ECOR4907

Capstone Project

Portable Water Quality Testing System

Project Proposal

Prepared for

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January 26, 2024

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1 Introduction

We are Ahmad and Abdal, 4th year undergraduate Software Engineering students. The purpose of this document is to propose the project we wish to develop and work on throughout the Capstone Project. As well as capture all the fine-grained details of how this project will be carried out. The project we are proposing is an intelligent and portable water testing system.

1.1 Background

We go about our everyday life without giving much thought to the quality of water we consume on a daily basis. Especially that we need to intake about 3.7 Litres of water per day [1] to maintain healthy body functions, therefore we must pay close attention to the quality of the water we consume.

Currently, the most widely used technique of determining the quality of the water is by using Test Strips. Which are rectangular pieces of paper that are saturated with a chemical agent, once these paper strips are submerged in a water sample, the chemical agent will react with the water and change colour. Then this colour will indicate the test result, which then the user will need to match the colour produced by the paper strip to a result chart with all the possible colours that can be produced by the test strip and what they indicate. This method of testing the water quality is not accurate and cannot provide exact quantitated results.

1.2 Motivation

Therefore, a better solution is needed to replace the paper strips test most commonly used today. With a portable water testing system, you would be able to determine the quality of the water available to you in a pinch. This is essential as there is no other way of finding out whether the water is acidic or if it contains small particles of contaminants, and as such you wouldn’t be able to judge if it is safe or healthy for consumption.

There is a wide range of applications for such a system and it can be useful to everyone on a daily basis. However, it can be more beneficial to users such as mothers with newborn babies, teachers, and parents in general. This system would confirm the quality of the water prior to consumption.

For the parents, it would put their mind at ease after being aware of the water quality their children will consume, especially when travelling or visiting a new city for the first time where they aren’t sure of how that specific municipality treats their water.

For the teachers, for example if they are accompanying children on a field trip, it would be immensely helpful to be able to check the water quality before everyone consumes it. Moreover, if the water happens to be acidic or contains contaminants, it will not provide the necessary hydration at the least, and worst-case scenario it would cause everyone to get sick. Thus, a simple test prior to consumption would allow us to mitigate any risks of drinking water of unknown quality or content.

1.3 Project Objective

The objective of this project is to develop a portable and intelligent water quality testing system that will enable users to check the quality of the water on the go.

1.4 Specific Goals

More precisely, the system shall provide the user with insight about the water including its pH level, amount of Total Suspended Solids, Total Dissolved Solids, it's Electrical Conductivity or Mineral Content and Temperature. The following is a list of functional and non-functional requirement we are aiming to achieve by the end of this project:

Functional Requirements:

- The system shall be able to measure the pH level of the water.
- The system shall be able to measure the amount of Total Dissolved Solids (TDS) in the water.
- The system shall be able to measure the amount of Total Suspended Solids (TSS or Turbidity) in the water.
- The system shall be able to measure the Electrical Conductivity (EC) of the water.
- The system shall be able to measure the Temperature of the water.
- The system shall be able to run remotely using a rechargeable battery.
- The system shall have a graphical user interface.

Non-Functional Requirements:

- The system shall be able to infer a useful observation(s) about the water quality using the sensor measurements.
- The system's user interface shall have a simple and an advanced mode of operation.
- The simple operation mode shall be tailored to a user with no prior expertise in water quality nor the measurements produced by the sensors.

- The advanced mode of operation shall be tailored to a user with previous expertise in water quality and/or the specific measurements collected.
- The user interface shall be easy to use and intuitive.

2 Engineering Design

2.1 Project Management

Although the project is currently in an early stage, we greatly benefited from creating a Gantt Chart in order to schedule and organize the execution of the project tasks in the upcoming months. We will continue to use and update the Gantt Chart as the project progresses in order to carry out the project objectives effectively and efficiently.

Additionally, we will be using YouTrack in order to track our progress and identify any issues that must be resolved in order to continue making progress. This will also enable effective and informed collaboration between us.

The use of GitHub issue tracking will be considered as well. Although using both YouTrack and GitHub issue tracking will be redundant and unnecessary. Thus, a choice shall be made between YouTrack and GitHub issue tracking.

2.2 Justification of Suitability for Degree Program

We are both Software Engineering students with a parallel experience in software development, however, each person has a unique interest and background experience.

