

Smart Aquarium Monitoring System

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Abstract—Nowadays, a lot of individuals keep fish as pets in their homes. The aquarist has been feeding the fish in the aquarium tanks, therefore correct setup and maintenance are required. The issues include shifting water quality, feeding the fish, keeping the temperature stable, managing the lights, and finding it challenging to physically verify the conditions of an aquarium. As a result, it's essential to regularly check the physical characteristics and improve the water quality. Thus, the system that this project suggests is fitted with sensors and may be used in real time. It carries out water renewal, aeration system, temperature monitoring, and pH level detection. A system based on the Internet of Things is put in place to keep an eye on the aquarium and provide updates to the user's mobile application. As a result, clever aquarium management has been put in place to ensure that the fish are neither overfed nor underfed, thereby lowering the amount of manual labor needed to maintain the aquarium.

Index Terms—Aquarium, Internet of Things, Fish feeding, Mobile Application, Turbidity Sensor.

I. INTRODUCTION

The number of people who keep fish has significantly increased in recent years, which is indicative of the growing popularity of aquariums as a pastime and a peaceful retreat. But keeping an aquarium clean and healthy for the fish can be difficult because it needs to be managed and observed all the time. Conventional aquarium systems need aquarists to actively monitor and control a number of parameters, including temperature, lighting, and feeding schedules. Fish usually need to be fed twice a day, and it can be challenging to provide constant care when the fish keepers are not there. This can lead to missed feedings and even harmful circumstances for the fish. In order to overcome these obstacles, we have created the IoT-Based Smart Aquarium System, an economical and effective fix that automates the maintenance procedure. With the help of this creative system,

automatic controls may be smoothly added to any current

II. METHODOLOGY

• Analyzing Requirements and System Design

Aquarium arrangement, negating the need for manual intervention. The user receives real-time data from the Smart Aquarium System, which continuously analyzes important water parameters like temperature and pH levels. Fish keepers may remotely control lighting, temperature, and feeding schedules through an intuitive interface, providing the best possible conditions for their aquatic animals even when they are not there. Our research makes use of the Internet of Things (IoT) to build an intelligent, networked system that improves fish care while making the aquarist's duties easier. By giving fish the proper amount of food at regular intervals, the automated feeding feature keeps them from being overfed or underfed. Furthermore, automatic lighting and temperature settings mimic natural environments, enhancing the fish's wellbeing.

Define the system's main objectives, including temperature control, water quality monitoring, automatic feeding, and lighting management.

Acquiring Requirements: Find out what the users' special demands are, what factors (such as pH, temperature, and ammonia levels) need to be monitored, how often data needs to be collected, and what kind of user interface is needed. Selection of Components: Select the proper actuators, sensors, microcontrollers, and communication modules.

III. DEVELOPMENT OF HARDWARE SENSOR INTEGRATION

Temperature Sensor: To detect the temperature of the water, use a dependable temperature sensor (such as the DS18B20). Select a pH sensor that works with the

microcontroller to keep track of the water's acidity or alkalinity. Ammonia, nitrite, and nitrate sensors are optionally included in water quality sensors.

Feeding Mechanism: Create and put into place an automatic feeder that dispenses food at predetermined intervals using a servo or stepper motor. **Lighting Control:** To replicate the cycles of natural light, integrate LED lights with programmable controllers.

Microcontroller: To interface with sensors and actuators, use a microcontroller (such as an Arduino or Raspberry Pi). **Connectivity Module:** Include Bluetooth or Wi-Fi modules (like the ESP8266) to provide remote control and monitoring.

IV. FIRMWARE PROGRAMMING FOR SOFTWARE DEVELOPMENT

Create firmware that instructs the microcontroller to: Gather sensor data. Actuators that control heater, lighting, and feeders. Speak with the cloud or server.

Cloud Integration: Construct a cloud server for data processing and archiving. Make use of services like Firebase, Google Cloud, and AWS IoT. Create a web or mobile application that allows users to: Track data in real time. Get notifications and alerts. Remotely adjust the aquarium's settings.

User Interface: Make sure the program has a user-friendly interface that makes it simple to navigate and operate.

