development of a program to convert the analog output of the detector to equivalent digital form within the microcontroller and coding for sending the message to the user and traffic police authorities.
3. Development of visual warnings (LCD and LED) to point smoke detection.
4. Development of audio warnings (buzzer) to point the presence of toxic gases in the smoke.
5. Development of textual matter to indicate that the brink level is crossed, to the driver.

The process of implementing the proposed system is represented in various steps shown in Fig 1. In the first step, all the sensor and devices which are required to measure the smoke detection is initiated. In the second step, the data is measured by the sensor and based on that the decisions are taken up for sensing, fixing the threshold value. In the next step the data measured by the sensor is acquiesced and based on that the intelligent environment determines when to send the warning signals and messages to the driver of the vehicle.

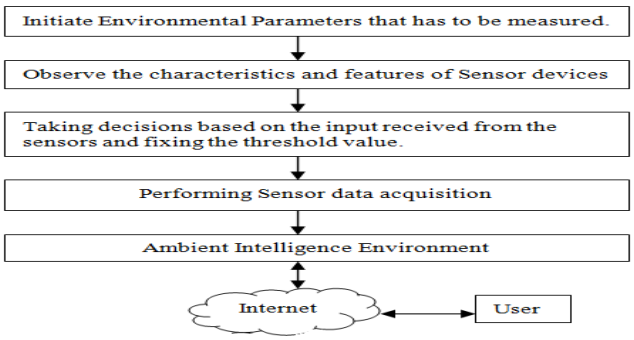

Fig. 1: Model for proposed system

The microcontroller collects the data from the sensors and processes it, analyzes it and then sends warning signals or messages to the driver using GSM sensor and also send the location of the vehicle to the nearby traffic control room using GPS sensors (its only when the maximum preset threshold value is exceeded by the vehicle).

A. *Block Diagram*

Fig. 2 represents the block diagram of the proposed system. The MQ2 smoke sensor is the main component of the detector block which is embedded into the exhaust of the vehicle. The sensor senses the amount of emission from the vehicle and feeds the data to the microcontroller through the analog to digital converter at regular intervals of time. The analog electrical signal is then converted into a digital signal using an ADC, so that, it can be compared with the predefined values, in the microcontroller and the smoke emission level is displayed on the LCD after the analog to digital conversion. The microcontroller is used manually to perform three functions namely comparison, timer and triggering circuit. The microcontroller takes in two inputs; one from the smoke sensor's output and another being the predefined threshold value specified by the government. When the MQ2 smoke sensor detects that the smoke emitted is exceeding the threshold value, the microcontroller will immediately trigger the timer circuit and an alarm is laid off to inform the driver of the vehicle by sending a warning message to the drivers registered number with help of GSM module. Also, the microcontroller triggers the LED lights and buzzer to indicate the driver that the threshold value has been crossed. Apart from the timer being triggered, a trigger is also given to the GPS, which helps in locating the address of the vehicle and sends it to the police so that the police can seize the driver's vehicle with help of the location given by the GPS.

B. *Flow of the System*

Fig. 3 represents the flow of control for the proposed system. The power system gets turned on when the vehicle is started by the user.

The Arduino board starts collecting the data from the sensors and performs the manipulations as per the code uploaded. Based on the results appropriate action is taken up to prevent the pollution emitted from the vehicle i.e. sending message to the owner of the vehicle and turning on LEDs and buzzers.

