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Improving Aquaculture Efficiency Through an Integrated Monitoring system

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ABSTRACT

The aquaculture industry has become increasingly important to meet the growing global demand for seafood. The use of Internet of Things (IoT) technology has become crucial to ensure the sustainability of fish farming practices. This summary provides an overview of IoT-based approaches to aquaculture fish farming. With IoT technologies such as Arduino UNO R3, DS18B20 waterproof temperature sensors, turbidity sensors, R365 DC 12V water pump, pH sensor, relays, and NodeMCU 8266 WiFi module, fish farmers can now monitor and control various factors of aquaculture systems. With real-time data collected by programs like ThingSpeak, farmers can maximize fish growth, minimize resource waste, and make informed decisions. This project highlights the main benefits of IoT-based fish farming, including water level management and monitoring. In addition, IoT-based solutions play a key role in optimizing production and reducing labour costs. The main controller of this system is an Arduino Uno, which is known for its flexibility and low price. Its ability to communicate with a wide range of sensors and actuators makes it an excellent choice for managing aquaculture conditions. In addition, the IoT connection enables a quick response to changes in measured parameters. In unsatisfactory situations, automatic alarms and notifications can be triggered, enabling quick corrective actions. Due to its scalability and easy integration with existing aquaculture systems, this system is a valuable tool for the industry. The introduction of such a system should promote the long-term growth of aquaculture by reducing operational risks and costs.

Keywords: Iot, Arduino UNO, Sensors, Wifi Module, Thingspeak, Aquaculture, Water Level Management, Real-Time Data, Regulate

I. INTRODUCTION

Aquaculture, which involves the cultivation of aquatic organisms, has become a critical economic sector as global demand for seafood grows. As wild fisheries are already overfished, sustainable and efficient aquaculture methods are now needed to maintain safety and mitigate the negative environmental impacts of overfishing. In this regard, the application of Internet of Things (IoT) technology in aquaculture has become important. By applying innovative methods to monitor environmental conditions, increase productivity, and improve the welfare of aquatic animals, our project aims to transform the aquaculture sector through the Internet of Things. Our project integrates cutting-edge technologies such as relays, Arduino Uno microcontrollers, and waterproof temperature and turbidity sensors to create a system that streamlines fish farming methods and promotes sustainability. practices We strive to solve the central problems of traditional aquaculture, such as water quality management, optimization of water level metrics, and more, with an emphasis on promoting ecologically sustainable and economically viable solutions. Let's dive into the specifics of our project and explore the various components that make up the core of our IoT aquaculture system. Our waterproof sensors provide fish farmers with real-time information on water temperature, turbidity, and other critical parameters so they can make informed decisions. Acting as a central unit, the Arduino Uno collects and analyses this data before triggering automatic actions via relays to ensure optimal conditions for fish development.

PROBLEM STATEMENT: The objective of this project is to design and build an IoT-based aquaculture monitoring and control system using Arduino Uno, various sensors, and relays. Our main goal is to provide a system that can continuously monitor important environmental parameters such as water temperature, pH,

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turbidity, and water height. Using sensors, we collect real-time information about the aquaculture environment and send it to the central control unit. We also use actuators and relays to control components such as heaters, ventilation systems, and water pumps. This enables automatic adjustments based on monitoring data. In addition, we aim to provide aquaculture managers with the ability to remotely monitor and control the system via mobile or web, allowing access from anywhere.

II. LITERATURE SURVEY

The literature review includes several articles on the effects of improved water quality parameters on aquatic organisms [1]. IoT has been found as a solution to this problem. K.Raghu Sita Rama Raju and G.Harish Kumar Varma (2017) developed a data-based real-time aquaculture monitoring system using IoT; which uses various sensors such as dissolved oxygen, temperature, ammonia, salt, pH, nitrate, and carbonates [2]. However, using many sensors is expensive and time-consuming. Therefore, there is a need for a low-cost system that can effectively determine the total water quality. This is where our research begins.

After extensive research on IoT, we were able to exploit its full potential. Research has mostly focused on certain types of sensors, such as pH, turbidity, and others, and their corresponding solutions [3], [4]. However, it is important to note that different chemical, physical, and biological aspects of water can affect fish production to varying degrees. IoT technology aims to identify, monitor, track, and locate things using data communication and connectivity between devices. Several devices have been developed to enable real-time monitoring in remote locations, including new sensor technologies, wireless communication technology, and data transmission technology [5].

Our extensive research has led us to the conclusion that not all parameters require monitoring. We can infer the status of some parameters based on their number, because some parameters imbalance can lead to imbalance in other parameters. Our first, second, third, and fourth operating parameters are temperature, pH, turbidity, and water level respectively. We now discuss the reasons for this [5].

