European Journal of Information Technologies and Computer Science
www.ej-compute.org

IoT Based Integrated System to Monitor the Ideal Environment for Shrimp Cultivation with Android Mobile Application

Hasan Mahmud, Md. Afzalur Rahaman, Subrata Hazra, and Shariar Ahmed

ABSTRACT

Bangladeshi shrimp aquaculture has shown to be successful and efficient at earning foreign cash. The country covers 147570 square kilometers, 17% of which is roughly made up of coastal brackish water. Shrimp farming is thought to be more favorable in this larger coastal tide area, and 0.276 million hectares of land are being used for brackish water shrimp farming. The coastal area offers the best prospects for shrimp and prawn cultivation for two key reasons. The mangrove ecosystems' distinctive biodiversity is the first justification, and a shrimp-friendly habitat is the second. A large number of fishing vessels are sent out into the seas in order to mine shrimp which is undoubtedly considered a challenging job. Therefore, growing shrimp in tanks, especially in tropical regions, is more sensible for farmers. In this paper, we have developed an IoT-based solution that connects devices to collect data on shrimp farms, and sensing equipment and then sends it to a distant server to analyze and generate decisions. This smart farm offers real-time agriculture monitoring. The main components of the system are three embedded sensors to assess the temperature, turbidity, and light that impact the quality of the water. The system also incorporates of an android-based mobile application that facilitates farmers with remote monitoring capabilities to keep track of sensor readings, manage the shrimp production cycle, and check on the health of shrimp from different farms.

Keywords: Internet of Things, shrimp farming, smart farming.

Published Online: January 8, 2023

ISSN: 2736-5492

DOI :10.24018/ejcompute.2023.3.1.89

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I. INTRODUCTION

Shrimp aquaculture is a successful industry. Shrimps are a constantly expanding market and are regarded as upscale delicacies, especially in industrialized nations. Poor water quality exposes animals to a variety of physical, chemical, and biological challenges that have an adverse effect on shrimp's rates of growth, reproduction, and survival. In addition to being delicious, shrimp is a great source of the vitamins A, E, B6, and B12 as well as iron, calcium, salt, phosphorus, zinc, and potassium. Both globally and locally, there is a huge need for shrimp. Shrimp farming is excellent for nations with extensive coastlines. Numerous factors, including turbidity, temperature, dissolved oxygen, salinity, pH, soil quality, soil nutrients, etc., affect the quality of water used for farming. We can attain a good yield by monitoring the pond continuously.

Geographically, Bangladesh is a country that is prone to natural catastrophes; each year, it experiences cyclones, unexpected floods, hailstorms, high rainfall, and other calamities. Because shrimp farming requires exact salinity levels, abrupt floods and excessive rain are the main causes of changes in the salinity of the water used to grow shrimp. The majority of Bangladeshi shrimp growers manually check the water's condition. In the fish farms, farmers monitor the farm manually. Farmers utilize their prior knowledge or predictions to gauge the quality of the water, a method that lacks scientific rigor and yields conclusions that cannot be verified. Prediction or experience-based observation never yields useful information. They rely on laboratories to measure things like pH and salinity. The manual monitoring procedure is inherently prone to errors due to the repeated nature of the activity, and they typically undertake this checking once a week. At this point, there is a potential that the environment will negatively impact shrimp growth and health. Consequently, automatic continuous real-time monitoring is required to get a high yield. Water quality control ponds need to be improved if shrimp farm profitability and expansion are to be guaranteed. Monitoring the water quality parameters on a regular basis is a requirement for achieving such management. The management of a healthy reservoir is crucial since the growth and viability of shrimp are closely tied to the physicochemical.

II. RELATED WORKS

Chalamala Srinivas Goud and five other individuals have completed a research project titled "Wireless Sensor Network (WSN) Model for Shrimp Culture Monitoring using Open

Source IoT." The temperature, pH, and dissolved oxygen sensor data would be collected by an Arduino Uno R3 connected to a GSM modem, which would then transmit the sensor data to the Think Speak IoT platform. In order to deliver information to the user for alerting, the acquired data are then compared with referenced values. Additionally, they suggested three potential remedies for the transfusion of diseases among birds [1].

