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Pothole Detection

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***Abstract*— The proposal is put forward to suggest a system for better conditioning of roads. The lack of funding to maintain the road surfaces is a main reason for the dilapidated condition of roads, but, it is not the only reason. The absence of an effective monitoring system is one reason for this problem. A monitoring system can help to take remedial actions and that can lower the cost of maintenance. However, the cost of an effective monitoring system itself can be quite costly and hardy affordable for a developing country. The document proposes an idea to develop a system to detect potholes using radio waves. It focuses on the current challenges with the existing technology and how the proposed idea would be a boon to solve the present-day problems with road commute due to disturbances like potholes.**

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.

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, ladar 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.

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II. Problem Statement

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 labour that goes into the detection of potholes, but also saves a lot of time and are a lot more efficient.
The paper focuses on the current challenges with the existing technology and how the proposed idea would be a boon to solve the present-day problems with road commute due to disturbances like potholes using automated systems overcoming the negatives of the already existing work.

III. Existing Methods

Automatic pothole-detection systems using various sensors are being studied to ease the work of people. Existing proposals include vibration-based methods, laser-scanning methods, and vision-based methods.
There are certain technologies that already exist in the area of pothole detection. Some of them are as mentioned. Each deal with the obstacle in a similar way .The only difference is the sensor and its technique of recognizing the obstacle. The following are the different approaches for the detection:

Table 1: Various Approaches For Detection

	vision based	vibration based	laser scanning
sensor	camera	accelerometer	laser
response time	high	low	high
sensing period	while approaching the pothole	while going through the pothole	while going through the pothole
maintenance cost	high	low	high
precision	low	average	high
physical presence	yes	yes	yes

[1]The system has a light sensor and a camera mounted on the top of a vehicle. Image data is collected when the vehicle is travelling on the road. Along with this, the vehicle speed and its GPS location are recorded as well. The movement of the vehicle allows the sensor to scan the roadway in a push-broom pattern. The image is produced based on the orientation of the vehicle and speed. The data is accumulated and analyzed in a centralized location for roughness, cracks, potholes and other road metrics and the valuation results are used in the road maintenance operations.
[2]A system assists the drivers in avoiding pothole previous warnings. The basic idea is to detect the pothole at a distance and warn the driver so that he can reduce the speed or take another road. The system is based on image processing developed to process and study the captured image using the camera mounted on the car that gives high efficiency and accuracy compared to the other methods of detection.
[3]A camera-laser arrangement is used to detect cracks on the road. The camera is mounted on the line laser. In the presence of a pothole, there is deformation in the line laser which is captured by the camera. Detection and measurement of the defect is done using image processing by matching with a template which is

evaluated on a straight pavement. The deepest point of the deviation is analyzed by the maximum deviation from which the depth of the pothole is calculated. The deviation is lesser for a water filled pothole due to refraction and hence, physics based geometrical analysis is used to detect both dry and water-filled pothole.

