A PRELIMENERY REPORT ON

POTHOLE DETECTION AND FILLING ROBOT

BACHELOR OF ENGINEERING
(Electronics & Telecommunication Engineering)

SUBMITTED BY

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CERTIFICATE

This is to certify that the project report entitled

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This is a record of bonafide work carried out by them, under the guidance of Dr. D.O.Patil and is approved for partial fulfillment of the requirement for the award of the Final Year Bachelor of Engineering (Electronics & Telecommunication Engineering) of **Savitribai Phule Pune University** for academic year 2023-2024.

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CONTENT

ABSTRACT

Potholes can significantly reduce both driving and road efficiency. According to data from the Ministry of Road Transport and Highways (MoRTH), there were a total of 5,626 fatalities from road accidents caused by potholes in 2018, 2019, and 2020, totaling 2,015, 2,140, and 1,471, respectively. As many as 4,775 and 3,564 accidents were caused by potholes in 2019 and 2020,respectively. The creation of effective pothole maintenance methods has been the focus of numerous researchers and transportation specialists. What we need is a efficient , cost friendly and long lasting pothole filling machine which need less human effort. The goal of this project is to design and build a prototype for an automated road maintenance vehicle known as the Automatic pothole filling robot.

It can automatically find and repair potholes on road surfaces without human intervention operator support. A simple mechanical method for pothole detecting was developed. It helps to minimize the costs and complexity, which until now have been the main a drawback of autonomous road maintenance vehicles. Ultrasonic sensors are used to detect and measure the depth and width of the pothole. The robot will automatically fill the pothole.

CHAPTER 1
INTRODUCTION

INTRODUCTION

In today's modern world, road infrastructure plays a pivotal role in ensuring efficient transportation and connectivity. However, one persistent issue that plagues road networks worldwide is the presence of potholes. These depressions in the road surface not only pose a significant hazard to vehicles and pedestrians but also lead to increased maintenance costs and traffic congestion. Traditional methods of pothole detection and repair often rely on manual labor, which is not only time-consuming but also prone to inefficiencies and delays. In response to this challenge, the proposed project introduces an innovative solution: an Autonomous Pothole Detection and Filling Robot using ESP32 microcontrollers.

At its core, this project aims to leverage advancements in robotics and embedded systems to develop a sophisticated yet practical solution for identifying and repairing potholes autonomously. By integrating state-of-the-art sensors, actuators, and microcontrollers, the robot will be capable of scanning road surfaces in real-time, detecting potholes with precision, and promptly initiating the filling process. The utilization of ESP32 microcontrollers serves as the backbone of the robot's intelligence, enabling it to process sensor data, make informed decisions, and execute complex tasks autonomously.

The significance of this project extends beyond mere technological innovation; it addresses a pressing societal issue with far-reaching implications. Potholes not only endanger road users but also contribute to economic losses through vehicle damage and increased maintenance expenditure. By automating the detection and repair process, the proposed robot offers a cost-effective and efficient solution to mitigate these challenges. Furthermore, the use of ESP32 microcontrollers facilitates seamless communication and coordination, enabling the robot to operate autonomously while remaining responsive to changing road conditions and environmental factors.

The development of the Autonomous Pothole Detection and Filling Robot represents a multidisciplinary endeavor that combines elements of robotics, embedded systems, and civil engineering. From the design and fabrication of the robot's physical structure to the implementation of sophisticated algorithms for pothole detection and navigation, every aspect of the project demands careful consideration and expertise. Moreover, the project underscores the importance of collaboration between academia, industry, and government agencies in addressing critical infrastructure challenges and fostering innovation.

As the project progresses, it is essential to conduct thorough testing and evaluation to assess the robot's performance under various operating conditions. Real-world deployment trials will provide valuable insights into the robot's efficacy, durability, and scalability, ultimately paving the way for widespread adoption and integration into existing road maintenance frameworks. Additionally, continuous refinement and iteration based on feedback from stakeholders and end-users will be crucial to ensuring the long-term success and sustainability of the Autonomous Pothole Detection and Filling Robot.

In conclusion, the Autonomous Pothole Detection and Filling Robot project represents a groundbreaking initiative that harnesses cutting-edge technology to tackle a ubiquitous problem with significant societal impact. By combining advanced sensors, actuators, and ESP32 microcontrollers, the robot offers a promising solution for enhancing road safety, reducing maintenance costs, and improving overall transportation efficiency. As the project moves forward, it holds the potential to revolutionize road maintenance practices and pave the way for smarter, more resilient infrastructure systems in the future.

OBJECTIVES

1. **Automated Pothole Detection:** Develop a system capable of autonomously detecting potholes on road surfaces using sensors, such as ultrasonic sensors or cameras, to accurately identify areas of road damage.

2. **Precise Navigation:** Implement a navigation system that enables the robot to navigate to the location of detected potholes with precision and efficiency, ensuring safe traversal of roadways without causing disruptions to traffic flow.

3. **Efficient Pothole Repair:** Design a filling mechanism that can effectively repair potholes by depositing appropriate filling material (such as asphalt or concrete) into the damaged areas, ensuring durable and long-lasting repairs.

4. **ESP32 Microcontroller Integration:** Utilize the ESP32 microcontroller to control the robot's operations, including sensor interfacing, motor control, and communication with external devices or applications.

5. **Wireless Communication:** Establish wireless communication capabilities, allowing the robot to communicate with external devices or applications, such as mobile phones or computers, for remote monitoring and control.

6. **User-Friendly Interface:** Develop a user-friendly interface, such as a mobile application or web-based dashboard, to enable users to monitor the robot's activities, receive real-time updates, and control its operations remotely.

7. **Safety Features:** Incorporate safety features into the design to

ensure the safe operation of the robot, including obstacle detection systems, emergency stop mechanisms, and fail-safe protocols to prevent accidents or collisions.

8. **Energy Efficiency:** Optimize the robot's energy consumption and power management systems to maximize battery life and enable prolonged operation without the need for frequent recharging or replacement of batteries.

9. **Documentation and Reporting:** Provide comprehensive documentation, including technical specifications, schematics, code documentation, and user manuals, to facilitate replication, troubleshooting, and further development of the project.

10. **Scalability and Adaptability:** Design the robot with scalability and adaptability in mind, allowing for future enhancements, upgrades, or customization to suit specific use cases, environments, or requirements.

By achieving these objectives, the pothole detection and filling robot project aims to provide an efficient, cost-effective, and sustainable solution for addressing road maintenance challenges and improving the quality and safety of transportation infrastructure.

CHAPTER 2
LITERATURE SURVEY

LITERATURE SURVEY

Before starting this project, it is important to research existing machines and the technologies used in them. This will help us understand any existing problems and try to find solutions for these problems in such a way that it can be implemented in our project. Going through the literature also helps us understand the practical outcomes of the project and how to attain the required outcomes. [1] Nevertheless, vast developing markets, such as India, are yet to benefit adequately from such advances because certain specific concerns remain unaddressed. For example, in countries such as India, one often encounters secondary roads dotted with potholes, which can get filled with water during monsoon. Detecting potholes and estimating their depth, especially when water is filled with bare yes while driving at night or in low light conditions, places an undue burden on the driver. In this paper, we provide the theoretical underpinnings for filling this gap by proposing a laser-based system. Specifically, we present a physics-based geometric analysis of the problem and validate it experimentally (in a scaled-down setup). Several attempts have been made at addressing related concerns. For instance, the Pothole Patrol system proposed by Eriksson et al. uses accelerometer data and GPS sensors to identify potholes and other irregularities on the road surface
[2] Men propose a similar kind of pothole detection system that uses Android smartphones with accelerometers is et al. [3] Rode et al. use accelerometers and Wi-Fi-enabled vehicles for pothole detection and warning system. [4] Shonil developed an FPGA based image processing system for pothole detection [5] However, these frameworks have been developed generally with high-quality roads in view and are limited only to the detection of potholes. Hence itis imperative that such potholes are not only detected, but their depths are also estimated in both dry and water-filled conditions. In this backdrop, we propose a physics-based geometric approach for detection and depth estimation.

