IoT Based Pothole Detection & Alert System

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Abstract: *This paper introduces an application of movable sensing: detection of potholes on roads and alerting the driver. I have describe a system and an associated algorithm to monitor the pothole conditions on the road & simultaneously it alerts the driver about those potholes. The IoT based Pothole Detection System, uses 2 ultrasonic Sensors for detecting those potholes more accurately then before and GPS is used for plotting the location of potholes on World Maps, it will give an alert to the driver about potholes using buzzer and staring (or handle) vibrator. Using the IoT concept, I have to show that I am able to identify the potholes from ultrasonic data (readings). The algorithm for pothole detection, detects the potholes in real-time. The recorded pothole data can be seen by the authorized person and by the driver of the vehicle on an app or webpage. I have assumed the threshold values of the x-axis and the y-axis of the GPS while designing the Pothole detection system.*

Key Words: *IOT; Ultrasonic Sensor; Vibrator(Alert); GPS Receiver; Database; Roads; safety*

1. INTRODUCTION:

As we know India is a fastest developing country after china. Although India is doing exceptionally well in certain field, we majorly lack in road ways. Roads are the dominant means of transportation in India today. However roads here are narrow and congested with poor quality and is not maintained properly. This road condition is a boosting factor for traffic congestion and number of road accidents. Hence, these conditions gave me a reason to make an affective system to make transportation more safe and healthy in my country.

Figure 1. Potholes due to heavy transports & water logging.

Kevin Ashton was laying the groundwork for what would become the Internet of Things (IoT) at MIT's Auto ID lab, in the early 2000's. Ashton was one of the pioneers who conceived this notion as he searched for ways that Proctor & Gamble could improve its business by linking RFID information to the Internet. This concept was simple but powerful. If all these objects in daily life were equipped with identifiers and wireless connectivity, these objects could be communicate with each other and be managed by the computers.

At the time, this vision required major technology improvements. After all, how would we connect everything on the planet? What type of wireless communications could be built into devices? What changes would need to be made to the existing Internet infrastructure to support billions of new devices communicating? What would power these devices? What must be developed to make the solutions cost effective? There were more questions than answers to the IoT concepts in 1999.

Today, many of these obstacles have been solved. The size and cost of wireless radios has also dropped much these days. IoT describes a system where items in the physical world, and sensors within or attached to these items, are connected to the Internet via wireless and wired Internet connections. These sensors can use various types of local area connections such as RFID, NFC, Wi-Fi, Bluetooth, and Zigbee. Sensors can also have wide area connectivity such as GSM, GPRS, 3G, and LTE.

The Internet of Things will:

- Connect both inanimate and living things.
- Using sensors for data collection.

• Change what types of item communicate over an IP Network.

IoT is a fast growing network of physical objects that feature an IP address for internet connectivity. Its main factor is to make relationships stronger and its promising parameter is to get communication solutions. The concept is basically connecting any device with an on and off switch or Sensors. According to the analyst scientists there will be over 26 billion connected devices by 2020. The IOT is considered as a giant network of connected "things" (which also includes people).

There are three types of relationship,

i) People-people, ii) People-things, iii) Things-things.

Sensor is a device used for detecting and measuring of physical property and records, indicates or otherwise response to it. In simple words they are used to detect events or changes in environment and send it to a controller. There are three types of sensors,

i) Analog ii) Digital iii) PWM. There are list of different sensors which fall under either of these types.

A "constellation" of approximately 30 well-spaced satellites that orbit the Earth is the GPS (Global Positioning System). It is easy for the people to pinpoint their geographic location or of others. The accuracy is anywhere from 100 to 10 meters for most of the tools. A GPS system works by receiving at least three satellite signals to calculate latitude and longitude and the movements. When GPS gets signal from four or more satellite then a 3-D position can be viewed i.e. latitude longitude and altitude. [2]

2. SOFTWARE AND HARDWARE REQUIREMENT:

The proposed system offers a cost effective solution for detecting potholes on roads and notifying vehicle driver and government officials about their presence. The system design model has the processing unit as the Arduino Board. [6]

Arduino refers to an open-source electronics platform or board and the software used to program it. Arduino programming language is a simplified from of C/C++ programming language based on what Arduino calls "sketches," which use basic programming structures, variables and functions.[9]

The other HTML programming is used for webpage development, to storing data recorded by the system. And this data can be used by the authorised person.

