Crack Identification Robot in Industrial Pipeline using Image Processing

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Abstract : The crack identification robot is designed based on image processing to detect cracks in industrial pipelines. The robot is equipped with a camera and an image processing algorithm that analyse the images captured by the camera to identify cracks. The robot is connected to the hotspot and enabling it to send real-time information about the cracks it detects to a remote server. The robot can be remotely controlled and monitored through a mobile application, which provides a user-friendly interface for managing and analysing the data collected by the robot. The proposed system is expected to enhance the efficiency of crack detection and reduce the need for human intervention in inspection activities. The experimental results showed that the crack identification robot was able to detect cracks accurately. The robot was able to detect cracks of different sizes and shapes, including both narrow and wide cracks, and cracks that were in different orientations. The real-time data transmission and remote monitoring capabilities of the robot were also demonstrated, showing the potential for the system to be used for large-scale crack detection in various applications, such as infrastructure maintenance, construction, and road safety. Overall, the crack identification robot using image processing has the potential to revolutionize the way cracks are detected and monitored, making the process more automated, efficient, and reliable.

Keywords: *Pipeline robot, IOT, machine learning, crack identification, image processing, raspberry pi 3.*

PROBLEM IDENTIFICATION

- Understanding the various types of cracks that can develop in structures, their causes, and any potential effects on stability and safety are crucial.
- To guarantee that damaged places are fixed or replaced before failure occurs, the industry mandates periodic inspections.
- Gases can spread into the environment if fissures are really large and become invisible.
- Many reasons, including settlement, movement, pressure, temperature changes, and chemical reactions, can result in cracks.

EXISTING METHOD

LESS EFFECTIVE: The current crack detection method might not be as successful in finding cracks in structures as alternative methods, like non-destructive testing (NDT) techniques. This is so that specific information regarding the size and severity of the cracks may be provided.

DIFFICULT TO FIND THE CRACK: Visual examinations of structures can be difficult to use to find cracks, especially if the structure is complicated or the cracks are in difficult-to-reach places. The safety and structural integrity of the building may be seriously compromised as a result of faults and inconsistencies in the detecting procedure. The current crack detection method can be costly, particularly if it necessitates the use of specialist tools or the participation of subject-matter experts. Smaller businesses or individuals who might not have the funds to invest in pricey crack detection techniques may find this to be a big hurdle. Visual inspections may not be able to find cracks that are too big or too deep, which is one of their limits. This occasionally results in circumstances where cracks go unnoticed until they are too large to repair or present a significant safety risk.

PROPOSED METHOD

The proposed method for in this research, cracks in intricate constructions will be found using a camera-equipped robot. Advanced image processing methods are employed to evaluate and locate cracks in the photographs that the robot has acquired and forwarded to a central computer. The photos will be processed using an image processing approach to produce a cracks map. To find the flaws in the photos, image processing will also be used.

INTRODUCTION

For various infrastructure components, like buildings, roads, and bridges, to be safe and long-lasting, fractures must be found and monitored. Traditional crack detection techniques include experienced personnel doing visual inspection, which can be time-consuming, expensive, and error-prone. With the growth of technology, there has been an increased interest in creating automated crack detection systems that can lessen the need for human involvement and boost inspection process effectiveness[1-2].

In this paper, we introduce a crack recognition robot that analyses images to find surface fractures. The robot has a camera, and an algorithm for image processing examines the photos it takes to look for cracks. The robot can communicate real-time data on the cracks it finds to a distant server thanks to its internet connection. With a smartphone application, which offers a user-friendly interface for controlling and analysing the data acquired by the robot, the robot may be remotely controlled and monitored[3-4].

The suggested approach has a number of benefits over conventional fracture detecting techniques. First of all, it lessens the need for human involvement in the inspection procedure, which can increase the safety and effectiveness of the inspection activities. Second, the robot's real-time data transmission and remote monitoring capabilities allow for speedy and accurate crack detection, decreasing the danger of damage and the expense of repairs. Finally, the system can identify cracks of all sizes and forms thanks to the use of image processing algorithms, which guarantees a high level of accuracy and reliability in fracture detection.

The crack identification robot created for the project is a remarkable accomplishment. It distills the major discoveries and results of the project into a useful tool for identifying structural flaws. The study outlines the project's objectives, techniques, outcomes, and the importance of the findings. The significance of this technology in maintaining the structural integrity of buildings, bridges, and other infrastructure is emphasised in the study. The potential applications of the crack identification robot in various fields, including building, aviation, and the automobile industry, are also discussed. The study identifies some of the obstacles and challenges encountered during the development process, such as the irregular shape and size of cracks, and highlights areas for further research and development. In terms of crack detection techniques, the study reviewed approaches from the machine learning and image processing fields[5-7]. It concludes that both of these sectors present unique difficulties when it comes to precise fracture identification. The study notes that the kind of the identified fracture can provide crucial cues about the nature of the crack, its origin, and its severity, which simplifies the inspection process. The study found that image processing techniques performed well on the unique datasets created by the researchers, but they are dependent on lighting conditions, image resolution, and noise levels. The study also notes that concrete structures' surfaces may not have the same texture, which can impact the accuracy of image processing techniques.The study proposes a solution for overcoming the need for big datasets to train neural networks by breaking down fitted networks into ensembles of low-bias sub-networks[8-9].

