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Smart Aquarium

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Abstract: ***Smart Aquarium "the smart homes for aquatic animals" is an idea that provides an artificial environment that aquatic animals need for their survival. IoT technology has been widely applied in everyday life. IoT technology has been applied to smart homes, smart cities, and several supporting applications implemented by IoT technology. IoT technology can also be applied in the hobby of keeping fish. In modern days, many people have fish as their pets at home. The fishes have been fed manually once daily. The problems faced are change in water quality, feeding the fish, maintaining the temperature and difficult to check the conditions of an aquarium manually. Therefore, it's necessary to monitor the physical parameters closely and enhance the water condition. So, this project proposes a system which is equipped with sensors to be operated in real-time. It performs temperature monitoring, water pH level detection and water renewal operations. An IoT based system is implemented to monitor and deliver the status of the aquarium to the user's mobile application. Thus, intelligent aquarium management has been implemented thereby reducing the manual effort required in the maintenance of the aquarium.***

Keywords: Arduino, ESP, pH, Feeding LoRa, Internet, IoT, Temperature

1. Introduction

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 between pets and their owners is evident from a report by Micheal Gross [1]. After cats and dogs, the most popular pet is now the freshwater fish. An aquarium is a vivarium usually placed in a place with transparent sides (from glass or high-strength plastic), in which animals and aquatic plants (usually fish, but can also be found invertebrates, amphibians, marine mammals and reptiles) are accommodated.

Fish require the utmost care because their environment is completely different from land animals, so they need specific conditions like a temperature range, pH, suitable oxygen and CO2 levels. Normally aquariums have oxygen pumps, heaters, and filters. This is not enough or equivalent to the natural habitat. Many scientists have worked on the effects of meteorological and hydrological diversity with respect to the spatiotemporal scales [2]. The maintenance of fish aquariums is a very difficult task itself. Whenever you have to clean up your aquarium or you have to feed, you have to do a lot of things. You have to turn off your aquarium's power-head/air pump and feed manually and turn on the air again after an hour. In the current system, all equipment such as light, heater, and filter are to be controlled manually using electrical switches. For this, the person needs to come near the aquarium and manually control the electrical switches to turn on /off the equipment. The fishes need to be fed twice a day. This requires the owner to walk up to the fish tank and feed the fish manually which makes the task of maintaining an aquarium much more difficult. At times when the owner is on vacation, he has no control over the aquarium and also can't feed the fish.

The project is an automated system to take care of fish. It will replace the manual maintenance of fish aquariums with its automated functions. The Smart aquarium system is a simple system that helps a user to monitor the different conditions of water like temperature, pH value.

Also, it allows the user to perform actions like fish feeding. This project is designed to decrease the labor time and can be controlled from anywhere, such as a mobile phone or PC etc. IoT is the technology that enables communication between devices; this minimizes human interaction with the machine, automates normal or routine.

2. Background and Related Work

The authors of [3] have implemented an IOT based system which monitors and controls the whole aquarium automatically and provides real time status on the user's Smartphone application. It contains water quality management in which it will monitor the physical changes in the water and will maintain it to the ideal conditions, with required changes. The aquarium will perform all the steps automatically like temperature control, turbidity level control, light monitor, feeding, water renewal etc. [4] The sensor node, we will use the Arduino Nano board and SX1278 LoRa-02 Transceiver module. Then we will interface multiple sensors like capacitive soil moisture sensor v1.2 to measure the quantity of water present in the soil. DS18B20 waterproof temperature sensor to measure the temperature of the soil. Similarly, in the cold season plants die due to fog and low temperature. Thus, DHT11/DHT22 Temperature & Humidity sensor is used to measure the temperature and humidity of surroundings. A 5V Single channel relay module anD water Pump are used for an automatic irrigation system. The authors of [5] summarized the management process or guide for a successful fish culture. The aquaculturist monitors the pond in time domain and takes necessary action. Such actions include feeding, draining and refilling of water, water and temperature level monitoring, while feeding can be done 3-4 times a day,

