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IoT based Smart Aquaculture Monitoring System for Fish Tank Management

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Abstract

Aquaculture, the farming of aquatic organisms, plays a critical role in meeting the increasing global demand for seafood. Effective monitoring and management of aquaculture systems are essential for ensuring optimal conditions and maximizing productivity. This research presents a comprehensive aquaculture-based fish tank monitoring system designed to enhance operational efficiency and fish welfare. At the heart of the system is the Arduino Uno microcontroller, serving as the central processing unit to coordinate various functions. Key components include pH sensor for continuous monitoring of acidity levels, turbidity sensor for detecting suspended particles, and water level sensor for maintaining optical water levels within the tank. In the event of abnormal pH levels or high turbidity, the system triggers automated alerts, sending notifications to the designated owner through SMS and transmitting data to an IoT website for remote monitoring. To ensure consistent environmental conditions, two pump motors are utilized: one for automatic water replenishment in case of water level fluctuations and another for removing water in case of particle accumulation. Furthermore, the system integrates a servo motor mechanism for precise dispensing of fish feed at predetermined intervals, promoting healthy growth and nutrition. Control over pump motors and feeding schedules is facilitated through a user-friendly website interface, providing operators with seamless management capabilities.

Keywords: Aquaculture Monitoring, Arduino Uno, pH Sensor, Turbidity Sensor, IoT Remote Monitoring

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1. Introduction

The production of aquatic organisms, or aquaculture, is essential to supplying seafood to the world's growing seafood market. Ensuring optimal conditions and optimizing productivity in aquaculture systems require efficient monitoring and management. This study proposes a comprehensive fish tank monitoring system based on aquaculture that aims to improve fish welfare and operational efficiency. The Arduino Uno microcontroller, acts as the system's central processing unit and manages many tasks. Three essential parts are the water level sensor which maintains optimal water levels in the tank, the turbidity sensor, which detects suspended particles, and the pH sensor, which continuously measures the acidity levels in the tank.[1]-[15]. In the event of abnormal pH levels, high turbidity [2]-[5], [8]-[12] or water level [2]-[4],[10]-[13] the system triggers automated alerts, sending notifications to the designated owner through SMS [9],[15] and transmits data to an IoT website [2]-[14] for remote monitoring. To ensure consistent environmental conditions, two pump motors are utilized: one for automatic water refilling in case of water level fluctuations and another for removing water in case of particle accumulation. Furthermore, the system integrates a servo motor mechanism for precise dispensing of fish feed at predetermined intervals, promoting healthy growth and nutrition. Control over pump motors and feeding schedules is facilitated through a user-friendly website interface, providing operators with seamless management capabilities. n Internet of Things (IoT) system monitors and reports the aquarium's status, controlling water quality and physical variations in the tank through automated feeding and light monitoring [1] [4]. Aquarists also check the feed conditions and take appropriate actions. Food is provided three to four times a day, and the water is frequently cleaned. The water cleaning equipment includes automatic detection and salinity removal capabilities. This is an extensive application of wireless networks in aquaculture aquariums. For large-scale aquaculture, a wireless network application and a water quality testing device are used.

2. Proposed

The proposed system integrates advanced sensors, including pH, turbidity, and water level sensors, to provide complete monitoring of important water quality parameters. Utilizing the Arduino Uno (ARDUINO IDE) microcontroller, the system allows real-time monitoring of these parameters, enabling immediate detection and response to deviations. Two pump motors, connected through a motor driver, regulate water inflow and outflow based on monitored water quality parameters.

The pH sensor is connected to an Arduino Uno microcontroller to continuously monitor the pH level in the water, displaying the value on the LCD screen. If the pH level is less than 7 or above 7, a SMS is forwarded using GSM, and a ‘pH abnormal’ message is displayed on the LCD. Additionally, the pH data can be monitored remotely through the io.adafruit.com website.

The turbidity sensor is used to detect the dust particles in the water and display the readings on the LCD screen. A fish feeding setup, controlled by the servo motor, is fixed on the top of the tank, to automate the feeding process based on the predetermined time intervals.

