Design of the Feeding System Automatic Koi Fish Based on Internet of Things Using the Fuzzy Logic Controller Method

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Abstract: Feeding is important in fish farming. However, in general, feeding is still done manually, which is oriented to human resources. This method has drawbacks that also affect fish growth, such as scheduling errors and uncontrolled feeding doses that can cause overfeeding. This research aims to create a system for feeding and scheduling feeds and checking feed remotely using Internet of Things (IoT) technology which is equipped with several types of sensors, namely temperature sensors, humidity sensors, and rain sensors that function to monitor weather conditions around the pond as input. fuzzy to determine the amount of feed issued, while the ultrasonic sensor functions to monitor the availability of feed in the container. The sensor takes the data and then it is received by the Arduino Uno microcontroller. Furthermore, the data will be sent to the ESP8266 and there is data processing with the fuzzy method as an output for how long the servo motor is open. The data that is ready will be passed to the database server (Firebase) using the ESP module with a Wi-fi network, then from the Firebase the data will be passed to the Android application via the API. That way users can see the results of monitoring feed conditions, automatic feeding scheduling, monitoring the weather around the pond in real time through an Android-based application. Feeding monitoring trials and application functionality have been successfully carried out with scenarios testing applications, devices, and sensors that are connected to each other that are attached to the feed container.

1 INTRODUCTION

Feeding is important in fish farming. However, in general, feeding is still done manually, which is oriented to human resources. This method has drawbacks that also affect fish growth, such as scheduling errors and uncontrolled feed dosages. Feeding koi fish is done 3-4 times a day with the right dose and time. Feeding that is too frequent and excessive will affect the health of the fish, because the leftover food will mix with feces so that it becomes ammonia and decomposes into nitrite which is harmful to fish health.

In addition to cultivation ponds, small koi ponds owned by many homeowners are often left to go out of town or are not at home, this is also a problem if the fish are not fed at the right time or even not fed at all. Outside temperature conditions greatly affect the amount of feed given to fish, if during the rainy season the dose of feed given is not as much as during the dry season or when it is not raining, the temperature also affects feeding (Rasyid, 2021).

The problem with koi fish farmers today is feeding fish in ponds. In traditional koi fish cultivators, human error often occurs with feeding hours and feed dosages in koi ponds, especially for small ponds if the homeowner is not at home for a long time. This system causes farmers to be unable to monitor feed availability and check feeding at any time or in real time in koi ponds. So that the management of koi pond feed with this system is still not optimal.

To solve the above mentioned problem, this research proposes feeding system automatic for Koi fish based on internet of things (IoT) using the fuzzy logic controller method. The development of feed management is needed to increase automation, intelligence, productivity, and expand the aquaculture industry.

Several studies have been carried out to solve the above-mentioned problems to build an automatic feed system. Sousa et al. proposed an integrated IoT platform for aquaculture environmental monitoring and environmental data collection. A mobile unmanned surface vehicle and buoy equipped with

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environmental sensors collects data on water conditions (aquatic), and sends it to a data centre for further data storage and processing (Sousa, 2019). Sun et al. proposed an integrated water quality monitoring system with GIS and IoT technology. The system performs remote monitoring, management and control of water temperature, dissolved oxygen, pH, and water level. The system performs packet loss rate analysis using a Wi-Fi network and analyses dissolved oxygen conditions (Sun, 2019).

Lee et al. proposed an IoT-based urban aquaponic system. The system consists of a fish tank, hydroponic tank, IoT monitor (pH), and a water test kit (pH, NO2, NO3). Case study using hydroponics plant lettuces and breed goldfish (Lee, 2019). Ismail et al. proposed a model for direct measurement and IoT-based fishpond water parameter monitoring system. The system consists of a Raspberry Pi microcontroller, DO sensor, temperature sensor, pH sensor. Data from the sensor is sent to the microcontroller, and then sent to the database server (Ismail, 2020).

Uddin et al. proposed a real-time freshwater shrimp monitoring system. The system detects the sensor values for temperature, pH, dissolved oxygen, salinity level, and turbidity. The system will give an alert if it is out of the range value that has been set. The system analyses the size, weight, and percentage of live shrimp (Uddin, 2020). Ouyang et al. proposed a monitoring framework for aquaculture farms. The framework consists of a robotic sensing platform equipped with water quality sensors, an automatic charging system and sensor cleaning, a data processing system using machine learning, and an aquaculture farm control centre (Ouyang, 2021).

