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Water Quality Monitoring and Alert System for Fish Farms using IoT and SMS Integration

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***Abstract*-This project proposes a water quality monitoring and alert system for fish farms using IoT (Internet of Things) and SMS (Short Message Service) integration. The system aims to ensure optimal conditions for fish growth and health by continuously monitoring important water parameters. IoT devices equipped with water quality sensors are deployed throughout the fish farm to collect real-time data on temperature, pH level, humidity and water level. The collected data is transmitted to a cloud-based platform via an IoT network for processing and analysis. If any parameter exceeds the acceptable limits, the system triggers SMS alerts to fish farm operators, providing timely notifications of potential water quality issues. Additionally, the system offers SMS-based remote control capabilities to enable immediate corrective actions. By combining IoT and SMS technologies, this system enhances the efficiency and effectiveness of fish farm management, enabling proactive responses to maintain optimal water quality and promote healthy fish growth.**

Keywords—aquaculture; wireless transmission; life expectancy; Internet of Things; robotic arm

I. Introduction

Aquaculture is prosperous in the western coastal areas of Taiwan, and most of its traditional farming methods rely on human expertise. Whether it is the time control of the waterwheel aerator, feeding, or water quality testing, all require human resources and is time-consuming for farmers. The sudden cessation of aquaculture during cold snaps causes the farmers to suffer heavy losses. The water quality monitoring instruments that are easy to obtain, such as pH and DO meters, are mostly hand-held and have traditional functions.pH and DO must be manually measured and the meters cannot perform regular measurements, return data, or perform form rendering.

Therefore, solving the measurement problem is fundamental. pH sensors cannot be submerged in liquid for an extended time and must be immersed in protective liquid during non-measurement periods to ensure its accuracy and prolong its life. The solution we propose is to use a self-designed robotic arm equipped with a pH sensor to replace the human arm and to measure the water quality of the fish farm. The water quality data are submitted to a set database for comparison and to determine whether the water quality meets the living condition requirements of the fish. However, due to cost considerations, it is impossible to assign one set of equipment to each fish farm. Therefore, the solution is to place a submersible motor in each fish farm and extract the water. Then, the pH sensor of each fish farm sequentially measures and is maintained through a set of robotic arms. The original concept was presented at ISPACS 2021[1].

In the last years, a real-time water quality monitoring system with widely distributed wireless sensor elements that transmit data back to the main control terminal[2]. Judging the water quality status through data analysis, when the water quality is abnormal, a warning is sent to the farmers, so that preventive measures can be taken in time. However, this type of water quality monitoring system still needs widely distributed monitoring nodes in the fish farms, which will be a big problem for the supply of electricity and the maintenance of equipment. In addition, the sensor needs to be regularly calibrated to improve the sensing accuracy, and frequent equipment calibration requires considerable human resources. To develop a system that integrates various sensors, including dissolved oxygen, pH, and water temperature in each water layer. This system uses Modbus TCP/IP communication to return the collected data and then provides the data to breeding managers through web data and mobile devices.

The wired transmission of data can reduce the transmission problems caused by poor signal, but it limits the field size and increases the difficulty of setting [3]. Management systems based on the Internet of Things and artificial intelligence are system architectures that many industrial blocks can use. Industry, commerce, agriculture, and fishery can all be improved through this architecture. The water productivity per unit on land is lower than the water productivity of the same volume at sea, which diminishes the economic benefits of aquaculture on land and leads to overfishing of wild resources, which has caused many conflicts between farmers and government. Through technological methods, traditional aquaculture has become a semiautomated or fully automated breeding system, which can effectively solve the conflicts between humans and the environment, ensure the livelihood of farmers, and help with achieving environmental protection sustainability. For the government, national breeding and environmental management can be directly checked through the Internet of Things and databases, which can save human resources. An auxiliary fishery breeding system designed based on the Internet of Things can become a truly fully automated breeding system. In addition to improving the output and quality of fish farms, it can also ensure the integrity of the natural environment through systematic monitoring technology to achieve the integrity of fishery resources and the sustainable development of the marine environment. Here, we use grouper to illustrate: the water temperature range is 22~28 ◦C, the pH range is 7~9, the dissolved oxygen content is 5 (mg/L), etc.