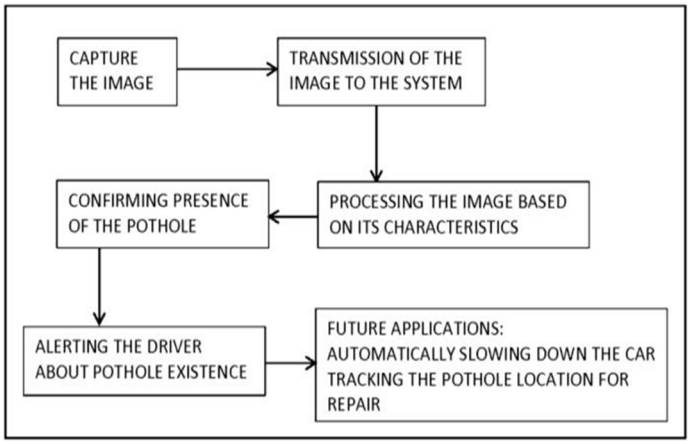

Figure 1. Flow diagram for avoiding the pothole

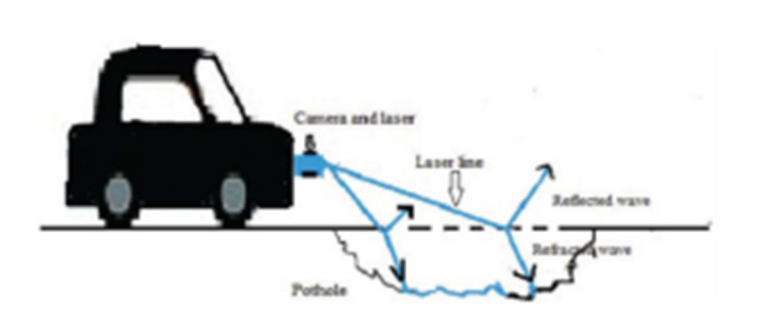

Figure 2. System mounted on the car

[4]The pothole patrol system using a mobile sensor network consists of two parts one of which is attached to the front of a vehicle and the other, worn by the operator handling it. The system in the vehicle looks for an obstacle and sends a signal to the system worn by the user and warns him of the obstacle by vibrating and blinking LED's. These hindrances are detected using two non-contact ultrasonic sensors modules. This detection system has three subsystems. First is the sensing system which detects the potholes; second is the one which handles the data transfer between the Wi-Fi access point and Mobile Node, called the communication subsystem. Last is the localization subsystem which studies the data received and warns the user about the obstacle.

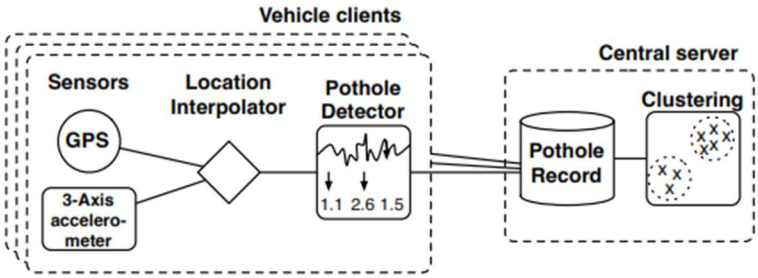

Figure 3. Ultra sonic sensor module

[5] Another detection system uses a black-box camera. It captures data such as size, location and appearance of the pothole and it is stored in the pothole database. Software developed for pothole-maintenance server provides information about the rut which includes their image, shape, size, location (latitude, longitude), route number of road and type of pavement. Using the GPS data, the pothole's location is pictured on a map. Through this, the officials are informed about the problem and can easily help in maintenance of the roads. They can also be fixed smartly using systems like the smart asphalt repair systems and the information regarding the potholes can be extended to others using Open API and external networks. It causes false recording when the intensity of sun light changes causing objects in front of the system to be detected as a pothole