HYPOTHESIS

Rationale and Expectations:

1. **Reduction in Road Hazards:**
    - The hypothesis posits that by employing an autonomous robot equipped with advanced sensor technology, the detection of potholes and other road defects will be more accurate and timely compared to manual inspections.
    - The robot's ability to continuously patrol roadways and identify potholes promptly is expected to reduce the occurrence of road hazards, minimizing risks to vehicles, cyclists, and pedestrians.
2. **Optimized Maintenance Costs:**
    - The implementation of the pothole detection and filling robot is anticipated to result in cost savings for road maintenance operations.
    - By automating the detection and repair processes, the project aims to reduce labor costs associated with manual inspections and repairs. Additionally, the optimized use of materials and resources is expected to contribute to overall cost-effectiveness.
3. **Improved Infrastructure Quality:**
    - The timely detection and repair of potholes facilitated by the robot are expected to lead to improved infrastructure quality.
    - By addressing potholes promptly, the project aims to prevent further deterioration of road surfaces and extend the lifespan of the infrastructure. This contributes to smoother road conditions, reduced vehicle wear and tear, and enhanced overall infrastructure reliability.
4. **Enhanced Efficiency and Productivity:**
    - The hypothesis suggests that the autonomous nature of the robot will enhance efficiency and productivity in road maintenance operations.
    - By automating repetitive tasks such as pothole detection and repair, the project aims to free up human resources for more strategic and high-value activities, leading to improved productivity in maintenance operations.

5. **Safety and Public Satisfaction:**
    - Improved road conditions resulting from the project's implementation are expected to enhance road safety and public satisfaction.
    - Reduced risks of accidents and vehicle damage associated with potholes contribute to safer roadways, while the timely repair of road defects leads to increased public satisfaction with the quality of infrastructure and municipal services.
6. **Accuracy:**
    - The hypothesis posits that the integration of ultrasonic sensors for pothole detection will enhance accuracy compared to visual inspection methods. Ultrasonic sensors can provide precise distance measurements, allowing the robot to accurately identify potholes and their locations on road surfaces.
7. **Timeliness:**
    - The hypothesis proposes that the autonomous nature of the robot will enable timely detection and repair of potholes. By continuously monitoring road conditions and initiating repair actions as soon as potholes are detected, the robot is expected to prevent further deterioration of road surfaces and minimize the risk of accidents caused by road defects.
8. **Cost-effectiveness:**
    - The hypothesis suggests that the use of the pothole detection and filling robot will result in cost savings for road maintenance operations. By reducing the need for manual labor, minimizing material wastage, and optimizing repair processes, the robot is expected to offer a more cost-effective solution compared to traditional methods.
9. **Improved Road Safety:**
    - The hypothesis implies that the implementation of the robot will contribute to improved road safety by addressing potholes promptly. By repairing potholes in a timely manner, the robot is expected to reduce the risk of accidents, vehicle damage, and injuries associated with deteriorating road conditions.

PLAN OF ANALYSIS

Functional Testing:

Objective: Evaluate the operational functionality of the robot's components, including sensors, motors, microcontroller, and communication systems.

Methodology: Conduct a series of functional tests to verify the correct operation of each component individually and in conjunction with others. Use test scripts or scenarios to simulate typical operating conditions and assess the system's response and behavior.

Pothole Detection Accuracy:

Objective: Measure the accuracy and reliability of the robot's pothole detection capabilities under different road conditions and scenarios.

Methodology: Deploy the robot on test routes with known pothole locations and variations in road surface conditions. Compare the robot's detected potholes with ground truth data obtained through manual inspections or reference measurements. Calculate metrics such as detection rate, false positives/negatives, and detection distance to assess accuracy.

Navigation Precision:

Objective: Evaluate the precision and effectiveness of the robot's navigation system in reaching detected potholes with minimal deviation.

Methodology: Track the robot's trajectory using GPS or other navigation tracking systems during test runs to assess navigation accuracy. Measure deviations from the intended path and calculate metrics such as mean error distance and standard deviation to quantify navigation precision.

Pothole Repair Quality:

Objective: Assess the quality and effectiveness of pothole repairs performed by the robot, including the coverage and compaction of filling material.

Methodology: Inspect filled potholes visually or using imaging techniques to evaluate repair quality. Measure parameters such as filling material depth, uniformity, and adherence to surrounding road surface. Conduct compression tests or density measurements to assess compaction and durability of repairs.

Communication Reliability:

Objective: Evaluate the reliability and stability of wireless communication between the robot and external devices for remote monitoring and control.

Methodology: Monitor communication performance metrics such as packet loss, latency, and signal strength during test runs. Conduct stress tests and range tests to assess communication reliability under varying environmental conditions and distances.

Safety Mechanism Validation:

Objective: Validate the effectiveness of safety mechanisms and protocols implemented to prevent accidents and ensure safe operation.

Methodology: Execute test scenarios involving obstacles, emergency situations, or system failures to trigger safety mechanisms. Evaluate the system's response and effectiveness in mitigating risks, such as emergency stop activation, obstacle avoidance maneuvers, or fail-safe protocols.

User Feedback and Satisfaction:

Objective: Gather feedback from users, stakeholders, and field operators to assess satisfaction with the robot's performance and usability.

Methodology: Conduct surveys, interviews, or usability studies to collect qualitative and quantitative feedback on user experience, system reliability, and overall satisfaction. Analyze feedback to identify areas for improvement and refinement.

Data Analysis and Reporting:

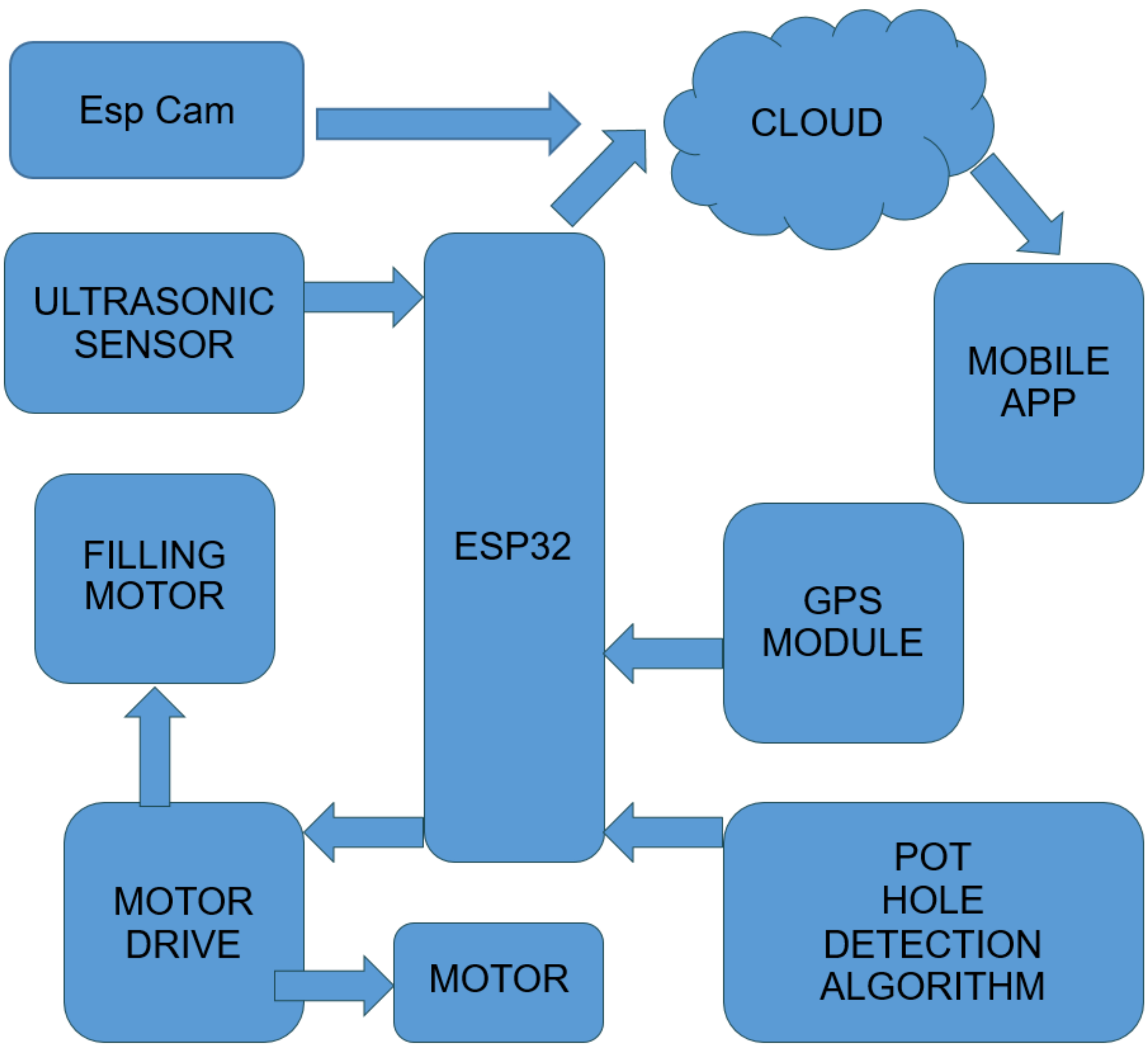
Objective: Compile and analyze collected data to generate insights, identify trends, and draw conclusions about the project's performance and outcomes.

