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DESIGN ARCHITECTURE DEVELOPMENT OF IOT-BASED CATFISH CONTROL AND MONITORING

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ABSTRACT

This study aims to improve the quality and productivity of catfish farming by improving the water quality of catfish ponds. Based on survey findings, cultivators need help to check pond water pH and temperature routinely and cannot carry out continuous monitoring. In addition, water quality also needs to be monitored and maintained continuously because water quality determines 50% of the success of catfish farming in the pond. From this problem, the Internet of Things can help in continuous control, monitoring and even automation. So, this research focuses on designing an IoT system that can do these three things for catfish ponds. By using the "design thinking" method, where the approach focuses on the problems and needs of users. Various designs have been made to help catfish farmers control and monitor water quality in catfish ponds. The result of this study is a variety of designs that describe how this whole system works. The designs that have been made include activity diagrams use case diagrams, class diagrams, database architecture, user interface design, and hardware design. The system created makes it very easy for cultivators. Cultivators only need smartphones and can monitor and control from anywhere and anytime. The system that has been created can help catfish farmers improve the quality and productivity of catfish farming.
Keywords: *Catfish cultivation, Internet of Things, Aquaculture, System Design*

1. INTRODUCTION

Catfish is one of the fish that Indonesian people often use for consumption because the price tends to be cheaper than other types of fish [1]. Catfish are due to their excellent market scope, ease of maintenance and breeding, and faster growth among other fish species[2]. Although catfish are said to be cheaper than other fish, the taste and nutritional content are not inferior to other fish. The nutritional composition contained in catfish per 100 g includes 17.7% protein, 4.8 fat, 1.2% minerals, 0.3% carbohydrates, and 76% water [3]. Of course, given Indonesia's high consumption and production rates of catfish, this is one of the most promising opportunities for a significant contributor to the country's foreign exchange [4]. From KKP (Ministry of Maritime Affairs and Fisheries) data, catfish production in Indonesia will reach 1.06 million tons with a value of Rp. 18.93 trillion in 2021. Compared to the previous year, catfish production rose 1.58% compared to 2020, which amounted to Rp. 18.63 trillion. This increase is proportional to the increase in consumption of catfish in Indonesia.

Even though it is relatively easy to start catfish farming, we must prepare a pond, feed, temperature, and pH of the water. Catfish cultivation is typically done in dug ponds, similar to fish ponds. On the other hand, traditional dug ponds are expensive and require a large area[5]. In addition to the pool, the temperature is also one of the things that need attention. A suitable temperature for catfish growth is 26°C–30°C, and it does not experience unstable temperature changes [6]. After the pond and temperature, pH is essential to pay attention to when cultivating catfish. The pH level in good water is 6–9 under conditions where the pH value does not experience unstable changes [6].

Currently, most people who cultivate catfish use tools traded everywhere, such as pH meters and thermometers. Generally, check the pool one to two times daily for catfish care. This check could be not effective and take a long time because we cannot see the stability of oxygen, pH and temperature in the pond because it is only done several times a day, requiring cultivators to spend more time checking. In addition, monitoring the water quality in fish ponds is also very important because the water quality determines 50% of the success of catfish farming in fish ponds. So a breakthrough is needed to make it easier for catfish farmers to cultivate catfish [7].

Regular monitoring and good pond maintenance can increase catfish productivity for catfish farmers [6]. So, we need a tool that monitors and controls continue to increase catfish productivity. With IoT

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technology and sensors connected to the microcontroller, we can still interact and monitor the cultivated catfish ponds without having to check them directly. Farmers can easily monitor the condition of the catfish pond being cultivated using a cell phone. Apart from that, IoT can also control or even do things that are needed automatically.

