AQUA MONITOR

SMART FISH TANK MANAGEMENT SYSTEM

CT/2023/05

B.Sc.(Hons) in Computer Science

Faculty of Computing

Sri Lanka Institute of Information Technology

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Project Report

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ABSTRACT

The purpose of this project is to implement an intelligent monitoring system for small and medium scale aquariums to constantly alert the user on various parameters essential for the undisturbed growth of fish. It is evident that aquarium owners and aquaculture professionals face various practical challenges in maintaining several fish tanks continuously with limited resources and human labor. Improper addressing to these challenges causes numerous problems of which short life span, spread of diseases and death of fish are prominent.

The proposed project intends to provide a smart cost-effective solution to the above-mentioned problems by developing an Internet of things (IoT)-based device which is installed on the wall of the fish tank. The device utilizes ESP32 microcontrollers and simple sensors to continuously monitor critical parameters such as temperature, food, water level and turbidity within the fish tank.

Temperature: The temperature sensor monitors the temperature of water and immediately alerts the user in a situation where the temperature deviates from the optimum range which is initially fed to the device as a data value.

Food Alerts: The system activates a reminder to notify the user to feed the fish on a schedule that has been given by the user. (The schedule of feeding depends on the type of the fish and their size)

Water Level: The ultrasonic sensor keeps track of the water level of the fish tank. The system alerts the user in case the water level goes below a certain limit or fills up more than the limit during refilling.

Turbidity: The turbidity sensor helps to maintain the clarity of water by alerting the user when water is cloudy or covered with particles to make any necessary filtrations or replace water.

The data collected on these parameters are fed to a database via the ESP32 microcontroller and stored for the access by the user through a mobile application / web application. Thus, the user can monitor the fish tank real time and access stored data depending on his desire through a user-friendly interface using a mobile device remotely and receive alerts in case of deviation from optimal conditions.

As various species of fish require a unique optimum tank condition, it is important that proper analysis is made based on the type of fish and their habitats to obtain maximum accuracy from the system. Therefore, as initial step in an advanced fish tank management system, we intended to limit our project to goldfish where optimum conditions necessary for goldfish are used as input criteria for the system.

The smart alerting system based on the sensor output, addresses the issue of fish being dead or ill due to unfavorable tank conditions proving a cost-effective efficient solution for aquarium enthusiasts and aquaculture professionals. Additionally, it improves the quality of the fish tank reduces and wastage of resources and manpower.

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INTRODUCTION

Problem Addressed

Aquarium management and aquaculture industries require ensuring optimal well-being of aquatic organisms nurtured in the tanks. The proper maintenance of such a setup is a field that requires precision and continuous attention on essential parameters such as food supply, water quality, temperature and water level. The failure to maintain all these condition at the optimum level cause detrimental consequences for the undisturbed lifestyle of aquatic organisms. The project mainly focuses on addressing the issues by introducing an innovative Fish Tank Management System, through a simple device controlled with microcontrollers based on IoT technology. The system specifically monitors each of the above-mentioned parameters constantly throughout and notifies the user in case any change in optimal conditions is observed. By cutting-edge sensors and microcontrollers, the system revolutionizes the way small aquariums and artificial aquatic eco-systems are managed, enabling a favorable habitat for aquatic organisms.

Background Context

The concept of Smart FTMS comes emerges from a broader vision of large-scale aquaculture and aquarium maintenance for a wide variety of aquatic organisms. With the growing enthusiasm on people for raring of aquatic creatures, the proper and maintenance of their habitat is a priority. Aquariums in the present world are no longer just fascinating show pieces, they are more importantly intricate ecosystems in which a wide variety of fish and other aquatic organisms are bred and nurtured. Therefore, the optimized and smart maintenance of these ecosystems is of paramount importance.

In more than 90% of the small and medium scale aquariums fish tank management has been a costly and inefficient process where imprecision is evident. Inability to maintain optimum tank conditions and improper feeding schedules cause stress and illnesses in fish causing short life spans and deaths.

