ITM Web of Conferences **57**, 02005 (2023) https://doi.org/10.1051/itmconf/20235702005
ICAECT 2023

Implementation of GSM Module based Smart Aquarium Monitoring and Controlling System

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Abstract. The aquarist feeds the fish in the aquarium tanks which demands a proper setup for maintenance. The challenges faced are alterations in water quality, fish care, temperature regulation, light control, and difficulty in manually monitoring the aquarium's conditions. Consequently, close monitoring of the physical parameters and improvement of water conditions become essential. As a result, this system utilizes a Global System for Mobile (GSM) module for aquarium observation and control, described real-time sensor capabilities. It conducts temperature checks, detects water pH levels, manages the aeration system, and handles water renewal operations. Based fish aquarium is a fully automated and remotely monitored aquarium, fully capable of operating without human intervention or interaction. The mechanical feed design, web-based fish feeding, and remote monitoring of all parameters are the crucial components of the project. Feed level, water temperature, pH, and water level are some of the parameters. These can be accessible through a phone app or through a website on a computer. This method's objective is to reduce errors and effort required by humans to manage an aquarium containing aquatic animals. As a result, this system achieves optimal results in terms of accuracy and efficiency.

KEYWORDS: Aquarium, Fish feeding, Sensor, Arduino, pH Sensor, Cloud, Manufacturing, Internet of Things (IoT)

1.Introduction

In recent times, the number of fish keepers has been steadily increasing. However, looking after an aquarium can be quite challenging for aquarists. Proper maintenance of the aquarium is essential for ensuring the good health of the fish. Presently, aquarists need to manually monitor and manage different aquarium parameters, including feeding. The fish need to be fed twice daily, but without keepers present, there is no control over the aquarium, and the fish can’t be fed. To tackle this problem, we have devised the Smart Aquarium Management System an affordable solution that enhances efficiency. This automated system can be easily installed in any aquarium, replace the need for manual maintenance procedures.

In order to satisfy the growing need for human consumption, aquaculture fish farming has developed into an intensive kind of production. To successfully control the intensification of inputs and discharges in this intense aquaculture production system, operational management must be improved [7]. Fish welfare is primarily affected by the water quality wherein the non-ideal condition of the water quality, such as the dissolved oxygen (DO), pH, temperature, ammonia, nitrites, and nitrates, will cause stress, health problems, and fish kill. Unconsumed food and waste material after food (feces) are examples of primary solid wastes that can accelerate the degradation of water quality [1]. To effectively address the needs of precision fish farming therefore, it is necessary to use sensing technologies, IoT, automation and intelligent systems.As mentioned these technologies offers various benefits, such as accurate control, decreased labor costs through automated processes, simplified monitoring, the ability to detect and predict abnormalities based on knowledge [3].

As the trend of keeping pets increases, people are keeping all sorts of animals at home and it is not a new concept in any way. The strong connection bond between pets and their owners is evident. All these animals require special care, but sometimes human caregivers may struggle to attend to their needs. At the moment, many individuals and organizations, including People for the Ethical Treatment of Animals (PETA), are actively promoting the ethical rights of animals. Fish demand particular attention among these creatures due to their unique aquatic environment and also requires specific conditions such as a certain temperature range, pH levels, a suitable quantity of oxygen and CO_2. While oxygen pumps, heaters, and filters are commonly observed in aquariums, these components are insufficient to the natural habitat. Numerous researchers have looked into the spatial and temporal consequences of hydrological and meteorological diversity. Manually maintaining these conditions is challenging, automation a highly valuable solution that can significantly reduce fish death rates and provide great convenience for pet owners.

Insufficient care is the main reason for fish death in both aquariums and fish farms. This remains true not only for this specific project but, automation demonstrates to be an exceedingly efficient method of completing tasks in general [9]. The objective of this project is to reduce labor time and allowing remote control from devices like mobile phones or PCs. IoT facilitates device communication and also reducing human involvement in routine tasks and speeding up processes as machines can communicate with one another. This interconnected network of smart machines operates independently of human intervention and continuously monitors product product or mistakes through sensors. IoT is a fusion of various concepts that create a user-friendly and autonomous product capable of performing diverse tasks [17]. Manufacturers benefit from IoT as it enables them to produce better products and diagnose issues more efficiently. They also have the ability to replace a part before it fails and to proactively shut down a machine. This convenience extends to users as they receive essential items in advance, without being concerned about less important matters.