Methodology: Use statistical analysis, data visualization techniques, and qualitative analysis methods to analyze test results, metrics, and user feedback. Prepare comprehensive reports summarizing findings, highlighting key insights, and providing recommendations for further development and optimization

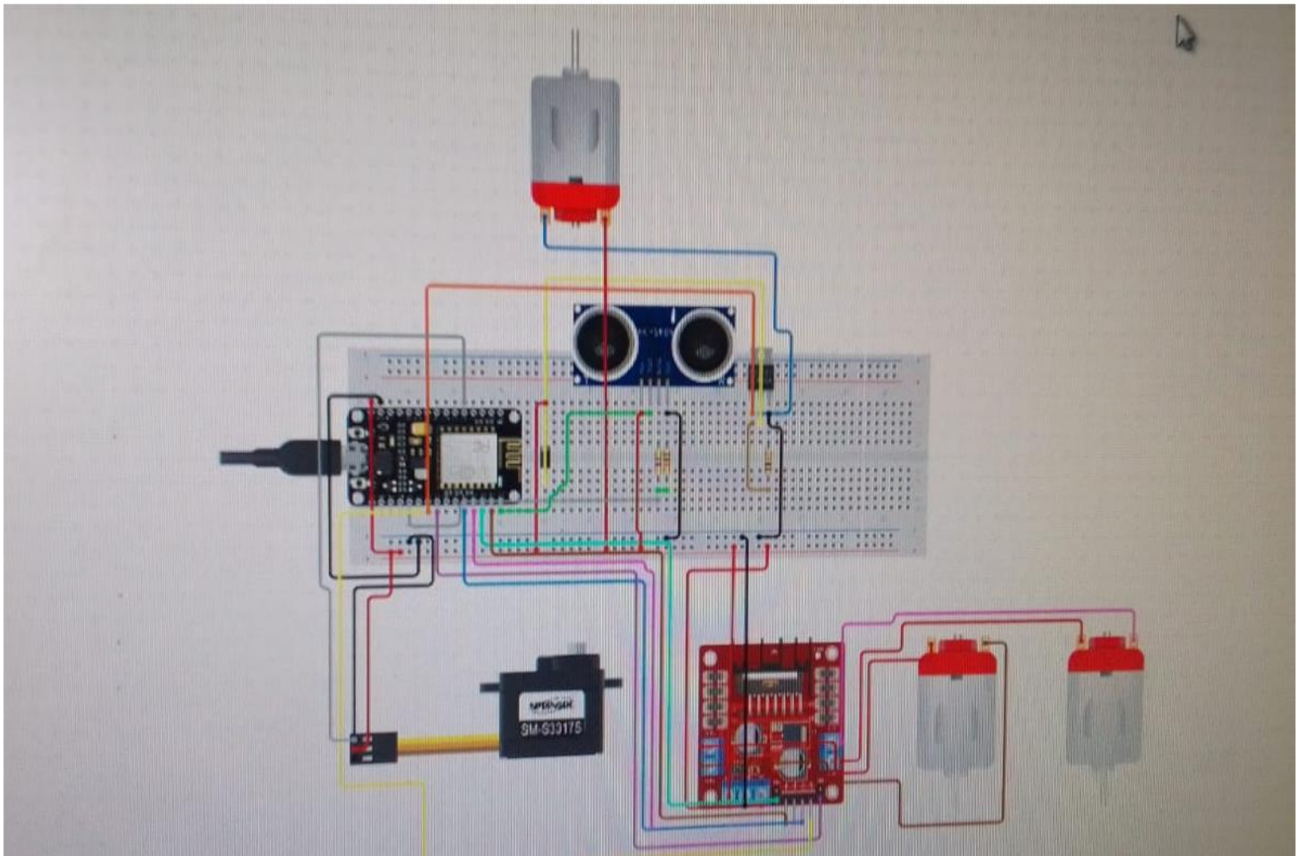
CHAPTER 3

DESIGN

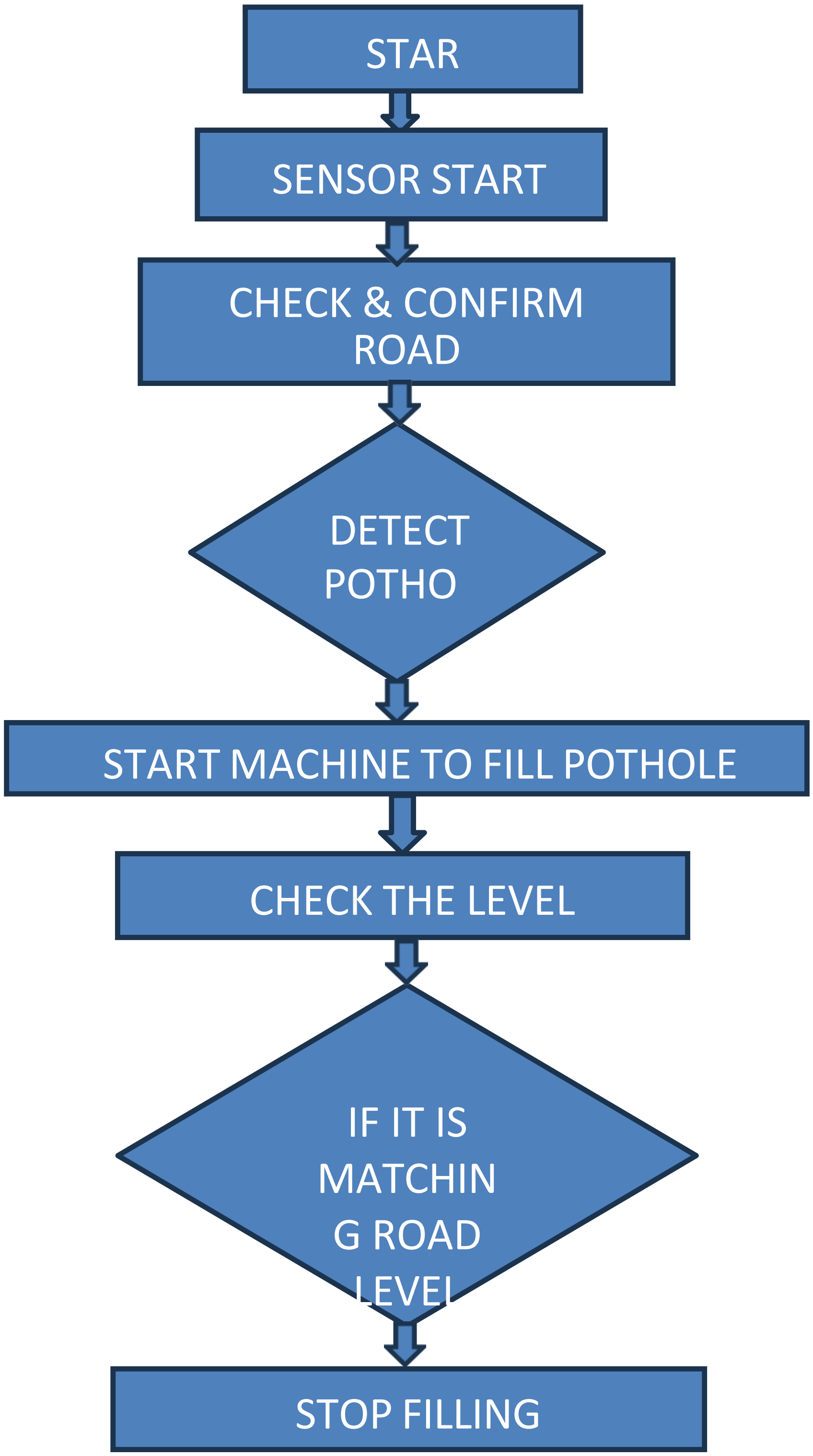
BLOCK DIAGRAM



CIRCUIT DIAGRAM



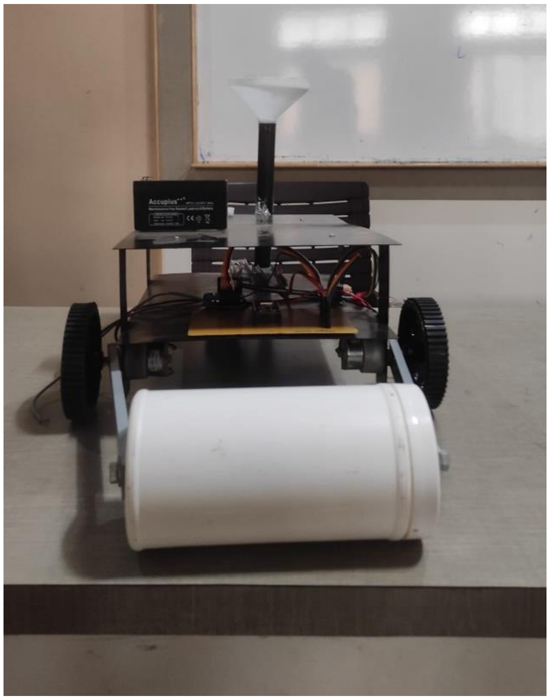
FLOWCHART

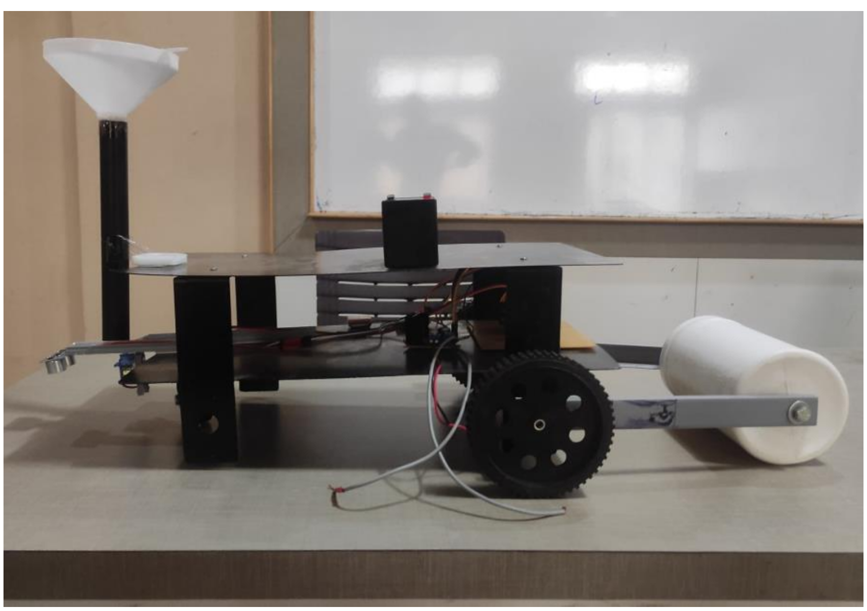

STAR
SENSOR START
CHECK & CONFIRM ROAD
DETECT POTHO
START MACHINE TO FILL POTHOLE
CHECK THE LEVEL
IF IT IS MATCHIN G ROAD LEVEL
STOP FILLING

Start

1. Initialize the system peripherals
2. Start the robot
3. Check the distance measured from Ultrasonic sensor
4. If distance goes high above reference level, then pothole is detected
5. Stop the robot
6. Servo motor starts
7. Cement starts dispensing
8. Robot moves forward and cement is rolled by roller attached to robot

Actual Model





CHAPTER 4
HARDWARE AND SOFTWARE

COMPONENTS

ESP32 Microcontroller:

The ESP32 microcontroller, developed by Espressif Systems, is a highly versatile and powerful system-on-chip (SoC) designed for a wide range of embedded applications. It features dual-core processing with a high clock speed, providing ample computational power for complex tasks. Additionally, the ESP32 comes equipped with built-in Wi-Fi and Bluetooth connectivity, enabling seamless communication with other devices and networks.

One of the key advantages of the ESP32 is its extensive set of GPIO pins, which allow for flexible interfacing with various sensors, actuators, and peripherals. This makes it an ideal choice for robotics projects where multiple components need to be controlled and coordinated. Furthermore, the ESP32 supports a variety of communication protocols such as SPI, I2C, UART, and CAN bus, facilitating interoperability with a wide range of external devices.

Programming the ESP32 is straightforward, with support for popular development environments such as Arduino IDE and MicroPython. This accessibility makes it suitable for both beginners and experienced developers alike. Moreover, the ESP32 boasts robust documentation and a large online community, providing ample resources and support for troubleshooting and development.

In the context of the pothole detection and filling robot project, the ESP32 serves as the central control unit, orchestrating the operation of all other components. It receives sensor data, processes it using algorithms for pothole detection, and coordinates the robot's movements and actions accordingly. Additionally, the ESP32 handles communication with external systems, such as a central monitoring station or a mobile app, enabling remote monitoring and control of the robot.