Therefore, this study designed a tool design to overcome the problems mentioned above with sensors that have been integrated with IoT. This system will monitor pH and temperature levels using a sensor connected to Arduino Uno and placed in a catfish farming pond. In this system, the pH level can also be adjusted remotely and works automatically. This system is run using a smartphone application which can make it easier for catfish farmers to monitor and control the pH of ponds anywhere and anytime. Controlling pH can be done with the help of 2 water pumps which can deliver acid or alkaline solutions as needed or ordered for catfish ponds. That way, checking and maintaining water ph quality becomes easy and effective. From the design architecture that has been made, it is hoped that it can provide a clear picture regarding this monitoring and controlling system, starting from the selection of the best hardware device, process of reading pH and temperature data, pH calibration, storing and sending data, and displaying data and controlling pH quality using a smartphone application.

2. RELETED WORK

In recent years, the development of IoT technology has helped aquaculture. From previous studies, of course, the authors get input such as hardware selection, the type of software used, the design model used in storage and data storage. The study [13] makes plans and designs for monitoring real-time measurement and monitoring systems based on IoT technology to measure and monitor water quality based on parameters such as oxygen levels, temperature, and water pH. This study only uses a block diagram design to explain data transfer flow from one component to another. From the results of this study, researchers can find out the system design and the cost requirements needed to make this system, such as the cost of purchasing sensors, microcontrollers, and web hosting.

In [18] study has designed and implemented IoT with aquaponic. The study monitored fish ponds using a pH sensor and DS18B20 sensor to detect water quality in these ponds. This study uses an Arduino Uno and sends Bluetooth to a smartphone application designed using the MIT App Inventor 2. This study also uses a system diagram to describe the interrelationships between components and a flowchart to describe the system's hardware and software flow.

In the[19] study, information about pH, temperature, and oxygen levels in fish ponds can be sent via SMS using the GSM module. Because it only uses SMS, this study does not develop or design software. The design used in this study includes a system framework to explain the roles between components and a block diagram to show the relationship between hardware components.

The study [20] create a monitoring and automation system in a fish aquarium. The design used to create a mini site is a hardware design that shows the connections between the hardware components used in this system. In addition, there is also an instrument design to show the location and presence of IoT hardware implemented in the aquarium. There are also flowcharts and smartphone application interface designs to explain how the application works.

A system called the Internet of Things Ponds (I-Tamb) was designed in a study[22]. The system aims to reduce crop failures and make it easier for farmers to market their crops. The output generated from this study is the design of the data transfer process. Design yang digunakan pada studi ini adalah berbentuk framework design yang menjelaskan hubungan antar hardware dan software yang digunakan. This study also uses a flowchart to explain the process of carrying out the research.

A Study [23] shows the implementation of the design thinking method to create an application for children with dyslexia. All stages are explained very clearly because all the techniques in progress are well explained. The result of this study is an application prototype designed to combine entertaining information but still contribute to academic performance.

3. RESEARCH METHODS

3.1 Design Methodology

The methodology used to develop this study is the design thinking process. In contrast to the usual creative design process, which is generally an intuitive and individual process, design thinking consists of a flexible sequence of process steps and iteration loops[24]. So this study will use an approach based on the problem or user needs and make it a solution for users.

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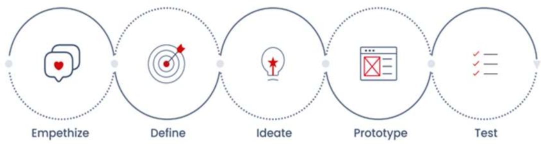

Figure 1: Design Thinking Model

3.1.1 Empathize

The first procedure is to approach the user with empathy. The purpose of this process is to know the user's needs so that the problems raised by the study are not personal assumptions. For this reason, this study requires direct interviews with users. Questions asked during interviews with farmers related to the respondents' background, daily life in cultivation, constraints in cultivation, and factors that affect the quality of the fish produced. Information will be obtained from the interview results, and an empathy map will be made to facilitate future processes.

