Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Summer 2020

Earth Wise
Smart Green House

Andrea Rivera
Duy Nguyen
Walter Mkpanam
Paras Shrestha
Christopher Jones

Revision History

Revision	Date	Author(s)	Description
0.1	07.01.2020	AR	Document creation
0.2	07.03.2020	DN	Complete documentation and reporting
0.3	07.10.2020	PS	System Overview, Cost Proposal, Facilities and Equipment Added
0.4	07.11.2020	WM	Mission,Vision,Success Added

Contents

List of Figures

1 Vision

The vision behind this project is to create a simple environment for plants to thrive with little or input from the user (farmer in this case). Tending to plants even on a small scale can require a substantial amount from the user. From constantly monitoring the environment to ensuring sufficient water intake, farming is an arduous task for an everyday user. Our project aims to remove (or reduce) that burden by utilising technology to perform several tasks with little to no inputs from the user. Our aim is to allow users embrace more subsistence farming practices while ensuring their plants are grown under the best conditions.

2 Mission

To successfully implement our vision, we will be using a greenhouse approach which would lead to our team utilizing sensors for environment and plant settings(humidity,sunlight,water intake), a control device (arduino) responsible for talking to the sensors,an irrigation a custom built application to allow the user view all activities of the system and make necessary changes, and a greenhouse structure to house all sensors and plants.

3 Success Criteria

Upon completion of the smart green house system, we expect the following success indicators implementing the application(software) and hardware specifications:

- Ability for system to accurately record environment settings and report to the user accordingly with no margin for error.
- Garden tasks user would have to do manually would be reduced by over 50%

Within 6 months after the prototype delivery date, we expect the following success indicators to be observed:

- Expansion of the current greenhouse to accommodate more than 1 type of plant.
- An additional 20% reduction in garden tasks for the user.

Within 12 months after the prototype delivery date, we expect the following success indicators to be observed:

- Addition of a harvest robot to take care of manual labor related to harvesting a plant thereby reducing user input by over 50%
- Addition of machine learning models to allow the system and harvest robot perform over 90% of garden tasks autonomously.

4 Background

Keeping plants alive is a challenge for most people, especially new plant owners, it requires monitoring, care, and discipline for plants to thrive. It can be tricky for plant-owners to know how much water, sunlight, and fertilizer each plant needs to survive. Learning all the information needed for properly nurturing a plant may seem complex, as the information that is readily available is riddled with vague terms such as "part shade" and "full sun" which are difficult to quantify. People can grow overwhelmed and frustrated when the beautiful plants they bought at the store start to dry-out and wither. Discouraged plant owners will usually convince themselves that they lack a "green thumb" and give up on gardening all-together. In recent years, there has been a growing distrust toward the produce that is readily available at food markets due to the chemicals that are commonly used to alter their size and make them ripen faster. Furthermore, many people have become aware of the environmental footprint impacting the earth due to chemicals used by fruit and vegetable companies polluting the waterways. Added to all of this, are the growing concerns that these chemicals could be causing adverse effects in the health and well-being of the general population. This has created a market for people who want to be in charge of the fruits and vegetables they put on their tables; from picking the seeds and planting to harvesting. Currently, there are very few options in the market aimed at helping inexperienced gardeners successfully grow a garden. Scouring books and magazines in search for tips on how to grow a garden takes time and effort that many people lack. Earth Wise can make the process of growing plants simple and intuitive for inexperienced gardeners and busy consumers interested in growing their own produce. Earth Wise self-waters, schedules when to fertilize plants, as well as monitors the amount of sunlight the plant receives to ensure its optimal growth environment. Earth Wise also includes a mobile application that keeps customers informed about the environment inside the greenhouse and allows users to track the growth of their plants. Unlike other smart gardens available on the market, Earth Wise can be temperature controlled so plants can grow indoors and outdoors. Earth Wise provides a zero-effort way for gardeners of varying expertise to grow their own fresh organic produce.