Because water quality sensors are placed in liquid for a long time, the chemical reactions of the water quality sensor are frequent. The reaction solution in the water quality sensor becomes exhausted, and the detection head becomes polluted, reducing the life of the water quality sensor. Fishers use manual measurements or rely on observation of fish movements and surrounding environments to judge the water quality of fish farms, requiring extensive human and material resources. We used a self-designed robotic arm to replace human measurement and maintenance. The measurement equipment can work continually. Its high reliability and stability are major advantages. The cleaning function of the robotic arm can prevent the sensor from being affected by excessive consumption of the reaction solution or environmental factors in the fish farm. The main water quality parameters detected are pH, dissolved oxygen, and temperature. The problem that the sensor cannot be immersed in liquid for a long time is solved using a robotic arm as an alternative solution. According to environmental changes, the system uploads data by a time setting[4]. Fishers can monitor the water quality of the fish farms at any time through mobile devices[5,6]. When the water quality is abnormal, the server sends a message to mobile devices to notify fishers to avoid the loss of fish.

II. Literature Survey

The study of [7] proves that too much feed given during feeding time may result in having left over feeds which eventually produced an environmental bad effect. The effect is very dangerous for the reason that, it will result in water contamination that will influence the water qualities while article [8] stated that the feeding problem arises especially in large fish ponds. Water quality monitoring and controlling must be practiced regularly to achieve great production [9] while [10] stated that to increase the production of healthy fish and to make it more profitable, a better water quality is needed. These tasks are extremely demanding in the side of fish raisers.

Fish farming automation like automated fish feeder is needed to solve the challenges in fish farming. It is a system that capable of feeding the fishes in real-time base on the time set by the user. It also monitors the feedstock in the feed storage, notifies the user regarding feeding time, feeds the remaining level, and detects water quality parameters. The article [11] emphasized that the use of controlled feeding mechanism ensures the consistency of the time and feeding plan will eliminate the problems of manual practices in feeding and lessen the labor cost, while [12] mentioned that using a smart system for farming can solve the issues of food security and sustainability in reasonable production cost.

Water could be a ‘universal solvent’ wherever numerous chemical dissolved within the water, in addition as all physical attributes moving them combined to contribute to the water quality. Sensible water quality level is set by all attributes gift within the water at associate degree acceptable level and not outside tolerable vary. Typically cultivation water quality does not capable environmental water quality. Therefore completely different parameters are employed in monitoring cultivation farm as compared to environmental water quality. it's additionally additional typically that sensible water quality criteria take issue from species to species [12]. Physical, chemical, and biological properties are interrelated and it affects survival, growth, and reproduction of cultivation. Cultivation also can have reverse impact to the atmosphere as aquatic organisms consume chemical element and manufacture byproducts, greenhouse emission and ammonia. Important water quality parameters to be thought of are; temperature, salinity, pH, DO, ammonia, nitrite/nitrate, hardness, alkalinity, and turbidness.

P. Fowler et. al in their study suggested that temperature, DO, and pH scale be monitored directly on a continuous basis since they have an inclination to alter quickly and have a big adverse result on the system if allowed to work out-of-range [13]. Therefore, these three parameters are chosen to be monitored in this system. Temperature refers to degree of hotness or coldness and it is measured in degree Centigrade. Water temperature has to be monitored often as outside tolerable temperature vary, sickness and stress can become a lot of rife. Among the consequences of temperature changes are; photosynthetic activity, diffusion rate or gases, amount of chemical element that may be dissolved, and physiological processes of the prawn and level of other parameters [14].

pH refers to the concentration or how acidic or basic as water is and pH is outlined as – log[H+]. pH worth vary from 0-14; pH seven is neutral, pH7 is basic. terribly high pH (greater than nine.5) or terribly low pH (lower than four.5) values square measure unsuitable for many aquatic organisms. Aquatic organisms square measure extraordinarily sensitive to pH levels below five and will die at these low pH values. High pH levels (9-14) will damage fish attributable to the actual fact that ammonia can address toxicant ammonia at high pH (>9) [19]. DO describes the concentration of chemical element molecular within the water and it's addicted to the temperature of the water and therefore the biological demand of the system [18]. It's utilized in aerobic decomposition of organic matter, respiration of aquatic organism, and chemical oxidization of mineral. As DO is employed by several organisms within the water, it tends to vary apace. DO is provided to water through many method; direct diffusion of oxygen from the atmosphere, wind and wave action; and chemical process [18].

