POTHOLE DETECTION SYSTEM

[1]Chetan Kumar Jain, [2]Niharika S, [3]Sripriya A N, [4]Shashikala H K
[1]UG Scholar, [2]UG Scholar, [3]UG Scholar, [4]Assistant Professor
[1]Computer Science and Engineering,
[1]School of Engineering and Technology, Jain University, Bangalore, India

Abstract: Potholes are becoming an increased problem in India and the number of casualties and accidents caused due to it are increasing every year. Poor road maintenance is a major cause for this. The lack of communication between commuters and the government officials is leaving the problem stagnant. Therefore, we propose a system which can inform the commuters about a nearing pothole and also produce analysis in the form of visuals such as graphs and maps to inform the government officials about the growing problem, so a quick action can be taken to fix the issue. This way not only is the problem detected, but is also addressed.

***IndexTerms* – Pothole, Ultrasonic sensor, ThingSpeak, Blynk, NodeMCU.**

I. INTRODUCTION

Any country's economic development depends on phenomena like urbanization, industrialization, population density, and infrastructure. Roads play a very important role in any developing country like India. Poorly maintained roads are a fact of life in most developing countries and there is a need to maintain the road surfaces. Potholes have had huge economic impacts and are causing troubles to our daily routine. Timely inspection can lead to a better road management system and reducing the impact of the anomalies on our lives. The absence of an effective monitoring system is one reason for this problem.

As per the Road Accident Report [2014], there were 3,039 deaths due to potholes, 3633 due to speed breakers and 4,726 due to humps on roads. On an average 4,096 people were killed on roads which were under repair/construction. In 2015, the number of deaths due to potholes rose to 3,416. They accounted for 2.2% of the accidents and 2.3% of fatalities in road accidents at national level. 1.5% of all the accidents were caused due to defect in roads and speed breakers accounted for 2.2% of the accidents. As of Oct 2017, there were around 15,935 potholes in Bangalore alone.

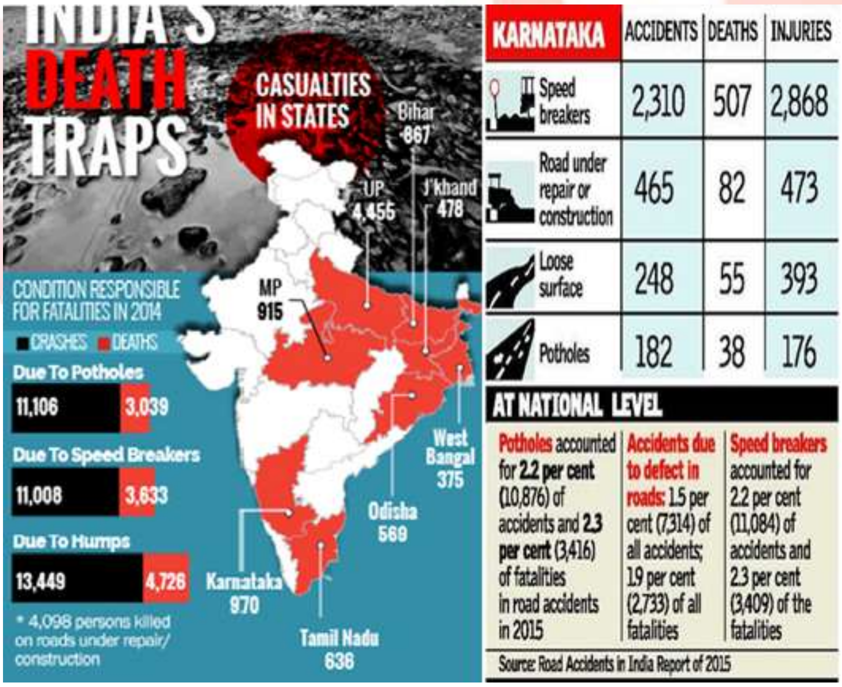


Figure 1: Statistical data

To lessen the damage caused due to irregularities on roads, several traffic detecting equipments are being invented and studied about which contain loop detectors, pressure sensors, infrared, RADAR, LIDAR or ultrasound-based sensors and video cameras. Loop detectors and pressure sensors, though cheap to manufacture have high maintenance and repair costs. Infrared, RADAR and ultrasound sensors, on the other hand, are more expensive to make. Also, their working may vary based on the weather conditions. Laser beams and radar-based systems are mainly added only to luxury cars due to their cost constraints and lastly GPS based systems have very high operational costs as they need to obtain the precise positions of the vehicles in every few milliseconds.