2 SYSTEM DESIGN

Figure 1 shows an overview of the proposed system design. In the design of this system, the data to be processed will be obtained directly from the data on the feed container in the fish pond. Where there are three parts contained in the design of this system, namely, block input, process, and output.

In the input block section there are users who can monitor the status of feed conditions and feeding schedules in real time with the Android application. And also, users can receive notifications of feeding schedules.

In the process block, there is an Arduino Uno as the sensor control centre. The sensor used is an ultrasonic sensor, which functions to measure the availability of feed. The DHT sensor and Rain detector for monitoring weather conditions as an output of the amount of feed measured using the fuzzy method. NodeMCU will receive the data value sent from Arudino Uno. The data values are sent by nodeMCU to Firebase.

At the output, nodeMCU gives commands to the servo motor to move the feed container valve to open it according to the specified time and the amount of feed depends on the fuzzy calculation.

After the data is processed, the data will be sent and stored on the Firebase real-time database server. The android application will display the data in the database in real-time to the application user via internet communication. The main features of the Android application as data visualization are monitoring feeder, control schedule, and monitoring weather.

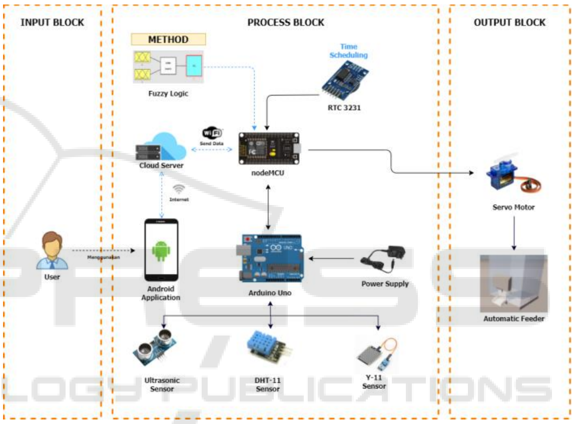


Figure 1: Design of an automatic feeder system in a koi fishpond.

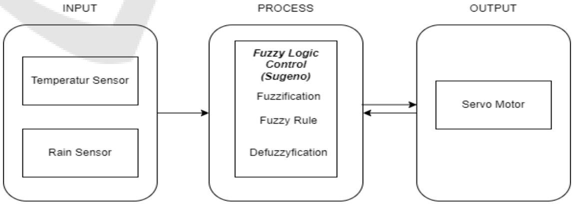


Figure 2: Design of an automatic feeder system in a koi fishpond.

Fuzzy logic control is applied to the servo motor. The function of this control is to control the length of time the servo motor opens the valve. The input of the fuzzy logic control system is data from temperature and humidity sensors and rain sensors. Both sensors are used to determine the outdoor weather conditions in the koi fish pond. The final desired result from this fuzzy logic control application is that fish feed can be distributed on a scheduled basis and according to the expected dose. The fuzzy logic control block diagram can be seen in figure 2.

This process aims to create a membership function from real numbers. The output is a linguistic variable that distinguishes each condition based on the range value.

a) Temperature Variable

Air temperature will be grouped into three different variables. The variables used include cold, normal, and hot. Then the values and variables are described in the fuzzy set of air temperature into the membership function in figure 3.

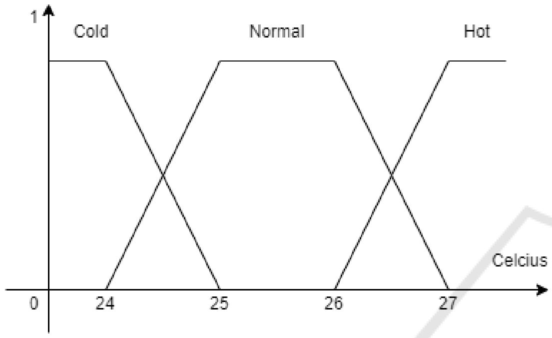


Figure 3: Temperature member.

For the temperature membership function as follows:

$$\mu_{cold}(x) = \begin{cases} 1, & x \leq 25 \\ \frac{25-x}{25-24}, & 24 < x \leq 25 \\ 0, & x > 25 \end{cases} \tag{1}$$

$$\mu_{normal}(x) = \begin{cases} 1, & 25 < x \leq 26 \\ \frac{x-24}{25-24}, & 24 < x \leq 25 \\ \frac{27-x}{27-25}, & 26 < x \leq 27 \\ 0, & x \leq 25 \\ 0, & x > 27 \end{cases} \tag{2}$$

$$\mu_{hot}(x) = \begin{cases} 1, & x > 27 \\ \frac{x-26}{27-26}, & 26 < x \leq 27 \\ 0, & x \leq 26 \end{cases} \tag{3}$$

b) Rain Variable

Rain Status will be grouped into two different variables. The variables used include rain and no rain. Then the values and variables are described in the fuzzy set of rain status into the membership function in figure 4.