3.1.2 Define

After the information from the previous stage has been obtained, this stage is the process where all the data is identified, and the problems and user needs are analyzed. When carrying out this stage, the principle of design thinking is needed, which is user-centered or focuses on the user. For this process, a user need statement will be made to clarify the user's needs.

3.1.3 Ideate

This stage is where all ideas and solutions are collected and developed according to the problems identified in the previous process. After gathering all the information, the researcher must select an idea that meets the user's needs, can be executed well, and works well. Of the three, the idea for the product to be made should be able to answer user needs.

3.1.4 Prototype

A prototype is needed to confirm the product concept. That way, collaborative work is easier to execute. In this study, a prototype was made using Figma to provide the user with a clear and interactive software description. Apart from using Figma, the software will be made using Circuit.io. However, due to the availability of sensors on Thinkercad, Figma is also needed to put together components that are not available in the Thinkercad application. So that the user can discover the fundamental functions of the design in progress using the prototype.

3.1.5 Test

After going through the previous stages, the final stage is testing. This stage is beneficial because it involves the user's response to the product or idea that has been created. Inventions that are deemed to be lacking, either from the standpoint of the user or due to design flaws in the circuit that has been designed, If an error or deficiency occurs that must be corrected, it will return to the process that must be corrected and return to this stage until the product meets the user's needs or not. The usual method used in the test phase is usability testing.

4. RESULT & DISCUSSION

4.1 Interview Finding

Figure 2: Empathy Map

After conducting interviews with several people engaged in catfish farming, the researcher made an empathy map. In Figure 2, there is an empathy map resulting from the interviews conducted. As the results can be seen in the picture above, some people who are engaged in catfish farming object to having to check regularly, but if they do not check regularly, they are worried that the catfish they are cultivating is of poor quality. They require a tool that can perform simple and effective checks, such as remote monitoring and control because they have heard of IoT, a technology remotely connected to a sensor.

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4.2 User Statement Need

This study creates a user needs statement to clarify and identify the problems and needs of the user. Figure 3 shows the result of making a user need statement based on the user's pain points. From this picture, we can find out the user's needs and what goals the user will achieve if these needs are met. It is explained in the picture that there is only one actor who needs to monitor the app and also wants to get notifications from the app or SMS if the water quality is terrible, which makes it easier to monitor with a smartphone and can immediately improve the water quality in catfish ponds if there is a moderate water quality notification.

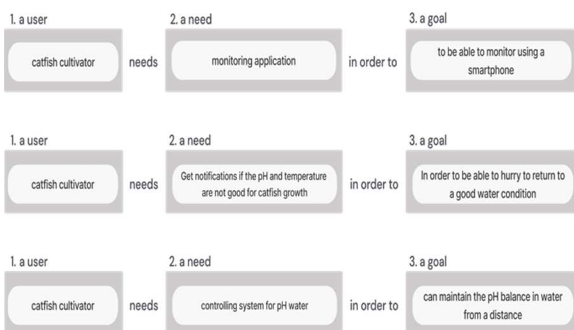

Figure 3: User Statement Need

4.3 Value Proposition Canvas (VPC)

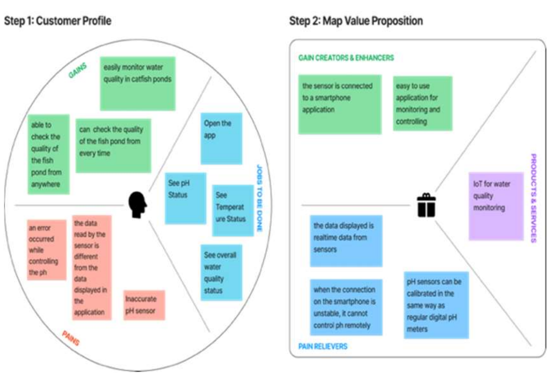

Figure 4: User Statement Need

VPC is used to define the solutions that will be offered to customers. The purpose of making VPC in this study is to learn more about the products consumers need so that this study can create value according to those needs. To create a VPC, we must identify the customer segment, what the customer needs to do, the pain from the customer's side, and the gain from the customer's side. Following that, gain creators and pain relievers were identified from the creator's perspective. As shown in Figure 4 below, the customer needs a system that is easy to use and can monitor and control the pool anytime and anywhere. They are also worried about data accuracy and data that could be more real-time. Based on the needs and concerns of consumers, this study will create a system using a smartphone to make monitoring easier. In addition, pH hardware can be calibrated in the same way as the digital pH sensors widely circulated today.