Due to the critically of watching water quality of the cultivation ponds, varied systems are proposed. Ceonget. al

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[15] planned associate degree eco aqua farm system that monitors water temperature, dissolved oxygen and salinity. The system may also send associate degree alert to the farmers once the ranges of environmental information square measure found to be abnormal. Han et. al [16] present style on setting watching system for cultivation farms. The planned system offers ubiquitous access to the monitored knowledge from the pond either from the net or on the mobile phones. Shifenget. al [17] studied and imply a system that's supported wireless RF and GSM to measure such parameters as dissolved chemical element and temperature. in line with the setting, the system will showing intelligence management the oxygen increasing machine and might remotely management the data and receive the report through itinerant. Another try was created by Sharudin [14]. He proposed associate degree intelligent system to observe the water quality remotely via SMS. The system monitors and records period of time knowledge of 2 parameters; pH scale level and DO level, that square measure reportable through centralized station victimization GSM network through Short electronic messaging Service [14].

III. PROPOSED METHODOLOGY

In proposed system, wireless transmission technology with various sensors is designed. It transmits the temperature, pH value and water level sensor in the fish farm to the server. The integrated data are transmitted to mobile devices through the Internet of Things. It enables administrators to monitor the water quality in a fish farm through mobile devices. When the water quality is abnormal, the server sends a message to mobile devices to notify fishers to avoid the loss of fish.By combining IoT and SMS technologies, this system enhances the efficiency and effectiveness of fish farm management. Additionally, the system offers SMS-based remote control capabilities to enable immediate corrective actions.

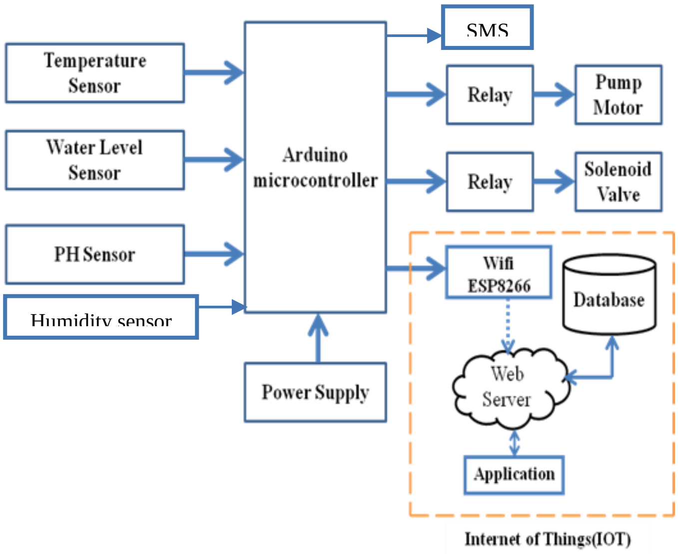

Fig.1 Proposed Block Diagram

After receiving the signal from each pond, the system transmits the data on the water quality of the pond. Each pond has a temperature, PH sensor and water overflow sensor. Each pond uses a submersible motor to pump water to the measuring tank, which then uses the pH sensor to measure. After a series of measurements, the system judges whether testing if finished for all the ponds. Finally, the data are combined and sent back to the server.

1. Temperature Sensor Subsystem

Water temperature affects many properties: in addition to physical properties such as density, vapor pressure, and surface tension, it also affects chemical properties such as microbial growth, dissolved oxygen, and material response rate. Water temperature indirectly affects the measurement standards values of other indicators such as conductivity, dissolved oxygen, etc.

