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FABRICATION OF POTHOLE DETECTION AND FILLING ROBOT

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Abstract

Potholes are a common road-maintenance problem. Their manual detection and repair is slow, labour-intensive and potentially unsafe for workers, who are exposed to traffic and weather. This project presents the design and proposed fabrication of a Pothole Detection and Filling Robot, a compact mobile robot intended to demonstrate a low-cost robotic approach to pothole repair. The proposed robot is built on a four-wheel chassis made of mild-steel square tube, with an overall envelope of approximately 1200 × 550 × 600 mm. An Arduino UNO controller reads two HC-SR04 ultrasonic sensors, one for obstacle detection and one for measuring the distance to the road surface. A sudden increase in this distance above a calibrated threshold is taken as a possible pothole. The robot then stops, and a servo- operated gate releases filling material from a tapered hopper. A rear cylindrical roller follows the filling area to compact and level the material. DC geared motors driven through motor drivers provide the motion, and an emergency stop and indicators are included for safety. The report presents the problem statement, literature review, proposed solution, methodology, circuit design prepared in a simulation environment, preliminary design calculations for mass, torque, motor power, battery capacity, hopper capacity, roller load and chassis loading, a bill of materials, and the proposed fabrication procedure. The mechanical design is to be modelled in SOLIDWORKS 2025. The values given are preliminary design values and the performance of the prototype is to be established by experimental testing. The work is intended as a prototype and a basis for future improvement, such as vision-based detection and better compaction control.

Keywords: pothole detection; pothole filling; autonomous robot; ultrasonic sensors; Arduino; road maintenance; robotic systems; low-cost automation

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Abstract

Potholes are a common road-surface problem that affects transportation safety, vehicle performance, and road maintenance. Conventional pothole detection and repair methods require considerable manual effort and expose maintenance workers to traffic-related hazards. This paper presents the design and proposed fabrication of a low-cost pothole detection and filling robot using an Arduino UNO microcontroller and ultrasonic sensors. The proposed system consists of a four-wheel mobile chassis, an ultrasonic sensing arrangement, a material storage hopper, a servo-operated dispensing gate, and a rear cylindrical roller for surface finishing. One ultrasonic sensor is intended to detect obstacles, while another measures the distance between the robot and the road surface. An increase in the measured distance beyond a calibrated threshold indicates a possible pothole. The controller then initiates a filling sequence by stopping the robot and operating the hopper gate for a predetermined duration. The robot subsequently moves forward so that the rear roller can level the deposited material. A preliminary mechanical design, electrical architecture, bill of materials, and engineering calculations are presented. The proposed design is intended for controlled testing on artificial road depressions. Experimental validation is required to determine detection accuracy, material dispensing consistency, compaction performance, and operating time.

Keywords: Pothole detection, Arduino UNO, ultrasonic sensor, mobile robot, automated road maintenance, material dispensing, mechanical design.

1. Introduction

Road infrastructure plays an important role in transportation, public safety, and economic development. Potholes are a common form of pavement damage caused by factors such as water infiltration, repeated traffic loading, and pavement deterioration. These surface defects can affect vehicle stability, increase maintenance requirements, and create hazards for road users.

Conventional pothole repair generally involves identifying the damaged location, preparing the affected surface, placing repair material, and compacting the material. These operations are labour-intensive and may expose workers to traffic, dust, and adverse environmental conditions. Automation offers an opportunity to reduce manual intervention and improve the consistency of selected repair operations.

This study proposes a compact pothole detection and filling robot that integrates ultrasonic sensing, microcontroller-based control, controlled material dispensing, and roller-based finishing. The proposed platform uses an Arduino UNO to coordinate the sensing and actuation systems. The design is intended as an educational engineering prototype rather than a fully autonomous road-maintenance machine.

2. Literature Review

Previous research has investigated pothole detection using vibration sensors, range sensors, cameras, laser scanners, and machine-learning techniques. Image-based methods can identify pavement defects from visual information, while three-dimensional sensing methods can estimate road-surface geometry. However, these approaches may require additional computing resources, calibration, and specialised hardware.

Research into automated pothole repair has also explored material extrusion, robotic vehicles, and automated dispensing mechanisms. Such systems demonstrate the potential for integrating defect detection with material placement. However, equipment complexity, material storage capacity, and operating costs can limit their use in small-scale applications.

The present project focuses on a simpler architecture using readily available electronic components and a mechanically operated filling mechanism. Its distinguishing design objective is to integrate basic depression detection, controlled dispensing, and roller finishing on a compact four-wheel chassis. The effectiveness of this approach must be established through experimental testing.

