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Smart Fish Farm Based on IoT Aas Monitoring to Reduce The Number of Death in Guppy Fish

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Abstract

During the transition from dry season to rainy season or vice versa, very high temperature fluctuations often occur, causing large number of deaths in guppy fish farming. The death of this guppy fish is also triggered by water conditions that are not maintained. Therefore, a system that can monitor water conditions in real time without being limited by distance, and that can cope the drastic temperature changes is needed. If water conditions can be monitored in real time, of course, the guppy fish in aquarium or tank will become healthier, well-maintained and will produce the best quality guppy fish. For this reason, the researcher makes a system that is able to monitor the condition of water in the aquarium to reduce the number of deaths in guppies. The researcher conducts trials using Fuzzy Mamdani method of three input variables from water temperature sensor, pH sensor and turbidity sensor which defuzzification result shows crips output value at 44.63. That result puts water condition in "Fair" level, and when it is matched with the calculation result of matlab r2013a using Fuzzy Mamdani, the result is 44.8 which is not far different. The result of this study is a smart fish farm system that can monitor water conditions in aquariums or tanks, such as: feeding time, checking and controlling temperature, monitoring water pH, monitoring water turbidity levels, lights control that can automatically turn on and off with room lighting indicators, and drain when the water is turbid. This smart fish farm system is made with an Arduino microcontroller that is connected to the internet based on Internet of Things (IoT) and the Mamdani Fuzzy Logic method. This smart fish farm system can also store records with platforms from Thingspeak and MitApp for the mobile applications making.

Keywords: *Internet of Things (IoT), Guppies, Smart Fish Farm, Fuzzy Logic, Microcontroller, Arduino, Thingspeak, MitApp*

INTRODUCTION

Interest in fish, especially guppies, during a pandemic like now is increasing. Therefore, a strategy or specific effort is needed to be able to meet market demand. One of the obvious efforts to fulfill this demand is adding the number of tanks (aquarium) for farming progress, which is done by a privately owned guppy fish farm located in Tangerang Regency. These tanks are the place where the guppies are put during farming progress until they are ready for sale. This progress stage is the most important thing to obtain the expected result. Due to the large number of tanks, not all fishes are well controlled during the farming progress. Many fishes die before they can be sold, resulting in crop failure.

This crop failure factor affects the decrease in the amount of fish production and turnover. To overcome this crop failure, it is necessary to monitor water temperature, water pH and water quality in the aquarium at all times to achieve the expected results. With well-maintained water quality, good temperature, and suitable water pH, guppies with attractive appearances can be produced, such as: wide tail shape, proportional body shape and not susceptible to disease. To maintain good water quality, water

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temperature and pH, it is necessary to have a system that can monitor and control it in real time. The researcher proposes that the system is made based on the Internet of Things (IoT).

According to (Wasista, et al., 2019) Internet of Things (IoT) is a term that appears with the notion of accessing electronic devices through internet media. The Internet of Things (IoT) is very useful for the development of intelligence as device access in broad and diverse sectors, for example: industrial sector, environmental sector, energy sector, hospital sector, transportation sector, public sector and so on.

In fisheries, Internet of Things (IoT) is very much needed. With Internet of Things (IoT), it becomes easier for farmers to monitor pH conditions, control water temperature and feed regularly without being limited by distance or time. The advantage obtained from controlling water quality, pH conditions, water temperature and regular feeding is that the guppy fishes in the tank (aquarium) become healthier and well-maintained. So that the development performance of the fish shape becomes more beautiful and charming. In addition, good water condition will make the percentage of living fish increases and thus can be harvested in large amount.

From the problems mentioned above, the researcher proposes a Smart Fish Farm system based on Internet of Things (IoT) with Fuzzy Logic method as an indicator for monitoring pH, water temperature and water turbidity. This system is expected to be able to help solving the problem of guppy fish death and reducing its number considerably.

LITERATURE REVIEW

Arduino Definition

According to (Kadir, 2013) Arduino Uno is one of Arduino labeled products which is actually an electronic board containing ATMega328 microcontroller (a chip that functionally acts like a computer). This device can be used to realize electronic circuits from simple to complex.