BLOCK DIAGRAM

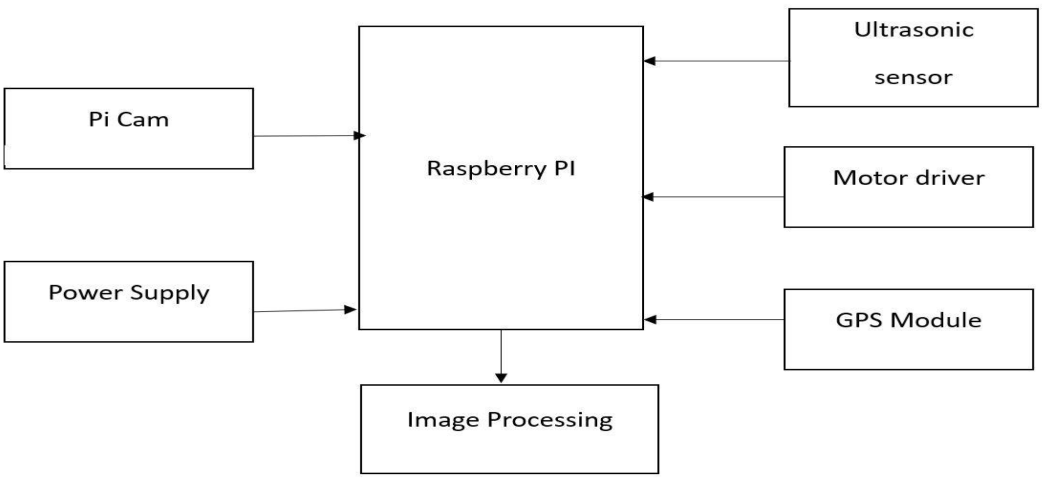

Fig.1 Block diagram of crack identification system

The crack identification robot consists of several parts, including a Raspberry Pi, GPS module, ultrasonic sensor, motor driver and motor wheels, power supply, and image processing system. The Raspberry Pi acts as the central processing unit for the robot, receiving input from the GPS module, ultrasonic sensor, and image processing system and sending commands to the motor driver to move the robot.The GPS module provides information on the robot's location, which is used to create a map of the contact region and track the robot's progress over time. The ultrasonic sensor detects cracks by emitting high-frequency sound waves and measuring the time it takes for them to bounce back, while the motor driver and motor wheels move the robot based on commands from the Raspberry Pi[10]. The power supply provides electricity to the robot's components, and the image processing system analyses photos from the camera to identify and provide details on cracks. All of these parts work together to create an effective crack identification robot. The L298N is made up of two H-bridges, each of which can control the direction of current flow to the motor. This enables the motor to be driven in both forward and reverse directions. The L298N also includes built-in protection circuits to protect the IC and the motors[11]. Thermal shutdown, overcurrent protection, and undervoltage lockout are examples of protection circuits. To use the L298N, you must connect it to a microcontroller or other control circuitry. For each motor channel, the L298N needs two input signals: one to control the motor's direction (forward or backward) and the other to control its speed. By adjusting the pulse width of the input signal via pulse width modulation, the motor's speed can be managed (PWM). In order to power the motors, the L298N additionally needs an external power source. The VCC and GND pins of the L298N can accept this power supply[12-13]. Moreover, the L298N has a separate power supply input (VS) that can be connected to either a different power supply or the same power supply as the motor to power its internal logic circuitry. The working principle involves the use of H-bridges, which allow the motor to be driven both forward and backward. The L298N includes two H-bridges, each with four MOSFET transistors. By turning on and off, these transistors control the flow of current to the motor. When one of the transistors is turned on, current flows through the motor in one direction, causing it to rotate in that direction. When the other pair of transistors is activated, current flows through the motor in the opposite direction, causing it to rotate in the opposite direction.The L298N requires two input signals for each motor channel to control the direction and speed of the motor[14]. The state of the input signals, which determine which pairs of transistors are turned on, controls the direction of the motor. The pulse width of the input signal controls the motor speed, which is accomplished through pulse width modulation (PWM). The L298N also includes built-in protection circuits to protect the IC and motors. Thermal shutdown, overcurrent protection, and undervoltage lockout are among the protection circuits. While the motors are shielded from excessive current by the over current protection circuitry overheating. In order to protect the IC from harm, the undervoltage lockout circuitry stops the IC from running when the input voltage falls below a predetermined threshold. The official Raspberry Pi OS is preinstalled on every Raspberry Pi board. Its original name was Raspbian, and it was designed especially for the Raspberry Pi. Even though the Raspberry Pi Foundation quickly developed this OS, the earliest examples of the board didn't run it. As a result, any board manufactured after June 2012 was compatible with it.The Raspbian operating system was first released as 32-bit, Debian-based variants. Nevertheless, more subsequent OS versions have shifted to 64-bit architecture and stopped using Debian as their foundation. Except for the Pico version, which is significantly less powerful and smaller in size, the Raspberry Pi OS was developed expressly with the Raspberry Pi in mind and is compatible with every type of Raspberry Pi board. Raspbian is free and open-source software that receives frequent updates that include security fixes and additional functionality. The GNU General Public License, which permits users to freely alter and share the programme, governs how it is delivered. Raspbian is also made to function well with the Raspberry Pi's hardware components, including the GPIO pins, camera module, and other add-on modules. This makes it a well-liked option for developers, educators, and hobbyists who want to use the Raspberry Pi in their projects[15-17].

