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Development of Automatic Home-Based Fish Farming using the Internet of Things

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Abstract*: *This research purposed to design an automatic home-based fish farming using the internet of things and to evaluate its efficiency. There were 3 processes in this research: 1. creating a home-based fish farming environment (fish pond) 2. designing and developing home-based fish farming by using the internet of things and 3. experimenting and implementing the system. The fish pond (90 x 180 x 50 cm) was made up of 90 blocks. It was coated with waterproofed plastic in order to contain a maximum of 80 cm x 170 cm x 40 cm. or 0.544 m3 of water.

The automatic home-based fish farming system using the internet of things consisted of 6 parts in the form of 1. A NodeMCU Microcontroller 2. An automatic fish feeder 3. A relay module 4. Home Wi-Fi 5. Web Application 6. Line Notify. The NodeMCU Microcontroller was the main module use to control the automatic working of the system. The experiment resulted in a number of findings. Firstly, Fish feeder experiment, Experiment for the fish feeder to release food for 30 grams, 5 times, average time 23 seconds, error rate + 8.70%, -7.25%; Experiment for the fish feeder to release food for 45 grams, 5 times, average time 35 seconds, error rate + 10.00%, -8.57%; Experiment for the fish feeder to release food for 60 grams, 5 times, average time 48 seconds, error rate + 2.08%, -5.27%; finally, 75g fish feeder, 5 times, average time 75 seconds, error rate +8.33%, -8.02%. As a result, the dispensing variation was no more than ±10%. Secondly, the timing of this machine was divided into 4 periods: during days 1 to 30, it dispensed food 30g. During days 31 to 60, it dispensed food 45g. During days 61 to 90, it dispensed food 60g. During days 91 to 142, it dispensed food 75g. It would feed 2 times: 7 am. and 6 pm. each day. Thirdly, the test was to turn on and off the water and oxygen pumps by just clicking a button on the web application. The system was used to feed 80 3-inch long catfish over a period of 142 days. At the end of the period, 43 catfish were left with 37 having died. The survival rate was 54%. These fish weighed 5,380 grams in total and their growth varied. There were 24 small fish which weighed 120-220 gram (61%), 10 medium sized fish which weighed 230-330 (23%) and 7 large fish which weighed 340-440 (16%). As a result, this system could be used for feeding fish, but it needs some improvements such as the introduction of a waste water monitoring system and an automatic water changing system which would enhance the automatic working of the system.

Index Terms*: *Automatic home-based fish farming, Internet of Things (IoT), Web application, Line notification.

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I. INTRODUCTION

Nowadays, breeding fresh-water fish is popular for commercial purposes and as a hobby in peoples' homes. However, looking after fish always has some problems such as the time it takes time to look after the fish with regard to feeding them, providing fresh water as well as ensuring the quality of the fish. As a result, it is hard work [1] for people who look after fish as a hobby and they often do not have enough time. Automatic feeding fish systems [2][3] are more convenient for such individuals. Such a system includes parts such as an automatic fish feeding machine, a water pump system and an oxygen pump system. These parts work automatically in order to save time, labor and to reduce some of the burdens. Moreover, they can be controlled by using a suitable computer program. Based on these ideas, researchers have developed an automatic fish feeding system by using the internet of things (IoT) to solve such problems as the owners being unable to feed the fish because they are busy or they finish work late, meaning that they cannot feed the fish when necessary [4]. Some fish become ill as a result. Automatic home-based fish farming using the IoT can be used to set up an automatic food feeding machine which can be controlled by the program. Feeders can set time to feed food. Feeding inadequate amounts of food based on the size of the fish will prevent them for growing to an appropriate size. As the time goes by the fish will grow and consequently it will need a gradually larger amount of food. The system is designed to increase the amount of food over time according to their physical growth rate. Moreover, beginners can use the automatic fish feeding machine as the additional choice. Automatic home-based fish farming using the IoT can decrease some of the burden of feeding fish such providing adequate amounts of food or ensuring the hygiene of the water, as well as ensuring the growth of fish for commercial or hobby purposes.

II. OBJECTIVES

1. To develop an automatic home-based fish farming system using the IoT.
2. To experimenting and implementing of the automatic home-based fish farming system using the IoT.

III. LITERATURE REVIEW

Buated and Junmark [3] undertook research into "Automatic catfish farming in a cement pond".