2.1 Block Diagram

The proposed system includes three main modules, which are as follows

- Parameter Monitoring
- Water Circulation
- Feeding Module

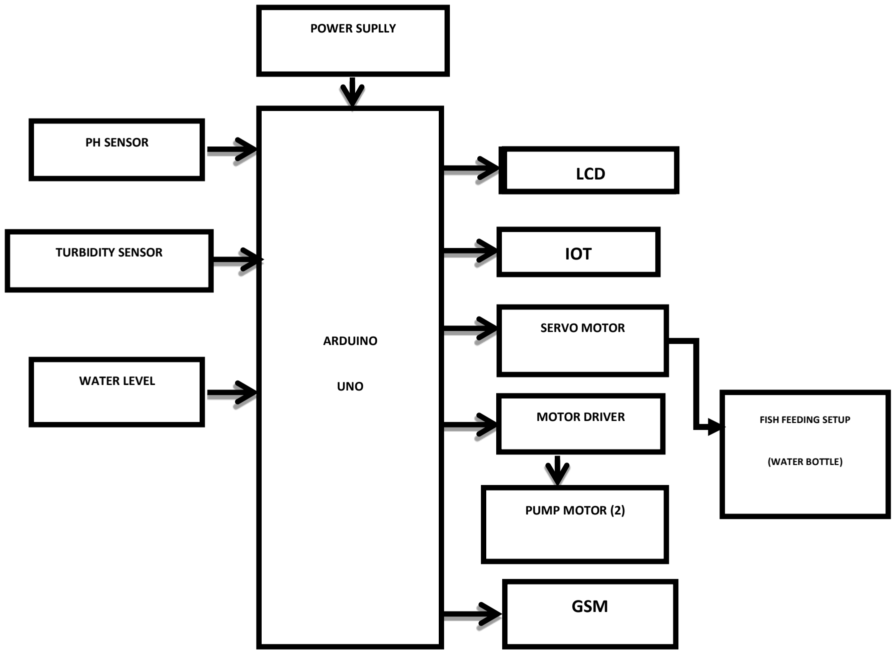


Figure.1 Proposed Block Diagram

The Figure.1 shows the proposed block diagram of smart aquaculture monitoring system for fish tank management.

- **Parameter Monitoring**

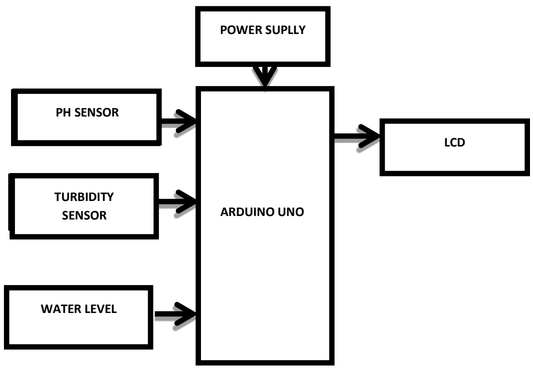


Figure 2. Parameter Monitoring Module

In this module (Figure 2), the Arduino Uno microcontroller is utilized as the central processing unit, serving as the brain of the aquaculture-based fish tank monitoring system. The primary components incorporated are pH sensors for monitoring acidity levels, turbidity sensors for detecting suspended particles, and water level sensors for assessing water levels within the fish tank.

The pH sensor enables the system to continuously monitor pH levels, essential for maintaining the optimal aquatic environment for fish. Additionally, the turbidity sensor plays a crucial role in identifying dust particles present in the water, which could affect water quality and fish health. Furthermore, the water level sensor ensures that the water level within the fish tank remains within the desired range

- **Water Circulation**

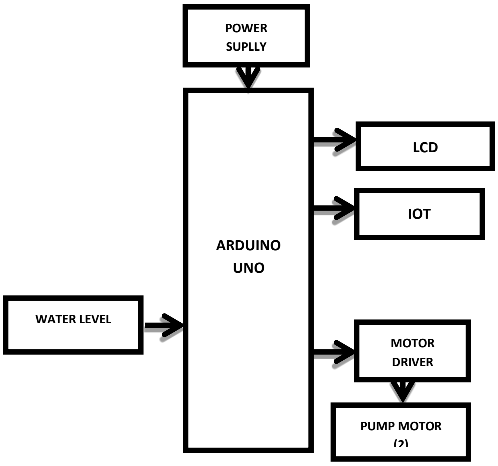


Figure 3. Water Circulation Module

In this module (Figure 3), the system is centered around the Arduino Uno microcontroller, which serves as the central processing unit. The water level sensor is utilized to monitor the level of water within the fish tank. When the water level drops below a certain threshold, the system triggers a pump motor to automatically fill the tank with water. Additionally, a turbidity sensor is employed to detect the presence of dust particles in the fish tank. If the turbidity sensor detects an accumulation of dust particles, the system activates another pump motor to extract water from the tank, effectively removing the impurities.