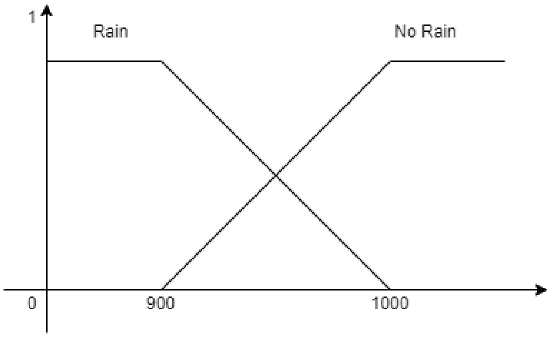


Figure 4: Rain member.

For the rain membership function as follows:

$$\mu_{rain}(x) = \begin{cases} 1, & x \leq 900 \\ \frac{1000-x}{1000-900}, & 900 < x \leq 1000 \\ 0, & x > 1000 \end{cases} \tag{4}$$

$$\mu_{norain}(x) = \begin{cases} 1, & x > 1000 \\ \frac{x-900}{1000-900}, & 900 < x \leq 1000 \\ 0, & x <= 900 \end{cases} \tag{5}$$

Fuzzy Rule

R1) IF Temperature = Cold AND Rain Status = Rain THEN Valve Condition = Fast
R2) IF Temperature = Cold AND Raining Status = No Rain THEN Valve Condition = Medium
R3) IF Temperature = Normal AND Rain Status = Rain THEN Valve Condition = Fast
R4) IF Temperature = Normal AND Rain Status = No Rain THEN Valve Condition = Long
R5) IF Temperature = Hot AND Rain Status = Rain THEN Valve Condition = Medium
R6) IF Temperature = Hot AND Raining Status = No Rain THEN Valve Condition = Old

Defuzzification

Defuzzification in the Sugeno method is to calculate the centre of single-ton or the centre point of the crisp value using the weight average method which is described in the following formula.

$$z = \left(\frac{a1 \,.\, z1 + a2 \,.\, z2 + \cdots + an \,.\, zn}{z1 + z2 + \cdots + zn} \right) \tag{6}$$

Description:
Z = fuzzy calculation result
an = value for the nth combination (singleton value)
zn = fuzzy membership rule value for the nth combination

The value of zn is obtained from the implication function that uses the minimum function, namely by looking for the i-th rule and can be expressed by the following equation:

$$\begin{aligned} z_i &= \mu_{A_i}(x) \cap \mu_B(x) \\ &= min\,\{\mu_{A_i}(x), \mu_B(x)\} \end{aligned} \tag{7}$$

Description:
z_i = minimum value of fuzzy sets A and B in the i-th rule
$\mu_{A_i}(x)$= degree of member x of the fuzzy set A in the i-th rule
$\mu_B(x)$= degree of member x of the fuzzy set B in the i-th rule

So, the value of the servo motor will open according to the z value obtained and according to the following z function.

$$z(x) = \begin{cases} fast, & x \le 2 \\ medium, & 2 < x \le 4 \\ long, & 4 < x \le 6 \end{cases} \tag{8}$$

Where if it's fast then the servo motor opens for 2 seconds, medium 4 seconds, and long 6 seconds.

2.1 Hardware

The components are assembled on a breadboard with the aim of making the components neat so that there are no many wires and no need for soldering. Arduino as the main microcontroller which is connected to each DHT sensor, ultrasonic, and rain sensor. While the NodeMCU is connected to the servo motor and RTC. Each component is connected by a jumper cable, for the voltage to the sensor is taken from the 5v pin available on the Arduino Uno, while for the servo and rtc motors the voltage is taken from the 3.3v pin available on the NodeMCU. The results design is as in figure 5.

The detailed sections of each piece of hardware are described as follows:

Main Component
The detailed sections of each piece of hardware are described as follows:

a. Arduino Uno
Arduino Uno using the ATmega328 chip functions to control sensors including dht11 sensors, rain sensors and ultrasonic sensors. This device requires 5v power.