5 Related Work

There are different solutions available aimed at automating the process of growing plants. Some of these solutions are available for purchase in commercial stores. The Smart Garden 9 is a planter which waters, fertilizes, and provides artificial light for plants [1]. This planter takes care of the whole process of growing herbs and vegetables with virtually no intervention by the owner. The only thing the owner needs to do is refill the Smart Garden 9's water tank when it runs low. The Smart Garden 9 is designed to work with hydroponic pods which are used to grow the plants without soil. Each hydroponic pod retails for $10 each. This is a disadvantage, as the Smart Garden 9 retails for $200 on its own. This means that a customer would have to pay $290 the first time they use the Smart Garden 9 and $90 extra each time they want to replant the planter's 9 pods. Bounty Elite is a planter similar to the Smart Garden 9 in that it requires almost no intervention by the owners for upkeep. Unlike the Smart Garden 9, Bounty Elite has a panel that displays the water level, nutrient level, and light cycle that the planter is on [2]. However, Bounty Elite is also designed to work only with hydroponic pods which become costly to repurchase. Several people have built their own prototypes of smart gardens that are larger, less expensive and do not require special pods. One of these projects was implemented by user Ryan Gill and published on Arduino's Project Hub website. Gill describes his project as a "real time plant monitoring system to view temperature, light exposure and moisture." [3]. Gill uses an Arduino MKR1000, a temperature sensor, moisture sensor, and a light sensor to record data about the plant's conditions. Gill then created an application that displays the data recordings in real-time as well as plots the overall data history of each sensor. Gill's plant monitor is great for monitoring the plant's conditions, but it lacks an automated system that can water, change temperature or alter the amount of light received by the plant. A similar project published on Project Hub is by user Billy King and it's a mini greenhouse that, like Gill's project, uses an Arduino and sensors to monitor the plant's conditions. However, King's greenhouse does have an automated system that acts in the "event [that] the temperature is low or high and the soil is dry" [4]. King's greenhouse, however, lacks an application that can display the conditions inside the greenhouse or that gives the owner power to control the greenhouse's environment remotely. YouTube user Practical Engineering has a video on a project he made which, similarly to the previous two, uses an Arduino and some sensors to monitor plant conditions and open a water valve when the sensors detect that the soil is too dry [5]. Practical Engineering's project also records and plots data from the sensors so that the owners can analyze it. However, the garden controller can only water the plants but cannot alter the amount of sunlight received by them or control the temperature the plants are exposed to. Earth Wise will be able to control temperature, light, and humidity conditions inside the greenhouse as well as automatically water the plants. Additionally, users will be able to monitor and control the greenhouse's environment conditions through a mobile application. Furthermore, Earth Wise can be used with any type of soil and is large enough to plant up to 8 plants.

6 SYSTEM OVERVIEW

The System we will be designing is a Smart Greenhouse Hub. We will develop both hardware and software needed for this system.

