Auto-Aquarium

ECE 445 Project Proposal

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1. Introduction

1.1 Problem

Owning an aquarium requires a lot of maintenance, especially for users that own tropical fish that require a very specific range of variables like water temperature or pH levels to survive. This requires the aquarium owner to constantly purchase testing kits and devices in order to monitor the quality of the aquarium water. Oftentimes, aquariums are put in hard to reach places within rooms, making it difficult to manually test the quality of the tank water.

1.2 Solution

Our product solution allows an automated experience in monitoring temperature, pH, and water quality (through conductivity). Our product is a modular, small, and easy to install design that doesn't intrude on the aesthetic of the aquarium. Our solution consists of a set of sensors that relays the current temperature, pH, and conductivity of the aquarium water to a mobile app via WiFi. This app will show the user the current data, along with acceptable ranges for certain species of fish. In addition, an LED will be attached to the device that will light up when any of the monitored variables is larger than the acceptable range.

1.3 Physical Design

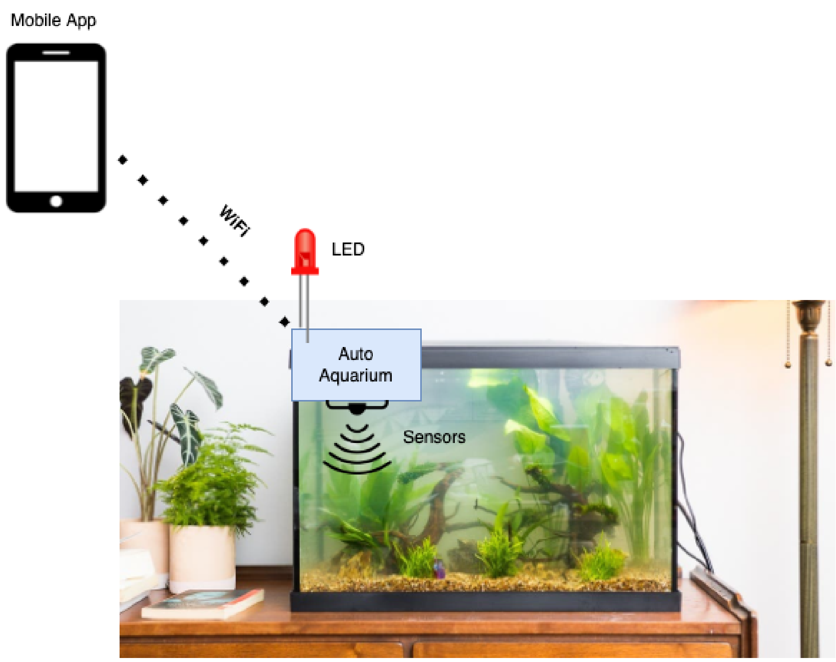

Figure 1: Overview of the Auto Aquarium components

1.4 Objective and Background

Goals and Benefits:

- Create a cost effective add-on to any aquarium that helps automate mundane maintenance tasks
- Alerts owner real time of any potentially hazardous living conditions in the aquarium via app and LEDs
- Combines monitoring of multiple variables (temperature, pH, conductivity) into one small product so it can sit in the corner of aquarium and not be aesthetically intrusive
- App allows user to set tolerance levels for each of the variables, and show the range of acceptable values for each variable based on the profile that the user sets

1.5 High Level Requirements:

- Device must be able to detect all of the aforementioned variables using sensors (temperature, pH, conductivity) and display this data, along with the acceptable range of values with a tolerance of +-2
    - Temperature: 75 F to 80 F
    - pH: 7-8
    - Conductivity: 20-30 μs
- Device must be able to alert the user within 30 seconds of dangerous conditions. This will be done by notifying the user via the app, along with lighting the LEDs when any of the variables is larger than the acceptable range stated above.
- Device must be modular and portable, no larger than 20 inches on any side with a tolerance of 3 inches.