The advantages we get by using Arduino are:

1. The price is relatively cheap compared to other microcontrollers with the advantages offered.
2. It can be used on various operating systems such as Windows, Linux, Max, and others.
3. It has a programming language that is easy to understand, Arduino project has been widely studied because they are open source.

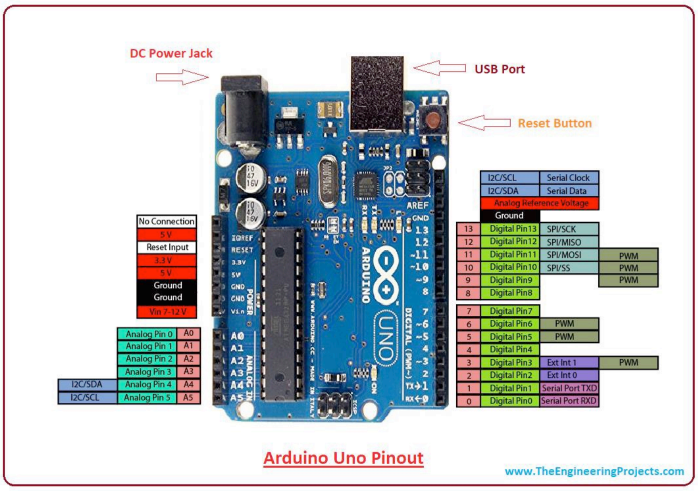


Figure 1. Arduino Uno Pinout (The engineering projects, 2018)

Internet Of Things (IoT)
According to (Wasista, et al., 2019) Internet of Things (IoT) is a term that appears with the notion of accessing electronic devices through internet media. Internet of Things (IoT) is very useful for the development of intelligence as device access in broad and diverse sectors, for example: industrial sector, environmental sector, energy sector, hospital sector, transportation sector, public sector and so on.
The IoT concept actually refers to three main elements in the IoT architecture (Teknologi Terkini, 2016), namely:
1. Physical goods equipped with IoT modules
2. Connection device to the internet such as a modem or home wifi
3. Cloud data center, a place to store applications and databases

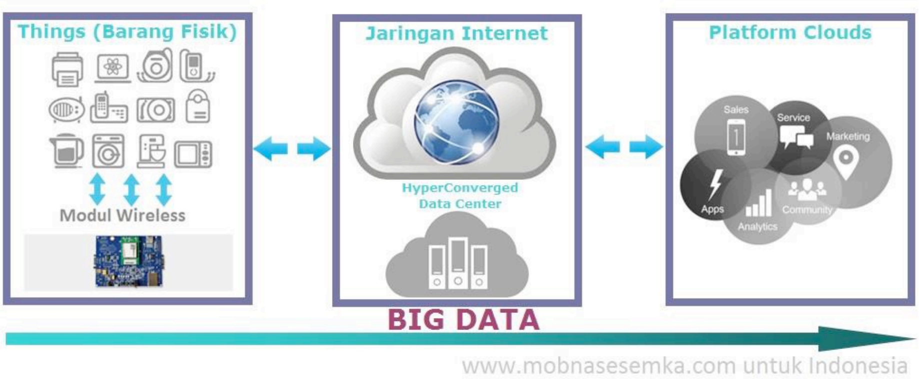


Figure 2. Internet of Things Concept(Teknologi Terkini, 2016)

Fuzzy Logic
According to (Kusumadewi & Purnomo, 2010) fuzzy logic is an appropriate way to map out an input space into an output space. There are several things that need to be known in understanding fuzzy systems, namely:
1. Fuzzy Variables
2. Fuzzy Assemblage / Set
3. Universe of Conversation
4. Domain

RESEARCH METHOD
Sample Selection Method
Random sampling technique is used in this study. This sampling technique is a technique where all fishes in the population have the opportunity to be selected. The purpose of this sampling is to test the growth, mortality rate, and quality of the fish itself until it is ready for distribution.

The categories of guppy fish taken for research sampling with this smart fish farm system are:

1. 45 days old / 1,5 months old
2. Healthy without defects
3. Type Albino Blue Topaz
4. Will be treated in aquarium with Internet of Things system

Analysis of Water Samples Used

The media used for this water condition sampling are two-liter jars and each contains one Albino Blue Topaz and male guppy fish. The location of this trial phase is conducted in a closed room (indoor) and carried out at night. The results and trials of the most suitable water conditions are shown in the image below.

