CONTROL AND SUPERVISION SYSTEM FOR SPIRULINA MICROALGAE CULTIVATION

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ABSTRACT

In the cultivation of Spirulina are some indicators of growth that must be met, including; water pH, water temperature, water level and intensity of light. The absence of a system that can provide information when Spirulina growth indicators are not met, the constraints experienced by Amorina Farm because monitoring is still done manually with a limited duration. Therefore, it is necessary to build a system to provide information when there is a change that can be directly addressed. System Control and Supervision for Cultivating Microalgae Spirulina is a system built using the technology of the Internet of Things (IoT), a based website that is integrated with a microcontroller to monitor changes in the value of each indicator. These values will be sent to the server so that managers can see the change in the indicator value online. In software development, prototype method is used with stage communication, quick plan, quick modeling design, construction of prototypes, as well as development delivery and feedback. Based on the results of the research that has been done, the system has been run in accordance with its functional and can provide information when growth indicators are not in accordance with the standards specified. The average value of a sensor error is sent to the server is less than 0.030%. Therefore in general, the system has been built already can help managers Amorina Farm in controlling and supervising the growth of Spirulina.

Keywords: Spirulina, microalgae, Amorina Farm, the Internet of Think, IOT

1. PRELIMINARY

Spirulina is a blue-green microalga that life is widespread in the aquatic ecosystem, whether it is freshwater, brackish water, and seawater. Spirulina can grow well in lakes with alkaline water acidity (pH 8.5 to 11). Spirulina can thrive in a temperature range of 18ºC-40ºC 500-350000 lux light intensity. [1] Spirulina contains very good for the human body. Spirulina as the development time of use is increasing. It's used among others in the field of industries such as the food industry. One example of the food industry using Spirulina as a raw material is Amorina Farm.

Amorina Farm is a Unit for Micro, Small and abbreviated Medium or SMEs engaged in agriculture or cultivation of Spirulina. Amorina Farm itself is at Arboretum Padjadjaran University, Jatinangor, established by the Michelle Azista Nabila Casandra, S.Si, M.Si and colleagues in 2011. Based on interviews with the owner verbally Amorina Farm Michelle Azista Nabila Casandra, S.Si, M.Si, to obtain the maximum results in the cultivation of Spirulina, it is necessary for certain ways like; means that a sterile or clean as well as indicators of support that must be met. These indicators are water pH, water temperature, light intensity and also the water level. To meet the growing indicators that have been mentioned previously, Amorina Farm has made the standard value indicator for the cultivation of Spirulina, namely; water pH equal to 10, the water temperature more than or equal to 18 ° C, the water level is equal to 30cm and light intensity more than equal to 1500 lux. So that these indicators can be met then it should be checked properly.

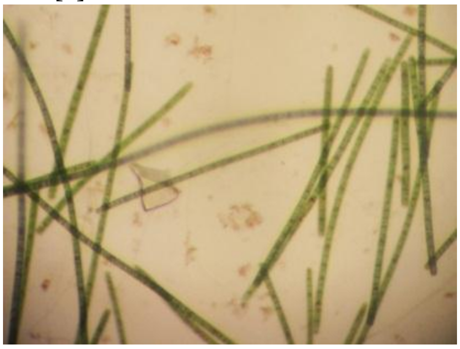
The cultivation of Spirulina is at a vulnerable time for two weeks disturbed growth since the beginning of cultivation and in times of growth indicators that must be fulfilled. Growth indicators such as water pH, water temperature, water level, and light intensity have not met an obstacle in the cultivation of Spirulina for the duration of the checks carried out twice a week, to keep the place clean cultivation of Spirulina. The next major issue that occurs in the cultivation of Spirulina is the lack of automation notification when the drastic changes in the pH of the water and the water level in the tub growth of Spirulina as well as changes in water temperature and light intensity according to standards that have been determined so as to cause the growth of Spirulina disturbed even die.

Based on the problems described earlier, the solution to this problem is to build a system of control and supervision on Spirulina microalgae cultivation technology using the Internet of Things (IoT). Internet of Things (IoT) itself can be defined as technology that allows for control, communication, and cooperation with various hardware devices through the Internet. With this system, is expected to help managers Amorina Farm in controlling and supervision system for Spirulina microalgae cultivation.