2. Literature Survey

J. Eksteen and L. Coetzee et.al, [16] the introduction of the concept of the Internet of Things brought about a significant transformation. IoT has progressed from computers to people and now to things in the last few years, unlocking a wide range of applications and services. Various domains are adopting IoT principles for their specific interests and offering guidance on its implementation. With the continuous advancement of IoT, globalization will take place in every technical field. As IoT continues to thrive in diverse technical fields, it has promising future. To reach this milestone, a growing commitment to working in the IoT field and the globalization of the internet are necessary, naturally propelling IoT to the top field. Consider the analogy of the progress of Transmission Control Protocol/Internet Protocol (TCP/IP), which facilitates communication between servers and users. It is like Imagining your clock alarm giving a signal to your geyser to turn on so you will have warm water before you get up. On leaving the house, all appliances receive a signal to automatically power off for energy conservation. These scenarios can be actualized only through the utilization of IoT.

Tao, Fei & Zuo, Ying & Xu, Li & Zhang, Lin., et.al, [13] defined cloud computing as a unit by Beihang University, where a cloud can act as a data monitoring and controlling unit in IoT-based networks, eliminating the requirement for a server. Cloud Manufacturing (CMfg) is a globally recognized intelligent service-oriented domain that collects significant attention. To ensure optimal implementation of CMfg, manufacturers must intelligently Cloud manufacturing resources, identifying the best and most accessible ones. The integration of IoT in CMfg is being researched to handle the test of keenly recognizing and getting manufacturing assets. The idea of resources and the usage, along with their interlinking, is presented through a five-layer integrated system. This five-layered framework comprises of the insight layer, asset layer, administration layer, application layer, and organization layer. An IoT-based intelligent resource recognition and access structure in IoT is arranged and exhibited.

N. K. Suryadevara, S. D. T. Kelly and S. C. Mukhopadhyay, et.al, [14]. The depiction is that there is yet an opportunity to get better in the field of IoT. This adds complexity to the decision-making process for organizations, when IoT adoption and utilization. Monitoring and control, big data and business analysis, and information exchange and collaboration are three main kinds of IoT applications. IoT can be leveraged to demonstrate investment opportunities and evaluate potential through metrics like Net present value (NPV) and real options. A study conducted in the United States of America explored five challenges in implementing IoT applications across different endeavors.

Kangning Yue, Yubang Shen, et.al, [2] IoT has been acknowledged as a critical disruptive technology in the analysis of aquaculture systems because it makes real-time global interaction. Enhancing the monitoring of environmental conditions in different aquaculture areas requires the combination of IoT with sensors and security cameras. The majority of IoT-focused research has employed one or more of the following techniques: 1) Using sensors for water quality monitoring is implemented, 3) feeding is remotely controlled, and 4) remote video surveillance is utilized to monitor fish condition.

Mr. Harish T., Ms. Gauri R.Dhage, Mahajan, Ms. Poonam A.Kapse, Dr. R.M. Rewatkar, Mr. Pawan P. Mahajan, Ms. Sanchalika M. Dubale,et.al [6] have To monitor and transmit the aquarium's state to the user's mobile application, an IoT-based system has been created. This system includes controlling the aquarium's physical changes, analysing water quality, and making adjustments as needed to ensure optimal conditions. Its functions involve controlling the fish's feeding plan, light monitoring, turbidity and temperature levels.

Francis E. Idachaba, Joseph O. Olowoleni, Augustus E. Ibhaze, Oluyinka O. Oni, et.al [8] has been noted that aquaculturists monitor the pond conditions and take timely actions accordingly. They keep an eye on the temperature, feed the fish 3-5 times a day, control the water, which is drained and refilled into the tanks based on the water condition.

Yi-Bing, Lin, & Tseng, Hung-Chun, et.al [4] For managing freshwater aquaculture ponds, a smart electronic system has been presented. The system oversees the hydrobiological parameters that are essential for fish growth. Nonetheless, the method for detecting and draining saline water is not specified. Their research focuses on an automated salinity removal and detection system for aquariums.

NayanKesarkar, Tejas Kambale, Tejaswini Khilare , Prof Arun S Tigadi, Zaid Kittur, et.al [5] the large-scale aquaculture demonstrated the utilization of an embedded system. It includes a water quality monitoring device and a wireless network application. Through a mobile application, these systems are linked to a central hub for monitoring and data transfer. However, the suggested approach does not include how the system should handle abnormal conditions once they are discovered.

