IoT-Based Smart Fish Tank Monitoring Device

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Abstract: *In modern times, fish tanks have become a popular home decor item, and many people keep fish as their pets. However, maintaining the fish tank's quality and beauty can be daunting, requiring significant time and effort. Hobbyists often need help with issues such as changes in water quality, controlling temperature and lighting, and manually monitoring the aquarium's conditions. When they are away from home, they cannot keep the fish fed. This project proposes a real-time monitoring system with temperature and water level monitoring sensors to address these issues. Having integrated sockets for necessary devices such as air pumps, water filters, and water renewal operations. An IoT-based system is implemented to enable users to monitor the vivarium's status through the mobile application. By providing personal aquarium management, this system ensures that the fish are neither overfed nor underfed, and the water in the tank always remains in good condition, reducing the manual effort required for aquarium maintenance. This project aims to enhance the water condition and monitor the physical parameters of the aquarium closely, ultimately providing a more convenient and efficient way to care for fish at home.*

Keywords: Networking IoT, Ultrasonic Sensor, Temperature Sensor, App Blynk.

1. Objectives

In the conditions of a fish tank, some factors have direct impacts on it, such as the temperature is too high or too low for the fish, dissolved oxygen level is enough or not, lighting, the need to change the water weekly, and the amount of food for the fish is lack or enough. Therefore, we target this object to develop a real-time monitoring system for fish tanks, including temperature sensors, ultrasonic sensors, and water renewal operations support. Implement an IoT-based system to enable users to monitor the status of the fish tank remotely through a mobile application. To ensure that fish are neither overfed nor underfed, provide the users a wheel to adjust the amount of food for the fish freely. Enhance the water condition by changing it weekly and monitoring the physical parameters of the fish tank closely to ensure the fish are healthy, safe, and less stressed. Provide a more convenient and efficient way for fish enthusiasts to care for their fish at home. Offer a cost-effective solution for maintaining a fish tank by minimizing the wastage of resources such as food and electricity. Provide alerts and notifications to the user in case of any anomalies or emergencies in the fish tank.

2. Rationale of the Study

Firstly, the growing popularity of smart homes and the Internet of Things (IoT) has increased interest in upgrading the traditional fish tank to an IoT-based and smart one. This allows for not only plugging all the devices and leaving them to run 24/7 but remote monitoring and control of various parameters such as temperature and lighting. These advanced features can make fishkeeping more accessible and more convenient for hobbyists and improve the welfare of the fish by ensuring optimal conditions are maintained at all times.

Figure 2.1

Figure 2.2

The adoption of intelligent fish tanks varies across different regions. In developed cities in North America, smart fish tanks have gained popularity among hobbyists and enthusiasts. The market for these tanks has grown significantly, with various products available from established companies and new startups. Similarly, in Europe and West Asia, the adoption of smart fish tanks is growing, although at a relatively slower rate than in North America. There is also a growing interest in using smart fish tanks for commercial aquaculture.

Figure 2.3

Figure 2.4

Figure 2.5

According to VASEP (Vietnam Association of Seafood Exporters and Producers), Vietnam is one of the largest aquaculture producers globally. The device assists restaurants, local shops, and supermarkets. It has been investing in developing innovative aquaculture technologies, including smart fish tanks for families and restaurants. While the adoption of smart fish tanks in Vietnam is still relatively low, there has been growing interest in these technologies among commercial and hobbyist fish keepers. Several Vietnamese companies have already developed and marketed smart fish tanks equipped with advanced sensors to monitor and optimize fish health and growth, automated feeders, and lighting systems that can be controlled remotely through mobile apps. The Vietnamese government has also expressed interest in supporting the development of smart aquaculture technologies to promote sustainable and efficient aquaculture practices.

Therefore, the group has developed a semi-automatic fish monitoring system capable of keeping the temperature, light, oxygen pump, and water level stable for the fish. Assist the user in feeding the fish. This method is controlled remotely and semi-automatically, avoiding anomalies and reducing time and effort for hobbyists to keep their aquarium good-looking.

3. Literature Review

a, Turning on or off the heating/cooling system, air pump, and aquarium filter, led using App Blynk and Relay.

b, Monitoring water level by App Blynk using ESP8266 and HC-SR04.

c, Supporting the water change process.

d, Using a step motor to control the fish feeding device.

e, Entering user personal set up.

f, Integrating information about popular kinds of fish.

g, Setting up the timer for the fish feeding device and led.

