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Development of Automatic Pond Reservoir System to Support Automatic Surface Vehicle

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Abstract. Water quality is an important segment in shrimp farming. The main factor of water in ponds is seen from several dimensions, including the amount of dissolved oxygen, pH, and temperature. The implementation of the farmers at the research site uses a waterwheel approach for toot oxygen, KOH/Lime for pH, and circulating water in the pond for temperature. As the main factor, water must meet standards, oxygen levels (3-7ppm), pH (7-9pH), and temperature (24-32°C). This standardization aims to produce optimal shrimp culture considering that shrimp is one of the sensitive and cannibalistic animals. For example, if the temperature or pH suddenly changes, the shrimp will eat each other, but this standardization is challenging for farmers due to limitations. Human Resources. This study aims to develop an Automatic Pond Reservoir. The system built in this study implements fuzzy logic control on the Arduino for the classification process. It triggers the Pond Reservoir to ensure the water remains in optimal conditions for shrimp growth and development. The results of the tests were 282 times, showing an accuracy of 90%.

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1. Introduction

Water quality is the main factor in shrimp farming, as the main factor of water in ponds seen from several dimensions, including the amount of dissolved oxygen, pH and temperature [1][2]. The implementation of the farmers at the research site uses a waterwheel approach for toot oxygen, KOH/Lime for pH, and circulating water in the pond for temperature. As the main factor, water must meet standards, oxygen levels in the range 3-7, pH in the range 7-9, and temperature in the range 24-32(°C)[3].

This standardization aims to produce optimal shrimp culture considering that shrimp is one of the sensitive and cannibalistic animals, for example if the temperature or pH suddenly changes, the shrimp will eat each other[4], but this standardization is a challenge for the community. farmers due to limited human resources who control water conditions and provide proper treatment of water conditions. This limitation results in the need for a system that can automatically assess and then provide appropriate treatment (accelerating the waterwheel lane, increasing/lowering the PH, and opening or closing the water flow to bring it to an optimal temperature).

This research is based on [5] aims to develop Automatic Pond Reservoir which is integrated with previous research on Realtime Surface Modeling Vehicle Tambak Shrimp (RSMeV-TU) [6][7]. The system built in this study implements fuzzy logic control on the Arduino for the classification process and triggers the Pond Reservoir to ensure the water remains in optimal conditions for shrimp growth and development, while the shrimp used in this study is the Vaname shrimp. The results of the tests carried out were 282 times, showing an accuracy of 90%. It is hoped that with the tools developed by this research, Vename Shrimp farming can be carried out with more precision.

2. Related Work

Shrimp is a unique living creature, this is because shrimp is one of the very sensitive, especially in water. Shrimp will become cannibals if there is a sudden change in the water, such as a change in temperature or pH [4]. This characteristic has been understood by farmers, but it becomes a challenge in itself to become the water temperature in ideal conditions, this is because in some cultivation conditions found in the study, the number of human resources is a challenge for farmers. On the other hand, farmers also face the challenge of optimal cultivation which leads to the efficiency of cultivation costs, so that research has emerged conducted by [8] ho tried to do alternative resources, but there are also those who take an approach such as research conducted by [9] which uses Fuzzy Logic. with industry expert forums to minimize production costs and maximize shrimp growth.

Research conducted by [10] tried to integrate several pools using XBee communication and motoring them. Research conducted by [11] uses deep learning: CNN to analyze dynamic parameters using images. Research conducted by [12] sed aquaculture optimization by performing pond management (parameters of water level, pH, temperature and humidity). Research conducted by [13][14][15][16] also carried out water quality classification.

The research conducted above focuses on reading water quality [17], but has not yet entered into the standardization/manipulation of water so that it reaches the optimal indicator of shrimp growth [18]. The standardization of water quality in this study was carried out by adding KOH, opening the pond drain valve and adding water with normal temperature (25°C), and accelerating PWM on the waterwheel. Readings designed at once every 15 minutes will allow one cycle of reading and adjustments to be made over the same range. This will certainly improve the quality of the readings/accuracy of the suitability of water quality according to the needs of shrimp growth and development.

3. Research Methods

The research method is shown in Figure 1, this study begins with a literature review, research conducted by [9], [19] and [20] that fuzzy is appropriate for partial data. Besides being suitable for fuzzy partial data, it is also suitable for monitoring needs. Fuzzy in this study will be used to acquire data from sensors on previously developed tools [6][7], to then refine the rules to control the valve (pH and water flow) and PWM for the waterwheel.

