Cost Efficient Automated Pisciculture Assistance System Using Internet of Things (IOT)

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***Abstract*- The Internet of Things (IoT) envisions all physical objects connected to the internet and able to communicate with each other. This research paper represents a technique to provide a low cost Automated Pisciculture Assistance System for indoor fish production using Wireless Fidelity (Wi-Fi). Although, Bangladesh is on third position among all the countries in Inland fish production [1], the method of Recirculation Aquaculture Systems (RAS), is used by Bangladesh, nowadays as pollution of pond water presents huge danger to fish population inhabiting pond water. In this research, we developed a complete assistance system which provides information to the user about the conditions of the water through the sensors and operates the device remotely. The key components of this system are a pocket-sized Wi-Fi module, Message Queuing Telemetry Transport (MQTT) for monitoring, controlling the sensors and alerting the user through SMS, an Android application to visualize the data provided by the module and to operate the device. Our main objective is to build a system that accurately monitors water conditions with minimal costing and easy installation process.**

***Index terms*- Internet of Things (IoT); Wireless Fidelity (WiFi); Pisciculture Automation System; Wi-Fi module; Android**

INTRODUCTION

Bangladesh is a developing country located in South Asia with about seven percent of the total area covered with rivers and inland water bodies [4]. Bangladesh is blessed with its conducive geographical position as it contains abundance resources to prosper fisheries business. Not only a major part of the population depends on fish as their staple food, but Bangladesh also earns a considerable amount of foreign currencies by exporting fish and other fisheries products [12]. In the recent years, there is a decline in the condition of open water fish stock which impact all the natural anthropogenic induces changes and it poised major company, concerned for the fishery business. It also affected water for irrigation construction of dams, activities of human beings contributing pollution for the fishery industry resulting in the over-utilisation.

Currently it is very difficult to maintain a healthy or natural water environment for fish production, so people are more interested in producing fish in a controlled artificial environment. Recirculating Aquaculture System (RAS) is one of the efficient technique to grow fishes in an indoor atmosphere. This technique breeds fishes in a controlled manner at high densities. It filters the water and clean it by recycling back through fish culture tanks. New water is added to the tank only to make up for splash out and evaporation as well as to flush waste materials. Fish grown in RAS must be provided a continuous supply of clean water at a given temperature and dissolved oxygen content which are essential for optimum growth. Water pH needs to be maintained so that acidity of the environment does not change abruptly through excretion of fishes. The fish must be fed a nutritionally complete diet daily to encourage fast growth and longevity.

With the introduction of IoT, research and development of automation are gaining popularity over the recent years. Therefore, a new idea of making a unique system that can provide updates about the aquatic conditions through a mobile application can be thought upon. This application would remotely monitor the temperature, pH, and turbidity through sensors, scheduling the events and control the appliances (oxygen pump, light, feeder, and heater) that are involved in enhancing fish production.

PROBLEM STATEMENT

Problems related to the quality of water in pisciculture systems are very diverse. An optimum balance of nutrients and other factors is essential to

maintain the essential culture conditions for fish health. These factors include temperature, pH, turbidity, transparency, hardness, balance between oxygen and carbon dioxide etc. In our system we have mainly focused on these parameters on which fish health is mostly dependent. Temperature affects the water quality and metabolic rate of fish varies with increase in temperature [13][14]. Therefore, temperature has a direct effect on the important factors such as growth, oxygen demand, food requirements, and food conversion efficiency. The higher the temperature the greater the requirement for food and oxygen and faster the growth rate. If the temperature is low, it can hamper the growth along with the health of the fishes through various diseases [6]. Therefore, a standard temperature should be maintained as mentioned in Table I. pH also influences the growth of fishes. Lower concentration of pH can accelerate the release of metals (copper and other heavy metals) from rocks and sediments which can affect the metabolism of the fishes and their ability to take up water through their gills [8]. Fishes are also prone to parasites and diseases in acidic waters. When pH rises over 11, the gills, lens, and cornea of fish eyes are destroyed [7]. Due to waste discharge from the factories, the required pH of the water gets reduced [3], the temperature of the water fluctuates [2] which causes death of fishes.