3. PROBLEMS & CHALLENGES:

A. Problem statement

Pothole detection system is a system that aims at warning the driver about the uneven roads and potholes in its path. [1] I study the different ways in which goal of the system can be achieved. I justify the methods that I have chosen in this projects. And then I have given details about the working of the different subsystems. The problem statement can be given as follows.

This system consists of two components one is mobile node and other is the access point. Access point is responsible for storing the information about potholes in its vicinity, taking the feedback from vehicle, updating the information in repository and broadcasting the information to the access point. Whereas Mobile node which is the small device placed in vehicle is responsible for sensing those potholes which it did not have previous information about, locating and warning the driver about the potholes which it has information about, and giving the data about newly sensed pothole to access point. [7]

The whole scenario works as follows. While deploying the access point I feed in some initial data about potholes to it. Then it keeps on broadcasting the data. Vehicle equipped with the client device catches that data. Now the device has the information about the locations of potholes. The device is responsible for warning the driver about occurrences of pothole. But new potholes may always be formed because of environment or fatigue. So client device also acts as a sensor and finds out the occurrence of newly formed potholes on the road. If it finds out any new potholes it gives data of new pothole to Access point in terms of the feedback. Access points updates this information to its data store and then adds it to the information broadcast.

B. Challenges involved

There are various challenges involved in this project, as given below:

- Client device must be able to sense the pothole. It will be an added advantage if it can characterize the pothole telling how severe it is.
- Placement of access points is an important factor. It should be in such a way that the data should be distributed to maximum vehicles.

- Communication between access point and client device can have many problems which should be resolved. Some of the problems that communication can face are interference, Low throughput due to large no of client devices, end to end reliability.
- Data representation should be in such a way that the client device should be able to locate and warn the driver about the potholes which it has information about.

4. ARCHITECTURAL DESIGN:

This System consists of three subsystems namely Sensing, Communication, and Localization. These three subsystems work independent of each other, but have one center point they revolve around; that is data. Sensing system generates the data; Communication collects, co-ordinates and distributes the data; lastly Localization uses the data and generates information for the driver.

There are different ways in which these subsystems can realized and implemented. All the ways have their own pluses and minuses. We explain some of the ways in this section and mention some of their pros and cons. We try to choose the best working system and we justify the choice taken.

The Sensing subsystem is responsible for getting the data. The data in this case would be the data about pothole e.g. location of pothole, the severity of the pothole. There were two methods under consideration for this subsystem one is Vision based and the other is vibration based.

A. Vision Based Method

This method uses 'Camera' as sensor to scan the road for any potholes. The camera captures the images in real time. These images are applied to image processing algorithms like edge detection. This requires lot of processing time and power. There

Are many design approaches. Hardware based methods like use of special Digital Signal Processors or Application Specific Integrated Circuits improve the performance over software based method. But still the response time of the operations required like windowing convolution for the image processing algorithm is still large. This method has one advantage over the other is, it can sense a pothole without experiencing it i.e. Vehicle does not actually has to pass through the pot hole to sense it. Characterization of pothole can be done on the basis of size of the pothole. Some other vision based method for obstacle detection are RADAR [4] but they have little use in pothole detection.