3. Problem Statement and Objectives

Manual pothole identification and repair require human intervention and may expose workers to moving traffic. Large automated repair systems can also be unsuitable for small-scale educational demonstrations because of their cost and complexity.

The objective of this project is to develop a low-cost robotic prototype capable of detecting a possible road depression, stopping near the detected location, dispensing filling material, and levelling the filled area using a rear roller.

The specific objectives are:

1. To design a four-wheel mobile chassis using mild-steel square tubing.
2. To develop an ultrasonic-sensor-based method for identifying road-surface depressions.
3. To design a hopper with a servo-operated dispensing gate.
4. To incorporate a rear cylindrical roller for levelling the deposited material.
5. To develop an Arduino-based control system and examine its operation through circuit simulation.
6. To prepare preliminary mechanical drawings, component specifications, and design calculations.
7. To establish a testing procedure for evaluating the integrated prototype.

4. Proposed System and Methodology

4.1 System Architecture

The proposed robot consists of four principal subsystems: locomotion, detection, filling, and finishing. The locomotion subsystem uses DC geared motors and a motor-driver circuit to move the chassis. The detection subsystem uses two HC-SR04 ultrasonic sensors. The filling subsystem consists of a tapered hopper, an outlet gate, and a servo actuator. The finishing subsystem consists of a cylindrical roller positioned at the rear of the robot.

An Arduino UNO acts as the central controller. It receives sensor and switch inputs and generates control signals for the motors, dispensing gate, and status indicators. Motor-driver circuits are required because the motors draw more current than the microcontroller pins can supply.

4.2 Pothole Detection

The pothole-detection sensor measures the distance between the sensor and the road surface. Let H represent the sensor height above a level road and d represent the measured distance. The estimated surface depression is:

Estimated depression depth = d − H

A possible pothole is indicated when the estimated depression exceeds a predetermined threshold. The threshold must be established experimentally because sensor mounting height, beam angle, surface irregularities, and measurement noise can affect detection.

The second ultrasonic sensor is positioned toward the front of the robot to identify obstacles. The control system is intended to stop the robot when an obstacle is detected or when repeated invalid sensor readings occur.

4.3 Material Dispensing and Surface Finishing

The filling mechanism consists of a tapered hopper and a servo-operated gate. When the controller identifies a possible pothole, the robot stops and opens the gate for a calibrated duration. The gate then closes to limit further material discharge.

The robot subsequently advances slowly so that the rear cylindrical roller passes over the deposited material. The roller is intended to provide basic levelling and finishing. Its ability to achieve adequate compaction will depend on roller mass, contact pressure, material properties, and operating conditions.

4.4 Control Sequence

The proposed operating sequence is as follows:

1. Initialise the Arduino controller and connected components.
2. Move the robot forward while monitoring sensor readings.
3. Compare the road-surface distance with the calibrated reference and threshold.
4. Stop the robot when a possible pothole is detected.
5. Open the hopper gate for the calibrated dispensing duration.
6. Close the gate and move forward slowly.
7. Pass the rear roller over the deposited material.
8. Resume inspection when the operating conditions permit.

An emergency-stop mechanism is included to interrupt operation. The physical prototype requires suitable motor drivers, fusing, protected wiring, and a hardware means of disconnecting motor power.

5. Preliminary Mechanical Design and Calculations

The preliminary design specifies an overall envelope of approximately 1200 × 550 × 600 mm. The chassis is planned using mild-steel square tubing of approximately 25 × 25 × 2 mm. Four pneumatic wheels of approximately 200 mm diameter provide mobility. The proposed rear roller has a diameter of approximately 200 mm and a width of 550 mm.

5.1 Estimated Mass and Wheel Load

The preliminary assumed total mass of the robot, including its operating material load, is 66 kg.

The estimated weight is:

$$W = Mg = 66 \times 9.81 \approx 647 \text{ N}$$

Assuming equal load distribution across four wheels, the average load per wheel is:

$$\text{Wheel load} = 647/4 \approx 162 \text{ N}$$

These values are estimates and must be updated using the actual mass of the fabricated components.

5.2 Hopper Capacity

The hopper is provisionally modelled as a frustum of a square pyramid. The assumed top opening is 500 × 500 mm, the outlet is 100 × 100 mm, and the height is 400 mm.

The volume is calculated using:

$$V = (h/3)(A_1 + A_2 + \sqrt{(A_1A_2)})$$

where A_1 and A_2 represent the top and outlet areas, respectively. Using the stated dimensions, the estimated geometric volume is approximately 0.0413 m^3, or 41 litres. The proposed operating fill is approximately 10 litres to limit the robot's mass.

5.3 Preliminary Drive Requirements

For a preliminary calculation, the rolling-resistance coefficient is assumed to be 0.05, the gradient is 5%, the additional drag allowance is 20 N, and the wheel radius is 0.1 m.