Temperature. The most important factor is temperature, which has a significant effect on biological and chemical processes. For every temperature increase of 10 °C, the values of chemical and biological reactions increased. Fish are cold-blooded animals that regulate their body temperature according to weather conditions. The temperature varies depending on the type of fish but is controlled and kept within a certain range. Higher temperatures increase fish metabolism, increase feeding and respiration, and generally increase movement as temperature varies with water depth. The need for dissolved oxygen increases with increasing temperature [1].

Turbidity is another physical element. The colour of the water indicates the type of turbidity. If the water is clear, it indicates little biological production and fish cannot live in it because it is not fertile enough. If the colour is green, it is caused by algae, and if it is brown, it is caused by clay. Sludge water is also harmful to fish because fish and gills can become clogged with clay particles, resulting in fish kills. Greenish water indicates excessive plankton [1]. The turbidity of water is due to the presence of these suspended particles in varying amounts. Water level the third factor is the water level.

Changes in the water level of the fish pond affect the behavior of the fish. Fish tend to congregate in certain areas of the pond where they can feed and relax. As water levels drop in an area, fish are more likely to compete for survival[5].

PH. Another water quality control parameter is pH, which should be between 6.5 and 8.5 for fish to survive. Fish become sluggish and stressed in water below 6.5 pH, and death is almost certain at pH 4.0 and above 11.0. pH is also known as hydrogen potential. Night breathing can cause fish to lack oxygen. In response, PH indicates whether the water is acidic or basic. The pH value of low alkalinity is 6-8 during the day, but when phytoplankton development accelerates at night, the pH level increases to 10 or higher. Carbon dioxide and ions affect changes in the pH of pond water [1].

Having a good understanding of water quality is essential for effective pond management. Water quality is measured by various parameters such as temperature, turbidity, transparency, colour, and pH, each of which

has an acceptable and desirable range, as shown in Table 1. These parameters can significantly affect water quality [6]. Some of the previous approaches proposed by the authors used cloud databases to store the output data, which made the architecture expensive due to the high consumption of the Internet. Our solution is to use a computer system as a server host to calculate, manage, and display the output values produced by the sensors. This approach is more cost-effective because the user can easily manage and retrieve the output values with minimal network overhead. If any of the parameters listed in Table 1 exceed the acceptable or desired range, our model provides a solution.

In addition, our model takes into account other factors that may affect fish growth. Most research papers emphasize four parameters: pH, temperature, turbidity, and water level.

Table 1: Describes the different water parameter ranges and their solutions[1][5].

Parameters	Range	Solution (if parameters cross the range)
PH	6.5 ~ 8.5	Pumping fresh water
Temperature	20C-30C	Pumping fresh water
Turbidity	6-7 ppm	Change thewater/Recycle the water
Water level Detection	>40%	Pumping fresh water

III. REQUIRED HARDWARE AND SOFTWARE

Arduino Uno: The Arduino UNO is an ATmega328P-based microcontroller board. It contains 14 digital I/O pins (six of which are PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino may be a single-board microcontroller meant to make the appliance more accessible which are interactive objects and its surroundings[7]. It contains everything needed to support the microcontroller simply connect it to a computer with a USB cable or battery to get started[8].

Sensors:

The **DS18B20 Waterproof temperature sensor** is a digital temperature sensor commonly used for measuring temperature in various applications. It's designed for immersion in liquids and wet environments, with an operating voltage range of 3.0V to 5.5V. This 1-wire programmable sensor operates using 1-Wire communication, with an info pin connected to a microcontroller and a pull-up resistor to maintain the bus in a high state when not in use. Its temperature range is from -25°C to -28°C, and its purpose is to monitor and maintain water temperature within a specified range[7],[11].

Turbidity sensors, or turbidimeters, are used to detect cloudiness or haziness in fluids caused by suspended solid particles. They find application in environmental monitoring, water treatment, and industrial processes, assessing water quality by measuring light transmission and dissipation to identify suspended particles. This sensor utilizes laser rays to analyze water quality, with the amount of reflected light indicating particle density [12].

pH sensors measure the acidity or alkalinity of a liquid, typically on a scale of 0 to 14, where 7 is neutral. They are widely used in chemistry, biology, environmental science, and industry. The Analog pH Sensor Kit is designed for Arduino controllers and features a power indicator, BNC connector, and PH2.0 sensor interface, illuminated by an LED[7].

Wi-Fi Module: One popular board for IoT and Wi-Fi projects is the NodeMCU ESP8266 CP2102 WiFi module. Its ESP8266 microcontroller serves as its foundation, and for simple programming, it has a USB-to-serial converter (CP2102). This module has been used in many Internet of Things applications, such as integrating with Arduino and establishing a connection with a continuous recovery server, and it provides flexible

connectivity options[8].