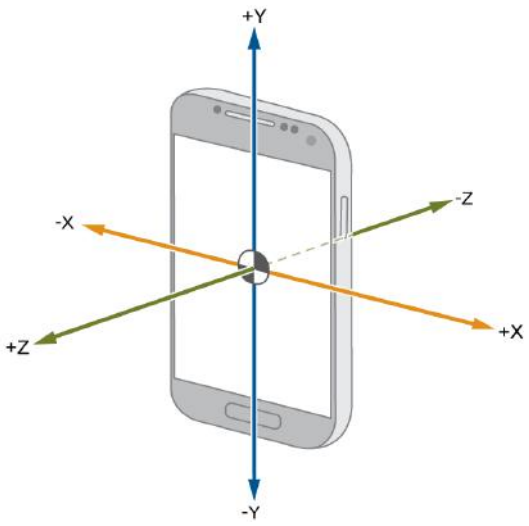
B. Vibration Based Method

This method uses 'Accelerometer' to sense potholes. Accelerometer: This is a device that measures total specific external force on the sensor. For example if the device is stationary, it will show some reading corresponding to earth's gravitational force. An accelerometer falling freely in the vacuum will show zero reading. The design of the accelerometer is often very simple.

This simplest design can be a mass hanging by a thread and some sensor to measure its deflection for original. The device is popularly used to measure vibration or inclination. It is popularly used in iTouch and some cameras to detect inclination and change the view of the display. [3]

The accelerometer device we are using for our project is LIS3L06AL [9] by ST. It can measure acceleration on three perpendicularly placed axis. It can measure acceleration up to 6g. Pothole induced vibrations can generally be measured on the

Vertical (z) axis readings. We can characterize the pothole on the basis of the magnitude of change in reading of accelerometer.



Accelerometer

C. Ultrasonic Based Method

Ultrasonic sensors are based on measuring the properties of sound waves with frequency above the human audible range. The HC-SR04 module includes ultrasonic transmitter, receiver and control circuit. It is used to measure distance between two objects and this distance is calculated based on the time taken by the ultrasonic pulse to travel a particular

Working of Ultrasonic Sensor

distance. The module automatically sends a 40 kHz square wave and automatically detect the received pulse signal. The distance is calculated based on the time taken by the transmitted signal to return at the receiver end.[6]

TABLE 1: COMPARISON BETWEEN DIFFERENT SENSING METHODS

	Vision Based	Vibration Based	Ultrasonic Based
Sensor used	Camera	Accelerometer	Ultrasonic Sensor
Response time	High	Low	High
Sensing time	While approaching the pothole	While going through the pothole	While going through the pothole
Processing	Complex image processing algorithms	Readings are directly used	Readings can be used directly
Maintenance	High because of delicate parts like lens	Low	Low
Characterization of pothole	Based on the size	Based on the vibrations	Based on sound reflection

5. PROPOSED SYSTEM & ITS IMPLEMENTATION:

This system will make an online record of all the locations of potholes which were came in the way of the vehicle having this system. This record of potholes will help the road maintenance department to locate these bad roads. This can help to make maintenance work faster.

In this System the driver of the vehicle will be able to avoid the pothole as he/she can get alert 10 sec before, when the vehicle speed will be medium i.e. 30 kmph. If speed of vehicle will be less, then alert time will be earlier and vice versa. The architecture of proposed system consists of 3 i.e. parts: sensing unit, server unit and user unit as shown in figure 2.

