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POTHOLE DETECTING ROBOT

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Abstract : The paper underscores the stark contrast in road accident rates between developing and developed countries, with a particular focus on India, where the surge in vehicle numbers has outpaced road infrastructure growth. Potholes are identified as a significant contributor to these accidents. It reviews various existing methods for pothole detection and proposes a cost-effective, user-friendly solution employing ultrasonic sensors for depth and height assessment. This system integrates GPS for precise location tracking, allowing for accurate measurement of pothole dimensions. Data collected is then transmitted to the cloud via an open-source application, facilitating easy access for analysis and action, either through email or government servers. Citing statistics from the World Health Organization (WHO), the paper underscores the grave public health implications of road accidents, with millions of lives lost and injured annually. Notably, despite the prevalent road accidents in developing countries, a considerable portion of such incidents occurs in developed nations, with 90% of pothole-related accidents reported in these regions. The paper emphasizes the urgent need to prioritize road safety efforts, not only for public health reasons but also for their broader economic implications. By reducing the human and economic toll of accidents, improving road safety measures indirectly contributes to economic growth. Thus, the paper advocates for increased focus on this sector to enhance human safety and promote economic prosperity.

***IndexTerms* – Literature Survey, Components, Methodology, Working, Advantages, Results, Conclusion, Future Scope.**

I. INTRODUCTION

Potholes pose significant challenges on roadways worldwide, causing damage to vehicles and posing safety hazards to motorists, while also contributing to costly infrastructure repairs. Traditional methods of identifying and repairing potholes have proven to be inefficient and time-consuming. In response to this challenge, innovative solutions utilizing robotics and artificial intelligence have emerged.

The Pothole Detection Robot represents a groundbreaking advancement in infrastructure maintenance and road safety. This autonomous vehicle is equipped with cutting-edge sensors, cameras, and AI algorithms specifically designed to detect and catalog potholes with precision and efficiency.

II. LITERATURE STUDY

[1] The paper proposes accelerometer-based pothole detection algorithms optimized for devices with limited resources, evaluated on real-world data from Android smartphones. Results show up to 90% true positive rates across different road conditions.
[2] Our strategy involved employing machine learning algorithms such as YOLO3 for pothole detection on roads. We aimed to improve road infrastructure by facilitating citizen-authority collaboration through a cross-platform website where citizens report issues and municipalities take action. Additional features like pothole-based route navigation would enhance monitoring capabilities for both citizens and authorities in managing their areas effectively.
[3] Continuous monitoring and timely repair of road infrastructure are vital for ensuring road safety. Mobile devices are increasingly used for pothole detection, offering a cost-effective solution. Developing a mobile sensing system for detecting road irregularities is essential, with various proposed methods in existing literature.
[4] The Kinetic sensor offers detailed pavement visualization and metrological analysis of potholes, outperforming simple vision techniques. It provides readily available depth measurements via IR camera, making it superior to stereo vision, and is cost-effective compared to lasers.
[5] Disparity Transformation of 3D Surface Models: Requires costly lasers for 3D surface modeling, making it expensive.

[6] Deep Convolutional Neural Network (CNN): While CNNs offer promising results, the performance might vary depending on the dataset and environmental conditions.
[7] Smartphone-Based Method: Not real-time based, which may limit its effectiveness in providing timely warnings to drivers.
[8] Mobile Sensing Detection: Lack of a centralized database and lower GPS accuracy could affect the reliability and scalability of the system.
[9] Image Processing with Hadoop: Hadoop's limitations in handling low-latency requirements and data distribution might impact the system's real-time processing capabilities.
[10] Pothole Detection Technique using Image Processing and Machine Learning: Susceptible to distractions such as heavy shadows and lighting problems, which could reduce the accuracy of pothole detection.

III. Component Details

3.1. Ultrasonic sensor (HC-SR04)

The HC-SR04 is an ultrasonic sensor module comprising two ultrasonic transmitters, a single receiver, and a control unit. For proper operation, the sensor requires a regulated +5V power supply and operates at a frequency of 40 Hertz. It utilizes ultrasonic waves to measure the distance of objects within a range of 2 to 400 centimeters. The detection angle for this sensor is stated to be less than 15 degrees, with ranging accuracy potentially reaching up to 3 millimeters. Distance measurement is based on the time taken by the transmitted pulse to return to the receiver. The sensor is equipped with pins labeled VCC, Echo, Trigger, and Ground. The dimensions and range of the HC-SR04 are crucial to its functionality, allowing it to accurately detect and measure distances within its specified parameters.