Data Collection: Implement continuous data logging from the sensors. **Threshold Setting:** Define safe ranges for temperature, pH, and other parameters. Program the system to trigger alerts if values go out of range. **Automated Control Algorithms:** Develop algorithms to automate responses, such as adjusting the heater if the temperature drops or dispensing food at set times.

V. TESTING AND CALIBRATION BENCH TESTING

Conduct initial tests to verify individual components and their integration. **Calibration:** Calibrate sensors to

ensure accurate readings. For instance, pH sensors may need to be calibrated with buffer solutions. **Field Testing:** Install the system in an actual aquarium and monitor its performance over time. **User Feedback:** Collect feedback from beta users to identify issues and improve the system.

VI. DEPLOYMENT AND MAINTENANCE INSTALLATION

Provide guidelines for users on how to install and set up the system in their aquariums. **User Training:** Offer tutorials and support to help users understand and utilize the system effectively. **Maintenance and Updates:** Regularly update the software to fix bugs, enhance features, and ensure compatibility with new hardware.

VII. EVALUATION AND IMPROVEMENT PERFORMANCE EVALUATION

Continuously monitor the system's performance and reliability. **Iterative Improvement:** Make iterative enhancements based on performance data and user feedback.

Design

A smart aquarium system includes sensors (temperature, pH, water quality), actuators (heater, feeder, pumps, lights), and a microcontroller (Arduino/Raspberry Pi) with Wi-Fi/Bluetooth for remote monitoring. It automates maintenance tasks via a mobile/web app, ensuring optimal conditions for aquatic life with potential AI and voice control enhancements.

Traditional water quality monitoring systems often rely on manual sampling and laboratory analysis, leading to delayed results and limited spatial coverage. These systems are typically labor-intensive, expensive, and impractical for continuous monitoring in large or remote areas. Moreover, they may not provide real-time insights into water quality parameters, limiting their effectiveness in addressing immediate issues such as pollution events or contamination. As a result, there is a growing demand for automated and IoT-enabled water quality monitoring solutions that can offer real-time data collection, analysis, and decision support.

Proposed System

The proposed water quality monitoring system integrates TDS, turbidity, and temperature sensors with a NodeMCU microcontroller for IoT-based data acquisition and transmission. TDS sensors measure the concentration of dissolved solids in water, providing insights into water purity and salinity levels. Turbidity sensors detect suspended particles or sediment in water, indicating its clarity and potential for sedimentation. Temperature sensors offer information about water temperature variations, which can affect aquatic ecosystems and indicate potential sources of pollution or thermal stress. By combining these sensors with NodeMCU's connectivity capabilities, the system aims to deliver real-time water quality data for informed decision-making and timely interventions.

Components:

1. turbidity sensor



Turbidity sensors are a piece of equipment used to measure the cloudiness or haziness and the concentration of total dissolved/suspended solids of a solution. A turbidity sensor is an analytical sensor that measures turbidity. They are highly useful and effective instruments to identify the clarity and particle content in a solution, like water. Turbidity sensors are used to reduce waste, improve yields, and analyze water quality in a wide range of industries. Turbidity sensors measure the amount of light that is scattered by suspended solids in a liquid, such as water. When the concentration of total suspended solids (TSS) and total dissolved solids (TDS) in a liquid increase, the turbidity also increases. Turbidity sensors are used to measure the cloudiness or haziness (turbidity) of a liquid, usually to determine water quality.

2. TDS Sensor



A Total Dissolved Solids (TDS) sensor is a device used to measure the concentration of dissolved solids in a liquid, typically water. TDS is an important parameter in water quality assessment, as it indicates the presence of various dissolved ions such as minerals, salts, and metals, which can affect the taste, quality, and healthiness of water. TDS sensors typically measure the electrical conductivity of the water. Since dissolved solids in water can conduct electrical current, the sensor can estimate the TDS level by measuring the water's conductivity. The more dissolved solids present, the higher the conductivity. The sensor converts this conductivity measurement into a TDS value, usually expressed in parts per million (ppm).