Figure 3. Analysis of 3 types of water

In Figure 3, three types of water have been tested in the farm environment. Those are rain water, well water and refill water. The results of water conditions testing from pH and water temperature on the first day can be seen in the image below.

Figure 4. Water pH Test Phase

From the experiment result of the three types of water above, it can be concluded that rainwater has a very high pH, refill water has a fairly high pH, and well water has a neutral pH and is the most suitable for guppy fish maintenance and cultivation.

Figure 5. Water Temperature Test Phase

From the experiment result of the three types of water tested, it can be concluded that well water and refilled water have a stable temperature between 27˚C - 29˚C compared to rain water which has a very low temperature of 25˚C, thus making the water temperature in aquarium cold and often causing fish to get infected with whitespot disease.

Analytics with Internet of Things

This study will use comparison sample where several guppy fishes will be groomed without any controlling and monitoring, and put outdoor in enlarged refrigerator boxes, styrofoam, ponds or basins. While other guppy fishes are maintained in indoor aquariums or tanks which can be controlled at any time and monitored in real time using the proposed system to find out the effectiveness level of the system which is created to reduce the mortality rate in guppy fish, so that it can be applied by guppy fish farmers or other decorative fish farmers.

Several factors that cause death in guppies can be controlled and monitored in real time as shown in table 1 below.

Table 1. Functionality Applied to Smart Fish Farm

No	Application of Internet of Things in Aquarium
1	Monitor the temperature in the water and stabilize the temperature automatically
2	Monitor water pH
3	Control the lighting to turn on/off automatically when it is dark
4	Check the level of water turbidity and automatically drain the water
5	Feed remotely
6	Automatically activated drain pump when water condition is bad

Analysis with Fuzzy Logic

Measurement in this study is carried out by comparing the results of the implementation of Internet of Things with the simulation results of the Fuzzy Mamdani method with membership functions and predetermined values.

Table 2. Variables to be used

Function	Variable	Linguistic Variables	
		Fuzzy Set	Domain
Input	Temperature	Cold	0 – 22
		Normal	20 – 30
		Warm	28 – 35
	pH	Acid	0 – 6
		Neutral	5 – 8
		Alkali	7 – 14
	Turbidity	Clear	0 – 15
		Fair	10 – 25
		Cloudy	20 – 30
Output	Water Condition	Good	0 – 35
		Fair	25 – 65
		Bad	55 – 100

Here is the line equation of the temperature input graph:

The membership function of COLD, NORMAL and WARM Fuzzy set of Temperature variable in figure 6.

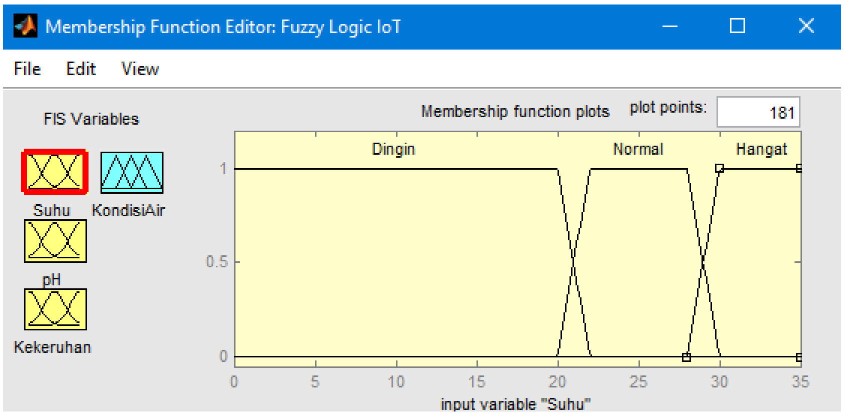


Figure 6. Fuzzy Sets on Water Temperature Variables

The membership function of ACID, NEUTRAL and ALKALI Fuzzy set of pH variable in figure 7