Novelty that has been found is then continued with system design, at this stage the working mechanism of the hardware and software of the application is designed. Hardware is used to acquire water quality data, the acquired data is then sent using NodeMCU/ESP8266 and stored in the database, the process then proceeds to the classification process. The results of this classification are used as the basis for activation of the pH valve and the PWM value for the waterwheel. The results of this design are then continued with the implementation of the system.

The implementation of this system consists of hardware and software implementation, so that in the next stage testing is also carried out for both. In addition, related to the method used, initial testing was also carried out at the system test stage using training data (70% data). While the rest of the data (30%), used in the next stage, namely evaluation and conclusions. At this last stage, conclusions will be drawn about the accuracy of the application of methods, hardware and software implementations that have been tested (black box).

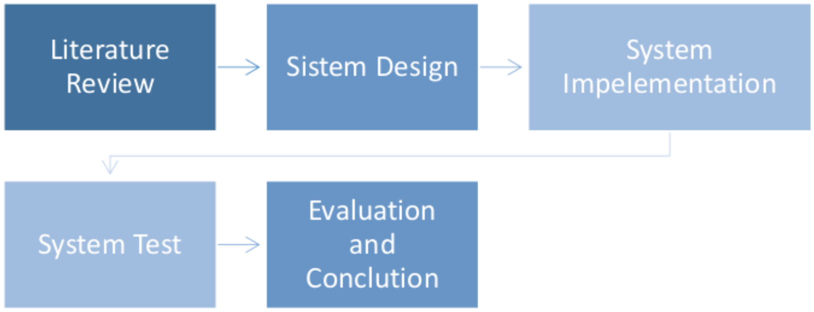

Figure 1. Research Methods

4. Discussion

4.1. Automatic Pond Reservoir System

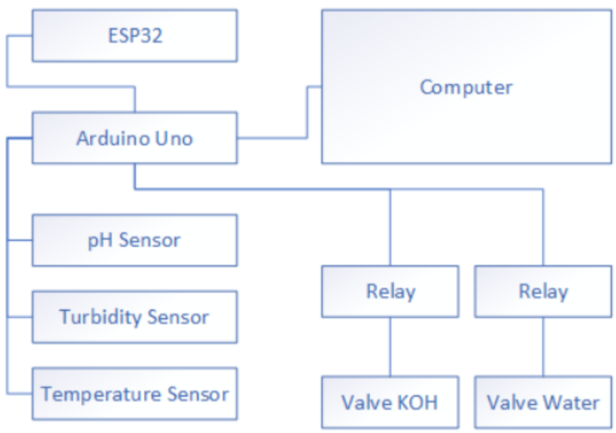

Figure 2. Block Diagram

The design of the system developed is shown in Figures 2 and 3. Where in the image it is clear that the components used in this study are used. In simple terms, the hardware communicates with the ESP32, which is also the main gate for data flow from the device. Then in the picture it is clear that there are three sensors (temperature, turbidity and pH) connected to the Arduino, then the data that has been processed according to the rule will activate the relay connected to the water valve and KOH and connected to the windmill by sending the required PWM.

Table 1. Variable Range

Class	Temp.	Range	pH	Range	Turbidity	Range	DO	Range
1	Low	≤ 26	Acid	≤ 7.5	Low	≤ 250	Low	≤ 4
2	Normal	24-32	Netral	7-9	Normal	200-450	Normal	3-7
3	High	≥ 30	Basa	≥ 8.5	High	≥ 400	High	≥ 6

Figure 3. Implementation Hardware

4.2. Fuzzy Calculation

The sensors used in this study: temp. (°C), pH (pH), turbidity (NTU) and DO (ppm) sensors. The output on the sensor will then be processed as input to Fuzzy, the value limits/ranges based on data obtained from the field are shown in Table 1. Each sensor is divided into three classes, In each component besides being processed to produce water quality classes, it is also used to calculate the value of each (fuzification only) for the trigres valve.

Equation 1 shows the membership function for pH, Equation 1 has 3 μ, where each μ represents the class used in this study. For research pH using three classes, namely low, neutral and alkaline. While the limit value for pH is obtained from shrimp farmers who in its implementation in the field still use the pH parameter as in general (no special limit), but in Vename Shrimp culture the optimal pH is in the range 7.5 to 8.5..

