IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, December 2025
Impact Factor: 7.67

Smart Pothole Detection and Clearance for Pothole Free Roads

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Abstract: *Smart Pothole Detection and Clearance is a semi-automated system that identifies potholes using sensors or camera-based image processing. The system detects the pothole, measures its size, and records the exact location using GPS. This information is then sent to road authorities through wireless communication for quick action. By automating detection and reducing the need for manual inspection, the system helps speed up repair work, improves road safety, and supports better road maintenance planning. In addition, the system provides real-time monitoring and data collection, which helps authorities prioritise repairs based on severity. This ensures efficient resource usage and minimizes road damage over time. Together, these features make the system a reliable solution for maintaining smoother and safer roads. Furthermore, the implementation of this smart technology encourages predictive maintenance by analysing repeated pothole occurrences and identifying high-risk zones. This helps in improving long-term infrastructure planning while reducing accidents, vehicle damage, and overall maintenance costs. The system thus contributes to creating more sustainable and technology-driven road management.*

Keywords: ESP32– Controls the whole system., Battery – Stores the solar energy for continuous operation., DCMotor – Moves the robot and its mechanism., WiFi Module-Sends and receives data wirelessly

I. INTRODUCTION

India, the second most populous country in the world and a rapidly developing economy, has an extensive road network that serves as the backbone of transportation. However, many roads are narrow, congested, and poorly maintained, leading to unsafe driving conditions. Over the past two decades, the surge in vehicle population has further strained road infrastructure, making daily commuting a risky and often life-threatening experience due to poor surface quality and inadequate maintenance.The increasing number of vehicles and expanding road networks have also led to a rise in pothole-related accidents. Reports indicate that thousands of people lose their lives or get injured every year due to potholes, faulty roads, and unexpected surface irregularities. Although some improvements have been observed, potholes remain a major cause of road accidents. Ensuring the safety of motorists and providing smooth, uninterrupted travel has become a critical need.To address this problem, we propose a smart system that detects potholes using a combination of IR and ultrasonic sensors. The goal is not only to identify potholes but also to support their repair by leveling them with the required materials. This multi-sensor system records pothole information and sends it to an IoT-based application, enabling authorities or operators to monitor and control the model efficiently. By integrating technology into road maintenance, the system aims to reduce accidents, enhance road safety, and support faster, more effective pothole management.

II. PROBLEM STATEMENT

Over the past few years, there has been a large increase in vehicle population. This increase in vehicle population has led to increasing road accidents and also traffic congestion. These accidents can be due to over speeding, drunk and driving, jumping traffic signals and also due to potholes. Hence it is important to collect information regarding these

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poor road conditions and distribute the same to other vehicles that in turn help reduce accidents caused due to potholes. Hence, in this system we have proposed a system that would notify the drivers regarding any hurdles such as potholes this information can be used by the Government to correct these roads effectively to develop a system based on IOT to detect Path holes and the road which will be uploaded on server and notified to all the user using the application and update as per the condition**.**

III. LITERATURE REVIEW

Recent research on smart pothole detection focuses on using computer vision, deep learning, and IoT/sensor-based systems to identify and map road defects in real time. Vision-based methods, often using CNNs or YOLO, provide high accuracy, while hybrid approaches combining sensors, GPS, and 3D data improve robustness under varying road conditions. Systems like iWatchRoadgo further by geotagging potholes and integrating maintenance alerts for authorities. Benefits include automated monitoring, faster repairs, improved road safety, and cost efficiency. However, challenges remain in detecting pothole severity, working under poor lighting or weather, high sensor costs, and translating detection into actual road maintenance. Future trends focus on *end-to-end platforms* that combine detection, mapping, and automated repair coordination.

Our Contribution**:**

1. Automation Mechanism:Built DC motor-driven concrete delivery for pothole filling.
2. Wireless Control:Implemented Wi-Fi/Bluetooth for remote operation.
3. Detection Technique:Used ultrasonic sensor for accurate pothole detection.

