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SENIOR DESIGN I

Initial Project and Group Identification Document

Divide and Conquer

"Automated Rotating Solar Plant Rack with Self Irrigation System and Moisture Level Sensors"

Group 23:

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Section 1: Project Narrative

Horticulture has been at the root of our civilization since the early days of mankind. Since the beginning, plants have been a necessity from providing nutritional food that gives us energy, to being used as shelter to keep us safe and warm. As time has progressed, they have been used to create an agricultural economy, providing a source of income as well as food for those around the world. In more recent years, plants have been harvested to create medicine to extend the lives of those suffering as well as to create a more lively living space for those cooped up in a small apartment. Although the usage of plants has been evolving for centuries, the method for growing them has remained relatively constant.

It is well known that plants require water and sunlight. With that, they can produce the nutrients required to survive. However, these living organisms cannot move around on their own and therefore, must receive their supplements from an outside source. Generally, this outside source is a human. We must be the ones to assure the plant is getting an appropriate amount of sunlight and water. Plants require these resources pretty regularly which can be an issue for some growers. In everyday life, some have an extremely busy schedule where they may not wish to give too much attention to their plantlife, or may have to leave their home for an extended period of time. Doing so can result in the plant dying off due to malnutrition. This is a problem that has been recurring for a long time. Many people try to work around this issue by asking others to take care of their plants for them or hoping that they survive regardless, but it is a problem that has yet to be solved entirely.

This project aims to address the problem of leaving plants unattended for too long. It does so by creating a system that will monitor the conditions of the plant and assure that it is receiving the appropriate amounts of water and light. This will allow the plant to be left alone for periods of time and still receive the care that it requires.

This project will be designed using multiple sensors as inputs to monitor the current state of the plant. The device will monitor the moisture in the soil using a moisture sensor. If it determines that the plant is too dry, it will use an irrigation system to provide it with water. The device will also be equipped with temperature and light sensors that will monitor the sun explode for the day. If the plant has spent too much time in the sun, an umbrella-like structure will be used to provide shade. Finally, a rotational system will be added in order to rotate the plant as needed. Generally, any form of plant will grow towards the sun so it gets maximum exposure. However, this is not ideal for some as the plant may look lopsided. In order to prevent this from occurring, it will be placed on top of a rotational system. This will assure that the plant gets equal exposure on all sides and will grow straight up.

This device can be used in many ways. For example, having a device that will take care of plants will be incredibly beneficial to those with houseplants. When a family decides to go on vacation, their plants can suffer as there will be no one around to water them. An automated system can assure that the plant receives all of the care that it requires while the family is away. This system can also be beneficial to those with busy schedules. Having a device that will always remember to water your plants will take one thing off of the person's schedule.

Section 2: Requirements Specifications

There are several pieces of equipment that must be operational in order for the project to be deemed successful. Two different systems will be working in parallel in order to properly monitor the plant's wellbeing and deliver the nutrients that it requires. Both systems are fully independent of one another so if one were to have issues, the other will remain fully operational. The finer details of both systems will be discussed in detail in the sections to follow.

To start, the project will include an irrigation system. The purpose of this is to assure that the plant always has an appropriate amount of water. The system will use a sensor within the pot that will measure the amount of water within the soil. This requires the use of a moisture sensor. This sensor will be placed on the side of the pot and will sample the amount of water every so often. The data will then be sent to the central CPU where it will be processed and an appropriate response will be executed. If the soil has enough moisture, nothing will occur. However, if the CPU determines that the plant is a little too dry, it will send a request to the irrigation system to water the plant.

In order for the device to successfully provide water to the plant, an irrigation system must be in place. This will be a mechanical device that is able to water the plant after receiving a signal from the central CPU. The irrigation system will include a bottle that stores water as well as pipes that connect it to the pot. A timer will be utilized to control how long the plant is watered. After the timer has run out, the moisture levels will be reassessed to determine whether the task has been successfully fulfilled. If not, the irrigation system will be reengaged. The cycle will continue until the moisture within the plant is at an ideal level.