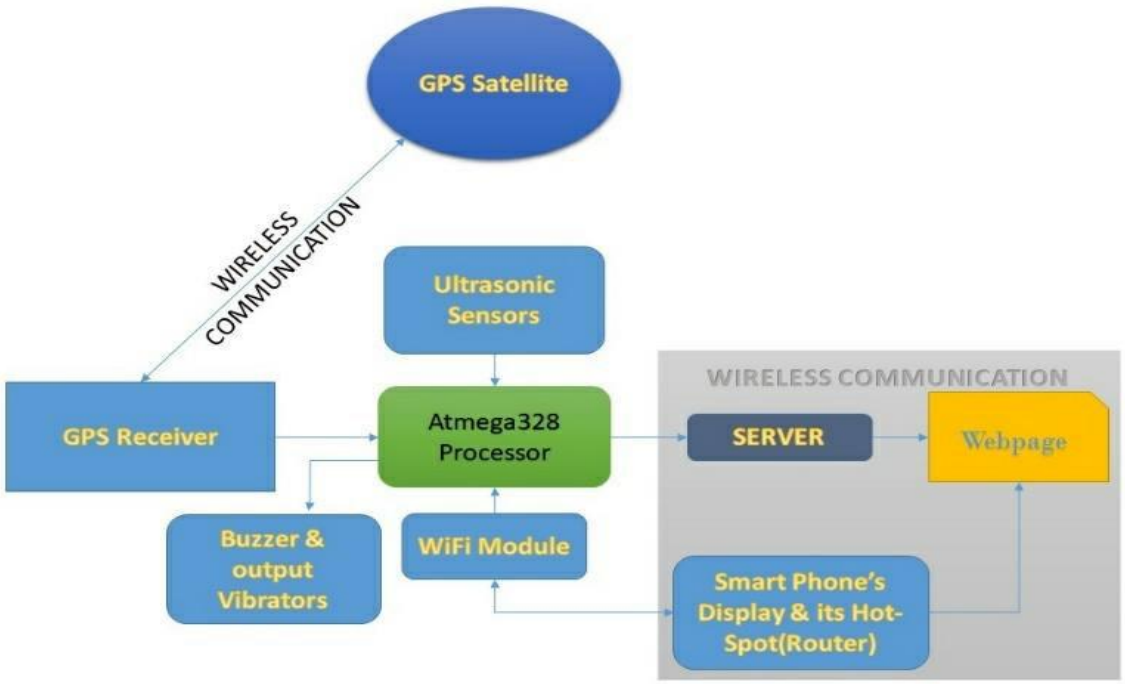


Figure 2. Block Diagram

A. Sensing unit:

This module consists of ATmega328 processor, GPS receiver, 2 ultrasonic sensors (HC-SR04) and a WiFi module (ESP8266). The distance between the car body and the road is measured using 2 ultrasonic sensors i.e. left and right sensors respectively. A threshold value is set such that the value depends on ground clearance of the vehicle.

The measured distance is compared with the threshold value to detect pothole. If the measured distance is greater when compared with the threshold value, then it is classified to be a pothole. The location co-ordinates retrieved by the GPS receiver, along with this data the information regarding the detected pothole at a particular location co-ordinate is transmitted to the server using a WiFi Module (ESP8266).

