Senior Design 1 Initial Project Document

June 8th, 2018

Smart Garden Controller

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Sponsored by: self-sponsored

Group 12

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Project Narrative

Cultivating a garden is a common past time in the United States. Home gardening can be relaxing and provides fresh fruits and vegetables. Other benefits of gardening include immune regulation, brain health, dexterity, heart health, and mental health. With such benefits, at a low cost it is a surprise more people do not have a home garden. A couple of reasons gardening is avoided by some is the time it takes to learn how often to water the different variety of plants and the time it actually takes to water them manually. It may seem that an easy solution would be to water the garden as often as possible, however, different varieties of plants require different amounts of water. Overwatering can drown the plant so the roots need oxygen and not enough oxygen will be in the soil when there is too much water in it. To make matters more intricate, the amount of watering required may change depending on environmental factors such as temperature and air moisture levels. The soil may dry up faster if the air is dry and hot. Therefore, a smart garden controller would be a vital addition to the success of a personal garden.

The primary goal for the smart garden controller is to take away the manual labor involved in watering plants and automate the watering maintenance. The smart garden controller will allow the gardener to set a schedule for each zone of the garden independent of one another. The watering will be triggered and the soil irrigated until a threshold is met. Irrigation will stop once the threshold is met. The gardener will be able to control how often to trigger the irrigation as well as for how long to water the plants. Soil moisture sensors will send data back to the system and automatically determine whether watering based on the user schedule is necessary. Based on the metrics for the garden, the user will be able to adjust how often the different zones get watered while taking into account environmental factors such as rainfall and temperature.

The watering needs will not always be the same since the outside conditions will changes throughout the year. Depending on location, there may be times throughout the year when irrigation will not be necessary and water from the rain alone will be enough. The user will be able to set thresholds in the system and decide what to do if such thresholds are met. Using thresholds, irrigation may be skipped when the soil is already wet enough due to natural resources. Using such setting will allow for the system to save water and money to the garden owner. The efficiency and potential cost savings associated with the elimination of unnecessary watering, as well as the likelihood of a higher crop yield are just two of the main business cases for this device.

Another goal of the smart garden controller is to shorten the research time a user would spend in determining how often to water a plant. For example, strawberries may require more water than tomatoes. A set of schedules would be provided which the user could pick from for a variety of fruits and vegetables. The different schedules would be available to the end user via a web application. Through the web application the user should be able to edit the smart garden controller's schedule and settings. The end user would simply choose the schedule based on what is being planted and let the smart garden take care of the irrigation. Additional schedules would be provided by a community of users and the number of schedules would grow over time. The user would not be limited to the watering schedules provided out of box and would be able to modify the schedules to meet its needs. Community input will be very important. Instead of trial and error the user could look up in the community resource for other people planting in similar location and weather. The long-term theory is that users would be able to upload their own schedules and profiles for different garden items, and the collective community would be able to rate and offer feedback, ultimately garnering an environment where the most successful profiles become easily evident. This increases the ease of use for the consumer to have a successful personal garden that does not require much maintenance.

The smart garden controller will also collect metrics throughout the day such as moisture, temperature, and light level data. The data will be available through the web application where it may be viewed or exported for download. There will be no personable identifiable information on the server or health related data, therefore, data will not need to be protected according to HIPAA (Health Insurance Portability and Accountability Act) standards. Nonetheless, the remote server will have basic authentication enabled to protect user data. The metrics will be available for review via a web application where they may also be downloaded. Review of the data will be useful in determining how long the watering system should be kept on for each zone. For example, review of the data could point that at w temperature it takes x minutes for the soil to dry. Based on the metrics collected, it could be determined instead that the watering valve should be on for y minutes when the temperature is at z. These metrics will eventually be available to the entire user community so that the learned metrics of one can benefit many. The hope is that eventually there will be a user feedback system where users are able to grow their crop during each season according to certain profiles and at the end of the season the user can upload feedback about crop yield or issues that occurred throughout the season. This feedback paired with the weather metrics collected could help improve the profiles performance once the data is analyzed.

The smart garden controller will be light weight and relatively portable, although it is mainly intended for stationary operation. The smart garden controller will be easy to use and configured via a web interface. The smart garden controller will also be configurable via a display and physical buttons on the device. The smart garden controller will be able to control multiple sprinklers and therefore allow for the garden to grow in size over time. Finally, the smart garden controller will be affordable. Similar system can range from cheap with basic features (4 zone watering system scheduler, no metrics, hoses, sprinklers, connectivity) to expensive with more features (Professionally installed sprinkler system that does not include soil and weather feedback). The smart garden controller should provide more then basic feature and allow for proper watering while at a lower price tag than the high-end sprinkler systems currently available.

