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Automated feeding system for aquariums based on the internet of things

Irfan Setiawan[1], Ilham Faiz Firmansyah[1], Muhammad Rifat Widiyana[1], Purba Daru Kusuma[1], Ashri Dinimaharawati[1]
[1]Department of Computer Engineering, School of Electrical Engineering, Telkom University, Indonesia

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ABSTRACT

The automated fish feeding system represents an innovation with significant contributions to the field of aquaculture and fish management. Feeding is influential for the survival of fish in the aquarium environment. With manual feeding, the aquarium owner often forgets to feed the fish in the aquarium, whether it's too little or too much, both in terms of scale or timing of the feeding. The research contribution lies in its ability to enhance the convenience and well-being of aquarium owners by automating the feeding process through IoT integration. This system ensures accurate and timely feeding schedules and leads to optimize aquatic life care and reduced owner burden. This study adopts descriptive and casual methods. The first one is used to describe the system concept and the system design plan used. This fish-feeding system with NodeMCU ESP8266 based on the Internet of Things (IoT) can be implemented to control the feeding of fish in an aquarium environment. Based on the results of testing the accuracy of the distance between the ruler and the ultrasonic sensor 5 times, an average error of 1.795% was found. In other words, the success of the ultrasonic sensor in detecting the distance of objects (fish) is 98.205%. This feeding system with NodeMCU E SP8266 based on the Internet of Things (IoT) can be implemented to control the feeding of fish in an aquarium environment. The final result is a tool with a size (140 cm x 105 cm). The tool is working properly, but sometimes there is a status bug from the output displayed on the LCD. The weakness of this tool is the turbidity sensor which is easily damaged.

Corresponding Author:

Irfan Setiawan
Department of Computer Engineering
School of Electrical Engineering, Telkom University
Bandung, Indonesia
Email: razorirfan1@gmail.com

1. INTRODUCTION

The development of technology encourages changing times which are increasingly rapid and play an important role in human life, in this modern era a lot of technology has developed very rapidly in the past few years in the technological aspect. One of the technologies that have developed rapidly and are very often used and implemented today, especially in everyday life, is a tool based on the Internet of Things (IoT). The Internet of Things is a concept in which an object or object is embedded with technologies such as sensors and software with the aim of communicating, controlling, connecting and exchanging data through other devices while still connected to the Internet [1].

IoT has a close relationship with the term machine-to-machine or M2M [2]. All devices that have M2M communication capabilities are often referred to as smart devices [3]. This smart device is expected to help humans work in completing various existing affairs or tasks. The Internet of Things (IoT) can be interpreted as activities between humans and things, things and things, such as sensors, robots, platforms and clouds that are connected via the Internet [4]. IoT can receive and send information to each other to enable certain work processes to become simpler and more efficient.

Nowadays, many people maintain aquarium-scale ornamental fish, either for breeding or just decoration. There are those who see this as just a hobby, but there are also some of them who use it as a cultivation business that can make money. There are various types of fish that can be kept or cultivated for business, ranging from freshwater ornamental fish and seawater ornamental fish. Freshwater ornamental fish are fish that spend part or all of their lives in freshwater, such as rivers and lakes. With a salinity of less than 0.05% in many respects, freshwater environments are different from marine waters and the main difference is the level of salinity. To be able to survive in freshwater, fish need environmental adaptations aimed at maintaining a balance of ion concentrations in the body [5]. Fish owners who travel may overfeed or underfeed their fish, depending on the situation. The water quality (temperature, PH level, etc.) is another factor to consider [6].

Feeding is very influential for the survival of fish in the aquarium environment. Until now, most people do manual feeding. With manual feeding, the aquarium owner forgets to feed the fish in the aquarium [7], whether it's too little or too much, both in terms of scale or timing of the feeding [8]. In addition, if the aquarium owner is doing activities outside the home, the fish will not get food. There are other things that need to be considered when feeding the fish unevenly will cause the aquarium water to become cloudy. Turbid water can cause the ornamental fish in it to die besides being unpleasant to look at [9]. Aquarium cleanliness must always be considered so ornamental fish can live a long time according to their natural habitat [10].