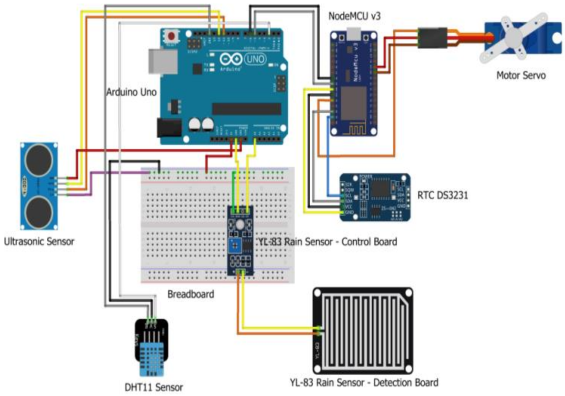


Figure 5: Design hardware.

b. Nodemcu v3 ESP8266
The NodeMCU with a power of 5v serves as a liaison between the hardware and the cloud server or database that is connected via Wi-Fi technology using the internet network.

c. DHT11 sensor(Temperature and humidity sensor)
The DHT11 sensor is a temperature and humidity measurement sensor that is directly related to the Arduino Uno on the digital pin (pin 2) with 5v input. °C and humidity from 20% to 90% with an accuracy of ±1 °C and ±1%.

d. Y-11 Rain Sensor
This Rain Sensor or Rain Sensor uses a 5v voltage which is directly related to the Arduino Uno on the analog pin, namely pin A0.

e. Ultrasonic Sensor
This ultrasonic sensor serves to measure the distance from the sensor to the fish feed, so that it can detect the availability of existing feed. This sensor uses a 5v voltage which is directly related to Arduino Uno on digital pins (pin 11 and pin 12).

f. Servo Motor
Servo motor as an automatic feed valve controller which is ordered by the NodeMCU to a certain angle according to the conditions and opening time from the fuzzy calculation results. The servo motor is connected to the NodeMCU on digital pin D4 with 3.3v input.

g. RTC DS3231
This DS3231 RTC is used for timing controllers. Directly connected to NodeMCU on digital pins D1 and D2 with 3.3v input.

Supporting Component
The following components function to support the main components so that the system and hardware design can work optimally:

a. Jumper Cable

Jumper cable serves as a connector between the hardware. In this study, 3 types of jumper cables were used, including: male to male, female to female, and male to female.

b. Micro USB Cable

This cable serves to connect the NodeMCU with the power adapter so that the NodeMCU can be turned on.

c. Breadboard

Breadboard is used to make temporary electronic circuits for the purpose of testing or prototyping without having to solder. This avoids components from being damaged if incorrectly soldered.

Hardware Assembly

The components that have been previously designed are then assembled into one according to the electronic component design. The results can be seen in figure 6.

The components are assembled on a breadboard with the aim of making the components neat so there are no many wires and no soldering required. Arduino as the main microcontroller which is connected to each sensor. While the NodeMCU is connected to the servo motor and RTC. Each component is connected by a jumper cable, for the voltage to the sensor is taken from the 5v pin available on the Arduino Uno, while for the servo and rtc motors the voltage is taken from the 3.3v pin available on the NodeMCU.

For the implementation of the manufacture of feed containers, acrylic is used as the main material in the manufacture of containers. Acrylic material is considered to have a lighter and more durable material quality, because later this container is placed in an outdoor environment. The following is the result of the implementation of the container which can be seen in figure 7. Pre-installed hardware will be installed or integrated with the finished receptacle. The hardware is stored on the back of the case consisting of arduino uno, esp8266, beardboard, rtc, etc. Meanwhile, the sensors are mounted on the outside of the top of the container in order to take maximum sensor data. There is a valve that is connected to a servo motor as the driving motor of the valve, so that the feed can come out through the hole in the front of the container.

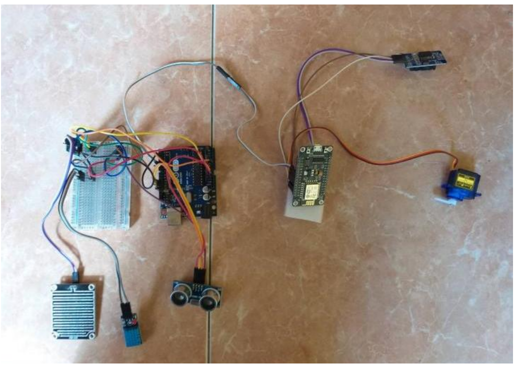


Figure 6: Assembled Hardware Components.