Another literature on aquaculture is "Knowledge Based Real Time Monitoring System for Aquaculture Using IoT" done by K. Raghu Sita Rama Raju and G. Harish Kumar Varma where several sensors such as DO, Temperature, Ammonia, Salinity, pH, Nitrate, and Carbonates are used [2].

A paper titled "IoT Based Automated Fish Farm Aquaculture Monitoring System" by Sajal Saha and 2 others describe a way of designing farm monitoring. They took 3 parameters into consideration where sensor value is sensed by Arduino and uses Raspberry Pi for data processing and acts as a server [3]. Watercolor is indicated as turbidity value, and it has been captured by taking photos and stored in raspberry pi and later shown on an android phone. However, by doing it this way, as opposed to utilizing a real sensor, it is impossible to change the water at passing reference value. Once more, taking a snapshot at the midday collapse of time from the morning will lower the shrimp survival percentage [4].

Among the domestically developed projects, "The Shrimp Farming BD" App contains information on improved technologies, from pond preparation through harvest, and has a calculator that farmers can use to work out the quantities of chemicals, feeds, and other inputs they need for their pond. For any query, there is a Frequently Asked Questions (FAQ) page where users can find answers to common questions with a single click.

An android-based mobile app called "CIBA Shrimpapp" is used to disseminate technical knowledge under the auspices of ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA), an institute of the Indian Council of Agricultural Research. The "Frequently Asked Questions" section of this app now offers details on the Better Management Practices of Pacific white shrimp farming. The client user has the option of viewing the content by keyword or by topic. Additionally, users can use the "post a query" option to submit their questions, and these will be responded to within two working days.

Bangladesh exports frozen fish items and makes significant annual foreign exchange profits. The importing nations have harshly condemned this industry, nevertheless. This is primarily due to farmers' inadequate knowledge of shrimp and prawn farming, particularly about the aspects affecting water quality. However, they require the right education and abilities to assess water quality criteria in order to adopt the best aquaculture techniques and produce safe seafood. Farmers frequently utilize various types of chemicals and pharmaceuticals in their farms to improve water quality parameters. Sensors used in integrated water quality monitoring ought to be scalable, long-lasting, and, if at all possible, calibration-free. The system utilized in conjunction with such probes should be able to display the measured parameter values and their temporal behavior, preferably as graphs and downloadable values. When selecting a sensor to monitor water quality, it is important to evaluate both the sensor's price and performance. It should be possible to conduct the experiment accurately and for a small operating and capital expenditure. Additionally, the chosen sensor should be simple to replace and maintain, preferably with little effort and for an extended period of time.

The primary goal of this project is to increase productivity, and another responsibility of this system is to take precise measurements. As a result, we can produce better results more quickly. People today prefer to use machines to complete their tasks. Thus, the requirement for human resources will decline thanks to this integrated system.

III. Architecture of Proposed System

Early illness problem diagnosis and the ability to adopt appropriate actions prior to an epidemic becoming uncontrollable are necessary for effective management of shrimp ponds. As a result of a combination of observations on shrimp health, food consumption, water quality, and other factors, changes in the health of the shrimp in most ponds only become apparent over time. More importantly, any alterations to the pond's environmental circumstances will materially deteriorate the shrimp's general state of health. Additionally, it is emphasized that the ponds' environmental conditions are varied and continually shifting in a variety of ways depending on the local climate, growing circumstances, etc. This makes shrimp farming much more challenging. Therefore, it's crucial to properly monitor these situations.

The temperature, pH, salinity, dissolved oxygen, turbidity and light sensor are connected with Arduino Uno R3. The Arduino Uno R3 communicates with ESP8266 through serial communication. In firebase real-time database device is linked via open bidirectional connection through websockets.