Previous research made the Design and Development of an Internet of Thing (IoT) Based Automatic Fish Feeder Scheduling and Monitoring System so that the feeding time can be adjusted according to the number and age of the fish so that it is more efficient in the dosage and duration of fish feeding. Monitoring and controlling of the Internet of Thing (IoT)-based Automatic Fish Feeder can be controlled on the bliynk application installed on a smartphone, this application can also control or regulate the feeding of fish as desired, the design of the fish feeding system is controlled by Wemose D1 R1 as the main part for running programs and detecting weight sensors [11]. The fish farmers will be concerned if they are away from their fish farms since they won't be able to feed the fish at the proper time. The timing for fish feeding can be planned by the farmer with the use of an automatic fish feeder [12]. IoT systems provide for continuous real-time notification of users. When necessary, the monitoring system serves as a platform to remind the user to clean or restock the feeder [13]. Other research on making automatic fish feed for tilapia based on IoT uses the Nose MCU ESP8266 as an Arduino liaison and the main control device consists of the ESP8266 MCU Node, HC-SRO4 Ultrasonic Sensors, Servo Motors, Relays, Dc Motors. The system can monitor feed conditions, feeding status, view statistics on feed expenditure and can view detailed statistics [14]. The monitoring system for fish feeding equipment using NodeMCU can also act as a microcontroller that is integrated with the wi-fi module. The monitoring system is built using a firebase realtime database. The remaining feed in the container can be detected by ultrasonic sensors. Based on the test results, the accuracy rate of the tool is 96.8%. QoS testing, namely delay, throughput, packet loss, and jitter for the monitoring system communication produces a very good value and index 4 based on the TIPHON standard [15].

2. METHOD

The aim of this IoT-based feeding system is to enhance the efficiency, accuracy, and overall management of feeding practices. This system will use several tools such as Breadboards, relay modules, jumper cables, NodeMCU esp 8266, Ultrasonic Sensors, turbidity sensors, DS3231 RTC modules, LCD Display 1602, buzzers which will connect to cellphones via wifi. This study adopts descriptive and casual methods. The first one is used to describe the system concept and the system design plan used. In this IoT-based fish feeding system with an aquarium scale, the main requirement is to provide feed automatically on a scheduled basis and detect water clarity to increase efficiency in feeding. This system requires a tool that is designed to be able to operate 24 hours a day in real-time with an application to regulate feeding and receive information on the clarity of the water in the aquarium.

The device as a tool for feeding fish will read all the information recorded by the sensor, then the information will be forwarded to the user via the cloud [16]. The cloud will process and store information data in the database in the web service and will be forwarded to the user, so the user will obtain information data through a mobile application that is connected to the cloud. Data is provided by the device to the user in real-time so the user can monitor the device in real-time through an interfaced mobile application. data that has been entered by the user will turn into output and will be forwarded to the device via the cloud. The device will process the output and will act according to the user's command. With this system, users can monitor devices flexibly. The system diagram can be seen in Figure 1.