As the aquaculture industry has developed vastly as a pet trade as well as a research field, the need for well maintained and reliable habitats is at increasing demand. With the invention of IoT concepts new ideas have open for the addressing of these challenges. The use of microcontrollers and sensors it is possible to create an intelligent FTMS which reports information real time continuously with the user.

As evident from these factors the concept of smart FTMS is to address a timely issue with an innovative solution using simple concepts and mechanisms.

LITERATURE REVIEW

Several research have been conducted on automated Fish Tank Management Systems including various concepts and mechanisms to implement them. Few of such work are cited as the report proceeds.

1. Smart Aquarium Management System

By Balasubramani S, Aakash Ram S, Akshay Bharadwaj S, and Bennet Niffin N, a Assistant Professor, Dept. of ECE, R.M.D. Engineering College, Chennai Student, Dept ECE, R.M.D. Engineering College, Chennai, Tamilnadu.

Their idea was to a build a Smart fish management system in order to manage the aquarium life,

The main objective of the project is to set up an aquarium which can be monitored using actuators and sensors via the internet. The fish feed dispenser is setup using the server motor and load cell where it can be monitored and controlled in mobile application. Temperature sensor is interfaced to keep track on the temperature of water. A lighting system is introduced, with manual turn on/off option to be controlled at specific time. Flow sensor is added to detect the water flow rate, which is automatically operated depending on the water level of the tank. Turbidity sensor is used to check the water quality and update to the mobile application."

The result for the project was a success,

"Result the proposed system for the control of aquarium using mobile app has been implemented. This system enables the aquarist to control the aquarium through their mobile phones."

https://www.researchgate.net/publication/345690191_Smart_Aquarium_Management_System

2. Research and design of an intelligent fish tank system

Viacheslav Kovtun, Vinnytsia National Technical University, UKRAINE

Their research was about finding and help the survival of fish who are in the tanks.

"The intelligent fish tank remote monitoring system uses the Internet of Things and intelligent equipment to monitor the whole process of fish survival. DS18B20 temperature sensor, BH1750 light intensity sensor, and water quality PH sensor arranged in a fish tank, Real-time collection of water temperature, light intensity, water PH value living environment parameters, suitable water temperature, light intensity and PH value of water bring a comfortable living environment to fish and improve the survival rate of fish. The main control module includes the circuit board, STM32F103 processor, bus communication interface, the data at the sensor acquisition end is processed by the algorithm written by the

main control chip STM32F103,send AT(Attention) commands through the serial port to connect to WIFI and send environmental data to the user through the MQTT(Message Queuing Telemetry Transport) server, customers can remotely control and adjust the control actuator of the fish tank at any time, computer terminal and mobile phone APP, Operate the feeding module, water purification module, and oxygenation module to change the environmental state"

Their research was a success and they have built a physical prototype of the device as well. A model of the prototype is given in figure 1.1.

Figure 1.1

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0285105

These projects which have already been designed to manage fish tanks have several drawbacks. The vision of our Smart FTMS was to rectify the drawbacks in these existing systems and provide a cost effective and more reliable solution to fish tank management.

METHODOLOGY

The methodology for developing and implementing the smart FTMS for goldfish was comprised of a methodical sequence of procedures that involve analysis, implementation and modification. A detailed guide on the process is elaborated in the topics to follow.

1. **Background Analysis**

Observation and gathering information regarding the issues addressed regarding goldfish which includes the optimum environmental conditions for their habitat. Analyzing and organizing information on specific temperature ranges, water level, turbidity level and feeding schedules that favor goldfish.

2. **Identifying User Requirements**

Identification of the needs and requirements of goldfish enthusiast and medium scale aquarium owners who own goldfish. Summing up the requirements and identifying the best possible solution for the issues addressed within the scope of the project to be developed.

3. **Sensor Selection and Calibration**

Choose appropriate sensors for temperature, turbidity, and water level measurements. For temperature, a waterproof temperature sensor was used. Turbidity was measured using a turbidity sensor or optical sensor, and water level measured using a water level sensor or ultrasonic sensor.