The purposes of this research were 1. to decrease the problems of feeding and waste water, 2. to control the temperature in the fish pond in the winter and 3. to apply a micro-controller to control the automatic catfish farming in a cement pond.

This fish farming system consisted of a cement pond, a fish food feeding machine, an oxygen generator, a heater, a micro-controller and a solar cell system. The cement pond was circular with a diameter of 100 cm. and a height of 50 cm. The food feeding machine was made of 3 mm. acrylic. It also had a DC motor which was the main controller for dispensing food and for measuring the level of food in 2 levels such as being full or empty. The controller consisted of a micro-controller, a switch, a feeding fish food kit, a water level sensor, a buffer, a water pump system, an oxygen pump, an electric valve, a heater and a food level sensor. The microcontroller would calculate the input then put the output to buffer in order to increase the pressure from the micro-controller to 5V. After that, the circuit would work. The energy system consisted of a solar panel, a battery and a charger. The result in terms of automatic catfish farming using a cement pond was that the fish food supplied was less than the demand by about 17-20%. The water temperature level experiment found that when the heater was turned on, the temperature increased from 18 to 20 centigrade degree. If it operated for more than 15 minutes, the temperature would be higher. As a result, the water level temperature kit could not work because the heat transferred for a spark plug was not sufficient. Water transfer worked automatically according to the timer. When the water was released up to the 2nd level, the valve would be closed. The pump would then add water up to the 3rd level and the pump stopped. The oxygen pump worked according to the program setting.

Binti Hasim, Ramalingam, Ernawan & Puviarasi [1] undertook research entitled “Developing Fish Feeder System using Raspberry Pi”. The fish owner would no longer have to worry about feeding the fish at home while they are away. This eliminates the risk of the fish dying, under/overfeeding the fish and also maintain the quality of the water in the fish tank. As a result, this system was important. This research proposed to design a food feeding system using a micro-controller - a Raspberry Pi - as well as web application. The owner could set the time for dispensing the fish food. This system was also designed to prevent the death of fish due to malfunction.

Geetha and Gouthami [5] undertook research entitled “Internet of Things enabled real time water quality monitoring system”. It proposed: 1. to survey the latest research with regard to the measurement of the quality of water using ICT and various kinds of sensor, 2. to present a system for measuring water system quality on a low budget and using Wi-Fi as the controller for measuring parameters such as pH, despondency and electric conductivity. This included notification for the change with regard to the parameter in the quality of the water. 5 parameters were experimented with in the form of electric conductivity, pH, despondency, temperature and water levels. This experiment was connected to the Ubidots platform. The sensors were put in 3 places around the researchers’ university. This system could send SMS, emails and notifications to the feeders if the parameters were out of balance. This research presented the details of the equipment and technique used to measure the quality of water, using a low budget quality of water evaluation system. This system would cause the sensor to provide online information to the feeders. This experiment indicated the suitability of the system for measuring for quality of water.

Akila, Karthikeyan, Hari & Hari [4] developed a domestic fish food feeding system by using the IoT (IoT-Based Domestic Fish Feeder). Raspberry pi was the main module and a step motor was used to dispense the food. A Pi-camera was used to see the fish in real time. There was a program to manage the system involving control of such items as an automatic feeder, manual feed, and the live streaming of fish. It was possible to set the time of feeding using an automatic feeder controlled by the program. Fish food could also be dispensed from a distance by using a web-interface. It was possible to see, capture, record using video and downloading such a video showing the fish. This research was beneficial to the feeders in that it operated perfectly. However, there were 2 mistakes: the readiness of the internet and the power supply which needed to work 24/7. Otherwise, the overall system would fail. This system was easy to repair.

Meethongjan & Kongsong [2] undertook research into the smart fish farming system by using the IoT and mobile application technology. It presented a mobile application system which worked with the IoT and Android application to control the level of water in a fish pond. This system used Android studio, Java, C, Arduino IDE, SQL and Firebase software. The controller system was from Node ESP8266 MCU V.2 board, Wemos-D1 boards and module ultrasonic hardware. This farming system was experimented on using a small fish pond in a house. Data was collected in order to determine the efficiency of the system. Black Box Testing was used to evaluate the system. Average and standard deviation was used for data analysis purposes. The results of the evaluation on the part of both feeders and experts were shown as 4.21, 4.15 and 0.74, 0.72 respectively. As a result, this system could be used for feeding purposes and it could be the model for the other smart farmers.