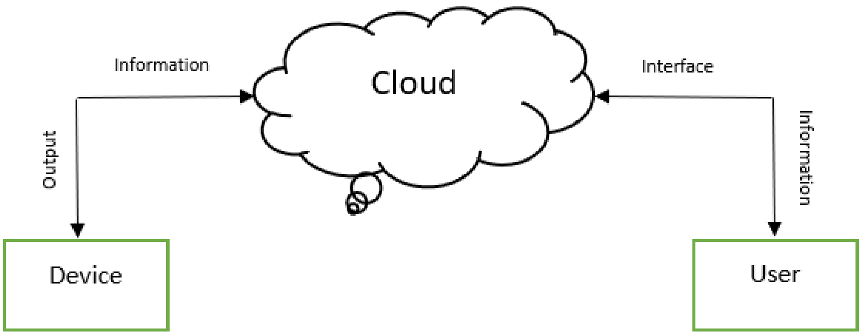

Figure 1. System diagram

In the device block diagram below (Figure 2) the device is divided into sub-systems. Each of the sub-systems are interrelated and affects the work of other systems. The sensor acts as a detector and will record information that will be passed on by the microcontroller [17]. A microcontroller as the control center of the device. Information will be forwarded to the cloud through communication between the device and the cloud. The cloud will send information to the user so the user can monitor the device via a mobile application. The user will send output to the device and the actuator will make decisions according to the wishes of the user. The device block diagram can be seen in Figure 2.

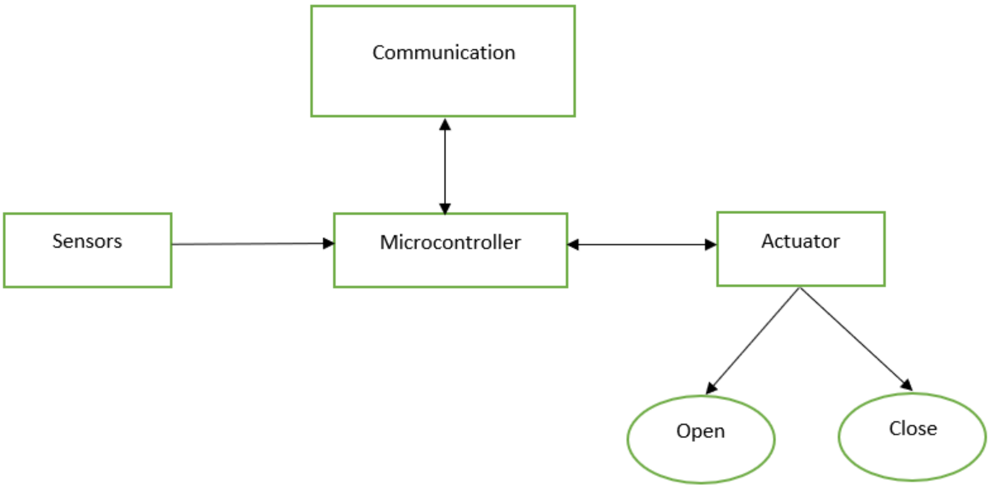

Figure 2. Device block diagram

The system works according to the flowchart in (Figure 3) where the tool can perform feeding by means of being regulated by the owner of the aquarium via a smartphone. The water clarity detector will send a warning to the aquarium owner if the water has entered a cloudy indication. The tool will process feeding through a servo that has been set by the user, the servo gate will close again if the feed has been removed.