Requirements Specifications – Absolute Requirements

- Controls at *Minimum* two zones
    - The system will regulate watering service of at least 2 plots of soil. Each plot will be independent of the others, meaning any number of plots can be watered at a time.
- Has low power consumption
    - 'Low' as used here to mean compared to other high functionality water regulation technology such as sprinkler systems. Typical standby power consumption of smart watering systems is from 3W to 6W.
- Is simple to setup
    - Users should not have to perform extensive setup tasks when installing the system, meaning they must only connect a water and power sources, connect the included sensors, start the system, and confirm operation.
- Low setup time
    - The tasks detailed above but be able to be completed in a time frame comparable to other small water regulation systems. This timeframe would include any wireless connectivity that would need to take place
- Should weigh less than five pounds, be lightweight
    - 'Lightweight' as used here to mean compared to other high functionality water regulation technology such as sprinkler systems. The system should be easily transportable by a single capable adult.
- Is Compact, smaller than 6x6x6 inches
    - The system, including sensors, control board, and independent power supply (if included) should be able to be transported at least short distances by a single capable adult.
- Has a web application interface
    - This interface must *at least* be compatible with standard desktop browsers, ideally compatible with mobile devices as well. This interface must *at least* allow the user to set a weekly watering schedule for their garden.
- Employs a display for user interface and configuration on the physical unit
    - This display interface must *at least* allow users to manually water any plot at any time, and ideally will provide all the functionality included in the web application interface.
- Collects soil moisture data
    - The system must *at least* collect data for each plot including but not limited to the last time & date that it was watered, the next scheduled time & date for it to be watered (if any), and the most recent moisture information from the soil sensors.
- Collect temperature data
    - This may require addition sensors, I recommend we save this for additions in case we are asked to add more.

- Uploads sensor metrics to web application
    - See above for soil moisture data
- Web application should have basic security
    - To login to web application a username and password will be required
    - Logged in users should only see information regarding their system
- Skips watering if soil moisture level meets threshold
- Is Water resistant
    - Meaning that under *very mild* wet weather conditions the system operates as normal.
- Connects to web application via Wi-Fi using the IEEE 802.11 standard
- Has a rechargeable battery
- Reports battery status to the user
    - Battery status will *at least* be displayed on the physical interface, and ideally displayed on the web application interface
- Maintains normal operations on battery power for at least 24 hours
- Automatically irrigates specific zones based on user settings and sensor inputs
    - Meaning the system will override the watering schedule set by the user, *if and only if* the system detects soil conditions that the user has set to indicate that immediate watering is necessary.
- Employs date and time scheduling function in which the user can schedule future actions/modes
    - The user, through use of the web interface or physical interface, will be able to set a weekly schedule for any number of plots, determining which days and times of the week those plots will be watered, and *possibly* how much water will be used each time.

Requirements Specifications – Stretch Goals

- Employs Amazon Alexa Interface
    - The user will be able to set up an at home Alexa device to interface with the smart garden, and be able to update settings and utilize basic controls through voice commands to Alexa.
- Uses a Predictive Weather based watering algorithm
    - The unit will retrieve weather forecast data from the internet and use that data to predict the appropriate watering scheme based on the user's soil moisture requirements.
- Shade Provisioning Device
    - The unit will employ an automatically deployed shading device that will help limit the amount of sunlight that a certain zone receives based on collected ambient light data.

- User Grow Profiles
    - The unit will interact with a user based community and be able to upload custom user profiles for specific types of plants and growing conditions, where the community can rate and modify the profiles to their needs and download them for use in their own system.

House of Quality

The House of Quality is a key component in any project that compares both the Engineering and End-User requirements. It also decides what pros and cons each aspect of the design has in relation to one another in order to evaluate for needed adjustments that may result in the future. This assists in understanding what exactly the projects main advantages and weakness may be and what to look at changing without disrupting other requirements. Below is the tradeoff matrix for Smart Garden Controller and how the different requirements correlate.