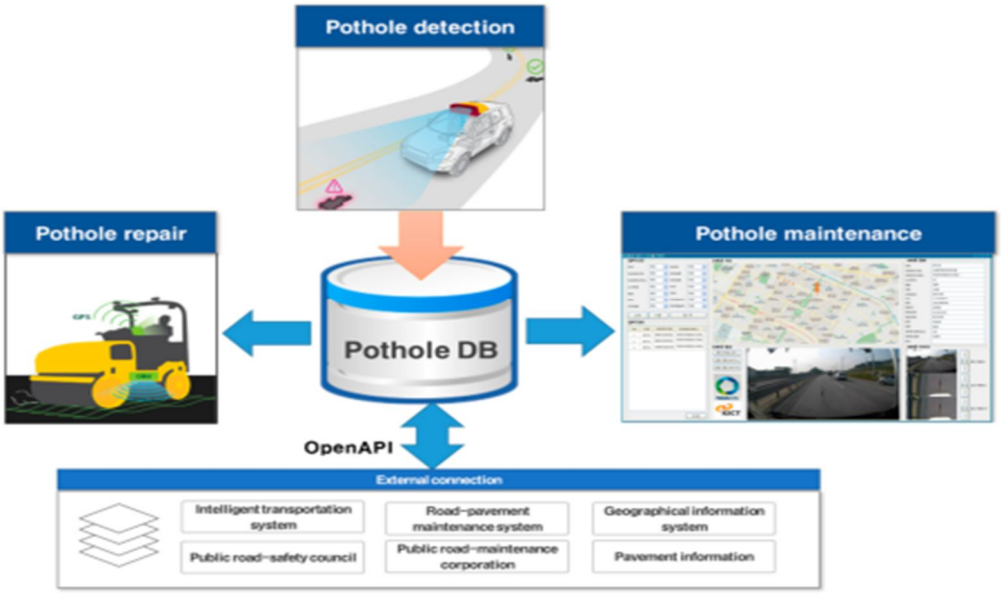

Figure 4. Block diagram of pothole maintenance system

[6] A new method to monitor road and traffic conditions uses a mobile Smartphone. It detects obstacles such as potholes and bumps using a microphone, accelerometer, GPS sensor and GSM radio which are present in the Smartphone. A trigger sensing technology is used where a high-consuming sensor like the GPS microphone is triggered by low-consuming sensors like cellular radio or accelerometer. This approach makes the system very energy efficient. The system uses an embedded accelerometer because the phone can lie at any random alignment and hence, must be slanted along the vehicle's axis before the inspection.

[7] Another approach uses ultrasonic sensors to detect potholes which also measure their dimensions such as height and depth. Using a GPS receiver, the system captures the geographical location of the potholes or bumps. The analysed data include depth of the pothole, height of the hump and the location. This is a crucial piece of information for the government officials and drivers. It also has an android application which is used to warn the drivers so they can take protective measures to prevent accidents. Alerts are given in the form of flash messages. Ultrasonic sensor and GPS sensors are placed at the foot of the vehicle where the ultrasonic sensor measures the distance between the road and the sensor and this collected data is received by the microcontroller. The location of the detected rut or hump is captured by the GPS receiver and a message is sent to the registered phone number using a GSM modem. The movement of the vehicle is sensed and the signal is transmitted through the ZIGBEE

[8] Laser sensors and pressure sensors are also used in the process of pothole detection. They are used in shock sensors to detect and calculate the intensity of the pothole. There is a unit in the vehicles which can access the centralized server containing the database of the locations of all the potholes. When a pothole is detected by a vehicle, all the other vehicles in the vicinity are also warned about the obstacle using a point-to-point connection.

Laser detector and transmitting device is used vehicles under carriage. A 3D laser scanner sweeps a laser across the pavement in two dimensions and at every pixel, and the time which is taken by the laser beam to

exit the sensor, strike the surface and return back to it is calculated. A pothole identification ID is linked with the depth and location of the pothole which can be easily accessed by the officials in charge