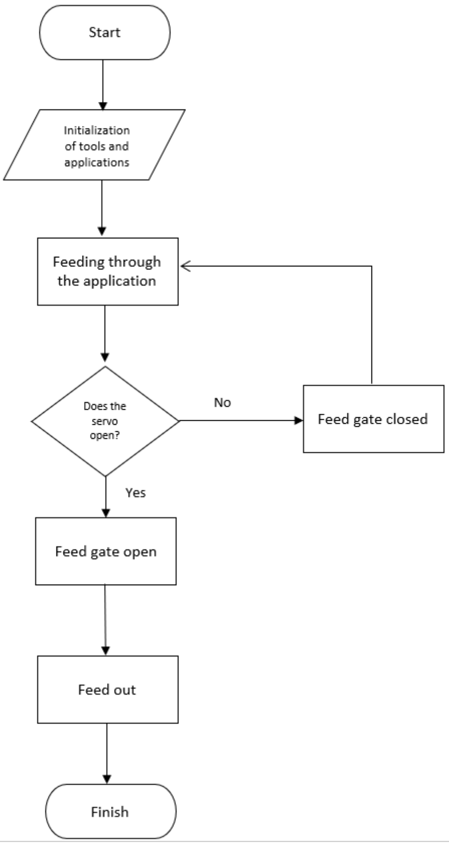

Figure 3. System process

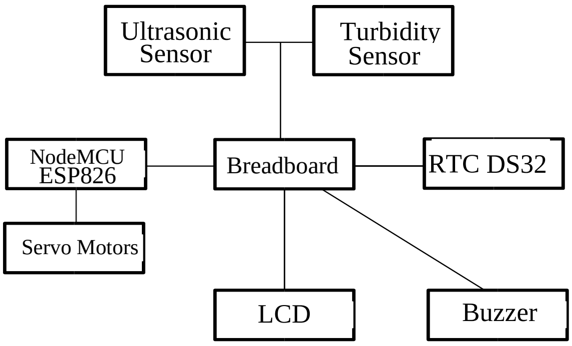

Figure. 4 System design plan

Based on the system Design Plan in (Figure 4) NodeMCU ESP8266 will be installed on the Breadboard as the control center for the system. The RTC module as a Real Time Clock will store data when feeding fish, the DS3231 RTC Module has the additional feature of measuring aquarium temperature and will send data to mobile users via Wemos D1 R1. The ultrasonic sensor is fully detected in the container when the fish feed runs out [18] and will send a notification to the cellphone via the connected Wemos D1 R1. The Turbidity Sensor functions to read water clarity. The Turbidity sensor will be connected to Wemos D1R1 so it will send a notification to the cellphone if the aquarium water is detected as cloudy. The servo motor will be attached to the container and will function to adjust the gate to open or close the fish feed container. The servo motor will be connected to Wemos D1 R1 so the user can manage fish feed via a mobile phone. The LCD functions as a monitoring of fish feed scheduling which will be installed on the device and a buzzer as an alarm when the fish feed has run out [19].

3. RESULTS AND DISCUSSION

3.1. The result of ultrasonic sensor testing

Ultrasonic sensor testing is used to detect the container when the fish feed runs out and will send a notification to the cell phone via the connected Wemos D1 R1. The results of ultrasonic sensor testing can be seen in the table below. The result of Ultrasonic sensor testing can be seen in Table 1.

Table 1. The result of ultrasonic sensor testing

Distance to Ruler (cm)	Sensor Testing Ultrasonic (cm)	Error Difference	%Error
4	4	0	0
4	3,937	0,063	1,575
5	5	0	0
5	4,99	0,1	0,2
6	5,993	0,007	0,1

Based on Table 1 The results of testing the accuracy of the distance between the ruler and the ultrasonic sensor 5 times, an average error of 1.795% was found. In other words, the success of the ultrasonic sensor in detecting the distance of objects (fish) is 98.205%.

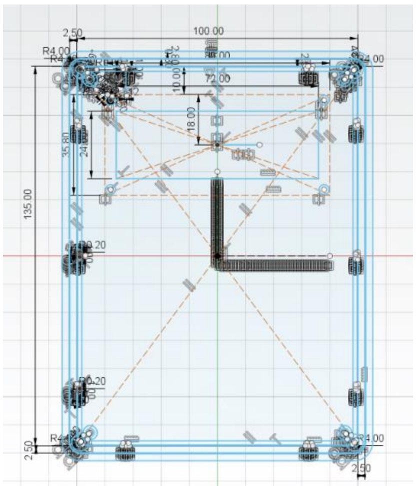

Figure 5. Initial design of the fish feeding equipment

Based on (Figure 5) The initial design of the fish feeding device used the AutoCAD application from Autodesk, this design was made as the beginning of printing the casing using 3D printing, this design has a length of 140 cm and a width of 105 cm.