In summary, the ESP32 microcontroller offers a compelling combination of performance, connectivity, and ease of use, making it an ideal choice for a wide range of embedded applications, including robotics. Its versatility and capabilities empower developers to create innovative solutions that push the boundaries of what's possible in the world of IoT and robotics.

Ultrasonic Sensor:

Ultrasonic sensors are essential components in robotics and automation systems, providing a non-contact method for measuring distance and detecting objects. These sensors emit ultrasonic sound waves at frequencies above the audible range of humans and then measure the time it takes for the waves to bounce back after hitting an object. By analyzing the time delay, the sensor can determine the distance to the object with high accuracy.

In the context of the pothole detection and filling robot project, ultrasonic sensors play a critical role in identifying and locating potholes on the road surface. Mounted on the robot's chassis, these sensors continuously scan the area in front of the robot, monitoring the road surface for irregularities indicative of potholes. The sensor data is then processed by the microcontroller to detect and analyze potential potholes, allowing the robot to navigate around them or take appropriate action to fill them.

One of the key advantages of ultrasonic sensors is their versatility and reliability. They can operate effectively in various environmental conditions, including low light, dust, and humidity, making them suitable for outdoor applications such as road maintenance. Additionally, ultrasonic sensors offer fast response times and high precision, enabling real-time detection of objects and obstacles in the robot's path.

When integrating ultrasonic sensors into the robot's design, factors such as sensor placement, orientation, and calibration must be carefully considered to ensure optimal performance. Mounting multiple sensors at different angles can provide a broader field of view and improve detection accuracy. Moreover, filtering and signal processing techniques may be employed to enhance the sensor's performance and mitigate noise or interference from external sources.

In summary, ultrasonic sensors are indispensable components in the pothole detection and filling robot project, enabling accurate and reliable detection of potholes on the road surface. Their versatility, reliability, and precision make them ideal for applications requiring non-contact distance measurement and object detection in robotics and automation systems.