draining and refilling of water is based on the condition of water. The temperature level of the aquarium is critical to the survival of the fish and requires close monitoring. An embedded wireless network and water quality measurement system for large scale aquaculture is described in [6] and [7]. The developed portable water quality measurement units are installed on a floating platform to measure water quality parameters such as dissolved oxygen, temperature. All these units possess wireless communication interfaced to communicate with the central unit for monitoring by using mobile app, control and data transfer. The systems described in [6] and [7] are not only expensive but also not easy to maintain. It also does not specify exactly how corrective measures will be taken electronically when abnormal conditions are detected. Many papers in literature survey focus on how actually the aquatic life get distracted because of modification in water quality parameters with respect to time, and how IoT technology is employed to overcome the problems [8], [9], [10]. Moreover, sending and storing the information in the cloud helps user for analyzing the data by data analytics, which might facilitate us to take proactive measures before the modification in water quality parameters [11]. I had [2] used SX1278 LoRa transceiver modules and I explained some basic things including the SX1278 Lora module Pinout, technical specifications, and its interfacing with the Arduino. I also interfaced the ESP8266 module to the receiver end and uploaded data to Blynk IoT Cloud. It was a LoRa based wireless one way sensor monitoring & automation system. The main objective of the researcher's Daniel Patricko Hutabarat et al. [12] was to create a smart system based on an internet of things (IoT) application for a plant aquarium. In this study, the parameters to be controlled by the system are light intensity and temperature. The hardware used to develop this system is the ESP32 as the microcontroller, BH1750FVI as the light sensor, high power led (HPL) light-emitting diodes (LED) lamp as the light source, DS18B20 as a temperature sensor, the heater, and the 220 VAC fan that is used to raise and lower the temperature. This study also developed an application that is used by the user to provide input to the system. The developed application is then installed on the user's smartphone and used to connect the user to the system via the internet. The ease of adding and removing devices used on the system is a capability that is also being developed in this smart system. The developed system can produce light intensity with an accuracy rate of 96% and always manage to keep the temperature within the predetermined range.

The authors Mohammad Fahmi Suhaimi et al. [13] created a project that was based on a computer-controlled system that detects physical changes in the water and keeps it in optimal condition. The aquarium will perform all the operations automatically including temperature control, pH control, turbidity control, feeding, and water level control. The aquarium's status was continuously transferred to the database via the IoT monitoring system, which users may check over the internet. The pH sensor module and the temperature module were then used to collect data for the freshwater fish monitoring system. To handle the data gathered from the sensor, the Arduino ESP8266 was employed as a controller. In the electrical box, the Arduino circuit and all sensor modules for this project are wired. The IoT platform used for this project is thinger.io. Also, when sensors detected any problem, they sent a notification to the IoT platform, which was marked as an alert and monitored automatically.

3. Hardware Architecture and Implementation

Arduino the concept used in developing the smart aquarium is described below: The system consists of LORA module, which is the key to all the communication and data transferring. The microcontroller collects the data from the aquarium using temperature sensor and ph sensor. The values are transferred to components by using LORA module for communication. Then the values which are obtained by LORA module at the transfer end sent to the LORA at the receiver end. The LORA at the receiver end sends data to arduino which is connected to ESP8266 Wi-Fi module updates the values to cloud. User gets the updated data from the cloud and makes the necessary measures for proper fish care. The servo motor which is connected feeds the fishes at the regular intervals.

Hardware Requirement:

- ARDUINO
- LORA MODULE
- ESP8266
- TEMPERATURE SENSOR
- PH SENSOR
- SERVO MOTOR
- Software Requirement:
- ARDUINO STUDIO
- ARDUINO IDE