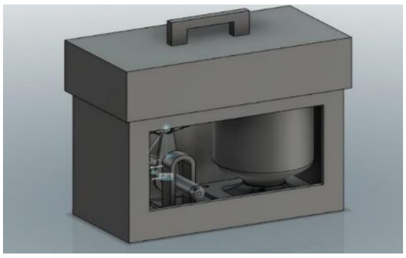

Figure 6. 3D Design of feeding equipment

Design of Feeding Equipment can be seen in (Figure 6). This design was made using the fusion 360 application from Autodesk which is a systemization of fish feed containers. The feeding equipment has several components consisting of containers, servos, ultrasonic sensors, container covers and container casing covers, made of filament material so the servo motor can drive cover the feed easily. This tool is more focused on feed storage containers which include feed storage containers or tubes, as well as ultrasonic sensors and feed container covers which have a smaller size than the casing of the tool components. The result is a tool with a size (140 cm x 105 cm) and has linear measurement calculations. It takes several calibrations, so the LCD matches the holes that have been made in the casing.

3.2. System tools works

The components work with the main components as well as the feedback generated from both the tool components and systems and applications that have been made. The sensors used in this series are ultrasonic sensors and turbidity sensors to measure water turbidity with a classification of water clarity levels and to send signals to the system or device regarding the amount or volume of feed available in the container.