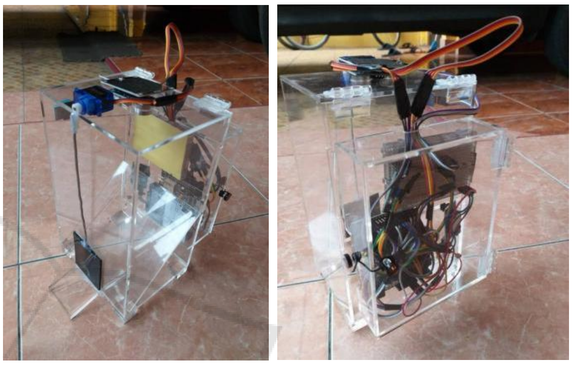
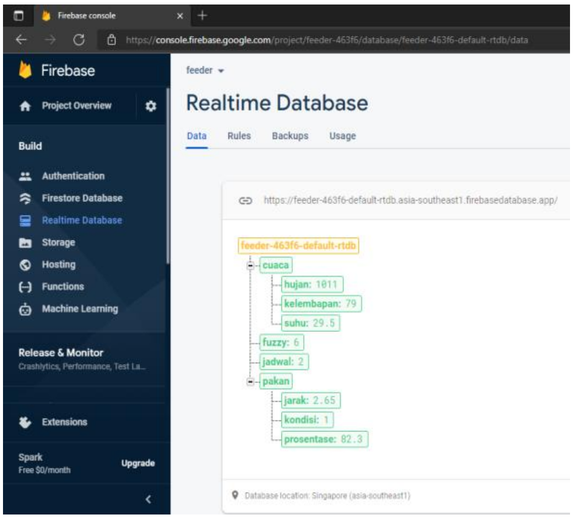


Figure 7: Implementation of feed containers.

2.2 Database Server (Firebase)

To accommodate sensor data from the microcontroller, a real-time database system is designed. Realtime database created using Firebase. To create a Firebase database project, you must first create a Google Firebase account. Then create a database and select the Realtime Database type.

In this study, there are three children in one database. The database that has been created is named feeder. Each database that has been created will automatically degenerate an account to perform remote data. This remote data function is to send data and retrieve data. The account that must be owned to connect firebase with the server and gateway is the url name and secret key which is automatically degenerated according to the database name created. Initialize firebase_host as account url and firebase_auth as authentication account in the form of a unique secret key. This secret key can be regenerated by requesting a request to firebase. So in connecting nodeMCU to firebase, it is enough to enter the url and secret key.



```
feeder-463f6-default-rtdb
  cuaca
    hujan: 1011
    kelembapan: 79
    suhu: 29.5
  fuzzy: 6
  jadwal: 2
  pakan
    jarak: 2.65
    kondisi: 1
    prosentase: 82.3
```

Figure 8: Design Database.

Figure 8 displays a database containing data that accommodates sensor data. The data type used in firebase is Float. The children used in this study include Weather, Fuzzy, and Feed. Weather is a child that is used to store weather sensor data outside the pool, while the reference child is rain, humidity, and temperature. Fuzzy Child is a child that is used to accommodate data on the value of defuzzification in this research system, which is used as a determinant of how long the feed valve opens. Feed Child is a child that is used to accommodate feed data obtained from ultrasonic sensors, there are reference children namely distance, condition, and percentage of feed availability. All children in this database have the Float data type. Each data sent will have a unique id generated by Firebase.

2.3 Software Application

Application made for visualization of data sent from a microcontroller based on android. The android application in this research uses the native java language that is built using the android studio tool. There are several features in the mobile-based (android) application in this research, namely:

1) Feed Monitoring Features.

Users of this application will get information about feed availability status data, information on remaining feed, and information about the feed itself. The sensor data displayed will be automatically updated at any time (realtime) using the firebase database.

2) Auto Feed Feature.

Users of this application will get information about the feeding schedule every day at previously set hours.

3) Weather Monitoring Features Around the Pool

This feature will display weather sensor data obtained in real time and users can see the results of fuzzy calculations as well as how long the feed valve has been open.

4) Real-time Notification Feature.

Users of this application will get notifications in real time if the feed valve opens according to a predetermined schedule. In the notification there is information on the schedule of feeding hours and how long the valve opens at that hour.

3 EXPERIMENTAL STUDY

This section describes the performance of measuring weather conditions and feed distances with each of the available sensors. We compare dynamic responses to get the weather state in seconds. We analyzed the results of this comparison experiment to find out how efficiently these monitoring devices work.