• **Fish Feeding Module**

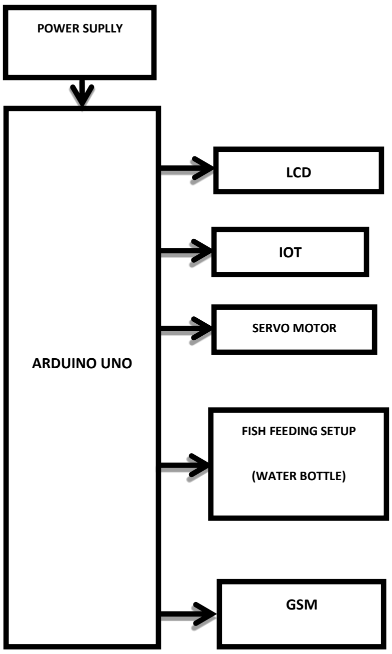


Figure.4 Fish Feeding Module

In this module (Figure 4), a feeding mechanism for the fish is facilitated by a servo motor connected to a water bottle. When the servo motor is activated, it opens the water bottle, releasing food into the fish tank to feed the fish. The servo motor is controlled through an IoT website, using the ESP8266 microcontroller.

The IoT website interface, allows the users to remotely initiate the feeding process, ensuring timely and precise dispensing of food for the fish. This integration of IoT technology enables convenient and efficient management of fish feeding schedules, promoting healthy growth and nutrition for the aquatic inhabitants.

In this innovative aquaculture-based fish tank monitoring system, the Arduino Uno microcontroller serves as the central processing unit, controlling various functions. Key components include a pH sensor for monitoring acidity levels, a turbidity sensor for detecting dust particles, and a water level sensor for gauging water levels within the tank.

Upon detecting abnormal pH levels or high turbidity, the system autonomously transmits alerts to an IoT website and sends SMS notifications to the designated owner. To maintain optimal conditions, two pump motors are employed: one for automatic water replenishment when levels drop and another for removing water in case of excessive particle accumulation.

Furthermore, the system features a servo motor responsible for dispensing fish feed at specified intervals. Control over pump motors and feeding schedules can be seamlessly managed through the dedicated website interface, ensuring precise and efficient operation of the aquaculture system. The Table .1 below shows the components used in the proposed work.

Table.1 Hardware and Software Requirements

Hardware Used	**SPECIFICATION**
1. Arduino Uno	ATmega328P
2. pH sensor	ATMEGA8 IC
3. Water level sensor	ARD2-3025
4. Servo motor	SG90
5. Turbidity sensor	SKU: SEN1089
6. GSM	SIM900
7. Motor driver	L293D IC
Software used	**Uses**
1. ARDUINO IDE	The code for the Arduino Uno, which integrates and controls the sensor, motors, and other components in fish tank monitoring system, is written and uploaded using the Arduino IDE.
2. EMBEDDED C	Used in developing the firmware for the microcontroller, enabling precise control over the hardware operations and communication protocols.

2.2 Flowchart

Figure 5 and 6 shows the flowchart of the parameter module for pH detection and feeding module for feeding the fish based on the predetermined times, respectively.

