International Journal of Scientific Research in Science, Engineering and Technology

Print ISSN - 2395-1990
Online ISSN : 2394-4099

OPEN ACCESS

Available Online at : www.ijsrset.com
doi : https://doi.org/10.32628/IJSRSET

Pothole Detection Robot Using Raspberry PI

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ARTICLEINFO

Article History :

Accepted: 15 Oct 2023
Published: 05 Nov 2023

Publication Issue :
Volume 10, Issue 6
November-December-2023
Page Number :
42-45

ABSTRACT

Municipalities are responsible for repairing potholes to prevent accidents and damage to vehicles. This research introduces an affordable and efficient system for monitoring and maintaining urban roads. The authors developed a method that utilizes photogrammetry techniques to predict the shape and size of potholes. They used a Raspberry Pi Camera Module 3 connected to a Raspberry Pi 4 Model B to capture a series of overlapping 2D images, which were then used to create a 3D model of the pothole. The Raspberry-based setup was installed on a robot, developed as part of the InfraROB European project, to minimize the risk to workers and automate the survey process. The accuracy of the photogrammetry software's results was verified through laboratory tests conducted on an asphalt tile that mimicked a real pothole. The system incorporated Global Positioning System (GPS) and Geographical Information System (GIS) technologies to map the potholes, providing information on their location, size, backfill material, and an accompanying image. Ten field tests demonstrated that the system is effective in uncontrolled environments, not just in a controlled laboratory setting. The results indicate that this system is a valuable tool for monitoring road potholes, prioritizing the health and safety of both construction workers and road users.

Keywords : Global Positioning System, InfraROB European project, Raspberry Pi

I. INTRODUCTION

Potholes present a widespread and frustrating issue in urban infrastructure, posing risks to road users and causing damage to vehicles. Both pedestrians and drivers are affected by these safety concerns. Tackling this problem requires creative solutions that combine technology and automation. The Pothole Detection and Repair Robot, which runs on Raspberry Pi, provides a promising method for efficiently and effectively identifying and fixing potholes. Raspberry Pi, a versatile single-board computer, acts as the central processing unit for this robot. With its computational capabilities, GPIO pins, and connectivity options, Raspberry Pi enables the robot to independently navigate, gather data, and carry out

repairs. This fusion of robotics and smart technology contributes to enhancing the quality of roads and the overall urban mobility experience. The Pothole Detection and Repair Robot powered by Raspberry Pi serves as a compelling example of how robotics and smart technology can address a pressing challenge in urban infrastructure. By autonomously detecting and temporarily repairing potholes, this robot contributes to safer roads and better driving experiences, showcasing the potential for innovation at the intersection of technology and public infrastructure.

II. METHODOLOGY

The system is comprised of various modules. Our project utilizes three specific modules: the ultrasonic sensor module, the Arduino module, and the Raspberry Pi module. Each module serves different purposes. The system incorporates the following.

Raspberry Pi Board

This compact computer board, known as the Raspberry Pi, is capable of performing a wide range of tasks similar to a standard computer. These tasks include gaming, word processing, spreadsheet management, and high-definition video playback. The raspberry pi board is an affordable and portable device that is accessible to everyone. Many smart phones utilize raspberry pi computers. In the 21st century, there has been a significant increase in the adoption of mobile computing technologies, largely driven by the mobile industry.

