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RASTE MITRA: AUTOMATED POTHOLES DETECTION AND FILLING SYSTEM

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Abstract - Potholes are one of the major issues on the roads because they cause damage to vehicles, lead to accidents, and incur higher maintenance costs. "Raste Mitra" in contrast is a comprehensive solution as it performs automatic pothole detection and classification, as well as repairs. The system employs a Raspberry Pi for controlling the functions, YOLOv5 for detecting potholes in movement, and ultrasonic sensors for object detection. The technique is sustainable due to the use of a solar powered battery management system and autonomous and self-filling technique eliminates need of labor. Additionally, the use of cloud notifications allows the responsible guards to be informed on occurrences of potholes in the dangerous state enabling them to take measures in time. The technologies adopted in "Raste Mitra" contribute to advancing road safety management through better maintenance systems and promotes the management of roads in a sustainable way. The paper discusses the processes used, hardware used, and the scope of the project on road maintenance.

***Key Words*: Automated pothole detection, YOLOv5, Raspberry Pi, road safety, sustainable infrastructure, ultrasonic sensors, cloud-based notifications.**

1. INTRODUCTION

India, having a huge and growing network of roads, particularly faces challenges regarding the road's maintenance. Over the years, the growth in the number of vehicles along with the lack of maintenance has worsened the issues such as potholes- which are concerning given how they are major contributors to both road accidents and vehicle damage. The impact of potholes on vehicles has resulted in 3400 deaths which is an alarming statistic. Potholes are caused by water intrusion and pressure from automobiles. The combination of these two elements affects the asphalt paving which deteriorates the surface of the roads. Preventive measures for this issue are vital turn in turning the roads safe and reducing the costs of maintenance.

To date, advice on potholes and pothole patching has relied prima facie on direct visual inspections, which are labor consuming. Such approaches throughout the solution of the problem may result in delays in pinpointing the location of the vulnerability in the road with an effect of increased risks for the user of the road. Moreover, typical motor vehicle repair and maintenance practices on urban roads are not always uniform and spot on, especially for congested inner-city areas with dense urban road networks.

In addressing these problems, the project proposes ''Raste Mitra'', a fully automated solution for the detection, classification and repairing of potholes. The system involves Raspberry Pi, YOLOv5 and ultrasonic sensors for object detection. It includes an automatic filling machine to repair the filled pothole and comes with a solar charged battery management system if required. Critical situations regarding potholes are taken care of by giving timely prompt responses through the notifications to the concerned authorities with the help of a cloud system which in turn leads to improved road safety. "Raste Mitra" aims to change the road maintenance culture by reducing dependence on manual processes and increasing the level of automation. This paper examines the methodological approach of the project, the implementation of hardware, as well as the possibility of improving the road infrastructure efficiently and in an environmentally friendly way.

2. LITERATURE REVIEW

Gaurav Singal, Anurag Goswami, Suneet Gupta, and Tejalal Choudhary [1] in their work titled "Pit Free: Potholes Detection on Indian Roads Using Mobile Sensors" (2018 IEEE) employed mobile sensors via an Android application to identify potholes. This application gathers data from an accelerometer sensor across the X, Y, and Z axes, in conjunction with GPS coordinates for latitude and longitude, to detect potholes based on variations in these readings. The collected data is stored in a CSV file, and pothole detection is achieved by analyzing fluctuations in gravitational force experienced by the device during transit. Ashish Gaikwad, Yashwant Belhekar, Mandar Dangre, and Ankit Chaudhary [2] in "Path Hole Detection System: Using Wireless Sensor Network" (IERJ, 2018) introduced a system designed to identify potholes and road humps utilizing ultrasonic sensors. This system comprises a sensing sub-unit for detecting potholes and humps, a server sub-unit for the storage of GPS data, and a user sub-unit that alerts drivers through a buzzer or advanced notifications regarding potholes on particular routes. Smita Saitwadekar and Dr. Payel Saha [3] in "Identifying and Reporting of Potholes and Humps Using IoT" (IRJET, 2019) created a cost-effective solution for the detection of potholes and humps using affordable ultrasonic sensors. The system employs a Raspberry Pi as the microcontroller, which gathers GPS data related to potholes and transmits it to a server. A web application notifies drivers and records pothole complaints, ensuring timely warnings and accurate documentation. Gunjan Chugh, Divya Bansal, and Sanjeev Sofa [4] in "Road Condition Detection Using Smartphone Sensors: A Survey" (IEEE, 2015) outlined a system that utilizes a Raspberry Pi-based sensing module alongside an Android smartphone to assess road conditions. The sensing module is equipped with an accelerometer and Bluetooth module, with data being relayed to the smartphone for visualization. The Android application facilitates Bluetooth communication, integrates Google Maps, and displays driving patterns. Aniket Kulkarni, Nitish Mhalgi, Sagar Gurnani, and Dr. Nupur Giri [5] presented a pothole detection system in their work titled "Pothole Detection System Using Machine Learning on Android" (IJETAE, 2012). This system employs an accelerometer to observe variations in acceleration across the X, Y, and Z axes. Additionally, it utilizes GPS coordinates to identify the locations of potholes. The Android application is designed to track changes in acceleration and records incidents, including geographic coordinates and timestamps, whenever a pothole is identified during the user's travel.