Table 2. Inference

Number	Temp.	pH	Turbidity	DO	Class
1	1	1	1	1	Very-Bad-Water
2	1	1	2	2	Bad-Water
3	1	1	3	3	Very-Bad-Water
4	1	2	1	1	Bad-Water
5	1	2	2	2	Enough-Water
...	..	..	..	..	..
78	3	3	2	1	Very-Good-Water
79	3	3	2	3	Very-Good-Water
80	3	3	3	1	Good-Water
81	3	3	3	2	Good-Water

$$\mu\, low = \begin{cases} 0 & ,x \geq 7.5 \\ \frac{(7.5 - x)}{(7.5 - 7)} & ,7 < x < 7.5 \\ 1 & ,x \leq 7.5 \end{cases} \qquad \mu\, netral = \begin{cases} 0 & ,x \leq 7\ and\ x \geq 9 \\ \frac{(x - 7.5)}{(7.5 - 7)} & ,7 < x < 7.5 \\ \frac{(9 - x)}{(9 - 8.5)} & ,8.5 < x < 9 \\ 1 & ,7.5 \leq x \leq 8.5 \end{cases} \tag{1}$$

$$\mu\, basa = \begin{cases} 0 & ,x \leq 8.5 \\ \frac{(x - 8.5)}{(9 - 8.5)} & ,8.5 < x < 9 \\ 1 & ,x \geq 9 \end{cases}$$

As for the inference process shown in Table 2, this table describes the AND process, for example in route number 1, If pH = acid and temperature = low and turbidity = not cloudy and DO = low then the water quality is very bad. One of the duplications in the route implementation. [R1] IF cold temperature AND low oxygen levels AND acidic pH AND turbidity not cloudy THEN very poor water quality 1 = cold temperature low oxygen acid pH not cloudy, shown by Equation 2.

$$\begin{aligned} \alpha 1 &= \mu\text{temperature low} \cap \mu\text{DO low} \cap \mu\text{pH acid} \cap \text{tubi. low} \qquad \text{z1 Very Bad} = 0.01 \\ &= \min\,(1\,,0,1\,,1) = 0 \end{aligned} \tag{2}$$

Fuzzy Sugeno (Weight Average) defuzzification in this study, for example in the sample used, can be seen from Equation 3. Where in the calculation the resulting Z value is 0.01.

$$Z = \frac{\alpha(1) * z(1) + \alpha(2) * z(2) + \alpha(3) * z(3) + \alpha(4) * z(4) + \cdots + \alpha(81) * z(81)}{\alpha(1) + \alpha(2) + \alpha(3) + \alpha(4) + \cdots + \alpha(81)} \tag{3}$$

$$= \frac{0 * 0.25 + 0 * 0.5 + 0 * 0.75 + 0 * 0.25 + 0 * 0.01 + 1 * 0.25 + \cdots + 0 * 0.5}{0 + 0 + 0 + 0 + 0 + 1 + \cdots + 0} = \frac{0.01}{1} = 0.01$$

4.3. Testing and Result

Table 3. Functional Tests: *Black Box* (BB)

Num.	Item Test	Function Test	Result Test
1	ESP32	Data Transmit	✓
2	Sensor: Temp.	Reda Temp. Val.	✓
3	Sensor: Turbi.	Read Turbi. Val.	✓
4	Sensor: pH	Read pH Val.	✓
5	Sensor: DO	Read DO Val.	✓

Table 4. *Fuzzy Testing Result*

Num.	Temp. Val.	pH Val.	Turbi. Val.	DO Val.	Class Result	Expert Assessment
1	28	7.18	276	11.30	0.38 (Bad)	Ep: False
2	28	7.52	276	11.21	0.51 (Enough)	Ep: True
…	..	..	..	..	..	
97	27	7.37	276	11.30	0.50 (Enough)	Ep: True
98	28	7.37	275	11.32	0.48 (Bad)	Ep: True
99	28	7.47	276	11.24	0.51 (Enough)	Ep: True
100	28	7.18	276	11.35	0.39(Bad)	Ep: False

The development was successfull based on the black-box tests shown in Table 3, where all the results: all successful (100%). This study use a ground truth, shown in Table 4. If the result is the same, it is counted as correct, otherwise it is counted as error. A test performed generated by the sensor (tool) returned an accuracy value of 90%.

5. Conclusion

As a result of our research, we were able to develop an automatic reservoir system. This is evidenced by black box test results showing a system compatibility score of 100%/all functions work normally. On the other hand, a test performed yielded an accuracy value of 90%. From the results obtained by the research, it is hoped that this tool can be implemented through further research to continue to help farmers.

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