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Wine Sampler

A Senior Project Report

presented to

the Faculty of California Polytechnic State University

San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science in Computer Engineering

By

Lance Litten

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Abstract

Quality testing is an important part of the wine industry. Without proper quality control, thousands of dollars could be wasted on bottling and recalling hundreds of gallons of wine. Due to this, labs are set up that collect wine samples from the tanks in a wine production plant and test them. A big part of this testing is determining exactly what tanks need to be tested and what tanks are at risk. My project aims to help automate this task by collecting data from the tanks wirelessly and keeping track of simple indicators such as pH and temperature. Automating this process will result in less time being spent on climbing up ladders and retrieving samples daily from tanks that do not need it thereby saving the industry time and money.

Introduction

Client:

The client for this project is the lab manager at Constellation Brands in Madera, CA. Constellation Brands started in 1945 as an upstate New York wine producer and have since expanded to include many consumer packaged goods. They own many iconic brands including Kim Krawford and Ruffino Wine.

Stakeholders:

The stakeholders in this project are the lab employees at the Constellation Brands lab, and the company as a whole and their investors.

Framed Insights:

During my meetings with the lab manager, I was told about the problem they had with keeping track of how much wine was in each tank. I asked questions about what sort of accessibility the tank had and if it had access to wifi. The lab manager told me that there were many tanks outside, most of which were not in range of wifi access, but employees passed them on their way to collect samples. I asked if an employee could use a company tablet or phone to connect to a device that keeps track of the amount of wine in the tank and then upload it to some kind of server when they got back into range of wifi. The lab manager said that would work. I then asked if other sensors inside the tank like a way to collect data on temperature and pH would be valuable. She indicated that they would. We talked about how often they would need to clean the device and she said it could not be more than 2-4 times a year. I also asked her whether or not I could float the probe in the tank. She said that it could, but it could not affect the wine, so it must be a food safe container. In a later meeting, we decided it would be best if the probe were placed on top of the tank rather than floating in the wine itself. Then the issue of keeping power to the probe came up. Originally I assumed a powerful enough battery could power the probe for a period of 3-4 months, but I quickly realized that even a fairly large battery would only power the device for 2-3 days so I asked if solar panels could be attached to the tank because they were outside; the lab manager said that was not a problem. The first pH meter I bought was broken so I mentioned this to my client and they suggested that I could use a conductivity probe as well because they had an equation that they used to calculate pH from conductivity.

Project Goals and Objectives:

My objective is to create a system that can both send and receive data to or from a phone, calculate the volume of the tank through means of some peripheral, read the temperature of the wine in the tank through a temperature probe, and get the pH of a tank through the use of a pH probe or connectivity probe. The phone should then have an app that stores measurements to an excel file that can be uploaded to a file server, google docs, or a lab computer.

Project Deliverables:

For this project, I am producing a physical probe that determines the volume of the tank and an app for an android phone that will help me transmit the data.

Project Outcomes:

If this project were to exist, less time would be needed to get this information on a daily basis to determine which wine tanks are at risk for contamination and therefore need further testing or which wine tanks can be cleaned and refilled after being emptied without having to look inside each tank. This project could also be used in other applications such as monitoring a fish tank to ensure the fish have enough water and that their tank is at an appropriate pH and temperature. It could also be used to monitor the status of a public pool to determine whether or not the heater should be turned on or if chlorine needs to be added. Another good example of a use for this probe is the olive oil industry as they check the level of their tank on a daily basis through visual checks on a marked glass level meter.

Background

Research on Electrical Component Container:

In order to fully implement this product, I wanted to make sure that if I decided to float my probe in the wine I had a compatible, food-safe container. Wine is typically acidic which can interact with materials and leave toxins in the wine. To prevent this and keep in line with US standards, I settled on a plastic container. Research shows that if plastic comes into contact with wine for a long period of time, plasticizers containing BPA (which has been linked to a growing list of human health problems) might leach into the wine causing contamination which affects flavor and possibly health. (Plank, p.7) So, I had the plastic container placed outside of the product to prevent health hazards.