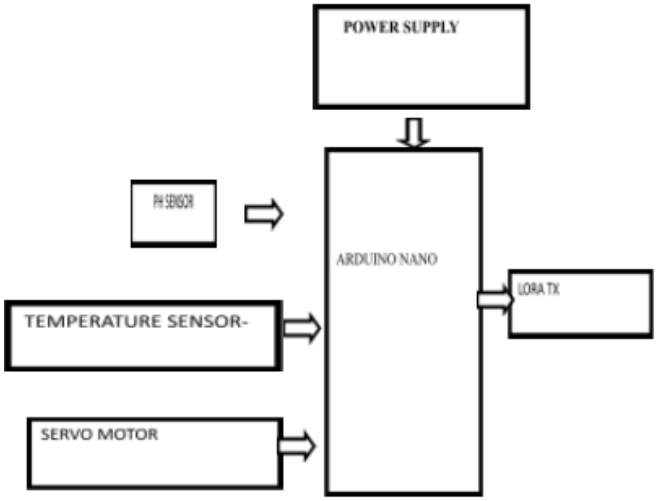


Figure 1: Transfer side Block Diagram

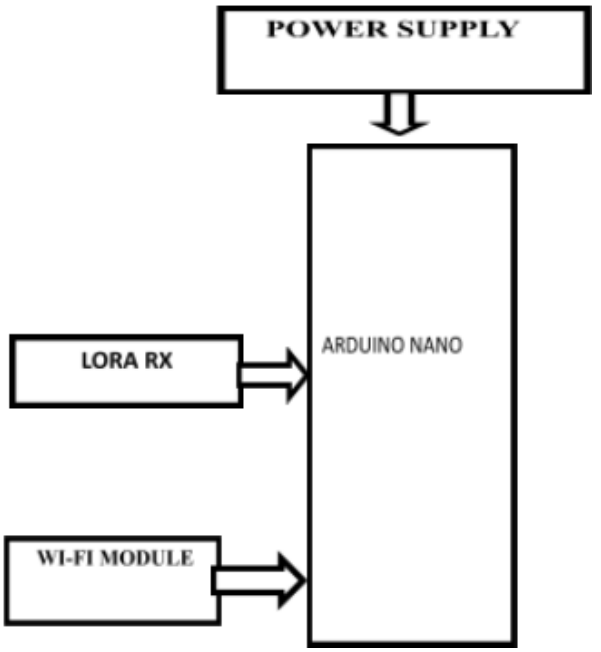


Figure 2: Receiver side Block Diagram

Functions of each block:

NOTE: Here the system is divided into two parts, one is the transfer end and the other is the receiver end.

1) ARDUINO:
The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. Here two arduino are used each at the two ends.

At the transfer end:
The temperature, ph sensors are connected to ARDUINO and the data is collected by it. The servo motor is also connected to ARDUINO which is used to feed the fish at regular intervals. ARDUINO collects and sends the data to LORA module at the transfer end.

At the receiver end
The ARDUINO receives the data from LORA. After receiving it sends it to ESP Wi-Fi module.

2) LoRa Module:
The LoRa SX1278 works with SPI communication protocol so it can be used with any microcontroller that supports SPI. It is the main thing that connects or used for communication between the components. Here two LORA modules are used one at the transferring end other at the receiving end.

3) ESP8266:
Esp32 is a low cost, low power system on a chip (SoC) series with Wi-Fi capabilities. It receives the data from the arduino and updates it to the cloud. It is a Wi-Fi module. Only one ESP8266 is used at the receiver end.

4) AC input:
It is nothing but input given to the system which is in the form of AC. Input is AC because we are provided with AC in our household, offices or elsewhere.

5) Rectifier:
It is a full wave bridge rectifier having one input and two outputs of 12V and 5V respectively; it also has a transformer which converts 220V AC to 12V AC for safety of the components inside the rectifier. Its main job is to convert AC input to DC because all the devices require DC voltage.

6) Servo Motor:
A servo motor is an electrical device which can push or rotate an object with great precision. We have used it to make a feeder since it can work with great precision and we can control the amount of food to feed. It provides food at regular intervals which is set by the user.

7) Temperature Sensor:
The Temperature Sensor senses the temperature inside the aquarium. The DS18B20 is a 1-wire programmable Temperature sensor from maxim integrated. It is widely used to measure temperature in hard environments like in chemical solutions, mines or soil etc. The constriction of the sensor is rugged and also can be purchased with a waterproof option making the mounting process easy. It can measure a wide range of temperature from-55°C to +125° with a decent accuracy of ±5°C. It senses the value and it is transferred to microcontroller from their it is transferred to LORA module.

8) PH Sensor:
The PH sensor is used to sense the ph value and is collected by the microcontroller. . The ph value should be 7 for the water, so when there is change in ph value we need to change the water.

9) Server or Cloud:
The data which is obtained is stored in an web page, where we can access it to get the values. It shows the data of the graph of temperature and ph sensors which is obtained through microcontroller. For these i have used THINGS SPEAK web page application to display the values.

10) Server and User Interaction:
The data collected and updated to the server, the user can get access to the server or cloud by using THINGS SPEAK web page. There we get the data related to temperature and ph values, user uses his mobile phone internet to get to the web page.

Server and ESP:
The ESP uses the Wi-Fi module by the arduino to receive and send the collected data to the server or updates it to the server. It interacts with the internet with its built-in Wi-Fi module.

ESP8266 AND ARDUINO: AT THE RECEIVER END:
The data received by the ARDUINO uses the ESP8266. The ESP8266 updates the received data from the arduino to the cloud or server.

LORA AND ARDUINO:
At the transfer end:

LORA transfers the data of temperature sensor and ph sensor which it gets from ARDUINO to another LORA module at the receiver end.