2. Design

2.1 Block Diagram

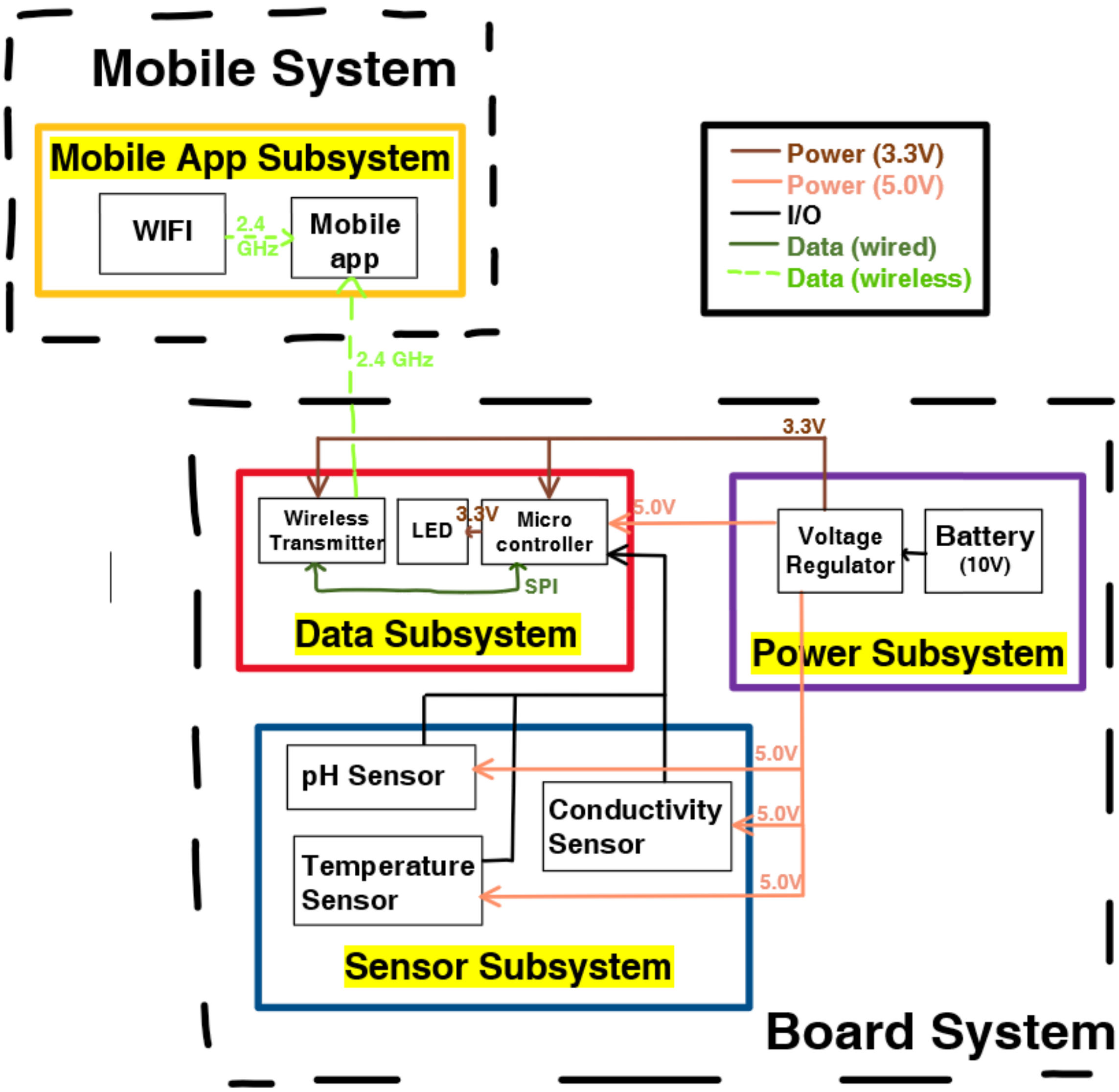

Figure 2: Block diagram of each subsystem and their components

2.2 Block Descriptions - Functionality and Requirements of each component

2.2.1 Sensor Subsystem:

- Sensor unit receives and manages the information from each of the sensors (temperature, pH, and conductivity). This subsystem communicates with the transmitter module and receives power for each of the sensors from the power subsystem.
    - **Temperature:** The High Temp Waterproof DS18B20 Digital temperature sensor will relay current temperature levels to be transmitted and displayed on the app.
    - **pH:** The SEN0161 pH sensor will relay current pH levels of the aquarium water to be transmitted and displayed on the app. Typically, the acceptable pH ranges for tropical fish is between 6.8 and 7.8.
    - **Conductivity:** The TDS water conductivity sensor measures the quality of the water based on the total dissolved solids (TDS) dissolved in one liter of the water. Pure distilled water is a poorer conductor of electricity than water with dissolved minerals [2].

  Requirements:
    - The sensors must constantly and accurately take measurements at an acceptable rate

2.2.2 Power Subsystem

- The power subsystem will provide power via a 10V battery to the sensor and data subsystem. This 10V will enter a voltage regulator to provide both 5V and 3.3V power to the two subsystems. The sensors and microcontroller will receive 5V power, while the wireless transmitter will receive 3.3V power.

  Requirements:
    - The power subsystem must be able to convert the 10V battery to 3.3V and 5.5V power
    - The subsystem must also simultaneously power the other subsystems in a parallel manner

2.2.3 Data Subsystem

- The data subsystem will be responsible for managing the constant stream of data from the sensor subsystem and sending it via the wireless transmitter to the mobile app. *Requirement:* The data subsystem must send data about each of the sensor values, at a rate of at most 30 seconds per cycle.
  - **Microcontroller:** The microcontroller receives 5V power from the power subsystem, and receives data from the sensor subsystem. It is responsible for communication via SPI (Serial Peripheral Interface) to the wireless transmitter.
  - **Wireless Transmitter:** The wireless transmitter receives 3.3V power from the power subsystem, and receives processed data from the microcontroller. It then sends this information in an HTTP request via WiFi to the connected mobile app on a 2.4 GHz channel.