Research on Volume Detecting Probe:

There are other solutions available for detecting volume on the market but they are fairly expensive such as the BinMaster Acoustic Level and Volume Sensor.
(BinMaster 3DLevelScanner - Acoustic level and volume sensor by BinMaster | DirectIndustry, 2020)
But this solution is expensive and it is unnecessarily complex for what we need it for. It uses acoustic technology to generate a 3d surface which allows them to to map a more solid substance like grain or sand.

MDPI published a paper where the authors created a non-invasive system that calculated the relationship between sound resonance frequencies and the content of a tank; they then connected these tanks through wifi and sent the data to a computer. They discovered that the more a tank fills the easier it is to detect a change. (Garcia, p. 2)
Their system overview formed the basis for my design.Their architecture is non-intrusive allowing measurements from outside of the tank making it ideal for my application, with a few changes as requested by the client like finding a more cost effective alternative to resonance measuring.

Formal Project Definition

Customer Requirements:

- Require maintenance no more than 4 times a year
- Supply its own power or be easily rechargeable
- Determine the volume of the tank as accurately as the volume equation based on height currently used
- Able to determine pH
- Able to determine temperature in fahrenheit
- Able to connect wirelessly to a device for data collection
- Able to be scaled

Engineering Requirements:

Spec. Number	Parameter Description	Requirement	Tolerance	Risk
1	Data Storage	16GB	Min	L
2	Power	5V,0.5A,2.5W	+/- .2W	L
3	Time to Collect and Transfer Data	2 min	MAX	L
4	pH	accurate	+/-.5 pH	L

Customer Personas:

Our customers will most likely be wine lab employees whose job it is to collect samples and info off the wine. They will be able to pull out their phone, connect to the devices wifi and press a button to get all the desired information, then they will be able to upload it when they reach their own wifi that's connected to the internet.

Use Case:

Wine Tank Probe: This product is meant to be used as a wine tank probe, it will collect the pH, temperature, and volume data from the tank. Then, it will create an excel file and send it to the users phone.

