

## IoT-Based Smart Glove for Pollution Monitoring and Potholes mapping using Node-MCU

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### Abstract:

In a nation where the majority of transport is characterized by road transport and the large number of vehicles moving on the expansive road networks, the pressing issues of potholes and pollution their stemming wear and tear, and the health hazards caused due to that have posed formidable challenges to the authorities as well as the individuals moving around also. To address these critical concerns of society we have introduced an IoT-based (Node-MCU) smart glove that continuously collects the real-time data of pollution and the exact locations of the potholes. This innovative solution not only provides enhanced pothole detection along the provided route but gives insights of the air quality along their routes. introducing the remembrance factor and managing the previous data on potholes and pollution along with the severity index to prioritize hazardous repairs on the route. All Together the smart glove ensures the driver's safety by delivering real-time data of the conditions of the routes.

**Keywords:** IOT, Monitoring, Node-MCU, Pollution, Potholes, Sensors, Smart glove, Monitoring.

## 1. INTRODUCTION

The road network, a cornerstone of economic development, bears a profound social impact, beyond its economic significance. Well-maintained roads foster seamless mobility, reduce vehicle operating costs, mitigate accident risks, and alleviate the burdens of illiteracy, poverty, and health issues, particularly in rural areas [1]. The perils of road travel, primarily attributed to driving under the influence and speeding, are further exacerbated by poorly maintained roads. Among the culprits, potholes emerge as stealthy adversaries, capable of causing severe accidents, especially at high speeds, catching drivers unaware of their presence [2]. Tragically, potholes, arising from heavy rains and vehicular traffic, contribute to traumatic accidents and the loss of human lives [3].

Traditionally, governments dispatch experts to photograph road damage, including potholes, creating meticulous maintenance reports. This method, while accurate, is a laborious, unreliable, and costly endeavor [4, 5]. In a nation as vast and populous as India, grappling with issues of pollution and global warming, efficient detection systems are imperative. Notably, Particulate Matter less than 2.5  $\mu\text{m}$  in diameter (PM2.5) reigns as a major air pollutant, jeopardizing respiratory health and

correlating with heart and lung ailments [6]. Therefore, a comprehensive solution encompassing road safety and air quality monitoring is paramount.

This paper introduces an innovative approach that harnesses the power of the Internet of Things (IoT), a technological revolution enabling objects to connect to each other and to digital services via the internet [7]. Comprising low-power sensing units or nodes and a cloud-based layer, this IoT architecture empowers real-time remote monitoring of critical parameters. Notably, embedded systems are pivotal for data collection and processing. In this pursuit, the ESP8266, equipped with Bluetooth and Wi-Fi capabilities, assumes a key role [8,9]. This platform excels in unearthing a wide array of information, from health metrics such as blood pressure and heart rate to environmental variables like air quality, temperature, and humidity [8].

To implement this multifaceted solution, we integrate various sensors into a smart glove. Accelerometers dissect road irregularities, unearthing the presence of potholes, with GPS sensors mapping their locations precisely on a digital canvas [2,10]. The air quality monitoring is entrusted to gas sensors, including the MQ135 and MQ7, capturing real-time data to assess environmental conditions. To manage this wealth of information, we leverage ThingSpeak for streamlined data collection and processing.

This project embarks on a transformative journey, introducing a smart glove that not only alerts drivers to road imperfections but also ensures vigilant air quality and temperature monitoring, all while tracking the vehicle's precise location. Informed by extensive research, our initiative stands as a beacon, enhancing road safety and augmenting the well-being of commuters while bolstering the sustainability of our vital road networks.

In the sections that follow, we delve into related work in this domain (Section II) and expound on our proposed system (Section III). Section IV presents our results and initiates discussions on the profound implications of our research.

## **2. LITERATURE SURVEY**

Singh et al., [2] developed the Smart PPM smart helmet design for effective pollution and pothole monitoring. The information gathered by the smart helmet is wirelessly transferred to a smartphone application, which then uses cloud server communication to deliver pollution and pothole detection data. Users can select a route that is comparatively free of potholes and pollutants by using the crowd sourced data to receive real-time alerts when potholes are near. The design details, including the parts of the prototype and pothole detecting techniques like computer vision and machine learning, are covered in the paper.

Jamakhandi and Srinivasa [11] describe a system that can detect and identify road imperfections in real-time using accelerometers, GPS, and wireless communication. The system gathers acceleration and coordinates data, which is subsequently transmitted to a cloud service for processing. The user can then plan their trip and take the appropriate safety precautions by using mapping tools to access the information about road abnormalities.