The estimated rolling resistance is approximately 32.4 N, and the gradient resistance is approximately 32.3 N. Including the assumed additional drag, the total tractive force is approximately 84.7 N.

The corresponding total wheel torque is:

$$T = Fr = 84.7 \times 0.1 \approx 8.47 \text{ N·m}$$

With four driven wheels, the nominal torque is approximately 2.12 N·m per wheel before applying a safety factor. Final motor selection requires consideration of starting torque, actual terrain resistance, drivetrain losses, and motor current.

These calculations are preliminary design estimates, not experimentally measured performance results.

6. Hardware and Control Implementation

The proposed hardware includes an Arduino UNO, two HC-SR04 ultrasonic sensors, four 12 V DC geared drive motors, motor-driver circuits, a servo motor, a hopper gate, a limit switch, an emergency-stop switch, a buzzer, an LED, a battery, and a rear cylindrical roller.

The preliminary circuit has been represented in Tinkercad Circuits. Simulation is intended to examine the control logic, sensor responses, motor commands, and dispensing-gate operation. Simulation alone cannot establish the mechanical performance, real motor-current requirements, material flow behaviour, or road-repair quality of the physical prototype.

The preliminary circuit design also indicates the need for a suitably rated driver for the drive motors and a separate driver for the roller motor. The servo requires an appropriately rated regulated power supply. A hardware emergency stop should interrupt motor power independently of the normal software control sequence.

7. Proposed Testing and Evaluation

The prototype should be evaluated through a structured test programme under controlled conditions.

First, dry tests should verify basic movement, sensor operation, gate actuation, and emergency-stop behaviour. Second, sensor calibration should be performed using artificial depressions of known depths. Detection performance can then be evaluated by comparing sensor classifications with the known test conditions.

Third, gate calibration should determine the mass of material released at different opening durations. Fourth, roller tests should assess surface levelling and the consistency of the finished patch. Finally, integrated trials should examine the complete detection, dispensing, and finishing sequence.

Useful performance measures include detection rate, false-detection rate, dispensing-mass variation, cycle time, battery current, operating duration, and the surface condition after rolling. Numerical performance results should be reported only after these tests have been conducted and the measurements recorded.

8. Challenges and Future Scope

Potential challenges include ultrasonic measurement errors, inaccurate positioning, inconsistent material discharge, hopper blockage, insufficient roller loading, and high motor-current requirements. These factors must be addressed through calibration, mechanical refinement, component selection, and controlled testing.

Future development could incorporate camera-based pothole recognition, improved depth estimation, automatic material-quantity control, enhanced navigation, better compaction mechanisms, and more robust fault detection. Field deployment would require additional engineering validation, environmental protection, and safety measures.

9. Conclusion

This paper presents the preliminary design of a pothole detection and filling robot that integrates ultrasonic sensing, Arduino-based control, a servo-operated material hopper, and a rear cylindrical roller. The proposed system combines basic defect detection with material dispensing and surface finishing in a compact mobile platform. Preliminary calculations provide a basis for selecting the chassis, drive system, hopper, and battery. The control architecture and simulation provide a starting point for implementation. However, the proposed design's practical effectiveness remains to be established through physical fabrication and controlled experiments. Further work should quantify detection accuracy, material dispensing consistency, roller performance, and overall operating reliability before considering practical road-maintenance applications.

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Conflict of Interest

The authors declare no conflict of interest.

Data Availability

No experimental dataset was generated for this preliminary design study. The design calculations and proposed testing procedures are described in the manuscript.

References

Ma, L., et al. Research on pavement distress detection methods using two-dimensional and three-dimensional road data, including image processing and deep learning. Verify the exact title, journal, year, volume, and pages against the original publication cited in the project report.

Awuah, K. B. Research on automated crack and pothole repair in bituminous pavements using a screw-extrusion-based filling system. Verify the original publication details.

Bruno, et al. Research on robotic cold-asphalt pothole repair and photogrammetric estimation of pothole geometry in the European InfraROB project. Verify the original publication details.

Del Serrone, et al. Conference research on robotic pothole repair and cold-asphalt mixture capacity. Verify the original publication details.

Ghafari, et al. Research on data-driven automation of pothole repair using unmanned ground vehicles. Verify the original publication details.

Patent reference for a pothole-repair apparatus incorporating a material hopper, spreading blade, and compaction by machine weight. Verify the patent number, title, inventor, and publication details.

Research or agency report on semi-automated pothole patching equipment and road-worker safety. Verify the exact source.

Arduino. Arduino UNO Rev3 documentation. https://docs.arduino.cc/hardware/uno-rev3/