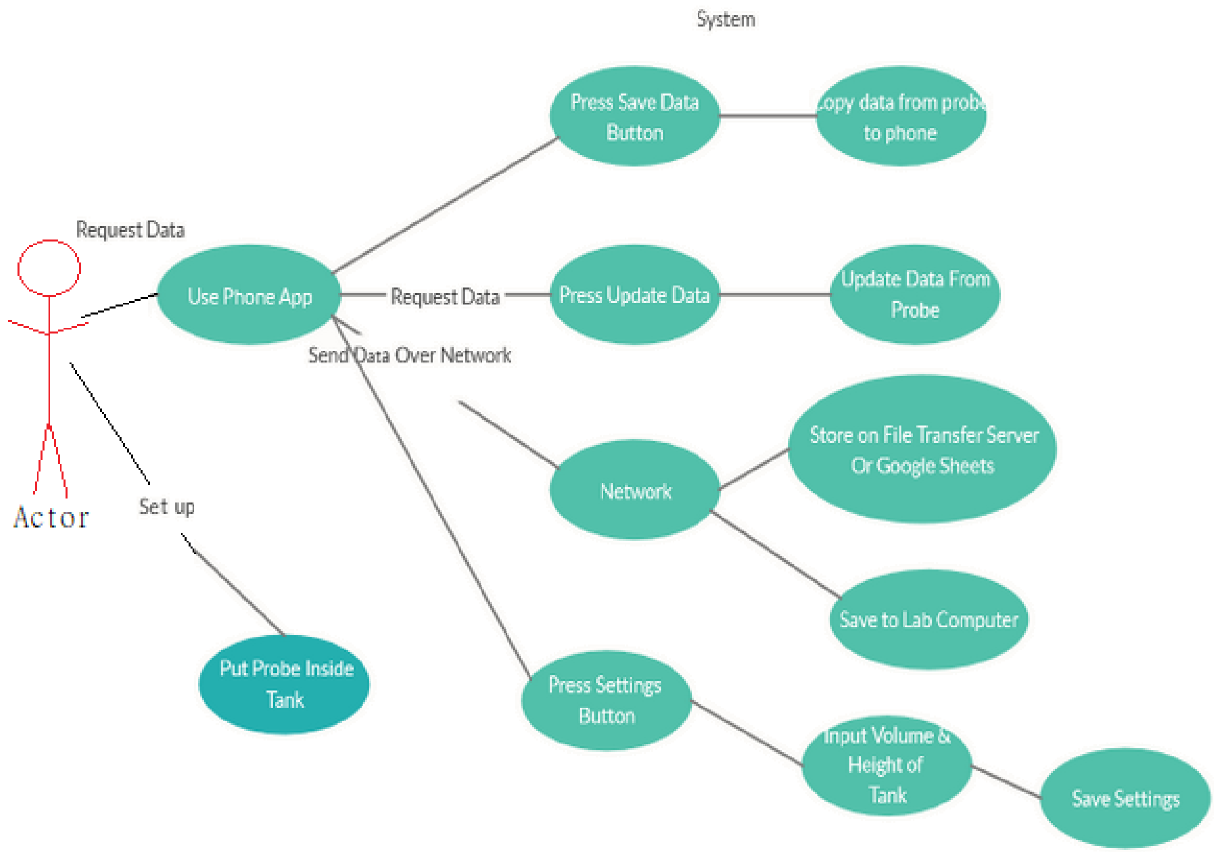


Fig. 1
Use case diagram of the intended customer.

Design

System Design Overview:

The system uses microprocessors and sensors to collect the pH, temperature and distance from the top of the tank to the wine. It takes the volume and height of the tank (provided by the user and saved in a file) and uses that to calculate the current volume of wine in the tank. It will then create a comma separated value(.CSV) file which can be opened in excel as a spreadsheet. The system uses an ad-hoc network to transfer the data to the phone. We use IDs to identify multiple tanks so that the solution is scalable.

Hardware:

The hardware I used for this project includes the following:

- 1x Raspberry Pi Zero W
- 1x Arduino Uno
- 1x Dongker FBM0-AAQ-13688 pH meter
- 1x Gikfun DS18B20 Temperature Sensor
- 1x Smraza Ultasonic HC-SR04 Distance sensor
- 1x 7352597 Solar Module

This project needed the raspberry pi in order to handle the wireless protocols in order to transfer the data to the phone. The Arduino Uno is needed because the Raspberry Pi has no analog to digital converter so we use the Arduino to handle all of the peripherals. I use WiFi for the data transfer as bluetooth does not have a long enough range for some tanks.

Software:

For the project to function I created software to allow the different processors to talk to one another. The Raspberry Pi and Arduino connect to each other via UART. The phone and the Raspberry Pi share an smb directory that allows them to share the data file and a .cfg file that stores the max height and volume of a tank along with a tank ID. The Raspberry Pi gets data from the Arduino, stores it in a CSV file, and uses the data stored in the cfg file to calculate the volume of wine in the tank. It does this by getting a ratio of the height of the wine currently in the tank to the max height of the tank. This is done every time a user connected to the adhoc WiFi network provided by the Raspberry Pi presses an “update data” button on the app.When a user wants to save the data from the pi to the phone they press the Download CSV file button.

System Level Schematic:

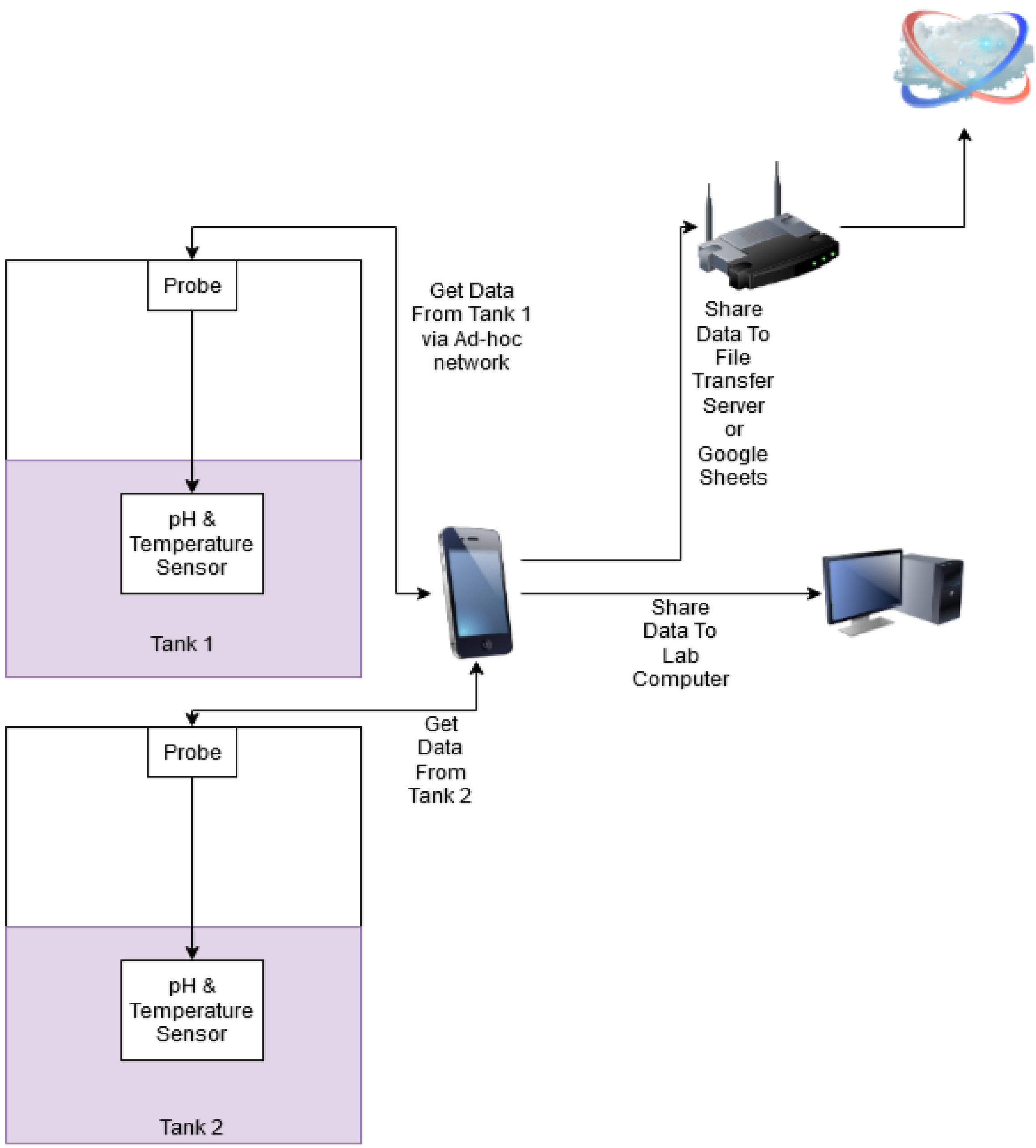


Fig. 2
A System Overview Diagram
(Image created with draw.io. Clipart courtesy of draw.io) (Open Diagram, 2020)

Hardware Block Diagram:

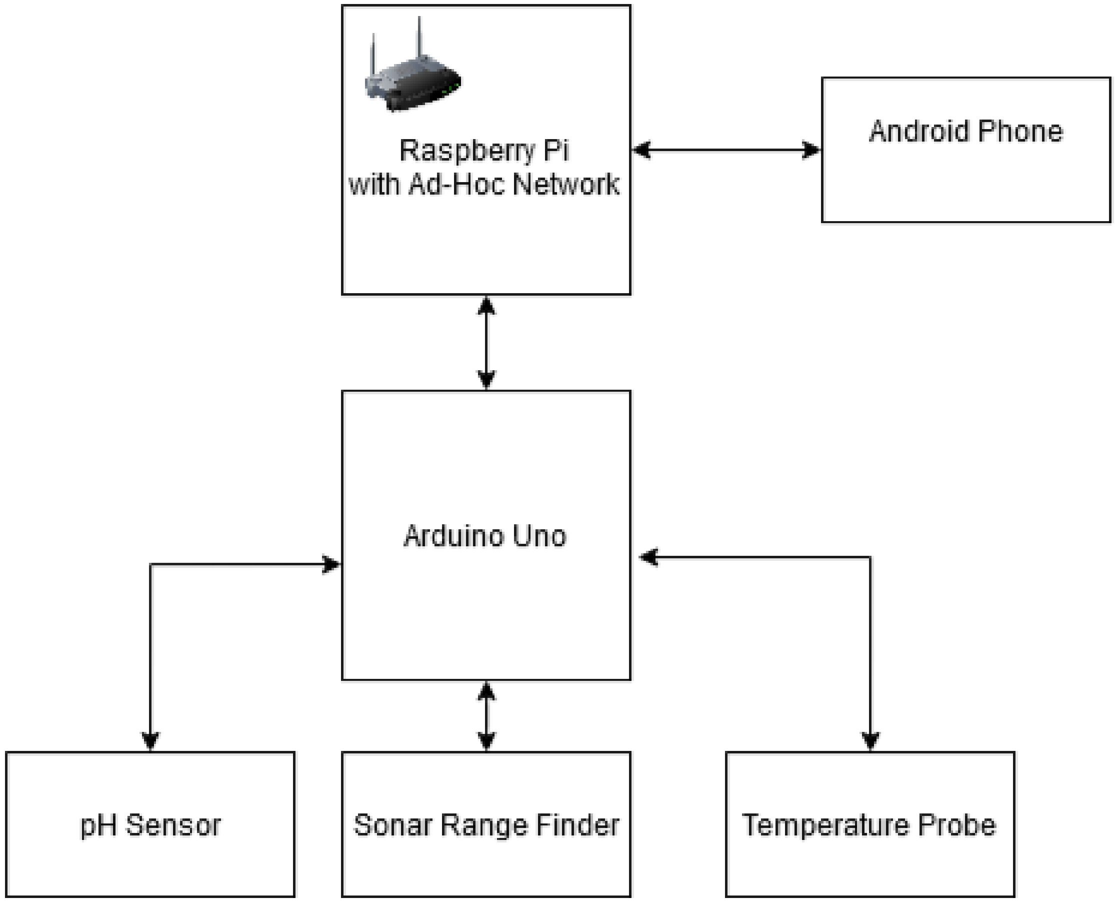


Fig. 3
Hardware communication diagram.
(Image created with draw.io. Clipart courtesy of draw.io) (Open Diagram, 2020)

Software Design FlowChart:

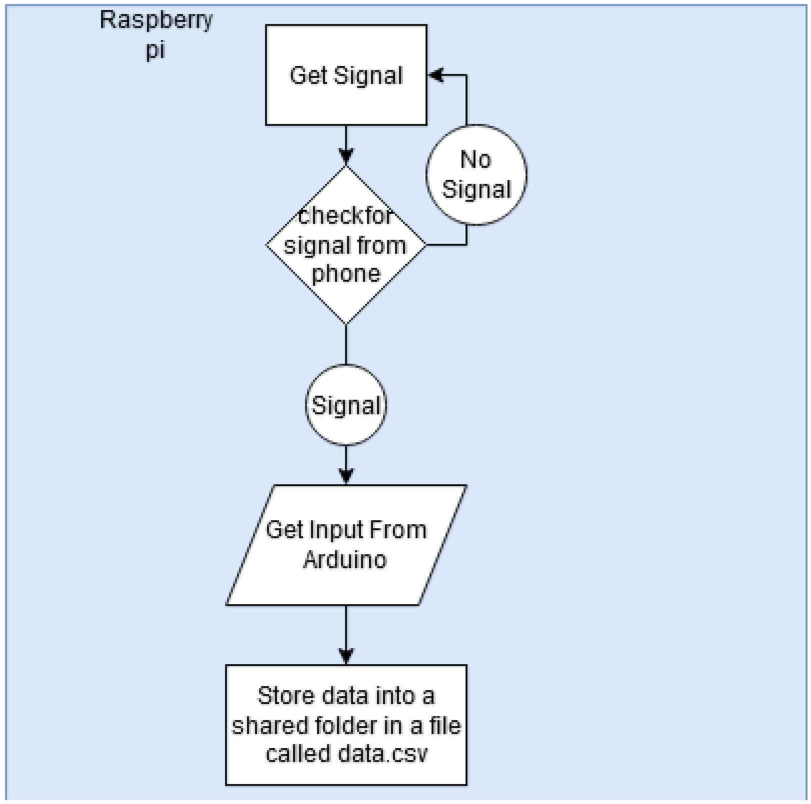


Fig. 4
Flow chart of the Raspberry Pi's software.
(Image created with draw.io.) (Open Diagram, 2020)