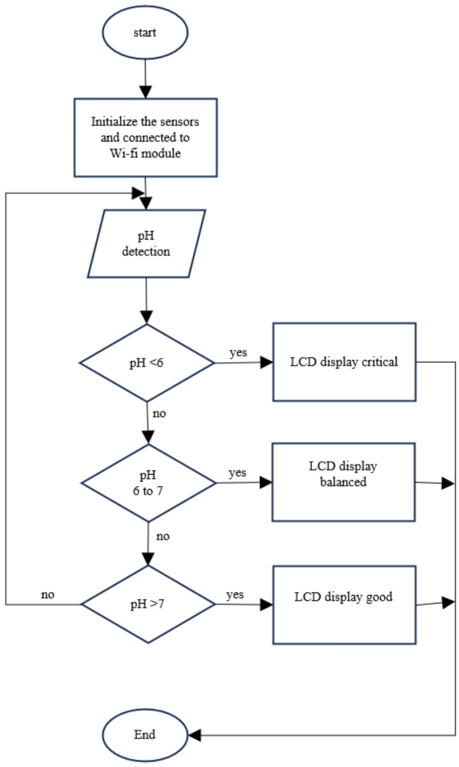


Figure.5 Flowchart for pH Detection

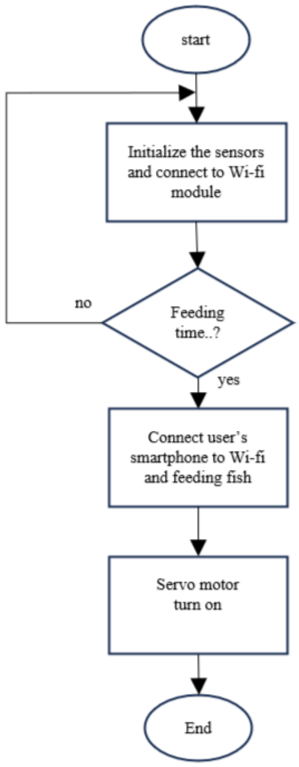
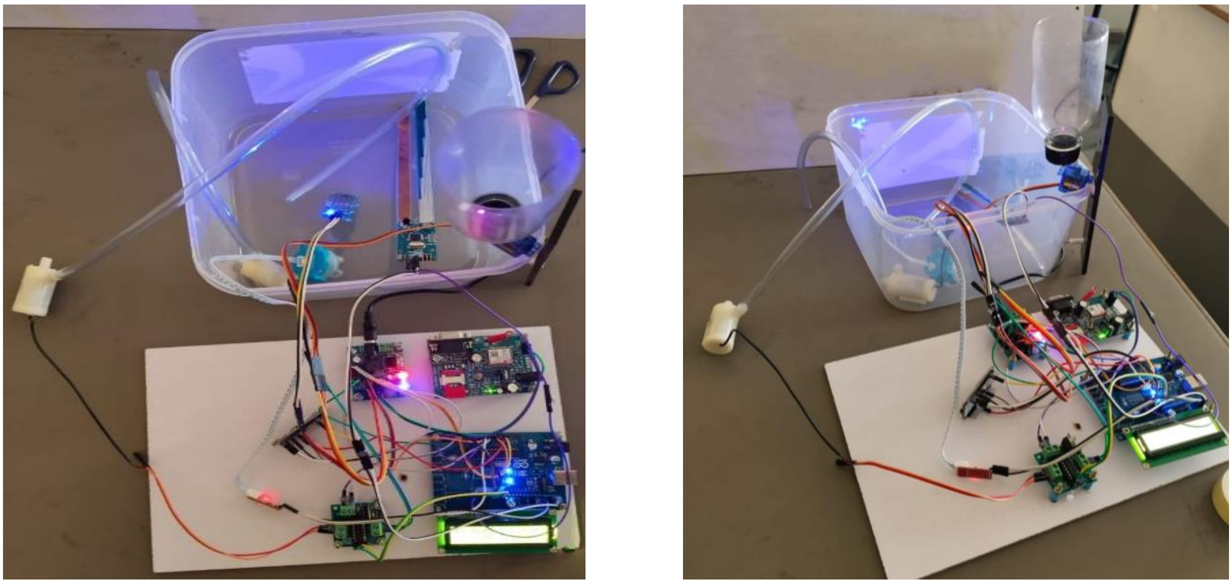


Figure.6 Flowchart for Fish Feeding

3. Results and Discussion

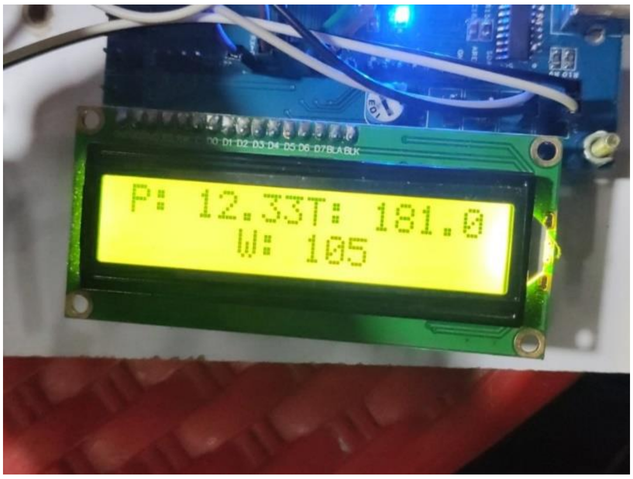
The smart aquaculture monitoring system was designed and implemented using the Arduino IDE and Embedded C programming. The code to integrate and control the sensors was developed by integrating libraries for the sensors and communication modules, which were then uploaded to the Arduino Uno using the Arduino IDE. Firmware in Embedded C enabled precise hardware control, optimized for performance and interrupt handling.

