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IoT integration with water cooler for temperature control automation in arowana ornamental fish aquarium

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Abstract

The maintenance of ornamental fish, especially arowana fish (Scleropages formosus), requires special attention to temperature stability and water quality to prevent stress and disease. This study develops an Internet of Things (IoT)-based system integrated with a water cooler to automate temperature control in ornamental fish aquariums. This system is designed to monitor important parameters such as temperature, pH, and ammonia levels in real-time using sensors connected to a mobile application, and provide automatic notifications if there are unsafe changes in conditions. The method used involves the design of hardware based on temperature sensors, pH, and IoT modules integrated with applications for remote monitoring and control. Testing was carried out by simulating an aquarium environment to evaluate the effectiveness of the system in maintaining temperature stability and water quality. The results of the study showed that the developed IoT system was able to maintain water temperature within the optimal range of 26–30°C and provide automatic warnings via a mobile application when the temperature goes beyond safe limits. The implementation of this system also reduces manual intervention by aquarium owners, increases maintenance efficiency, and saves energy consumption with more controlled water cooler operation. The implications of this research include contributions to the development of IoT technology for aquaculture, making it easier for aquarium owners to maintain fish health, and inspiring further innovation in the field of IoT-based fisheries. This research is expected to be a reference in creating a healthier and more environmentally friendly aquarium environment.

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Keywords

IoT, Water cooler, Aroawana, Aquarium

Introduction

Keeping ornamental fish is a very interesting activity, currently ornamental fish enthusiasts, both as a hobby or for commercial purposes are increasing. One of the popular ornamental fish today is the Arowana fish (*Scleropages formosus*). Arowana fish are ornamental fish that have beautiful body shapes and colors. The types are varied and the selling price is relatively high, this is because the shape of their bodies resembles ancient fish, as well as their beautiful colors and scales, but there are several obstacles that are often experienced by arowana fish owners, especially related to disease. Diseases in arowana and their causes are also diverse. The types of pathogens in arowana fish are also the same as those in warm-blooded animals, such as bacteria, viruses, fungi and parasites [1]. These diseases include scale blooms caused by bacterial infections, fungal diseases caused by fungal spores, changes in the tail due to fish biting their own tails, bent spines and stress. Often occurs sudden death caused by ammonia poisoning from leftover food and fish waste itself. Environmental factors also greatly determine the health of pet fish. The ideal temperature for arowana fish is 26 - 30 degrees Celsius, the acidity level (pH) of the water in the aquarium is 6.5 - 8.0 [2] [3] [4]. The temperature and pH levels of water in an aquarium are difficult to observe without using tools, even though many diseases are caused by poor temperature and pH conditions.

One way to overcome this problem is to create a tool that can automatically monitor to display pH, ammonia levels and temperature in the aquarium. Internet of Things (IoT) technology can be used to facilitate automatic monitoring and control of aquariums. IoT integration, temperature and water quality data in aquariums can be monitored in real-time and can be accessed via a mobile application. This allows owners to make adjustments quickly and efficiently, and can easily ensure that fish health is well maintained.

Previous studies that have been conducted include: A F Daru conducted a study on the importance of maintaining water pH between 6.5 and 7.0 for optimal growth of arowana fish [2]. Research on low-cost sensors has been conducted by de Camargo et al. This research focuses on the evaluation and integration of affordable temperature, pH, and ammonia sensors to create an efficient and economical monitoring system [5]. Ghazali et al., conducted research on the design and implementation of an automatic water-cooling system controlled by an IoT platform, ensuring that the aquarium temperature remains within optimal limits without manual intervention [6]. Ramaiah et al., conducted a study on the design and evaluation of an interface that allows users to monitor temperature, pH, and ammonia levels in real-time through an IoT device [7]. The advantage of this research compared to previous research is the use of low-cost sensors and integration with an automatic cooling system, thus offering a practical and economical solution that is beneficial for hobbyists in the field of aquaculture.