Ahmad has taken special interest in Linux Operating System and hardware components. He has always been keen to take on personal projects that utilize the Raspberry Pi microprocessor, such as a smart mirror and automatic door lock and opener.

Abdal’s interest is purely vested in software development. More precisely in user interface design and development. Additionally, he has taken on multiple personal projects in the past involving website design and development, and he has an extensive experience in working with distributed database systems.

Collectively, we believe that we have developed the suitable skills and experience throughout our degree program, and by taking on personal projects in the past.

2.3 Individual Contributions

2.3.1 Report Contributions

Ahmad Alkawasmeh	Abdal Alkawasmeh
Chapter 1, Chapter 3, Chapter 4, Appendences	Chapter 2, Chapter 5, Chapter 6

Table 1: Breakdown of Report Contributions of Each Member

3 Work Plan

3.1 The Project Team

We are both Software Engineering students with a main knowledge base consisting of Object-Oriented Programming. However, we've also had some exposure to working with hardware in the past, more specifically the Raspberry Pi, where we have worked on personal projects including a smart mirror and garage door opener. This makes us a strong fit for this project as we possess the necessary experience and knowledge to complete this project.

3.1.1 Roles and Tasks

The table below reflects the specific tasks that are assigned to each member, which is based on interest and prior experience of a member with that specific task.

Ahmad	Abdal
Developing the main software functionalities	Developing the main software functionalities
Unit Testing	Integration Testing
Interfacing the EC and pH sensors with the Raspberry Pi	Interfacing the TDS and TSS sensors with the Raspberry Pi
Designing the housing for the system using 3D design software	Developing the GUI
Interfacing the screen and buttons with the Raspberry Pi and GUI	Test fitting all the components into the designed housing

Table 2: Assigned Tasks to Each Member

3.1.2 Teamwork Strategy

The way we will ensure the work is done effectively and efficiently as a team I going to be mostly through GitHub version control and weekly team meetings. The team communication will be ongoing and constant throughout the project. Moreover, since we are siblings and we live together, we are in contact every day and will keep each other informed of what we are currently working on. This is to ensure we are working towards our goals effectively and efficiently.

We will also be using Jet Brains Labs YouTrack to keep track of all ongoing activities and tasks being worked on.

3.1.3 What we will need to learn

Although we are familiar with GitHub version control, we need to learn more about GitHub Issue Tracking. This tool is going to be immensely useful to ensure that issues or incompatibilities, with each of our code parts, are kept track of and solved efficiently.

We will also have to revisit 3D design software as our experience with working with the software PTC Creo was in our first year of university and we need a refresher on how to use it.

3.2 Project Milestones

The table below reflects the major milestone deadlines and the dates on which they are to be handed in.

Milestone	Date
Project Proposal	January 26, 2024
Progress Report	February 16, 2024
SW/HW Request Form	February 14, 2024
Oral Presentation	March 22, 2024
Video and Poster	June 14, 2024
Final Report	July 31 to August 10, 2024

Table 3: Major Milestones and Associated Due Dates

3.3 Schedule of Activities

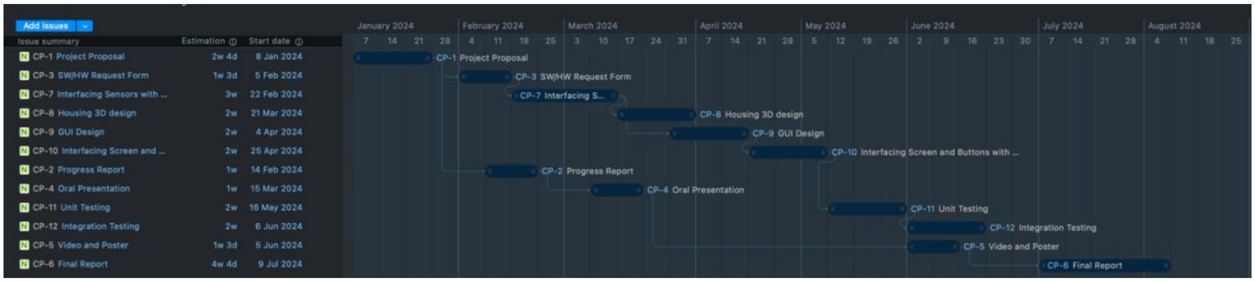

Figure 1: Gantt Chart Outlining Schedule of Project Tasks Execution

4 Project Risks and Mitigation Strategies

The risks associated with this project, although are minimal, they still exist and must be addressed appropriately with a mitigation strategy to avoid any bodily harm to the user.