2. THEORETICAL BASIS

2.1 Spirulina

Spirulina is a microscopic alga (microalgae) bluish green that life is widespread in aquatic ecosystems, be it freshwater, brackish water, and seawater. Spirulina is grown in lakes with alkaline water acidity (pH 8.5 to 11). Spirulina can thrive in a temperature range of 18ºC-40ºC with low to high light intensity (lux 500-350000). [1] Spirulina contains a complete nutrient, such as proteins which reaches 60-70%, a full eight amino acids are easily digested because the walls are composed of proteins and complex sugars, fatty acids, vitamins, and antioxidants are high. In addition, Spirulina has phycocyanin pigment that functions as an antioxidant and anti-inflammatory, polysaccharides, which have anti-tumor and antiviral effects, γ-linolenic acid (GLA), which function in cholesterol reduction [2].



Picture 1. Spirulina Fusiformis

2.2 Control

Control comes from the word that means the control of the reins. According to the Dictionary of Indonesian control means the process, way, control actions; restraint, supervision of the progress of (task) to compare the results and objectives on a regular basis and adjust the business (activity) with the results of supervision [3].

2.3 Relative Error

Error is the excess of the true value of the approximation value. Suppose â is the value of approximation to a true value, then the difference = a - â. For example, if â = 10.5 and a = 10:45, then the error is = -0.01. If the error sign (positive or negative) is not taken into consideration, then the absolute error can be defined as a = | a - â |. To resolve the interpretation of the value of the error, the error must be normalized to its true value. This idea gave birth to the relative error.$\varepsilon\varepsilon|\varepsilon|$

The relative error is defined as follows:

$$\varepsilon_r = \frac{\varepsilon}{a}$$

If the percent is defined as follows:

ε_r = × 100% [4]$\frac{\varepsilon}{a}$

2.4 Internet of Things

Internet for all or in Britain the Internet of Things are better known by the acronym IOT, is a concept that aims to extend the benefits of Internet connectivity are connected continuously. As for capabilities such as data sharing, remote control, and so on, as well as the objects in the real world. Examples of foodstuffs, electronics, collectibles, any equipment, including all living things are connected to local and global networks through an embedded sensor and are always active. [5]

2.5 webServer

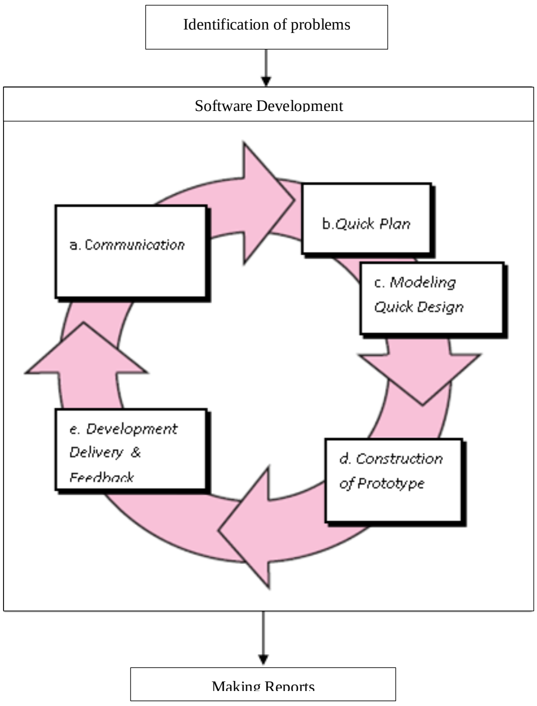
Web servers are computers that are used to store document-web documents, the computer will serve a web document request from the client. Web browsers communicate over a network (including the Internet) with a web server, using HTTP. The browser sends a request to the server to ask for specific documents or other services provided by the server. The server gives a document or its services if available, by using the HTTP protocol. [6]

2.6 Arduino Uno

Arduino UNO board using the ATmega328 microcontroller. In general, the position or location of the pin-pin input or output on a variety of Arduino board position similar to the position or location of the pin-pin input or output of the Arduino UNO which has 14 digital pins that can be set as an input or output and six-pin Analog Input. [7]

3. RESEARCH METHODS

The research methodology used in this study using a quantitative approach with descriptive analysis method is a method that aims to get a clear picture of the things related to the research. The stages can be seen in Picture 2.