3.2. Power source

A 12V rechargeable battery serves as the power source for the proposed system, with voltage being stepped down to 5V suitable for the ESP32 through the use of motors. Capacitors are integrated into the system to eliminate DC impulses, and a regulator is employed to ensure the main controller's protection from potential damage.

Key points:

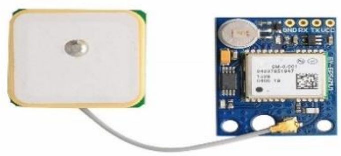
- The 12V battery powers the system.
- Motors are instrumental in converting the voltage from 12V to 5V for ESP32 operation.

3.3. IR Sensor

The device in question comprises a pair of IR (infrared) LED and photodiode components. IR light emitted by the LED has a wavelength typically falling within the range of 700nm to 1nm. The emitting angle of the device ranges from approximately 20 to 60 degrees, with a detection range spanning 10cm to 15cm. The photodiode functions as the IR receiver, activating when exposed to light. Operating as a PN junction diode in reverse bias, the photodiode conducts current in the reverse direction when light falls on it. This reverse current flow is directly proportional to the intensity of the incident light, facilitating IR detection capabilities of the device.

3.4. GPS Module (NEO-6M)

The NEO-6M GPS module is highly regarded for its exceptional performance, boasting an integrated 25x25x4mm ceramic antenna renowned for its robust satellite search capabilities. Additionally, the module incorporates an onboard memory chip, adding an intriguing feature to its functionality. One of the most notable aspects of the NEO-6M module is its built-in rechargeable battery, which serves as a valuable asset during emergencies. In the event of an accidental power loss, this battery backup ensures that data within the module remains intact, offering peace of mind to users. Operating seamlessly with a 5V power supply, the NEO-6M module comes preconfigured with a default baud rate of 9600 bps, making it compatible with a wide range of applications a
and systems.



3.5. DC Motor

The specifications for the 12V DC motor:
Motor operating voltage: 12V
Maximum speed: 150 rpm
Torque produced: 2 kg-cm
Maximum no-load current: 60mA
Load current: 300mA
Shaft diameter: 6mm with an internal hole.

3.6. Blynk Software of IOT

Blynk is an Internet of Things (IOT) platform that offers iOS and Android apps for controlling devices such as Arduino, Raspberry Pi, and ESP32. This versatile software simplifies the design and implementation of smart IOT devices, enabling users to quickly and easily read, store, visualize sensor data, and remotely control hardware. With Blynk, users can create custom digital dashboards by simply dragging and dropping widgets, allowing for the creation of visually appealing and functional interfaces for their projects. The software is compatible with a wide range of hardware models and connection types, providing flexibility and compatibility for various IOT applications. One of the key features of Blynk is its ability to ensure secure communication between IOT devices and the internet. By closing and encrypting communication channels, Blynk helps safeguard data transmitted by IOT devices, enhancing security and privacy for users and their projects.

3.7. LCD Display

The LCD screen on the pothole detection robot provides real-time data visualization, system status updates, and interactive menu navigation. It also offers error alerts, historical data logging, user feedback, and customization options. This integration enhances user engagement, supports proactive maintenance, and facilitates informed decision-making during pothole detection missions.