Nelson Latap, Chiemela F. Anyanwu, Ricardo L. Ildefonso, et.al [11] the management process or guide for a successful fish culture is outlined. The aquaculturist monitors and manages the pond in a timely manner, carrying out essential tasks such as feeding, draining, and refilling water. Additionally, they conduct regular monitoring of water and temperature levels. 3-4 times a day is the norm for feeding, but the amount of water that needs to be drained and refilled depends on the water's condition. Close monitoring of the aquarium's temperature level is crucial for the well-being of the fish.

Robles, Tomas & Alcarria, Ramón & Martín, D. & Navarro, Mariano & Calero, Rodrigo & Iglesias, Sabela & López, M, et.al [12] presented the Smart electronic system for freshwater aquaculture pond management maintains continuous monitoring and regulation of various hydrobiological parameters essential for fish growth. Nevertheless, the method for detecting and draining dirty water is not explained. The research involves an automated detection and removal unit for unclean water in the aquarium system.

M.Z.H., Hussian, A.K., Saaid, Noor, M.F., Ali, M.S.A.M. and Zolkapli, M et. al.,[15] used PIC16F886. The developed system integrates mechanical and electrical elements to regulate fish feeding activity. The pellet storage, former, stand, DC motor, and microcontroller for this device are all included. The DC motor controls the pellet release from under the pellet storage. This device is linked to a control system, allows the fish to be fed at specific or user-defined cycle times. The motor connected to the sphere forming, which dispenses the pellets into the water, it is rotated under the direction of a timer. Due to the microcontroller's lack of internet access, this system's disadvantage is that the user is unable to remotely change the Direct Current (DC) motor speed. The microcontroller solely automates the pellet dispensing process at scheduled times.

Agung Nugroho Jati; Nurliani Hidayah Ritonga; Rifki Wijaya et. al., [10] the framework, called Automatic Arowana Raiser (AURORA) systems, is made with a Raspberry Pi serving in, as the microcontroller, which remains consistently on the web. It also associated an actuator like a servo motor for feeding, an aquarium light, and a water pump. It is connected to a few sensors, including an ultrasonic sensor and a temperature sensor. The Raspberry Pi receives the sensor data, which is then uploaded to the cloud where Android-based end devices may access it and take the appropriate actions.

The mix of the Internet of Things (IoT) concept is this project's strong point. Through cloud services, an Android application is used to screen to control the sensors and actuator connected to the microcontroller. This makes it possible for anyone in the globe to easily view and control aquarium information internet. The project's limitation is that human interaction is still needed to regulate the servo motor for feeding, turn on and turn off the aquarium light, adjust the water pump despite the integration of sensors that monitor the aquarium's condition, Android apps for monitoring and actuator control.

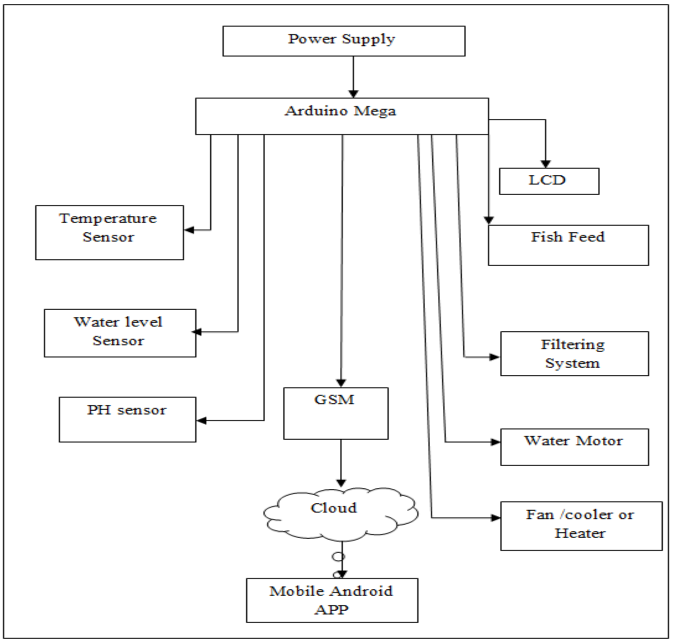
3. Methodology

Figure 1 illustrates the implementation of a GSM module-based smart aquarium monitoring and controlling system. The primary goal of this project is to create an aquarium that can be observed online using actuators and sensors. A servo engine and load cell that can be seen, managed by a handheld application are utilised for organising a fish feed container. The power supply is an electrical device that offers electric capacity to electronic burdens, like workstations, servers, or other devices. The essential capability of the power supply is to change over electric flow from a source into the appropriate voltage, current, and frequency required to power the load.

