Fish feeding control system and water pH monitoring in Tilapia fish ponds based on Internet of Things (IoT) using mini PC

M. Syahzali Ardini[1], Mukhlidi Muskhir[1], Habibullah[1], Fadhli Ranuharja[1] Afdal Luthfi[1]
[1]Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

Article Info

Article history:

Received August 08, 2024
Revised October 12, 2024
Accepted November 15, 2024

Keywords:

Automatic Feeder
Raspberry Pi
Monitoring
Internet of Things (IoT)
Web Server

ABSTRACT

The aquaculture sector currently has a real contribution to food security, including increased production, animal protein consumption, employment, income and regional development. Some problems in tilapia farming are manual feeding and unstable water pH levels. This research aims to design and build an automatic control system for fish feeders and monitoring water pH in tilapia ponds based on the Internet of Things (IoT). This system uses a Raspberry Pi as the system control. In the feeding mechanism, the HX711 load cell sensor is used to weigh the feed, the servo motor functions as the opening and closing of the main feed container, and the DC fan acts as a blower of the weighed feed into the pond area. In addition, a PH-4502C sensor is used to measure the acidity (pH) of the pond water in real-time. All data related to feed weight and water pH are displayed through a web server interface that can be accessed remotely by users. This system is expected to improve the efficiency of feeding and monitoring water quality, thus supporting optimal tilapia growth. The test results show that this system is able to operate well and provide accurate monitoring results as well as timely feed control and in accordance with the needs of tilapia.

Corresponding Author:

M. Syahzali Ardini
Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang
Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia
Email: msyahzali@gmail.com

1. INTRODUCTION

The aquaculture sector currently has a real contribution to food security, including increasing production, animal protein consumption, employment, income and regional development [1]. Tilapia is one of the freshwater fish that is widely cultivated in the community [2], [3]. Cultivation of this fish does not require large capital but produces a lot of profit. The nutritional content that can meet animal protein in humans so that many people like to consume this fish [4]. Some problems in tilapia cultivation are manual and unprogrammed feeding. Tilapia owners are sometimes late in feeding the fish because they are busy with other things [5]. In addition, another problem in tilapia cultivation is the unstable pH level of the water in the cultivation pond [6]. The pH value of the pond water greatly affects the development and survival of tilapia [7]. When the pH of the water in the cultivation pond is too acidic or too alkaline, it will cause digestive problems in the fish [8].

The development of technology that continues to increase every day will make it easier to get all the facilities needed to help human life [9]. Current technological developments encourage humans to remain creative, not only finding new discoveries, but also maximizing existing technology to help humans carry out daily activities [10]. Some technologies that are developing very rapidly are automation and IoT technology [11],[12]. Automation technology can be used to provide feed automatically which is usually done by cultivators manually at certain times every day [13]. IoT technology can be used as a communication medium or interface that can be used to monitor the pH level of water in cultivation ponds [14].

Research on fish farming control and monitoring tools has been conducted by many researchers, such as automatic fish feed control using Arduino Uno [15], monitoring of water pH levels in IoT-based fish farming [16], automatic fish feed control systems and measuring temperature and pH levels in fish ponds [17]. Some of the reference results that have been understood in this background were obtained from various studies discussing fish farming control and monitoring tools. In this discussion, there are still several problems that occur, including the system that has been created cannot be accessed and monitored using a smartphone. In addition, the system that has been created also does not use a scale sensor as a medium for measuring the weight of the feed to be given [18]. From the results of this study, this study will try to develop a fish feed control and water pH monitoring tool in tilapia ponds using an IoT-based mini PC. Mini PCs have several advantages when used as a control system when compared to other components, including being practical and low power [19], [20]. Mini PCs are also equipped with processors, RAM, hardware ports [21]-[23]. In addition, the Mini PC is also equipped with a DS1307 module that functions as a time system [24]. In addition to being used as a control system, this Mini PC can also be used to design a device that can be controlled remotely using a smartphone [25].

2. METHOD

Tool design is an important thing to do in determining what components will be used when making a final assignment, this is so that the tool to be made works as desired. This research method includes designing and making hardware and software. Hardware design is made using the Autodesk Investor application, an application used to create a design. While software design uses the fritzing application to create a schematic circuit design, VNC Viewer and PuTTy to remote or program the raspberry pi and Visual Studio Code to create a web server that will be used as a media interface to monitor the pH of water in fish ponds.