4.3 Activity Diagram

4.3.1 Software Activity Diagram

As shown in Figure 5 below, it is a process where catfish farmers can enter and use the application to monitor the water quality in the catfish ponds they are cultivating. This application allows users to add hardware devices, view pH and temperature status, and check water quality status.

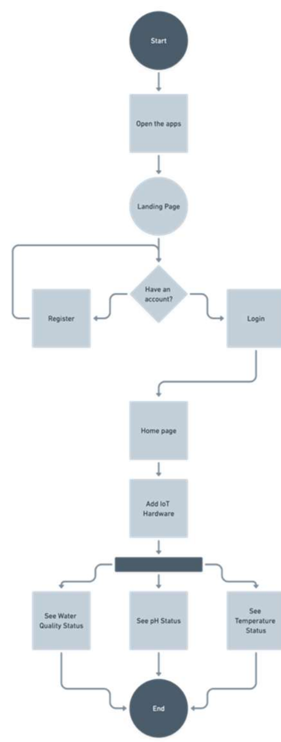

Figure 5: Software Activity Diagram

4.3.2 Hardware Activity Diagram

Based on Figure 6 below, it is a hardware process that works to send processed data to catfish farmers. The process inside is converting data from sensors, displaying values on the LCD, sending notifications via SMS or applications, saving the data to database storage, and sending it to applications. From the picture, it is undoubtedly helpful in the hardware design

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process because the outline of the design has been explained. As shown in Figure 5 below, it is a process where catfish farmers can enter and use the application to monitor the water quality in the catfish ponds they are cultivating. This application allows users to add hardware devices, view pH and temperature status, and check water quality status.

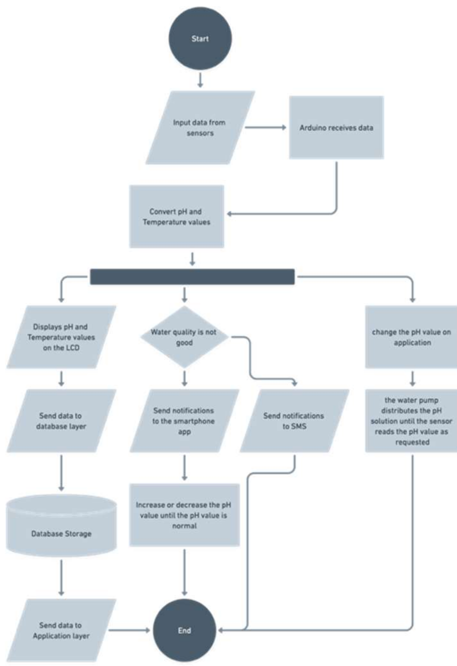

Figure 6: Hardware Activity Diagram

4.4 Use Case Diagram

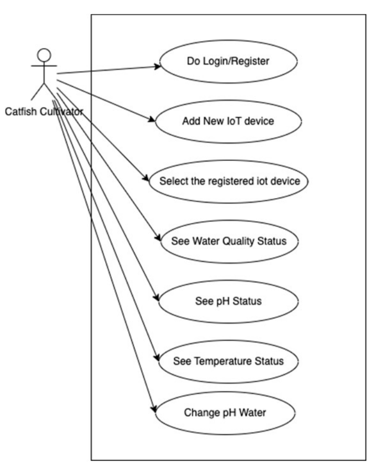

Figure 7: Use CaseDiagram

In Figure 7 above, there are seven use cases, starting with logging in, adding or registering hardware devices to the application, selecting hardware that has been registered, viewing water quality status, viewing water pH status, viewing water temperature status, and also changing the pH value in the pool. This use case also has several actors who play a role in this process, such as catfish farmers, IoT devices, databases, and applications.