Calibration of sensors to suit the optimum range and obtain accurate and reliable output tailored for requirements for goldfish.

4. **Hardware Design**

Designing the sensor hardware circuitry, including power supply, sensor interfaces, and microcontroller. Ensured that the circuit is waterproof or water-resistant to protect the electronics from the tank environment. Assembled the sensors with an ergonomic casing to facilitate easy installation on the fish tank with minimum disturbance to maintenance.

5. **Software Development**

Selected an appropriate microcontroller with an integrated wi-fi module (ESP32) and a developing platform (Arduino IDE) to code the functionality of the assembled sensors. Used a suitable programming language such as C++ depending on the type of the chosen microcontroller and write code to facilitate the sensor reading.

6. **System Integration**

Addition of connectivity to access sensor information via wi-fi or Bluetooth through the aid of a web application. Developing a firebase database to store the recorded information to a

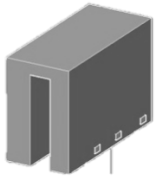
cloud-based server which is accessible through the web application for the user. Establishing flawless connectivity among sensors, database and web application to transmit, process and display information in real-time through the user interface.

7. Alerting Mechanisms

Defining critical values for each parameter such as temperature, water level and turbidity for each sensor. Setting up an alerting system that notifies the user on the web app when any of these threshold and critical values are exceeded.

Hardware Components

 ESP-32 Wi-Fi + Bluetooth microcontroller module	The ESP32 microcontroller wi-fi module acts as the main driving body of the system. It manages all the sensor inputs, processing algorithms and communication with the user interface.
 18B20 Waterproof Temperature Sensor	The waterproof temperature sensor is immersed in the fish tank to monitor temperature changes continuously. The sensor provides high accuracy readings with a compact design.
 HC-SR04 Ultrasonic Sensor	The ultrasonic sensor is used to find the distance between the sensor and water using contactless mechanism with ultrasonic technology. It provides a wide range of readings with reliably high precision.

 SEN0189 Turbidity Sensor	The turbidity sensor specializes in measuring the cloudiness in water. The sensor uses an optical method using scattering of light to assess the turbidity of the liquid.
 18650 3.7V – 1200mAh Li-ion Battery	The 3.7V Li-ion rechargeable battery works as the power source for the sensors and the ESP32 microcontroller.
 Jumper wires	Accessories including jumper wires which enable easy connectivity of the hardware components.
 Plastic body	A plastic body is designed to connect all the hardware components within the wall of the fish tank.

Design of the IoT device

The hardware components including the wi-fi module, sensors and battery are integrated to a handy handheld device. The device is designed in such a way that the device is easily installed on the wall of the fish tank and accessed easily from outside. The device comprises of a plastic body with a 'U' shaped structure that enables the sensors to be connected on one side and the microcontroller and the battery is connected on the other side. This ensures the safety of the device and its users where the microcontroller and the power source is kept outside the wall of the fish tank free from the risk of electrocution in any case of emergency. The proposed design of the device and the fish tank with the device installed can be seen from figure 2.1 and figure 2.2 respectively.