The key road anomaly, i.e. potholes has been causing mayhem for commute. It can be caused due to internal factors like pavement erosion by water seeping under it, due to change in climate like heavy rainfall, or external factors such as poor construction management and heavy traffic. Other factors for this include mole rats tunnelling under the road and mechanical damage.

Potholes are inflicting major effects such as engine damage, traffic coagulations, vehicle damage and accidents which are leading to deaths. Potholes have had huge economic impacts and are causing troubles to our daily routines as well. Few of the approaches to fix the potholes include regular inspection of roads, establishing hotlines, creating awareness among public and requesting them to inform the local authorities and implementation of modern technologies such as automated systems.

The detection of potholes using automated systems is highly studied about now. The identification and fixing of the problem may reduce the fuel consumption, wear-tear, and maintenance cost of vehicles. Automation of systems not only reduces the human labor that goes into the detection of potholes, but also saves a lot of time and is a lot more efficient.

II. RELATED WORK

[1] S. Gnanapriya et al., proposed an innovative method to prevent hazards by using an advanced sensor system. Sensors are attached to the vehicles. The sensor data obtained along with the GPS location data is communicated to the authority through IOT to take necessary action. A UV sensor is used to find the difference between a pothole and a speed breaker. Accelerometer, a vector quality defines the direction in which it is occurring. The unevenness of the road is determined by three parameters XYZ where X-value is the left and right movement of the vehicle, Y-value is the movement of the vehicle in forward and backward direction and Z-value is the movement of the vehicle when it passes over a pothole. A vibration sensor is used as well, which finds the potholes if the vehicle vibrates more than the threshold value. When the Z-value and vibration value passes beyond a threshold value, the latitude and longitude value is sent into the web server through IOT for Road transport officers to take the necessary action. Data analytics too is incorporated to predict the quality of road condition.

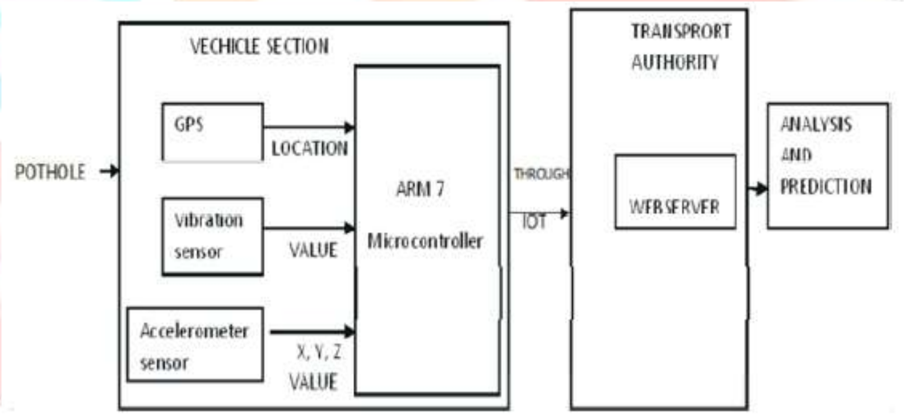


Figure 2: Architecture of the system

[2] Omkar Rajmane et al., proposed a paper to produce a Road Condition Detection Device (RCDD). The system has a sensing module based on Arduino and the user interface is provided through Android. The Arduino module collects the data about the road from the accelerometer and passes it on to the smartphone using Bluetooth technology. Android is used to collect the sent data and process it and locate the position on Google Maps. The Android programming part is designed to enable Bluetooth communication, GPS, and Google Maps API. If the value of the slope and average of accelerations are larger the pre-defined threshold, the specific GPS position is marked on the Google Maps and the driving raw data is saved on the SD card. By this, the drivers of the vehicles can obtain nearby road information from the Google maps to manage their driving behavior for improving driving safety, comfort and efficiency.

[3] Dalia Danielescu et al., proposed a few approaches for the detection of anomalies on the road using morphological algorithms. This paper describes about the algorithm used for road anomalies detection. The image was acquired by mounting a GoPro camera on the back of a car. Still images and video frames were acquired. An individual frame from the video frames was considered to be an image which was processed later. The resolution of an individual video frame or that of a still image was selected in such a way that it ensures compatibility. The preliminary work included applying watershed segmentation to the collected data. The aim of the pre-processing algorithm was to extract only the road surface. Further, the original image was cropped based on the road extraction algorithm and noise was removed using Gaussian Low Pass Filter(LPF). Simplification of the original image was done by

binarization using Otsu's algorithm. Finally, skeletonization morphological operation was applied. Clustering-based image thresholding was realized to be the most suitable to use in this case.