At the receiver end:
Where the other LORA module receives the data and sends it to ARDUINO.

Temperature Sensor, Arduino:
At the transfer end:
The ARDUINO collects the temperature value using the TEMPERATURE SENSOR which is connected to it.

PH Sensor and Arduino
At the transfer end:
The ARDUINO collects the PH value using PH SENSOR which is connected to it.

Servo Motor and Arduino
The servo motor is connected to Arduino, which is used to feed the fish at regular intervals specified by the user. The mobile application, we can post our keyword in the cloud and Node MCU can receive the keyword from the cloud. The frequency of the Lora is 433Mhz and its range is 10-15Km. A Server room is located at a point it consists of all the LoRa transmitters of all the houses within that 15km region and all the microcontrollers are connected with the internet to receive the keyword. The keyword is then transmitted from the transmitter LoRa to all the respective receiver Lora. The Arduino uno microcontroller receives the keyword and performs its respective operations.

Table 1: Arduino Connections

Arduino as ISP	ATMega328
Vcc/5V	Vcc
GND	GND
MOSI/D11	D11
MISO/D12	D12
SCK/D13	D13
D10	Reset

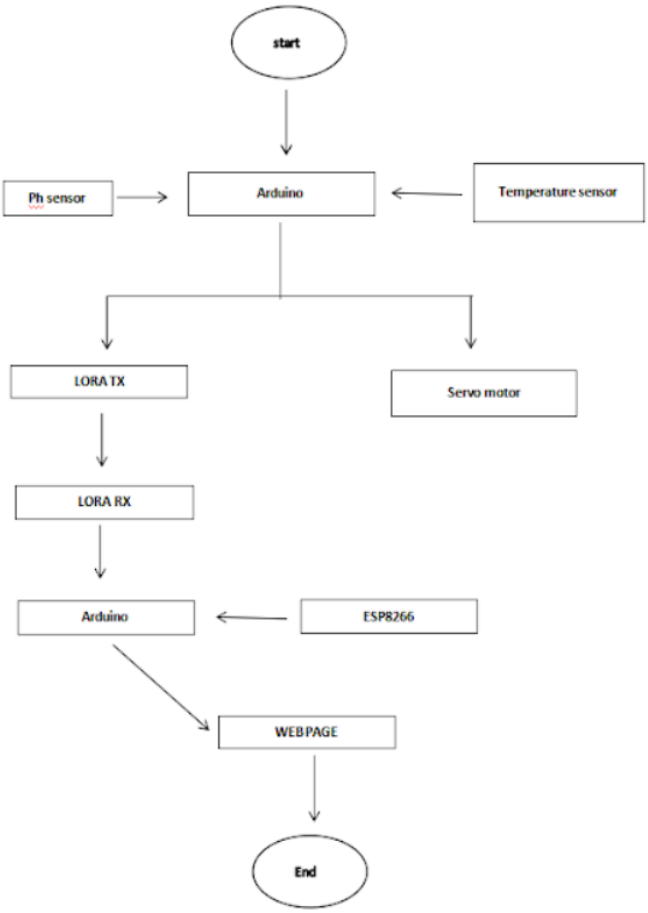


Figure 3: Flow Chart of the System

Software Description

1) Arduino IDE is an open-source software, designed by Arduino. cc and mainly used for writing, compiling & uploading code to almost all Arduino Modules.
2) It is official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

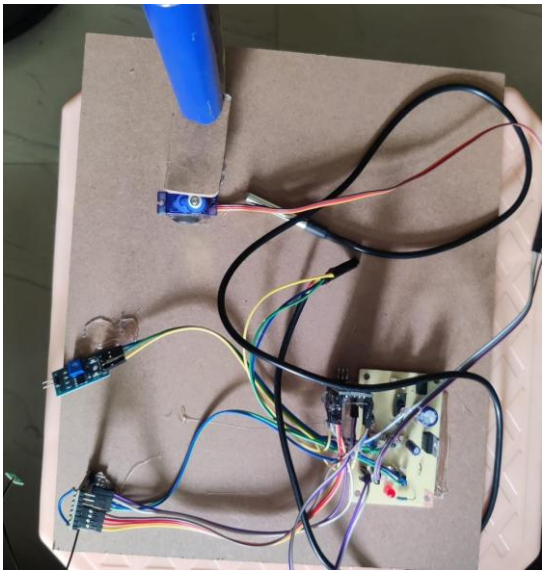
3) It is available for all operating systems i.e. MAC, Windows, Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role in debugging, editing and compiling the code.
4) A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more.
5) Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code.
6) The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board.
7) The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module.
8) This environment supports both C and C++ languages.