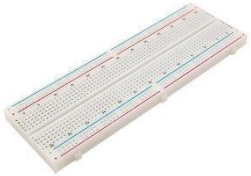
4. Materials

+ Specifications

Parameter	Property	Unit
Operating voltage	220, 12, 5, 3.3	V
Network	Wi-fi	
Connect Ability	Wi-fi	
Processor	ESP8266	1 board
Processor	Arduino Uno R3	1 board
Sensor	DS18B20	1
Sensor	HC-SR04	1
Sensor	24BYJ48-5V Stepper Motor	1
Module	ULN2003	1
Lighting	Led Neon Ring Pixel WS2812B	1

+ The necessary components for the project

ESP8266 Node MCU Lua CP2102		1
Arduino Uno R3		1
HC-SR04 Ultrasonic Sensor Module		1
DS18B20 Temperature Sensor		1
Module Relay		4

24BYJ48-5V Stepper Motor		1
Led Neon Ring Pixel WS2812B		1
Module ULN2003		1
Breadboard		1
10 Jumper Wire male – female 10cm		1

10 Jumper Wire male – male 10cm		1
Mini pump R385		1
RS heater		1
AP303H filter		1
RS-248A Air pump		1

5. Research approach and methods

Apply basic knowledge of IoT techniques and sensor devices, based on applying the research results of domestic and abroad products to build a temperature, oxygen pump, lighting, water changing, and feeding monitoring system to keep a fish tank with a capacity of approximately 22 liters. Based on the technological process of keeping fish, the monitoring system is developed as follows:

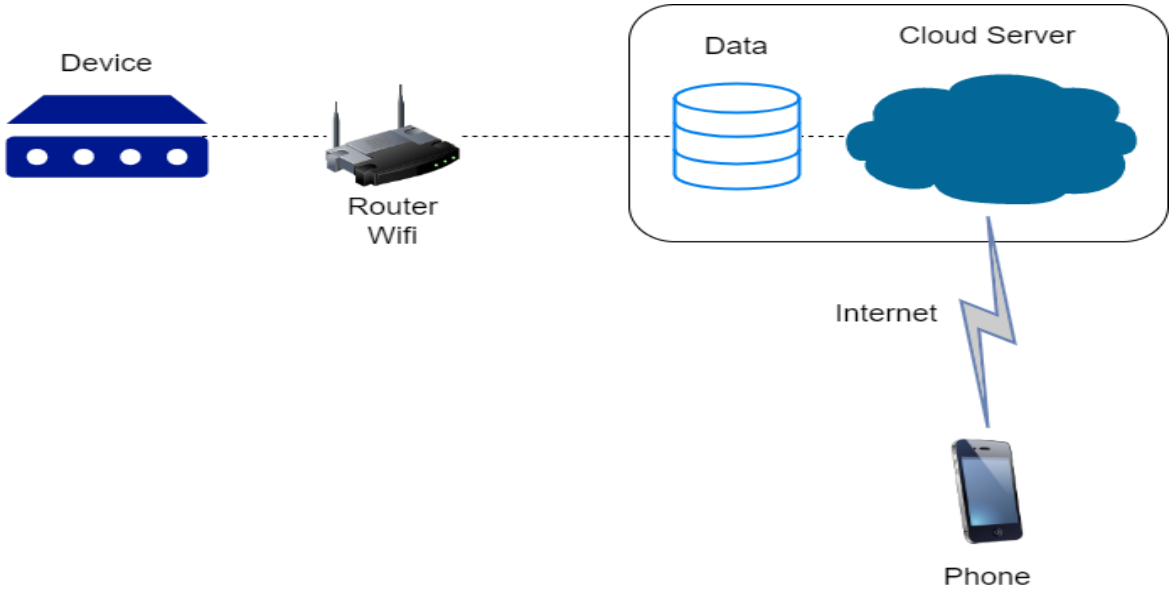


Figure 5.1: Structure diagram

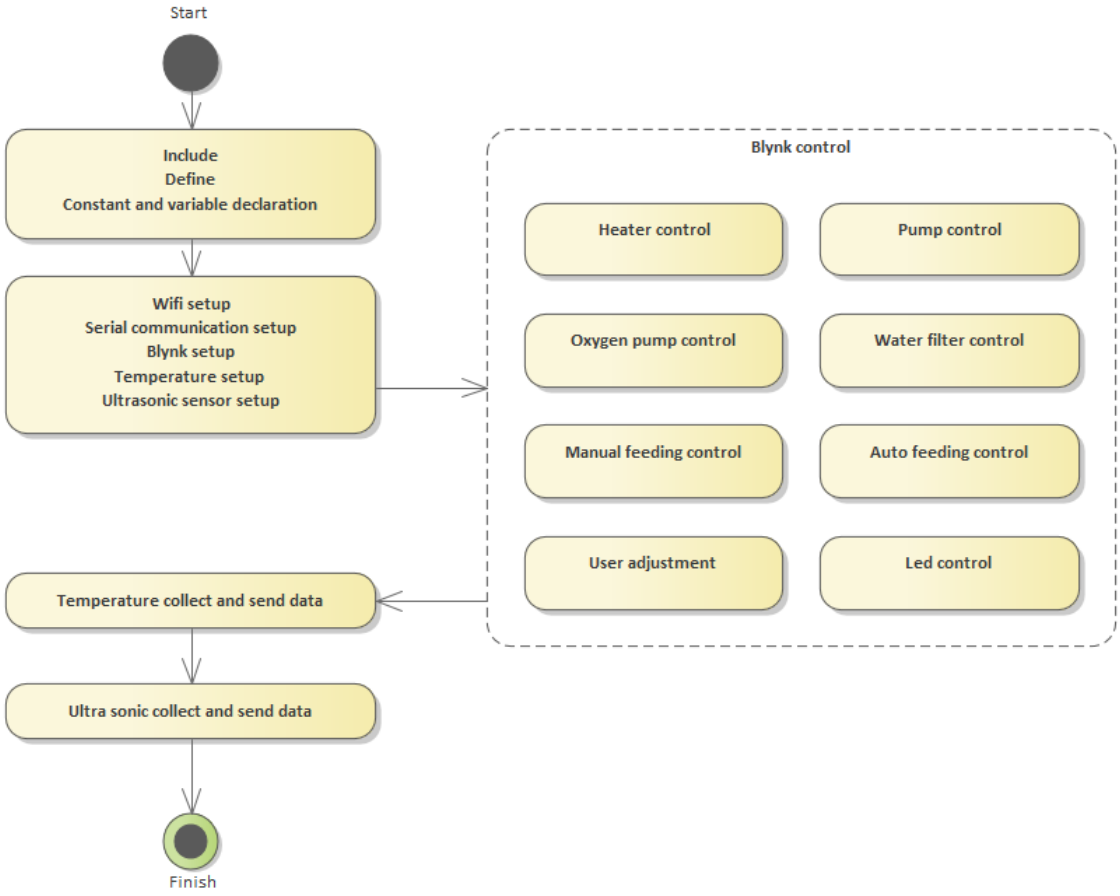
Operating Principle

The system works based on the combination of Node MCU ESP8266 Module, Arduino Uno R3, and App Blynk on the smartphone. App Blynk, in addition to controlling the devices and receiving the data from the fish tank sensor, also displays the device control interface, temperature, and water level data to the user's phone interface.

Hardware: There is a power plugged into the 220V external power outlet for three sockets inside the device; 3 sockets are used for users to plug in external devices such as heating or cooling, dissolved oxygen pump, and water filter. Then through an adapter to convert 220V to 12V to power the pump, one adapter to convert 220V to 5V to power the Arduino Uno processor. Then there is a voltage regulator from 12V to 5V to power the ESP8266 module and a 5V power module to 3.3V to power the relay to switch off three sockets and pumps. Control pins, power pins of temperature sensor DS18B20, ultrasonic sensor HC-SR04, and four toggle relays connected to ESP8266 (4 relays are separate sources). On the side of the Arduino Uno, control the step motor to control the fish feeding device and the turning on or off the led.

Software: Firstly, the processor ESP8266 module connects to the wifi with the internet to connect to the Blynk server, then the user installs the Blynk app on the phone and then connects to the device to enter the setup parameters for the tank; control devices such as turning on and off heating, aeration, water filter, lighting, fish feeding device. The device also has sensors such as an Ultrasonic sensor and temperature sensor to measure and notify the status of the tank to the phone.

+ Temperature Sensor DS18B20: Measure the temperature. When the temperature is too high compared to the user-set temperature, it will notify the phone and turn off the heating. If the temperature is too low, it will notify the user and turn the heating on.



+ Ultrasonic Sensor HC-SR04: Measures the water level in the tank based on the tank height entered by the user and the distance from the water that the sensor measures. If the water level is too high, the user will be notified to pump out the water. When the pump reaches a certain water level set by the user, the pump will be turned off.