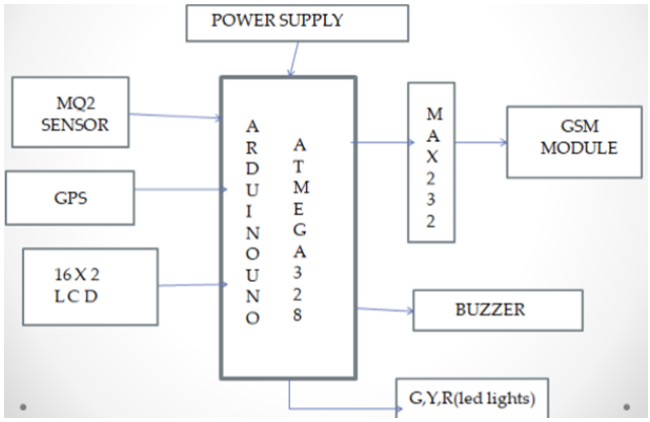

Fig. 2: Block Diagram of Proposed System

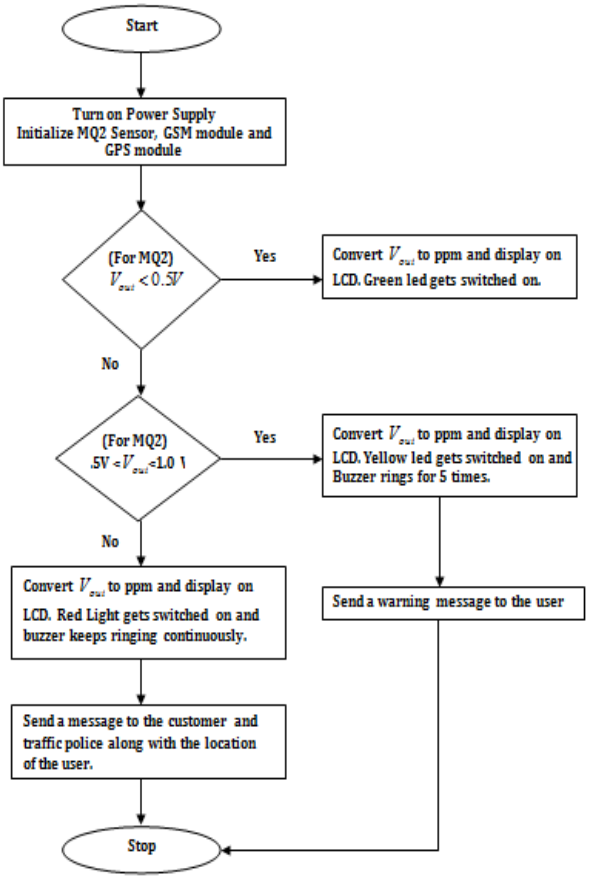

Fig. 3: Flow chart of Proposed System

III. EXPERIMENTAL SETUP OF THE PROPOSED SYSTEM

The implementation of proposed system generally has software and hardware requirements.

2.1 Hardware Implementation

A. *Arduino Uno Board*

Fig. 4: Arduino Uno Mode

It is one of the most common versions of Arduino family. It has ATmega328 microcontroller on board. It has 14 pins (digital) out which 6 can be used as PWM outputs. Apart from that it has analog input pins (6 in number), a ceramic resonator which has a frequency of 16 MHz, a Universal Serial Bus Connector which is used to connect the board to the computer to dump the code into it and also for providing the power supply.

The alternative way to provide the power to the board is by making use of external power supply which can be either an AC-to-DC adapter or a battery that is connected to the board's power jack.

Further it consists of ICSP (In-circuit Serial Programming) header. This header contains 6 pins and it allows the microcontroller to receive the firmware which performs all the advanced functionalities that are required. A reset button on board is provided to restart the Arduino which sets the ROM to the starting address. Several other types of components do exists on the board such as 1 kilobyte EEPROM, 2 kilobyte SRAM, 32 kilobyte Flash memory, timers and general purpose registers.

B. *MQ-2 Gas Sensor*

The MQ-2 Gas sensor is used to detect or measure gasses like LPG, Alcohol, Propane, Hydrogen, CO and even methane. It comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. The analog pin is used to measure the gas in ppm. It is also TTL driven and works on 5V and hence can be used with most common microcontrollers. It can represent results both in analog and digital and the digital output is either high or low based on the adjustable preset threshold. It is represented in Fig. 5

Fig. 5: MQ-2 Sensor

C. *GSM*

SIM800 module is a GSM quad-band module. It is based on the latest GSM/GPS module SIM800 from SIMCOM, supports GSM/GPRS Quad-Band network and combines GPS technology for satellite navigation. It is used for sending and receiving messages. The module controlled by AT command via UART and supports 3.3V and 5V logical level.