The first is hardware testing and sensor performance in detecting the weather.

3.1 Rain Sensor Testing

This test is carried out to determine whether the rain sensor is able to read rain conditions through water droplets. In this rain sensor, the test is carried out by dripping water on the sensor panel using a tissue moistened with water as shown in figure 9 below. This test is a simulation as if it were raining in the original conditions outside the room.

We observed the interaction of changes in the rain sensor value whose sensor value was received and displayed by Arduino Uno. Table 1 shows data from the rain sensor that has been tested. It can be seen in output number 1 when the rain senor is still dry and has not been wetted by water and shows the value is 1022. Then at output number 2 the sensor starts to be wetted by water droplets, and the value drops to 414, as well as at output number 3, which are 439. The sensor value means that the more puddles or water intensity on the rain sensor panel, the smaller the sensor value obtained. It can be seen that the more water droplets are given, the smaller the value of the rain sensor will be. The average delay obtained is 2 seconds. So it can be concluded that the rain sensor data that has been tested has a change in value and the rain sensor test has been successful.

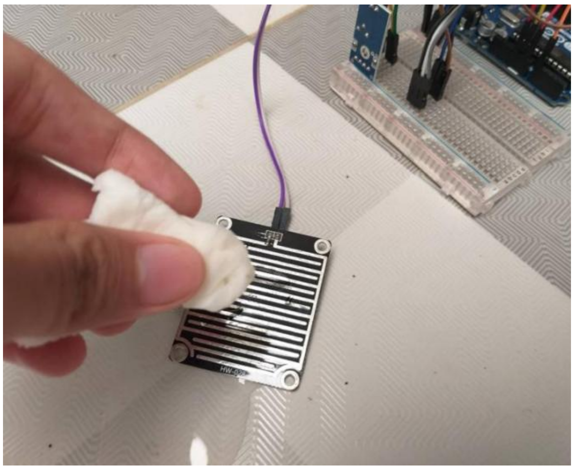


Figure 9: Rain sensor testing.

Table 1: Rain Sensor Test Results.

No	Time	Analog Value	Panel Condition
1.	07:42:42	1022	Dry
2.	07:43:00	1018	Starting to drip water
3.	07:43:19	975	Dropped by water
4.	07:43:37	929	Dropped by water
5.	07:43:56	577	Dropped by water
6.	07:44:14	673	Dropped by water
7.	07:44:33	499	Dropped by water
8.	07:44:51	452	Dropped by water
9.	07:45:10	390	Dropped by water
10.	07:45:28	250	Dropped by water

3.2 DHT Sensor Testing

This test is carried out to determine whether the dht-11 sensor is able to read the condition of temperature changes in the outside air. On the temperature and humidity sensor, the test is carried out using ice cubes that are brought closer to the sensor as shown in figure 10. This test is a simulation as if there is a change in outside temperature.

Table 2 shows data from the temperature and humidity sensors that have been tested. Data is retrieved every 10 seconds and displayed on a serial monitor. It can be seen that when the sensor is brought near to an ice cube, the temperature value will decrease as well as the humidity level. There is an average delay of 1.5 seconds when reading the temperature and humidity values. At the time of data collection, the sensor value does not immediately change in value when brought close to ice cubes. So it can be concluded that the temperature and humidity sensor data that has been tested has been successful.

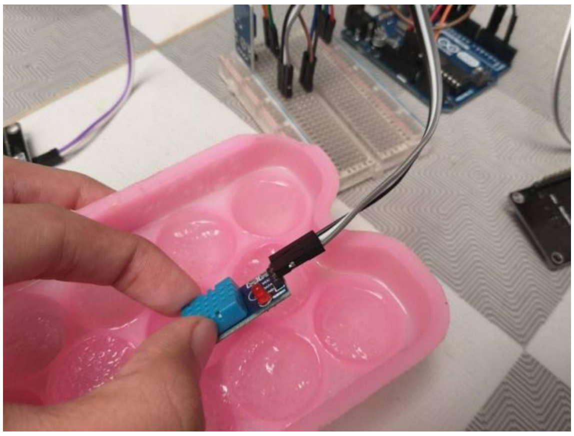


Figure 10: DHT sensor testing.

Table 2: DHT Sensor Result.