Figure 2 - Raspberry PI

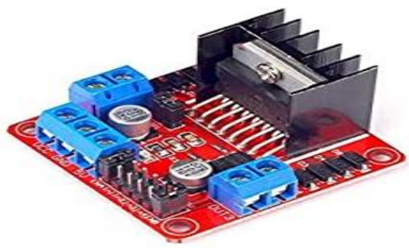

Figure 3 - L298 Motor Driver

Figure 4 - GPS module

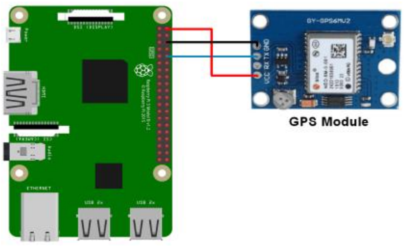

Figure 5 - Interfacing of with GPS module

INTEGRATION AND TESTING OF THE ROBOT

Simulations and functional software testing are traditional methods for robotic system validation. Figure 1 shows a crack identification robot. Despite being intriguing, these approaches do not provide coverage information to direct testing activity. In this regard, it appears promising to use coverage testing in the validation of mobile robotic systems. For robotic systems in a simulation environment, the suggests an integration testing methodology shown in figure 2. The strategy consists of test scenarios built using functional testing and structural testing in order to identify flaws and improve the systematisation of the testing activities in this application domain. The suggested method concentrates on robot operating system (ROS) platforms that support publish/subscribe interaction with establishing communication.

The paper gives a case study of how robotic systems can be used to apply the integration testing approach and measured distance shown in figure 3. An experimental study carried out with creators of mobile robotic systems analysed the benefits and demonstrated the approach's industry applicability. The outcomes supported its benefits for mobile robotic system integration testing. It may detect typical flaws in mobile robotic systems and perform functional behaviour checks shown in figure 4.

The integration testing methodology proposed in the study provides a comprehensive and systematic approach to validate the mobile robotic system. By combining functional and structural testing, the method can detect typical flaws in the system and achieve high structural coverage.

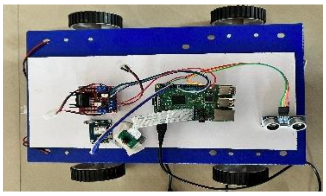

Figure 5 – Crack Identification Robot

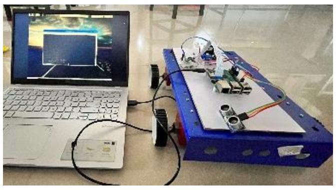

Figure 6 – Crack Identified

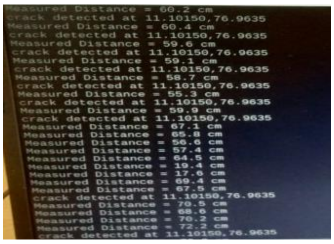

Figure 7 – Measured distance

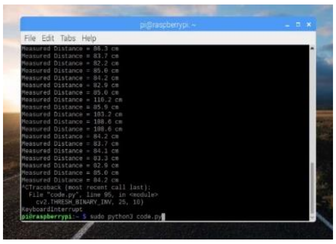

Figure 8 – Crack Identified with distance

CONCLUSION

Robotic crack detection has the potential to improve infrastructure safety by automating inspections and spotting cracks before they pose a serious threat. In comparison to conventional inspection techniques, it has a number of benefits, such as speed, safety, accuracy, and consistency. We are able to guarantee the security and dependability of our infrastructure for many years to come with the continuing development of this technology.

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