			Engineering Requirements							
			Sensor Precision	Efficency	Power Consumption	Weight	Dimensions	Cost	Set-up Time	Water Use
			+	+	-	-	-	-	-	-
End-User Requirements	Cost	-	↓↓	↓	↓	↓	↓		↓	↓↓
	# of zones (Total Area)	+			↓	↓	↓↓	↓	↓↓	↑↑
	Battery life	+	↓	↑	↑	↓	↑	↓	↑	
	Ease of use	+				↓	↑	↓	↑	
	Ease of installation	+	↓			↑	↑↑	↓	↑	
	Water use reduction	+		↑↑		↓		↓↓		↑↑
	Data analysis	+	↑↑		↓			↓		
	Web application	+			↓			↓	↓	
	User interface	+			↓	↓	↓	↓	↓	
	Goal for engineering requirements		< +/- 2% Error	>70%	>6Watts	>5 Pounds	>6"x6"x6"	<$350	>5Minutes	>5Gallons/Wk

Key	
+	Positive Polarity
-	Negative Polarity
↑	Positive Correlation
↓	Negative Correlation
↑↑	Strong Positive Correlation
↓↓	Strong Negative Correlation

Figure 1 - House of Quality Diagram

Block Diagrams

Hardware Block Diagram

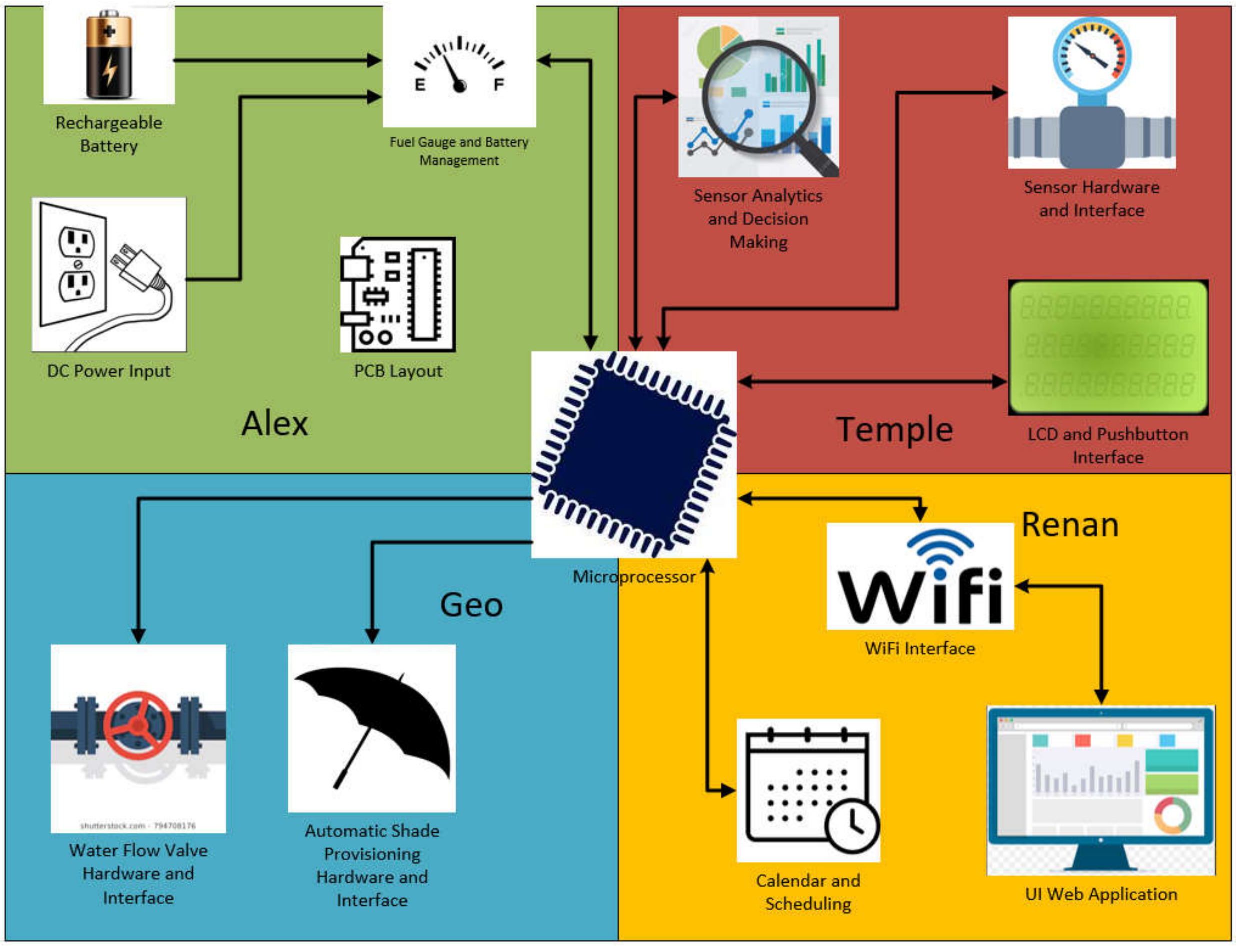

Figure 2 - High Level Block Diagram

Status of each block:

- Ongoing research for each block
- Wi-Fi/MCU unit sample requested for review. Other than the Wi-Fi/MCU module, no other parts were ordered at this point.
- All blocks are being designed
- No blocks are being prototyped
- No blocks are complete