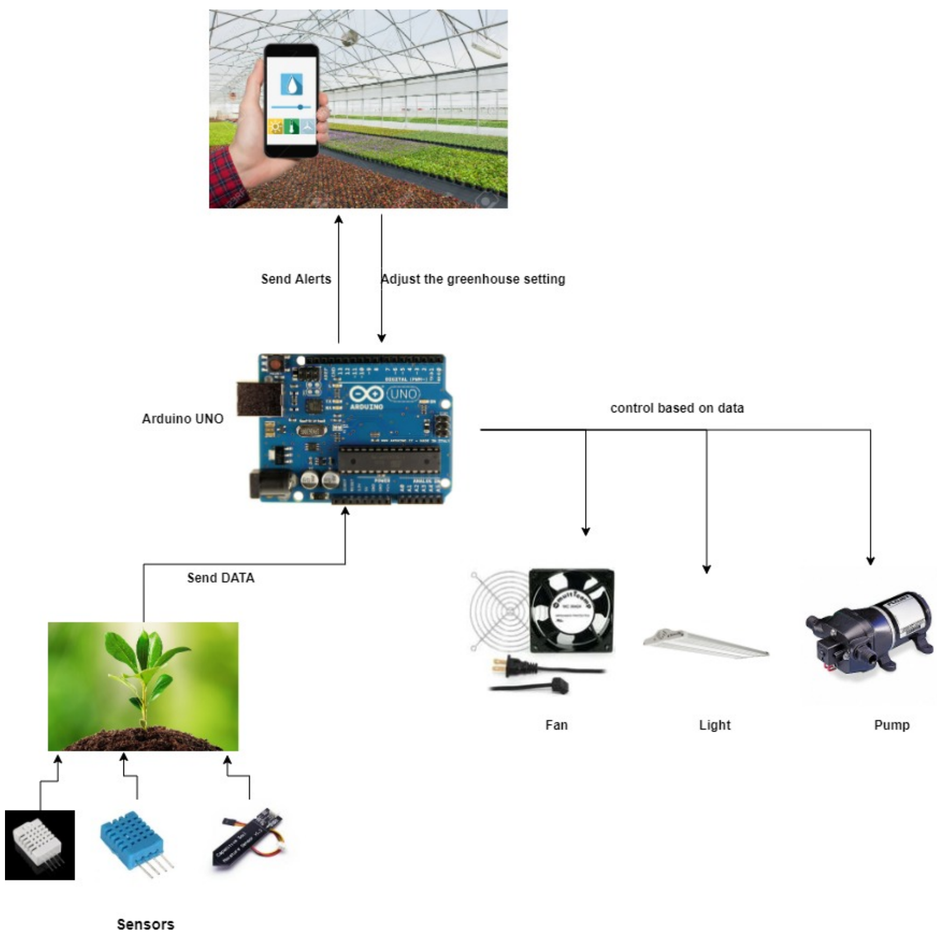

Figure 1: Overview of System

For this system, we will be using Arduino UNO to process the data. The hub will be integrated with moisture sensor, temperature sensor, humidity sensors, fans, artificial light and water pump. The hub will be programmed to check the current soil moisture, temperature, light condition and humidity in a continuous loop. So whenever the soil moisture goes down, the hub will water the plants automatically to certain level of moisture.Also when temperature fluctuates, the hub should be able to use integrated fans to maintain proper environment for plants. Similarly, the hub will be also be able to change the intensity of light as per the requirement on its own. The hub will also have functionality to measure volume of water in reservoir and alert user if the level is critical low.

The System will also include an android application to control the greenhouse hub. With the use of this application, the user will be able to monitor the current condition of Greenhouse hub, set the desired moisture level,temperature and light condition. The user will be also able set the time frame for irrigation to happen. Moreover the application will be used to send alerts to user regarding low water level, sudden drop on temperature and other events.

7 Roles & Responsibilities

This project will have our team members broken up into two teams. The first team is the hardware team that will be responsible for planning and construction of the greenhouse and its components. the second team is the software team responsible for writing the code that will control and regulate the greenhouse. Although team members have different teams, all members will work with the other team as needed to complete the project successfully. Below is a list of our team members and their roles.

Team Members

- **Duy Nguyen**

  This is our team leader. He is responsible for keeping track of all team member progress by creating meetings and asking questions about progress. He is also part of the hardware team.

- **Paras Shrestha**

  Responsible for determining needed parts and costs associated with the project. Is also part of the hardware team.

- **Walter Mkpanam**

  Part of the software team. Responsible for tracking scrum progress and determining what need to be accomplished in the next sprint.

- **Chris Jones**

  Part of the software team that will develop the code for the Arduino system. Will also track progress of the scrum.

- **Andrea Rivera**

  Part of the software team that will develop the code for the Arduino system.

Stakeholders

The stakeholders for the greenhouse project can be broken into to categories. The first category is the internal stakeholders. The internal stakeholders consists of our team members which act as the owners and employees. Our team has a direct influence on the failure or success of the greenhouse project and are directly effected by the results. The second category consists of external stakeholders. These are companies, investors, or other groups that do not have direct influence on the project, but are still effected by the actions taken by the company. The main external stakeholder is the University of Texas at Arlington as the university is providing the funding for the project. Therefore, UT Arlington is effected by the success of the project. While we are not directly in contact with any other companies, there are still some groups that may have an interest in the greenhouse project. These groups may consist of farmers or agriculture companies like Tyson Foods who would need to produce clean food for their animals.

8 Cost Proposal

Since our project integrates hardware as well, our team will need number of physical components like micro controller,sensors, motors, breadboards, wires, wooden enclosure and other many circuit materials. We do not expect expenses to be extreme but given the requirement of physical components, the expenses can go up to few hundred dollar.

8.1 Preliminary Budget

This part includes the expenses required for parts and tools required for this project.

Component	Quantity	Price per quantity
Wooden Enclosure	1	120
Adruino Uno	1	25
Water pump	1	50
Fan Kit	2	25
Moisture Sensor	1	8
Temperature Sensor	1	15
Humidity Sensor	1	15
Breadboard	2	10
100pc wires	1	10
Mini LCD display	1	15
Vinyl Tubing	1	10
Water Reservoir	1	50
Ambient Light Sensor	1	5
Speaker	2	10
LED Light strip	1	40
Other Circuit components like resistors, capacitors etc.	several	50
Total Estimated Cost		$493

8.2 Current & Pending Support

The UT Arlington CSE department will be providing the funds for this project. The CSE department will be providing budget up to 800 dollars which should be more than enough to complete the project.

Funding Source	Amount
CSE Department	$800

9 Facilities & Equipment

The hardware team will need significant lab space and lab materials. The greenhouse hub is estimated to be around 30 * 20 * 15 inch. So we will need enough space to accommodate our tools and parts.