The second system within this project controls the amount of sun exposure the plant receives. Two individual sensors will provide data for this system. The first is a light sensor. It will examine the amount of sunlight beaming on the plant. The second determines the temperature. It will measure the temperature of the air surrounding the plant and determine whether or not the plant is too warm. The central CPU will use the data from both devices to determine how much sun exposure the plant has gotten that day as well as the temperature and react accordingly. If the plant has reached its maximum amount of sun or is at a high temperature, then it will activate the shading mechanism. This umbrella-like feature will protect the plant from the sun's rays and cool it down. Doing so will assure that the plant gets an appropriate amount of sunlight.

The amount of sun exposure as well as the temperature of the plant will be controlled using a shading-mechanism. This is a mechanical device that will cover the plant so that it remains unaffected by the sun. The device will be a combination of a foldable fan and an umbrella. The device will start folded like a fan. Upon receiving a signal from the central CPU, the umbrella will unfold in a similar fashion to the foldable fan, spreading out to form a complete circle. Once fully expanded, it will look like an umbrella and provide shade for the plant. This will allow for regulation of the temperature and sun exposure. Once the central CPU determines that the plant needs more sun, the shading mechanism will fold back on itself and allow the sun to shine on the plant once again.

An additional feature that will be implemented in this project is a rotational structure. It will be a mechanical device that can rotate the plant on an axis so that all sides receive even amounts of sun exposure. This will work using the light sensor and a timer. Once one side of the plant has received a certain amount of sunlight, the central CPU will send a signal to the rotational system. This will cause the plant to rotate around its center so that a different side of the plant will receive maximum sun exposure. This will be utilized to assure that the plant grows straight up instead of at an angle towards the sun.

All systems will be controlled by a central CPU. This will be designed using a basic microcontroller. The device must be capable of taking multiple inputs at once and responding accordingly. It must have multiple timers as well as the ability to send signals to many different outputs. The device also requires a storage unit as it will be storing data from the sensors as well as data inserted by the user through the app. Time is not of the essence for the project as the responses don’t need to be executed right away. Therefore, the CPU can function on a lower frequency. However, the CPU must be accurate. The response signals must be sent the correct devices. Otherwise, the plant may not receive the sunlight or water that it requires.

The project will have two sources of power. First, it will be powered using solar panels. These will convert energy received from the sun into electricity for the device. However, this is not the most reliable source as the sun isn’t always out. Therefore, a backup powering system will be in place. This will consist of a battery that will take over powering the device when the solar panels cannot provide. This system will provide the electricity for the sensors, the CPU, and all mechanical systems within the project.

Finally, the entire system will be controllable through an app. This app will allow the user to input data about the plant which will in turn control the amount of water and sunlight the plant receives. The user will be able to select from a list of plants that have already been included or can insert their own data. If they choose to insert their own, they will be able to include information about the number of times the plant should be watered as well as how much sun it should receive. The device will use that data in order to successfully care for the plant.

Overall, this project aims to create an automated system for caring for plant life. With the help of all of the features listed above, this device will successfully care for any plant it comes across without the help of a human.

Section 3: Project Constraints

As of the writing of this report, there is no sponsor attached to this project. Thus, the team is responsible for funding it themselves. Each team member is willing to contribute $500 to the project, summing up to a grand total of $2000. Since all the project materials with the exception of the shading are easily acquirable via gardening, mechanics, the overall cost should be under our maximum budget. The cost breakdown is explained in the Project Cost Breakdown Section.

There are also time constraints stemming from our class schedules and semester lengths. All members are taking a full-time workload with part-time employment. In addition, they only have this semester (4 months) to work on the initial documentation and prototype and next semester to complete its documentation and physical design. Currently they scheduled project planning meetings twice a week, but depending on project needs and everyone's availability, there might be additional meetings in a week.