4.5 Class Diagram

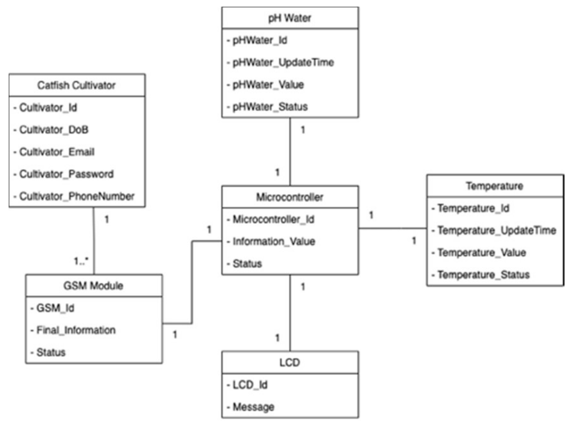

Figure 8: Class Diagram

As shown in Figure 8 above, the system has six objects that are interrelated and have their respective duties. The circulation of information and the interrelationships between objects can also be seen from these objects. Catfish cultivators can obtain information using their smartphones or seeing directly various information stored and processed in this system, such as the update time for each device, the status of each device, the information processed, and the information displayed.

4.6 Database Architecture

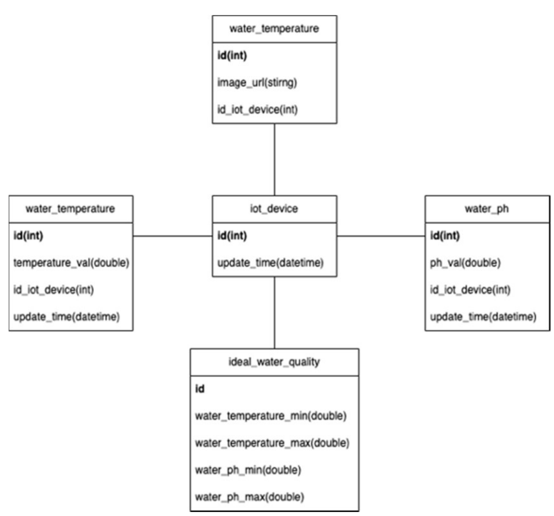

Figure 9: Database Architecture

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Figure 9 above shows the database architecture. In this study, database architecture helps explain the tables used, the data types used, and the interrelationships between databases. This study contains five tables, including an IoT device, water temperature, pH, image, and ideal water quality. The ideal water quality table is used to check whether the pH and temperature captured by the sensor meet good water quality. Each device sends updated time data to the database to ensure that the data displayed is current. The variable water pH and water temperature values use the double data type because the pH and temperature values allow decimal numbers.

4.7 User Interface

In difference to the previous studies described in chapter 2, most of the studies that have been carried out make applications using templates, so that the interface design of the application cannot be made freely and follows with the needs of its users. Therefore, the researchers designed the application to make the application attractive and according to user needs.

Firstly, if the catfish cultivator still needs to create an account on the smartphone application, the cultivator will enter the registration page, as shown in Figure 10. The catfish cultivator only needs to enter their name, email address, and password. It can be added after successfully logging in to the Hydropatrol application for more complete details regarding the profile. Catfish cultivators can register after entering the correct registration information. If it turns out that the catfish cultivator already has an account, then we can click the "I have an account" button.

In Figure 11, there is also an application login page with two input fields: the registered email address and password. If it turns out that we have never registered an account, catfish cultivators can click the "I do not have an account" button. However, if the data entered is correct and the cultivator has previously been registered, we can click the login button, and it will redirect to the home page.