Wang et al., [12] Talk about the two pothole detecting techniques: mobile sensing and picture recognition. The pothole detecting process in the image recognition approach makes use of artificial

neural network algorithms and laser imaging techniques. The mobile sensing method gathers accelerometer data and location information for pothole identification using a bus's G-sensor and GPS. In addition, the study offers experimental findings and suggests a mobile sensing-based real-time pothole identification technique.

Various techniques for identifying potholes on roadways are covered by Girisan et al. [13]. The three primary approaches investigated are vibration-based, ultrasonic-based, and vision-based. Cameras and image processing methods are used in the vision-based method to locate potholes. Accelerometers are used in the vibration-based method to monitor vibrations and find potholes. The ultrasonic-based approach measures distances and finds potholes by using ultrasonic sensors or lasers. The research suggests a system that combines accelerometer, GPS, and NodeMCU-ESP8266 for pothole identification. Each approach has pros and cons of its own.

Strutu et al., [14] use Internet of Things (IoT) technology to collect and analyze data in order to track and evaluate road conditions. The system makes use of a mobile platform that has sensors installed on cars, including GPS, accelerometers, and video modules. These sensors gather information on road imperfections, which are subsequently processed and analyzed using algorithms. The system also includes data aggregation and wireless connectivity to send the gathered data to a central server for additional processing and archiving.

Kumar and Jasuja [15] have created a standalone, real-time air quality monitoring system using IoT and a variety of sensors. The system measures a number of variables, including temperature, humidity, air pressure, PM 2.5, and carbon monoxide and carbon dioxide. Cloud computing in conjunction with IoT technology makes it possible to manage data gathered from various sensors more effectively. The Raspberry Pi is an inexpensive, low-power, ARM-based minicomputer that transmits data. The local environment control authority's data is compared with the sensor measurements, which are then shown in IBM Bluemix Cloud.

Deekshath et al., [16] demonstrate an Arduino UNO and Thingspeak-powered Internet of Things environmental monitoring setup. The system uses sensors to continuously monitor environmental data, including temperature, humidity, soil moisture, precipitation level, and gas concentration. Wi-Fi is used to transfer the gathered data to the Thingspeak cloud platform, where it is stored and accessible via an Android app. Users of the system can monitor and assess the environmental conditions of their farmland in real time.

Kularatna [17] explain how an Environmental Air Pollution Monitoring System (EAPMS) built on the IEEE 1451 standard was developed. The system measures the concentrations of important air pollution gases, including CO, NO<sub>2</sub>, SO<sub>2</sub>, and O<sub>3</sub>, using semiconductor sensors. A network capable application processor (NCAP) linked to the smart transducer interface module (STIM) and powered by the ADuC812 micro converter, as well as a graphical user interface (GUI) for showing system data and gas concentrations are all part of the system. The static chamber approach was used to calibrate the sensors. The EAPMS can be evolved into a low-cost version for underdeveloped countries and is capable of issuing warnings when pollution levels surpass predetermined limits.

Shete and Agrawal [18] describe a system that uses Internet of Things and Raspberry Pi to monitor the climate in cities. Sensors that measure light intensity, pressure, temperature, humidity, carbon

monoxide, and pollutant concentration are used by the system to gather data. The Raspberry Pi serves as the main controlling node and receives the data. The technology enables remote monitoring and control and displays data in real time on a dashboard. The system is affordable and dependable due to the utilization of low-cost hardware and effective communication protocols.

Velasquez et al., [19] install an inexpensive Internet of Things-based environmental monitoring system. The system consists of dispersed remote nodes throughout the city that monitor a range of environmental parameters, including UV radiation, noise, temperature, humidity, PM2.5, and carbon monoxide. These nodes' data are wirelessly transferred to a central server for management and storage. An online portal that facilitates real-time data visualization, report and alarm generating, and community engagement is also a part of the system.

Silva et al., [20] suggest a method for identifying potholes using photos taken by unmanned aerial vehicles (UAVs). In essence, this is a multi-agent system in which a number of intelligent agents collaborate to complete a task. It also describes how several elements work together to enhance the precision and effectiveness of the pothole identification procedure. It offers a way to find potholes more effectively.