Fig. 6: SIM800 Quad Band GSM/GPRS module

D. *Liquid Crystal Display (LCD)*

It's an electronic display module which is used in wide range of applications. It's a very basic module used in various devices and circuits. It is generally termed as 16X2, where 16 represents sixteen characters per line and the numerical value 2 represents there are two such lines. Each character in this device is represented in 5x7 pixel matrix.

Fig. 7: Liquid Crystal Display

Apart from this it consists of two registers. They are:

- **Command Register:** It generally stores the instructions which are provided to the LCD for performing some predefined task such as: initializing, clearing the screen etc.
- **Data Register:** It stores the information which has to be displayed on the LCD screen. This information is generally in the format of ASCII value of the character to be displayed on the screen.

E. *Global Positioning System*

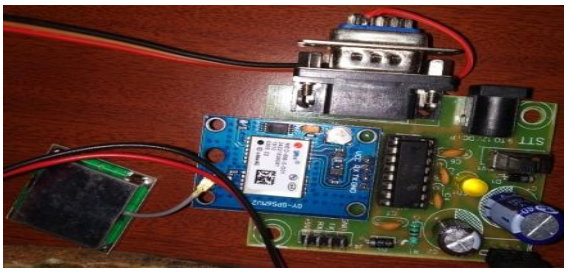

Fig. 8: GPS Module with EEPROM

The NEO-6 is a GPS receiver which has high performance u-blox 6 positioning engine. It offers various connectivity options and is available in a 16x12.2x2.4 mm package. The architecture of this device is designed in such a way that it can be used in battery operated mobile devices with less costs and space constraints. Its innovative design and technology leads to suppressing the jamming sources making them a excellent navigation performance even in the most challenging environments.

Some of the specifications of Global Positioning are:

- Supply Voltage : 2.7 to 3.6V
- Supply current : 67 mA
- Antenna gain : 50 dB
- Operating temperature : -40 to 85°C
- Antenna Type : Passive and active antenna
- Interfaces : UART,USB,SPI,DDC
- Tracking & Navigation : 160 dBm
- Reacquisition : 160 dBm
- Cold Start (Autonomous) : 146 dBm

F. *Buzzer*

It's an audio signaling device that is used to alert the driver that the threshold limit for the smoke from the vehicle has been exceeded. These buzzers are typically used for various purposes such as alarm devices, timers and some time as confirmation of user input such as keystrokes etc.

G. *Light Emitting Diodes*

The term LED is referred as "Light Emitting Diodes". It is an electrical component that consists of two terminals which conducts the electricity only in one direction. The current helps the diode to emit bright light around the small bulb. These are used in various applications such as radios, televisions, computers and electrical components for conduction.

H. *MAX 232*

It's an integrated circuit that converts signals from a TIA-232 (RS-232) port to signals appropriate to be used in TTL-compatible digital logic circuits. It is a dual transmitter / dual receiver too that typically are used to convert the RX, TX, CTS, and RTS signals.