Picture 2. Phase Research

The method used to research the plot is as follows:

a. Identification of problems

Conduct research on issues related problems in the cultivation of Spirulina microalgae.

b. Software Development

In making the system more user engagement is high. Because it used methods of software development prototype, which aims for the system to meet user needs better. Stages of a development software prototype model are communication, quick plan, quick modeling design, construction of prototypes, as well as development delivery and feedback. [8]

c. Making Reports

At this stage the preparation of reports based on the results of research using techniques of primary and secondary data collection so that it becomes a research report can provide the full picture of the system that is being built.

4. RESULTS AND DISCUSSION

4.1 Problem Analysis

Based on the interviews that have been made to the CEO Amorina Farm, found some constraints on the cultivation of Spirulina, including:

a. Checking the Spirulina growth indicator done twice a week.

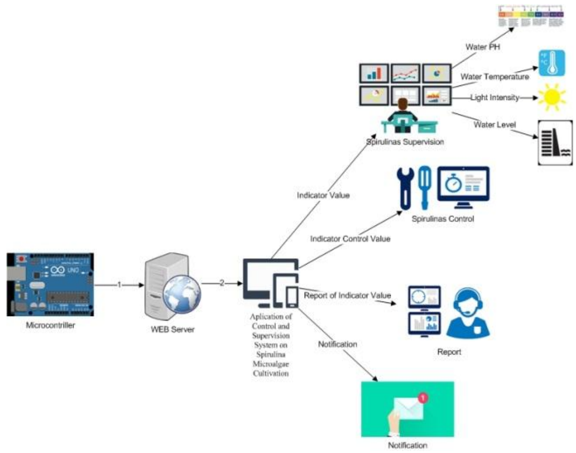
To obtain Spirulina with a good quality indicator is the growth of Spirulina itself must be met such as; ideal water pH 10, the ideal water temperature of 25ºC - 27ºC, the water level in the tub 30cm maximum growth and much more. Currently, Spirulina growth indicator checks done every two weeks to maintain the cleanliness of the hatchery in order Spirulina cultivation in ponds is not contaminated from the outside. As a result of checks carried out only twice a week, sometimes there are indicators of growth are not being met and result in the death of Spirulina which is being cultivated so that the cultivation must take place.

b. The absence of a notification system when the indicators of the growth of Spirulina changed.

The absence of a notification system when a drastic change in pH of the water, the water level, water temperature, and light intensity become constraints experienced during the cultivation of Spirulina. To determine changes in Spirulina growth indicators should be performed twice a check every week, but sometimes changes occur when the checks were not last so handling should be done late. Of these problems, we need a system that can provide automatic notifications to help managers in controlling and supervision on Spirulina cultivation.

4.2 The Concept of Openness

In the construction of this system, there is a flow of the system or the system concept. The concept can be seen in Picture 7:



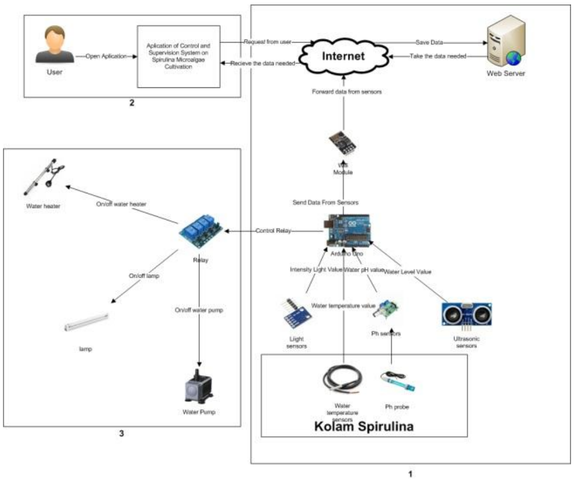
Picture 7. System Concept

Here's an explanation of Picture 7:

1. The microcontroller will send the value indicators such as water pH, water temperature, water level and intensity of light to a web server.
2. The web server will store all the data sent by the microcontroller, then sends it to a web-based application when the user needs it.
3. Application Control Systems and Control On Cultivating Microalgae Spirulina has four main features include:
   a. Users can view the values of water pH indicator, water temperature, water level and the latest light intensity transmitted by the microcontroller.
   b. Users can set the minimum pH value of water and the water level.
   c. Users can obtain reports based on the date you want to search.
   d. Users can receive notifications via e-mail when there are indicators of growth are not in accordance with the arrangement.