Obira et al., [21] provide the example of African nations experiencing fast urbanisation and industrialization, which has led to air pollution being a major health hazard. It demonstrates a system that uses sensors and an Arduino Uno to monitor the levels of smoke and carbon monoxide. Data analysis and archiving have been done using cloud computing services. Additionally, it provides a graphical representation of the supplied data for simple analysis. The suggested approach works well for real-time air pollution monitoring.

Rainio et al., [22] explain the link between driver illnesses and traffic accidents. It goes on to examine the autopsy findings and other traffic accident reports, coming to the conclusion that mental illnesses like drunkenness and depression may contribute to traffic accidents. In light of this, they propose that drivers' fitness should be taken into account in medical practice, especially when treating patients who suffer from alcoholism and other disorders. The data obtained from here formed the basis for our research to detect the quality of roads using IoT.

Dimple et al., [23] explain how poor maintenance has led to uneven and bumpy roads, increasing the number of traffic accidents. It states that potholes are primarily to blame for making driving difficult. This study suggests a method for detecting potholes using their "ROAD MODE" application as a means of overcoming them. As a result, this system offers a two-way interface for updating and accessing data on potential irregularities on the route.

Shwetali et al., [24] they firstly report that a number of causes that are contributing to the rise in air pollution. Additionally, it offers a real-time cloud computing and Internet of Things (IoT) air pollution monitoring solution. It talks about the advantages of this suggested strategy in lowering air pollution and the benefits that come from putting it into practice.

Kadam and Ghogare [25] explain to us the difficulty a nation faces in having roads filled with potholes. Additionally, how poorly designed roads impact people's health and lead to issues like accidents and unexpected delays in transportation. It suggests a method to identify potholes and alert

drivers to their proper location in order to solve this issue. It transfers the data to the central server for additional processing using a step counting technique. It ultimately implements a system that provides correct results at a reasonable cost and doesn't require any additional sensors.

All these papers and articles have laid the foundation for this research and project to integrate IoT into road safety and air quality monitoring.

### 3. PROPOSED SYSTEM

#### A) Block Diagram and Algorithm

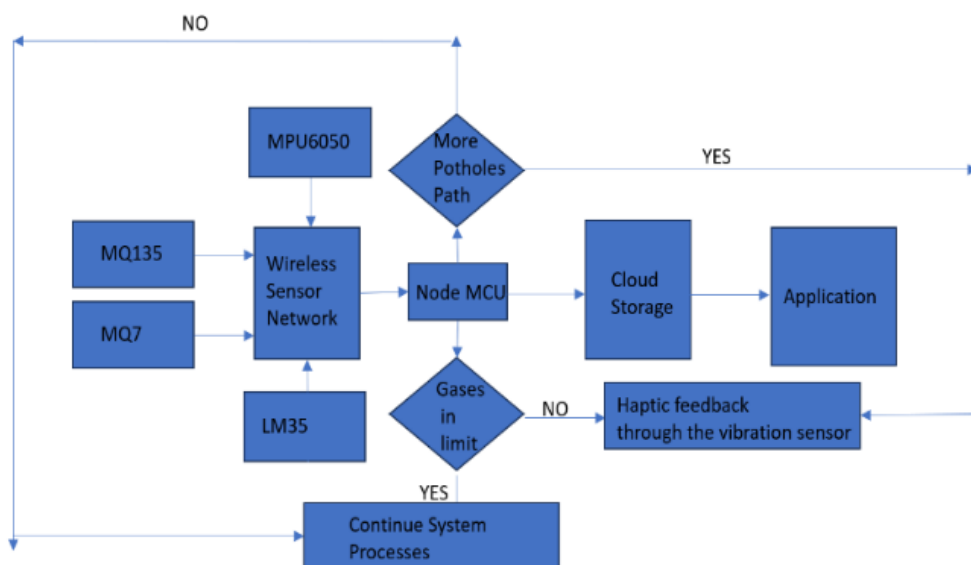


Fig 1. Flowchart of the IoT System

Figure 1 shows the sample flowchart of the system as proposed. The micro controller- ESP8266 is continuously taking readings from its surroundings. The sensors namely MQ135 and MQ7 takes readings of the air quality, it detects mainly CO and other pollutants like NH<sub>3</sub>. Consequently, the accelerometer so used (MPU 6050) is actively reading any changes in the linear and rotational axis of the sensor along with the temperature. As a pothole is detected the readings reach the threshold or go beyond it and hence a pothole is logged with its location using Google's geo location API (Application Package Interface). All this data is plotted on graphs and maps on the Thingspeak cloud platform where it can be further analyzed. Like the average temperature of the route chosen, the number of potholes on the route and the average air quality index. Now extending this same concept on two different routes the user can easily identify which route is safer in terms of road quality and air quality.