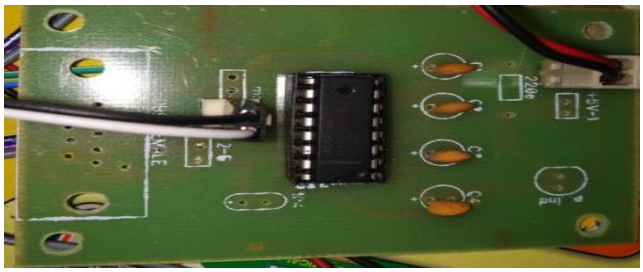

Fig. 9: MAX 232

I. *Power Supply*

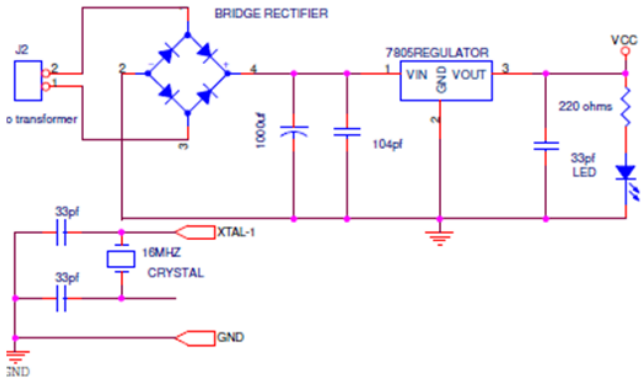

Fig. 10: Circuit Diagram of Power Supply

Without the source of power it's highly impossible to trigger any invention of latest technology. So power source is the basic requirement and since all the components are very tiny, they consume only DC power ranging from 5V to 12V.

2.2 Software Used

Software is a collection of programs which instructs the computer to perform a specific task. These programs are written by the user to get interacted with computer, its hardware.

Computer will have no meaning without the existence of software. Most required software is:

- Operating System : Windows 7
- Software : Arduino IDE 1.8.5
- Programming Language : Embedded C

A. *Arduino Software (IDE)*

It is an Integrated Development environment provided as a single platform to code as per our requirements.

It has a text editor usually called "Sketch", a place where the code is written. Apart from that, it has an output pane that is used to represent the output after compilation of the code as well as saving and exporting the data. It is integrated with Arduino for uploading the programs and communicating it with the hardware.

The editor has a flexible feature for searching /replacing text. The message area is used for prompting the errors while compiling the code. The control display represents the information regarding the error messages as well as other information.

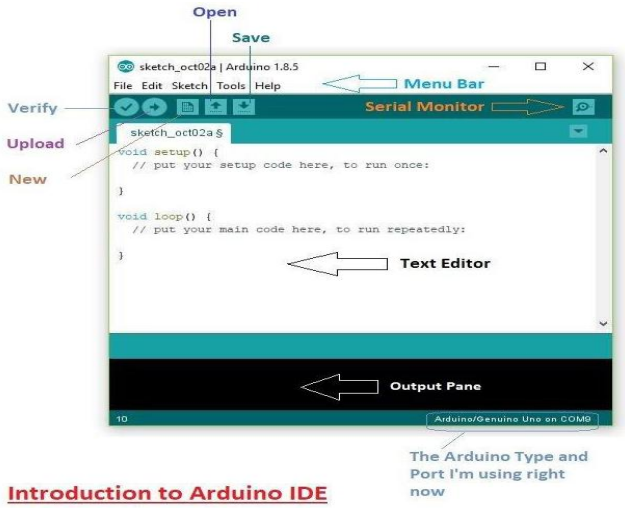

Fig. 11: Arduino Uno IDE

IV. IMPLEMENTATION

Fig. 12: Implementation View

In the implementation view, the code for detecting the three cases is written using Arduino Uno and is dumped into the Arduino board with forms a flourished system that detects the pollution causing parameters and gives the alert signals to the driver of the vehicle from time to time. This project is implemented keeping in view of the small scale industries and it's very economical. Since the detection of pollution is being done at run time i.e. in the environment itself, it definitely increases its degree of protection.

V. EXPERIMENTAL RESULT

After the code is uploaded the power supply is switched on and all the modules within the system are initialized and the results are generalized. The results are represented in three different cases:

Fig. 13: Measuring the toxic gas released from Vehicle.

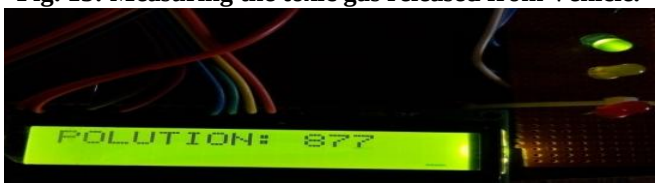

Fig. 14: Green LED turning on indicating safe state.