DC MOTOR :

Direct current (DC) motors are electromechanical devices that convert electrical energy into mechanical motion. They operate based on the principle of electromagnetic induction, where a magnetic field interacts with current-carrying conductors to produce rotational motion. DC motors consist of two main components: the stator and the rotor. The stator is the stationary part of the motor, typically composed of a series of permanent magnets or electromagnets arranged to create a magnetic field. The rotor, on the other hand, is the rotating part of the motor, usually consisting of a coil of wire (armature) mounted on a shaft. When an electrical current is applied to the armature, it generates a magnetic field that interacts with the magnetic field produced by the stator, resulting in a torque that causes the rotor to rotate. DC motors are commonly classified into two types: brushed and brushless. Brushed DC motors feature brushes and a commutator mechanism that transfers electrical power to the armature, causing it to rotate. In contrast, brushless DC motors use electronic commutation to control the direction and speed of rotation, eliminating the need for brushes and resulting in smoother operation and reduced maintenance requirements. DC motors find widespread use in various applications, including automotive systems, industrial machinery, robotics, and consumer electronics, due to their simplicity, reliability, and controllability. They are favored for their ability to provide precise speed and torque control, making them suitable for tasks requiring accurate motion control. However, DC motors may exhibit drawbacks such as limited efficiency, susceptibility to wear and tear (particularly in brushed motors), and electromagnetic interference. Nevertheless, ongoing advancements in motor design, materials, and control technologies continue to improve the performance and efficiency of DC motors, further expanding their range of applications in diverse industries.

Filling System:

The filling system is a crucial component of the pothole detection and repair robot, responsible for efficiently depositing filling material, such as asphalt or concrete, into potholes identified by the robot's sensors. Its primary mechanism typically comprises a dispensing system, storage container for filling material, and an actuator for controlled deposition. When the robot detects a pothole, the filling system is engaged, and the actuator precisely dispenses the filling material into the pothole to ensure uniform coverage and compaction for effective repair. The system may include sensors or feedback mechanisms to monitor the filling process, ensuring quality and consistency. Design considerations encompass material compatibility, precision, reliability, and integration with the robot's control system. Such systems find applications in road maintenance, infrastructure projects, urban development, and emergency response, with future developments focusing on smart functionality, advanced materials, and remote monitoring capabilities.

ESP32-CAM:

The ESP32-CAM is a compact module that integrates an ESP32 chip and a camera. It enables IoT applications with image capturing and processing capabilities. It supports Wi-Fi and Bluetooth connectivity, making it suitable for remote monitoring and control systems. The OV2640 camera sensor provides 2MP resolution for capturing images. It can stream video over Wi-Fi, allowing real-time surveillance applications. The module has GPIO pins for connecting various sensors and peripherals. It can be programmed using the Arduino IDE or ESP-IDF framework. Its low power consumption makes it suitable for battery-powered applications. The ESP32-CAM is commonly used in projects such as home security cameras and wildlife monitoring systems. It offers flexibility and ease of use for implementing camera-based IoT solutions.

Motor Driver:

The motor driver plays a vital role in controlling the speed and direction of DC motors in the pothole detection and repair robot. It employs an H-bridge configuration to manage the flow of current through the motor windings, allowing bidirectional control. Pulse Width Modulation (PWM) signals regulate motor speed by adjusting the duty cycle of the PWM waveform. Motor drivers come in various types, including integrated and modular versions tailored for brushed and brushless DC motors. These drivers enable precise and efficient motor control, essential for the robot's movement and functionality. Operating principles involve toggling the state of H-bridge transistors to change the motor's direction and adjusting PWM signals for speed control. Design considerations encompass compatibility, efficiency, reliability, and integration with the robot's control system. Motor drivers find applications in robotics, automation, drones, RC vehicles, and industrial systems, with advancements focusing on enhanced performance, efficiency, and integration capabilities.

GPS Module:

The GPS module serves as a critical component within the pothole detection and repair robot, providing precise location data essential for navigation and geospatial mapping. Utilizing a network of satellites orbiting the Earth, the GPS module receives signals to triangulate the robot's position accurately. This information enables the robot to determine its coordinates, altitude, and speed, facilitating efficient navigation along predefined routes and aiding in the identification and recording of pothole locations. The GPS module typically comprises a receiver unit, antenna, and associated circuitry for signal processing and data interpretation. Operating on the Global Positioning System (GPS), Glonass, or Galileo satellite networks, the module communicates with the robot's microcontroller to integrate location data into its decision-making algorithms. Design considerations encompass sensitivity, accuracy, acquisition time, and power consumption. Applications of GPS modules extend beyond navigation to include geotagging, asset tracking, precision agriculture, and outdoor recreation. Future developments focus on improved accuracy, multi-constellation support, and enhanced integration with other sensor systems for comprehensive situational

SOFTWARE USED

Blynk App:

The Blynk app revolutionizes the way users interact with their Internet of Things (IoT) devices, offering a seamless and intuitive platform for remote control and monitoring. Its user-friendly interface allows for effortless customization of IoT projects, enabling users to create virtual interfaces tailored to their specific needs. With drag-and-drop functionality, designing interfaces for controlling sensors, toggling switches, and receiving real-time data updates becomes incredibly straightforward. Blynk supports a diverse range of hardware platforms, from Arduino to Raspberry Pi, ensuring compatibility with various IoT setups. Moreover, the app provides comprehensive analytics, empowering users to track device performance and usage patterns effectively. Blynk's extensive library of widgets offers endless possibilities for creativity, allowing users to build unique and innovative IoT applications. Facilitating communication between devices through its cloud-based infrastructure, Blynk ensures seamless connectivity and interaction. Robust security measures are also in place to safeguard data privacy and protect against unauthorized access. Whether for hobbyists exploring IoT projects or professionals implementing sophisticated IoT solutions, Blynk simplifies the journey into the world of connected devices, making IoT accessible and enjoyable for users of all levels of expertise.

Arduino IDE:

The Arduino Integrated Development Environment (IDE) serves as the cornerstone for enthusiasts and professionals alike in creating interactive electronic projects. Its user-friendly interface facilitates the programming of Arduino microcontrollers with ease, enabling users to write, compile, and upload code seamlessly. With a simple and intuitive layout, the IDE caters to both beginners and experienced developers, offering a range of features such as syntax highlighting, automatic code indentation, and a vast library of example sketches. The Arduino IDE supports a wide array of Arduino boards, shields, and third-party hardware, ensuring versatility in project development. Furthermore, its compatibility with multiple operating systems including Windows, macOS, and Linux enhances accessibility for a diverse community of users. Whether tinkering with basic circuits or designing complex systems, the Arduino IDE empowers individuals to bring their ideas to life in the realm of electronics and robotics.

CHAPTER 5
WORKING

METHODOLOGY

Potholes represent a ubiquitous road hazard, posing risks to both vehicles and pedestrians. Conventional methods of pothole detection and repair are often labor-intensive and time-consuming, relying on manual inspection and maintenance processes. In response to this challenge, the development of an automated pothole detection and filling robot using ESP32 technology is proposed. The primary objective of this project is to create a robotic system capable of autonomously identifying potholes on road surfaces, navigating to their location, and repairing them using a filling mechanism. The integration of ESP32 microcontroller technology facilitates wireless communication, sensor interfacing, and control logic implementation, while ultrasonic sensors enable accurate distance measurement for pothole detection. Additionally, the incorporation of a motor driver allows for precise control of DC motors used for navigation, and the integration of a filling system automates the repair process. The Blynk app serves as a user-friendly interface for remote control and monitoring of the robot's operations, enhancing user accessibility and convenience.

The planning phase of the project involves defining clear objectives, scope, and requirements. This includes identifying the key functionalities of the robot, such as pothole detection, navigation, filling mechanism operation, and remote control capabilities. A detailed project plan is developed, outlining the timeline, budget, and resource allocations for each stage of the project. Additionally, the necessary hardware and software components are specified, including the ESP32 microcontroller, ultrasonic sensor, DC motors, motor driver, filling system, and Blynk app. Clear project goals, deliverables, and success criteria are established to guide the development process effectively.