4.1 Electrical Shock

Due to the utilization of electronics and electrical components in this project, there is a risk of electrical shock to the end user if the device is misused. In order to mitigate this risk. The electrical connections and electronic components will be placed in a compartment that is inaccessible to the user. Moreover, the user will not be able to make contact with the wiring and electrical components of the system, thus mitigating the risk of an electrical shock.

4.2 Fire and Burns

One of the system components will be a rechargeable battery pack, which will be used to supply power to the system and allow it to be mobile. The battery pack type is Lithium-Ion, which remains in a stable state so long the battery casing is intact. If the casing becomes punctured or compromised at any time, the battery may catch on fire [2]. This would be catastrophic as it can cause burns to the user. The strategy to mitigate this risk is to apply metallic plates to the battery pack. This will reinforce the battery casing and would make it much harder to penetrate the original thin plastic casing of the battery.

5 Hardware Required

5.1 List of Required Hardware

The following table captures the details of the hardware needs for our project.

Part	Description	Link	Quantity	Price in CAD (tax inclusive)
Microprocessor	Raspberry Pi 4 8GB	Link	1	(Available at Carleton)
Microcontroller	Texas Instruments EK-TM4C123GXL ARM Development Board	Link	1	$37
Power Supply	PiJuice Hat	Link	1	$118
ADC Converter	Analog to Digital Converter IC MCP 3008	Link	3	$16 ($5.30 per 1 count)
pH Sensor	Gravity Analog pH Sensor Kit	Link	1	$61
Turbidity Sensor	Gravity Analog Turbidity Sensor	Link	1	$15
TDS Sensors	Gravity Analog TDS Sensor	Link	1	$18
EC Sensor	Gravity Analog EC Sensor	Link	1	$107
Temperature Sensor	Gravity Digital Temperature Sensor	Link	1	$12
Potentiometer	Gravity Analog Potentiometer	Link	1	$5
Breadboard	DfRobot Solderless Breadboard	Link	1	$5
Jumper Wires	Male to Male Jumper Wires	Link	1 pack (includes 20 pieces)	$4
Jumper Wires	Female to Male Jumper Wires	Link	1 pack	$4

			(includes 20 pieces)	
Display	5" Touch Display	Link	1	$65

Table 4: Required Components, Website Links, and Price List

5.2 Trade-off Analysis

5.2.1 Microprocessor

There was a choice that needed to be made between the Raspberry Pi microprocessor and Arduino Due microcontroller [3]. Given our extensive experience with the Raspberry Pi, we decided to go with it instead of the Arduino Due.

The main differences between them is their ability to process digital and analog signals. Where the Arduino Due has the ability to process both digital and analog signals, the Raspberry Pi is only able to process digital signals.

Given the majority of the sensors we are aiming to utilize produce analog signal output, we needed to address the downfall of the Raspberry Pi. This will be achieved using the MCP 3008 Analog to Digital Converter.

5.2.2 Microcontroller

The use of a custom, dedicated microcontroller for our system will always be superior to using an off the shelf microprocessor like the Raspberry Pi. We are planning on developing a preliminary prototype with the Raspberry Pi as a proof of concept. Then if time permits, we will develop a dedicated microcontroller firmware for our system using the Texas Instruments EK-TM4C123GXL ARM Development Board. This board is more power efficient, costs a quarter of a Raspberry Pi, and will have a much smaller footprint in comparison to the Raspberry Pi. We have consulted with a graduated colleague, with a vast experience in electronics and embedded systems, about the board choice. He recommended this specific development board due to its form factor and sufficient power capability for our system.

5.2.3 Power Supply

In case of the power supply, the choice was between a power bank that is intended for use with mobile devices or a PiJuice Hat that is specifically intended for use with the Raspberry Pi. The PiJuice Hat has a much smaller footprint and integrates smoothly with the Raspberry Pi, when compared to a power bank that has a larger footprint and has to be plugged in manually every time you need to power the Raspberry Pi. Due to the downfalls of a power bank, the choice was made in favour of the PiJuice Hat.

5.2.4 Analog to Digital Converter

The choice for an Analog to Digital Converter was between the MCP3008 and ADS1x15 [4]. The MCP3008 is capable of 8 channels of input simultaneously where the ADS1x15 is only capable of 4. Also, the MCP3008 cost is one third of the ADS1x15. The better capabilities of the MCP3008 combined with its superior value, has led us to make a choice in favour of the MCP3008.