Software Flow Diagram

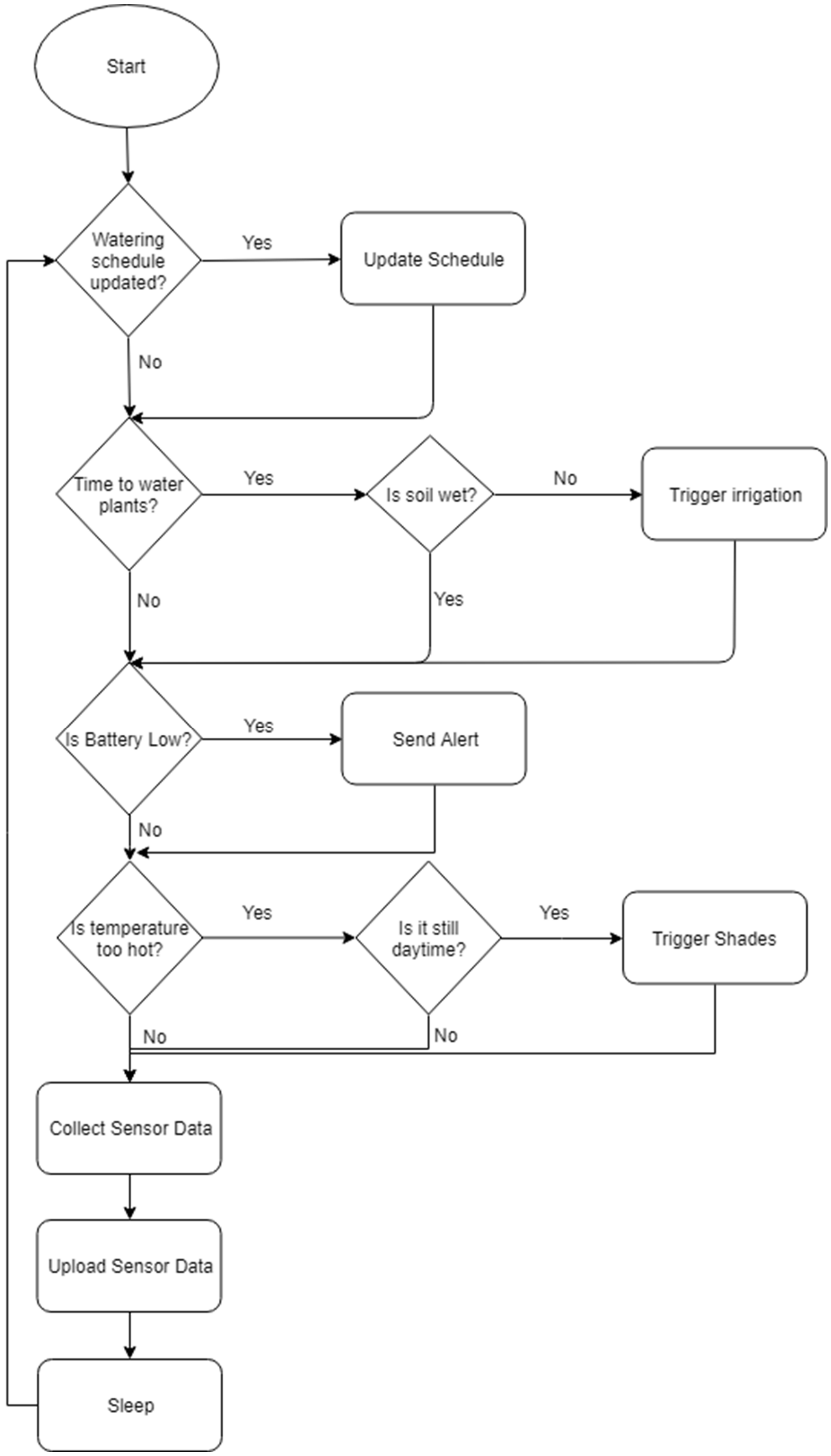

Figure 3 - Software Logic Flow Diagram

Budget and Financing

Currently, the project is self-sponsored. The students will pay for any and all expenses. The following budget is not final as the components have not been decided upon at this moment. As research continues, components may be removed or added to the project due to requirements, constraints, and budged limitations. The following prices are based on online research for low quantities of components and no current production level costing effort has been performed. The budget and the prices of the components will be updated once decisions are finalized and there will be a continuing effort to reduce bill of materials costs. To take into account faulty parts and testing malfunctions or errors that result in damage to the parts, most parts will be ordered three times more than necessary. Therefore, the budget will have a column to display the value for a single final product and another column for the total cost of the project.

Description	Unit Cost	Project Parts Count	Project Cost Estimate	Final Product Parts Count	Final Product Cost
MCU/Wi-Fi Module	10	3	30	1	10
Sensors	5	9	45	2	10
Batteries	2	8	16		
Water Valves	7	4	24	2	14
PCB	30	3	90	1	30
Chassis (Custom Enclosure)	10	3	30	1	10
Power Source	10	2	20	1	10
Shading Component	N/A				
Miscellaneous (Cabling, small components for testing, breadboard, etc)			50		
Total Cost			$305		$74

Figure 4 - High Level Bill of Materials

Note: Some items do not need to be included in the final product which would go to an end user. For example, the end user could buy its own battery. Therefore, battery pricing would be empty for final product. Also, some components do not have a price set at the moment and are to be left empty.

Project Milestones

Hard course dates:

10 Page Initial Documentation due	8 June 2018
60 Page Draft Documentation due	6 July 2018
100 Page Draft Documentation due	20 July 2018