3. DS18B20 Temperature Sensor



The DS18B20 is a digital temperature sensor widely

used in various applications due to its accuracy, ease of use, and digital interface. It is particularly popular in hobbyist and embedded systems projects. The DS18B20 measures temperature using an integrated temperature sensor and converts it into a digital value. It communicates using the One-Wire protocol, which allows for both power and data to be transferred through a single wire. The sensor can operate in three main modes:

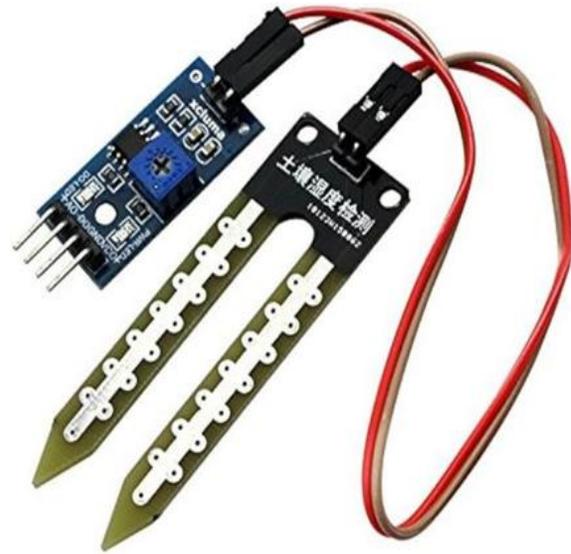
Normal Mode: Powered by an external power source.
 Parasitic Power Mode: Powered by the data line itself, eliminating the need for a dedicated power wire.
 Sleep Mode: Minimizes power consumption when not actively measuring temperature.

4. Water level sensor



Water level sensors are devices designed to measure the level of water in a container, tank, or other systems. These sensors are critical in various applications, including industrial processes, water management systems, and household appliances. Water level sensors are crucial components in many systems for monitoring and controlling water levels. They come in various types, each with specific advantages and suitable for different applications. Whether for industrial use, environmental monitoring, or household appliances, selecting the right water level sensor depends on factors such as accuracy, range, environment, and specific application requirements.

4. Soil moisture sensor



A soil moisture sensor uses capacitive or resistive techniques to determine the amount of water in the soil. Capacitive sensors monitor variations in the dielectric permittivity of the soil, whereas resistive sensors identify changes in the electrical resistance between two probes. These sensors maximize irrigation, save water, and enhance plant health in horticulture, environmental monitoring, and agriculture. Precision irrigation systems that are automated can also be coupled with them. Resistive sensors are useful, but the type of soil they are in might affect how accurate they are, and they need to be maintained because of corrosion over time.

Working

The proposed IoT-based Smart Aquarium System offers a comprehensive solution for automated maintenance and real-time monitoring of aquarium conditions. Sensor Integration:

The system incorporates various sensors to monitor key parameters such as: Temperature: A temperature sensor (e.g., DS18B20) detects water temperature variations. pH Level: A pH sensor measures the acidity or alkalinity of the water.

Water Quality: Optionally, sensors for ammonia, nitrite, and nitrate levels may be included to monitor water quality. Turbidity: A turbidity sensor assesses the clarity of the water by measuring suspended particles. These sensors continuously collect data on the aquarium's environment.

Actuator Control:

Actuators such as heaters, feeders, pumps, and lights are connected to the system. Based on the data collected by the sensors, the system controls these actuators to maintain optimal conditions: Heating: The heater adjusts the water temperature as needed

Figure and table:

To keep it stable. Feeding: An automatic feeder dispenses food at predetermined intervals to ensure the fish are properly fed. Lighting: LED lights are controlled to replicate natural light cycles, promoting the well-being of the aquatic life.

Microcontroller:

A microcontroller (e.g., Arduino or Raspberry Pi) serves as the central processing unit of the system. It interfaces with the sensors to collect data and controls the actuators based on predefined algorithms. The microcontroller also manages communication with the cloud server for remote access.

Connectivity Module:

The system includes Bluetooth or Wi-Fi modules (e.g., ESP8266) for remote monitoring and control. This enables users to access the system via a mobile or web application from anywhere with an internet connection.