Method

The research stages carried out in this study are shown in Figure 1, as follows:

1. Literature Study. This stage is carried out by searching for references related to tools, materials and similar research.
2. System requirement analysis. This is the stage of preparing tools and materials that will be used to develop the system.

3. Tools Design. This is the stage of designing tools based on the materials that have been prepared.
4. System Design. The system designer is the stage of implementation into a computer program using a programming language.
5. Testing. Testing the performance of the tools that are built.
6. Implementation. The last stage, namely implementing in a real environment.

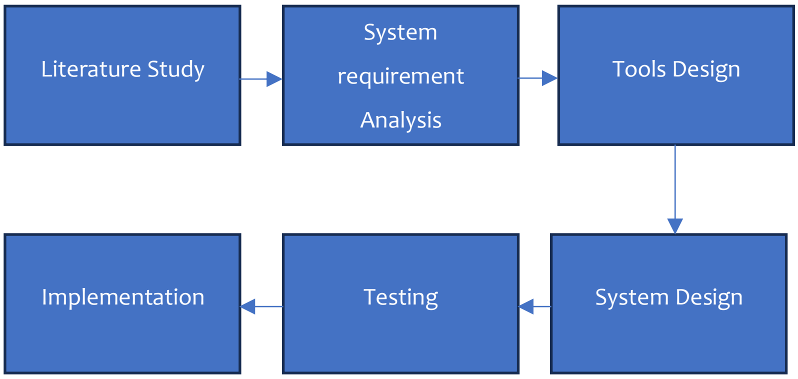

Figure 1. Research Stages

Tools Design

The design of this tool is used to represent an IoT system designed to monitor and control temperature, pH, and ammonia levels in an Arowana ornamental fish aquarium. This system integrates several sensors and actuators connected to an ESP8266-based microcontroller to ensure the aquarium is in optimal condition. The wiring diagram is shown in Figure 2.

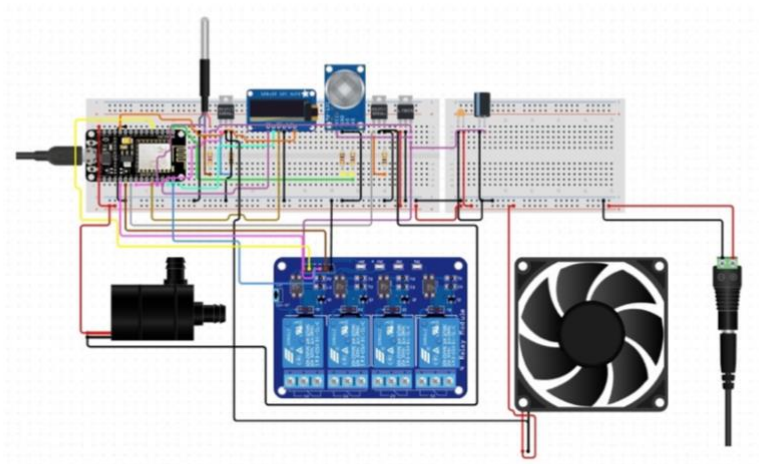

Figure 2. Wiring diagram

Block Diagram

How the tool works in Figure 3 is explained that ESP8266 Microcontroller reads the DS18B20 temperature sensor, MQ-135 Ammonia sensor, pH sensor -4502. The results of the sensor readings will be displayed on the 16x2 LCD and the data will be sent to the Blynk server in real time and process the output.

