AI Based Crack Detection and Monitoring for Under Water Application

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Abstract - Infrastructure maintenance, especially in underwater environments, poses significant challenges due to the harsh conditions and limited accessibility. Submerged structures, such as pipelines, bridges and offshore platforms, are susceptible to deterioration, and timely detection of defects, particularly cracks, is crucial for ensuring structural integrity and preventing catastrophic failures. This paper presents an Artificial Intelligence (AI)-based approach for the detection and monitoring of cracks in underwater structures using advanced imaging and machine learning techniques. The proposed system employs underwater cameras and sensors to capture high-resolution images and collect relevant data from the submerged structures. These data are then processed using computer vision algorithms to identify potential areas of interest that may indicate the presence of cracks. Node MCU ESP8266 is an one of the main component in the hardware, which is used for wireless operation and communication. Furthermore, a real-time monitoring systems is integrated to enable continuous surveillance of the underwater structures. The monitoring system utilizes the processed data to track changes in crack dimensions, growth patterns, and structural deformation is essential for predicting potential structural failures, facilitating proactive maintenance measures, and optimizing resource allocation for repair and rehabilitation.

Keywords -- Artificial Intelligence (AI), Internet Of Things (IOT) crack detection, convention neural network, PIC controller

I.INTRODUCTION

AI-based crack detection and monitoring for underwater applications represents a cutting-edge approach in the field of structural health monitoring (SHM) and maintenance of submerged structures. The underwater environment poses unique challenges for infrastructures integrity, particularly in critical structures like pipelines, offshore platforms, and under water bridges. The detection and monitoring of cracks in these structures are crucial to ensuring safety, preventing environmental hazards, and optimizing maintenance efforts.

Artificial intelligence (AI) technologies, including machine learning and computer vision, play a pivotal role in the automating and enhancing the accuracy of crack detection and monitoring processes in the underwater settings underwater environments aften have low visibilities due to factors such as turbidity, sedimentation, and low light conditions. These challenges make traditional visual inspection methods less effective. Submerged structures are exposed to corrosive saltwater, biofouling, and extreme pressure conditions, which can impact the structural integrity over time. Manual inspection and maintenance of underwater structures are costly, time-consuming, and poses risks to human drivers. Automation desirable to streamline processes and reduce operational expenses. AI-based crack detection and monitoring for underwater applications represent a significant advancement in the field of structural integrity management. As technology continues to evolve, these systems are poised to play a crucial role in ensuring the safety and reliability of submerged infrastructure worldwide.

II. LITERATURE SURVEY

Underwater concrete structures play a critical role in various civil engineering applications, including dams, bridges, and offshore platforms. However, the detection of cracks in these structures poses significant challenges due to the murky underwater environment and the complex nature of concrete degradation (1). The presence of cracks on dam surfaces can compromise their structural integrity and poses significant risks to downstream communities and ecosystems (2). Concrete structures are integral components of various civil engineering projects, and the detection and monitoring of cracks in concrete play a crucial role in ensuring structural Integrity and safety (3). Cracks in concrete dams poses serious threats to the safety and stability of critical infrastructure, necessitating effective detection methods for early intervention and maintenance (4).

To validate the effectiveness of the proposed approach, experimental tests are conducted on underwater concrete beams subjected to controlled damage scenarios. Piezoelectric sensors embedded in the beams capture ultrasonic signals before and after damage initiation, which are then processed using time reverse modelling algorithms to detect and localize damage (5). Tunnels are critical infrastructure components that require regular inspection and maintenance to ensure their structural integrity and safety. Water leakage and cracks in tunnel linings are common issues that can lead to significant risks and costly repairs if left undetected (6). Experimental evaluation conducted on real-world subway tunnel images demonstrate the effectiveness of the proposed system in accurately detecting cracks and minimizing false positives (7). Cracks in tunnel linings pose significant risks to infrastructure integrity and public safety. To address this challenge, we propose a novel tunnel crack detection method and crack image processing algorithm based on an improved retinex model and deep learning techniques (8).

III. PROPOSED SYSTEM

The proposed concept involves the development of an AI-based crack detection and monitoring system specifically designed for underwater applications. This system aims to address the challenges associated with identifying and monitoring cracks in underwater structures such as pipelines, underwater platforms, and offshore structures. The key concept revolves around leveraging artificial intelligence (AI) algorithms to analyse data collected from sensors installed on the underwater structures. These sensors may include acoustic sensors, pressure sensors, and cameras, among others, capable of capturing various signals and images related to the structural integrity of the underwater assets. The AI algorithms are trained using a combination of supervised and unsupervised learning techniques on a dataset comprising underwater images, acoustic signals, and other relevant data associated with both cracked and intact structures. Through this training process, the AI model learns to recognise patterns and anomalies indicative of cracks or potential structural damage.