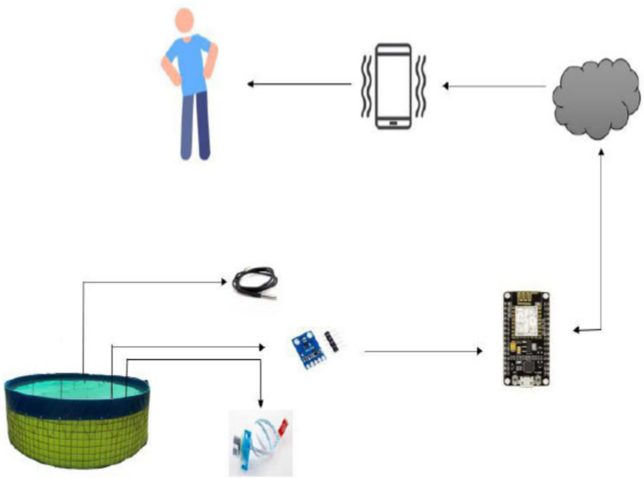

Fig. 1. Architecture of proposed system.

The app was made with Android Studio, and it links to a json file to receive real-time updates. The user can view the acquired sensor data at the GUI front panel where it is shown in a waveform chart. The system can then issue the necessary alerts after comparing the received data with the specified threshold value to determine whether the received values fall within or outside of the safe range. The user's personal mobile phone will also receive an alert about any environmental conditions at the same time they are presented on the screen. Fig. 1 provides a comprehensive breakdown of the process.

A. Temperature

Freshwater prawns are "cold-blooded," or poikilothermic. With every 10 °C increase in temperature within the animal's range of tolerable temperatures, the metabolic requirement for oxygen in aquatic animals typically doubles or triples. The biological activity and metabolic rates of aquatic species can be significantly impacted by water temperature, which can impair marine life in many different ways. An increase in temperature of 10 °C is sufficient to change the biological and physiological effects on shrimp, and it can also lower the amount of dissolved oxygen in the water. For M. Rosenbergii, the ideal metabolic temperature range is between 26 °C and 32 °C, and there is a clear correlation between this temperature range and the temperature of dissolved oxygen. It uses a Dfrobot Waterproofed DS18B20 Arduino Temperature Sensor (DFR0198). It is accurate to within 0.5 °C from -55 °C to 125 °C. The benefit of this sensor is that it only needs one pin for data communication in order to connect to several sensors at once, and because it has digital output capabilities, it can connect to any GPIO port. As seen in Fig. 2, the sensor is utilized to measure temperature using the One Wire Library for Arduino.

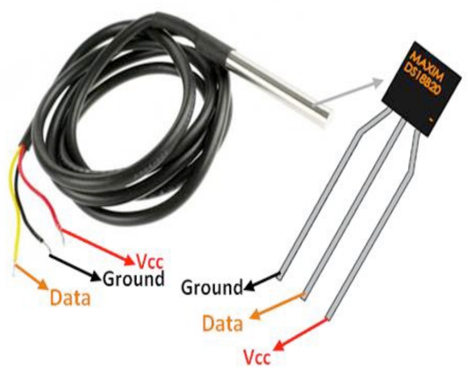

Fig. 2. Arduino UNO.

B. Turbidity

The turbidity of the water in the shrimp pond is measured by the amount of dissolved and suspended solids. It might be brought on by biological activity, the addition of feed and manure, soil erosion, and sediment resuspension. On the other hand, it is made up of both organic (plankton and microorganisms) and inorganic stuff (mineral, lime). Poor productivity is indicated by low turbidity, but high turbidity can lead to a number of issues, including gill damage and the suppression of photosynthesis.

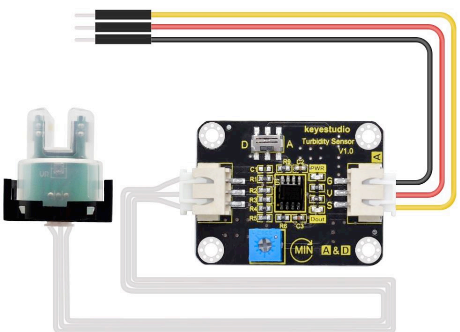

Fig. 3. Turbidity sensor.

C. Potential of Hydrogen (P^{H})

The hydrogen ion concentration ratio, or pH, determines whether the water is reacting acidic or basic. The pH of the water body rises during the day and falls at night because phytoplankton and other marine plant life remove carbon dioxide from the water during photosynthesis. Prior to sunrise, waters with low aggregate alkalinity typically have pH values of 6 to 7.5, but in the evening when phytoplankton development is intense, pH values can increase to 10 or even much higher. Because carbon dioxide is an acidic gas, its convergence has a considerable effect on the pH of natural waterways. Most of the time, carbon dioxide and ions working together with it have an impact on PH alterations in pond water. To reduce the poisonous of ammonia and H2S, pH must be controlled. We can see that many other parameters are directly or indirectly related to pH, and thus changing pH is rather simple; pH is our second factor because of this.