2.2.4 Mobile Subsystem

- The mobile subsystem consists of a mobile app that connects to the product via WiFi. In the app, the various data (temperature, pH, and conductivity) are reported. The data is fetched and updated every 30 seconds, and the app displays this information, along with the acceptable ranges based on the profile that the user selects. When a variable is larger than the accepted range, the mobile app will send a notification to alert the user. *Requirement*: the mobile app must update the displayed information immediately after it receives it from the wireless transmitter.
  - **User Profiles:** The user can specify a profile, and for each profile can set the custom ranges for each variable (i.e. pH from 6.8 to 7.8). *Requirement*: the user must be able to set custom values for pH, temperature, and conductivity, independently.

2.3 Tolerance Analysis

The sensor subsystem poses the greatest risk to a successful completion of the project, due to sensor failure. According to the datasheet for the SEN0161, in 25 Celsius pure water, the pH electrode probe will only last 6 months of continuous testing [1]. After that, inaccuracies in the amount of millivolts detected by the electrode probe may occur, which in turn would inaccurately report pH data.

VOLTAGE (mV)	pH value	VOLTAGE (mV)	pH value
414.12	0.00	-414.12	14.00
354.96	1.00	-354.96	13.00
295.80	2.00	-295.80	12.00
236.64	3.00	-236.64	11.00
177.48	4.00	-177.48	10.00
118.32	5.00	-118.32	9.00
59.16	6.00	-59.16	8.00
0.00	7.00	0.00	7.00

Figure 3: SEN0161 datasheet voltage measured vs. pH

Given that the acceptable pH range of tropical fish is between 6.8 and 7.8, we can extrapolate this data from the sensor datasheet to calculate the range of acceptable voltage. Based on the above data in Figure 3 [1], we can create a linear relationship between voltage measured by the electron probe and pH value to be:

$$V = -59.16pH + 414.12$$

Thus, the acceptable voltage for 6.8-7.8 pH is from 11.832mV to 47.328mV, or a range of 35.496mV. With an inaccuracy of mV which would occur due to the lifespan of the electron probe, it is easy for our device to inaccurately report pH levels.

3. Ethics and Safety

This project will follow proper ethical and safety protocol by creating a device that will prove to be non-toxic and harmless to both humans and animals. Section I.1 of the IEEE Code of Ethics [3] states for us “to hold paramount the safety, health, and welfare of the public” (IEEE p.1 I.1). This means that in our practices, we must uphold the necessary requirements to create a safe product for anyone to use. Since our device will be suspended in water, it should not leak any material into the water that could be harmful to the fish inside. All circuitry components should be airtight to ensure no water damage can occur to the device. No wire should be exposed underwater to ensure that a current cannot enter the aquarium. In the event where a component malfunctions, the sensors are not able to change any values, such as temperature, pH level, and conductivity, in the aquarium itself. If someone were to misuse the product, they would only be able to damage the sensors or circuitry of our device. This will not be able to affect the water and will not harm any of the fish inside.

To ensure proper safety when creating our device, we must follow the proper guidelines for electrical, mechachinal, and lab safety. We should never work alone in the lab, bring food or drinks, and should always clean up after ourselves and clear our lab stations. We must report any broken equipment and properly dispose of any materials not needed. When building our device, potential hazards and things that we must be careful of are glass, soldering equipment, electrical components, and batteries. Once the device is complete the user will only need to make sure that no components are broken when placing the device into their aquarium. If something were to be broken, the possible dangers are exposed electrical wires, broken glass, or sharp plastic.

Citations and References

[1] DFRobot, “SEN0161 SEN0169 DFRobot Datasheet”, SEN0161 datasheet, 2017. https://www.application-datasheet.com/pdf/dfrobot/sen0161.pdf (accessed Feb. 9, 2022).

[2] T. Scherer and M. Meehan, “Using Electrical Conductivity and Total Dissolved Solids Meters to Field Test Water Quality”, North Dakota State University, July 2019, [Online]. https://www.ag.ndsu.edu/publications/environment-natural-resources/using-electrical-conductivity-and-total-dissolved-solids-meters-to-field-test-water-quality. (accessed Feb. 10, 2022).

[3] IEEE. “IEEE Code of Ethics.” IEEE Code of Policies, Section 7 - Professional Activities (Part A - IEEE Policies). June 2020. https://www.ieee.org/about/corporate/governance/p7-8.html. (accessed Feb. 10, 2022).

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