Table 1: Water Quality Standards for Fish Production

Parameters	Acceptable Concentration
DO	>5 mg/L
pH	6.5-8.5
Temperature	>20° C for warm water species
	15-20° C for cool water species
COD	20-30 mg/L
TSS	>80 mg/L
Nitrite	<0.02
Nitrate	0-100
TAN	0-0.2

[5] Parameters Acceptable Concentration DO >5 mg/L pH 6.5-8.5 Temperature >20° C for warm water species 15-20° C for cool water species COD 20-30 mg/L TSS >80 mg/L Nitrite.

Dissolved oxygen is one of the important parameters in pisciculture. Low levels of dissolved oxygen adversely affect respiration and metabolic activities in fishes, hence causing large number of deaths among them. Fishes need to be fed from time to time. Surrounding temperature controls the metabolism of fish. If the temperature is low, the digestive time will be lower. Furthermore, most fishes do well on one feeding per day. So, if excessive food is given to fishes, they may die of over eating. Lastly, turbidity is a measure of how particles are suspended in water and is responsible in affecting water clarity. It is an important indicator of suspended sediments and erosion levels. Sometimes the water becomes muddy due to excessive rainfall or because of excessive algae in water which affects the fish health.

EXISTING SYSTEM

There are many technologies that are already involved in pisciculture but only few of them are automated and demands human interventions. Firstly, monitoring and operating the systems, demands physical presence of a user. Secondly, the devices for measuring the various parameters are available as individual components, but not within a single device. Therefore, these devices are cumulatively expensive and relatively unaffordable for indoor fish farms. Most of the systems are very bulky and heavy weight. As a result, in order to accommodate in an indoor environment, the monitoring systems require large space which sometimes becomes very hard to accommodate.

Proposed System

In this paper we have introduced a system which is very light weight and mobile. It can be installed anywhere without any complications as it is a compact device having four sensors and a relay using which the other appliances are connected and can be operated remotely. A user can receive updates about the conditions of the water anytime as temperature, pH, turbidity, and percentage of water damage can be shown within the mobile application and if required user can activate the switches of certain monitoring entities, whose functionalities need to be performed, using the app. User can also schedule the events when he/she is away for a long time. If any abnormalities are seen in the water, the user will be notified through an SMS or in app notifications.

System Design and Implementation Details

A) Hardware Parts

In this system Node MCU is at the center of the system which is based on ESP8266-12E Wi-Fi module. It is a low cost and highly integrated chip that can be configured to connect to the IoT devices. The temperature sensor, turbidity sensor, 4 channel relays are connected to it. The temperature sensor is a one wire waterproof temperature sensor that measures temperature with a minimal amount of hardware and wiring. This sensor uses a digital protocol to send accurate temperature readings directly to the NodeMCU without the need of an analog to digital converter or additional hardware. A simple and convenient analog pH is used in this technique which have practical connection and features. It has an LED which works as the power indicator, a bayonet neill–concelman (BNC) connector and pH sensor interface. To use the pH sensor, it needs to be connected with a BNC connector and plugged into the pH interface into an analog input port. It needs to be calibrated whenever it is going to be used within a new environment. We have used water turbidity sensor to detect water quality by measuring the levels of turbidity. It uses a special light to spot suspended particles in water by calculating the light transmittance and rate of scattering, which modify the number of total suspended solids (TSS) in water. As the TSS increases, the liquid turbidity level increases. Here, 4 channel 5V relay is used to connect oxygen pump, light, feeder, and heater in the system. These appliances will be activated whenever they will receive data from the Node MCU through mobile application and also, activate automatically if the events (on/off) of these appliances are scheduled. To design an automated water pump we have used a 12V relay, a standalone microcontroller and liquid level probe. There are 3 wires in the liquid level probe. Among them, one is for detecting when the water tank is full, so that the water pump will turn off automatically. The other is for turning on the water pump whenever the water goes below the liquid level probe.