Block diagram is a definition of a system that is comprehensive. The rule in the analysis process is that it is necessary to define the system that is designed comprehensively, meaning that there must be a clear picture of the scope of the discussion, namely by using a block diagram. Figure 1 show a block diagram of the system on the tool used.

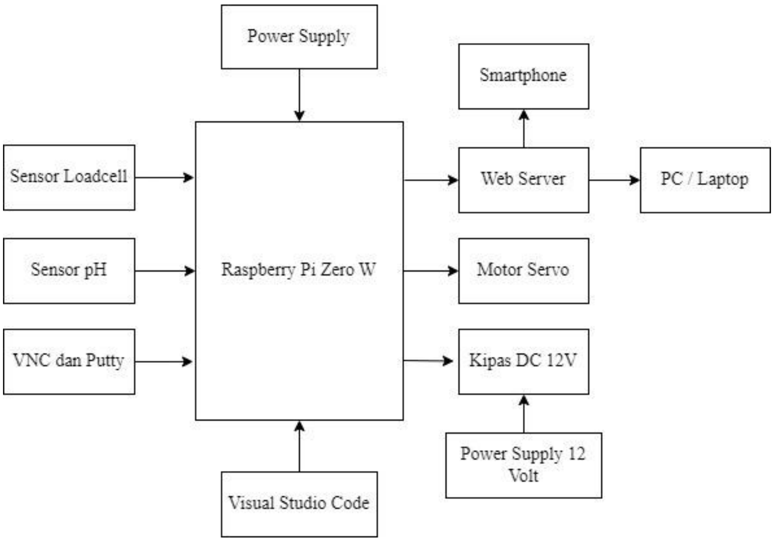

Figure 1. Block diagram of the proposed automatic fish feed control and water pH monitoring system

Based on the block diagram above, the design of each block diagram has the following functions: 1) Raspberry Pi Zero W is the main component in this system which functions as the brain or controller, 2) The load cell sensor functions as a measure of the weight of fish feed that will be given to the cultivation pond, 3) The pH sensor functions as a measure of the pH quality of the water in the cultivation pond, 4) VNC Viewer and PuTTy are software used as remotes to program Raspberry Pi, 5) Visual Studio Code is software used as a medium for creating websites and programming Raspberry Pi, 6) The servo motor functions as a driving medium to open and close the main container of fish feed, 7) The 12 Volt DC fan functions as a spreader or feeder from the load cell sensor scale to the fish pond, 8) The web server functions as a medium for monitoring the pH level of water in tilapia ponds, and 9) The power supply functions as a source of electricity used to operate the components used.

The working principle of the designed tool is a process carried out by the Raspberry Pi control system. This part is the most important part in data processing in the designed control and monitoring system. Raspberry Pi will set the time in real time with the DS1307 IC which regulates the movement of the servo motor at a predetermined time. The hx711 load cell sensor will be used as a measure of the weight of the feed given and as a trigger to turn off the servo motor and turn on the DC fan. The DC fan is used as a driving medium to push the feed in the weighing container. The PH-4502C sensor is used as a detector of the pH level of water in the fish pond where the detected pH results will be displayed on the designed website. Figure 2 shows the proposed design of a fish feeding device.