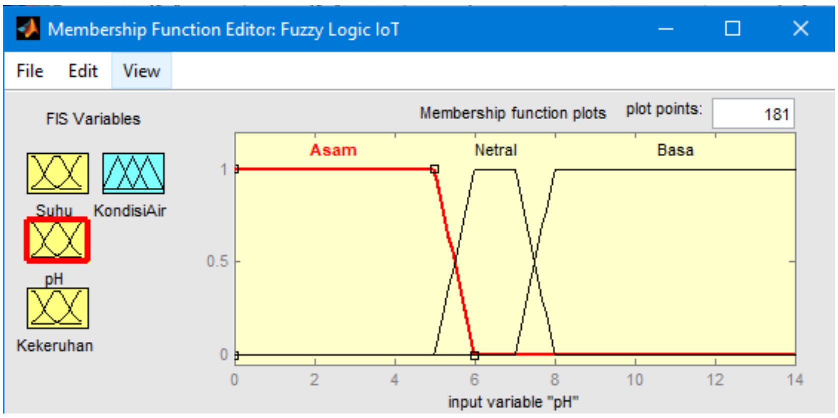


Figure 7. Variable Input pH

The membership function of CLEAR, FAIR and CLOUDY Fuzzy set of Turbidity variable in figure 8

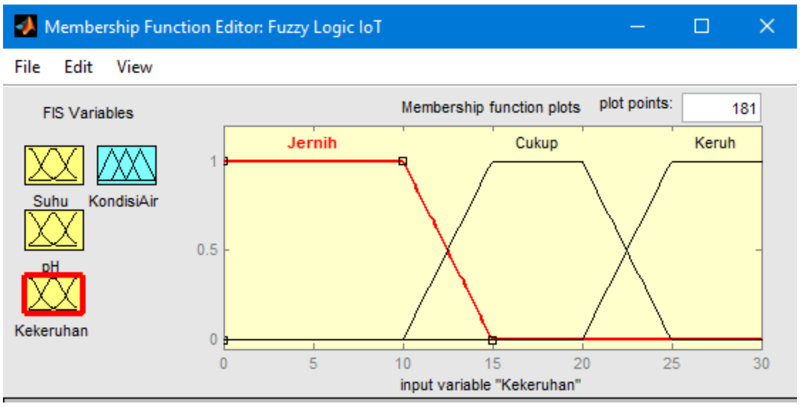


Figure 8. Turbidity Input Variable

The membership function of GOOD, FAIR and BAD Fuzzy set of Water Condition output variable in figure 9

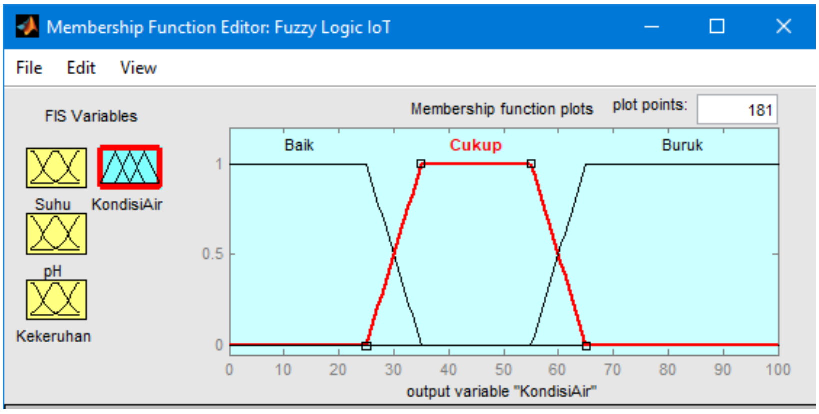


Figure 9. Water Condition Output Variable

FINDINGS AND DISCUSSION

Inference and Implication

The rule uses the logical AND operator, so the implication is that it uses the MIN function and the aggregation uses the MAX function

1. [R1] If the temperature is cold and the pH is acid and the turbidity is clear, then the water condition is bad. α-predicate$_1$ = min (0;0;1) = 0
2. [R2] If the temperature is cold and the pH is acid and the turbidity is fair, then the water condition is bad. α-predicate$_2$ = min (0;0;0) = 0
3. [R3] If the temperature is cold and the pH is acid and the turbidity is cloudy, then the water condition is bad. α-predicate$_3$ = min (0;0;0) = 0
4. [R4] If the temperature is cold and the pH is neutral and the turbidity is clear, then the water condition is fair. α-predicate$_4$ = min (0;0,4;1) = 0
5. [R5] If the temperature is cold and the pH is neutral and the turbidity is fair, then the water condition is fair. α-predicate$_5$ = min (0;0,4;0) = 0