The algorithm for the above system is as follows:

```

# Read the gas sensor values
co_value = mq7.value
nh3_value = mq135.value
    
```

```
# Read the accelerometer values
linear_acceleration= mpu6050.acceleration
rotational_acceleration= mpu6050.gyro

# Detect a pothole if the linear acceleration in the y axis exceeds the threshold
pothole_detected = False

if abs(linear_acceleration.y or rotational_acceleration.y)>
pothole_threshold:
    pothole_detected = True

# Read the temperature
temperature = mpu6050.temperature

# Construct a data packet
data_packet = {
    "co_value": co_value,
    "nh3_value": nh3_value,
    "linear_acceleration": linear_acceleration.y,
    "rotational_acceleration": rotational_acceleration,
    "pothole_detected": pothole_detected,
    "temperature": temperature
}

# Send the data packet to the cloud platform
cloud_client.send_data(data_packet)
```

*B) Circuit Diagram*

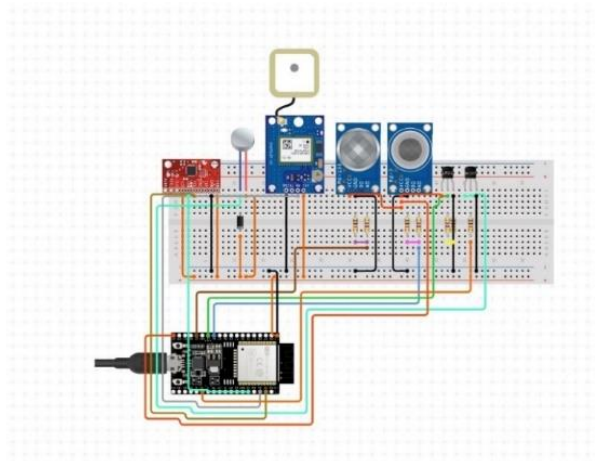


Fig 2. Circuit connection for the smart glove

Figure 2 shows the sample circuit that has been used in order to develop the required system. All the mentioned sensors are connected to the Node-MCU in the fashion as shown above.

C) Theory

$$\theta = \sin^{-1}\left(\frac{a_y}{g}\right) \tag{1}$$

Here,

$a_y$  is the acceleration of the object in the y axis

$g$  is the acceleration due to gravity.

$\theta$  denotes the change

Used in MPU6050, equation (1) is the change in the y axis which is measured by taking the sine inverse of acceleration in y axis divided by the acceleration due to gravity (9.81 m/s<sup>2</sup>).

$$R_s = R_\theta * e^{\alpha * C} \tag{2}$$

In equation (2) which is used for air pollution monitoring (using MQ135 and MQ7), it can calculate the presence of required gas (here CO).  $R_s$  is resistance in presence of the air to be detected,  $R_\theta$  is the resistance in clean air,  $\alpha$  is the sensitivity constant and C is the concentration of the target gas.