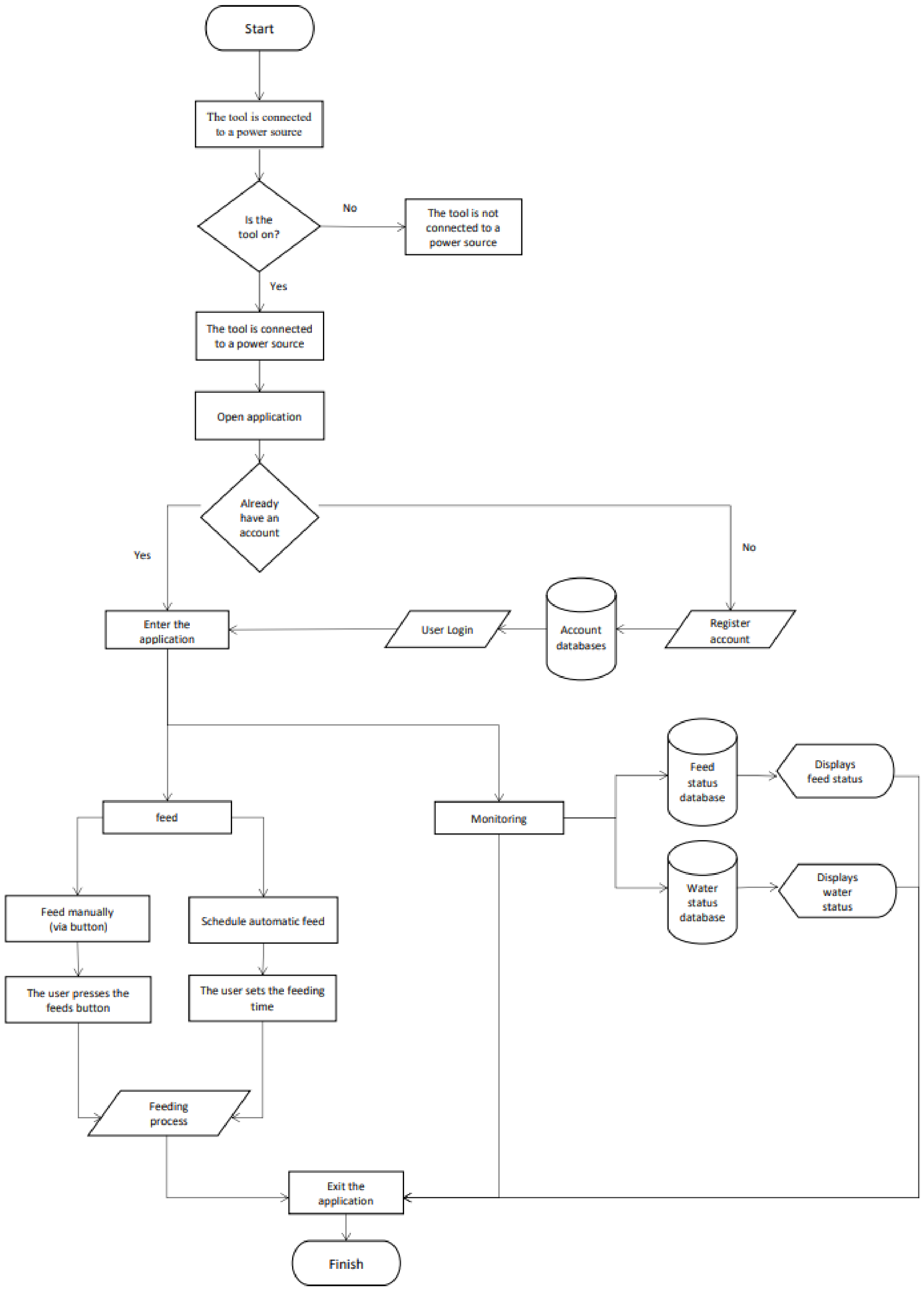

Figure 7. Hardware system

Systems of Tools can be seen in (Figure 7) Based on the flowchart both the ultrasonic sensor (A) and the turbidity sensor (B) can capture signals regarding information that occurs immediately (real time) then provide feedback in the form of information sent to the user's device and the LCD contained in the device and provide suggestions from the classification that has been made both the classification of turbid water and the feed has run out, whether the water should be replaced and the feed should be added. The tool is working properly, but sometimes there is a status bug from the output displayed on the LCD. The weakness of this tool is the turbidity sensor which is easily damaged.

3.3. Application works

Blynk is an application that is used to control the esp 8266 module which functions to connect to the internet network (Wi-Fi) [20]. The following is the UI/UX display of the Fish Feeder Automatically application. There is a log in and Sign-Up menu for new users. This application also provides several options such as “Feed Manually”, “Timer to feed automatically”, “Muddy Water Status” and “Amount of Feed Status”.

1. Feed Manually refers to the process of feeding ornamental fish in an aquarium by manually adding the appropriate amount of food at regular intervals. This method involves observing the fish’s behavior, appetite, and overall health and then providing the necessary portion of food accordingly. It allows for flexibility and customization in adjusting the feeding regimen based on the specific needs of the fish. Manual feeding involves direct interaction with the fish and requires the aquarist to be present to administer the feed. It is a common feeding method in small-scale or home aquariums where the number of fish is manageable.
2. Timer to feed automatically involves the use of an automated feeding system that is programmed to dispense fish food at predetermined intervals. This method eliminates the need for manual feeding and allows for a consistent feeding schedule even when the aquarist is not physically present. The feeding system is equipped with a timer that triggers the release of a specified portion of fish food into the aquarium at the set times. This method provides convenience and ensures regular feeding for the fish. However, it is important to monitor the feeding system and adjust the portion sizes as needed to prevent overfeeding or underfeeding.
3. Turbid Water Status refers to the condition of the aquarium water, characterized by reduced clarity and increased turbidity. Turbid Water Status presents the turbidity level of water in the aquarium with a clean water scale of 5-25 NTU and turbid > 25 NTU Muddy water occurs due to the presence of suspended particles, such as uneaten fish food, debris, and waste, which affect water quality and visibility. Muddy water can be a result of overfeeding, as excess food that remains uneaten contributes to the accumulation of organic matter in the water. It can also be caused by inadequate filtration, insufficient water circulation, or poor maintenance practices. Regular monitoring of water parameters and proper aquarium maintenance, including regular water changes and filtration system maintenance, can help prevent and address muddy water conditions. Clear water promotes the overall health and well-being of the fish and allows for better visibility and enjoyment of the aquarium.
4. Amount of Feed Status refers to the quantity of food provided to the ornamental fish during each feeding session. “Amount of Feed Status” presents a scale of the amount of feed from 1-100, 0 is used up, <50 is almost used up and >50 is a lot It is essential to provide an appropriate amount of feed to meet the nutritional needs of the fish while avoiding overfeeding. Overfeeding can lead to water quality issues, such as increased ammonia and nitrate levels, which can harm the fish and negatively impact the aquarium ecosystem. Underfeeding, on the other hand, can result in malnutrition and stunted growth. The amount of feed status is determined by factors such as the fish species, size, age, and metabolic rate. It is important to follow feeding guidelines specific to the fish species and adjust the portion sizes based on the fish’s appetite and behavior. Observing the fish during feeding and ensuring that all fish have access to food without excessive competition is crucial. Regular assessment and adjustment of the amount of feed given contribute to the overall health and well-being of the ornamental fish and help maintain water quality in the aquarium.