The entire technological part of the system can be constructed using hardware costing under BDT 5772. Table 2 defines the components and their associate cost.

Table 2: Cost of the used Components of the System

Components	Cost (BDT)
NodeMCU	350
4 Channel ISO relay	250
Logic level shifter	150
I2C 16-bit ADS	650
Power stick board (5V,3V)	115
pH Module	2230
Turbidity module	999
Switches, sockets, wires, resistors	200
Variable power adapter	218
12V DC adapter	400
DS18B20 waterproof temp sensor	100
12V relay, stand-alone microcontroller	110
Total	5772

NodeMCU 350, 4 Channel ISO Relay 250, Logic Level Shifter 150, I2C 16-bit ADS 650, Power Stick Board (5V,3V) 115, pH Module 2230, Turbidity Module 999, Switches, Sockets, Wires, Resistors 200, Variable Power Adapter 218, 12V DC Adapter 400, DS18B20 Waterproof Temp Sensor 100, 12V relay, stand-alone microcontroller 110, Total 5772.

B) Proposed IoT Architecture

In this system NodeMCU is the main controlling unit which can be connected to a smart phone application via internet to control the peripheral devices as shown in Figure 1. With the help of internet, MQTT [9] is used to deliver the data from the NodeMCU to the android application and the website. It is used for setting the triggering conditions and controlling the appliances as well from detecting any abnormalities in water health, the user will be notified by an SMS/pop up notification. For customizing the messages, we have integrated the SMS service of Webhook applet of IFTTT which is a free of cost service. [10]

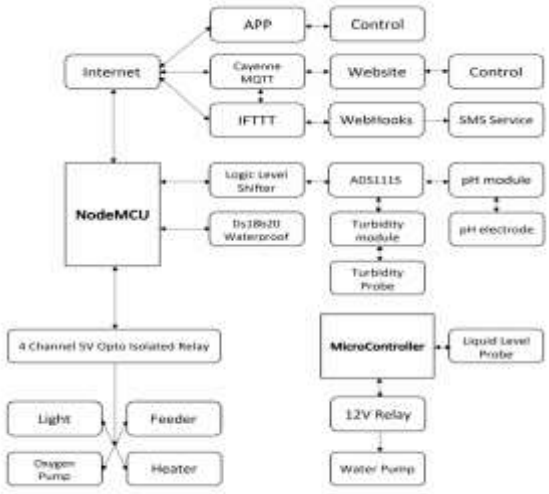

Figure 1: IoT architecture of the proposed system

For accuracy and measurements, the system needs to calibrate pH sensor and turbidity sensor. By putting the pH electrode into pH standard solution, the gain potential is adjusted to stabilize the value equal to buffer solution. The turbidity sensor is calibrated from web interface (MQTT). As shown in Figure 2, the water turbidity has a relation with the voltage which is applied in our system for calibration. From the web interface a user can know the water grade point value(=voltage) of clean water after introducing the probe into new environment and set that value to calibration point via web interface as shown in Figure 3. Thus, a user can simply configure the server and every setting from web interface.

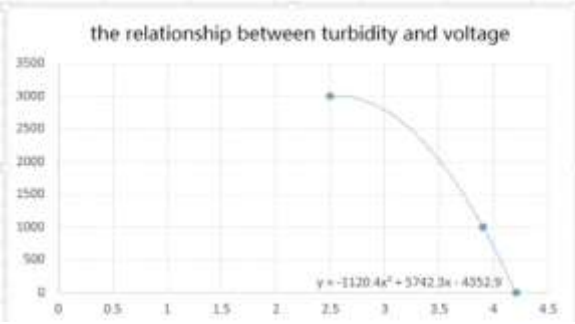

Figure 2: Relationship between turbidity and voltage [11]