4. Results

After developing the system with hardware and with suitable code the results are discussed in these chapter. In these project it includes the monitoring of temperature, ph values and feeding the fish at regular intervals. The values are displayed on the web page of THINGS SPEAK, where we can see the updated values of the temperature and ph values by using the mobile phone.

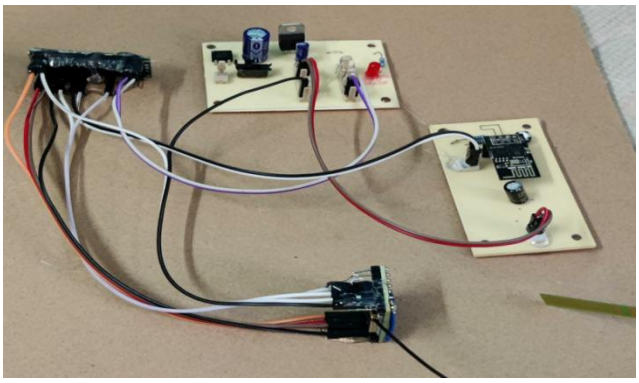
Figures of the Hardware Parts Connections:

At the Transfering End:



Here the arduino microcontroller collects the temperature and pH values and sends it to the LORA module and the LORA module transfers it to the receiver end LORA module. The servo motor connected will provide the feeding at the prescribed time

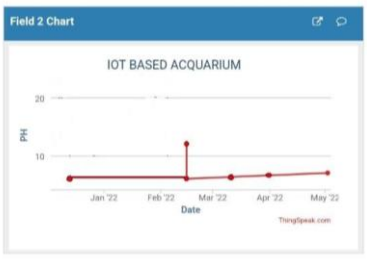
At the Receiver End:



Here, the LORA module receives the data from the transfer end LORA module and sends it to arduino from arduino it is transferred to ESP8266 Wi-Fi module which updates the values to the cloud.

It mainly depends on the distance it covers, we use LORA to cover the maximum distance instead of bluetooth. In open place it covers a distance of 600-800mts, but in close place the data received is time taking and data is obstructed for some time.

Results on the Web Page:



Here the above fig shows the temperature and ph values on x-axis it shows the date and on the y-axis it shows the values. When we click on the dots it shows the info like in the above figure.

The normal temperature is room temperature is maintained, pH values are to be 7 for normal water it ranges between 6-

7. To test the temperature sensor different kinds of water samples are used so when it is hot water the temperature is increased to 37c we can see it in the figure. like wise pH sensor is also tested with muddy water so the pH value is changed and it can be observed in graph.

By sending data or by testing it multiple times, the system is found working almost all the time. The proper internet connection has somehow made the system more responsive. Thus for this stable internet connection is required at home, if the internet connection is breaking from time to time the system is found to behave in unexpected way. By these the data may be held in traffic. Sample are taken to test the sensors and they have giving correct values we can see the change in figures above when the sensors are tested with other means the values are changed compared to the normal times.

The servo motor used for the feeding mechanism is rotated at an angle of 90 degrees from initial position so that the sufficient amount of food is dropped to the fishes. The container for the feeder is cylindrical with hole on the bottom for the food to drop out of the container. The servo motor rotates at an angular speed of 5 degrees per second

5. Conclusion

Aquariums are difficult to maintain if the components used in aquariums are controlled manually. The keeper of the aquarium must do a lot of research and invest a lot of time if he wishes to keep a traditional aquarium. Because of this reason, many people hesitate to keep aquariums in their homes. The project was inspired by an idea, to create a system that could automatically take care of the fish and the ability to be able to control these devices remotely over the cloud.

The purpose of our project is to make keeping aquariums easier and more fun. By these project the user can get the information on what is the temperature and ph values of the aquarium are, these are updated on the web page. Where user can get the info and make the necessary changes in order to maintain the fish care. The servo motor is used to feed the fishes at the regular intervals. By using the IoT platform, it can monitor these variables, visualize the data and even control some features manually, over the internet which is successfully implemented in this project. this project achieves, simplicity, efficiency, time saving and cost saving. This project serves as a way to practically implement our skills to solve a very important management related problem and assist in achieving an ideal environment for fish in an aquarium.

There is a tremendous need for projects like these in the market as more and more people are struggling with aquarium maintenance either due to lack of time or due to lack of experience of fish keeping.

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