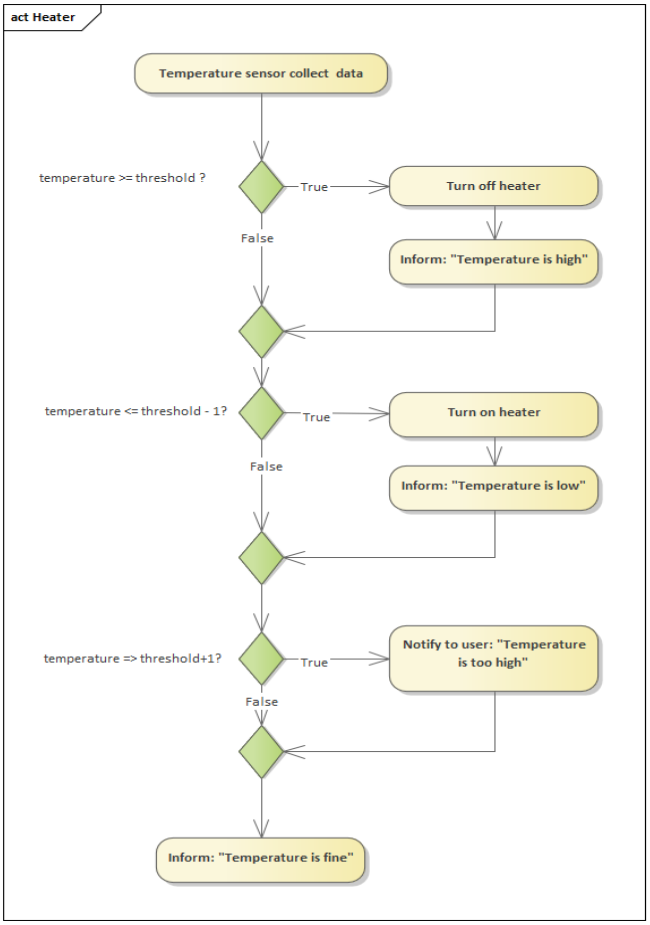


Figure 5.1: Algorithm diagram

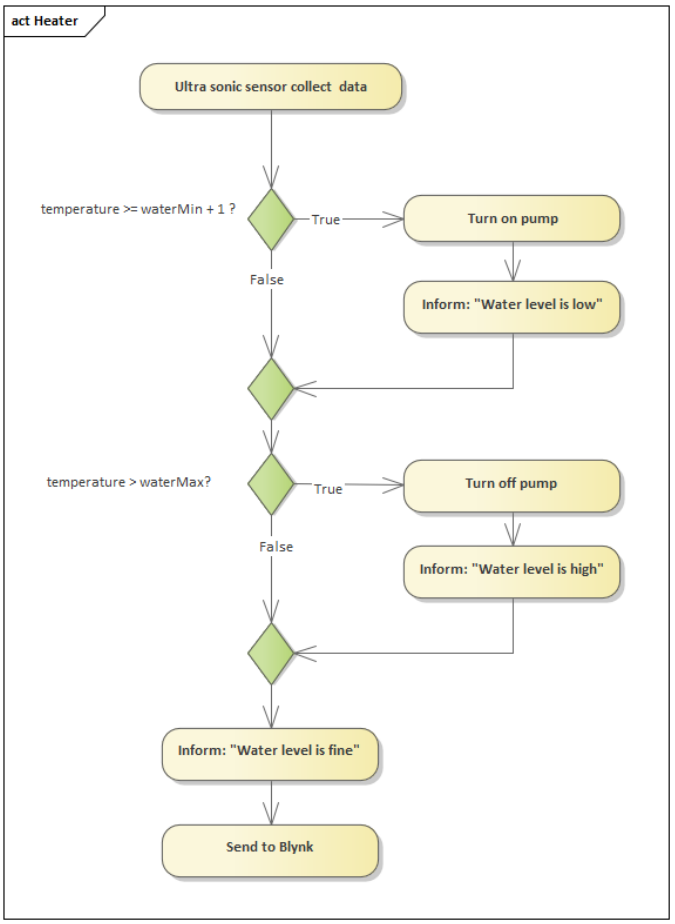


Figure 5.2: Structure diagram

When the user sets up the time to feed the fish, the clock will automatically count down until it reaches 0 and will provide the fish once and then return to the countdown from the beginning. If the countdown is on, the user sets a new timer and will start counting down from the beginning.