Fig.2. Temperature Sensor

Most temperature sensors on the market now have a problem with temperature drift. To solve this problem, we adopted the constant voltage method and characteristics of the bridge circuit, and low-pass filters to filter out the temperature drift noise generated and then an amplifier to amplify the signal.

In order to reduce the mortality rate, the water temperature of the growing environment of fish must be maintained. Pt100 was selected according to the environment and characteristics of the breeding pond, as shown in Figure 6. At the same time, it was necessary to avoid the expansion and contraction of the platinum wire body caused by temperature change because the error caused by temperature changes affects the measurement results.

2. Water Overflow Sensor Subsystem

The water overflow sensor subsystem mainly replaces the traditional floating ball water level switch, as shown in Figure 3. In the traditional floating ball switch, the water level is mainly set at a fixed height, and the water level state cannot be accurately known. When there is a sudden rainstorm or the water quality needs to be adjusted, it may cause the fish to flow out. Therefore, the main water overflow sensor in this study identifies low, medium, and high water levels, and overflow, which is convenient for aquaculture so the water level can be

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adjusted according to the needs of farming. The principle of overflow primarily uses the characteristics of water conduction to judge water level. The advantage is that compared with the traditional float switch or the water overflow sensor in the industry, the system is more convenient and less expensive.

Fig.3. The traditional floating ball water level switch.

The purpose of this subsystem circuit, is to adjust the water level within the safe height range. When the water level is higher than the high-water level during typhoon season, the subsystem notifies the manager of the condition of the fish farms and reminds them to avoid loss of fish. When there is no rain for a long period of time, water level decreases due to evaporation. This decrease is not conducive to the survival of the fish. Therefore, an automatic pump motor is required to pump the underground reserve tank to replenish the water level to normal.

3. Humidity sensor

A humidity sensor is a device that measures the amount of water vapor in the air. There are three main types of humidity sensors: capacitive, resistive, and thermal.Capacitive humidity sensors work by measuring the change in capacitance of a material as it absorbs water. The material is typically a thin film of metal oxide or polymer.Resistive humidity sensors work by measuring the change in resistance of a material as it absorbs water. The material is typically a hygroscopic salt.Thermal humidity sensors work by measuring the change in temperature of a material as it absorbs water. The material is typically a semiconductor.

The most common type of humidity sensor is the capacitive humidity sensor. These sensors are relatively inexpensive and easy to use. They are also relatively accurate, especially in the range of 30% to 90% relative humidity.Resistive humidity sensors are less common than capacitive humidity sensors, but they are more accurate at low relative humidities. Thermal humidity sensors are the least common type of humidity sensor, but they are the most accurate.

Humidity sensors are used in a wide variety of applications, including:

- Weather forecasting
- Air conditioning and humidification systems
- Industrial process control
- Medical devices
- Agriculture

The working principle of a humidity sensor is based on the fact that the electrical properties of certain materials change when they come into contact with water vapor. For example, the capacitance of a capacitor changes when it absorbs water, and the resistance of a resistor changes when it absorbs water.

DHT22 pins	
1	VCC
2	DATA
3	NC
4	GND

Fig 4.Humidity sensor

In a capacitive humidity sensor, a thin film of metal oxide or polymer is sandwiched between two electrodes. As the humidity level changes, the capacitance of the film changes. This change in capacitance can be measured and used to determine the humidity level.In a resistive humidity sensor, a hygroscopic salt is sandwiched between two electrodes. As the humidity level changes, the resistance of the salt changes. This change in resistance can be measured and used to determine the humidity level.In a thermal humidity sensor, a semiconductor is heated by a current. As the humidity level changes, the temperature of the semiconductor changes. This change in temperature can be measured and used to determine the humidity level.Humidity sensors are an important part of many devices and systems. They are used to measure the amount of water vapor in the air, which can be used to determine a variety of things, such as the weather, the efficiency of an air conditioning system, or the moisture content of a product.

4. pH Sensor Subsystem

The pH value, also known as the hydrogen ion concentration index, is a measure of the concentration of hydrogen ions in a solution. The large amount of excrement in fish farms produces amino acids, which increase the acidity of the water and cause the fish tobecome sick.