A microcontroller called the Arduino Mega 2560 has 54 digital input/output pins, 15 of which can be utilised for Pulse Width Modulation (PWM). The Arduino Mega 2560 is equipped with a 16MHz crystal oscillato, a Universal Serial Bus (USB) port for connecting to a computer and transferring code. Additionally, the board can be supplied with an operating voltage of 9v-12v through an external DC power jack. For programming and code uploading, the Arduino Mega 2560 features an ICSP header on the board. Compared to other Arduino family members, the Arduino Mega 2560 offers more memory space, it is suitable for complex circuitry projects. By coupling the GSM module with an Arduino board, internet connectivity, SMS message sending and receiving, and voice calls can be achieved using the GSM library.

The module serves as a GSM modem, connecting to a Printed Circuit Board (PCB) that generates various signals, including Transistor-Transistor Logic (TTL) output. Temperature sensors are crucial in numerous applications, such as monitoring the temperature in a fish aquarium. Normally, temperature sensors such as thermocouples or Resistance Temperature Detector (RTDs) are employed. However, opted for a thermistor-based sensor to monitor water temperature. This sensor operates on the principle of inverse time characteristics, wherein its resistance decreases with rising temperature and indicates an increase in temperature. The power and sense traces form a variable resistor, adjusting resistance based on water exposure. Greater water immersion results in better conductivity and lower resistance, while lesser immersion leads to poorer conductivity and higher resistance.

The sensor produces an output voltage proportional to its resistance, allowing us to determine the water level by measuring this voltage. The pH sensor's raw data originally displayed a lower slope than the desired measurement. However, upon calibration, the slope nearly reached one and the Root Mean Square Error (RMSE) decreased from 0.546 to 0.037. It was determined that the calibration's results were precise enough to meet the intended error tolerance.The program commences by initializing sensors and then proceeds to sense the water temperature. The thermistor detects the temperature of the water and signals the Arduino with its findings. We added a condition to the code that checks to see if the water temperature is between 20 and 28 degrees Celsius. The programme advances to the following stage if the temperature is within this range. If the temperature is outside of this range, it assesses the next condition. The temperature greater than, 28 degrees Celsius in the event, the program triggers the fan until the water temperature returns to the optimal range.



. **Fig.1: Implementation Of GSM Module Based Smart Aquarium Monitoring And Controlling System**

In case the condition fails, signifying that the temperature is below 20 degrees. The heater will turn on to raise the temperature to its ideal range if the temperature rises over 28 degrees Celsius.

The pH sensor then starts the process of sensing the pH of the water. We have implemented a condition that, if the water's pH falls within the range of the next step and the Arduino will activate motors m1 and m2 to extract impure water and refill with pure water. The process will keep going until the condition is met. Next, the feed level will be assessed and shown. Proceeding to the subsequent phase, the water level is examined. The data from the sensors will be transferred to the internet if the water level rises beyond 80 percent and is displayed. If the condition is not met, the aquarium will be refilled.

The relays, sensors, and motors are controlled by the Arduino, which connects to the GSM module. Its main role is to conduct calculations, collect data from sensors, control motors and pumps through relays, and transmit data to the module, serving as an interface. The GSM module forwards sensor data to the website and instructs the operation of the servo motor for feeding. Additionally, the GSM module executes the functions of a Wi-Fi module and giving the entire circuit access to the internet. To enable the use of the I2C adapter, the wire.h library is used in Arduino. For the GSM module, the Esp8266 board libraries are downloaded and installed. By using the "servo.h" library, the servo motor is operated by creating an object called "my servo." By using this library, the use of cayenne is pretty straight forward it is like displaying data on an LCD or serial monitor. The control of the feeding system is like to interfacing the motor with Arduino.

4. RESULT ANALYSIS

The performance analysis of implementation of GSM module based smart aquarium monitoring and controlling system is observed.

This analysis is compared with another method in terms of efficiency, accuracy.