6. Design and Deploy the System

6.1 Block diagram

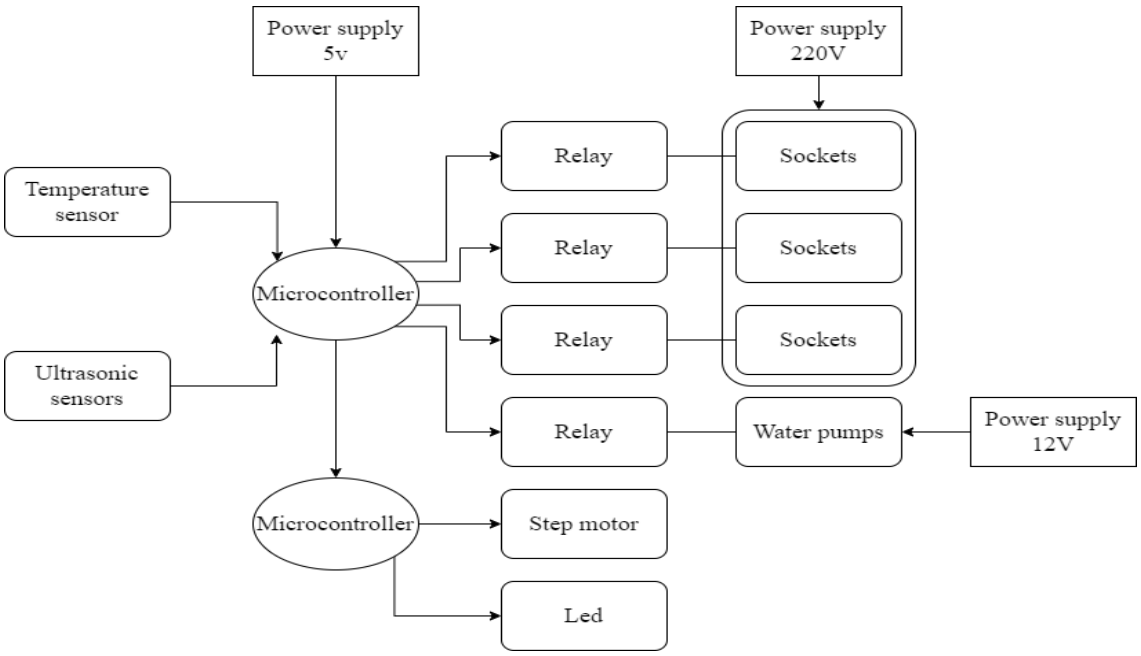


Figure 6.1.1: Block diagram

6.2 Connection diagram

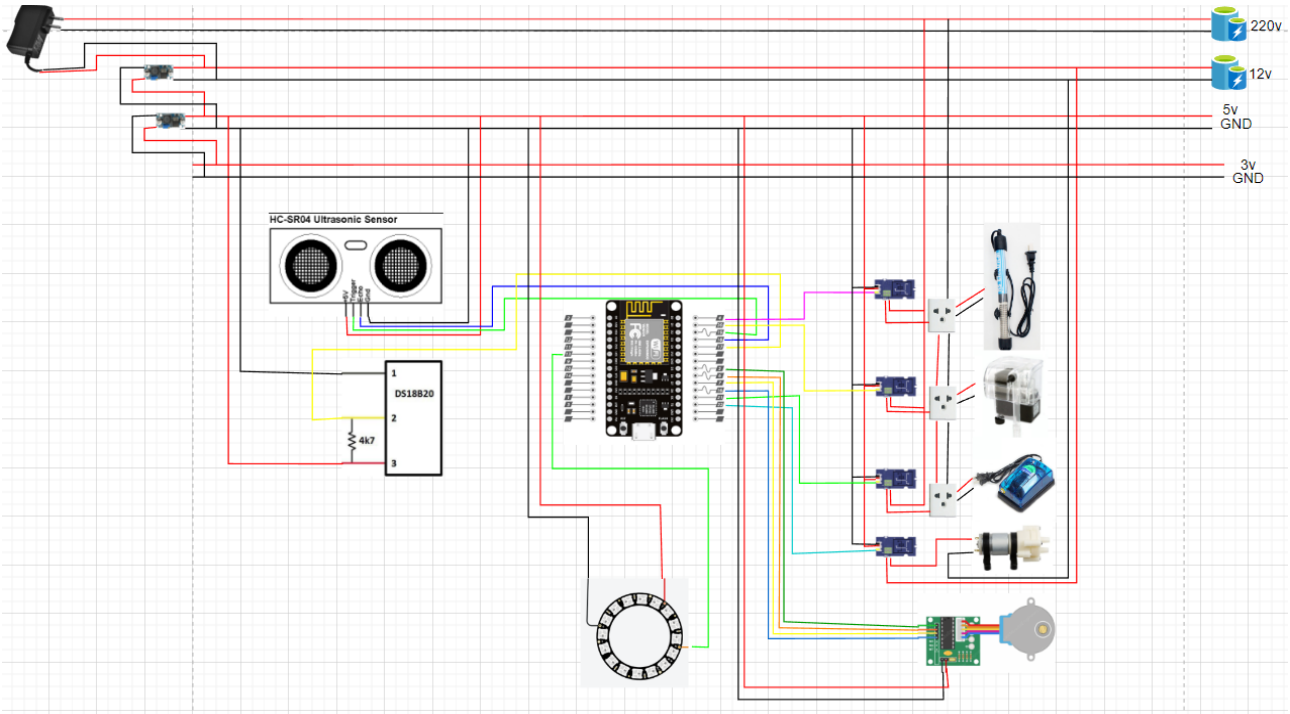


Figure 6.2.1: Connection Diagram

6.3 Install on App Blynk on your mobile phone

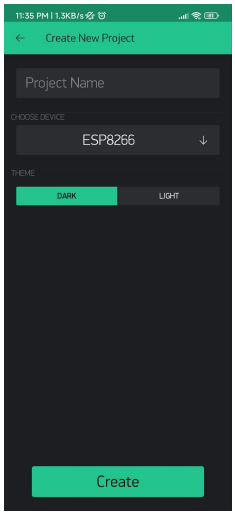


Figure 6.3.1

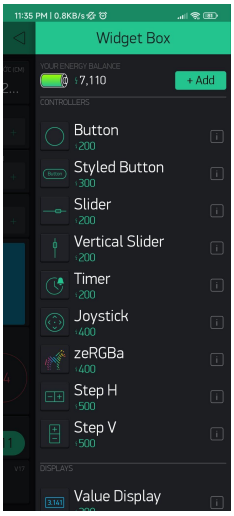


Figure 6.3.2

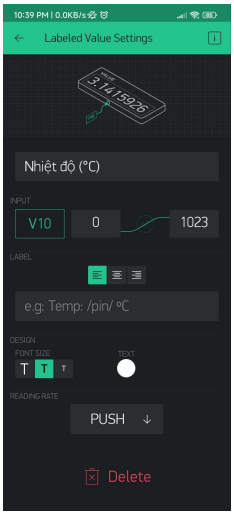


Figure 6.3.3

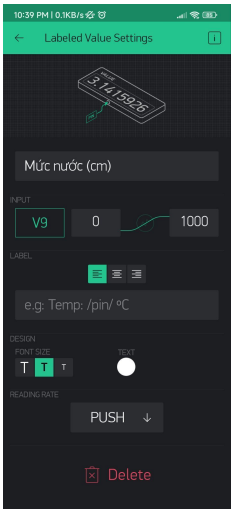


Figure 6.3.4

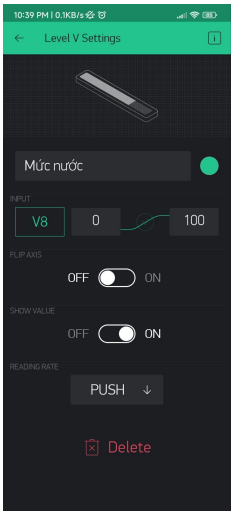


Figure 6.3.5

- Figure 6.3.1: Download the App and create a Project on Blynk
- Figure 6.3.2: Click on GAUGE to proceed with parameter setting.
- Figure 6.3.3: Temperature parameter setting
    - In GAUGE: Name the temperature scale (temperature).
    - INPUT: Configure for the PIN to connect; here I choose Virtual > V10 in return (0 ~ 1023).
    - LABELS: eg: Temp:/battery/degrees c.
    - REFRESH INTERVAL: Click Push to select the temperature sensor reading speed (sec).
- Figure 6.3.4: Water parameter setting same to temperature setting in figure 6.3.3 with Virtual > V9 in return (0 ~ 1000)
- Figure 6.3.5: Water parameter setting
    - In GAUGE: Name the water scale (Water level).
    - INPUT: Configure the PIN to connect, here we choose Virtual > V8 in return (0 ~ 100).
    - FLIP AXIS: off