4.3 System Architecture Analysis

The system architecture is built utilizing an Arduino Uno microcontroller, which is connected to sensors for checking the growth indicators. The sensors are water pH sensor, water temperature sensor, ultrasonic sensor, and sensor light intensity. The concept of the system can be seen there are Picture 8 below:



Picture 8. System Architecture

Here's an explanation of Picture 8:

1. The sensor sends data to the Arduino Uno analog value will be converted into float value or decimal value. Arduino Uno will send the value to the web server at 09:00, 12:00 and 15:00 through acceptable Internet connection wifi module. Before sending the value previously obtained, Arduino Uno will convert a float or a decimal value into a string value that can be read by a PHP file with getting format data.
2. The user opens a web-based application using the device (PC, smartphone or tablet) that is connected to an internet connection. Users log in to the admin panel to view the data sent by the sensor and also the user can apply the settings on the system.
3. Arduino sends a command to the relay according to an order made earlier based on data from the sensors.

4.4 Software Requirements Specification Functional

Functional software requirements specification can be seen in Table 1:

Table 1. System Software Requirements Functional

code SKPL	Software Requirements Specification
SKPL-F-001	The system provides the facility to log into the system.
SKPL-F-002	The system provides the facility forget the password.
SKPL-F-003	The system provides the facility to manage user data.
SKPL-F-004	The system provides the facility to monitor changes in the pH value of the water.
SKPL-F-005	The system provides the facility to monitor changes in water temperature value.
SKPL-F-006	The system provides the facility to monitor changes in the value of the water level.

Table 1. System Software Requirements Functional (Continued)

code SKPL	Software Requirements Specification
SKPL-F-007	The system provides the facility to monitor changes in light intensity value entered into the greenhouse.
SKPL-F-008	The system provides the facility to manage report data.
SKPL-F-009	The system provides the facility to manage the data notification.
SKPL-F-010	The system provides facilities for water pH limit settings.
SKPL-F-011	The system provides facilities for setting the water level limit.

4.5 Software Requirements Specification Non-Functional

Specifications of non-functional software requirements are listed in Table 2:

Table 2. Software Requirements System Non-Functional

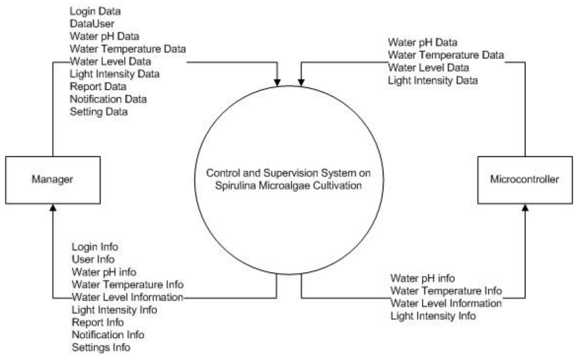
code SKPL	Software Requirements Specification
SKPL-NF-001	The system can run on software specifications required a minimum.
SKPL-NF-002	The system was built using hardware specifications that meet the minimum standards required.
SKPL-NF-003	The system can be used on the user are recommended.