The required pH of the aquaculture environment for the growth of fish and shrimp about 6.5~8.5. The survival rate of fish and shrimp in an acidic environment is higher than in an alkaline environment. Long-term water pH that is too high or too low makes the fish and shrimp sick, poisons them, stagnates their growth, and increases their mortality rates. After rainwater passes through substances such as carbon dioxide in the air, it becomes acidic. Therefore, when the weather is cloudy and rainy, the pH value of the pool water gradually drops due to the

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injection of too much rainwater. At this time, the body of water is acidic. In the case of long rainy days or heavy rain, the lack of sunlight causes many beneficial algae to die, and blue-green algae rapidly multiply. The density of algae plants in the water affects the pH value because the oxygen content in the water for photosynthesis by plants slowly rises during the day. Moreover, the pH value slowly rises at night because the pH value slowly decreases during respiration. Therefore, if the density of algae is too high or low, the dissolved oxygen in the water becomes insufficient, and the algae die and produce a large number of algal toxins. Furthermore, the excessive accumulation of fish and shrimp excrement or excessive feeding results in the excessive accumulation of waste at the bottom of the pool, which cannot be effectively decomposed, and the oxidation state efficiency significantly reduces. Continuous anaerobic fermentation produces a large number of anaerobic bacteria and toxic substances such as methane, hydrogen sulfide, ammonia nitrogen, nitrite, etc. In this study, to detect the life of the pH sensor and record the change in pH value, the detected data were compared with those obtained by the sensor.

5.

ntegrated Design of IoT Gateway

The design of IoT gateway is based on the purpose of solving the need for data transmission using two different protocols, namely, WiFi and GPRS. The gateway nodes transmit the data to the remote server in the packet format of Wi-Fi. Wi-Fi provide the underlying communication of the IoT architecture to enable the integration and interconnection of physical and virtual things. Every gateway is given a unique user ID, which is randomly generated after sign up in the designed Website portal.

The IoT Gateway serves as the bridge between the IoT devices and the SMS gateway. It collects data from the IoT devices and communicates with the SMS gateway to send and receive SMS messages. The gateway may also perform data processing, filtering, or aggregation tasks before forwarding the information to the SMS gateway. The SMS gateway is responsible for sending and receiving SMS messages. It interfaces with a mobile network provider or SMS service provider to establish the communication channel. The gateway typically provides an API (Application Programming Interface) that allows integration with other systems, such as the IoT gateway. This API enables programmatically sending SMS messages from the IoT gateway to designated recipients.

The IoT gateway processes the collected data to extract relevant information or detect anomalies. This processing may involve applying algorithms, performing calculations, or comparing the data against predefined thresholds. For example, if the water temperature exceeds a certain threshold, it may trigger an alert for the fish farm manager.

6.

ODE MCU (ESP8266)

General-purpose input/output (GPIO) is a pin on an IC (Integrated Circuit). It can be either input pin or output pin, whose behavior can be controlled at the run time.

NodeMCU Development kit provides access to these GPIOs of ESP8266. The only thing to take care is that NodeMCUDev kit pins are numbered differently than internal GPIO notations of ESP8266 as shown in below figure and table. For example, the D0 pin on the NodeMCUDev kit is mapped to the internal GPIO pin 16 of ESP8266.

ESP8266 is a system on a chip (SoC) design with components like the processor chip. The processor has around 16 GPIO lines, some of which are used internally to interface with other components of the SoC, like flash memory.

The ESP8266 is a very user friendly and low cost device to provide internet connectivity to your projects. The module can work both as a Access point (can create hotspot) and as a station (can connect to Wi-Fi), hence it can easily fetch data and upload it to the internet making Internet of Things as easy as possible. It can also fetch data from internet using API's hence your project could access any information that is available in the internet, thus making it smarter. Another exciting feature of this module is that it can be programmed using the Arduino IDE which makes it a lot more user friendly. However this version of the module has only 2 GPIO pins (you can hack it to use upto 4) so you have to use it along with another microcontroller like Arduino, else you can look onto the more standalone ESP-12 or ESP-32 versions. So if you are looking for a module to get started with IOT or to provide internet connectivity to your project then this module is the right choice for you.