Also we will be needing specific tools like multi-meter, soldering kit etc which is already present in lab. The software team will be most likely using visual studio which we already have access to. Also the lab space should enough be accommodate both hardware and software team when we will have to work together. Any other test ground and equipment do not seem necessary at this moment.

10 Assumptions

The following list contains critical assumptions related to the implementation and testing of the project.

- All necessary components will be obtained before Fall 2020 semester.
- All the necessary designs required to construct the greenhouse will be completed by sprint 2.
- Planning of the Arduino software will be worked on throughout Summer 2020 semester.
- Development for the Arduino software will be completed in the Fall 2020 semester.
- Testing will be performed to determine if the smart green houses effectiveness compared to a control setup.
- Will be controllable via internet through an application.

11 Constraints

The constraints most considered in the implementation and testing of the project are listed below.

- Software will be designed to be adaptable to larger greenhouse designs.
- Cost to complete project will not exceed the $800.00 budget provided by UT Arlington.
- The completed prototype greenhouse should produce at least 2 times the yield of outdoor growth.
- The greenhouse will installed outdoors where the plants needs are provided autonomously, such that no user interaction is required unless necessary to maintain functionality.
- The greenhouse will be tested by growing one type of plant. More plants may be tested in the future.

12 Risks

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
Access to work lab unavailable/restricted due to COVID-19	0.50	20	10
Unable to meet in person with teammates	0.50	14	7
Distance communication issues	0.20	7	1.4
Testing grounds unavailable	0.30	15	4.5
Unable to obtain necessary equipment or part failure	0.30	7	2.1

Table 1: Overview of highest exposure project risks

13 Documentation & Reporting

13.1 Major Documentation Deliverables

13.1.1 Project Charter

On Tuesday, June 23rd, 2020, we will voluntarily pick the sections of Project Charter depend on individual strengths. Our team leader will review and assign the tasks again to make sure the workload is fair for everyone. Every Thursday and Saturday, we will meet up in 15 minutes, our scrum master will ask questions and make sure that everyone is on the same track. The initial version be delivered on July 12, 2020. After the initial version is finished, every Tuesday, a team member can suggest a change in Project Charter. The final version is delivered on August 10th, 2020. The project charter can not be changed after the final version is finished.

13.1.2 System Requirements Specification

On Tuesday, July 14th, 2020, we will meet up and suggest all requirements of the system. We will voluntarily pick the requirement sections of System Requirements Specification. Our team leader will review and assign the tasks again to make sure the workload is fair for everyone. Every Thursday and Saturday, we will meet up in 15 minutes, our scrum master will ask questions and make sure that everyone is on the same track.The initial version be delivered on July 27Th, 2020. After the initial version is finished, every Tuesday, a team member can suggest a change in Project Charter. The final version is delivered on August 10Th, 2020. The system requirements specification can not be changed after the final version is finished.

13.1.3 Architectural Design Specification

On Tuesday,August 4Th, 2020, hardware team members have the responsibilities to discuss and explain to software team members about the overview of the architectural systems. Hardware-team members will voluntarily pick and complete the sections of architectural design specification. The initial version and final version is due on August 12ND ,2020. During the sprint, all team members can change the document.

13.1.4 Detailed Design Specification

On Tuesday,August 4Th, 2020, software team members have the responsibilities to discuss and explain to hardware team members about the overview of the Detailed Design Specification. We will voluntarily pick the sections of the Detailed Design Specification depend on individual strengths. Our team leader will review and assign the tasks again to make sure the workload is fair for everyone. On Tuesday, July 31st, 2020, the initial version and final version is due on August 12th ,2020. During the sprint, all team members can change the document.

13.2 Recurring Sprint Items

13.2.1 Product Backlog

Based on the SRS, we will add items to the product backlog on an excel scrum template which is shared with team members and stake holders. At the beginning of the sprint, we will prioritized the items of the product backlog by using a group vote. Then, we will develop the most prioritized item first.

13.2.2 Sprint Planning

Every Tuesday, each sprint will be planned. We will develop at least 2 items of product backlog. One item is related to software. Another item is related to hardware. We will start to build the project on August,25th,2020, and finish it on November, 22nd, 2020. We will have the total of 13 sprints. Each sprint has 1 week period.

13.2.3 Sprint Goal

The team members will determine sprint goals every Tuesday. The team leader will consider the goal, and address concerns in the upcoming meeting schedule. The customers can be invited in the team meetings.