5.2.5 Sensors

The two makers of sensors we considered are Grove [5] and DfRobot [6]. Both manufacturers' sensors are capable of the same measurements' accuracies. However, Grove priced their sensors much higher than DfRobot and they had less support available for their sensors.

The fact that DfRobot's sensors were of better value combined with the availability of sufficient support and documentation, has led us to make a choice in favour of DfRobot's sensors.

5.2.6 Potentiometer, Bread Board, and Jumper Wires

The purpose of these components will only be for rapid prototyping and testing the system. After which, they will become obsolete as we plan to move on from messy wiring and circuitry to a sleeker solution consisting of a printed circuit board. Thus, the only factor that played a role in choosing these components is price. There is no reason for choosing a higher priced jumper wire, for example, if they both capable of making the required connection.

5.2.7 Display

In case of the display choice, it was the most challenging as it required planning for a much more advanced stage of our project. There was three main factors to consider, connectivity, display size, and price.

In case of the connectivity, the choice was between a display that connected through the GPIO, HDMI connector, or the Display Serial Interface. We are unable to use the GPIO option as we will need to use the GPIO for our sensors connectivity. The HDMI connector is a good option but it will still require the use of GPIO pins for touch input. This leaves us with the DSI which is capable of handling the video stream output to the display and touch input simultaneously.

Once the connectivity method was decided upon, now a suitable size needed to be picked. We wanted to pick a size that is large enough for the user to comfortable interact with the user interface, and simultaneously keeping the device form factor as small as possible. There was two size options we arrived at, 5 and 7 inches displays. The 7 inch display would be too large and nearly the size of an iPad display, thus a more suitable size would be the 5 inch display.

With the connectivity and size options decided, there is one more variable left that plays a role in choosing a display. That is the price. At this point, there is no reason for choosing a more expensive display if it achieves the same functionality as the less expensive option and reflects our needs. The choice was made in favour of the Waveform 5 inch DSI Touch Display. Since it satisfied our needs and it had great reviews, it was the best valued option for our application.

6 References

Your background and motivation sections will be more convincing if you refer to the literature (stats, articles, etc.) I suggest you use a citation manager, such as Mendeley. Otherwise, you will have to format your citations by hand. You can use any citation style (e.g., IEEE, Vancouver, Chicago); just be consistent. You can also copy pre-formatted citations directly from Google Scholar results.

[1] "Water: How much should you drink every day?," Mayo Clinic, Oct. 12, 2022. https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/water/art-20044256#:~:text=So%20how%20much%20fluid%20does,fluids%20a%20day%20for%20women

[2] "Lithium-ion-batteries | DFES." https://www.dfes.wa.gov.au/hazard-information/fire-in-the-home/lithium-ion batteries#:~:text=There%20are%20several%20situations%20that,piercing%2C%20and%2For%20vibrations)

[3] "Arduino due," Arduino Official Store. https://store.arduino.cc/products/arduino-due

[4] A. Industries, "ADS1115 16-Bit ADC - 4 Channel with Programmable Gain Amplifier." https://www.adafruit.com/product/1085

[5] "Grove - Seeed Studio." https://www.seeedstudio.com/category/Grove-c-1003.html

[6] dfrobot.com, "Buy Sensors Gravity - DFRobot," dfrobot.com. https://www.dfrobot.com/topic-282-36.html

Appendix A: Microprocessor Datasheet

Raspberry Pi 4 Model B Datasheet

Appendix B: Microcontroller Datasheet

TM4C123G LaunchPad Evaluation Board Datasheet

Appendix C: Battery Pack Datasheet

PiJuice Hat Datasheet

Appendix D: ADC Datasheet

MCP3008 Analog to Digital Signal Converter Datasheet

Appendix E: pH Sensor Datasheet

Gravity Analog pH Sensor Kit Datasheet

Appendix F: Turbidity Sensor Datasheet

Gravity Analog Turbidity Sensor Datasheet

Appendix G: TDS Sensor Datasheet

Gravity Analog TDS Sensor Datasheet

Appendix H: EC Sensor Datasheet

Gravity Analog EC Sensor Datasheet

Appendix I: Display Datasheet

Waveshare 5” DSI Touch Display Datasheet