Case 1: Fig. 13 and 14 represents the measuring of toxic gases from the vehicle and turning on the LED. In this case the measured value from the ignition of the vehicle is usually lower than the threshold value i.e. 1000ppm. So a continuous green light will glow indicating that the vehicle is in good state and it's not polluting the environment with toxic gases.

Case 2: In this scenario the measured reading from the ignition of the vehicle is usually higher than the threshold i.e. in between 1000ppm – 2000ppm. Immediately a yellow light starts blinking with a buzzer beeping for 5 times and at the same time a warning message will be sent to the owner of the vehicle.

Fig. 15: Yellow LED turned on indicating partial unsafe state

Fig. 16: Message sent to the owner of the vehicle.

Case 3: In this scenario the measured reading from the ignition of the vehicle exceeds the maximum threshold value i.e. 2000ppm. A red light will be turned on, buzzer will beep continuously and a message is sent to the traffic police along with the dynamic location of the vehicle.

Fig. 17: Red LED turned on indicating fully unsafe state

Fig. 18: GPS location sent to Traffic Police

Table – I: Experimental Results

Equivalent Smoke quantity	State of green led	State of yellow led	State of red led	State of buzzer	State of GSM	State of GPS	LCD display
0ppm	On	Off	Off	Off	Message not sent	Location not sent to police control room	QTY = 0ppm
500ppm	On	Off	Off	Off	Message not sent	Location not sent to police control room	QTY =500ppm
800pp	On	Off	Off	Off	Message not sent	Location not sent to police control room	QTY =800ppm
1000ppm	Off	On	Off	On	Message sent to user	Location not sent to police control room	QTY =1000pm
1400ppm	Off	On	Off	On	Message sent to user	Location not sent to police control room	QTY =1400ppm
1800ppm	Off	On	Off	On	Message sent to user	Location not sent to police control room	QTY =1800ppm
2000ppm	Off	Off	On	On	Message sent to user and police	Location sent to police control room	QTY =2000ppm
2500ppm	Off	Off	On	On	Message sent to user and police	Location sent to police control room	QTY =2000ppm
3000ppm	Off	Off	On	On	Message sent to user and police	Location sent to police control room	QTY =3000ppm
3770ppm	Off	Off	On	On	Message Sent to user and police	Location sent to police control room	QTY =3770ppm
4000ppm	Off	Off	On	On	Message sent to user and police	Location sent to police control room	QTY =4000PPM
4500ppm	Off	Off	On	On	Message sent to user and police	Location sent to police control room	QTY =4000PPM

Table – I represents the consolidated result analysis which is drawn from the test implemented on different vehicles using the proposed system.

VI. CONCLUSION

The proposed system represents the design and development of the system for pollution monitoring in vehicles using IoT. It is very much useful for controlling the pollution caused by various types of vehicles which releases different types of toxic gases. The designed system upon detecting the pollutants from the vehicle intimates the owner to get the vehicle serviced in order to control the pollution. If the owner is reluctant to take the necessary step to control the pollution then a message is delivered to the traffic control room along with latitude and longitude details to take appropriate action against the owner such as releasing challan for imposing fines or seizing the vehicles. The implemented system is very much economical and can be integrated easily in any vehicle and can be used with ease and better accuracy. As a scope of future work we can try to integrate sensors for detecting speed of the vehicle and based on that the alerts can be generated for the owner of the vehicle to avoid over speeding.

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Ajay Kumar Badhan received the B.TECH degree in Computer Science Engineering from JNTU Kakinada, India 2011 and pursued his M.TECH in Computer Science and Technology from Gitam University, Visakhapatnam, India in 2014 respectively. Certified in NPTEL courses such as Programming in Java with gold medal, Internet of Things with silver medal, Software Engineering with Elite and have received a merit certification in the Internet of Things – an online contest by Texas Instruments University Program conducted in June 2019. He is an active member of IAENG. The major research interests are the Internet of Things, Machine Learning.

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