Firmware Programming:

The microcontroller's firmware is programmed to: Gather sensor data continuously. Control actuators based on predefined algorithms and user inputs. Communicate with the cloud server for data storage and remote access.

Cloud Integration:

A cloud server is set up for data processing, storage, and remote access. Services like Firebase, Google Cloud, or AWS IoT may be utilized for this purpose. The cloud-based platform enables real-time data tracking, notifications, and remote adjustments of the aquarium settings via a user-friendly interface.

A mobile or web application provides users with a graphical interface to monitor the aquarium's parameters, receive alerts, and remotely control the system. The interface is designed to be intuitive and easy to navigate, allowing users to adjust settings and

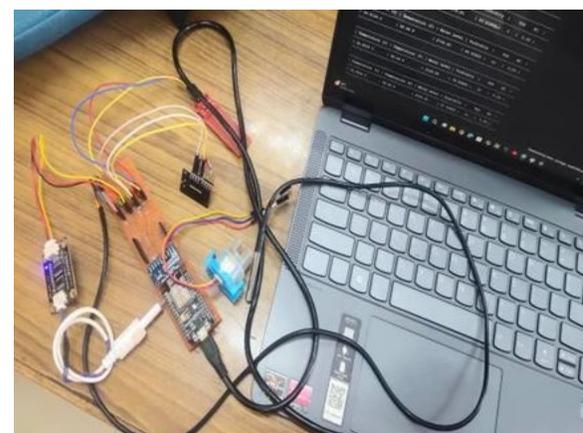
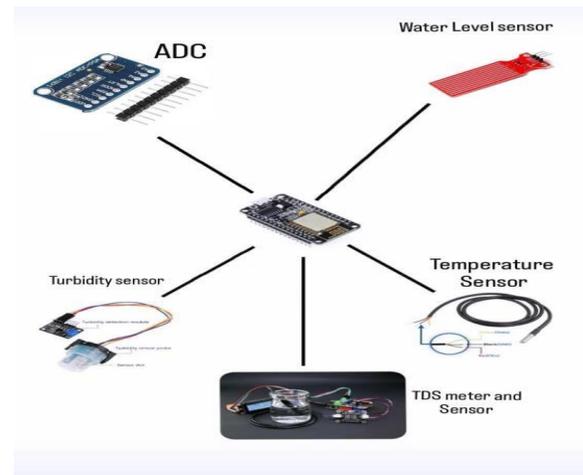
view real-time data. Testing and Calibration: Before deployment, the system undergoes testing to verify the functionality of individual components and their integration. Sensors may be calibrated to ensure accurate readings. Field testing is conducted to monitor the system's performance in an actual aquarium environment.

Deployment and Maintenance:

Once tested, the system is deployed in the aquarium, and users are provided with installation guidelines and training. Regular maintenance and updates are conducted to ensure optimal performance and compatibility with new hardware or software updates.

Evaluation and Improvement:

The system's performance and reliability are continuously monitored. Iterative improvements are made based on performance data and user feedback to enhance the system's functionality and user experience.





REFERENCES

[1] Hardyanto, R. Hafid, Prahenusu Wahyu Ciptadi, and Andik Asmara. "Smart aquarium based on internet of things." *Journal of Business and Information Systems (e-ISSN: 2685-2543)* 1.1 (2019): 48-53.

[2] Daud, Ahmad Kamal Pasha Mohd, et al. "An IoT-based smart aquarium monitoring system." *2020 IEEE 10th Symposium on Computer Applications & Industrial Electronics (ISCAIE)*. IEEE, 2020

[3] Chen, L. B., Liu, Y. H., Huang, X. R., Chen, W. H., &

[4] Wang, W. C. (2022). Design and implementation of a smart seawater aquarium system based on artificial intelligence of things technology. *IEEE Sensors Journal*, 22(20), 19908-19918.

[5] Kori, S., Ayatti, S., Lalbeg, V., & Angadi, A. (2019). Smart live monitoring of aquarium an IoT application. In *Information and Communication Technology for Intelligent Systems: Proceedings of ICTIS 2018, Volume 2* (pp. 1-9). Springer Singapore.