[4] Kiran Kumar Vapparaboina et al., presented a physics-based geometric framework to find the depth of the pothole in both dry and water-filled conditions. Detection of the pothole and estimating the depth of it was proposed to be done using a laser. A camera-laser was considered to be placed on top of the car where the camera is placed above the laser to capture the laser projection. For determining the depth of a dry pothole, simple ray optics concepts were applied. In the case of a pothole filled with water, the laser deviation is less due to refraction. The apparent depth of the pothole was measured with the help of laser projection and the actual depth was calculated using Snell's law and other mathematical calculations. The estimated depth matched closely to the calculated depth with an error of 1% for dry potholes, whereas for water-filled potholes there was a varying error of 5%-17%. The paper stated that there might be a few challenges to the idea, such as the angle of the laser and the camera may vary within the limit statistically. It also stated that there might be many challenges while trying to deploy in real time like resolution of camera, frame work etc. A crucial factor in this paper would be the maximum speed a vehicle can maintain.

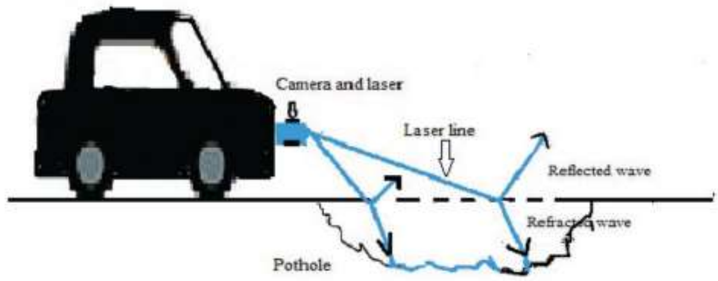


Figure 3: Schematic diagram of the laser detection system

[5] The paper by Youngtae Jo and Seungki Ryu proposed a system to detect potholes using a black box camera. Details of the pothole such as appearance, size and location was captured by the camera and stored in a pothole database, based on which a new software was developed. The software contained details such as pothole location, size, lane number, region, images, video clips etc. The detection algorithm had three steps: Pre-processing, Candidate extraction, Cascade detection. Through this, first, the dark regions are separated from the images and then possible potholes are extracted in the second step, and finally the possible potholes are tested to find out if they are actually potholes. The experiment's results after several trials proved that the algorithm could remove similar objects such as manholes, moving vehicles, shades and patches. However, sometimes the system failed to detect potholes which were bright and flat. Also, the system couldn't detect potholes when there was a change in intensity of sunlight. Despite the limitations, it was believed that it has potential use.

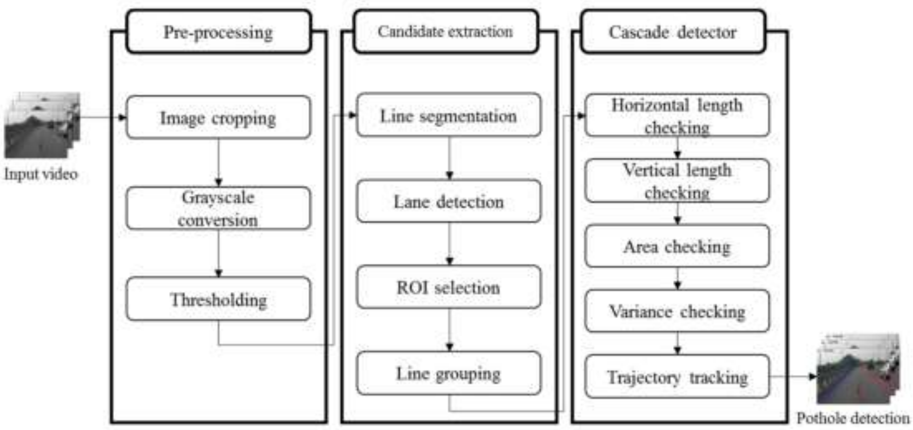


Figure 4: Algorithm of Black Box System

[6] Victor Akinwande et al., proposed a project which describes and implements pothole detection in real-time and traffic monitoring system and was been able to solve a global challenge by making use of smart phone technology. Machine learning was applied in the real world to develop a reliable, scalable system which was derived by the power of crowd sourcing. The proposed system consists of 8 (eight) core modules: the sensing module which is responsible