Following the planning phase, the design phase focuses on creating detailed schematics and diagrams for the robot's hardware and software architecture. This involves designing the physical layout of the robot, specifying the connections between components, and developing algorithms for pothole detection, navigation, and filling operations. The hardware design encompasses the selection and integration of components, such as mounting the ESP32 microcontroller, ultrasonic sensor, DC motors, and motor driver on a suitable chassis. The software design involves developing code for sensor interfacing, motor control, communication with the Blynk app, and integration of the filling mechanism. Additionally, the user interface and functionality of the Blynk app are designed, outlining the control commands and data exchange protocols between the app and the robot.

With the design finalized, the project progresses to the implementation phase, where hardware and software components are assembled and programmed. The ESP32 microcontroller is programmed using the Arduino IDE or PlatformIO, with code developed to interface with sensors, control motors, and communicate with the Blynk app. Hardware components are connected according to the schematics, with attention to wiring, soldering, and mounting for stability and reliability. The filling mechanism is integrated, with suitable actuators and dispensing mechanisms employed for pothole repair operations. Integration testing is conducted iteratively to validate individual components and ensure compatibility and functionality across the system.

Testing plays a crucial role in verifying the performance and reliability of the robot. Functional testing is conducted to validate pothole detection, navigation accuracy, filling mechanism operation, and remote control functionality through the Blynk app. Additionally, stress testing is performed to assess the robot's performance under various environmental conditions, such as different road surfaces, lighting conditions, and weather conditions. Any issues or discrepancies identified during testing are addressed through optimization techniques, including code refactoring, parameter tuning, and hardware adjustments.

Documentation is essential for capturing the project's design, implementation, and testing processes. This includes creating detailed technical documents, such as system architecture diagrams, circuit schematics, code documentation, and user manuals. Additionally, a project report is compiled, summarizing the objectives, methodologies, results, and conclusions of the project. Visual aids, such as photographs, videos, and demonstration recordings, are incorporated to enhance understanding and showcase the robot's capabilities. The documentation serves as a valuable resource for future reference, replication, and dissemination of the project's findings.

WORKING

The pothole detection and filling robot's operation involves several sequential steps, starting from the detection of potholes to the automated repair process. Here's a detailed description of the working of the project:

1. Pothole Detection:

The process begins with the robot's ultrasonic sensor scanning the road surface to detect irregularities, such as potholes. The ultrasonic sensor emits high-frequency sound waves and measures the time it takes for the waves to bounce back after hitting an obstacle. By calculating the time delay, the sensor determines the distance to the detected object. When a significant deviation in distance is detected, indicating the presence of a pothole, the robot's control system triggers further action.

2. Navigation to Pothole Location:

Upon detecting a pothole, the robot's control system initiates navigation towards its location. This involves using the ESP32 microcontroller to control the DC motors through the motor driver. The motor driver receives commands from the microcontroller to adjust the speed and direction of the motors, enabling the robot to navigate autonomously towards the detected pothole. The navigation algorithm may involve obstacle avoidance techniques to ensure safe traversal to the pothole location.

3. Pothole Verification and Repair Preparation:

As the robot approaches the detected pothole, it verifies the presence and severity of the pothole using additional sensors or confirmation algorithms. Once confirmed, the robot prepares for the repair process by aligning itself appropriately for filling the pothole. This may involve stopping near the pothole, adjusting the position of the filling mechanism, and ensuring proper alignment for accurate filling.

4. Pothole Repair Process:

With the robot in position, the filling mechanism is activated to initiate the repair process. The filling mechanism, which may include a dispensing system and actuator, deposits the appropriate filling material (such as asphalt or concrete) into the pothole. The actuator, controlled by the ESP32 microcontroller, regulates the flow and placement of the filling material to ensure uniform coverage and compaction. The robot's control system monitors the filling process, adjusting parameters as needed to optimize repair quality and efficiency.

5. Quality Assurance and Completion:

After filling the pothole, the robot conducts a quality assurance check to verify the completeness and effectiveness of the repair. This may involve sensor feedback or visual inspection to ensure that the pothole has been adequately filled and leveled. Once the repair is deemed satisfactory, the robot may proceed to the next pothole detection and repair cycle or return to a designated location for maintenance or standby.

6. Communication with Blynk App:

Throughout the operation, the robot communicates its status and progress to the Blynk app via wireless connectivity. The Blynk app provides a user-friendly interface for remote monitoring and control of the robot's operations. Users can view real-time data, receive status updates, and send commands to the robot, such as initiating or pausing the pothole detection and repair process. This bidirectional communication enhances user interaction and enables efficient management of the robot's activities.

7. Power Management and Safety Features:

The robot's power management system ensures efficient utilization of energy resources, prolonging battery life and enabling extended operation. Safety features, such as emergency stop mechanisms and obstacle detection algorithms, are integrated to prevent accidents and ensure safe operation in various environments. Additionally, the robot's control system incorporates error handling routines to address unexpected situations and maintain system integrity.

In summary, the pothole detection and filling robot's operation involve a systematic process of detecting potholes, navigating to their locations, conducting repairs, and communicating with the user via the Blynk app. Through the integration of ESP32 microcontroller technology, ultrasonic sensors, and automated control mechanisms, the robot provides an efficient and effective solution for addressing road maintenance challenges and enhancing infrastructure quality

CODE

```
 #define BLYNK_TEMPLATE_ID "TMPL3rKv1VYTW"
#define BLYNK_TEMPLATE_NAME "Pothole detection Robot 186"
#define BLYNK_AUTH_TOKEN "MOtOIE848X-npHvjP9ju5MEDKEhpN-Ow"

#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

#include <Servo.h>

Servo servo;

//Motor PINs
#define ENA D0
#define IN1 D1
#define IN2 D2
#define IN3 D3
#define IN4 D4
#define ENB D5


bool forward = 0;
bool backward = 0;
bool left = 0;
bool right = 0;
int Speed;

char auth[] = "MOtOIE848X-npHvjP9ju5MEDKEhpN-Ow"; //Enter your Blynk application auth
token
char ssid[] = "PotholeDetection"; //Enter your WIFI name
char pass[] = "1234567890"; //Enter your WIFI passowrd

const int trigPin = 12;          //D6
const int echoPin = 13;           //D7

//define sound velocity in cm/uS
#define SOUND_VELOCITY 0.034
#define CM_TO_INCH 0.393701

long duration;
float distanceCm;
```

```
float distanceInch;

void setup() {
  Serial.begin(9600);
  pinMode(ENA, OUTPUT);
  pinMode(IN1, OUTPUT);
  pinMode(IN2, OUTPUT);
  pinMode(IN3, OUTPUT);
  pinMode(IN4, OUTPUT);
  pinMode(ENB, OUTPUT);
  Blynk.begin(auth, ssid, pass);
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  servo.attach(15); //D8
  servo.write(0);
  delay(2000);
}

BLYNK_WRITE(V0) {
  forward = param.asInt();
}

BLYNK_WRITE(V1) {
  backward = param.asInt();
}

BLYNK_WRITE(V2) {
  right = param.asInt();
}

BLYNK_WRITE(V3) {
  left = param.asInt();
}

BLYNK_WRITE(V4) {
  Speed = param.asInt();
}

void smartcar() {
  if (forward == 1) {
      carforward();
      Serial.println("carforward");
  } else if (backward == 1) {
      carbackward();
      Serial.println("carbackward");
  } else if (left == 1) {
```

```
    carturnleft();
    Serial.println("carfleft");
  } else if (right == 1) {
    carturnright();
    Serial.println("carright");
  } else if (forward == 0 && backward == 0 && left == 0 && right == 0) {
    carStop();
    Serial.println("carstop");
  }
}
void loop() {

  // Clears the trigPin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin on HIGH state for 10 micro seconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);

  // Calculate the distance
  distanceCm = duration * SOUND_VELOCITY/2;

  // Convert to inches
  distanceInch = distanceCm * CM_TO_INCH;

  // Prints the distance on the Serial Monitor
  Serial.print("Distance (cm): ");
  Serial.println(distanceCm);
  Serial.print("Distance (inch): ");
  Serial.println(distanceInch);
   if(distanceCm >= 8){
      Serial.println(" pothole");
      servo.write(0);               //chk
      delay(5000);
      servo.write(90);               //chk
     // delay(2000);
   }
  Blynk.run();
  smartcar();
}

void carforward() {
```

```
  analogWrite(ENA, Speed);
  analogWrite(ENB, Speed);
  digitalWrite(IN1, HIGH);
  digitalWrite(IN2, LOW);
  digitalWrite(IN3, HIGH);
  digitalWrite(IN4, LOW);
}
void carbackward() {
    analogWrite(ENA, Speed);
    analogWrite(ENB, Speed);
    digitalWrite(IN1, LOW);
    digitalWrite(IN2, HIGH);
    digitalWrite(IN3, LOW);
    digitalWrite(IN4, HIGH);
}
void carturnleft() {

    analogWrite(ENA, Speed);
    analogWrite(ENB, Speed);
    digitalWrite(IN1, HIGH);
    digitalWrite(IN2, LOW);
    digitalWrite(IN3, LOW);
    digitalWrite(IN4, HIGH);
}
void carturnright() {
    analogWrite(ENA, Speed);
    analogWrite(ENB, Speed);
    digitalWrite(IN1, LOW);
    digitalWrite(IN2, HIGH);
    digitalWrite(IN3, HIGH);
    digitalWrite(IN4, LOW);
}
void carStop() {
 digitalWrite(IN1, LOW);
 digitalWrite(IN2, LOW);
 digitalWrite(IN3, LOW);
 digitalWrite(IN4, LOW);
}
```