Figure 12 below is the home page for the hydroponics application. A menu bar on this page can take us to other pages, such as the calendar, profile, and notifications. This page displays the current status of active devices. In addition to the hardware options that have been registered, catfish cultivators can click on the device options that have been registered for monitoring. On this page, catfish cultivators can also add their IoT hardware devices.

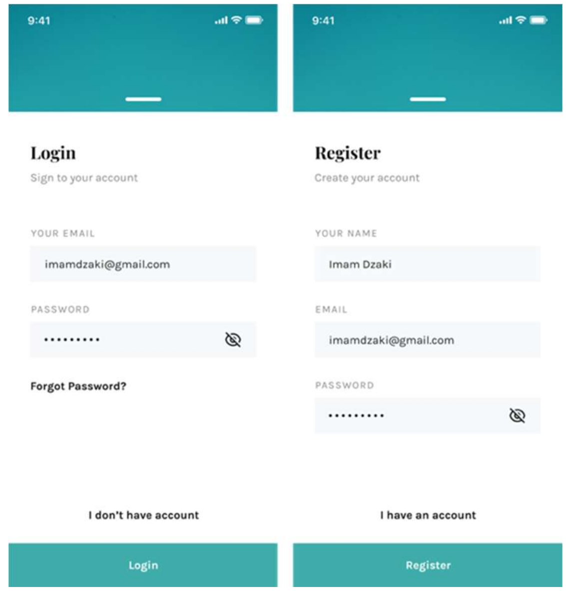

Figure 10: Login and Register Account

Besides that, in Figure 12, there is also a detail page. The page that will appear after selecting the registered hardware device is the detail page. This page contains information about water quality, temperature status, pH status, and buttons to increase or decrease pH. On this page, we can see the hourly changes in water quality status along with the percentage of water quality.

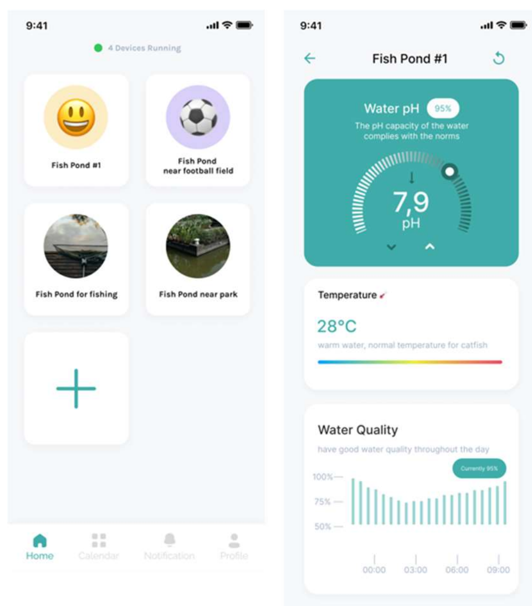

Figure 12: Home Page and Detail Page

Figure 13 below is the process of adding an IoT hardware device. Farmers can add an IoT device that can be monitored using this application. It is

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necessary to add some code as a device representative that connects the IoT device to the application. Apart from that, to distinguish between device one and the others, it is necessary to have a name and a photo or an emoji to indicate a particular device. For example, it was providing a name with the location or using a photo of the location.