for collecting various parameters from the sensors used in the smart phone, the virtual re-orientation module which obtains the 3-axis parameters from the accelerometer, the threshold computing module which is responsible for determining the values for classifying the state as breaking events, potholes, humps or anomaly, the artificial learning module which is responsible for identifying road condition using supervised approach, the road condition detection module where the actual vehicle state is being predicted based on the sensors, the pothole visualization module which is responsible for deriving value for the user by making use of road condition data, the traffic information module which gives the information related to traffic from road condition module, and the data aggregation module which serves as the warehouse for all related data aggregated from different components in the system. With the adoption of smart phone technology and mobile application the real-time problems can be tracked and solved.

III. PROPOSED SYSTEM

In our proposed system, safety of the vehicle and informing the government officials regarding the road conditions are the key concern. To address this problem we are developing a device which would detect the pothole and inform the daily commuter.

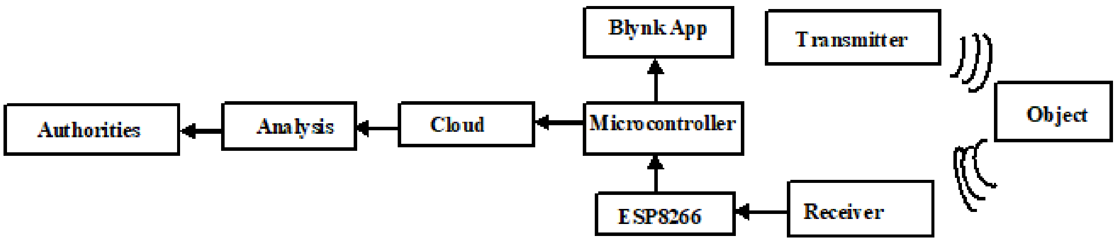


Figure 5: Block diagram of the system

The system consists of an ultrasonic sensor which is mounted near the bumper of the car at ground clearance level. There is an LED and a buzzer which are placed near the speedometer to show alert messages to the driver. These all are interfaced to NodeMCU with Arduino Mega. NodeMCU is an open source IoT platform which is used to help in real-time analysis. It also gives the current location which is helpful in our project.

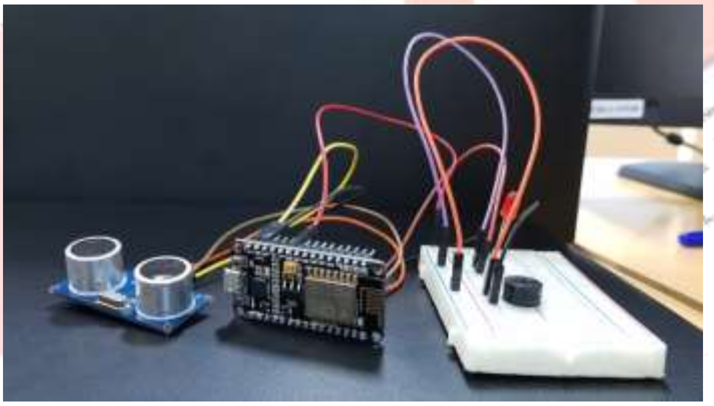


Figure 6: Connections of the system

The sensor is placed at a particular angle on the vehice so that maximum distance can be covered. Initially the threshold value is calculated i.e., the distance between the sensor and an even surfaced road. This threshold value is then used in detecting the potholes. When the vehicle starts moving the sensor keeps reading the values and compares the value with the threshold value. If the value is more than the threshold value then it indicates the presence of a pothole.

The pothole is detected few meters before the presence so that the driver can be alerted of the upcoming pothole through LED and buzzer . As and when the pothole is detected the led lights up and the buzzer beeps so as to give an indication. There is a provision of Blynk app which displays the distance with an appropriate message such as “Obstacle ahead” or “Safe to ride” or “Pothole ahead”. The Blynk app also has a map in it, which displays the present location of the user with the help of a marker.

The latitude and longitude values are obtained using Google’s Geolocation API and are uploaded to ThingSpeak using the internet provided by ESP8266 module of the NodeMCU. The so uploaded values along with the count are exported as .csv files to Google SpreadSheet. In this, using Two-way geocoding add-on of the Google SpreadSheet, we can extract the address associated with the latitude and longitude along with details such as area code. Later, a graph is plotted for Number of Potholes versus Area code. This information can be sent to the government officials to give them an insight of the damage caused.