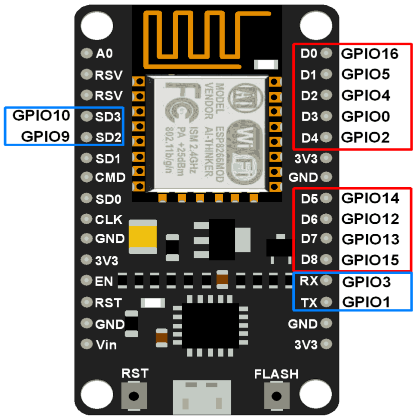

Fig 6.NodeMCUDevKit GPIOs

IV. Results and Discussion

This system takes Arduino as the core, which collects various water quality data. Using sensors to analyze water quality replaces the previous method of judging the water quality through aquaculture expertise, which can improve water quality control and be used to detect early signs by observing changes in data, identifying problems and improving them. However, if the sensor rod is placed in water for an extended time, it becomes covered by biofilm, which affects the measurement accuracy and reduces the sensor's life. Because most of the aquaculture is located on the coast, fishers use semi freshwater and semi seawater aquaculture types. The precise sensing rods are easily eroded by salt, so regular maintenance, replacement, or numerical correction is required.

The sensed data are graphed, and the remote monitoring of the breeding environment can reduce labor costs. IoT is highly promising: the existing the network does not need to be rebuilt, and the industry chain is also consistent with the existing telecommunication network industry.

The measurement values are changing all the time, so the most important aspects are the real-time data transmission, design of the robotic arm, selection of materials, and installation tests. Improving the wireless transmission rate and durability of the equipment are also directions to be considered in the future.

The microcontroller based self-kept up aquarium utilizing with sensors framework utilizes the utilization of various advances in its structure, improvement, and execution. The framework utilized microcontroller to screen the procedure of fish tank in an over-head tank stockpiling framework and can identify the degree of water in a tank, switch on/off the tank utilizing sensors as needs be and show the status on a LCD screen. User can monitor the water condition using anweb app through Wi-Fi within Wi-Fi range and through Internet from anywhere in the world. Some analysis is performed with the three parameters value to determine the overall approximate condition of the water and required action. Every feature in this checking gadget can work legitimately and easily.

The use of IoT and SMS integration in water quality monitoring and alert systems for fish farms is a promising technology with the potential to improve the efficiency, profitability, and sustainability of fish farming operations. The system can provide real-time monitoring, remote monitoring, and early warning of water quality problems. This would help the farmers to ensure the health of their fish and prevent fish mortality.

In addition to these benefits, the use of IoT and SMS integration in water quality monitoring and alert systems for fish farms can also help to improve the efficiency of fish farming operations. For example, the system can be used to track the feeding and watering schedules of the fish, which can help to ensure that they are getting the nutrients they need. The system can also be used to track the growth of the fish, which can help the farmers to identify any potential problems early on.

V. CONCLUSION

Overall, the use of IoT and SMS integration in water quality monitoring and alert systems for fish farms has the potential to revolutionize the fish farming industry. By providing farmers with real-time information about the water quality in their farms, the system can help them to make better decisions about how to manage their farms and ensure the health of their fish.Here are some of the challenges that need to be addressed in order to fully realize the potential of IoT and SMS integration in water quality monitoring and alert systems for fish farms. Despite these challenges, the use of IoT and SMS integration in water quality monitoring and alert systems for fish farms is a promising technology with the potential to improve the efficiency, profitability, and sustainability of fish farming operations. As the technology continues to develop, the cost of setting up and maintaining systems will decrease, and the data security and interoperability issues will be addressed. As a result, IoT and SMS integration will become a more widespread technology in the fish farming industry.

In the future, artificial intelligence analysis and deep learning feedback control technology will be combined to build a complete intelligent breeding system including production technology, facilities, equipment, information, communication, Internet of Things, artificial intelligence, or related front-end technologies connected in series. We must continue to accumulate expert experience from water testing institutes and import the basic aquaculture environment parameters into database systems. To improve breeding, breeding experience can be accumulated, inherited, and adapted to form best practices.

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