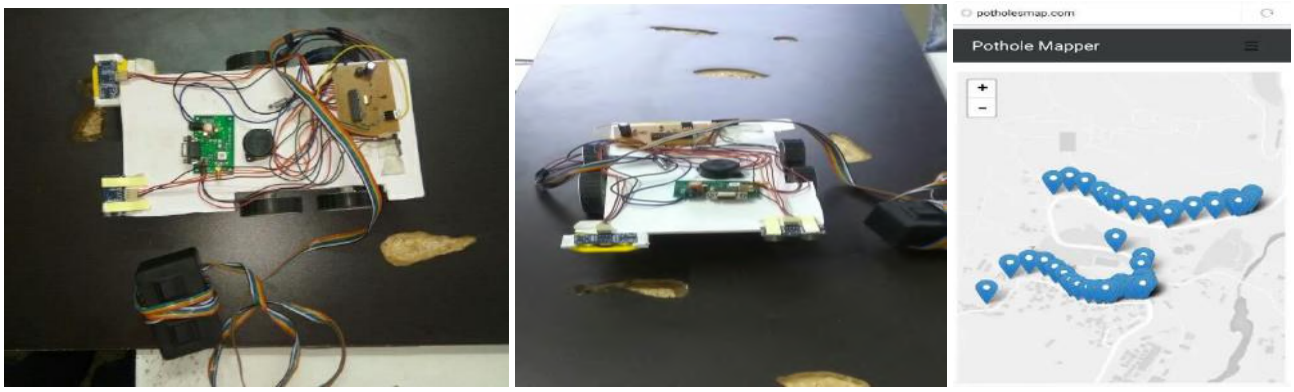


Figure 3. Vehicle Proto-type robot & its testing on Webpage

B. Server unit:

The server unit is nothing but the database. It is an intermediate layer between sensing and user units. Its function is to store the information received by the sensing unit and provide the same to the user unit when requested. In this system the server unit will be used by the users or drivers smart phone. As the smart phone contains a Hotspot in it. This Hotspot will give an internet connection to this system by connecting to the system with the help of ESP8266 (WiFi module). After its successful connection. When the sensing unit will give inputs, these locations will be recorded to the database of the server page and can be used further. This unit can also be updated regularly for accurate information regarding the potholes.

C. User unit:

The user unit is responsible for providing alerts regarding the potholes or humps on roads at a particular given location. The GPS receiver is constantly receiving information regarding its location co-ordinates, using this information the database is checked for any data around the given location co-ordinates. Any data found, it is received by the processor from the database through the WiFi module and the same is displayed on the displayed on Smart Phone in the user vehicle. A Buzzer and 2 vibrators (left and right) are used in the vehicle to provide the alerts. The alert is given 2 meters before the pothole or hump appears.

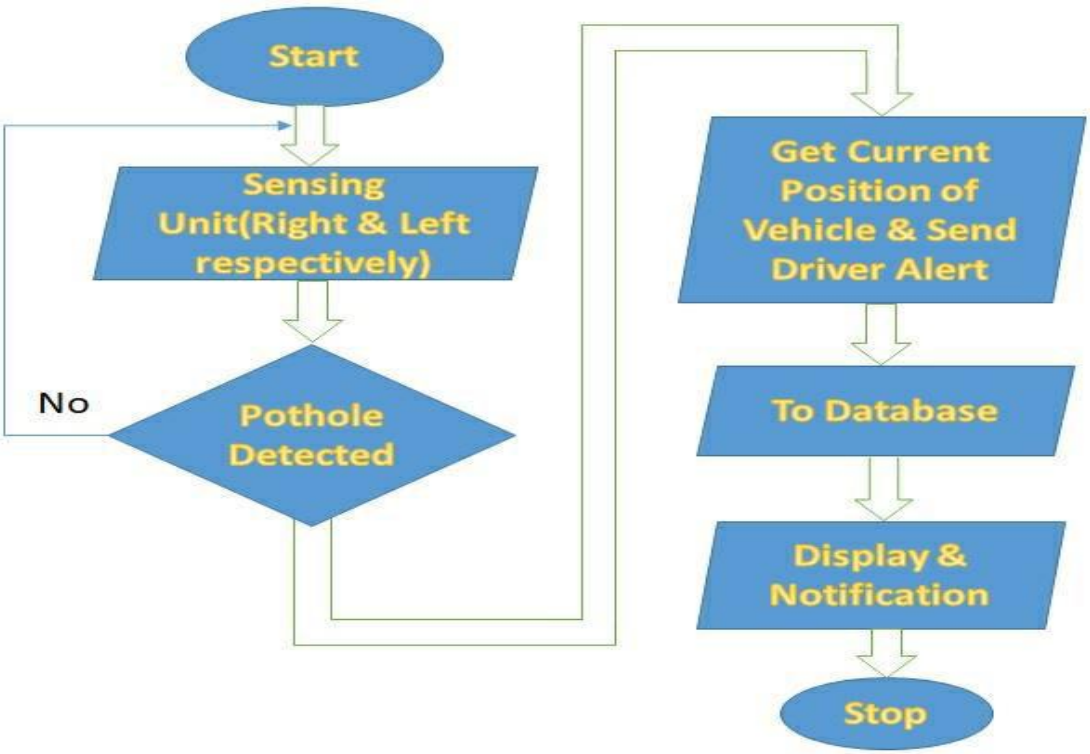


Figure 4. Flowchart for the System

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