To get analog pins, ADS1115 (an analog to digital converter) is used here, as analog sensors (pH, turbidity) need to be connected to NodeMCU. Also, the analog pins of Node MCU serves 10-bit data and ADS1115 serves 16 bitdata for which it gives more accurate and efficient data. Thus, ADS1115 is used in the system for getting accurate data from the sensors. Also, a logic level shifter is used in the system as ADS1115 does serial communication and it is obvious that other devices connected to it need to be operated within the same voltage. As NodeMCU can operate only in 3V and for serial communication with ADS1115 it needs to be operated in 5V as well as to get the data from the sensor which is functioning at 5V.

Figure 3: Web interface of the system.

C) User Interface

To operate the device remotely and to visualize the readings that we will be getting from the sensors in real time there is an app designed for the user. In the first page of the app the user will be updated about the different parameters of the water i.e. temperature, pH, turbidity, and water damage percentage through internet and in the second page of the app there are buttons of four appliances to turn them on/off remotely.

RESULTS AND DISCUSSIONS

The main aim of the system is to make it cost efficient and small in size, so that anyone could afford it. In order to make it cost efficient and compact device, we have implemented the hardware part according to the design of the system, so that it can be installed very conveniently. Also, comparing to the existing technologies this system is much more efficient as it doesn't require large amount of money to replace the components when they are not functionable. We have tested our system against different types of environment water and satisfactory results were obtained through the mobile application, shown in Figure 4. The water pump worked very smoothly as needed and also the appliances were remotely operated without any difficulty. The outputs are shown in the smartphone instead of a dashboard LED screen thus reducing the cost and making the system installation easy. The triggering conditions that we have set in the system which can detect any kind of abnormalities in the water and notify the user by sending an SMS was working satisfactorily, shown in Figure 5. The system automatically takes necessary actions that we have predetermined and set in the system when it meets its triggering conditions. Also, the events can be scheduled correctly if the user is away. Therefore, the fishes' environment is easily and conveniently monitored remotely and automatically through this system.

Figure 4: Notification message received on user's cell phone.

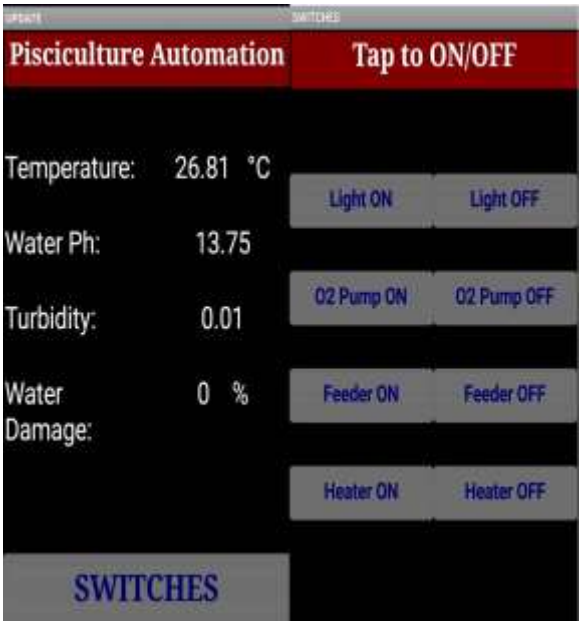

Figure 5: Update of water health.

This system can be used in outdoor fish farming as well through small updates. As it requires very less human engagement, it saves a lot of time as well as ensures proper growth and health conditions of the fishes.

CONCLUSION

The internet of things is an interrelated device that uses Computer to computer that provide human to human or human to computer interaction. This allows a user to access his devices from anywhere around the world. Thus, this system can significantly improve the overall pisciculture system. The usage of smartphones that are ubiquitous nowadays, due to low cost and easy availability, makes the system affordable. The user-friendly application interface conveniently helps the user to be in control of most situations by using internet. Our goal is to ensure healthy water for fishes, in case of unhealthy conditions taking proper actions will be much easier than before.

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