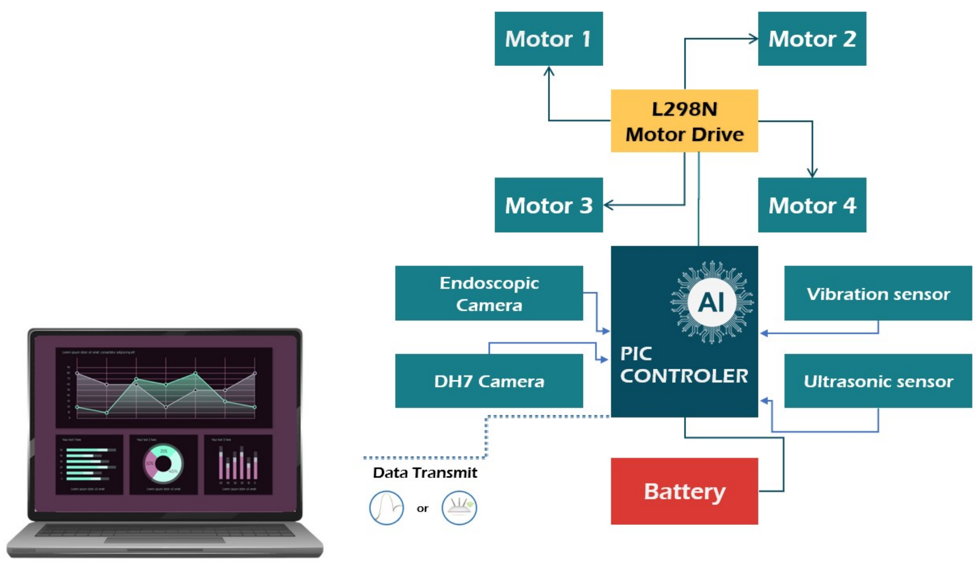

Figure 1. Block diagram of Proposed work

The proposed concept of AI-based crack detection and monitoring for underwater applications represents a significant advancement in structural integrity management for submerged infrastructure. Leveraging artificial intelligence (AI) algorithms and sensors technologies, this concept aims to enhance the detection and monitoring of cracks and structural anomalies in underwater assets such as pipelines, offshore platforms, and underwater structures. By deploying a network of sensors equipped with AI- powered algorithms, the system can continuously monitor the underwater environment in real-time, analyzing data streams to identify potential cracks or defects. Through machine learning technique, the AI model can be trained to recognize patterns and anomalies indicative of structural damage, enabling early detection and intervention to prevent catastrophic failures. Additionally, the system can provide valuable insights into the progression of cracks over time, facilitating proactive maintenance and repair strategies. Overall, the proposed concept of AI-based crack detection and monitoring holds promise for improving the safety, reliability, and longevity of underwater infrastructure, contributing to more sustainable and resilient marine operations.

1. PIC Microcontroller:The PIC16F877A is an 8-bit microcontroller manufactured by microchip technology. It is part of the PIC (peripheral interface controller) family of microcontrollers, which are widely used in various embedded systems and electronic projects due to their versatility, low cost, and ease of use. The PIC16F877A utilizes a Reduced Instruction Set Computing (RISC) architecture, which simplifies instruction execution and enhances processing speed. The PIC16F877A includes a wide range of peripherals, including Analog-To-Digital Converters (ACD), timers, USART (Universal Synchronous/Asynchronous Receiver/Transmitter) modules, SPI (Serial Peripheral Interface), and I2C (Inter-Integrated Circuit) communication interfaces, as well as GPIO (General-Purpose Input/Output) pins.

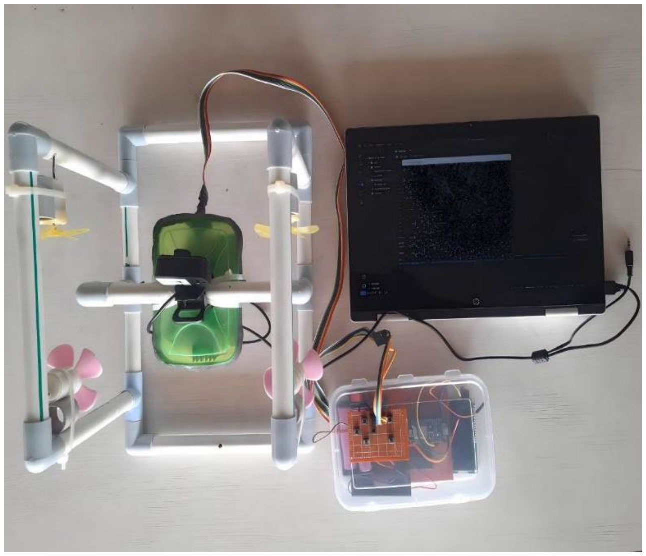

Figure 1. AI based crack detection and monitoring for under water application hardware kit

2. Web Camera:

This versatile device is commonly integrated into laptops, desktops computers, tablets, and smartphones, or it can be a standalone unit connected to a computer via USB or other interfaces. The webcam comprises several key components, including a camera sensor, lens, image processor, microphone, and mounting mechanism. The camera sensor is responsible for capturing visual information and converting it into digital data, typically using either a charged-coupled devices (CCD) or a complementary metal-oxide-semiconductor (CMOS) sensor.