13.2.4 Sprint Backlog

The team member can decide the print backlog. The backlog will be maintained on a shared Scrum excel.

13.2.5 Task Breakdown

On Tuesday, the team members will voluntarily pick the tasks they want to work on depend on their strengths. Every Thursday and Saturday, we will meet up and address concerns of the tasks. Although the tasks are individual, other team members have responsibility to help if needed. Each team member will document time spent on each task in their engineering notebook and then logged in an Excel spreadsheet.

13.2.6 Sprint Burn Down Charts

The sprint burn down charts are generated by a Scrum template excel. A team member can daily writes the total amount of effort and update on a Scrum template, so others can see how the Sprint progress is.

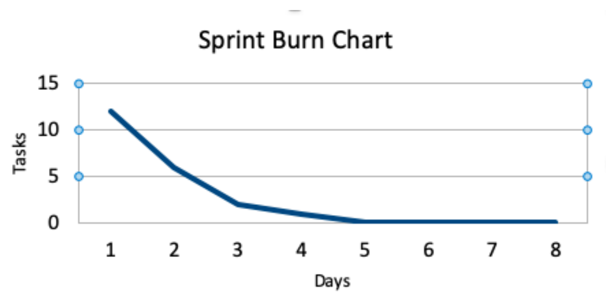

Figure 2: Example sprint burn down chart

13.2.7 Sprint Retrospective

The sprint retrospective will be on Sunday every week. We will discuss what we have finished and and what tasks we need to push more in the next sprint. A team member will record what we discussed on a meeting agenda template and a sprint retrospective file.

13.2.8 Individual Status Reports

The team members will write our individual status reports on our engineering notebooks. Also, the team members will update the scrum spread sheet after each completed features. Every Sunday, we will review what we did for each sprint.

13.2.9 Engineering Notebooks

The engineering notebook will be updated every week. The minimum amount of pages will be depend on the load work of each week. Every Tuesday, everyone will post their new pages on Teams group chat to keep each member accountable about the project.

13.3 Closeout Materials

13.3.1 System Prototype

The final product will be a smart green house which has soil, lettuce, irrigation system, light, and sensors inside. A micro controller - Arduino will be the brain of the green house. A smart phone will control the green house. It will adjust the temperature, set up the time interval and conditions to water the plan. PAT and FAT will be available if product owner requires it.

13.3.2 Project Poster

The poster will include the team name, project name, executive summary, background, conceptual design phase, detailed design phase and prototype test, conclusion, and references. The poster will be 18" by 24". It will be delivered on August 10, 2020.

13.3.3 Web Page

As right now, there is no plan to create a web page. As an alternative, we will post the project on the UTA website.

13.3.4 Demo Video

The demo video will show how the smart green house grows the plant effectively, such as automatically adjust the temperature inside the green house, decide when to water the plant depend on light and soil moisture. The video will approximately 5 minutes.

13.3.5 Source Code

Our source code will be maintained on GitHub. We will prove the binaries file to customers. The project will be open source, because we want to improve the project in the future. We will choose GNU as our license terms. The license terms will be listed in a single README file.

13.3.6 Source Code Documentation

Source Code Documentation will be employed in PDF format.

13.3.7 Hardware Schematics

We will use EAGLE software to create the printed circuit board.

13.3.8 CAD files

We will use Fusion 360 to create CAD files. The project won't involve much mechanical design. 3D printed parts are primary for designing the box which contains micro controller and sensors.

13.3.9 Installation Scripts

Users can download and install an app on App Store or Google Play as a controller of our product.

13.3.10 User Manual

We will create a digital user manual video on YouTube to show instructions of how to use our product.

References

[1] The Smart Garden 9. Click and Grow. www.clickandgrow.com/products/the-smart-garden-9

[2] Bounty Elite. Aerogarden. www.aerogarden.com/new-aerogarden-bounty-elite.html

[3] Gill, R. (2016 March 30). Plant Monitoring System. Project Hub. https://create.arduino.cc/projecthub/ryanjgill2/plant-monitoring-system-88ed2b?ref=userref_-id=17809offset=4

[4] King, B. (2019 May 8). Mini GreenHouse 1.20X0.60X0.60. Project Hub. https://create.arduino.cc/projecthub/billy-king/mini-greenhouse-1-20x0-60x0-60-f43bcc

[5] Practical Engineering. (2015 April 2). Arduino Garden Controller - Automatic Watering and Data Logging[Video]. YouTube. https://www.youtube.com/watch?v=O_Q1WKCtWiAlist=LLMAzAl-kG3tbLTmvKKMpGcAindex=41t=0s