The website was created to provide external information about PIO “*Pakan Ikan Otomatis*” (Automatic Fish Feed), made in JavaScript, HTML, CSS, has a menu of options such as Home, About, How to Use, Contact, uses google maps API feature. The problem (lack) of this website is when hosting, it will fail to subscribe, so the solution is to use GitBash. Additionally, it is not connected to the tool (just a resource). This website has advantages such as providing detailed external information on how to use PIO (Automatic Fish Feed) and is easy to access by simply scanning a barcode.

PIO can also be accessed using a telegram bot which has the same function as the website, the difference is that it has more question templates and more detailed explanations, the website and the telegram bot will be redirected to 1 barcode which will be scanned by the user, within that 1 barcode there are 2 url links that can be accessed easily, all you have to do is press the URLs and then immediately redirect to the website or the telegram bot. The disadvantages of using telegram bots are that there is a word limit for each question and a complicated classification of the contents of the title. The advantages of this telegram bot are that it is easy to access and there are question templates.

3.4. Comparison of manual feeding and automatic feeding

This comparison will explain the difference between manual feeding and automatic feeding. The comparison forms are shown in tabular form.

Table 2. Comparison of Manual Feeding and Automatic Feeding

Parameter	Manual (M)	Automatic (M)	Manual (L)	Automatic (L)
Aquarium Size (cm)	36x22x26	36x22x26	40x25x28	40x25x28
Number of Fish	6	6	12	12
Water Cloudy (day)	2	4	3	5
Water Very Cloudy (day)	5	8	6	9
Dietary Habit (day)	2 times/day	2 times/day	3 times/day	3 times/day
Growth (cm)	1.5 cm/month	2 cm/month	2.5 cm/month	3 cm/month
Stress Level	Low	Medium	Medium	High
Life Sustainability/Year (%)	98%	97%	88%	89%

Based on (Table 2) Table provides a comparison between fish feeding methods manual feeding and an otomatic feeding (IoT). Various scenarios were tested, considering different factors such as the size of the aquarium, the number of fish, and the parameter of the feeding system, including feeding timers and water conditions. Table includes two types of fish habitats ponds and aquariums, with aquariums categorized into medium (36x22x26) cm and large (40x25x28) cm sizes, and the number of fish being 6 and 12. For each scenario, several key parameters related to fish and water conditions were recorded. Manual feeding scenarios were observed with fixed feeding times and regular monitoring of water conditions. On the other hand, the IoT-based automatic feeding system allowed for controlled feeding frequencies and conditions for controlled feeding frequencies and conditions adjustments. Parameters such as fish feeding behavior, growth rate, stress levels, and survival rate were closely monitored for each scenario.

4. CONCLUSION

This feeding system with NodeMCU E SP8266 based on the Internet of Things (IoT) can be implemented to control the feeding of fish in an aquarium environment. The purpose of this automatic feeding system is to ensure that the feed given to the fish in the aquarium is evenly distributed. Feeding the fish unevenly will cause the aquarium water to become cloudy. Turbid water can cause the ornamental fish in it to die besides being unpleasant to look at. Based on the results of testing the accuracy of the distance between the ruler and the ultrasonic sensor 5 times, an average error of 1.795% was found. In other words, the success of the ultrasonic sensor in detecting the distance of objects (fish) is 98.205%.

Some suggestions for future research are looking for ways to reduce the energy consumption of automated feeding systems, such as incorporating energy-efficient components, optimizing power management, or utilizing renewable energy sources.

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