Power is provided by a supply board with solar panel-powered NiMH rechargeable batteries, alkaline non-rechargeable batteries, and voltage regulators. The alternating solar and non-rechargeable power must supply the controller, mechanical systems, and sensors at the different voltage levels required for each of them. Voltage regulators can produce the necessary voltage levels. However, the number of design components requiring power might necessitate an additional power system.

Water will be provided by either a water container with several liters or a built-in water hose connected to an outdoor faucet. If the water container is used, the user will need to refill the container when the moisture sensor detects a low water level. If a water hose connector is used, the plant system will need to be nearby to an outdoor and indoor water source to hook up to.

Section 4: Project Requirements & Specifications

Project Requirements Table

Section	**Requirements**
Power	5 V supply from AA batteries and DC-DC voltage regulator
Irrigation System	Plastic piping dispersed throughout the soil and connected to water supply
Light Sensor	Minimum detection range from 1000 to 80000 lux (illuminance unit)
Moisture Sensor	Corrosion-resistant and analog output
Shading System	Curved, waterproof plant covering
WiFi Module	802.11 protocol and WPA/2 security
Microcontroller	16 bit architecture with low power and I2C/UART capabilities
Application	Easy-to-download mobile application

Table 1: List of Requirements

Project Specifications Table

Section	Specifications
Plant System	The plant system must be able to hold the plant and its soil as well as all sensors or systems required by this device without being too large for the average sized house.
Irrigation System	The irrigation system must pump water into the soil when given the command as well as stopping after a specified duration of time.
Light Sensor	The sensor must sense the amount of light beaming on the plant and send that data to the CPU.
Moisture Sensor	The sensor should be able to sense the amount of water in the soil and provide that data to the CPU.
Temperature Sensor	The sensor should be able to sense the temperature of the air surrounding the plant and provide that data to the CPU.
WiFi/Bluetooth Module	The WiFi/Bluetooth module must allow the device to send and receive data from the application and send it to the CPU.
Rotation System	The rotation system must be able to rotate the plant on an axis after a specified amount of time has passed.
Shading System	The shading system must be able to cover the entire plant when given the signal by unfolding without the assistance of any other device. The system also must close up when told to do so.
Microcontroller	The microcontroller must take data from the sensors and the app and use that data to send appropriate signals to the correct systems within the device. This should be done autonomously and without the assistance of a user.
Power System	The power system must be able to provide enough power to the system so all components can function properly.
Solar Panel	The solar panel must convert light to electricity to assist in powering the system.
Application	The application must allow the user to insert data about the plant which will be sent to the CPU via WiFi Bluetooth.