    - SHOW VALUE: on if you want to show the value
    - READING RATE: Click Push to select the ultrasonic sensor reading speed (sec).

Figure 6.3.6

Figure 6.3.7

Figure 6.3.8

Figure 6.3.9

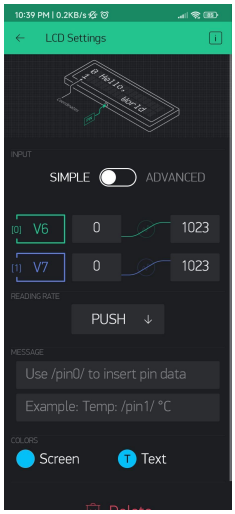


Figure 6.3.10

- Figure 6.3.6: Height of fish tank setting
  - In GAUGE: Name the height of the fish tank (Water level).
  - INPUT: Configure the PIN to connect, here we choose Virtual > V14 in return (0 ~ 1000).
  - SUFFIX (OPTIONAL):
  - STEP: choose the number of each step, here we choose one step
  - LOOP VALUES: Off if you don't want values run around
- Figure 6.3.7: Max of water level setting same as the height of the fish tank setting in figure 6.3.6 with Virtual > V16 in return (0 ~ 1000)
- Figure 6.3.8: Min of water level setting same as the height of the fish tank setting in figure 6.3.6 with Virtual > V15 in return (0 ~ 1000)
- Figure 6.3.9: Setup temperature setting same as the height of the fish tank parameter setting in figure 6.3.6 with Virtual > V13 in return (0 ~ 1000)
- Figure 6.3.10: LCD setting
  - In GAUGE: Name the LCD (LCD).
  - INPUT: Choose SIMPLE for simple setting, and configure for the PIN to connect, here, I choose Virtual_0 > V6 in return (0 ~ 1023) and Virtual_1 > V7 in return (0 ~ 1023).
  - READING RATE: Click Push to select the LCD reading speed (sec).
  - MESSAGE: Example: (Temp: /pin1/F)