[6] Afifah, Y., Rosadi, R. A., & Hafiz, M. R. (2019, April). The smart monitoring and automation control system for fish aquarium based on internet of things technology. In *AIP Conference Proceedings* (Vol. 2097, No. 1). AIP Publishing.

[7] Sa, B., Ram, S. A., Bharadwaj, S. A., & Niffin, N. B. (2020). Smart aquarium management system. *Intelligent Systems and Computer Technology*.

[8] Junaedi, J., & Ki, H. (2022). Smart Aquarium with IoT based as Monitoring in Fish Farming. *bit-Tech*, 4(3), 116-122.

[9] Rahul, S. G., et al. "Integrating IoT and Deep Learning for Smart Aquaculture Management in Freshwater Aquariums." *2024 2nd International Conference on Sustainable Computing and Smart Systems (ICSCSS)*. IEEE, 2024.

[10] Khan, J., Onib-Ur-Rehman, Z. J., Ali, S., & Danish, A. S. (2019). Implementation of Smart Aquarium System Supporting Remote Monitoring and Controlling of Functions using Internet of Things. *Journal of Multidisciplinary*

Results:

Table1

Turbidity value	Type of water
10 ntu	Drinking
15 ntu	Tap water
20 ntu	Bottled water
25 ntu	River water

Table 2

Temperaturevalue	Type of water
20	Drinking
22	Tap water
18	Bottled water
25	River water

Table 3

TDS value	Type of water
150 ppm	drinking
155 ppm	Tap water
148 ppm	Bottled water
160 ppm	River water

- Approaches in Science, 9(1), 9-28.
- [12] Amrita, M., Dharmadhas, B., Nivetha, S., & Sivanesan, P. (2021). IoT based Smart Water Quality Management in Aquarium. SSRN Electron. J., 0-4.
- [13] Sung, W. T., Tasi, S. C., & Hsiao, S. J. (2022). Aquarium Monitoring System Based on Internet of Things. *Intelligent Automation & Soft Computing*, 32(3).
- [14] Asokan, A., Dharshini, K., Dhevadharshini, M., Gnanariddhika, R., & Shanmugapriya, M. (2024, April). Smart Aquarium and Water Quality Monitoring using IoT. In *2024 International Conference on Cognitive Robotics and Intelligent Systems (ICC-ROBINS)* (pp. 631-635). IEEE.
- [15] Jacob, Pramod Mathew, et al. "An Internet of Things Based Mobile Application for Remote Monitoring and Management of Aquariums." *2024 1st International Conference on Trends in Engineering Systems and Technologies (ICTEST)*. IEEE, 2024.
- [16] Meethongjan, K., & Kongsong, S. (2019). Aquarium fish smart farming on internet of things (IoT) and mobile application technology. In *International Academic Multidisciplinary Research Conference in Amsterdam 2019*.
- [17] Thilagaraj, M., Dhanush, S. P., Ramaraj, K., Mamani, C., & Patil, A. (2023, November). IoT-enabled Smart Aquarium for the betterment of Aquatic living beings. In *2023 7th International Conference on Design Innovation for 3 Cs Compute Communicate Control (ICDI3C)* (pp. 148-152). IEEE.
- [18] Rahman, M. A., & Rajendra, K. (2024). Smart Aquarium Monitoring System (SAMS). *Jurnal Kejuruteraan, Teknologi & Sains Sosial (JKTSS)*, 10(1), 72-80.
- [19] Prasad, M. V., Vamshi, S. K., Chandu, S. M., & Sohel, M. (2022). Implementation of Smart Aquarium Monitoring System.
- [20] Lin, Y. B., & Tseng, H. C. (2019). FishTalk: An IoT-based mini aquarium system. *IEEE Access*, 7, 35457-35469.
- [21] Al-Sadder, N., & Abdulkareem, M. (2023). Smart Aquarium (Doctoral dissertation, An-Najah National University).
- [22] Ali, K., Memon, S., & Shakoor, A. (2020). Monitoring of Water Quality of Aquarium by using IOT technology. *Journal of Applied Engineering & Technology (JAET)*, 4(2), 22-34.