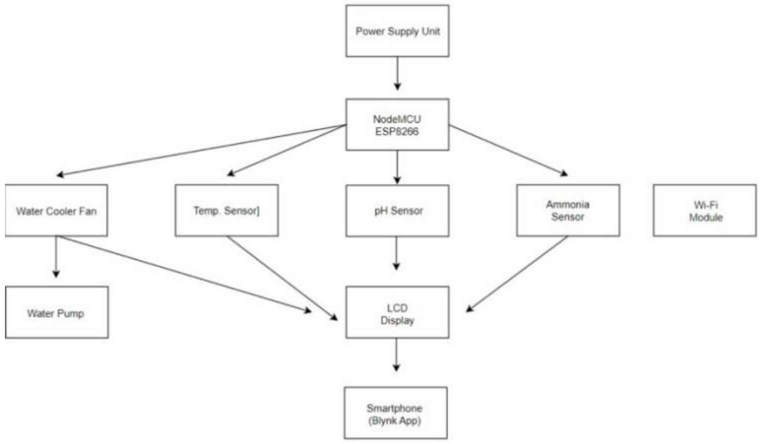

Figure 3. Block diagram

Use Case Diagram

This system uses 2 actors, namely user and admin. User can see the temperature, pH and ammonia levels in the aquarium. Admin can set the temperature, pH and ammonia sensors according to the optimal needs for the arowana in the aquarium as seen in Figure 4.

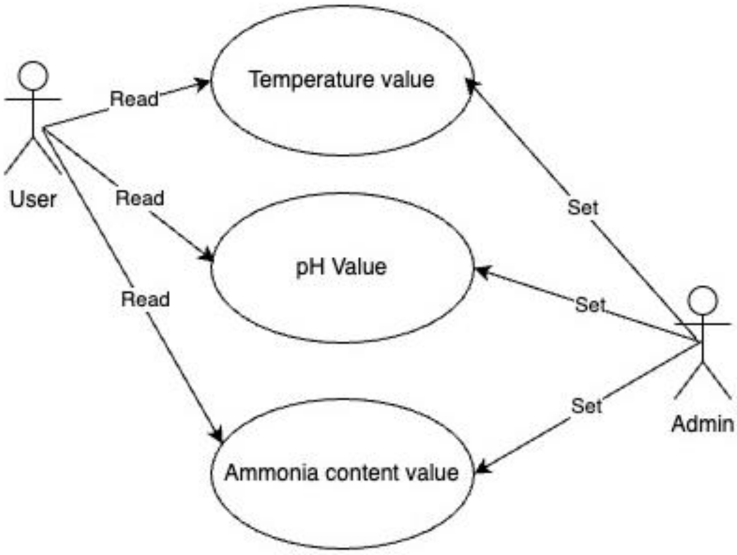

Figure 4. Use case diagram system

Result and Discussion

Hardware Implementation

The hardware implementation in the IoT system is designed using several main components as shown in Table 1.

The prices of the components used are relatively cheap, ranging from 10,000 to 75,000. The relatively expensive component is the pH sensor which costs around 230,000. This device uses ESP82 as the main microcontroller, as well as several other components such as a water pump, relay module, cooling fan and other necessary sensors. The DS18B20 temperature sensor will detect the water temperature periodically.

Temperature data is sent to the NodeMCU microcontroller to be compared with a predetermined threshold, namely a maximum temperature of 28°C. If the water temperature exceeds the threshold, the NodeMCU activates the relay to turn on the water cooler fan. If the temperature still does not drop, the water pump will be activated to help cool the water. After the water temperature reaches the normal limit, the fan and pump will be turned off automatically. Temperature data is displayed on the LCD and sent to the Blynk application on the smartphone. Water pH monitoring, using pH-4502c Module, NodeMCU, LCD. The pH module reads the pH value of the water using an electrode probe submerged in the aquarium. The pH data is received by the NodeMCU via the analog pin. The pH value is processed to determine whether the water is in a neutral, acidic, or alkaline condition with the pH indicator 7: Neutral <7: Acid7: Alkaline.

Table 1. Main components

Components	Series/Uses	Price (2024) (IDR)
Microcontroller	ESP82 or Arduino	47.900
Temperature Sensor	DS18B20	8.900
pH Sensor	pH-4502c Modul	231.900
Ammonia Sensor	MQ 135	22.000
Water Pump	Aquarium Pump	25.000
Water cooler	Tube cooler	75.000
Relay Module	4CH Channel Relay Modul	25.000
OLED Display	Temperature, pH, ammonia Monitor	31.000
Power Supply	5V 5A	51.900

The pH data is displayed on the LCD in real-time and sent to the Blynk application. This information can be used to take manual action if necessary, such as adding pH balancing chemicals. Ammonia level monitoring is carried out using the MQ-135 Sensor, NodeMCU, LCD. The MQ-135 sensor detects the presence of ammonia gas dissolved in water. Ammonia level data is sent to the NodeMCU via the analog pin. The microcontroller processes the data to determine whether the ammonia level is within safe limits. The results of the ammonia level measurement are displayed on the LCD in real-time and sent to the Blynk application. If the ammonia level is too high, the user can be notified via the application to change the aquarium water.