IV. METHODOLOGY

A. Creating the fish pond

This fish pond was built from 90 blocks of 10x30x10 cm. There were 72 interlocking blocks (see Fig. 1) and 18 smooth blocks (see Fig. 2).

Fig. 1 Interlocking blocks

Fig. 2 Smooth blocks

This pond was 3 blocks wide, 6 blocks in length and 5 blocks in height. The area of the pond was 90 x 180 x 50 cm. and it can contain 80 x 170 x 40 cm water (see Fig. 3)

1. NodeMCU Microcontroller

NodeMCU was open-source LUA-based firmware for ESP8266 WIFI which is developed for operation with regard to the NodeMCU development board. In the NodeMCU is included an ESP8266 chip which can work with Wi-Fi. NodeMCU which has the characteristic like that of Arduino such as analog and digital. It also supports UART, SPI, I2C. NodeMCU can use I2C to connect with an empowered LCD show, Magnetometer HMC5883, MPU-6050 Gyro meter, accelerometer, RTC chips, GPS modules, contact screen shows, SD cards and so forth. The NodeMCU development board was the board which worked with Wi-Fi, pins and interfaces in order to connect to the other devices. Feeders can apply it to the other work on NodeMCU. (see Fig. 5) [6]

Fig. 3 Fish pond

B. Design and development

Design and development of an automatic home-based fish farming system using the IoT involved the creation of a fish pond, and the installation of a fish food dispensing machine, a controller kit, a water pump, an oxygen pump, a web application and Line Notify application as shown in Figure 4. The details are as follow:

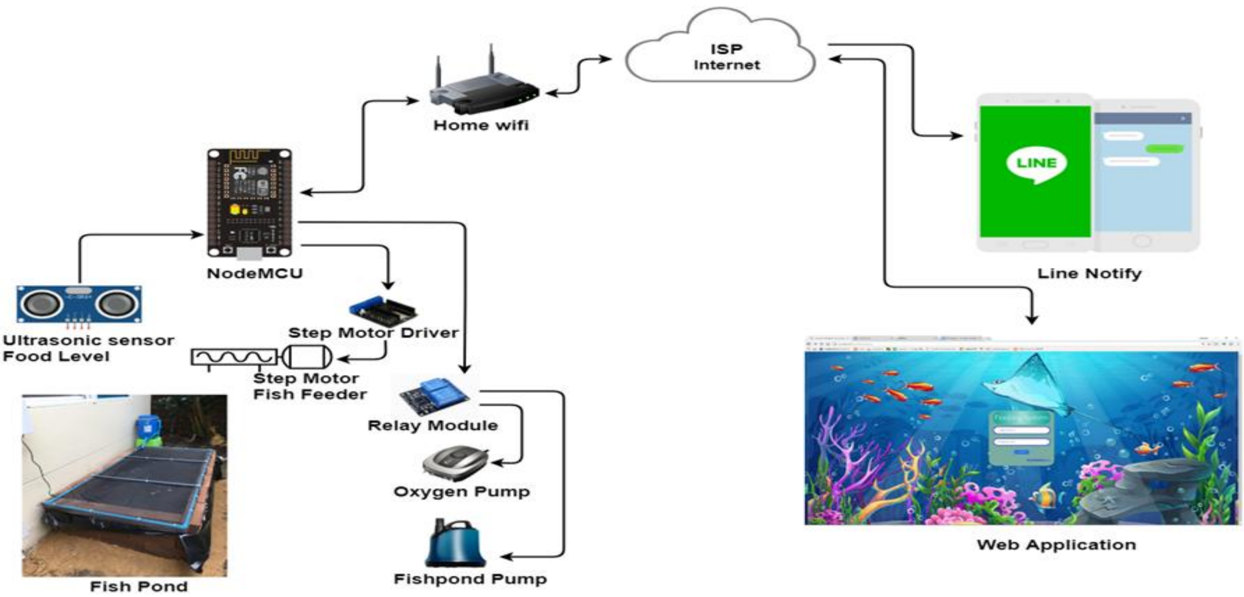

Fig. 4 Architecture of automatic home-based fish farming using internet of

Fig. 5 NodeMCU Version 2 (ESP8266-12E)