Table 2: List of Specifications

Section 5: House of Quality

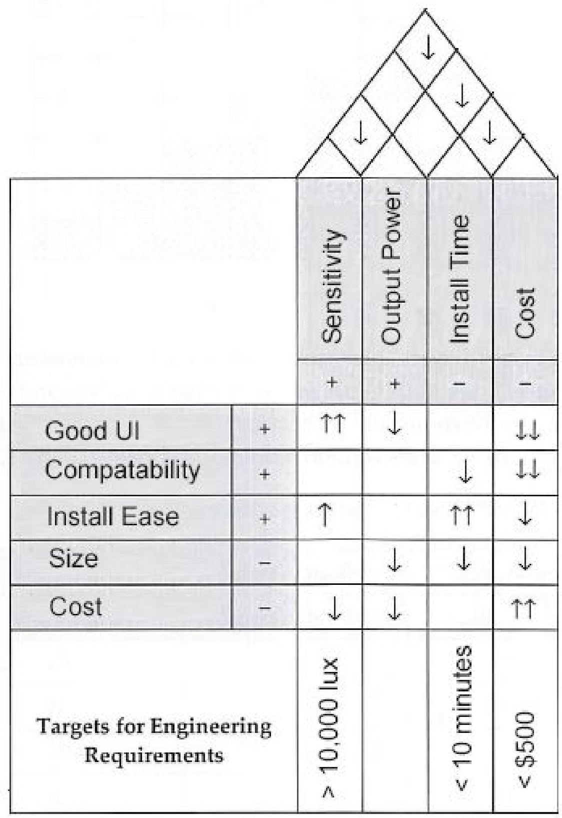

Figure 1: House of Quality Diagram

Section 6: Block Diagram

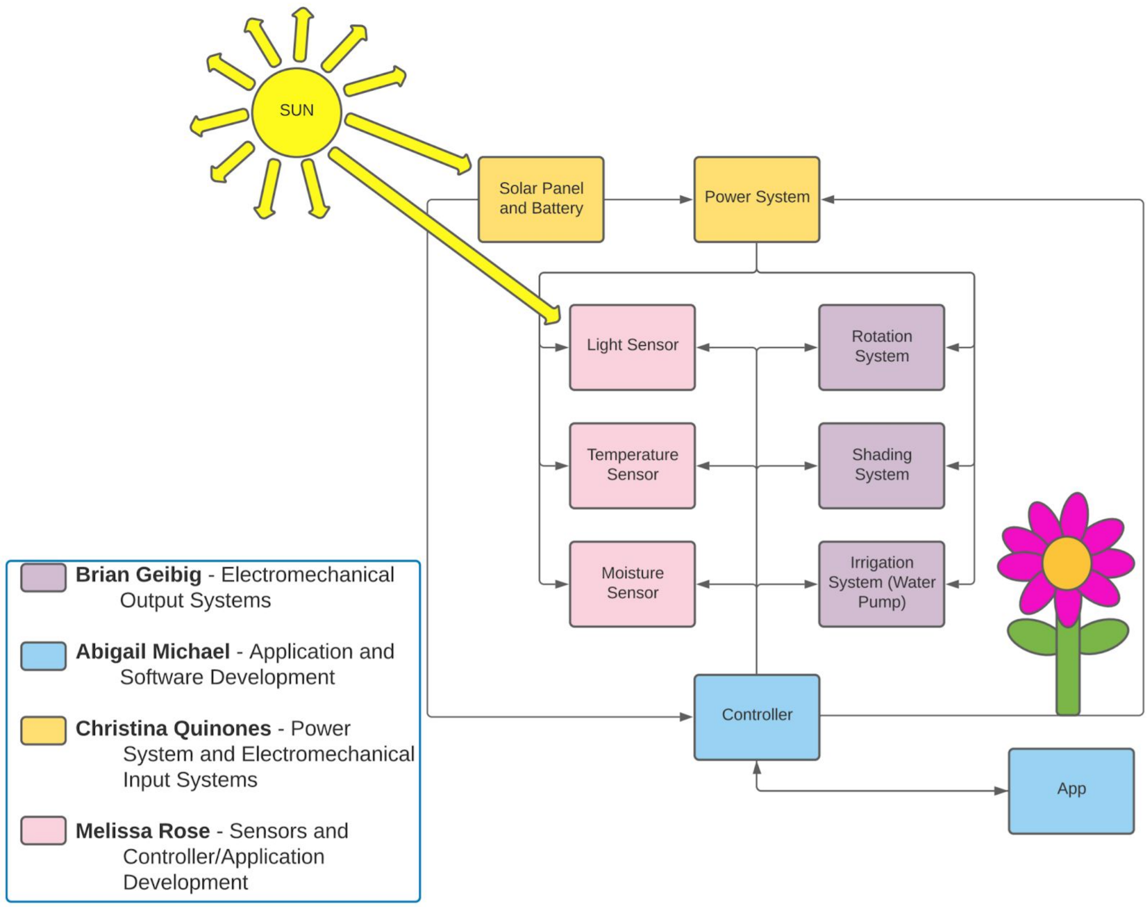

Figure 2: Project Block Diagram

Project Block Diagram Status as of 9/15/2020:

- Each block is currently being researched
- All blocks are currently in design process
- None of the blocks have been purchased or acquired
- None of the blocks are being prototyped
- None of the blocks have been completed