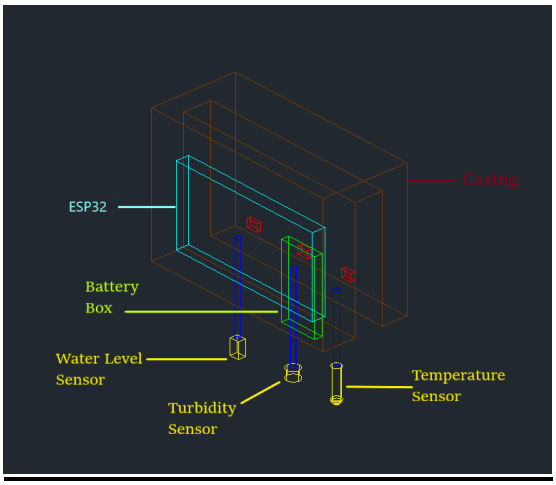


Figure 2.1

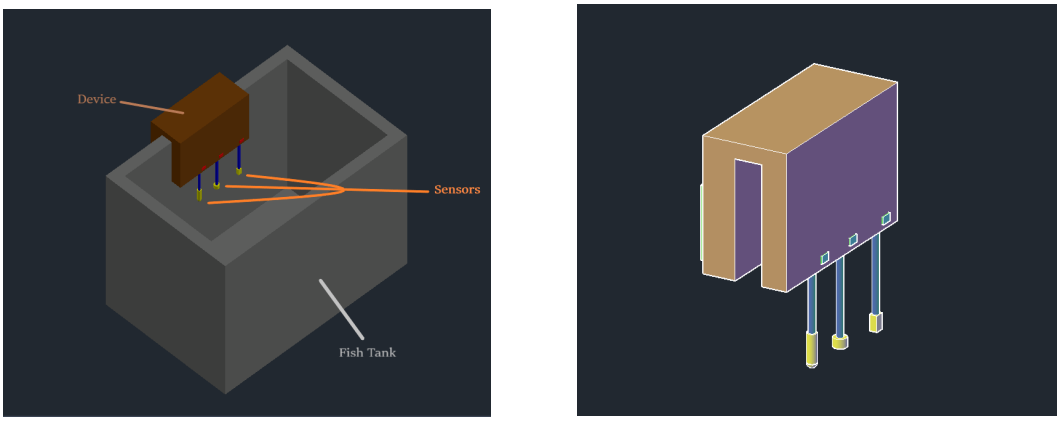


Figure 2.2

IMPLEMENTATION

The hardware components were properly assembled and tailored to get the appropriate readings. The ESP32 module was programmed using Arduino IDE to establish communication with sensors and transmit the data to the Firebase database via secure Wi-Fi connectivity.

The firebase database was configured to receive and store the incoming data from sensors ensuring efficient data management and retrieval.

The web application was developed using standard web development technologies using html and CSS. JavaScript was used for the connectivity between the web app and the Firebase database for real-time data visualization and providing alerts.

The plastic hardware component was designed to hold the microcontroller and sensors along with the power source as a handy device that can be installed on the side wall of the fish tank.

The final system was integrated with a fully compact device containing all the hardware components. The sensor data is pushed to the Firebase database and thereby instantly transmitted to the web app for user observation.

TESTING AND EVALUATION

A series of continuous testing was conducted to ensure the compatibility and the accuracy of the system.

Initially each sensor was tested separately with the ESP32 module, and the fluctuations were monitored carefully. It was ensured that each sensor provided accurate data readings.

Secondly the hardware components were integrated with all three sensors and tested simultaneously again to make sure that the combined system was functioning as required.

The web application was tested by manually changing the readings from the Firebase database. Readings were provided within the range and out of the range to make sure that the web app displayed accurate messages for within and out of range values separately.

Finally, the combined system comprising of the hardware, database and web application was tested to ensure that the system functionality was flawless.

CONCLUSION

AQUA MONITOR, the Smart Fish Tank Management System using IoT presented in this project represents the advancement in aquaculture management. By employing accurate sensors and IoT technologies to accurately monitor parameters in fish tanks, the system provides real time alerts and prompts alerts to the user simultaneously. This smart system improves efficiency and provides easy access to fish tank monitoring in small and medium scale aquariums and domestic users.

As future advancements to the system, using highly accurate sensors can be used to improve precision. Furthermore, other important parameters such as dissolved oxygen level and pH level can be monitored using relevant sensors and mechanisms.

The hardware component can be made more compact with a more convenient structure to ease handling.

In addition to that developing an automation system for controlling parameters remotely can be added as the next step to make a fully automatic SFTMS.

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GLOSSARY

FTMS – Smart Fish Tank Management System

IoT – Internet of Things

Wi-Fi – Wireless Fidelity