IV. Methodology

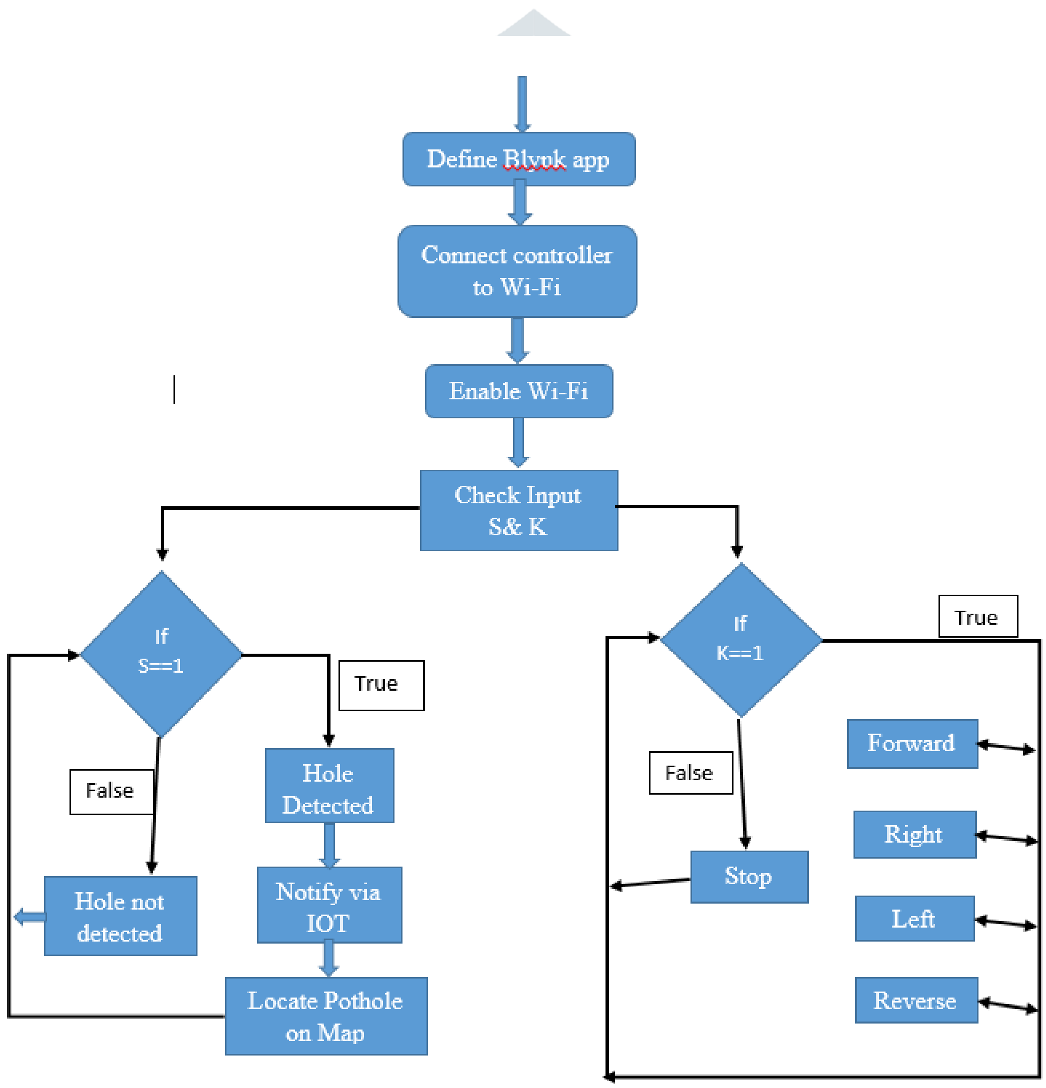


Fig 1: Flow chart

V. Working

The proposed IOT-based robot detects humps and potholes using ultrasonic and IR sensors. Controlled and monitored via an open-source Android app, it features a graphic user interface (GUI) for ease of operation. Utilizing a microcontroller with built-in Wi-Fi, the system sends sensor data to the Blynk server, including geographical location for further transfer to specific or government servers via email. The system comprises sensing, controlling, and output units for efficient functionality.

5.1. Sensing unit

The proposed system utilizes two sensors, an ultrasonic sensor and an IR sensor, to detect potholes and humps. Ground clearance measurement serves as the threshold value, determining whether the surface is smooth, a pothole, or a hump based on sensor readings. If measurements exceed the threshold, it indicates a pothole; if they fall below, it signifies a hump. Data collected by the sensors is sent to the microcontroller for processing and further action. The system components include the ultrasonic sensor, IR sensor, and microcontroller, working together to accurately detect road conditions and ensure vehicle safety.