Section 7: Project Cost Breakdown

Section	**Cost**
Plant System	$10
Irrigation System	$20
Light Sensor	$5
Moisture Sensor	$5
Temperature Sensor	$10
WiFi/Bluetooth Module	$10
Rotation System	$20
Shading System	$50
Microcontroller Kit	$200
Power System (including Battery)	$50
Solar Panel	$30
Total	$410

Table 3: Project Cost Breakdown

The cost breakdown is based on suppliers given in the Sources section. The plant system includes the grown plant, pot, and soil and fertilization materials. The irrigation system would consist of mini plastic piping, water container, sprinkler, and hose. The sensors, WiFi/Bluetooth module, and solar panel can be purchased in whole at popular electronics supply stores. The rotation system would consist of a plate stand underneath the plant pot and a servo motor controlling its spin. The shading system would consist of curved, connected sheet metal pieces that mechanically spread out to cover the plant. The microcontroller kit consists of a controller IC and a FET (flash emulation tool) to program the IC. The power system includes two battery holders with rechargeable and non-rechargeable batteries respectively and voltage regulator circuits on PCB(s). This PCB is wired to systems, sensors, and a microcontroller to power them.

The total cost is estimated to be $410, more $1500 less than the team's $2000 budget. Therefore, the team would have the resources to easily replace or rebuild non-working components and remain within budget.

Section 8: Project Milestone

Senior Design I Milestones

Senior Design I			
	Activity	**Date**	**Status**
I.	Ideas	-	Completed
II.	Project Selection and Role Assignment	-	Completed
III.	Project Report		
1.	Divide and Conquer 1.0	9/18/2020	Completed
2.	Divide and Conquer 2.0	10/2/2020	In Progress
3.	60-page Draft Documentation	11/13/2020	-
4.	100-page Report	11/27/2020	-
5.	Final Documentation	12/8/2020	-
IV.	Research, Documentation and Design		
1.	Light Sensor	11/6/2020	Researching
2.	Temperature Sensor	11/6/2020	Researching
3.	Moisture Sensor	11/6/2020	Researching
4.	WiFi/Bluetooth Module	11/6/2020	Researching
5.	Solar Panel	11/6/2020	Researching
6.	Power Supply System	11/6/2020	Researching
7.	Rotation System	11/6/2020	Researching
8.	Shading System	11/6/2020	Researching
9.	Irrigation System	11/6/2020	Researching
10.	Microcontroller	11/6/2020	Researching
11.	PCB Layout	11/6/2020	Researching
12.	App	11/6/2020	Researching

Table 4: Senior Design I Project Milestones

Senior Design II Milestones

Senior Design II		
1. Build Prototype	4 weeks	-
2. Testing and Redesign	2 weeks	-
3. Finalize Prototype	2 weeks	-
4. Peer Presentation	TBA	-
5. Final Report	TBA	-
6. Final Presentation	TBA	-

Table 5: Senior Design II Project Milestones

Section 9: Project Goals

The initial goal of this project is to make an autonomous programmable irrigation system for the growth of a potted plant. This system will be implemented with the use of several different moisture sensors in order to detect when the plant life needs watering. After the initial goal of creating an autonomous irrigation system is completed, the group will start on the implementation of the second operational goal which is a self shading system using a solar intensity detection system. The completion of this second goal will help assure the plant obtains the optimal amount of sunlight daily for healthy growth. Another feature that will be implemented is that of a rotating structure. This rotational base will assure the plant gets an even distribution of sunlight. We also hope to add a temperature sensor so that the user may be alerted whenever the plant is in a substandard environment by sending an alert when the plant is at either too high or low of a temperature for an extended period of time. Finally, we hope to make these goals customizable with a user application which will be implemented in a way so that the customer may input settings for a variety of plantlife. A goal with this application, is making sure it is both easy to use and highly programmable. One way of achieving ease of access is to enable the application to work on a bluetooth connection, that way a user can wirelessly input their custom settings from a distance.

Section 10: Sources

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