2. Automatic Fish Feeder

The automatic fish feeder consisted of a motor circuit, a step motor, a distance measuring module using ultrasonic waves. The step motor is used to turn around spiral part of the machine which contains the food putting fish food into the fish pond. The distance measuring module using ultrasonic waves is used as a sensor to measure the level of food on order to whether or not it is empty (see Fig. 6). The details are shown as follows:

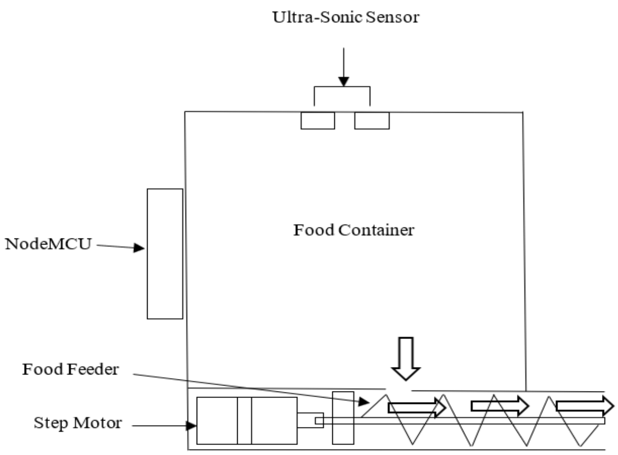

Fig. 6 Automatic Fish Feeder

a. ESP-12E Motor Shield

The ESP-12E Motor Shield is a module which can work with NodeMCU. The plug can put on the motor shield. A DC motor can work in this circuit using 2 ports and with a stepper motor for 1 port. It uses 1.2A to run the circuit. There are 4 ports such as D1, D2, D3 and D4 which are used for the PWMA (motor A), PWMB (motor B), DA (direction of motor A), and DB (direction of motor B). (see Figs.7, 8) [7].

Fig. 7 NodeMCU Motor Shield + NodeMCU [8]

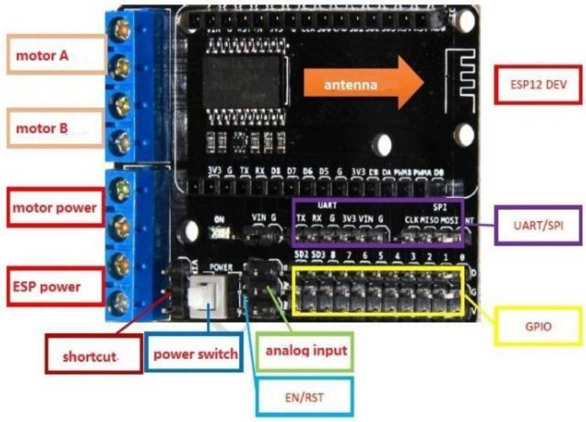

Fig. 8 NodeMCU Motor Shield [8]

b. Stepper Motor

The stepper motor will work when the electric current goes to the motor. It will then turn and stop according to the circumference. It is different from the other motor which turns and does not stop. The advantage of a stepper motor is that it can determine the position of the turning number by using the microcontroller as the controller.

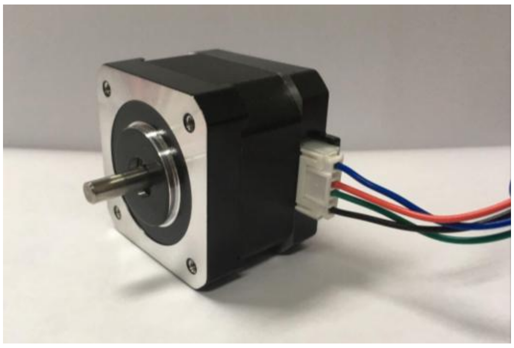

Fig. 9 Stepper Motor

c. HC-SR04 Ultrasonic Module

The distance measuring module using ultrasonic waves can measure from 20 mm. to 4000 mm. The resolution is 0.3 mm. The module consists of ultrasonic transmitters, a receiver and a control circuit. The steps with regard to working the module are as follows:

- prepare HC-SRO4 for measuring. The signal will be sent from the NodeMCU to trigger an input pin by using more than a 10 us signal.

- the NodeMCU will receive a signal from the HC-SR04 module (This module will send the signal 8 plus at 40Khz).

- the NodeMCU will receive the signal back from the HC-SR04 module. [9].