6. [R6] If the temperature is cold and the pH is neutral and the turbidity is cloudy, then the water condition is bad. α-predicate$_6$ = min (0;0,4;0) = 0
7. [R7] If the temperature is cold and the pH is alkali and the turbidity is clear, then the water condition is bad. α-predicate$_7$ = min (0;0,6;1) = 0
8. [R8] If the temperature is cold and the pH is alkali and the turbidity is fair, then the water condition is bad. α-predicate$_8$ = min (0;0,6;0) = 0
9. [R9] If the temperature is cold and the pH is alkali and the turbidity is cloudy, then the water condition is bad. α-predicate$_9$ = min (0;0,6;0) = 0
10. [R10] If the temperature is normal and the pH is acid and the turbidity is clear, then the water condition is fair. α-predicate$_{10}$ = min (0,75;0;1) = 0
11. [R11] If the temperature is normal and the pH is acid and the turbidity is fair, then the water condition is fair. α-predicate$_{11}$ = min (0,75;0;0) = 0
12. [R12] If the temperature is normal and the pH is acid and the turbidity is cloudy, then the water condition is bad. α-predicate$_{12}$ = min (0,75;0;0) = 0
13. [R13] If the temperature is normal and the pH is neutral and the turbidity is clear, then the water condition is good. α-predicate$_{13}$ = min (0,75;0,4;1) = 0,4
14. [R14] If the temperature is normal and the pH is neutral and the turbidity is fair, then the water condition is good. α-predicate$_{14}$ = min (0,75;0,4;0) = 0
15. [R15] If the temperature is normal and the pH is neutral and the turbidity is cloudy, then the water condition is fair. α-predicate$_{15}$ = min (0,75;0,4;0) = 0
16. [R16] If the temperature is normal and the pH is alkali and the turbidity is clear, then the water condition is fair. α-predicate$_{16}$ = min (0,75;0,6;1) = 0,6
17. [R17] If the temperature is normal and the pH is alkali and the turbidity is fair, then the water condition is bad. α-predicate$_{17}$ = min (0,75;0,6;0) = 0
18. [R18] If the temperature is normal and the pH is alkali and the turbidity is cloudy, then the water condition is bad. α-predicate$_{18}$ = min (0,75;0,6;0) = 0
19. [R19] If the temperature is warm and the pH is acid and the turbidity is clear, then the water condition is bad. α-predicate$_{19}$ = min (0,25;0;1) = 0
20. [R20] If the temperature is warm and the pH is acid and the turbidity is fair, then the water condition is bad. α-predicate$_{20}$ = min (0,25;0;0) = 0
21. [R21] If the temperature is warm and the pH is acid and the turbidity is cloudy, then the water condition is bad. α-predicate$_{21}$ = min (0,25;0;0) = 0
22. [R22] If the temperature is warm and the pH is neutral and the turbidity is clear, then the water condition is fair. α-predicate$_{22}$ = min (0,25;0,4;1) = 0,25
23. [R23] If the temperature is warm and the pH is neutral and the turbidity is fair, then the water condition is fair. α-predicate$_{23}$ = min (0,25;0,4;0) = 0
24. [R24] If the temperature is warm and the pH is neutral and the turbidity is cloudy, then the water condition is bad. α-predicate$_{24}$ = min (0,25;0,4;0) = 0
25. [R25] If the temperature is warm and the pH is alkali and the turbidity is clear, then the water condition is bad. α-predicate$_{25}$ = min (0,25;0,6;1) = 0,25
26. [R26] If the temperature is warm and the pH is alkali and the turbidity is fair, then the water condition is bad. α-predicate$_{26}$ = min (0,25;0,6;0) = 0
27. [R27] If the temperature is warm and the pH is alkali and the turbidity is cloudy, then the water condition is bad. α-predicate$_{27}$ = min (0,25;0,6;0) = 0

Mamdani Rules Composition

The next step is to choose a rule that has the largest degree of membership with a max function for each linguistic variable. From the Good variable group it is found in Rule 13 or [R13], the Fair variable group is found in Rule 16 or [R16] and for the Bad variable group it is found in Rule 25 or [R25].