No	Time	Temperature Value (°C)	Humidity (%)
1.	08:23:48	28.70	63.00
2.	08:24:01	28.30	57.00
3.	08:24:13	27.50	44.00
4.	08:24:25	26.60	57.00
5.	08:24:37	25.50	52.00
6.	08:24:49	24.40	49.00
7.	08:25:02	23.50	48.00
8.	08:25:14	23.20	68.00
9.	08:25:26	23.70	50.00
10.	08:25:38	24.00	55.00

3.3 Ultrasonic Sensor Testing

This test is carried out to determine whether the ultrasonic sensor is able to measure the distance from the sensor to the fish feed in order to determine the availability of feed in the container. The test is carried out by reducing the content of the feed periodically and comparing it with manual measurements using a ruler which can be seen in figure 11.

Table 3 shows of data from the ultrasonic sensor that has been tested. Table 4 shows that ultrasonic sensor testing has been successfully carried out. The sensor measures the feed distance from 6 cm to 26 cm which is done by periodically reducing the feed content in the feed container. The sensor measurement results are compared with a ruler, from the data it can be concluded that the data read by the ultrasonic sensor is very accurate and the accuracy value is 100%, because the value is the same as the manual measurement. There is a delay that is obtained an average of 1.5 seconds.

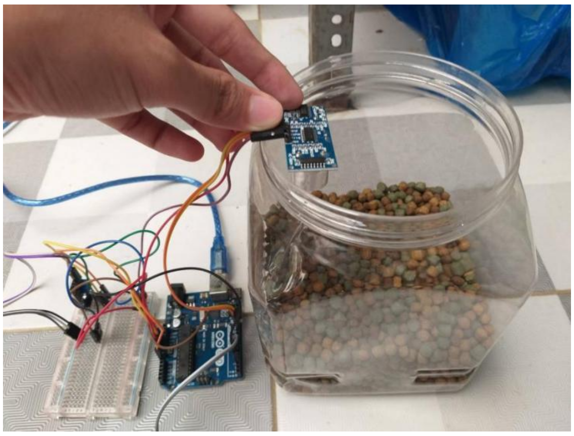


Figure 11: Ultrasonic Sensor Testing.

Table 3: Ultrasonic Sensor Testing.

No	Sensor Measurement (cm)	Manual Measurement (cm)	Feed Status
1.	6	6	full
2.	6	6	full
3.	10	10	will run out
4.	12	12	will run out
5.	15	15	will run out
6.	15	15	will run out
7.	18	18	will run out
8.	22	22	run out
9.	25	25	run out
10.	26	26	run out

The second is testing the fuzzy method on the device. Fuzzy testing is carried out, with the aim of knowing the success of the system in determining the amount of feed issued based on fuzzy calculations. This test is carried out by monitoring the readings of the temperature and rain sensors to get fuzzy output results. The test is carried out by simulating weather changes on a regular basis, namely with scenarios of rain and hot temperatures, rainy and cold, no rain and cold temperatures, no rain and hot temperatures. This scenario was carried out to see if the old valve opened in accordance with the existing conditions. The following output is displayed from the NodeMCU serial monitor.

Table 4 shows the fuzzy test result. The fuzzy test uses 10 data samples with different input values for temperature and rain. The test carried out is to analyze that the fuzzy formula applied to the system can produce output according to manual calculations and can control the servo motor according to the given fuzzy output. From the many experiments and various tested scenarios, it can be concluded that the system can run according to the previous design, and the fuzzy output results have shown 100% accuracy results, namely by comparing the system output value with manual calculations and can provide controlling the length of the servo motor valve to open it.

Table 4: Fuzzy test result.

No	Temperature Sensor (°C)	Rain Sensor	Output Fuzzy System	Output Fuzzy Manual	Valve Opening Condition
1.	28.80	1020	6,00	6,00	6 second
2.	24,90	1021	5,80	5,80	6 second
3.	**24.50**	**1022**	**5,00**	**5,00**	**6** second
4.	24.40	1020	4,80	4,80	6 second
5.	23.80	1020	4,00	4,00	4 second
6.	21.90	1017	4,00	4,00	4 second
7.	24.40	704	2,00	2,00	2 second
8.	24.60	590	2,00	2,00	2 second
9.	25.00	1014	6,00	6,00	6 second
10.	25.60	1019	6,00	6,00	6 second

After doing some hardware and software testing, then test the sustainability of the automatic feed system when it was run with several days of observation trials. This test is carried out by running the tool for a period of one week (7 days). Observations were made by monitoring each feeding schedule. The focus of this test is to see how long the valve opens every hour and calculate the timeliness of the tool throwing the feed whether it is in accordance with the specified. Data is taken directly and periodically. Sensor data is taken every 2 seconds from the tool and sent directly to firebase.