CHAPTER 6
ADVANTAGES AND LIMITATIONS

KEY FEATURES:

Key features of the pothole detection and filling robot project include:

1. Autonomous Operation: The robot operates autonomously, detecting potholes, navigating to their locations, and repairing them without human intervention.

2. Pothole Detection: Utilizes ultrasonic sensors to accurately detect potholes on road surfaces.

3. Navigation System: Incorporates DC motors and motor drivers for precise navigation towards detected potholes.

4. Filling Mechanism: Features a filling system with an actuator to deposit filling material (such as asphalt or concrete) into potholes.

5. ESP32 Microcontroller: Controls the robot's operations, including sensor interfacing, motor control, and communication with the Blynk app.

6. Blynk App Integration: Enables remote monitoring and control of the robot's operations via a user-friendly mobile application.

7. Wireless Communication: Communicates real-time data and status updates between the robot and the Blynk app wirelessly.

8. Safety Features: Includes safety mechanisms such as obstacle detection and emergency stop functionalities to ensure safe operation.

9. Power Management: Implements power-efficient operation to optimize battery life and enable extended usage.

10. Quality Assurance:* Conducts quality checks to ensure effective and uniform pothole repair.

11. Documentation: Provides comprehensive documentation, including technical specifications, schematics, code documentation, and user manuals.

12. Scalability: Designed for scalability, allowing for potential enhancements and upgrades in the future

ADVANTAGES

The pothole detection and filling robot project offers several advantages:

1. **Improved Road Safety:** By autonomously detecting and repairing potholes, the robot contributes to enhancing road safety by reducing the risk of accidents caused by damaged road surfaces.
2. **Efficient Maintenance:** The automated nature of the robot's operation allows for efficient and timely maintenance of roads, ensuring that potholes are detected and repaired promptly, preventing them from worsening and extending the lifespan of road infrastructure.
3. **Cost Savings:** Traditional methods of pothole detection and repair often involve labor-intensive processes and frequent manual inspections. The robot's automation capabilities help save on labor costs and minimize the need for manual intervention, leading to overall cost savings in road maintenance.
4. **Minimized Traffic Disruption:** Pothole repair activities can cause traffic disruptions and inconvenience to road users. The robot's ability to autonomously perform repairs reduces the time and resources required for manual repair operations, minimizing disruptions and enhancing traffic flow.
5. **Increased Efficiency:** With its autonomous operation and precise navigation capabilities, the robot can efficiently cover large areas of road networks, systematically detecting and repairing potholes without the need for human intervention.
6. **Enhanced Accuracy:** The use of sensors and control algorithms ensures accurate detection of potholes and precise placement of filling material, resulting in effective repairs and improved road surface quality.
7. **Remote Monitoring and Control:** Integration with the Blynk app enables remote monitoring and control of the robot's operations, providing real-time data and status updates to users, thereby enhancing transparency and accountability in road maintenance activities.
8. **Adaptability:** The project's modular design and scalability allow for flexibility in adapting to different road conditions and environments.

Additionally, it provides the potential for future enhancements and upgrades to further improve performance and functionality.

9. **Environmental Benefits:** By facilitating timely pothole repairs and reducing the need for repeated maintenance activities, the project contributes to minimizing environmental impacts associated with road construction and repair processes.
10. **Promotion of Smart Infrastructure:** The implementation of innovative technologies such as ESP32 microcontroller, ultrasonic sensors, and wireless communication systems promotes the development of smart infrastructure solutions for efficient and sustainable urban development.

Overall, the pothole detection and filling robot project offers a comprehensive solution to address road maintenance challenges, providing benefits in terms of safety, efficiency, cost savings, and environmental sustainability.

LIMITATIONS

1. **Sensor Limitations:**

    - The accuracy and reliability of pothole detection heavily depend on sensor performance. Ultrasonic sensors may struggle with certain road surface materials or environmental conditions, such as wet or uneven surfaces, leading to false positives or missed detections.
    - Limited sensor range may restrict the robot's ability to detect potholes in advance, particularly at higher speeds or on roads with long-range visibility.

2. **Navigation Challenges:**

    - Navigation accuracy may be affected by factors such as GPS signal interference, urban canyons, or densely populated areas with tall buildings that obstruct satellite signals.
    - The robot's ability to navigate complex road networks, including intersections, roundabouts, and multi-lane highways, may be limited by its programming and decision-making algorithms.

3. **Filling Mechanism Constraints:**

    - The effectiveness of the filling mechanism depends on the type and quality of filling material used. Certain materials may be unsuitable for certain road conditions or climates, leading to suboptimal repairs.
    - The robot's filling mechanism may have limitations in reaching potholes located in narrow or inaccessible areas, such as between parked vehicles or along roadside obstacles.

4. **Communication Reliability:**

- Wireless communication between the robot and external devices, such as the Blynk app, may experience connectivity issues or signal interference, particularly in areas with high electromagnetic interference or limited network coverage.
- Latency or delays in communication may impact the responsiveness of remote monitoring and control functions, affecting real-time decision-making and intervention capabilities.

5. **Safety Concerns:**

- Despite safety mechanisms and protocols, the robot may encounter unpredictable hazards or obstacles that pose risks to itself and other road users. Failures in safety systems or unexpected environmental conditions could lead to accidents or collisions.
- Limited situational awareness and decision-making capabilities may prevent the robot from effectively anticipating and responding to dynamic or rapidly changing traffic conditions.

6. **Energy and Battery Life:**

- Energy consumption and battery life are critical factors, especially for autonomous operation. The robot's range and operational duration may be limited by battery capacity and charging requirements, necessitating frequent recharging or battery swaps.
- Extended operation in harsh environmental conditions, such as extreme temperatures or inclement weather, may further reduce battery life and performance.

7. **Maintenance and Reliability:**

- The complexity of the robot's systems and components may increase the need for regular maintenance and servicing to ensure optimal performance and reliability.

- Mechanical wear and tear, sensor degradation, or software bugs could lead to system malfunctions or failures over time, requiring troubleshooting and repairs.

8. Regulatory and Legal Considerations:

- Compliance with regulations and standards governing autonomous vehicles and road maintenance equipment may pose challenges, particularly in terms of safety certifications, liability, and insurance requirements.
- Legal issues related to liability in the event of accidents or property damage involving the robot may need to be addressed to ensure legal compliance and risk mitigation.