IV. METHODOLOGY

The study will collect road images and sensor data (GPS, accelerometer) under various conditions. Potholes will be labelled and preprocessed, then detected using a deep learning model (e.g., CNN or YOLO), with optional sensor integration for higher accuracy. Detected potholes will be geotagged and mapped for real-time monitoring, and system performance will be evaluated using accuracy, precision, and recall. Finally, the results will support maintenance workflows, helping authorities prioritize repairs, with potential future improvements including severity assessment and hybrid sensors.The system uses an ESP32 microcontroller as the main control unit. A battery powers the ESP32 and all other components. The ESP32 receives inputs from ultrasonic sensors to detect obstacles and from an ESP-CAM module for live video monitoring. It can also communicate wirelessly through Bluetooth and Wi-Fi for remote control and data transmission. Based on the sensor data and user commands, the ESP32 sends signals to motor drivers, which control the movement of DC motors for robot direction and operation. Another motor driver controls the motor connected to the concrete storage unit, allowing the system to pour or release concrete when required. The system works together to move the robot safely, avoid obstacles, and perform concrete dispensing operations efficiently.

V. WORKING

The system works in three main stages: detection, analysis, and pothole clearance. The ESP32-CAM captures real-time road images or videos, while the ultrasonic sensor measures the depth or presence of potholes. The captured data is processed by the ESP32 microcontroller and can be transmitted via Wi-Fi or Bluetooth to a control system for analysis. Once a pothole is detected, the DC motor and motor driver control the robotic concrete delivery system to fill the pothole automatically. The system is powered by a battery and power supply, ensuring mobility and independent operation. This integrated system allows the system to detect, locate, and repair potholes efficiently, aiming for pothole-free roads.

WORKING PRINCIPLE

Step 1:ESP32-CAMcaptures road images or video.
Step 2: Ultrasonic sensor detects pothole depth and presence.
Step 3:ESP32 processes image and sensor data to identify potholes.
Step 4: Wi-Fi/Bluetooth transmits pothole information for monitoring.

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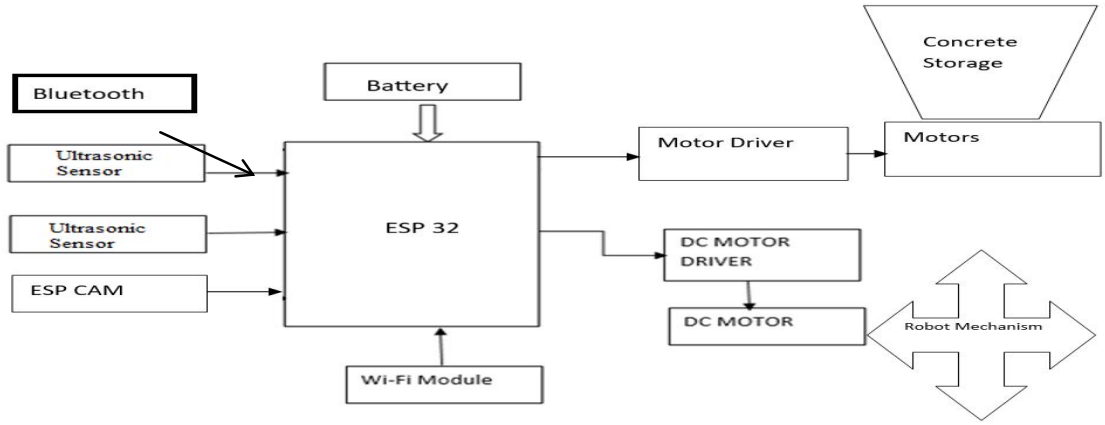
Step 5: DC motor driver controls DC motor for robotic concrete delivery.
Step 6: Concrete is deposited to fill detected potholes.
Step 7: Battery/power supply powers the entire system for autonomous operation.

VI. BLOCK DIAGRAM



COMPENTS USED

- ESP 32
- WiFi Module
- Ultrasonic sensor
- Battery
- ESP CAM
- Power supply
- DC motor
- Bluetooth
- DC Motor driver
- Robotic Concrete Delivery

VII. COMPONENTS DESCRIPTION

ESP32

The ESP32 is a low-cost, low-power microcontroller with a dual-core 32-bit processor (up to 240 MHz), built-in Wi-Fi and Bluetoothand a 3.3V operating voltage. It supports GPIOs, ADCs, DACs, PWM, I²C, SPI, UART, I²S, CANand secure features like AES, SHA, and hardware RNG. It can be programmed via Arduino IDE or ESP-IDF and is ideal for battery-powered, connected devices like home automation, robotsand data loggers.