4.6 Functional Needs Analysis

Analysis of functional requirements is the description of activity backend process to be applied in systems that can explain the necessary requirements in order to learn the system well in accordance with the needs of the system. Analysis conducted modeled using Data Flow Diagram Context and diagram.

a. diagram Context

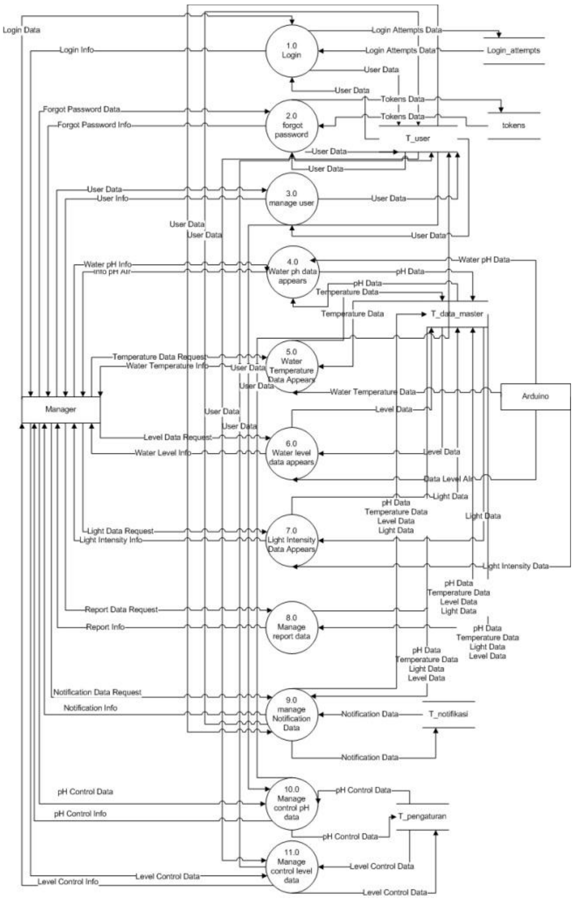
A context diagram is the highest level of the DFD diagram a portrait of the input or output of a system and its relationships in the system. Diagram the cortex control and supervision system in Spirulina microalgae cultivation can be seen in Picture 9:



Picture 9. Diagram Context

b. Data Flow Diagrams

DFD is used to describe a system existing or new systems that will be developed logically without considering the physical environment where the data flow or physical environment in which the data will be stored. DFD level 1 on the system of supervision and control in the cultivation of Spirulina microalgae can be seen in Picture 10:



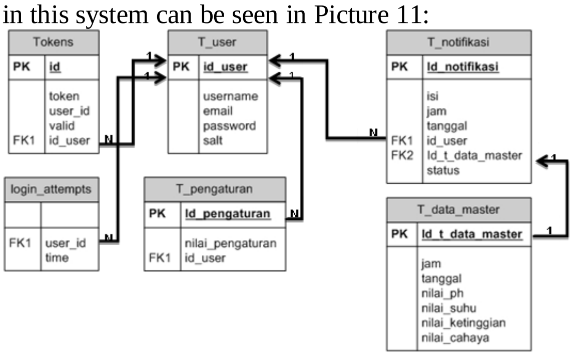
Picture 10. Level 1 DFD

4.7 System planning

This section will explain the design of the system to be built as a database design.

a. Design Database

At this stage of database design, modeling will be described using the relation scheme. Relationship scheme is a series of relationships between two or more tables in the database system. Scheme relations in this system can be seen in Picture 11:



Picture 11. Scheme Relation

4.8 System implementation

Implementation of the system includes the implementation of hardware and software.

a. Hardware Systems

The hardware system is divided into two parts: the hardware client and server hardware:

1. Hardware Client

The hardware includes hardware client personal computer or laptop, smartphone or tablet hardware as well as hardware IOT. Client hardware can be seen in Table 3 to 5:

Table 3. Hardware Specifications Personal Computer

No.	Hardware	Specification
1	RAM	2 GB
2	Free Space	1 GB
3	Processor	2.53 GHz
4	Mouse and Keyboard	Standard
5	Monitor	14 "with a resolution of 1336 x 768 pixels
6	Network interface	*onboard* Wifi (wireless internet network use)

Table 4. Hardware Specifications Smartphone or Tablet

No.	Hardware	Specification
1	RAM	3 GB
2	ROM	16 GB
3	*processor*	1.4 GHz
4	screen dimensions	5.5 inches
5	Internet	HSPA +