Arduino module

- **USB Power:** The Arduino board can draw power from a power socket by using the USB cable.
- **Barrel Jack Power:** The Arduino boards can be directly powered from the mains AC by connecting it to the Barrel Jack.
- **Voltage Regulation:** The voltage regulator on the Arduino board controls the voltages supplied to the board and stabilizes the DC voltages used by the processor and other components.
- **Crystal Oscillator:** The crystal oscillator on the Arduino handles timing and determines whether the frequency is 16,000,000 Hertz or 16 MHz.
- **Arduino Reset:** The first reset button on the Arduino can be used to initiate the program compilation from the beginning.
- **Pins:** The 6th pin supplies a 3.3V output voltage, the 7th pin supplies a 5V output voltage, the 8th pin is the ground (GND), and the 9th pin (Vin) can be used to supply external power to the Arduino board. The default voltages for components used with the Arduino board are 3.3V and 5V.
- **Analog Pins:** On the Arduino UNO board, pins A0 to A5 are analog pins. These pins read analog signals from sensors such as ultrasonic, humidity, or temperature sensors and convert them into digital values that can be processed by microprocessors.
- **Power LED Indicator:** The Arduino board has an LED that indicates whether the power supply plug is properly connected. The LED lights up when the connection is correct and remains off if there is a problem with the plug connection.
- **TX and RX LEDs:** The TX LED lights up when transmitting serial data, while the RX LED lights up when receiving serial data.
- **Digital I/O:** The Arduino UNO board has 13 digital I/O pins from 0 to 13, with 6 of them capable of Pulse Width Modulation (PWM) output.

Raspberry Pi Module

- **Memory:** The raspberry pi model board comes with 256MB of SDRAM, while model B has 16GB of built-in memory. In comparison, normal PCs typically have RAM memory available in gigabytes, with the raspberry pi offering over 512MB of RAM memory.

- **CPU (Central Processing Unit):** The central processing unit serves as the primary component of the raspberry pi board, functioning as its brain. It carries out logical and mathematical operations to execute instructions.
- **GPU (Graphics Processing Unit):** The raspberry pi board features a dedicated graphics processing unit, designed to optimize the speed of image operations. These units are highly efficient for computer graphics manipulation and image processing.
- **Ethernet Port:** The raspberry pi can communicate with additional devices via its Ethernet port. By connecting a home router to the Ethernet port, users can access the internet.
- **GPIO Pins:** The raspberry pi utilizes general-purpose input and output pins to connect with other electronic circuits. These pins accept input commands and provide output based on programming instructions. The board is equipped with digital general-purpose input and output pins, allowing for the attachment of various electronic components. For instance, users can connect an ultrasonic sensor to the raspberry pi to transmit digital data.
- **ZigBee Socket**: The raspberry pi employs a ZigBee socket for wireless communication.
- **Power Source Connector:** The power source connector, a small switch located on the side of the shield, enables the use of an external power supply.
- **UART:** The Universal Asynchronous Receiver/Transmitter serves as a serial input and output port. It facilitates the transfer of serial data in the form of text and is particularly useful for converting debugging code.
- **Display:** To run programs on the raspberry pi and view the results on a laptop, only a connection to a laptop HDMI display is required.

III. BLOCK DIAGRAM

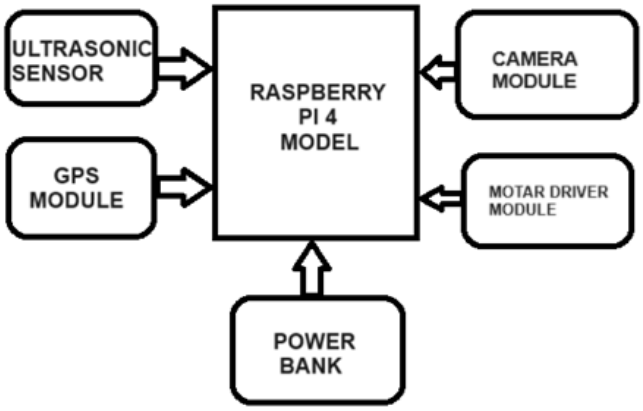

Figure 1 : Block Diagram of Pothole Detection System

IV. CONCLUSION

The proposed system has two primary functions. Firstly, it utilizes an ultrasonic sensor to automatically detect potholes. When a pothole is detected, a buzzer will sound to alert the driver. Additionally, when a pothole is detected, the system will cause the vehicle to come to a stop and capture an image of the pothole using a camera.

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Cite this article as :

Prof. A. S. Shirkande, Yogiraj Hange, Suraj Naiknaware, Dnyandev Shelar, "Pothole Detection Robot Using Raspberry PI", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 10 Issue 6, pp. 42-45, November-December 2023.

Journal URL : https://ijsrset.com/IJSRSET2310563