An automatic fish feeder will use module HC-SR04 (see Fig. 10) which is installed on the fish food box. The module is 2 cm higher than the peak of the fish food box. The purpose of the module HC-SR04 is to use an ultrasonic wave to measure the level of the amount of fish food in the box and to determine whether or not it is empty. The resolution is 3mm. which is adequate for measurement purposes.

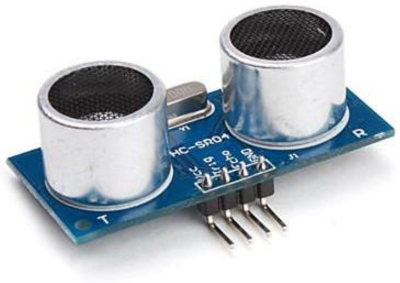

Fig. 10 Ultrasonic Sensor Module

3. Relay module

The relay module is a digital switch for the microcontroller to allow it to work with high voltage appliances. The electrical capacity of this module is 10A. It can work with direct circuit and alternating circuit. It can wihtstand 5V pressure from the NodeMCU. LED is used to show the status of the relay module. This module is used to open and close the water and oxygen pumps in the tank as shown in Figure 11.

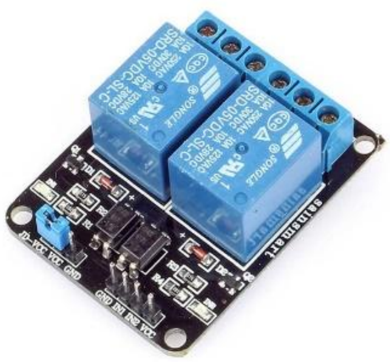

Fig. 11 Relay Module

a. Water pump

A water pump is used to purify the water in the fish tank. It uses 55w and 4500L/Hr pump power (see Fig. 12). Fish will eat food and then excrete. The feeders need to purify the water as a consequence.

Fig. 12 Water Pump

b. Oxygen pump

The oxygen pump is an air pump that is a crucial component used to supply oxygen to the fish tank. This machine will input air to the fish pond through the pipe. The air will bubble into the water because it goes through a filter. Oxygen will be dissolved in the water while the bubbles float to the surface. As a result, the dissolved rate of oxygen depends on the kinds of filter used, given that these determine the amount of bubbles, based on the power of the oxygen pump. The greater the depth of the fish pond, the greater is the dissolved oxygen. The air pump increases the amount of oxygen in the pond, thereby ensuring a satisfactory rate of fish growth (see Fig. 13).

Fig. 13 Oxygen Pump

4. Home Wi-Fi

Home Wi-Fi is available from the internet service provider and can be installed in each house. There are many internet service providers such as AIS, 3BB and True. At this time, the service is in the form of the fiber internet which is more stable and faster than other means. The provider will install Wi-Fi Router Dual-band which has 2 signal ports (2.4 GHz+5 GHz) which can work together. The internet can be connected to any appliance. It is called home Wi-Fi and can connect notebooks, smart TVs, and smart phones to the internet and the IoT.

5. Web Application

The web application is equipment that can be used to manage the fish farming system such as login, fish food dispenser timer which determine the time for feeding food such as 8.00 a.m. and 6.00 p.m.,

showing the readiness status of the system (the amount of food, turning on and off the water and oxygen pumps). The web application is shown in Fig.14.

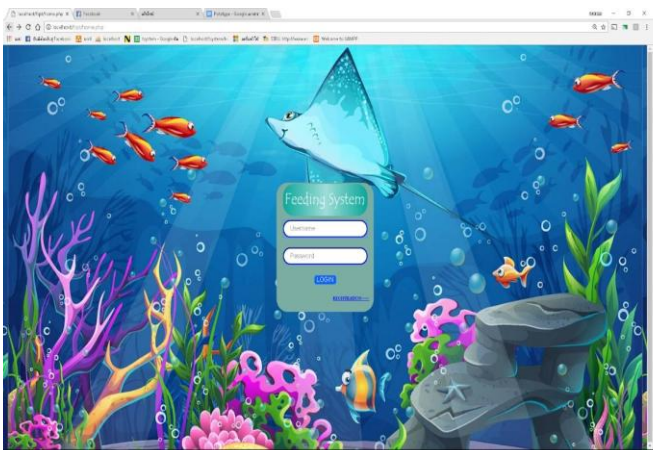

Fig. 14 Web Application

6. Line Notify

Line Notification involves notification from the LINE program which can send messages to the feeders' account. The LINE program is a free chatting program which is used in this research such that the user will be notify via this application and the Mackerel platform which is the platform for checking servers for GitHub engineering, a web service which can work with IFTTT software. It is a web service which can connect to the LINE program [10]. In this research, the NodeMCU worked by notifying via LINE program sending notification to the feeders with regard to the following situations: Fish Feeder: On, Fish Feeder: Off, Air Pump: On, Air Pump: Off, Water Pump: On and Water pump: Off as shown the Fig. 15.