Table 5. Hardware Specifications IOT

No.	Hardware	Information
1	Microcontroller board	Arduino Uno R3
2	pH sensor	pH Sensor Module V 1.1
3	pH probe	Probe E201-C-9
4	temperature sensor	DS18B20
5	Light sensor	GY-30 BH1750
6	Height Sensor Water	HC-SR04 Ultrasonic Sensor

Table 5. Hardware Specifications IOT (Continued)

No.	Hardware	Information
7	Relay module	4 Relay Module
8	RTC module	DS1307 RTC
9	Wifi module	NodeMCU 8266 ESP 1.0
10	wifi Adapter	HUAWEI E5673

2. Hardware Servers

Here are the specifications of the server hardware used to implement the control and supervision systems In Microalgae Spirulina cultivation could Dilip in Table 6:

Table 6. Server Hardware Specifications

No.	Hardware	Information
1	CPU Power	3.75 GHz
2	memory	256 MB

b. System Software

The system software is divided into two parts: client software and server software:

3. Client Software

The software includes a software client personal computer or laptop, smartphone or tablet software as well as software IOT. Client software can be seen in Table 7 to 9:

Table 7. Specifications Personal Computer Software

No.	Software	Information
1	Operating system	Windows 7
2	Browser	Chrome

Table 8. Software Specifications Smartphone or Tablet

No.	Software	Information
1	Operating system	Android Version 5.1.1 (lollipop)
2	Browser	Chrome

Table 9. Software Specifications IOT

No.	Software	Information
1	Code Editor	Arduino IDE

4. Server Software

Here are the specs Server software used to implement the control and supervision systems In Microalgae Spirulina cultivation can be seen in Table 10:

Table 10. Server Software Specifications

No.	Software	Information
1	DBMS	MySQL
2	Web Server	Apache

4.9 Overall System Testing

Testing the overall system includes a sensor testing and functional testing of the system.

a. Sensor testing

Sensor testing serves to compare the value obtained from the sensor to the comparator in order to obtain the value of the relative error or error margin of comparative data. Experiments performed 10 times with a duration of between probation for two minutes due to consider the duration of the checking.

1. PH Sensor Testing

PH sensor testing is done by comparing the values obtained by the sensor with a pH meter. The following test results:

Table 11. pH Sensor Testing

Trial	PH Sensor value	pH Tester	The percentage of error abs (PH1-PH2) / PH2 * 100%
1	10.01	10.1	0.008911
2	10.06	10.1	0.00396
3	10.06	10.1	0.00396
4	10.17	10.1	0.006931
5	10,11	10.1	0.00099
6	10.08	10.1	0.00198
7	10.7	10.1	0.059406

Table 11. pH Sensor Testing (Continued)

Trial	PH Sensor value	pH Tester	The percentage of error abs (PH1-PH2) / PH2 * 100%
8	10.7	10.1	0.059406
9	10.75	10.1	0.064356
10	10.42	10.1	0.031683
Average Percentage Error%			0.024158

Based on the results of the test, the average value of the percentage of error in the pH sensor is equal to 0.024158%, or if rounded to 0.024%. Maximum error tolerance value in testing the pH sensor is equal to 0.036% or the pH value scale of 1 to 14 is 0.5. Due to 0.024% <0.036%, it can be concluded that the pH sensor can work good view and meet predetermined tolerance value

2. Temperature Sensor Testing

Testing the temperature sensor is done by comparing the values obtained with the thermometer sensor. The following test results:

Table 12 Temperature Sensor Testing

Trial	Temperature Sensor Value	Thermometer	The percentage of error abs (S1-S2) / S2 * 100%
1	25.75	25.7	0.00194553
2	26	26	0
3	26	26.2	0.00763359
4	26	26	0
5	26	26	0
6	26	25.9	0.003861
7	26	26	0
8	26	26	0
9	25.88	25.8	0.00310078
10	26	26.9	0.03345725
Average Percentage Error%			0.00499981

Based on the results of the test, the average value of the percentage of errors at the temperature sensor is equal to 0.00499981% or if rounded to 0.005%. Rated maximum fault tolerance on the test temperature sensor is equal to 0.02% or the scale value of 0 ° C to 50 ° C is equal to 1 ° C. Due to 0.005% <0.02%, it can be concluded that the temperature sensor can work good view and meet a predetermined tolerance value.