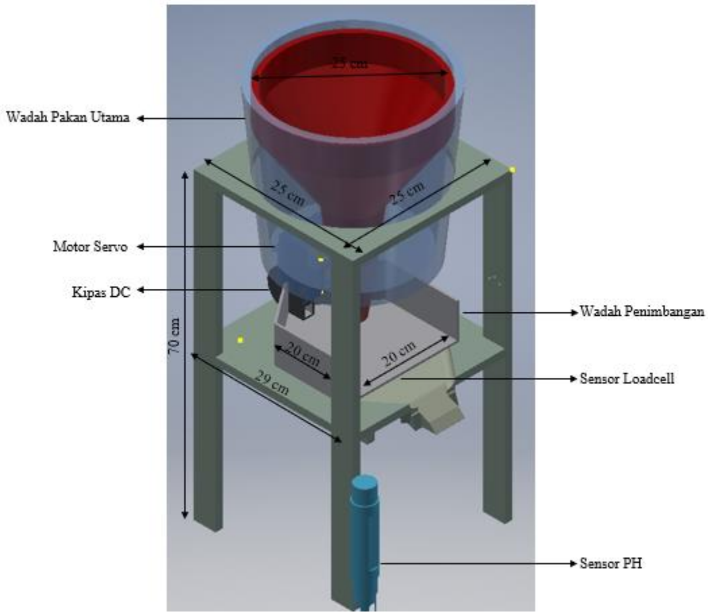

Figure 2. Design of the proposed automatic fish feed

Design planning is a stage or process in making a tool so that it can reduce errors when making the tool. In the tool design, you can see the size and components used in making this tool. The components used will become a unified tool that can automatically feed fish and monitor the pH level of water in tilapia ponds. Figure 3 The overall circuit of the hardware component system shows the connection between one component and another, so that it becomes a unified system that can be used in the control system on electrical equipment. This circuit is a picture of the I/O installation of the design of the components that will be used if they have been assembled.

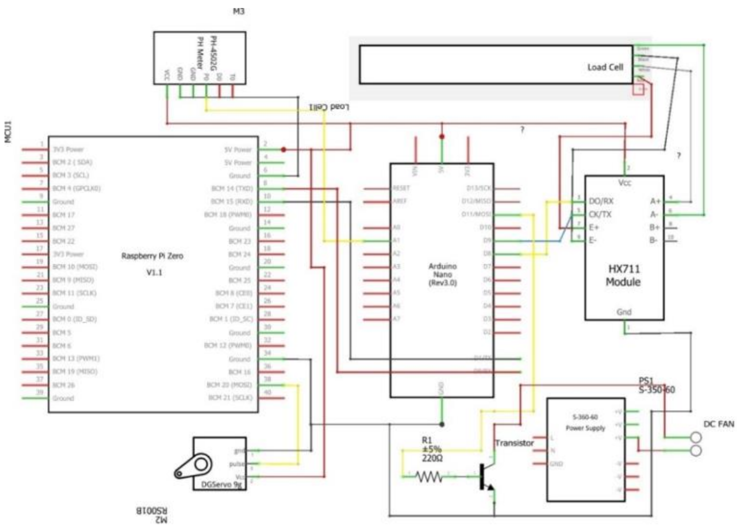

Figure 3. Circuit schemeatic of proposed system

Figure 4 is a display of the website that will be used on this tool. The function of this website is to monitor the condition or pH level of water in tilapia ponds. The website will be connected to the Raspberry Pi when connected to the same network. The website will display data generated from the pH sensor that is read and sent using the Raspberry Pi to the website that has been designed. The results of the sensor readings can be seen via the website that can be accessed using a PC, Laptop and smartphone connected to the internet network.