The results of the observations can be seen in table 5, by displaying the length of time the valve opens, the dose issued, and the time the valve opens.

Table 5: Automatic Feed Observation Result (7 Days).

Day 1 Trial	Open Valve (second)	Dose (gram)	Time (hh:mm:ss)
first time	4	52,3	07:00:04
second time	6	73,6	11:50:05
third time	4	52,3	15:30:02
fourth time	2	22	19:00:03
Total Feed		200,2	
Day 1 Trial	Open Valve (second)	Dose (gram)	Time (hh:mm:ss)
first time	6	73,6	07:00:21
second time	6	73,6	11:50:10
third time	2	22	15:30:05
fourth time	2	22	19:00:03
Total Feed		191,2	
Day 1 Trial	Open Valve (second)	Dose (gram)	Time (hh:mm:ss)
first time	4	52,3	07:00:15
second time	6	73,6	11:50:07
third time	2	22	15:30:10
fourth time	2	22	19:00:12
Total Feed		169,9	
Day 1 Trial	Open Valve (second)	Dose (gram)	Time (hh:mm:ss)
first time	4	52,3	07:00:05
second time	6	73,6	11:50:12
third time	4	52,3	15:30:11
fourth time	2	22	19:00:07
Total Feed		200,2	
Day 1 Trial	Open Valve (second)	Dose (gram)	Time (hh:mm:ss)
first time	4	52,3	07:00:06
second time	6	73,6	11:50:05
third time	4	52,3	15:30:02
fourth time	2	22	19:00:11
Total Feed		200,2	
Day 1 Trial	Open Valve (second)	Dose (gram)	Time (hh:mm:ss)
first time	6	73,6	07:00:11
second time	6	73,6	11:50:02
third time	2	22	15:30:08
fourth time	4	52,3	19:00:09
Total Feed		221,5	
Day 1 Trial	Open Valve (second)	Dose (gram)	Time (hh:mm:ss)
first time	6	73,6	07:00:14
second time	6	73,6	11:50:07
third time	4	52,3	15:30:05
fourth time	4	52,3	19:00:09
Total Feed		252,8	

From the table 5, the automatic feed system can already do its job of throwing feed according to the specified schedule. Thus the RTC function as a time scheduler has been running well. There is a time difference between the scheduled time and the launch time. From these observations, the average time difference is 7.89 seconds. With the longest difference of 21 seconds, and the fastest time difference of 2 seconds. This can happen due to the difference in the seconds of the hour on the time measuring device and the seconds of the hour on the tool. The time difference can also be caused by the delay in collecting data from the device.

Because the feed released depends on the weather around the pond, it can be seen the efficiency of the feed that cultivators must use within these 7 days. Prior to the existence of this tool, cultivators needed 320 grams of feed per day with each feeding time of 80 grams for fish ponds with medium fish needs as many as 15 fish with a pond size of 3 x 2 meters. After the equipment in this study, the need for daily feed consumption is only about 200.2 grams. This is because the need for feed consumption at each feeding time depends on the weather around the pond, because previously cultivators gave the same amount of feed every time they were fed. With this tool, it can save up to 37.44% of feed usage per day, this can have a good impact on the expenditure of fish farming costs from the cost of fish feed itself. The comparison and efficiency table can be seen in table 6.

Table 6: Feed consumption efficiency.

Time	Modus (second)	After (gram)	Before (gram)
first time	4	52,3	80
second time	6	73,6	80
third time	4	52,3	80
fourth time	2	22	80
Amount of Feed Consumption		200,2	320
Feed Efficiency		Save 37,44 %	

4 CONCLUSIONS

This research has been carried out to create an automatic feed system application that is integrated with the Internet of Things in the aquaculture environment in the case of koi fishponds. The experimental results show that the sensors connected to the microcontroller retrieve data and the microcontroller integrated with the ESP8266 can connect to a wireless internet network to send sensor data using Wi-Fi communication to the cloud server, where sensor data can be displayed in the android application in real time. The data processing process in the fuzzy method runs as expected in accordance with the input temperature sensor and rain sensor which are read correctly and in accordance with fuzzy manual calculations. The android application is able to display sensor data and send notifications to users when the feed has been launched by the tool. The automatic feed system as a whole has been running according to the specified schedule and the dose issued is according to the weather around the pond at that time. For the next research, Communication between NodeMCU and Android can use Socket IO to be more secure in data communication.

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