3. METHODOLOGY

The approach to creating the Pothole Detection and Filling Robot combines sophisticated

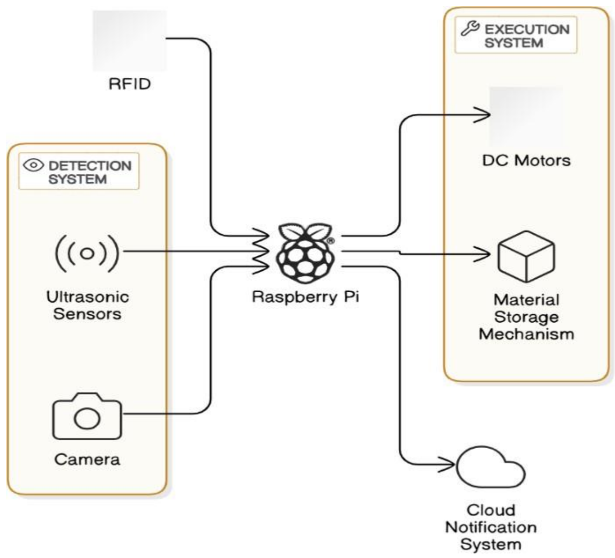

Fig.1. System Architecture.

hardware and software elements to streamline road maintenance operations. The architecture of the system is largely constructed around a Raspberry Pi which acts as the microcontroller and interfacing with multiple sensors and dispatching commands. For its part, the robot is in a position to grab a video stream using a USB camera and later this video footage can be processed using the YOLOv5 algorithm. This algorithm can take the entire image and run a model over it once while dividing the input picture into sectors spotting the potholes by placing boxes with registered weight scores. The reasons for applying YOLOv5 are its significant precision as well as the speed at which multiple objects are indexed making it easy to locate a large number of potholes. Also, there are ultrasonic sensors that work with visual sensing to be able to perceive barriers. It takes the reliability of the robot to a higher level by confirming the discrepancies perceived by the camera so that it can safely move around. The Raspberry Pi receives the information and identifies the degree of damage caused by the pothole after it has been located. Those tiny potholes that can be filled and patched by the robot are repaired by the robot itself. Through a motor, a controlled quantity of filling material is released from a storage container attached to the robot. Following the dispensing process, a leveling system is employed to smooth the road surface, thereby preventing further damage or discomfort to vehicles. In the case of deep and wide potholes that exceed the robot's repair capability, the system generates a notification to the cloud. DC motors which are connected through motor drivers to the Raspberry Pi concerning locomotion drive the robot. These motors make provision for moving and positioning over the located potholes. The use of a solar system-based battery management system increases energy resource availability, such quality makes the system viable economically as well as eco-friendly for a longer time. The integration of the system software is a basic step of the procedure. Real-time video streams are processed by the YOLOv5 model trained with Python and OpenCV for examples of potholes. Preprocessing image functions such as cropping and sharpening are performed with OpenCV to make it easier for identifying the potholes. The system employs cloud-based APIs for sending alerts and notifications to the relevant personnel. The sequence of tasks starts with the camera and ultrasonic sensors of the robot assisting it in scanning the road surface for any depression. After locating the pothole, its picture is taken, and the damage is evaluated. Based on this classification, the robot either autonomously fills the pothole or issues a notification for external repair. This entire sequence is repeated as the robot continues to monitor the road, ensuring uninterrupted operation. The system's architecture prioritizes modularity, facilitating future enhancements such as advanced detection algorithms, improved material storage, and the addition of sensors for wider applications. This approach facilitates a seamless integration of hardware and software, thereby guaranteeing that the robot executes its functions with both efficiency and reliability. The incorporation of sophisticated algorithms, sustainable energy sources, and IoT connectivity establishes this system as a notable progression in automated road maintenance. It has the potential to lower labor expenses, enhance road safety, and reduce operational interruptions.