4. RESULTS AND DISCUSSIONS

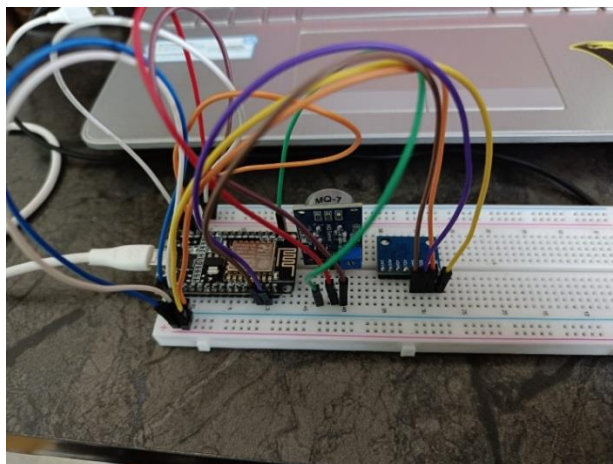


Fig 3. Sample Circuit Connections

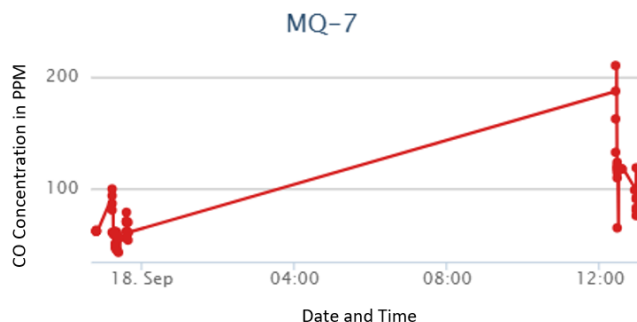


Fig 4. CO concentration monitoring

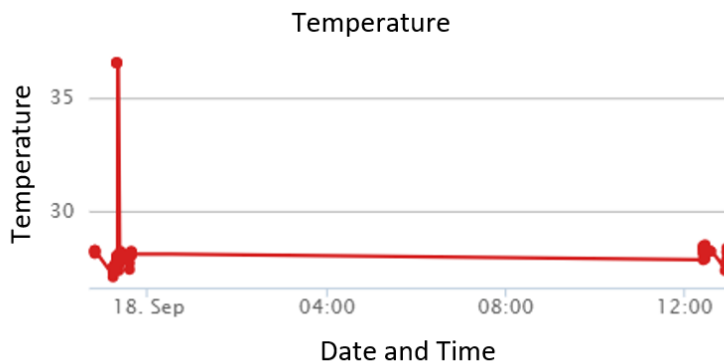


Fig 5. Temperature Readings

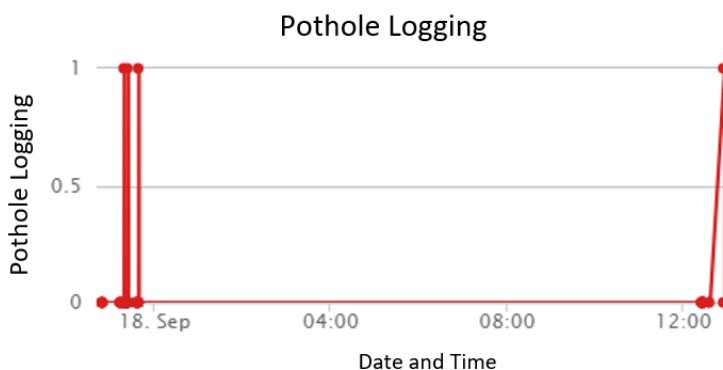


Fig 6. Logging of potholes

Figure 3 shows the sample circuit used for testing. Figure 4 shows the graph of concentration of Carbon Monoxide as detected by the MQ7 sensor. The Y axis is the concentration while the X axis represents the date and time at which it was recorded. Similarly figure 5 shows the temperature as recorded by MPU 6050’s in built sensor, again the Y axis is the temperature reading while the X axis is the date and time at which it was recorded. Figure 6 shows all the records of when a pothole was detected by the system, whenever the graph spikes towards 1, a pothole was recorded. The novelty of the system lies in the method of pothole detection, where on calibration it is found out that Y-axis of linear and angular acceleration are useful for its detection.

Index	MPU 6050 Readings	Output
1	Y_acceleration = 2	No Pothole logging
2	Y_acceleration = 3	No Pothole logged
3	Y_acceleration = 4	No Pothole logged
4	Y_acceleration = 5 (Threshold)	Pothole logged
5	Y_acceleration = 8	Pothole Logged

Table 1) Test-cases for MPU6050

Table 1 indicates the different test cases that have been used to calibrate the sensor in order to detect the pothole accurately.

Index	MQ135 Readings	Output
1	10 ppm	No CO detected
2	20 ppm	No CO detected
3	30 ppm	No CO detected
4	40 ppm	CO detected
5	50 ppm	CO detected
6	60 ppm	CO detected

Table 2) Test-cases for MQ135 for CO detection

Table 2 indicates the different ppm that needs to be detected to understand the air quality.

All these results show a positive sign of development of a smart IoT enabled glove so that the driver can take judicious decisions in future based on this data.

### 5. CONCLUSION

This study concludes with a novel IoT-based approach to the urgent problems of pollution and potholes in road mobility. The suggested method makes use of a smart glove with sensors to continuously gather data in real-time on the locations of potholes and pollution levels. The solution ensures driving safety by incorporating IoT technologies to give improved pothole detection and insights into air quality along routes. Users can select a route depending on road and air quality quality by using the ThingSpeak cloud platform to analyse and visualise the collected data. This work provides a comprehensive response to the transportation-related problems that both individuals and authorities must deal with by laying the groundwork for the integration of IoT into air quality monitoring and road safety.

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