IoT Enabled Floating Robot For Enhanced Water Quality Measurement and Waste Management in Aquaculture

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***Abstract*—Research introduces an innovative solution for advancing water quality monitoring and waste management practices in aquaculture through the design and implementation of an Internet of Things (IoT)-enabled floating robot. Aquaculture ponds, crucial for sustainable food production, face challenges related to water quality degradation and waste accumulation. The proposed floating robot leverages cutting-edge IoT technologies and a diverse array of sensors to provide comprehensive and real-time insights into water conditions and facilitate targeted waste management. The proposed IoT-enabled floating robot offers a transformative approach to addressing water quality and waste management challenges in aquaculture ponds. By harnessing the power of IoT and advanced sensor technologies, this robotic solution contributes to the efficient and sustainable management of aquaculture ecosystems, ensuring the production of high-quality aquatic products while minimizing environmental impact.**

***Index Terms*—Water monitoring robot, Sensors, Actuators, Boat, IoT, Aquaculture**

I. Introduction

Rapid growth in aquaculture has occurred to fulfill the growing demand for aquatic products, as it is an essential part of the world food production system. The upkeep of ideal water quality in aquaculture ponds, however, is crucial to the industry's production and survival. Nowadays, water is considered as one of the most scarce natural resources on our planet [1]. It is important to humankind, animals, and plants [2]. In addition to protecting aquatic life's health and welfare, maintaining a balanced ecosystem affects aquaculture operations' capacity to make a profit. Conventional approaches to water parameter monitoring have mostly depended on hand sampling and recurring laboratory testing, providing a snapshot of the situation that might not include the dynamic variations that are characteristic of aquatic settings. An unparalleled chance to completely transform the aquaculture monitoring paradigm has arisen with the introduction of the Internet of Things (IoT).Therefore, technology is used in making agriculture more efficient without endangering the environment. Aquaponics is one approach which integrates plant and fish farming in a single system that relies on each other [3]. Aquaponics is an efficient way in food production involving plants and fishes simultaneously without endangering the environment [4]. Through the integration of IoT technology and robotics, this study aims to present a new approach: an IoT-enabled floating robot that is carefully designed to monitor water quality in real-time and efficiently manage trash in aquaculture ponds.With the goal of giving aquaculturists continuous, accurate, and useful data, this robotic innovation seeks to go beyond the constraints of traditional monitoring approaches. Consequently, it has the potential to transform the field of aquaculture management by promoting increased sustainability, effectiveness, and adaptability to changing environmental issues. Works by [5], [6], and [7] uses WeMos board for various IoT applications such as smart garbage monitoring and collection system, IoT based agriculture monitoring system, and IoT based weather information prototype. The design is simple since the WeMos board comes with a microcontroller integrated with a Wi-Fi module built-in together.The floating robot is equipped with a suite of sensors, including pH sensors, dissolved oxygen meters, temperature sensors, turbidity sensors, and nutrient level detectors. These sensors collectively ensure continuous monitoring of key water quality parameters critical for the well-being of aquatic organisms in aquaculture ponds. The real-time data generated by the robot enables prompt identification of fluctuations in water quality, empowering aquaculturists to take proactive measures to main- tain optimal conditions.Wireless communication capabilities enable seamless data transmission to a centralized platform, facilitating remote monitoring and analysis.

II. Literature Review

Water quality management has always been a great chal- lenge to the aquaculturist for cultivation of aquatic organisms under proper aquatic conditions.In today's time , the aquatic organisms are facing several threats, owing to deterioration of water quality due to excessive pollutants disposal. Extensive researches has been done on designing IoT enabled float- ing robot for water quality monitoring and management. In some previous work[8] , a system has been designed that is subdivided into different subsystems - intelligent robotic arm which has Arduino Mega 2560 as core component, sensor chamber consisting of various sensors like Temperature sensor
, pH sensor , Dissolved Oxygen sensor and four different chambers for collecting water samples from four different ponds , within the same subsystem. The research study used a programmable logic controller embedded with a PC- based server and NB-IoT technology has been used to transmit data to the server. In another research work , a low cost , real time water quality monitoring system [9] has been developed. The measured information is analyzed graphically and transmitted through a web based portal on mobile phones to end users.So, Cloud Computing has been used to transmit the data from cloud servers to users at distant locations. A further extended research has been done by making the robot floating, due to buoyancy , and its hull design incorporates DC geared motors with propellers , controlled by the motor driver L293D.This enables the robot to perform various movements such as moving backward , forward , left , right by the manipulationof DC motors and adjusting their polarity[10]. [11] A floating airboat was developed which contains a Raspberry Pi as the controller , a Wifi Router for connecting to smart devices and sensors . The airboat was used in two lagoons in Fortzela and in a reservoir in Pacatuba.The main purpose is to develop an autonomous system for collection and analysis of water quality parameters. Another good research paper [12] proposed a low cost advanced water garbage cleaning robot called 'Aquatic Iguana'. This robot basically moves on the water surface and collects waste materials and also monitors water parameters like temperature , pH , turbidity and a live streaming feature. Besides , these significant works , further researches are still going on regarding development of IoT based smart robot for water quality management as well as it's implementation in large scale.With the evolution of Industrial revolution 4.0
, works are going one to design 3D printed water quality monitoring system and thus , more advancement in developingsuch prototype is expected in the future also.