Using Two-way Geocoding add-on, we can also mark the latitude and longitude values onto Google Maps, in which the locations can be highlighted using markers. Each marker is associated a unique number and is plotted in a table with its associated address, longitude, latitude and pincode.

To summarise, the following are the outputs obtained by the users:

- Commuters:
    - Distance from the pothole on Blynk app.
    - LED and buzzer to indicate them about the nearing pothole
- Government officials:
    - Graph of Number of potholes versus Area
    - Map with potholes marked

IV. RESULTS AND CONCLUSION

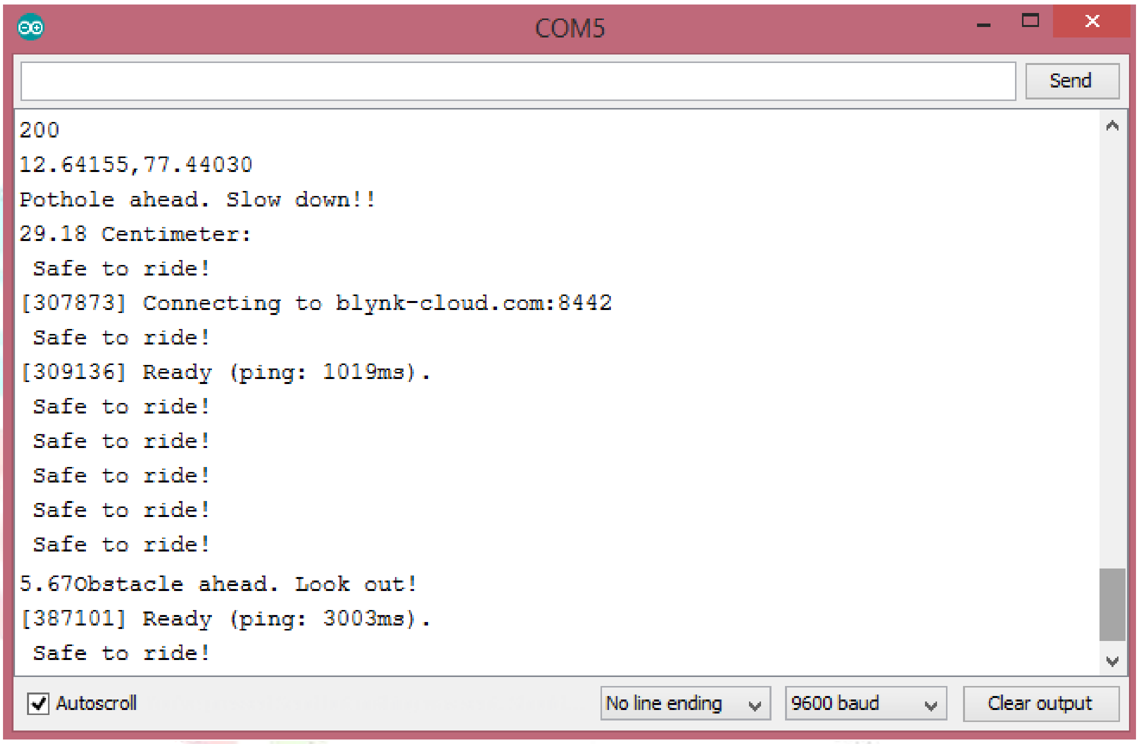


Figure 7: Serial monitor

The above figure shows the serial monitor when a sensor detects a pothole or any obstacle. It displays the distance of the pothole from the sensor, which is placed on the vehicle at a ground clearance level. It also displays the latitude and longitude of the location upon detecting a pothole. This is obtained through geolocation with the help of a NodeMCU. In the snapshot above, the latitude and longitude values are 12.64155 and 77.44030 respectively. On the serial monitor, along with the distance, latitude and longitude, a message related to it as well is printed. So, when it detects an obstacle, such as a speed breaker, it prints the message, “Obstacle ahead. Look out”. In the same way, when there is no obstacle or pothole on the way, “Safe to ride!” is printed.