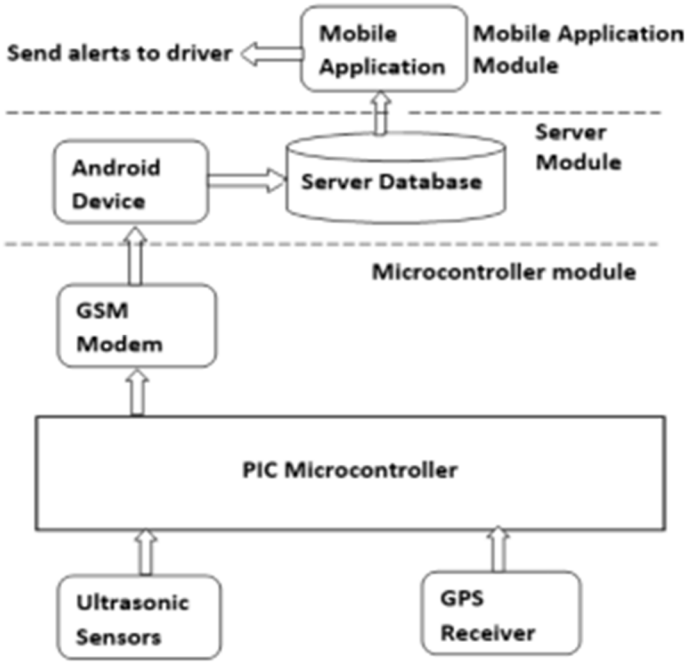

Figure 5 . Point – point connection system

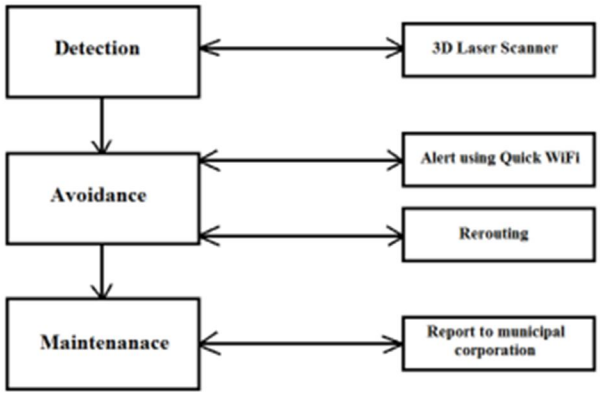

Figure 6. Laser detection

IV. PROPOSED SYSTEM

Safety of vehicles and road maintenance is the key concern in the proposal. It checks the anomalies on the road with the help of a device mounted on a pole. The data concerning the physical dimensions like the width and depth of the pothole is analyzed and stored in the server and forwarded to the concerned officials, along with the GPS location, informing them about the problem.

First, the radio waves from a device are made to reflect on an even surface. These radiations hit the surface of the road and return back to the device. The time taken by the signal to return back to the device is recorded and is stored as the threshold value, which is later used as a reference to compare with. The devices are installed at a height on a pole in pathways which are prone to potholes or other anomalies like cracks. Again,

the time taken by the signal to revert back is calculated based on the distance. This time is then compared with the threshold time and the difference between them indicates the presence of a pothole.
The method followed to find the dimensions of the pothole is by dividing the road into equal-sized imaginary grids. The time taken by the signal to hit the grid on an even surface and return back to the device is calculated and stored. Every time a road is examined for evenness, it is matched with the value of the grid of an even surface. . The difference of time with respect to the number of grids gives us the width of the pothole. The depth of the pothole is calculated on the basis of the delayed time. This data along with the GPS location will be stored in the server which will be forwarded to the concerned officials who will be prompted to fix the problem as early as possible. Once in every few days, the server resends the prompt to the officials if the pothole is not mended, ensuring quick fixing of the pothole.
The proposal's extension includes making an app with the data obtained from the analysis. This would include the route map along with stating the condition of the road indicating any deformities like cracks and potholes. The driver can then make an informed decision about which route to travel in which would make his ride safer and easier.

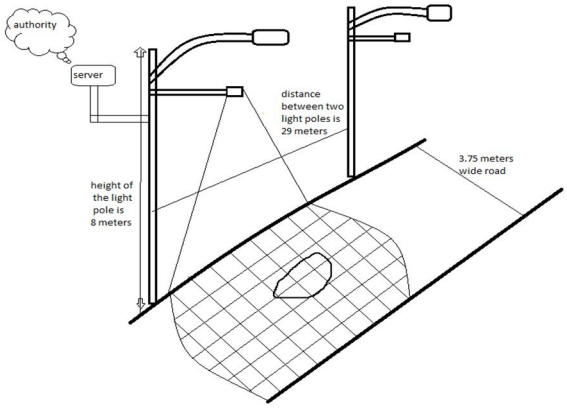

Figure 7. Proposed system

On the analysis of the existing technology some drawbacks of these methods were identified. The proposed paper tends to overcome the disadvantages of these existing technologies. All the vibration based, laser and other methods were implemented by placing the device on moving vehicles. By these methods, the pothole will be detected only if the vehicle runs over it or if the pothole comes in the region near the vehicle. With the help of these existing methodologies many potholes towards the edge of the road goes unrecognized. To overcome this, the device proposed in the document is mounted on a fixed pole which will help to identify the potholes in any region of the road. The data of these detected potholes will be stored on the server which can be accessed by the authority, it reduces the manpower. The presence of the investigator is not required to check the condition of the road. The information regarding the road maintenance can be retrieved at any point of time. As the system automatically detects the unevenness of the road and communicate the same to the government authority, it will even keep the concerned updated about the condition of each road in the city. The server is connected to the application that can be used by any normal drivers. So this will help all the passengers who travel in that way irrespective of the type of vehicle. In this way the method proposed in this paper tend be more helpful.

V. CONCLUSION

The document describes the major problems faced by the society and proposes the idea of an automated system to solve it. An automated system requires less labour work where the database is continuously updated in order to communicate with the concerned authority and to help in the direction to repair it. The system comprises of a sensor and uses radio waves which in turn make use of grid technology to detect the

pothole. This system would of great help for the government to have a regular check on roads of the city and to maintain them. This would lead the country into becoming a smart country.

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