4. HARDWARE SETUP

Fig.2. Raspberry Pi 4 for controlling the functions.

Fig.3. Ultrasonic sensor for obstacle detection.

Fig.4. DC Motor to manage the moving parts.

Fig.5. USB Web Camera for object detection

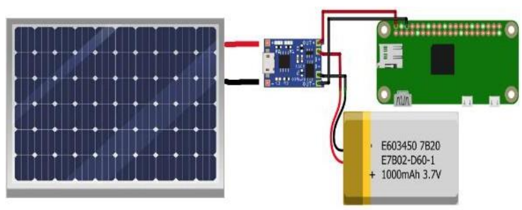

Fig.6.Wifi Module for wireless communication.

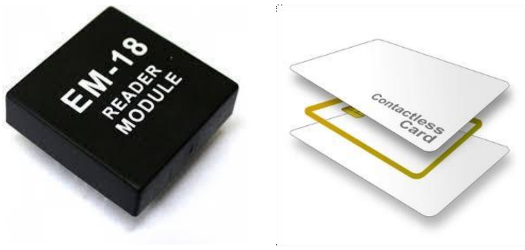

Fig.7.RFID based authentication system.

5. RESULTS

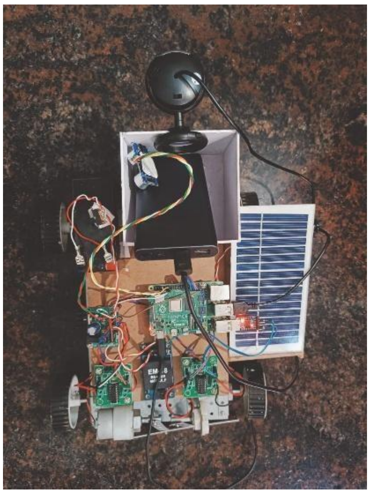

Fig.7.: Hardware setup of the proposal Model.

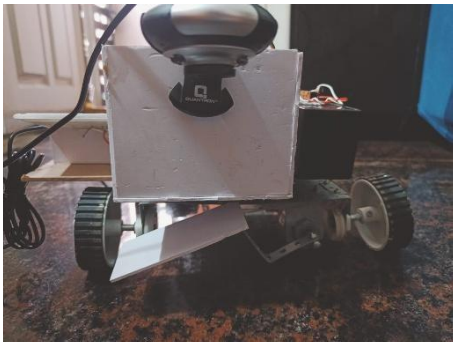

Fig.8.: Potholes filling mechanism

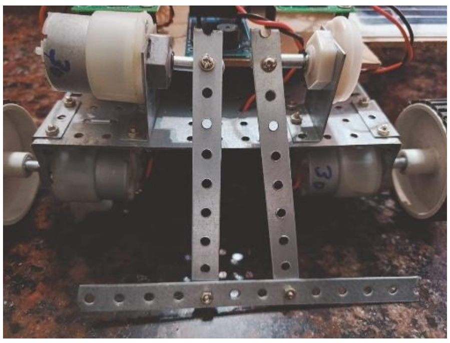

Fig.9.: Levelling mechanism

Fig.10.: Telegram Notification System.

6. CONCLUSION

The Pothole Detection and Filling Robot demonstrates the potential for automated systems to revolutionize road maintenance practices. By leveraging advanced object detection algorithms, such as YOLOv5, combined with a robust hardware design, the robot efficiently identifies and addresses minor potholes while alerting authorities for severe cases. Its integration of solar power and IoT technology ensures sustainability and real-time communication, respectively. Despite its success, challenges such as limited performance in low-light conditions and frequent material refills indicate areas for further refinement. Adding infrared cameras and increasing storage capacity could enhance operational reliability. The robot's modular design allows for these and other upgrades, such as advanced machine learning models for complex damage identification and integration with smart city infrastructure. In conclusion, this project represents a significant step forward in automated road maintenance. It addresses critical issues like labor inefficiency, road safety, and environmental sustainability. With continued development, the Pothole Detection and Filling Robot can become a cornerstone of modern urban infrastructure, improving the quality and safety of roadways worldwide.

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