120 Page Final Documentation due	1 August 2018
Hardware purchased & tested	1 August 2018
Software Design Complete	15 August 2018
Schematic Completed	1 September 2018
Wi-Fi portion of Firmware Complete	15 September 2018
Layout Completed	1 October 2018
Calendar/Scheduling Firmware Completed	15 October 2018
PCB Printed & tested	1 November 2018
Web Application Code Completed	15 November 2018
Final Demonstration	10 December 2018

Soft group work dates:

Documentation milestones	1 week prior to hard date
Hardware purchased & tested	10 July 2018
PCB printed & tested	15 September 2018
Final Demonstration	15 November 2018

Research and Sources

Current Market Automated Watering Systems Research:

1. http://www.energy.ca.gov/appliances/irrigation/documents/2009-06-01_workshop/presentations/Brown_Rich_LBNL_Irrigation_Controls.pdf

Soil Moisture Monitoring for Water Conservation Research

1. http://www.mait.com.au/wp-content/uploads/CaseStudy-Smart-irrigation-Ispwich.pdf
2. http://gridalternatives.org/sites/default/files/International%20case%20study.pdf4

Wi-Fi and MCU and other PCB component investigation

1. www.ti.com
2. www.digikey.com
3. www.findchips.com

Sensor Research

1. https://www.sparkfun.com/products/13322
2. https://www.specmeters.com/weather-monitoring/
3. https://www.amazon.com/XCSOURCE-Moisture-Automatic-Watering-TE215/dp/B00ZR3B60I
4. https://www.rainbird.com/products/smrt-y-soil-moisture-sensor
5. https://www.whiteboxes.ch/shop/i2c-soil-moisture-sensor/?v=7516fd43adaa
6. https://www.dfrobot.com/wiki/index.php/Capacitive_Soil_Moisture_Sensor_SKU:SEN0193

Budget Research

1. www.google.com
2. www.digikey.com
3. www.findchips.com
4. www.ti.com
5. www.mouser.com
6. https://www.adafruit.com/product/997

Gardening Research

1. https://www.cropking.com/blog/light-greenhouse-how-much-enough
2. https://www.jainsusa.com/blog/6-signs-you-are-overwatering-your-plants
3. https://learn.eartheasy.com/articles/6-unexpected-health-benefits-of-gardening/