The **Arduino IDE** is a cross-platform application available for Windows, macOS, and Linux. It is the primary software tool for writing and uploading code to Arduino boards.

ThingSpeak is an open-source IoT platform developed by MathWorks. It allows you to collect, analyze, and visualize data from different IoT devices. What makes ThingSpeak stand out is its open nature, which enables users to customize and extend their IoT applications using MATLAB and Simulink. This feature has made it popular among researchers, hobbyists, and businesses. With tools for data logging, real-time data processing, and custom analytics, ThingSpeak helps users monitor, manage, and gain valuable insights from their connected devices, driving the growth of the IoT ecosystem.

IV. PROPOSED SYSTEM

This paper proposes the establishment of an IoT-based aquaculture system to improve water quality and monitor the fishing industry. Important parameters such as suitable temperature and pH level were considered in this study. The proposed system should make the aquatic environment more profitable, productive, and sustainable. For the fish to grow properly, we also need to focus on things that harm the aquatic environment. The overall objective of the survey was to ensure fish health to increase fish production. For this, an IoT-based fish monitoring system was built, which checks basic measurements and ensures that the fish are healthy and get everything they need for a happy life. Fisheries can use this system to determine the pH level and temperature and provide the necessary equipment to maintain a balanced level. As a result, the fish grow healthy.

V. SCOPE

The IoT-based aquaculture monitoring and control system is a complete solution to optimize aquaculture conditions, reduce waste, and increase energy efficiency. With continuous monitoring, this system helps prevent disease and promotes the overall health and growth of aquatic species. Automation features, such as adjusting ventilation based on real-time data, reduce operating costs and increase revenue. In addition, incorporating the Internet of Things into aquaculture improves the sustainability of aquaculture practices by minimizing environmental impacts by closely monitoring water quality and natural resources. It also enables predictive analytics to identify potential problems at an early stage.

VI. LIMITATIONS

Arduino Uno is a popular choice for many DIY Internet of Things (IoT) projects. However, it may not be suitable for certain applications due to several limitations. For example, a card has limited processing power and memory, which can limit its ability to handle complex data analysis and decision-making tasks. Additionally, its connectivity options are limited, with no built-in Wi-Fi or Ethernet options. This means that external shields or modules may be required, causing data transfer speed and reliability issues. Additionally, the board has a limited number of digital and analog I/O pins, which can be a limitation when using multiple sensors and actuators for monitoring and control. Another issue is scalability, as the Arduino Uno may not be suitable for large-scale aquaculture applications due to the number of sensors and devices required. Real-time processing capabilities are also limited, which can cause problems in applications that require fast response times, such as controlling pumps or aerators. Security is critical in IoT systems, and Arduino Uno may lack built-in security measures, leaving the system vulnerable to unauthorized use and data breaches. Data storage on the Arduino Uno is limited, requiring the use of external storage solutions for long-term data logging and historical analysis. In addition, compatibility issues can make it difficult to ensure compatibility with all sensors and actuators. Ongoing maintenance and support can be a challenge as the platform is primarily DIY and offers limited support compared to industrial IoT solutions. Additionally, managing software and firmware updates can be difficult, jeopardizing system stability and security.

VII. FUTURE WORK

The future of aquaculture monitoring and control systems based on the Internet of Things (IoT) holds great promise for increasing the sustainability and efficiency of the aquaculture industry. As technology continues to advance, significant developments are likely to occur in several key areas. First, IoT sensors are becoming more sophisticated and cost-effective, enabling real-time monitoring of water quality, temperature, dissolved oxygen, and more. It provides accurate information for timely action and proactive management of aquaculture conditions. Advanced data analytics and artificial intelligence are integrated into aquaculture systems that process large data sets to predict diseases, optimize feeding schedules, and reduce operating costs. Remote management via IoT allows aquaculture farmers to remotely monitor and control operations, including nutrient systems, water quality control, and automatic collection, reducing labour requirements and ensuring 24/7 monitoring. Environmental sustainability is a priority because IoT-based systems reduce water and energy use, reduce waste, and impact surrounding ecosystems. In addition, future systems will prioritize secure connectivity, information security, and system resilience, protecting aquaculture facilities against cyber threats and ensuring uninterrupted operations.

VIII. CONCLUSION

Aquaculture monitoring and control systems based on the Internet of Things (IoT) have several advantages. They enable remote monitoring, real-time data collection, and automation of key processes such as environmental monitoring and water quality management. This in turn can increase productivity, lower operating costs and improve sustainability across the aquaculture industry. However, for such a system to be effective, several critical factors must be considered, including scalability, connectivity, and sensor accuracy. Overall, IoT technology has the potential to significantly improve aquaculture, promote ethical and productive seafood, and promote sustainability.

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