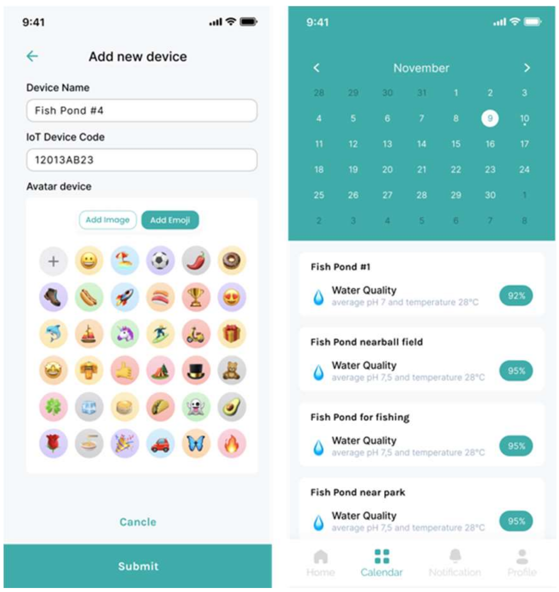

Figure 13: Add Page and Calendar Page

Apart from that, one of the exciting features of this hydropatrol application is the calendar. In this calendar, catfish cultivators can see a summary of water quality, pH, and temperature from the previous days. Figure 14 shows a calendar display where catfish cultivators can see the overall water quality of the previous days and each registered hardware device.

4.8 Hardware Design

Five hardware designs are used for water quality monitoring systems in catfish ponds. Among them are pH sensors, temperature sensors, GPS modules, LCDs, and water pumps.

4.8.1 pH Sensor

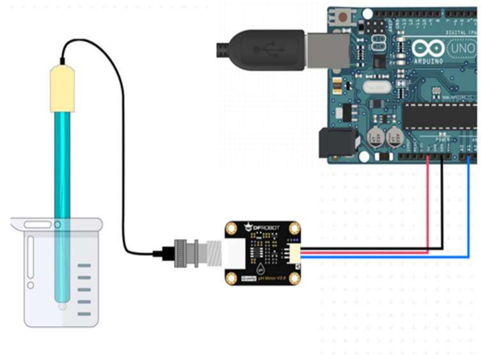

Figure 14: pH sensor

As shown in Figure 14 above, it can be seen that the pH sensor is connected to the Arduino Uno microcontroller. This pH sensor is placed in the pool water and will read the pH level in the pool water, send it to the database, and display it on the application. This sensor must be calibrated first to produce an accurate pH value, in the same way as the digital pH meters in circulation.

4.8.2 Temperature Sensor

In Figure 15 below, a circuit connects the Arduino Uno microcontroller and the temperature sensor. The Waterproof DS18B20 sensor was used. This sensor can be placed underwater because it is resistant to water, so it fits the needs of this system. A 4.75K resistor is needed to avoid a short circuit in the system to connect the temperature sensor and the microcontroller. Like the pH sensor, this sensor will also send data to the database and display it on the application.

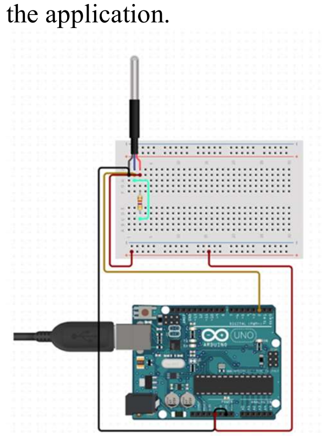

Figure 15: Temperature sensor

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4.8.3 GSM Module

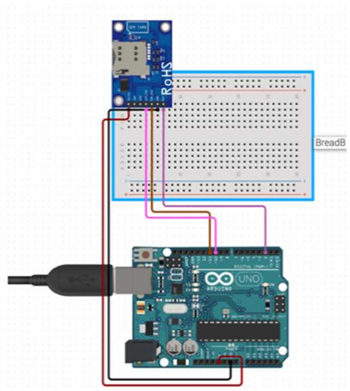

Figure 16: GSM Module

Figure 16 above is a series between the GSM module and the Arduino Uno. The GSM module helps store SIM cards and communicate between the Arduino Uno and smartphones. With the GSM module, apart from being able to communicate online, of course, we can also send SMS messages. The GSM module can also be used to place hardware devices anywhere without wifi because it can work on its own using a SIM card.