Table.1: Performance Analysis

Parameters	IoT	GSM
Accuracy	99	96
Efficiency	98.6	98.1

In fig.2, accuracy comparison graph is observed between GSM and IoT, which is based on smart aquarium monitoring and controlling system. The IoT shows higher accuracy.

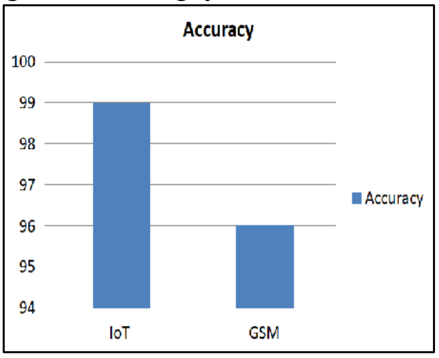
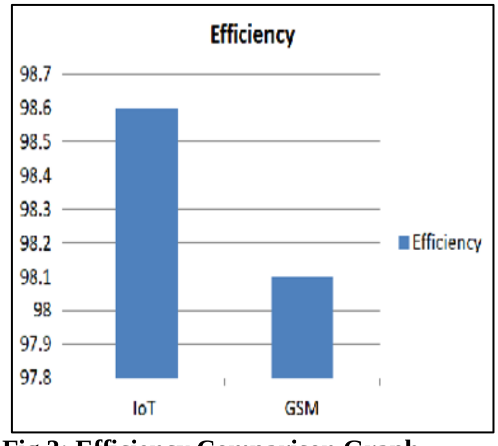


Fig.2: Accuracy Comparison Graph

In fig.3, efficiency graphical representation is seen between GSM and IoT. The IoT achieved efficiency.



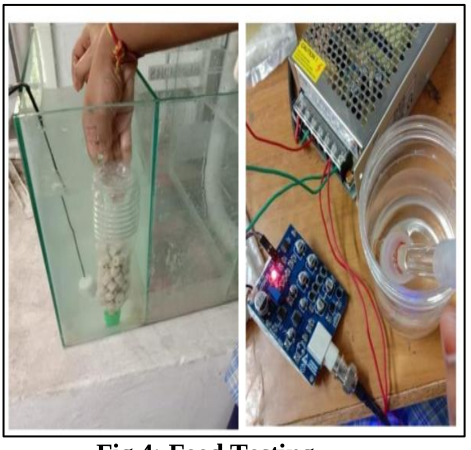


Fig.3: Efficiency Comparison Graph **Fig.4: Feed Testing**

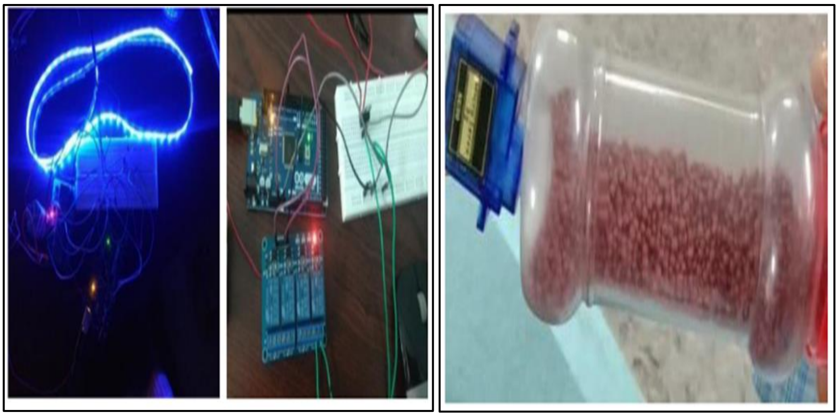


Fig.5: Circuit Wiring and Feed

5. CONCLUSION

The GSM module-based smart aquarium monitoring and controlling system is successfully developed. Its primary objective is to provide aquarium owners with a more convenient and effortless way to maintain and monitor their aquariums. This monitoring system is highly reliable and providing real-time updates on the current conditions. Moreover, the system autonomously makes decisions based on pre-programmed instructions, minimizing the need for user intervention. The water quality is kept at an appropriate level to promote the growth of freshwater fish by using pH and temperature sensors. The system continuously monitors parameters like feed level, water temperature, pH, and water level and all of which can be accessed through a website on a computer or through a mobile app.

With this simplified method, operating an aquarium with aquatic animals requires less human resources and reduces the risk of errors. Therefore, this framework achieved optimal results in terms of accuracy and efficiency.

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