We discovered that a "Analog pH Meter Kit" can offer us an excellent answer for pH level measurement. A pH sensor circuit board and a pH probe are included in this package (BNC connector). It offers a complete pH testing range of 0 to 14. It functions well in the 0 to 60 °C temperature range. Its operational temperature range is 0 to 60 degrees Celsius, with a pH precision of 0.1 at standard temperature of 25 degrees. Accurate data collection is possible by connecting the sensor circuit board's PH2.0 interface to any Arduino analog input port.

D. Dissolved Oxygen

Prawns need oxygen for respiration, which they obtain from the water by diffusing it across their gills. Prawns' respiratory and circulatory systems have developed to work well in a range of dissolved oxygen concentrations, from above air saturation to a value at which oxygen-demanding activities are restricted. Prawns may maintain a roughly constant rate of oxygen absorption when dissolved oxygen concentrations steadily fall but other water quality indicators are stable by increasing ventilation rate and perfusion. For M. Rosenbergii, these regulatory methods are exhausted when the level of dissolved oxygen goes below 1 mg/L, which has major physiological consequences and can result in asphyxia. A dissolved oxygen sensor is used to measure the amount of dissolved oxygen. The embedded D.O. circuit of the EZO class from Atlas Scientific and a D.O. probe electrode make up this sensor's components. They provide a very high level of accuracy and stability when combined. With an accuracy of up to 0.2, this offers a complete range of D.O. values from 0.01 to +35.99 mg/L. This device is compatible with any microcontroller that supports one of the two data protocols it supports, UART and I2C. Additionally, it enables low-power applications, which lowers this device's power consumption to just 0.995 mA at 3.3V.

E. Light

Shrimp grow more quickly under artificial lighting, have a 35 percent higher survival rate, and are more resilient to weather and seasonal variations. Artificial lighting eliminates sudden changes in light that could cause stress reactions in shrimp. Additionally, it enables farmers to regulate shrimp behavior, such as eating activity, and physiological processes, such as metabolism, growth, and maturity. BH1750 is a Digital Ambient light sensor. A microcontroller is simple to communicate with since it employs the I2C communication standard. An inbuilt Opamp-AMP transforms the photodiode's current into voltage in the BH1750 sensor. It transforms the analog values supplied by AMP into digital ones using an ADC. It has an approximate +/- 20% fluctuation factor. This sensor can operate in temperatures between -40 °C and 85 °C.

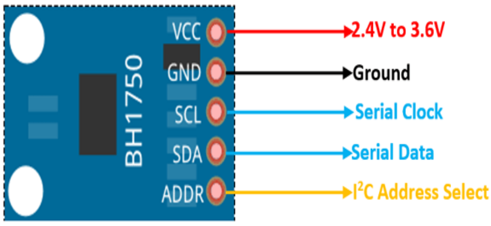

Fig. 4: BH1750 light sensor.

F. Salinity

The total concentration of electrically charged ions (anions: HCO3-, CO3-, SO4-, Cl-; cations: Na+, K+, Ca++, Mg++; and other components: NH4+, NO3- and PO4-) is known as salinity. Salinity is defined as the sum of all dissolved ions in natural water, and it is measured in milligrams per liter. With rising salinity, solutions' osmotic pressure rises. There is a correlation between conductivity and TDS, and a conductivity sensor can be used to measure conductivity, determine the approximate salinity, and quantify conductivity. The ionic fixation and types of dissolved solids in water affect its conductivity. Therefore, it is sufficient to test conductivity alone rather than TDS and other ions separately. Salinity is the third factor we are taking into account.

IV. Implementation

Using a simplified schematic that depicts the interaction of the technologies involved in the proposed project, the system architecture of the integrated system to monitor the ideal environment is described.