In practical implementation, depicted in Figure 7, Arduino pins were initialized for sensor and actuator connections. Functions were developed to accurately read sensor data and execute necessary actions. Communication protocols ensured timely SMS alerts through the GSM module for pH abnormalities, while IoT integration through the ESP8266 enabled remote monitoring and control through an online platform. Additionally, a servo motor was programmed to dispense fish feed at scheduled intervals, promoting fish nutrition and growth in the monitored environment.



(a) (b)

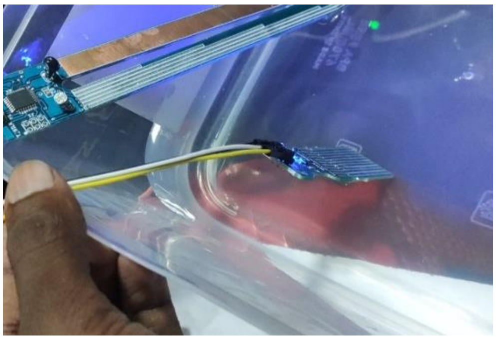
Figure.7 Hardware Prototype (a) Top View (b) Side View



(a) (b)

Figure.8 (a) (b). pH Sensor Output

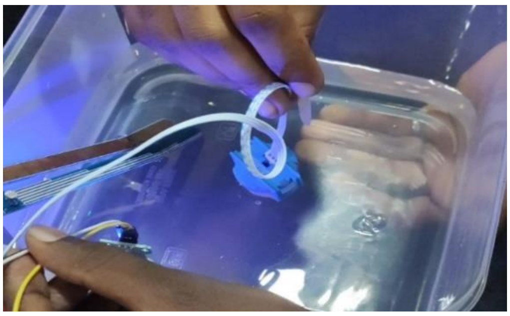
Figure 8 illustrates the pH detection process, where pH sensors (a) immersed in the fish tank continuously monitor the water's pH level and display the readings on the LCD screen (b).



(a) (b)

Figure 9 (a), (b) Water Level Sensor Output

Figure 9 illustrates the water level sensor output, the water level sensors (a) immersed in the fish tank continuously monitors the level of the water in the fish tank and displays the readings on the LCD screen (b).

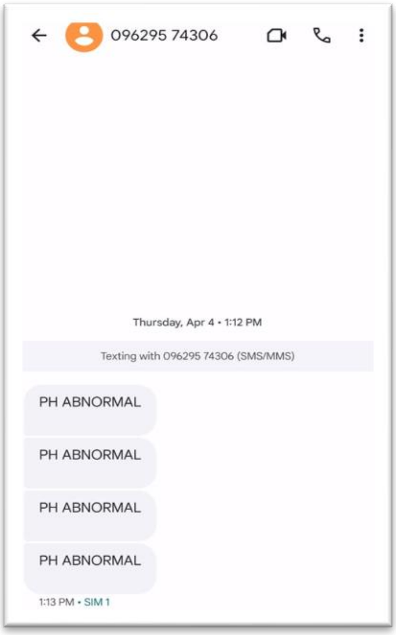


(a) (b)

Figure 10 (a), (b) Turbidity Sensor Output

Figure 10 illustrates the turbidity sensor output, the turbidity sensors (a) immersed in the fish tank continuously monitors the level of the water in the fish tank and displays the readings on the LCD screen (b).

(a)



(b)

Figure 11 (a) LCD Display, (b) SMS Alert

On detecting any abnormalities, the alert is forwarded as SMS through GSM and also displayed on the LCD screen as shown in Figure 11.

Figure 12 Web Monitoring Output

Additionally, the system also enables the information to monitored remotely through io.adafruit.com website as shown in Figure12.

4. Future Enhancement

Apart from pH, turbidity, and water level sensors, integrating additional sensors such as dissolved oxygen sensors, temperature sensors, ammonia sensors, or nitrate sensors can provide more comprehensive monitoring of water quality parameters. This broader dataset can offer deeper insights into the overall health of the aquatic environment.

5. Conclusion

This proposed system offers a comprehensive aquaculture monitoring for fish tank management by integrating the sensors, microcontroller, IoT technology. The system enables a robust functionality to maintain the optimal conditions in the fish tank. By integrating pH sensors, turbidity sensors, and water level sensors, the system continuously monitors key parameters essential for fish health. Automated alerts as SMS and LCD notifications ensure quick responses to abnormalities, while remote monitoring through io.adafruit.com enhances accessibility and management efficiency. The system's ability to control pump motors for water management and a servo motor for precise fish feeding further promotes sustainable aquaculture practices. Overall, this integrated approach supports efficient and effective fish tank management.

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