Figure 6.3.11

Figure 6.3.12

Figure 6.3.13

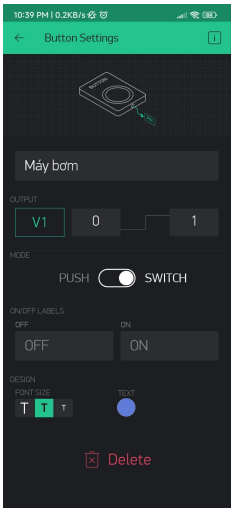


Figure 6.3.14

Figure 6.3.15

- Figure 6.3.11: Relay for heater setting
  - In GAUGE: Name the relay for the heater (Heater).
  - OUTPUT: Configure for the PIN to control, here, we choose Virtual > V4 in return (0 - 1).
  - MODE: Choose a type of button to control, here we choose SWITCH
  - ON/OFF LABELS: name the button (ON/OFF)
- Figure 6.3.12: Relay for water filter setting same to relay for heater setting in figure 6.3.11 with Virtual > V3 in return (0 - 1)
- Figure 6.3.13: Relay for oxygen pump setting same to relay for heater setting in figure 6.3.11 with Virtual > V2 in return (0 - 1)
- Figure 6.3.14: Relay for water pump setting same to relay for heater setting in figure 6.3.11 with Virtual > V1 in return (0 - 1)
- Figure 6.3.15: Step motor setting
  - In GAUGE: Name the Step motor (Feeding).
  - OUTPUT: Configure for the PIN to control, here we choose Virtual > V11 in return (0 - 1).
  - MODE: Choose a type of button to control, here we choose PUSH
  - ON/OFF LABELS: name the button (ON/OFF)

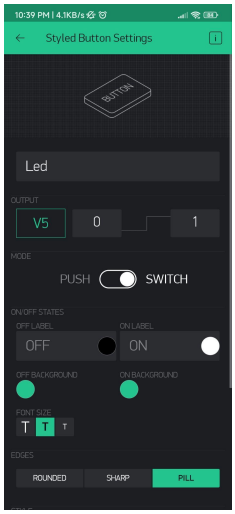


Figure 6.3.16

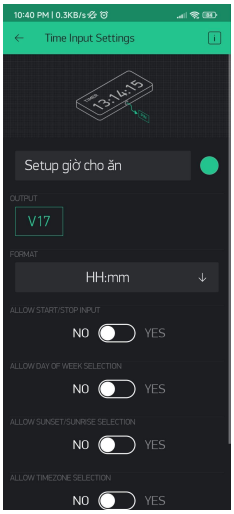


Figure 6.3.17

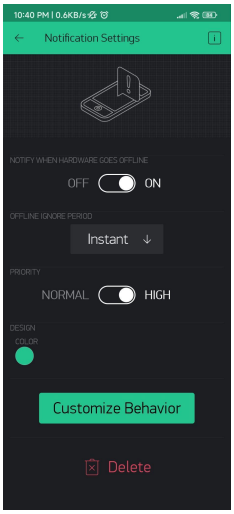
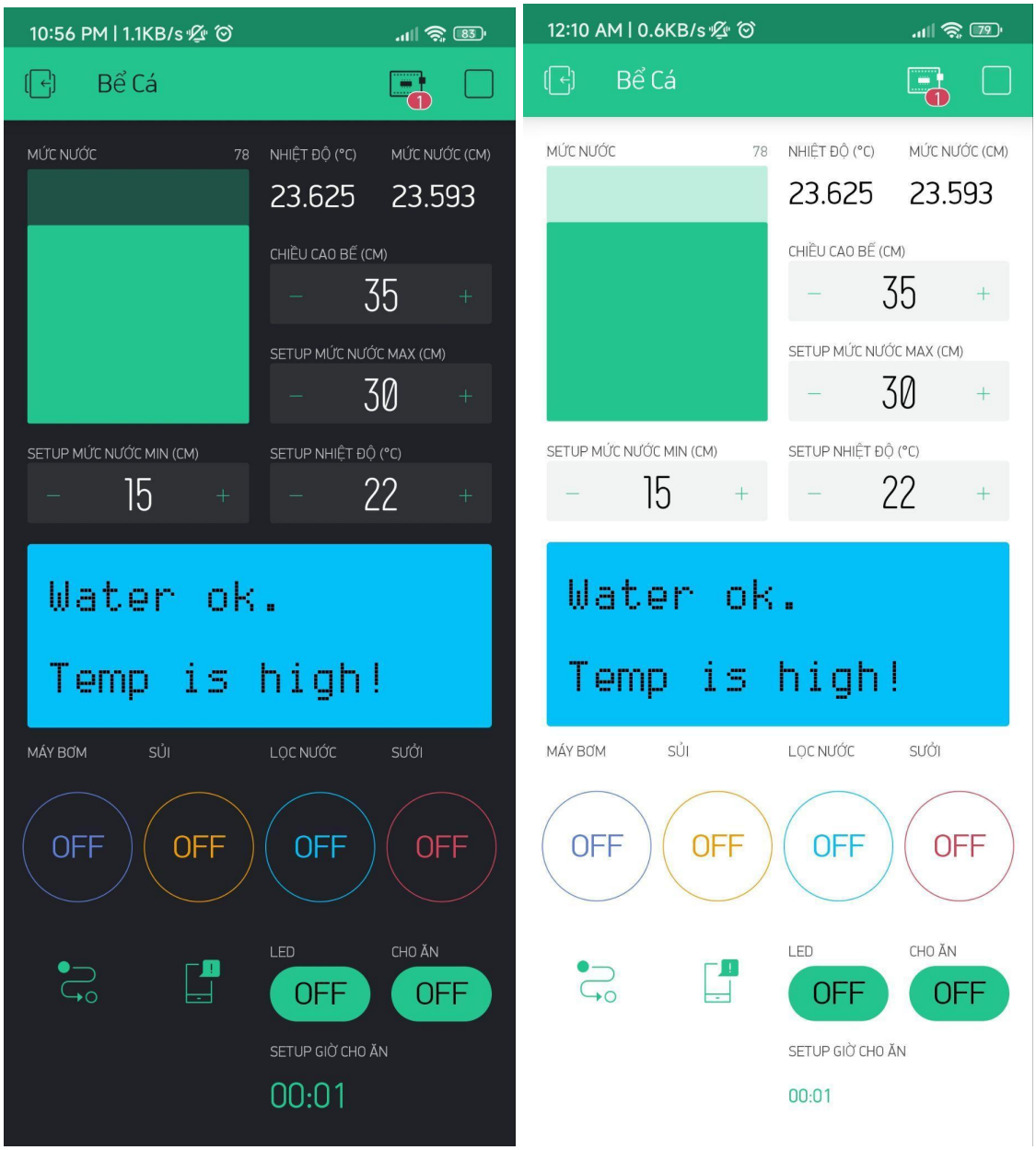