WiFi Module

The ESP32 has a built-in Wi-Fi module allowing it to connect to wireless networks without extra hardware. It supports 2.4 GHz 802.11 b/g/n and can operate in Station mode (connect to a router), Access Point mode (create its own network)or both. With a complete TCP/IP stack, it communicates using HTTP, HTTPS, MQTT, WebSockets and UDP, supporting secure connections (WPA2/WPA3, SSL/TLS). Features include OTA updates, power-saving modes, and hosting a local web server, making it ideal for IoT devices, smart appliances, sensorsand camera-based systems.

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Ultrasonic sensor

An ultrasonic sensor is a device used to measure distance by sending out sound waves at a very high frequency (ultrasound) and listening for the echo that bounces back from an object. It has a transmitter that emits ultrasonic pulses and a receiver that detects the reflected signal. The time taken for the sound wave to return is used to calculate the distance between the sensor and the object. Ultrasonic sensors are commonly used in robots, vehicles for obstacle detection, water level monitoring, and automation systems because they are accurate, work in any lighting condition, and do not require physical contact with the object.

Battery

AccuPlus++ batteries are rechargeable power sources suitable for electronic devices and portable applications. Available in various chemistries like NiMH and sealed lead-acid, they provide stable output, support multiple charging cycles, and are economical and environmentally friendly. Commonly used in remote controls, sensors, emergency devices, and small automation projects, they offer durability, reusability and long service life.

ESP32-CAM

The ESP32-CAM is a compact, low-cost camera module featuring Wi-Fi/Bluetooth, an OV2640 camera, flash, and a micro SD card slot. It's used for IoT vision projects like home security and remote monitoring, supporting live video streaming over Wi-Fi in either Access Point or Station mode. While it has no built-in USB, it's programmed using an external USB-to-TTL converter. The module has dedicated pins for 5V power, GND, and programming (GPIO1/TX, GPIO3/RX, with GPIO0 needing to be LOW for code upload).

Power Supply

The **power supply distribution board** used in an electronic or robotic system to provide stable voltage levels to different components. The board receives power from a battery or DC input through the connector, and then regulates the voltage using onboard components such as voltage regulators and capacitors. It provides **12V, 5V, and 3.3V output terminals**, allowing different devices like motors, controllers, sensors, and modules to receive the correct voltage for safe operation. The red LED on the board acts as a **power indicator**, showing that the circuit is active and power is being supplied. Multiple output pins make it easy to connect and distribute power to different parts of the system, while the common ground ensures all modules share the same electrical reference. Overall, this power supply board plays an essential role in supplying and stabilizing power for the entire robotic circuit.

DC Motor

The DC motoris an electromechanical device that converts DC electrical energy into mechanical rotation, based on the principle that a current-carrying conductor in a magnetic field experiences a rotational force (Lorentz force). Its main components are the stationary stator (which produces the magnetic field) and the rotating rotor/armature, along with a commutator andbrushes that maintain continuous rotation by reversing the armature current's direction. DC motors are valued for providing precise speed control, high starting torque,andsmooth operation,making them common in applications like robotics, electric vehicles, and industrial machinery, and they come in types such as brushed, brushless (BLDC), shunt-wound, series wound, and permanent magnet motors.

Bluetooth

The HC-05 Bluetooth module is a popular, low-cost wireless communication device for embedded and IoT projects, using Bluetooth 2.0 and supporting both Master and Slave modes. It operates on 3.3V logic levels and communicates using UART (TX/RX pins), making it easy to interface with microcontrollers like Arduino or ESP32. It typically has an operating range of up to 10 meters and is widely used in robotics, wireless control systems, and home automation due to its reliability and ease of use. The VCC pin supplies power (3.3V to 5V input), GND is the ground connection, and the TXD pin transmits data from the HC-05 to the microcontroller's RX pin.

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DC Motor driver

A DC motor converts DC electrical energy into mechanical rotation based on the Lorentz force principle, where a current-carrying conductor in a magnetic field experiences a force. Key components include the stationary stator, the rotating rotor/armature, a commutator and brushes. DC motors are popular in applications like robotics and electric vehicles due to their precise speed control and high starting torque. A DC motor drive (like the L293D) is an electronic interface that regulates the voltage and current between the power supply and the motor, acting as a controlled power switch. It receives control signals from a microcontroller (e.g., Arduino, ESP32) and uses H-bridge circuits to control the motor's speed, direction, and torque. The drive also protects the motor and controller from electrical issues like high currents and voltage spikes.