3. Testing Ultrasonic Sensor

Testing of ultrasonic sensors is done by comparing the values obtained with the meter sensor. The following test results:

Table 13. Testing Ultrasonic Sensor

Trial	Ultrasonic Sensor Value	Meter	The percentage of error abs (M1-M2) / M2 * 100%
1	28.19	25	.1276
2	25.93	25	.0372
3	26.86	25	.0744
4	27,28	25	.0912
5	26.86	25	.0744
6	24.69	25	.0124
7	28.26	25	.1304
8	26.83	25	.0732
9	26.9	25	0.076
10	24.45	25	0,022
Average Percentage Error%			0.07188

Based on the results of the test, the average value of the percentage of errors in the ultrasonic sensor is equal to 0.07188% or if rounded to 0.072%. The value of the maximum error tolerance testing ultrasonic sensor is equal to 0.008% or the value scale height of 0 cm to 25 cm is equal to 2 cm. Due to 0.072% <0.080%, it can be concluded that the ultrasonic sensors can work good view and meet a predetermined tolerance value.

4. Light Intensity Sensor Testing

Testing the light intensity sensor is done by comparing the values obtained by the sensor with a lux meter.

Table 14. Testing Sensor Light Intensity

Trial	Light sensor	LUX Meter	The percentage of error abs (LUX1-LUX2) / LUX2 * 100%
1	451	460	0.01956522
2	270	270	0
3	261	265	0.01509434
4	256	260	0.01538462
5	251	255	0.01568627
6	241	241	0
7	236	240	0.01666667
8	239	245	0.0244898
9	208	210	0.00952381
10	208	208	0
Average Percentage Error%			0.01164107

Based on the results of the test, the average value of the percentage of error in the light intensity sensor is equal to 0.01164107% or if rounded to 0.012%. Rated maximum fault tolerance on the test sensor is a light intensity of 0.1% or the light intensity value scale of 0 lux to 500 lux is 50 lux. Due to 0.012% <0.1%, it can be concluded that the light intensity sensor can work good view and meet a predetermined tolerance value.

b. Interview

To find out the results of a functional system that has been built we conducted this interview with the CEO of Amorina Farm Michelle Azista Nabila Casandra, S.Si, M.Si, the results of the interview can be seen in Table 15:

Table 15 Interview

Question	answer
Does the existence of this system is already able to help you keep an eye on the growth of Spirulina?	Yes, it's been quite helpful.
Can this application allow you to obtain the information needed?	Yes, very easy.
Whether the application is easy to learn and use?	Yes, easy to learn.
Is there a problem when you use this app?	So far there are no obstacles in using this application.
Does this application can provide a positive impact Amorina Farm?	So far it is enough to help
Are there any features that need to be added to this application?	No, it's just still needed improvement to be more mobile friendly.
Are there any comments and suggestions for future app development?	The tools used must be set tidier and set in order for Waterproof. Kulturisasi Spirulina using water media so that for application on an industrial scale, of course, the equipment used should be more secure.

c. conclusion Testing

Based on the results of testing and functional testing system sensors can be concluded that the system has been run in accordance with the functional, as well as sensor values generated by the average value of the error is less than 0.030%, so the results are still fairly accurate.

5. CONCLUSION

5.1 Conclusion

Based on the results of the testing that has been done, it can be concluded that:

1. The system can help managers to control and monitor the growth of Spirulina by turning on the water pump automatically when the water level is less than the standard, the system can turn on the heating water in automatically when the water temperature is less than the standard, and the system can turn on the lights automatically when the light intensity is less than the standard ,
2. The system can provide the required information for the user such as water pH, water temperature, water level and intensity of the light as well as

providing information when growth indicators such as water pH, water temperature, water level, and light intensity are less or more than the prescribed standards.

5.2 Suggestion

Therefore, there are many limitations in the research, there are several suggestions for further development include:

1. Therefore, there are many limitations in the research, there are some suggestions for the developer system is currently used only for the pool alone. Future is expected to be used for multiple pools in a single location.
2. Currently for nutrition still manually by considering the pH value of the water and the volume of water. Expected future can be done automatically by the system.

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