5.2. Controlling Unit

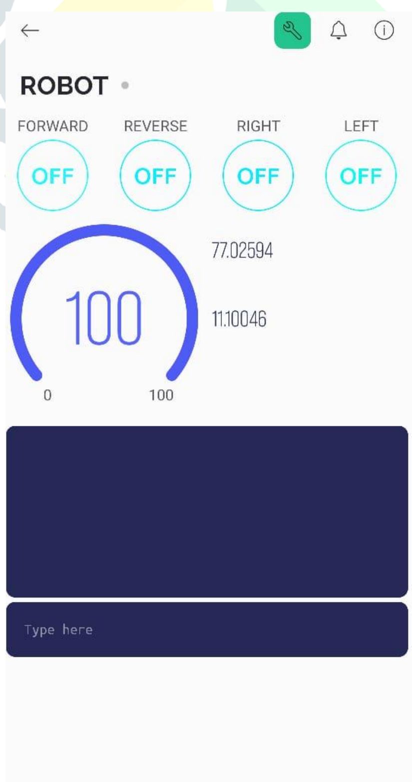
The controlling unit of the proposed system comprises a microcontroller with GPS and inbuilt Wi-Fi capabilities. It receives commands from the IOT application module and controls motor driving accordingly. Sensors and the Android application serve as input sources for the microcontroller, which also houses the programming code. Utilizing its inbuilt Wi-Fi, the microcontroller sends information, including geographical location of potholes and humps, to the Android application. Serving as an intermediary platform, the microcontroller facilitates communication between the sensing unit and the output module unit.

5.3. Output unit

ESP32 Controller: Receives data from the ultrasonic sensor and compares it with predefined threshold values to identify potholes and humps.

Blynk Application: Facilitates communication between the ESP32 controller and the server. The detected pothole and hump data is transmitted from the controller to the Blynk application.

Server: Receives the data from the Blynk application and stores it for further analysis or action. This data helps in identifying areas with poor road conditions and facilitates maintenance efforts.



VI. Advantages

The proposed system sounds like a promising solution for addressing the issue of potholes on roads. By utilizing a cost-efficient approach that doesn't rely on high-spec cameras and automates the detection process, it offers several advantages: Prioritization of Repairs, Safety Improvement, Automated Detection, Cost Efficiency.

VII. Result

Pothole	Hump	Location
18.45 cm	Not Detected	19°10’25.6”N 72°52’18.0”E
19.58 cm	Not Detected	19°10’26.7”N 72°52’18.2”E
22.05 cm	Not Detected	20°11’25.4”N 72°52’15.0”E
25.00 cm	Detected	19°10’25.6”N 72°52’18.0”E
27.57 cm	Detected	19°10’25.5”N 72°52’19.3”E

VIII. Conclusion

The proposed system involves a bot capable of two applications: pothole and hump detection, and status sharing of road conditions via email notification. Equipped with ultrasonic and IR sensors placed at the bottom of the vehicle, abnormalities in the road surface are detected and compared with preset threshold values. The GPS receiver determines the location of detected potholes, which is then transmitted to the server and authorized individuals via an IOT application and email. The system promptly alerts the relevant department upon detecting any road surface abnormalities, enabling timely intervention to mitigate the risk of accidents.

IX. Future Scope

The future scope of pothole detection robots includes advancements in autonomous navigation and data collection capabilities, integration of advanced sensors for improved accuracy, and the development of intelligent algorithms for real-time analysis and decision-making. Additionally, potential enhancements involve the incorporation of machine learning techniques for detecting and classifying various road defects beyond potholes, as well as the implementation of self-repair mechanisms for immediate remediation of identified issues. Moreover, there's potential for collaboration with smart city infrastructure for seamless integration and proactive maintenance strategies.
Versatile Movement: Capable of both automated and manual movement, providing flexibility in navigating various terrains and environments.
Precise Pothole Sensing: Equipped with sensors to accurately detect potholes, enabling efficient identification and assessment of road defects.
Automated Filling: Capable of autonomously filling potholes, reducing the need for manual labor and expediting repair processes.
Intimation System: Provides notifications or alerts to relevant authorities or maintenance teams upon pothole detection, enabling prompt action and timely repairs.

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