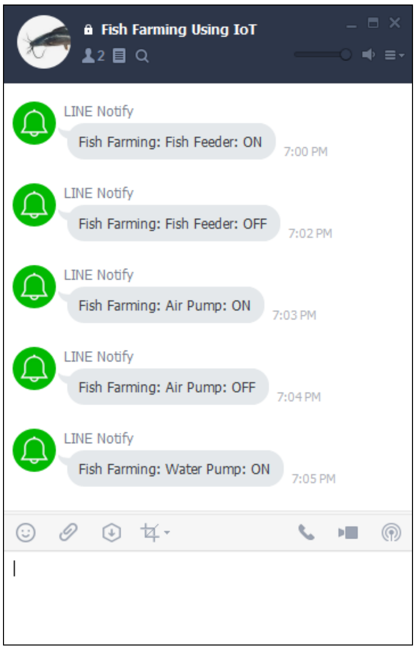

Fig. 15 LINE Notification

C. Experiment and the implementation of the system

1. Feed fish food experiment

There is an ultra-sonic sensor in the food dispensing machine to measure the level of fish food. It measures the distance between the level of fish food and the sensor. This distance will be sent to the web to measure the amount of fish food. Notification is then sent to the feeder. The main function of the stepped motor is to add fish food to the fish pond. The experiment will be done by adding fish food and masuring time as follows:

a. small sized fish food: 30 g

The experiment on feeding fish food using machine: small sized fish food (30g) was fed 5 times. The timing was taken each time of feeding. Results are shown in Table 1.

Table 1 Result of dispensing small sized fish food (30g)

No.	Amount of fish food	Time (seconds)
1	30	26
2	30	20
3	30	22
4	30	22
5	30	24
Average		23

b. small sized fish food: 45 g

The experiment on feeding fish food using machine: small sized fish food (45g) was fed 5 times. The timing was taken each time of feeding. The results are shown in Table 2.

Table 2 Result of dispensing small sized fish food (45g)

No.	Amount of fish food	Time (seconds)
1	45	30
2	45	32
3	45	40
4	45	37
5	45	34
Average		35

c. Medium sized fish food: 60g

The experiment on feeding fish food using machine: medium sized fish food (60g) was fed 5 times. The timing was taken each time of feeding. The results are shown in Table 3.

Table 3 Result of feeding medium sized fish food (60g)

No.	Amount of fish food	Time (seconds)
1	60	48
2	60	47
3	60	44
4	60	49
5	60	50
Average		48

d. Medium sized fish food (75g)

The experiment on feeding fish food using machine: medium sized fish food (75g) was fed 5 times. The timing was taken each time of feeding. The results are shown in Table 4.

Table 4 Result of dispensing fish food (75g)

No.	Amount of fish food	Time (seconds)
1	75	72
2	75	72
3	75	68
4	75	80
5	75	82
Average		75

According to Tables 1-4, the experiment involves feeding fish food in 30, 45, 60 and 75 g amounts. The average time taken to dispense fish food on 5 occasions are 23, 35, 45 and 75 seconds.

2. Table showing schedule of feeding food machine

According to experiment 1), we provide information to determine the time needed for the machine to add fish food. The microcontroller NodeMCU can apply this information to control the dispensing on the part of the fish food machine. The details of the setting are shown in Table 5.

Table 5 Timings of the feeding food machine

No.	Days	Time in morning		Time in evening	Amount of food (g)	Period (seconds)
1	1-30	7.00		18.00	30	23
2	31-60	7.00		18.00	45	35

3	61-90	7.00		18.00	60	48
4	91-142	7.00		18.00	75	75

3. Experiment with regard to turning on and off the water and oxygen pumps

Feeders can turn the water and oxygen pumps on and off by clicking on and off in the web application. The result was that when feeders accessed the web application in terms of the turning on and off module, when they clicked “turn on”, the pumps worked. The button “turn on” and “turn off” work as the name suggest.