Figure 6.3.18

- Figure 6.3.16: LED setting same to relay for led setting in figure 6.3.11 with Virtual > V5 in return (0 - 1)
- Figure 6.3.17: Fish feeding timer setting
    - In GAUGE: Name the Fish feeding timer (Fish feeding time).
    - OUTPUT: Configure for the PIN to control, here I choose Virtual > V17
    - FORMAT: Choose a type of time display, here choose HH:mm
    - ALLOW START/STOP INPUT: No
    - ALLOW DAY OF WEEK SELECTION: No
    - ALLOW SUNSET/SUNRISE SELECTION: No
    - ALLOW TIMEZONE SELECTION: No
- Figure 6.3.18: Notification setting
    - NOTIFY WHEN HARDWARE GOES OFFLINE: On
    - OFFLINE IGNORED PERIOD: Instant
    - PRIORITY: High

7. Results and Discussion

Results displayed on App Blynk



Based on that, users can easily monitor the water level and temperature in the tank. Manually turning on or off the oxygen pump, water pump, water filter, heater, lighting system, and feeding system can also keep the fish fed when the users are not at home.

8. Conclusion and development direction

Applying modern technology in keeping a small aquarium tank allows people to control environmental factors that directly affect the condition of the fish and the water. The demands have fulfilled the results of the research. The software program is easily changed to match all sizes of tanks and some kinds of fish, such as betta fish, goldfish and their variants, angel fish, and other popular pet fish.

The development direction of the project is to integrate more sensors such as pH value detection sensor and water turbidity sensor. Combine multiple fish tanks into one device to control, making the aquarium fully automated and making the users more convenient.

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Task Name	Priority	Owner	Start date	End date	Status	Issues
Idea	High	All	31/01/2023	07/02/2023	Finished	Too many ideas
Making slide show	Low	All			Finished	None
Find documents	High	Nguyễn Trường Hưng	10/02/2023	16/03/2023	Finished	None
Buying material	Medium	All	……	……	Finished	Some of the components need to be more suitable for the project.
Test each material	High	All		……	Finished	Broke three neon ring leds
Storing material	Medium	Nguyễn Minh Đức, Đào Bá Hội			Finished	None
Building Model frame	Medium	Nguyễn Quang Huy, Đào Bá Hội, Nguyễn Minh Đức	……	……	Finished	None
Wiring connection test	Medium	Nguyễn Minh Đức, Nguyễn	……	……	Finished	None

		Quang Huy				
Wiring connection (on the machine)	High	All	……	……	Finished	It took much time and consumed a lot of hot stick glue.
Replace broken components / not suitable.	Low	Nguyễn Quang Huy	07/03/2023	07/03/2023	Finished	Three relays, 1 12V - 5A power supply needs to be replaced.
Coding	High	Nguyễn Minh Đức, Nguyễn Quang Huy			Finished	None
Create Google sheet	High	All			In Progress	None
Writing report	Medium	Nguyễn Trường Hưng	07/03/2023	Just now	Finished	None
Writing appendix	Low	Nguyễn Trường Hưng	……	……	Finished	None
Future works	High	All	Now	Future	In Progress	Making better and developing more options for users.