4.8.4 LCD

As shown in Figure 17 below, which is a circuit between the LCD and the Arduino Uno, the LCD in this study helps show the pH and temperature values captured by the sensor. The LCD is placed near the fish pond to help check when the catfish farmer is in the catfish pond area. The LCD used in this study is a 12c 16x2 LCD. This study chose to use this LCD because it is the right size and only uses four pins, making it easier to assemble.

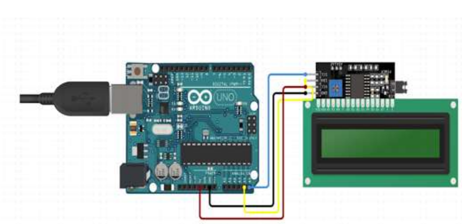

Figure 17: LCD

4.8.5 Water Pump

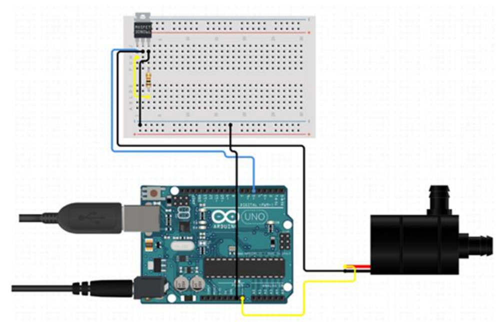

Figure 18: LCD

In Figure 18, the water pump is connected to the Arduino Uno. The pump will work automatically if the pH in the pond water is not suitable for catfish growth. The pump can also work according to commands from the smartphone application. The pump will distribute the pH solution until the pool sensor reads the pool's pH level as requested by the application or works automatically when the pH in the water is abnormal.

4.9 Block Diagram

Figure 19 below is a block diagram used in this study. Two sensors become input data in this system: the temperature sensor and the pH sensor. Both of them send data from the sensor to Arduino Uno. Arduino Uno will change the values obtained by the two sensors according to their use, for example, changing the temperature value to Celsius units. Apart from the Arduino Uno sensor, it also requires a GSM module to send data. After the Arduino has processed all the data, the data will be sent to the LCD to display the pH and temperature values. Apart from that, data is also sent from Arduino Uno to the network to be stored and sent to the application so catfish cultivators can view it from their smartphones.

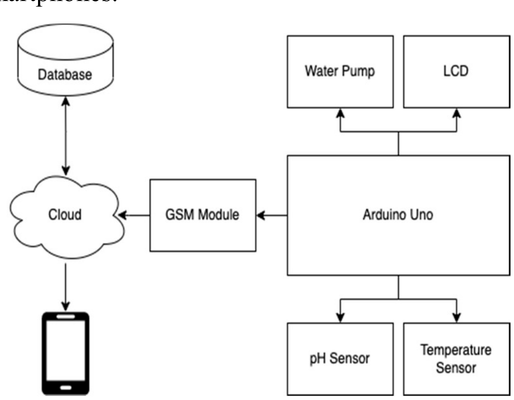

Figure 19: Block Diagram

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5. CONCLUSION

The researcher's findings have resulted in an overall system design is expected to help catfish farmers manage water quality in their ponds. This system can remotely monitor and control water quality in catfish ponds using a smartphone connected to IoT hardware. Water quality parameters used in this study were pH and temperature in catfish pond water. With this system, it is possible to automate work processes that are usually manual. This system can also work automatically if the pH value is less or more than the pH value suitable for catfish growth. This system makes the cultivation process more efficient and effective because the monitoring process is carried out non-stop. All data relating to the water quality of the cultivators are also stored in a database so that the cultivators can see developments in the water quality in the ponds. Farmers also get notifications if the water quality needs to be better for catfish growth. The design of the entire system that has been made is expected to provide a clear picture of all the processes in this system. However, because this research is still in the system design stage and its scope is limited to catfish, future research will apply the results of this research to fish cultivators and expand the scope of fish by adding sensors such as oxygen sensors and water turbidity so that they can be used and beneficial for other fish. This study hopes to increase effectiveness and make it easier for catfish farmers to produce good quality fish.

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