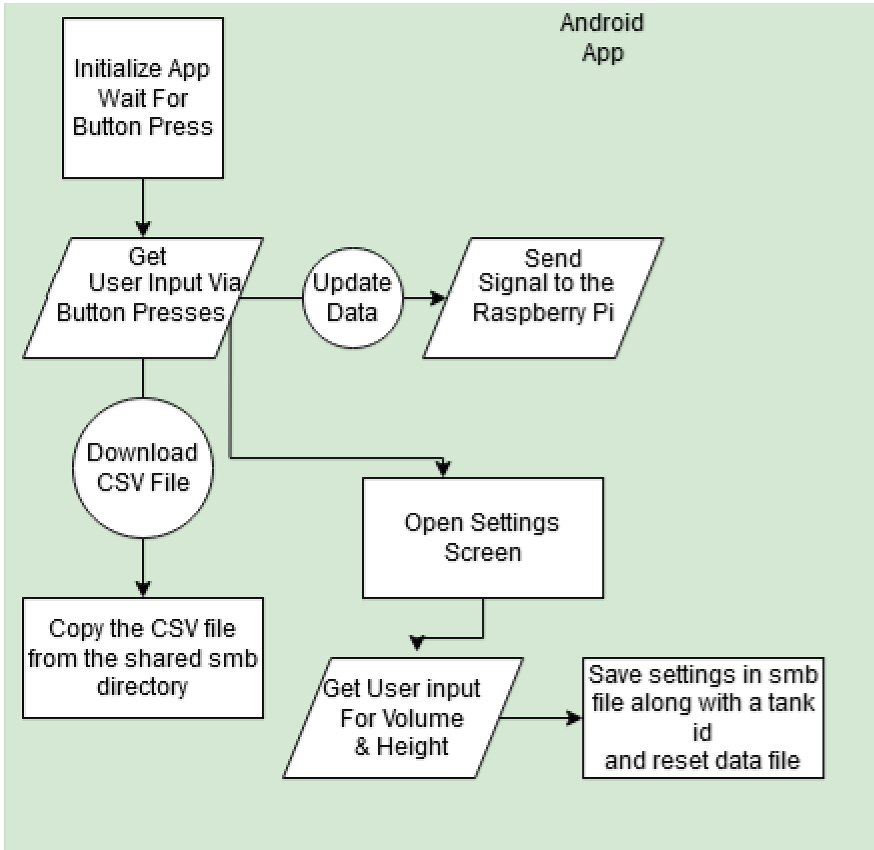


Fig. 5
Flow chart of the Android app’s software.
(Image created with draw.io.) (Open Diagram, 2020)

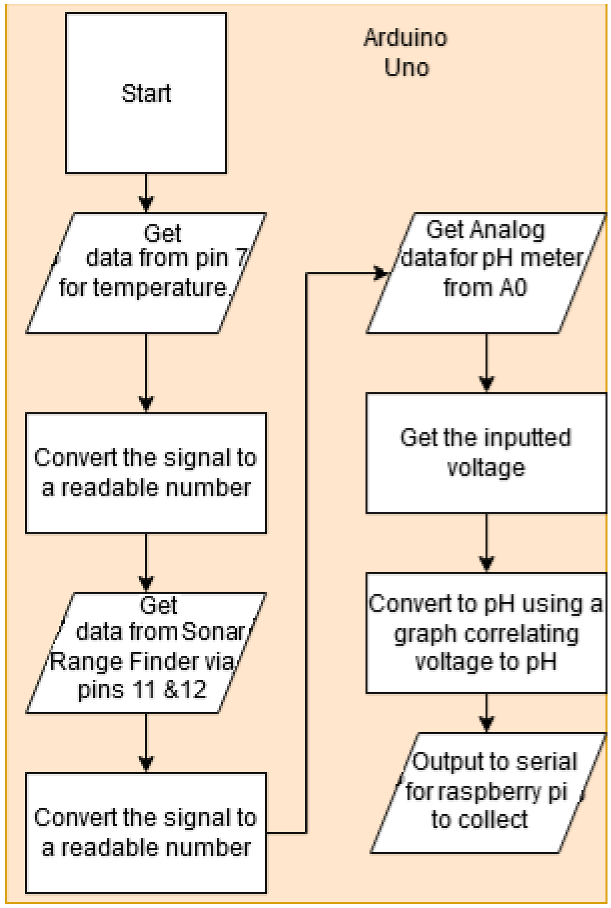


Fig. 6
Flowchart of the Arduino Uno's software.
(Image created with draw.io.) (Open Diagram, 2020)