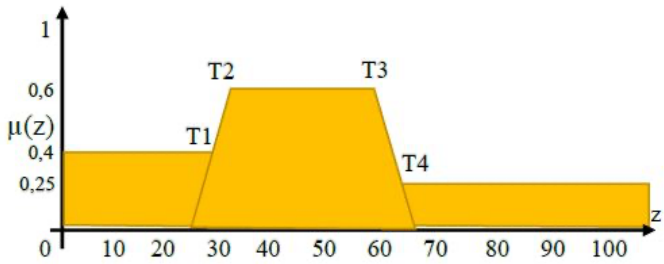


Figure 10. Results of Merging Three Groups of Linguistic Variables

Based on the membership function of Good set output variable, the value of 0,4 d(13) is obtained at α13 as follows:

T1 (d13) = α13 ⟷ $\frac{d(13)-25}{35-25} = 0,4$

d(13) = 29

Based on the membership function of Fair set output variable, the value of 0,6 d(16) is obtained at α16 as follows:

T2 (d16) = α16 ⟷ $\frac{d(16)-25}{35-25}=0,6$

d(16) = 31

Based on the membership function of Fair set output variable, the value of 0,6 d(16) is obtained at α16 as follows:

T3 (d16) = α16 ⟷ $\frac{65-d(16)}{35-25} = 0,6$

d(16) = 59

Based on the membership function of Fair set output variable, the value of 0,25 d(25) is obtained at α25 as follows:

T3 (d25) = α25 ⟷ $\frac{65-d(25)}{65-55} = 0,25$

d(25) = 62,5

The modification of the membership function of output variable after it is applied is:

$$\mu(z) = \begin{cases} 0,4\,;\, z \leq 29 \\ 0,6\,;\, 31 \leq z \leq 59 \\ 0,25\,;\, z \geq 62,5 \end{cases}$$

Defuzzification

At this defuzzification stage, the calculation process is carried out using the centroid or center of area method, as follows:

$M_1 = \int_0^{29} (0,4)z \ dz = 168,2$ $M_2 = \int_{31}^{59} (0,6)z \ dz = 756$ $M_3 = \int_{62.5}^{100} (0,25)z \ dz = 761,7$

$A_1 = \int_0^{29} 0,4 \ dz = 11,6$ $A_2 = \int_{31}^{59} 0,6 \ dz = 16,8$ $A_3 = \int_{62,5}^{100} 0,25 \ dz = 9,37$

So the crisp output value becomes:

$$Z = \frac{M_1 + M_2 + M_3}{A_1 + A_2 + A_3} = \frac{168,2 + 756 + 761,7}{11,6 + 16,8 + 9,37} = \frac{1686}{37,77} = 44,63$$

Based on the data above and samples which are analyzed using Mamdani method, it can be concluded that the water condition can be categorized as Fair.

The circuit design and layout of this tool have been adapted to the aquarium or tank that will be used in this study. These set of tools are placed in a box to make it look neat and not scattered. The set of tools can be seen in figure 11