A. Hardware

Electrical conductivity is measured using an analog EC (Electrical Conductivity) meter for Arduino (DFR0300) from Dfrobot. This EC sensor is designed specifically for Arduino and includes an easy connection and features built-in. Since EC is temperature-dependent, a temperature sensor (DS18B20) attached to the connecting terminal of the terminal sensor adapter is also necessary.

A BNC connection is needed to connect the EC sensor to the Arduino. This sensor's operating temperature range is 5–40 °C, and its precision is 10% F.S.

In the circuit diagram, the analog Electric Conductivity (EC) sensor for quantifying salinity is connected to the analog pin of the Arduino's A0. Similarly, the Dissolve Oxygen sensor, pH sensor, and turbidity sensor (right to left) are connected to Arduino's analog pins A1, A2, and A3 respectively, and these require 5v. The BH1750 for light intensity measurement and DS18B20 for temperature are connected to Arduino's digital pin 2. The ESp8266 is connected to Arduino as a master device for controlling remote features such as aerator on/off, alarm conduction, time schedule, or user requests and also sending the parameters' values to the cloud for monitoring in real-time using a phone for automated controlling and continuous monitoring. With the Fig. 6 we have demonstrated how the system gathered information with sensors.

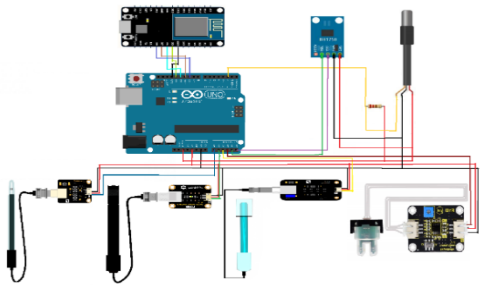

Fig. 5. Circuit Connection of Hardwires.

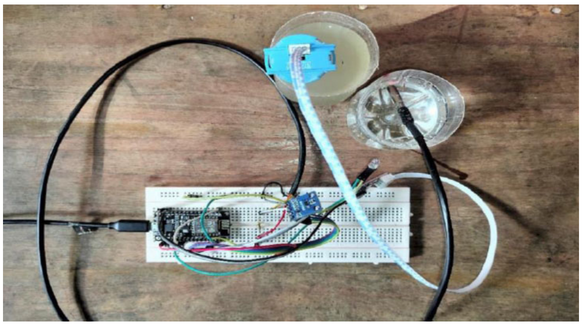

Fig. 6. Information gathering process.

B. Software Implementation

The app was made with Android studio, an official integrated development environment for Android applications. For the development of apps for Android Wear, Android TV, Android Auto, Android phones, and tablets, Android Studio offers a unified environment. Projects can be divided into functional pieces using structured code modules, allowing for autonomous building, testing, and debugging.

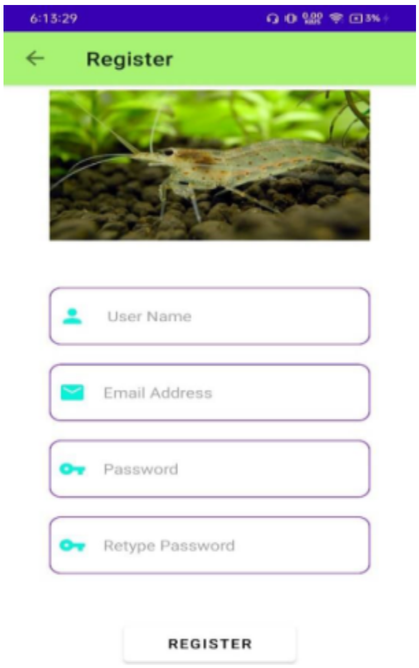

Fig. 7. Registration page.

All the users of the system have to log in using their email addresses and password to see and access the different functionalities they want to use. Two different users are supposed to log in to access their functionalities and these are the Administrator and Customer. All the users log in using the same login form. Below is the login form for admin.

Our app handles authentication and authorization through Firebase SDK Authentication in the form of email and password-based authentication. Solutions to some of the common problems as follows also have been implemented:

- ✓ Password strength and length checking.
- ✓ Throttling of login attempts.

Dashboard page contains all the information the farmer can need and the real-time status of his farm. From here he can see shrimp diseases, information about shrimp, and types of shrimp and also manually control water parameters.