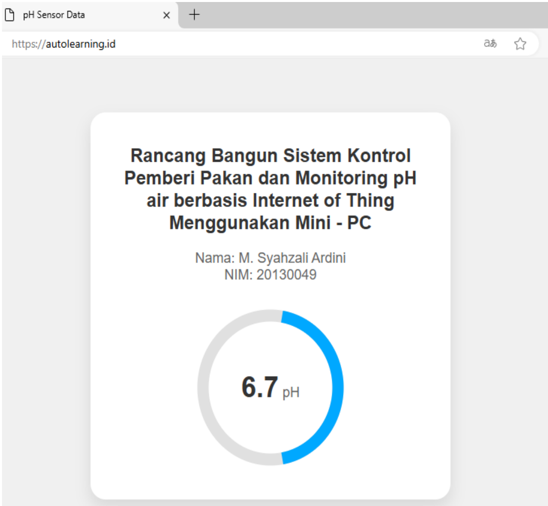

Figure 4. Design of a water pH monitoring website

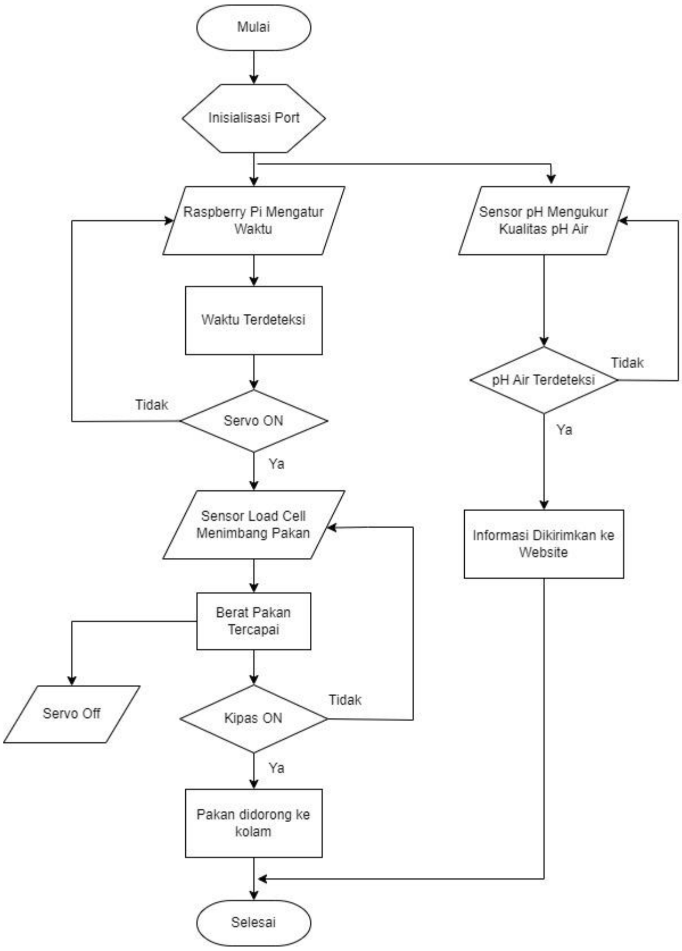

Figure 5. Flowchart of the proposed system

Figure 5 is a flow diagram or work steps of the program created on this tool. A flow diagram is a diagram depicting a process, system, or computer work algorithm [30]. The first thing to do is initialize the port. Furthermore, the automatic fish feeding system starts from the Raspberry Pi Zero W will set the schedule according to the time that has been determined in real time, namely at 08.00 and 17.00. When the clock shows that time, the servo motor will be ON so that it opens the fish feed cover in the main feed container, then the feed will fall into the weighing container and will be weighed using a load cell sensor. After the feed weight reaches the specified weight, the servo will turn off and close the main feed container then the 12 Volt DC fan will turn ON and push the feed in the weighing container into the fish pond. After the fish are fed automatically, the next process from IoT to monitor the pH of the water using a smartphone via a web server that has been designed. The pH sensor will measure the pH quality of the water in the fish pond. The results obtained from the pH sensor will be sent to the smartphone via a web server that has been designed.

3. RESULTS AND DISCUSSION

Tool testing is an important part of the final project because it involves hardware and software assembly and functional testing to ensure that all components work as expected. Furthermore, performance testing is carried out to evaluate the timeliness, accuracy of sensor readings and the connection between the sensor and the website. The test results are carried out to ensure that the tool works properly and meets the requirements. This fish feeder and water pH monitoring tool uses several components to work properly, including Raspberry Pi, Servo Motor, load cell sensor, DC fan and pH sensor. The physical form of the tool that has been designed can be seen in Figure 6.

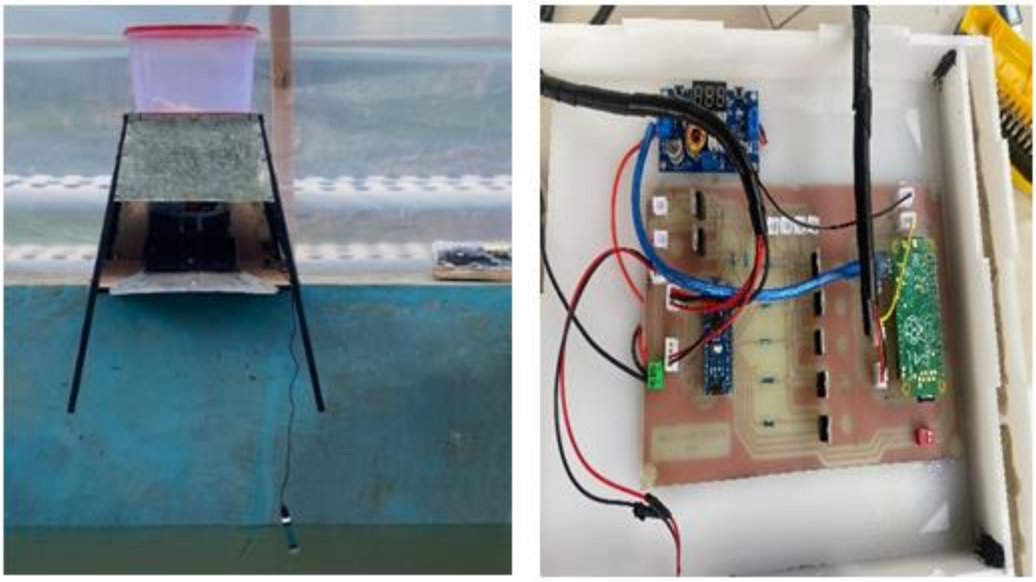

Figure 6. Results of making automatic fish feeding devices and water pH monitoring.