Test Results

System testing uses the main parameters as shown in Table 2, including:

Table 2. Testing parameters [8]

Parameter	Standard Value
Temperature (^{o} C)	26 - 30
pH	6.5 – 8
Ammonia Level (ppm)	<0.02 ppm
System Respond	The speed of the system in responding to parameter changes
Power Consumption (Watts) (Watt)	Measuring the electrical power used by the system

Based on Table 3, the test results show effective temperature control. This shows that the IoT-based system developed successfully maintains the temperature of the Arowana fish aquarium in the optimal range, namely between 28°C to 30°C, according to the biological needs of Arowana fish which is its ideal condition [9]. Test results show that this system is able to respond to temperature changes automatically in a short time.

Table 3. Test results

Parameter	Initial Conditions	Test Conditions	Results	System Response	Notes
Temperature (°C)	28	32 (warm)	32	Fan on in 3 seconds	Temperature back to 28
pH	7.0	6.0 (acids)	6.0	No response	Sensor works fine
Ammonia Level (ppm)	0.01	0.03 (ammonia added)	0.03	Notification sent	Needs additional water
Power Consumption (Watt)	Idle:1.5 Watt	Active: 7.0 W	-	-	Power consumption is stable

Accuracy of Sensors and Devices used shows that the temperature sensor used, namely DS18B20, shows high accuracy in detecting changes in water temperature. The error rate of temperature measurement compared to a standard digital thermometer is below ±1°C, which is considered reliable enough for aquarium applications.

The system is equipped with an IoT-based application that utilizes platforms such as Blynk, allowing users to monitor and control water temperature in real-time via mobile devices, providing convenience and flexibility for aquarium owners. The water cooler system is only activated when the water temperature exceeds a predetermined limit. This helps reduce energy consumption compared to conventional cooling systems that work continuously.

The relevance of IoT implementation in modern aquariums in this case study, IoT provides an innovative solution for modern aquariums by increasing precision in environmental parameter management. This system has succeeded in becoming a more sophisticated and easier-to-use alternative to manual methods. Biological implications for arowana fish which are very sensitive to temperature changes, so that the stability achieved by this system helps reduce stress and the risk of disease, this is in line with research conducted by Daru et al. which states that monitoring water quality is important for the welfare of arowana fish [10]. This proves that automation can support ornamental fish cultivation professionally. Compared to manual methods that require continuous supervision, this system provides advantages in the form of time and energy efficiency. In addition, the system can also work autonomously without human intervention, except for device maintenance. Although this system is effective in its implementation, it also has limitations such as dependence on a high internet connection for remote monitoring functions. Sensor calibration also needs to be done to ensure sensor accuracy is maintained.

Conclusion

This study successfully developed an IoT-based automation system to regulate the temperature in an Arowana ornamental fish aquarium. The test results showed that this system was able to maintain the temperature within the optimal range according to the needs of Arowana fish, with a high level of accuracy compared to the manual method. This is indicated by the Arowana fish kept in the test aquarium showing more active behavior. The implemented IoT system provides an efficient solution in real-time water temperature management, so that it can improve the quality of life of fish and reduce the risk of stress due to extreme temperature fluctuations. The use of temperature sensors and other supporting components shows stable performance. The resulting error rate is relatively low, so this system is suitable for application to ornamental fish cultivation with a high level of precision. The potential for further development requires the addition of a water turbidity monitoring feature so that the integration of various sensors can provide a more holistic view of the aquarium.

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