Fig. 8. Dashboard page.

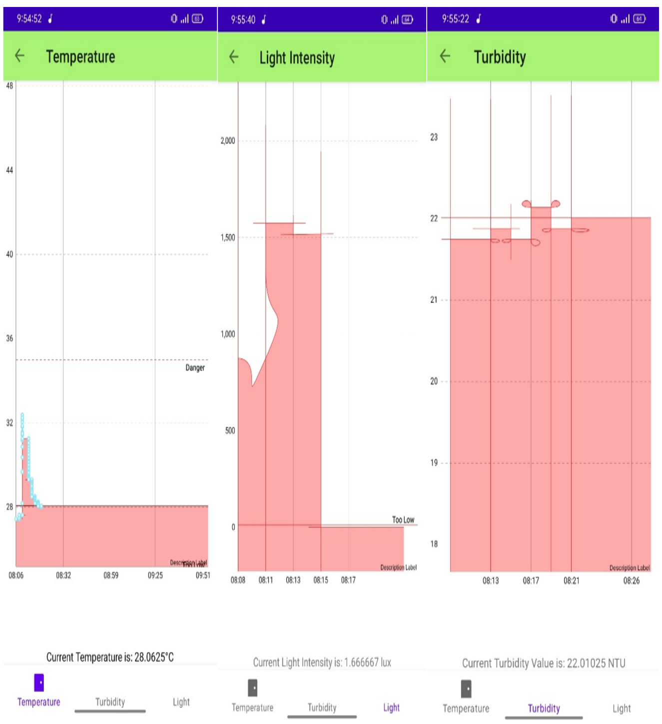

Fig. 9. Real-time graph of three parameters.

C. *Real-time Monitoring*

The android app has a dashboard page that holds information about various groups or categories of shrimp representation, various diseases remedy and identifications criteria, the method of preparation of hatcheries, the process of farming, and feed management. It has a real-time monitoring section to keep track of changing parameters and setting alarms if a preset threshold value is passed. Finally with a decision flow checking as shown in Fig. 10 we took the decisions.

V. System Outcomes

The Android app enables users to keep an eye on the shrimp farm from any location. The three main benefits that our proposal brings to the shrimp farming process are: (1) a decrease in the mortality rate of the shrimp; (2) the prevention of disease by warning the user about water restrictions; and (3) increased output. On the other side, IoT technology reduces the expenses associated with this system's installation. As a result, the created system offers shrimp growers a workable option.

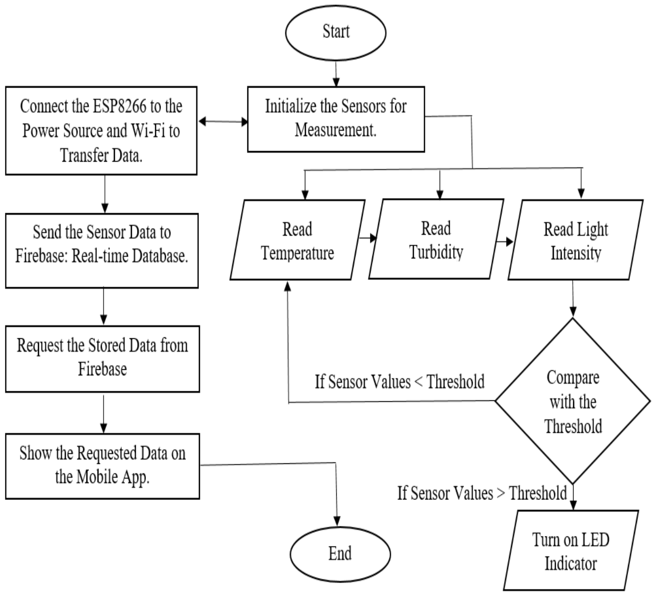

Fig. 10. Decision table.

VI. Conclusion

The constructed prototype is capable of carrying out all intended functions. It has achieved all of the desired goals, so the system is operating automatically in the shrimp farm, resulting in high accuracy and a reduction in the amount of labor required. Node MCU ESP8266 and Firebase Real-time database employ an internet connection to store the sensor data in the cloud, allowing the user to remotely monitor their farm from anywhere.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

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