III. Methodology

A. Applied techniques and tools

1) Sensors

Industrial Grade Analog pH Sensor Kit for Arduino:

- Function: Provides an analog voltage output that corresponds to the pH level by measuring the acidityor alkalinity (pH) of water.
- Significance: pH values are essential markers of the quality of water. Low pH implies acidic water, which could be dangerous for aquatic life since heavy metals and other pollutants are present. On the other hand, high pH denotes basic water, which can interfere with biological activities and alter oxygen levels.
- Benefits: Industrial grade sensors are essential for long-term deployments because they provide excep- tional durability and dependability in challenging outside conditions.
- Ideal Value Range: A healthy pH range for the majority of freshwater habitats is between 6.5 and 8.5 [15]. Potential contamination incidents may be indicated by deviations from this range.
- Deployment: The sensor is immersed in water for deployment. To find the pH level, the Arduino readsthe analog voltage output.

DS18B20 Temperature Sensor:

- Features: Digital temperature sensor for water.
- Significance: Variations in water temperature can have a big impact on aquatic life and water quality. Injurious organisms can develop more quickly in warmer climates and dissolved oxygen levels can drop. On the other hand, lower temperatures have the potential to limit living things.
- Benefits: Suitable for applications involving envi- ronmental monitoring, the DS18B20 is an affordableand extremely precise digital sensor.
- Range of Ideal Values: Different ecosystems have different ideal water temperatures. Freshwater fish, on the other hand, often thrive in a temperature range of 15 to 25 degrees Celsius. A departure from this range may be a sign of possible environmental stresses.
- Deployment: Water submerges the sensor during deployment. The temperature is read via digital communication between it and the Arduino.

2) Actuators and Communication

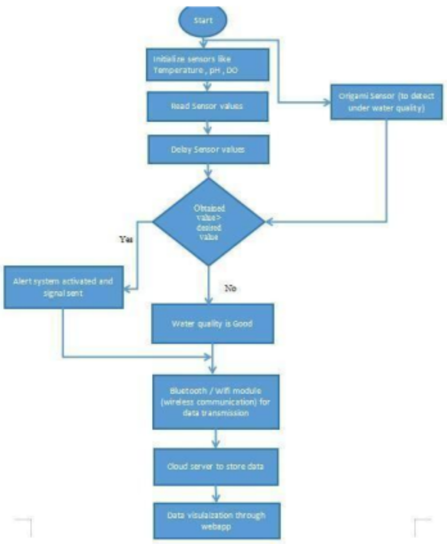
RF Module Kit (e.g., Bluetooth, Wi-Fi):

- Function: Allows sensor data (temperature, humid- ity, and pH) to be wirelessly transmitted to a base station or other device for analysis and monitoring.
- Significance: Since wireless connectivity enables remote data access, physically retrieving the robot for data gathering is no longer necessary. This is especially helpful in places with limited access or big bodies of water.

Fig. 1. Flow chart of the working model

- Benefits: By eliminating the constraints of conventional connections, wireless communication offers freedom in data collection.
- implementation: To send sensor data wirelessly, the Arduino and RF module communicate.

B. Algorithm



C. Working

- The whole circuit is connected to the floating base which is made of foam board or thermocol.
- Sun-board is used to make the rotating blades of the wheels.
- The wheels (BO wheels) are attached with the gear motor (BO motor) so that the whole attached can rotate to enable the boat to move.
- RF module is used instead of relay because relay has more cost complexity. Rf module is used along with the motors.
- In the No33 box - ESP32, Buck converter, vero board, ph sensor module, DHT sensor are contained inside it.
- Rocker Switch is used for on and off the system to retain battery consumption.
- The battery used in this water monitoring robot is 2200 mah Lithium ion Battery.
- The whole structure is attached in such a way which makes the boat floatable and easy to move.
- A remote is used for controlling the movement of the water monitoring robot.
- Since pH sensor, DHT sensor and Waterproof temp sensor are used, the data we get is presented in terms of numeric level meter (pH of the water body, Humidity and Temperature [environment surrounding the robot] and Temperature of the water body).

Fig. 2. Enter Caption

- The platform used for wireless transmission of data is Blynk IoT. When the boat system is made on it starts sensing the environment it is in, then the sensed data is wirelessly transmitted to mobile applications using the wifi module.
- The wifi module is made working by connecting it to the internet or network access with detailed credentials.
- Moreover the sensed data is observed in the mobile application (Blynk IoT), according to the algorithm if observed values do not meet the desired values , then an alert signal is sent wirelessly to the connected platform and the user can take action.
- Further details are explained using the algorithm given below.

IV. RESULT

The datas obtained in the form of graphs can be processed and analyzed using some machine learning algorithms. Based on the statistical data analysis , the trend of aquatic water bodies can be observed and also the water bodies suitable for aqua-cultural activities can be identified.This will help in identification as well as labelling of different aquatic bodies on the basis of water quality parameters and thus , the aquatic life will be free from life threats.

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V. FUTURE WORK

- future work for IoT-enabled floating robots in aquaculture couldinvolve enhancing sensor capabilities for more precise water qualityMeasurements.
- ORIGAMI / FOLDABLE : The ensors and actuators
- Implementing machine learning algorithms to enhance the robots'
- decision-making abilities in dynamic aquaculture environments.

VI. CONCLUSION

To sum up aquaculturists can reap a number of advantages by installing an internet of Things -based floating water quality monitoring system system in their ponds.This system delivers real-time data that is essential for preserving the ideal conditions for aquatic life by continuously monitoring critical factors like pH,dissolved oxygen,temperature and turbidity.Aquaculturists can reduce the risks,optimize operations and make well-informed decisions through remote access and data visualization,which eventually improves productivity and sustainability in aquaculture methods.By creating healthier habitats for aquatic life and promoting the expansion of the aquaculture sector,this creative approach represents a breakthrough in precision aquaculture management.

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