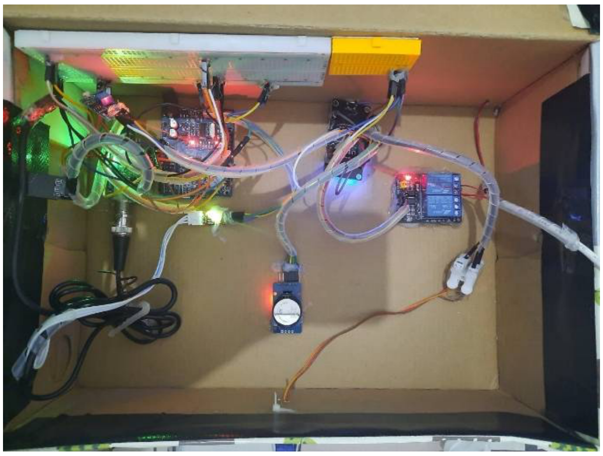


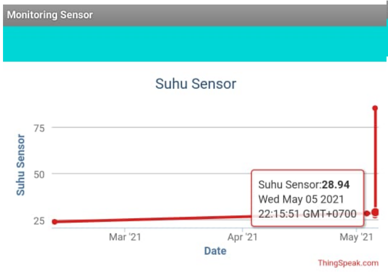
Figure 11. Smart Fish Farm Toolkit

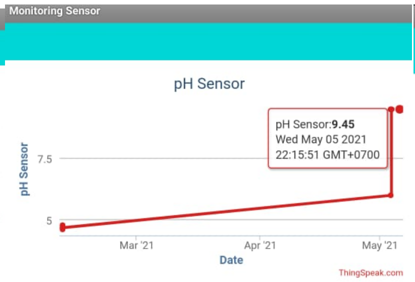
Figure 12. Implementation of Smart Fish Farm

Figure 12 is the implementation of a smart fish farm prototype in an aquarium that is used for approximately 30 days.

Application Interface Design

At this stage a User Interface will be designed. The interface design in this application is made as an interaction between the user and the smart fish farm mobile application to be able to connect to an Arduino device and activate the internet to be able to communicate with one another.





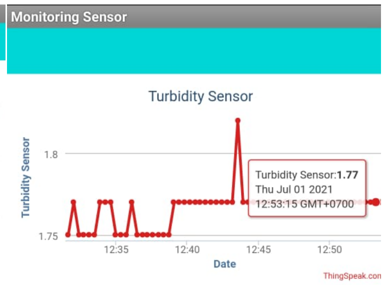
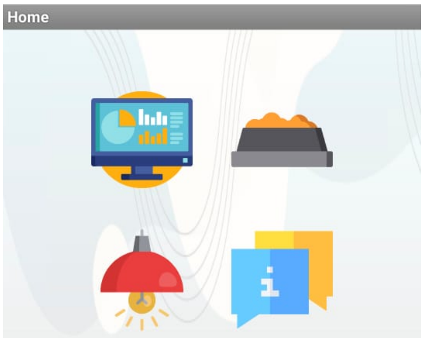
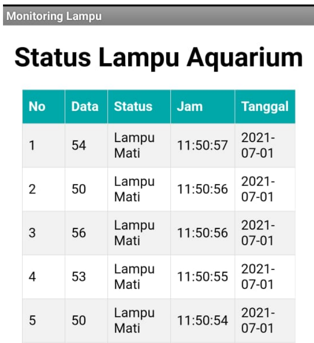


Figure 13. Temperature Interface Figure 14. pH Interface Figure 15. Turbidity Interface





No	Data	Status	Jam	Tanggal
1	54	Lampu Mati	11:50:57	2021-07-01
2	50	Lampu Mati	11:50:56	2021-07-01
3	56	Lampu Mati	11:50:56	2021-07-01
4	53	Lampu Mati	11:50:55	2021-07-01
5	50	Lampu Mati	11:50:54	2021-07-01

No	Keterangan	Jam	Tanggal
1	Makan pagi	11:37:53	2021-07-11
2	Makan pagi	11:37:52	2021-07-11
3	Makan pagi	11:37:51	2021-07-11
4	Makan pagi	11:37:51	2021-07-11
5	Makan pagi	11:37:50	2021-07-11

Figure 16. Main Menu Interface Figure 17. Light Status Figure 18. Feed Status

CONCLUSION

From the results of IoT-based Smart Fish Farm research using the Mamdani fuzzy method, it can be concluded as follows:

1. Smart Fish Farm system based on Internet of Things (IoT) and Fuzzy Mamdani method makes it easier to control the condition of water in aquarium or tank since it can be monitored in real time from your smartphone. Good water condition can also set the condition of the ecosystem in it, helping fish and aquatic plants to stay healthy.
2. The test in this study used Fuzzy Mamdani method, resulting in a crisp output value at 44.83%. This result puts the water conditions on "Fair" level.

Further Research

Based on the research results and the conclusions described previously, there are several suggestions that the researcher must convey for the development and improvement of research, as follows:

1. It is necessary to add several other variables related to water conditions such as water level, dissolved oxygen in water, etc as additional indicators to examine water condition.
2. Further research is expected to use other fuzzy methods so that they will be able to get more accurate calculations in this study.

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