Robotic Concrete Delivery

Robotic Concrete Delivery is a modern construction technology that uses automated robots to transport and pour concrete on-site. Instead of manual handling with wheelbarrows or buckets, robots carry concrete in built-in hoppers and deliver it precisely where needed. These robots contain microcontrollers, sensors, motors, and navigation systems that help them move smoothly and avoid obstacles. They can work autonomously or be controlled remotely, making them useful in narrow, hazardous, or hard-to-reach areas. The system ensures accurate concrete placement, reduces human effort, and improves safety. It also avoids material wastage and maintains consistent flow. By automating heavy tasks, this technology speeds up construction work. Overall, robotic concrete delivery supports smart and efficient building practices.

VIII. ADVANTAGES

- **Improves Road Safety:** Detects potholes early and prevents accidents, especially for two-wheelers.
- **Accurate Detection:** Uses sensors, cameras, and automation for precise pothole identification and location mapping.
- **Automation in Road Maintenance:** Robotic or automated filling systems can repair potholes without human labour, improving efficiency.
- **Reduces Traffic Disruptions:** Quick detection and repair reduces traffic jams caused by faulty roads.
- **Enhances Riding Comfort:** Smoother roads improve travel experience for drivers and passengers.

IX. LIMITATIONS

- **Limited coverage** – The kit can only detect and repair potholes where it physically moves; large road networks require multiple units.
- **Detection accuracy** – Ultrasonic sensors and cameras may struggle under poor lighting, rainor rough surfaces, causing false detections.
- **Concrete limitations** – The robotic delivery system may not fill large or deep potholes efficiently.
- **Speed and mobility** – Filling potholes is slower compared to manual or large-scale repair machinery.

X. CONCLUSION

The smart pothole detection and clearance system is an advanced approach designed to improve road quality and safety using modern technology. It continuously monitors road surfaces using sensors and automated mechanisms, allowing potholes to be detected early before they become serious hazards. Once a pothole is identified, the system can either alert the authorities or start an automatic repair process, ensuring quick and efficient maintenance. This reduces road accidents, vehicle damage, and traffic delays caused by uneven and damaged roads. By automating both detection and repair, the system reduces human effort and speeds up road maintenance activities. It is particularly useful for busy cities, highways, and remote areas where manual inspection is difficult. The solution also supports smart city initiatives by integrating data monitoring, communication technologies, and automated repair methods. In the future, this system can be enhanced with artificial intelligence, drones, and autonomous robots for fully automated road maintenance.

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XI. FUTURE SCOPE

The future scope of smart pothole detection and clearance systems is highly promising as road infrastructure continues to advance toward automation and smart city integration. With the development of artificial intelligence and machine learning, future systems will not only detect potholes but also predict where they are likely to form based on road condition data, traffic patterns, and weather conditions. Autonomous robots and drones can be deployed to continuously monitor roads and perform automatic repairs without human intervention, ensuring faster and more efficient maintenance. The system can be integrated with connected vehicle technology, where vehicles communicate road damage data in real-time and warn other drivers. As smart materials like self-healing concrete evolve, minor potholes may repair themselves, significantly reducing manual maintenance. In the long run, country-wide smart road networks can be developed, with cloud-based platforms and blockchain ensuring transparent reporting and maintenance records. Overall, this technology has the potential to transform road maintenance into a fully automated, intelligent, and cost-efficient system, ensuring safe, smooth, and pothole-free roads for the future.

REFERENCES

[1]. Pothole Detection: An efficient based vision-based method using RGB color space Image segmentation [2017] Authors: Amila Akagic, Emir Buza, Samir Omanovic J.

[2]. A Deep Learning-Based Approach for Road Pothole Detection in Timor Leste [2018] Authors: Vosco Pereira, Satoshi Tamura, Satoru Hayamizu, HidekazuFukai.

[3]. Road Pothole Detection System based on Stereo Vision [2018] Authors: Yaqi Li, Christos Papachristou, Daniel Weyer.

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