3.Ultrasonic Sensor:

Ultrasonic sensors are widely used in industrial automation, robotics, automotive, healthcare, and consumer electronics for various purposes such as proximity sensing, object detection, level measurement, and flow monitoring. In manufacturing and robotics, ultrasonic sensor plays a crucial role in detecting obstacles, positioning components, and ensuring safety in automated production lines. In automotive application, they are used for parking assistance, collision avoidance systems, and adaptive cruise control. Furthermore, ultrasonic sensors find applications in healthcare for non-contact temperature measurements, ultrasonic imaging, and medical diagnosis. In consumer electronics, they are integrated into devices such as ultrasonic toothbrushes, distance meters, and gesture recognition systems. One of the key advantages of ultrasonic sensors is their ability to operate in harsh environments and under challenging conditions, such as dust, smoke, or low visibility. They are non-contact sensors, which means they do not require physical contact with the target object, making them suitable for applications where contact sensors may not be feasible or practical.

4.Vibration Sensor: A vibration sensor, also called a vibration detector or accelerometer, is a tool that gauges the intensity and rhythm of vibrations within a system. It is widely employed in a variety of fields including automotive, aerospace, industrial machinery, and consumer electronics. They play aa crucial role in condition monitoring, predictive maintenance, and structural health monitoring by detecting anomalies such as bearing wear, misalignment, unbalance, or structural damage. By continuously monitoring vibration levels and analysing data trends, maintenance professionals can identify potential issues before they escalate, enabling proactive maintenance and minimising downtime. In addition to industrial applications, vibration sensors are also used in consumer electronics, wearable devices, and medical equipment for various purposes such as motion detection, inertial measurements, and gesture recognition. Overall, vibration sensors are vital tools for ensuring the safety, reliability, and efficiency of mechanical systems and structures in a wide range of industries and applications.

5.L298n Driver:

The L298N is a binary H-ground motor motorist integrated circuit (IC) that’s extensively used in robotics, mechatronics, and other systems taking motor control. This protean IC allows druggies to control the direction and speed of two DC motors or a single stepper motor using a microcontroller or other control signal source. The L298N consists of two H-ground circuits, each able of driving a motor in either direction (forward or reverse) with PWM (palpitation range modulation) control for speed regulation. It can handle fairly high currents, making it suitable for driving motors with advanced power conditions. Also, the L298N incorporates erected-in flyback diodes to diodes to cover against back EMF (Electro Motive Force) generated by the motors during operation. The IC features two enable inputs (EN1 and EN2) that can be used to enable or disable the separate motor labors, allowing for independent control of each motor. It also has two sets of input legs (IN1, IN2, IN3, and IN4) for controlling the direction of gyration of the motors. By applying sense signals (high or low) to these input legs, druggies can control the direction of gyration and speed of the motors.

6. DC Motor:

A DC gear motor is a type of electric motor that integrates a gear box with a direct current (DC) motor. The combination of the motor and gearbox serves to increase torque while reducing the rotational speed of the output shaft. DC gear motors find application in various industries and devices where precise control of speed and torque is essential.

V. RESULTS AND DISCUSSION

The results of AI-based crack detection and monitoring for underwater applications have shown promising outcomes in enhancing the safety, efficiency, and reliability of submerged infrastructure. Through the utilization of advanced AI algorithms and sensor technologies, the system has demonstrated the capability to accurately detect and monitor cracks and structural anomalies in real-time. By analyzing data collected from underwater sensors, the AI model can effectively identify patterns and anomalies indicative of potential structural damage, enabling early detection and intervention to prevent catastrophic failures. Overall, AI-based crack detection and monitoring represent a significant advancement in underwater structural integrity management, offering improved safety, reliability, and performance of submerged infrastructure. The crack will be displayed in maximum of 95% accuracy.

In this development stage the project can attain over 15meter depth. The camera can able to display over 1080p & 30fps. As AI technology continues to evolve and mature it holds great potential for revolutionizing the way underwater assets are monitored and maintained, ensuring the longevity and sustainability of critical infrastructure in marine environments. It will show the live footage taken in underwater, using AI once the crack is detected it will display the detected cracks.

VI. CONCLUSION AND FUTURE SCOPE

AI-based crack detection and monitoring for under water applications represents a significant advancement in structural integrity management for submerged infrastructure. By leveraging artificial intelligence algorithms and sensor technologies, this innovation approach enables accurate and real- time detection of cracks and structural anomalies in underwater environment. The system offers numerous benefits, including enhanced safety, efficiency, and reliability of underwater infrastructure, as well as reduced maintenance costs and downtime. Overall, the future scope for AI-based crack detection and monitoring for underwater applications is vast and multidisciplinary, spanning areas such as artificial intelligence, robotics, marine engineering, and environmental science.

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