4. The implementation of the system

This system is used to feed 3 inch long catfish (80 catfish). It started on 17 March 2018 and lasted until 5 August 2018 (142 days).

V. RESULTS

The results of “Development of Automatic Home-Based Fish Farming System Using the Internet of Things” consists of 6 parts: a NodeMCU microcontroller, an automatic fish feeder, a relay module, a home Wi-Fi system, a web application and a LINE Notification system.

The system is used to feed 3-inch catfish (80 catfish). It operated for 142 days between 17 March 2018 and 5 August 2018. The details are shown in Table 6. The survival percentage of the fish was 54% with 37 dead catfish. The total fish weight was 5,380g. (see Fig. 16). The details are shown in Table 7. Their growth rate of the fish was not stable. There were 26 small catfish: 120-220g (60%), 10 medium sized catfish: 230-330g (23%), and 7 large catfish: 340-440g (16%). The information is shown in Table 8.

Table 6 The number of fish and their weight

No.	Weight (g)	Amount of catfish
1	120	2
2	130	2
3	140	1
4	150	2
5	160	2
6	170	2
7	180	3
8	200	3
9	210	6
10	220	3
11	230	1
12	240	1
13	250	4
14	280	2
15	300	2
16	340	1
17	390	1
18	400	2
19	410	1
20	420	1
21	440	1
Total	5,380	43

Table 7 The number of dead catfishes

No.	Date	Number of dead catfishes
1	3 April 2018	8
2	9 April 2018	1
3	10 April 2018	2
4	11 April 2018	9
5	12 April 2018	15
6	24 April 2018	1
7	11 May 2018	1
Total		37

Table 8 The categorization of catfish into 3 sizes

No.	Size	Weight (g)	Number of catfishes
1	Small	120-220	26
2	Medium	230-330	10
3	Large	340-440	7

The results of the system were that 1) the average time of experimenting with regard to dispensing fish food as shown in Table 1 was 23 seconds and the variations were +8.70% and -7.25%. The average time in Table 2 was 35 seconds, and the variations were +10.00% and -8.57%. The average time in Table 3 was 48 seconds and the variations were +2.08% and -5.21%. The average time in Table 4 was 75 seconds and the variations were +8.33% and -8.02%. As a result, the average variation is no more than ±10%. 2) The timing of the automatic fish feeder varied over 4 periods: day 1-30 (30g. fish food), day 31-60 (45g. fish food), 61-90 (60g. fish food), 91-142 (75 g. fish food). The feeders dispensed fish food twice each day (7 a.m. and 6 p.m.). 3) The experiment involved turning on and off the water and the oxygen pump. The feeders can open and close these pumps by clicking on and off in the web application. These buttons work separately.

Fig. 16 Catfish (142 days)

VI. CONCLUSION AND DISCUSSION

The development of the Automatic Home-Based Fish Farming System Using the Internet of Things relates to the research work of [1], [2] and [4]. This system can facilitate the automatic dispensing of fish food.

There is a module which sends notifications to the feeder by using the LINE program. Users will be notified everytime the food has been dispensed by the machine via notification in LINE. It relates to the research work described in [10] which is about applying LINE notification to send a message about the quality of air. Moreover, the feeder can open and close the water and oxygen pumps by using the web application which relates to the research works described in [2] and [3] which relate to the feeding of catfish. When the feeding finished, the catfish survival rate was 54%. The reason for the dead catfish was due to wastewater because the fish pond was small and there were a lot of catfish in it. Their waste led to concentration of wastewater. According to this research, the researchers changed the water every 5-7 days, taking 1 hour to do so each time. Changing water can be improved by changing the water automatically by measuring the quality of water in real time as can be seen in the research described in [5] and by adding 2 water pumps to remove water out and to put water in. The water needs to be in a water tank to decrease the amount of chlorine before it is put into the pond. Dispensing fish food involved the use of a spiral conveyor whose variation was about ±10%. This might affect the growth rate of the fish. In future research, researchers should explore other methods for dispensing fish food in order to decrease the variation. Moreover, the implementation Wi-Fi should be more stable, to avoid latency. The electrical circuit should work all the time. If it stops, the overall system will not work. The feeder can use a battery to ensure the flow of electricity in order to reserve energy. This system can apply to feeding fish, but it needs further development such as with regard to the wastewater measuring system which would allow water to be changed automatically.

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