System Testing and Analysis

Because of the scope of this system, I tested each microprocessor’s tasks individually.

pH Test:

To make sure my pH meter was giving me the correct value, I used pH strips to determine the pH of a solution of vinegar water. According to the ph strip, the vinegar had a pH of about 3, and the pH strip is accurate up to +/-0.5 pH.

I then used the pH meter to get the pH and the output was 2.98

Example output:
76.891,1,2.98

The result is as accurate as the pH strip and so it conforms to specification.

Temperature Test:

To test the temperature I compared its value to the values read by a digital thermometer. According to my digital thermometer it was 79 degrees fahrenheit and the probe registered 79.25 degrees.

Example output:
79.251,1,2.97

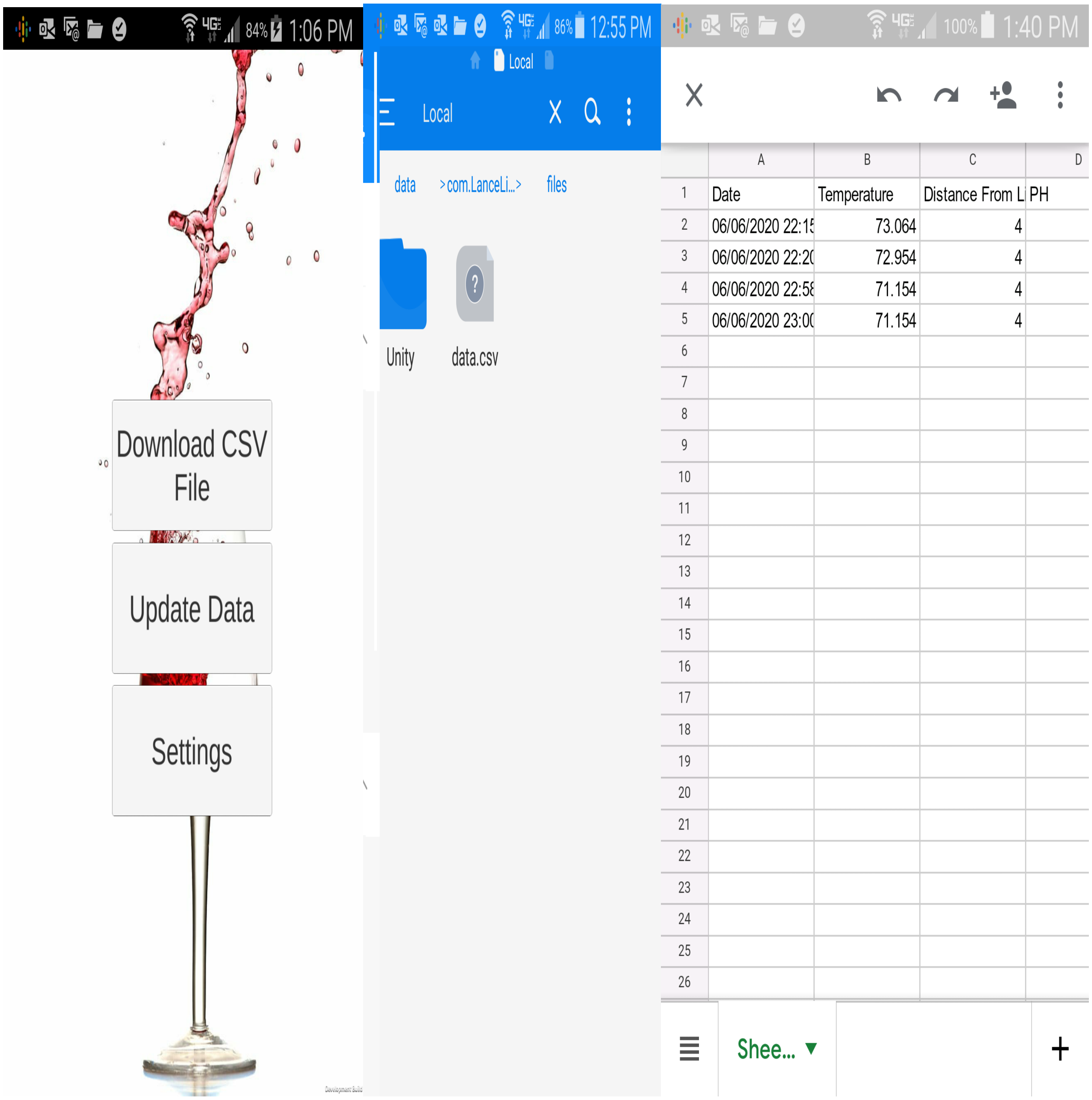
Depth Test:

To test the sonar range finder I changed the distance of a reference point along a measuring tape to see if it accurately gets the distance. It works and is accurate up to about 12 feet but it doesn’t give fractions of inches.

System Test:

To test the system in a representative environment I put the probe on a 2 gallon 9 inch tall bucket of water, filled up 4 inches from the top with a little over 1 gallon of water.

I use the phone app I created to update the data and save the CSV file. After that I check the CSV file and use visual inspection to make sure all the data is present and reasonable.



Date	Temperature	Distance From Liquid	pH	Volume
06/06/2020 22:15:51	73.064	4	7.36	1.111
06/07/2020 22:20:47	72.954	4	7.72	1.111
06/08/2020 22:58:46	71.154	4	7.77	1.111
06/09/2020 22:00:44	71.164	4	7.75	1.111

Conclusion and Future Work

In conclusion, I think that this project was a success, I managed to create a probe that could be part of a scalable solution to keep track of liquids inside tank farms. I created an app to help facilitate the process of using the probe to the customer. My solution was similar to the solutions that I found during my research but in the end it was cheaper because I had focused my probe to handle liquid solutions instead of potentially solid materials. I envision that this project could be expanded upon to receive more probes like an O2 probe and maybe even eventually be able to collect data on alcohol content. The lab manager reviewed my solution and said that it would be very helpful. She was concerned about extending the temperature probe and pH probe into deeper tanks, but I told her this could be solved by lengthening the wires, or using a second probe dedicated to the temperature and pH that floats in the wine if lengthening the wires is not a reasonable option.

Reflection

This project has allowed me to grow as an engineer. I worked with a member of another company in order to find a solution for a problem that they were experiencing. This allowed me to expand my skills in dealing with a customer and learning how to interact with and look out for solutions that the customer didn't even realize that were needed. There were many times throughout this project where I learned that the easiest way is not always the best way and that I should keep my eyes open for another solution that might present itself. This Project also helped me grow my experience with handling hardware and integrating it into custom applications. I learned that sometimes finding a solution is not as difficult as finding the *right* solution but it is always worth the extra effort. I feel glad to have been given this chance to solidify my skills as an engineer.

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Appendices

Bill of Materials

Item	Quantity	Price
Raspberry Pi Zero W	1	$29.99
Arduino Uno	1	$23.00
Dongker FBM0-AAQ-13688 pH meter	1	$38.99
Gikfun DS18B20 Temperature Sensor	1	$12.98
Smraza Ultasonic HC-SR04 Distance sensor	1	$9.59
ECO-Worthy SolarPanel	1	$42.99
Total		$157.54

Failure Mode Effects Analysis

Item: Wine Sampler
Model: Current
Core Team: Lance Litten
Responsibility: Lance Litten
Prepared by: Lance Litten

Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Process Controls	Detec	RPN	Recommended Action(s)	Responsibility and Target Completion Date
Data Update	Peripheral Failure	Loss of Data/ Erroron-eous Data	4		Sensor Failure	2	Rigorous Testing	1	8	Visually Inspect Data after update	
Data Retrieval	Wireless Communi-cation Malfunction	Loss of data	3		Software Failure/ Network Failure	1	Testing and using ad-hoc network Data Backups on raspberry pi	1	4	ensure the network is connected before attempting to recieve data	
Device Communication	Data Retrieval Failure	Loss of Data/ Erroron-eous Data	4		Software Failure	2	Rigorous Testing	3	30	Visually Inspect Data after update	