Figure 7 is the appearance of the website when opened using a smartphone. After testing the appearance of the website, the next step is testing the automatic fish feeder system. This feeding is done twice a day, namely at 08.00 and 17.00. The performance testing of this feeder is carried out for three consecutive days. In table 1 can be see the results of the fish feeder experiment for three days.

Table 3. Results of the Automatic Fish Feeder Experiment

Day	Time	Weight (g)	Feeder status
1	08.00	20	Succeed
	17.00	20	Succeed
2	08.00	20	Succeed
	17.00	20	Succeed
3	08.00	20	Succeed
	17.00	20	Succeed

After the fish feeding experiment was conducted, a water pH monitoring experiment was conducted in the fish pond for three days. Water pH monitoring was conducted before the feed was given with the aim that if the water pH was below the average limit of 6.5-8.5, then fish feeding would be stopped because the water pH greatly affects fish digestion. Table 2 shows the results of water pH monitoring in the tilapia fish pond.

Table 2. Results of monitoring water pH in fish ponds

Day	Time	pH	Status
1	07.00	7,23	Secure
	16.30	7,5	Secure
2	07.00	7,14	Secure
	16.30	7,38	Secure
3	07.00	7,06	Secure
	16.30	7,6	Secure

Table 2 shows the results of monitoring the pH of the water in the tilapia pond for three days. After conducting the water pH monitoring experiment, the next step was to measure the spray distance and spread distance produced by the automatic feeder. Measurements were carried out 10 times to obtain a consistency graph of the distance produced by the feeder. Table 3 and Figure 7 show the results of the measurements and graphs of the spray distance and spread distance of the automatic fish feeder.

Table 5. Results of measuring the spray distance and spread of the feeder

Test	Forward spray distance	Spread distance to the side
1	60 cm	46 cm
2	59 cm	40 cm
3	60 cm	40 cm
4	60 cm	45 cm
5	58 cm	47 cm
6	63 cm	48 cm
7	61 cm	50 cm
8	59 cm	48 cm
9	62 cm	51 cm
10	60 cm	47 cm

Table 3 and Figure 7 are the results of the experiment and the distance graph produced by the fish feeder. In this experiment, the results obtained were the furthest spray distance that the fish feeder could do was 63 cm and the furthest spread distance was 51 cm. The purpose of this distance test was to prove that the tool made was able to spread feed to the middle of the pond with a small pond. This test was carried out on a pond measuring 2 × 3 meters.

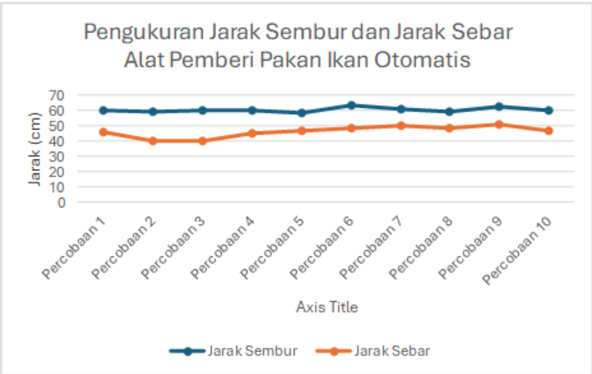

Figure 7. Graph of measuring the spray distance and spread of the feeder.

4. CONCLUSION

The results of testing and analysis that have been carried out in the study can be concluded that the implementation of the use of automatic fish feeders can help fish farmers in providing fish feed according to the amount needed by the fish and with accurate timeliness. In addition, the use of a web server to monitor the pH levels of water in fish farming ponds can help farmers monitor changes in water pH in fish ponds in real time. Therefore, the use of Mini PC as a control system has been proven to be able to work effectively in managing the time for providing fish feed automatically and in monitoring the pH of water in fish ponds in real time.

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