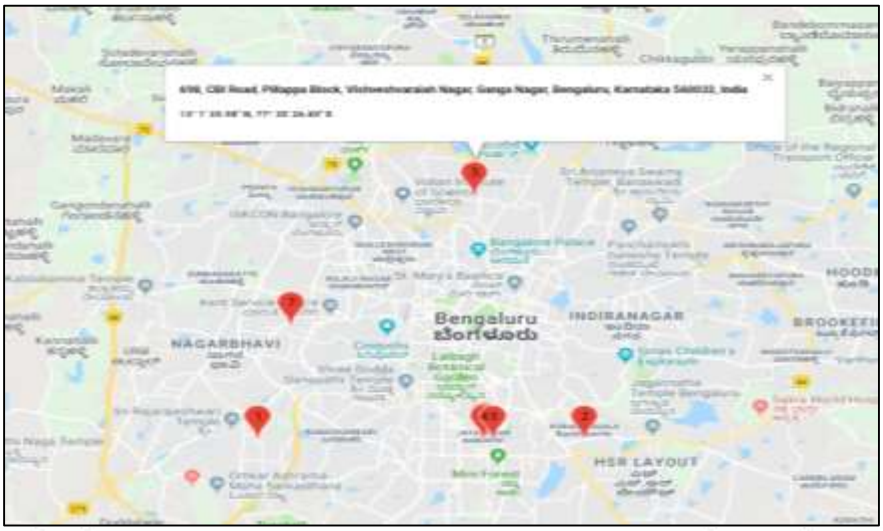
Figure 8: Blynk app display

The Blynk app interface displays the distance of the pothole from the vehicle and prints the value with an alert message. It also shows the live location of the vehicle on a map in the form of a marker.

	ADDRESS	LATITUDE	LONGITUDE
2	2084/47, 1st Main Rd, Ideal Homes Twp, RR Nagar, Bengaluru, Karnataka 560098, India	12.9242	77.5191
3	Kudremukh colony Rd, Santhosapuram, Koramangala 2nd Block, Koramangala, Bengaluru, Karnataka 560034, India	12.9242	77.6271
4	334, E End Main Rd, 4th T Block East, Jayanagar, Bengaluru, Karnataka 560041, India	12.9242	77.597
5	1142-1144, 35th C Cross Rd, 4th T Block East, Jayanagar, Bengaluru, Karnataka 560041, India	12.9242	77.594
6	698, CBI Road, Pillappa Block, Vishveshvaraiah Nagar, Ganga Nagar, Bengaluru, Karnataka 560032, India	13.0266605	77.590791
7	1152, 26th Main Rd, 4th T Block East, Jayanagar, Bengaluru, Karnataka 560041, India	12.9250074	77.5938028
8	116, 3rd Cross Rd, Govindaraja Nagar Ward, Saraswathi Nagar, Vijaya Nagar, Bengaluru, Karnataka 560040, India	12.9719161	77.5298856
9	1152, 26th Main Rd, 4th T Block East, Jayanagar, Bengaluru, Karnataka 560041, India	12.9250074	77.5938028

Figure 9: Extraction of address from latitude and longitude in Google Spreadsheets

An add-on in the Google Spreadsheets called Two-way Geocoding allows us to extract the address based on the latitude and longitude values. The above figure depicts the same.



Marker	Name	Address	Latitude	Longitude
1		2084/47, 1st Main Rd, Ideal Homes Twp, RR Nagar, Bengaluru, Karnataka 560098, India	12.9242	77.5191
2		Kudremukh colony Rd, Santhosapuram, Koramangala 2nd Block, Koramangala, Bengaluru, Karnataka 560034, India	12.9242	77.6271
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Figure 10: Markers are added onto maps using Two-way geocoding

After the address is extracted, we can mark those locations on the Google Maps with the help of markers. Every new location is pointed out by a marker with a unique ID for each. On hovering over the marker on the map, it displays the entire location. This is depicted in the above figure. A table is generated automatically with the information available which contains the fields Marker, Address, Latitude and Longitude.

The paper discusses about a solution to a growing problem, potholes. It consists of a sensor which is used to detect the presence of a pothole. Through a Wi-Fi module and Geolocation API, the latitude and longitude values of the pothole are captured and sent to an online platform for analysis. The address and area code of the pothole is extracted from the latitude and longitude in Google SpreadSheet and a graph is plotted for Area versus the Number of potholes. A map is also generated with markers on it having a unique ID to indicate the presence of potholes in a visual manner. The graph and map are sent to the Government officials to emphasize the problem. Through this system, we are detecting and addressing the problem of potholes.

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