Despite these limitations, addressing them through continuous refinement, testing, and iteration can help enhance the performance, reliability, and safety of the pothole detection and filling robot project, making it a more viable and effective solution for road maintenance in the future.

CHAPTER 7

APPLICATIONS

APPLICATIONS

The application of the pothole detection and filling robot project extends to various sectors and scenarios, each benefiting from its capabilities in distinct ways:

1. **Urban Infrastructure Maintenance:** In urban areas, where road networks are extensive and heavily used, the robot can play a significant role in maintaining road infrastructure. It can autonomously patrol city streets, detect potholes, and perform repairs efficiently. This reduces the burden on municipal maintenance crews, ensuring that roads remain safe and well-maintained for residents and commuters.
2. **Highway Maintenance:** On highways and expressways, where high-speed traffic increases the risk associated with potholes, the robot can be deployed for routine inspections and repairs. Its ability to autonomously navigate and conduct repairs minimizes the need for manual intervention, reducing the risk to maintenance personnel and ensuring uninterrupted traffic flow.
3. **Rural Road Maintenance:** In rural areas with less frequent maintenance schedules, potholes and road damage can pose significant challenges to transportation. The robot can be deployed to patrol rural roads, detecting and repairing potholes efficiently. This helps improve connectivity, safety, and accessibility in rural communities.
4. **Construction Sites:** Construction sites often experience heavy vehicle traffic, leading to rapid wear and tear of temporary roads and access routes. The robot can be deployed on construction sites to identify and repair potholes, ensuring smooth and safe transportation for workers and equipment.
5. **Emergency Response:** Following natural disasters or emergencies such as earthquakes or floods, road infrastructure may be severely damaged, leading to hazardous conditions for rescue and relief efforts. The robot can be deployed in emergency response scenarios to quickly identify and repair potholes, facilitating access for emergency vehicles and personnel.

6. **Military Applications:** Military installations, training grounds, and deployment areas require well-maintained roads for logistical operations. The robot can be used by military personnel to patrol and maintain roads within military facilities, ensuring operational readiness and safety for personnel and equipment.
7. **Airport Runway Maintenance:** Runway surfaces at airports must be kept in optimal condition to ensure safe aircraft operations. The robot can be deployed at airports to conduct routine inspections and repairs of runway surfaces, enhancing safety and reducing the risk of damage to aircraft during takeoff and landing.
8. **Smart Cities Initiatives:** As part of smart cities initiatives, the deployment of autonomous robots for infrastructure maintenance aligns with the goal of leveraging technology to improve urban living. The robot contributes to sustainable urban development by optimizing maintenance processes, reducing environmental impact, and enhancing the overall quality of infrastructure.

In summary, the application of the pothole detection and filling robot project extends across various sectors and scenarios, offering benefits in terms of safety, efficiency, and sustainability in road maintenance and infrastructure management.

CHAPTER 8
FUTURE SCOPE

FUTURE SCOPE

The pothole detection and filling robot project has a wide range of future possibilities and potential advancements, paving the way for innovative solutions in road maintenance and infrastructure management. Some of the key areas for future development and expansion include:

1. **Advanced Sensor Technologies:** Integration of advanced sensor technologies such as LiDAR, infrared sensors, or high-resolution cameras can enhance the robot's ability to detect and characterize road defects with higher accuracy and precision. These sensors can provide detailed data about road conditions, enabling the robot to identify not only potholes but also cracks, rutting, and other surface irregularities.

2. **Machine Learning and Artificial Intelligence:** Incorporating machine learning algorithms can enable the robot to learn and adapt its behavior based on real-world data and feedback. By analyzing patterns and trends in road damage, the robot can improve its pothole detection capabilities and optimize repair strategies for different road surfaces and environments.

3. **Automated Repair Techniques:** Future iterations of the robot may include advanced repair techniques such as automated patching or 3D printing of road materials. These techniques can streamline the repair process, reduce material waste, and improve the longevity and durability of repairs, leading to more sustainable and cost-effective road maintenance practices.

4. **Integration with Smart City Infrastructure:** Integration with smart city infrastructure systems such as traffic management systems, road monitoring networks, and data analytics platforms can enhance the efficiency and effectiveness of the robot's operations. Real-time data exchange and collaboration between the robot and other infrastructure

components can enable proactive maintenance and optimize traffic flow on roadways.

5. **Energy-Efficient and Sustainable Design: Future** developments may focus on optimizing the robot's energy consumption and environmental footprint. This can involve incorporating renewable energy sources such as solar panels or energy-efficient components to minimize the robot's reliance on fossil fuels and reduce its carbon footprint during operation.

6. **Global Deployment and Adaptation:** The project can be adapted for deployment in various geographical regions with diverse road conditions and infrastructure requirements. Customization options may include adjustments to sensor configurations, repair materials, and navigation algorithms to suit specific local contexts and challenges.

7. **Public-Private Partnerships and Collaborations:** Collaboration with government agencies, transportation authorities, and private sector stakeholders can accelerate the adoption and deployment of the technology. Public-private partnerships can facilitate pilot projects, funding opportunities, and regulatory support for widespread implementation of the pothole detection and filling robot.

In conclusion, the future scope of the project is vast and promising, with opportunities for continued innovation, collaboration, and adaptation to address evolving challenges in road maintenance and infrastructure management. By leveraging emerging technologies and stakeholder partnerships, the project has the potential to revolutionize the way potholes are detected and repaired, leading to safer, smoother, and more sustainable roadways for communities worldwide.

CHAPTER 9
CONCLUSION

CONCLUSION

In conclusion, the pothole detection and filling robot project demonstrates the potential of autonomous robotics in revolutionizing road maintenance practices. Through innovation, collaboration, and continued refinement, the project has the capacity to make a significant and lasting impact on road safety, efficiency, and sustainability, ultimately improving the quality of transportation infrastructure for communities worldwide.

CHAPTER 10
REFERENCE

REFERENCE

- AUTOMATIC DETECTION AND FILLING OF POTHOLES Boopathi D*1, Gagana BP*2, Girish S Tevari*3, Kiran M*4, Mr. Channappa Gowda D V*5 *1,2,3,4Student, Department of Information Science and Engineering The Oxford College of Engineering, India. 05/May-2023

- POT-HOLE DETECTION AND CLEARANCE ROBOT Ripal Patel*1, Devayya*2, H. Lallawmawma*3, Harsha KG*4, Suraj P*5 *1Assistant Professor, Department Of Electronics And Communication Engineering Dr. Ambedkar Institute Of Technology, Bengaluru-560056, India. 07/July-2022

- Automatic Detection, Estimation and Filling of Pothole Vadiraj.R.S #1 , Navaneeth.K *2 , Shashank.K.S #3 , Abhishek.H.N*4 , Srinath.J#5 , Shashi Raj.K*6 #1,2,3,4,5 Students,#6 Asst. Profesor, Electronics & Communication , DSCE Bangalore, India 15 | April 2019

- "Identifying and Reporting of Potholes and Humps using IoT" Smita Saitwadekar1, Dr. Payel saha2International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 06Issue: 02 | Feb 2019.

- Gaurav Singal, Anurag Goswami, Suneet Gupta, Tejalal Choudhary "Pit free: Pot-holes detection on Indian Roads using Mobile Sensors",978-1- 5386-6678-4/18/$31.00 c 2018 IEEE.

- Ashish Gaikwad, Yashwant Belhekar, Mandar Dangre, Ankit Chaudhary" Path hole Detection System: Using Wireless Sensor Network" International Engineering Research Journal (IERJ), Volume 2 Issue 12 Page 4643-4646, 2018 ISSN 2395-1621.

- Pothole Detection using Machine Learning Hyunwoo Song, Kihoon Baek and Yungcheol Byun Dept. of Computer Engineering, Jeju National University, Korea chzhqk1994@gmail.com, masinogns@gmail.com, ycb@jejunu.ac.kr. February 2018

- Pothole Damage Costs U.S. Drivers $3 Billion Annually, https://www. oregon.aaa.com/ 2016/02/pothole-damage-costs-u-s-drivers-3-billion-annually/. (2017)