AutoPot

Team 7

Anny Ni
Edwin Cho
Grace Lee
Raymond Xu

Contents

1 Project Description

Plants are difficult to grow and keep alive. There have been countless times when people forget to water their plants or end up watering them too much. AutoPot is a smart gardening system that will allow the users to easily raise their plants by having automated plant care. After users place their pots with their plants in them onto the AutoPot base, AutoPot will track plant health and growth by keeping track of the soil moisture, soil nutrients, and sunlight exposure, and will refill these resources automatically when they are lacking. For instance, if there is not enough sunlight exposure on one side of the plant, AutoPot will rotate its base and expose that side to the sun.

In order to lessen the chance of user negligence, AutoPot will have notifications for the plant status and possible concerns and tasks, and an improved user interaction through a web app and a display on the pot where the plant will become more like a pet. There will also be customizable settings for the AutoPot for amateur and experienced plant owners and these settings will be populated with defaults for common plants. This allows for both an easy-growing, no-research experience for beginners and a more selective experience for experts who want to test out different levels of sunlight, nutrients, and moisture.

2 Design Requirements

2.1 Explicit Requirements

- Track soil moisture, soil nutrients (N, P, K), and sunlight exposure
  - Moisture sensing
  - Automated soil tests
  - Light sensing and plant rotation to accommodate light source
- Automatically satisfy a lack of resource:
  - Moisture - waters the plant
  - Nutrients - adds fertilizer to the soil
  - Sunlight- rotates the plant
- Data collection from the sensors for plant monitoring
- Customizable settings for different plant needs, controlled via web app
- Display on plant to notify users of its status as well as a notification system that pings the users with possible concerns
  - UX component and web app

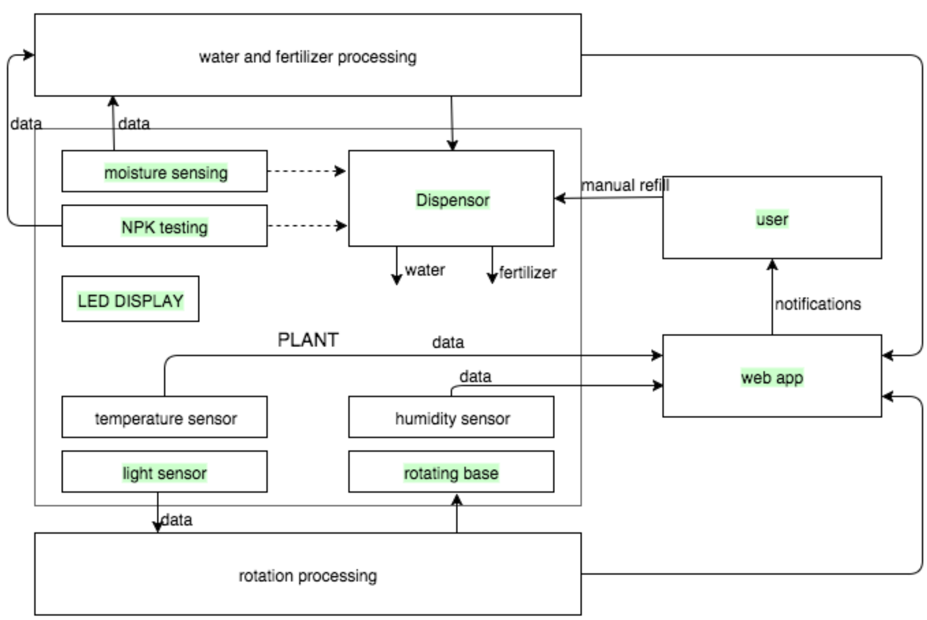
- Measure temperature and humidity, and alert users when there are unfavorable environments
- Users receive alerts and notifications via the web app and associated accounts (email)
- Extendability of base height to encompass various pot heights

2.2 Implicit Requirements

- Safety
  - Should operate without any major safety concerns to the user or the plant
- Reliability
  - Should operate with minimal user input, other than tasks that require human interaction
  - Readings should be accurate, actions should occur in a timely manner
- Usability
  - Pot needs to be within certain dimensions

3 Functional Architecture

3.1 Block Diagram



3.2 Moisture and NPK

Time event sensing of moisture and testing of NPK levels within pot soil. When either moisture or NPK levels are below threshold, dispense water or NPK (as necessary) from reservoirs. Water and fertilizer are dispensed directly into soil. When either water or fertilizer reservoirs are below threshold, users are prompted to refill.

3.3 Light Sensor and Rotating Base

Time event sensing of sunlight. Reported data is used to compute rotation of the pot, so that the plant receives even amounts of sunlight from all directions.

3.4 Web Application

All data gets compiled and visualized in the web application. The user interfaces with the project mainly through this application.

3.5 LED Display

This allows the user to see the status of their plant. Any immediate worries will be displayed on the screen and the user should be alerted through the web application as well as the display.

4 Design Trade Studies

4.1 Microcontrollers

The choice of type of microcontroller to use was between distributed microcontrollers and centralized microcontrollers. Centralized microcontrollers are easier to use and access. There is no need to connect them to all of the other microcontrollers. However, they are bad for unit testing and if there is a failure then the whole system will fail. With distributed microcontrollers, there can be different units that adhere to the different timings of each sensor. Distributed microcontrollers can constantly read and store data on a schedule so that timing and hanging do not have to be worried about. Distributed also allows for more work on the project to be done in parallel so it was chosen.

Another consideration is whether calculations and actions should be event-triggered or time-triggered. Although event-triggered would be better for only doing calculations when things actually change for the plant, errors are costly. There could be instances where an event trigger gets missed and that leads to no calculations ever being made which leads to a faulty system. On the other hand, time triggers would lead to a more constant tracking although there are some subtle events that may sneak by during the time between checks. However, since changes with the soil and plant are usually not sudden, time-triggered calculations would not miss many crucial events and would be a better choice for the project's goals.

4.2 Soil Moisture Sensor

There were considerations for which moisture sensing method to use between capacitive and resistive moisture sensors. Resistive soil moisture sensing tend to oxidize when in moisture so they do not last long enough even when switching the polarity. Capacitive soil sensing, on the other hand, do not require direct contact and therefore lasts longer and is also more accurate.

4.3 NPK Testing

For nitrogen (N), phosphorous (P), and potassium (K) analysis, there were two primary methods considered. It was between fertility analyzers and wet chemistry analysis through reagents. There is no known sensor that specifically tells you much of N, P, and K the soil contains. There are 3-in-1 soil analyzers that measure pH, fertility, and moisture, but without a breakdown of each element there cannot be a more controlled way of determining which fertilizer to add to the soil. Wet chemistry tests with the individual N, P, and K reagents allow for a more concrete method of keeping track of how each element affects the health, growth, and the characteristics of the plant.

4.4 Light Sensor

Initially the choices for a light sensor were between a sunlight sensor, an infrared sensor, and an ultraviolet sensor. However, after researching the subject, it was concluded that plants seem to use the full spectrum of visible light. Photosynthesis does not rely on infrared or ultraviolet light. There are also certain plant cycles where plants are more attuned to lights near the lower end of the visible light spectrum while they are absorb more of the higher end during other cycles. Ideally, the light sensor should be able to sense the full visual spectrum in order to account for this.

4.5 Structure

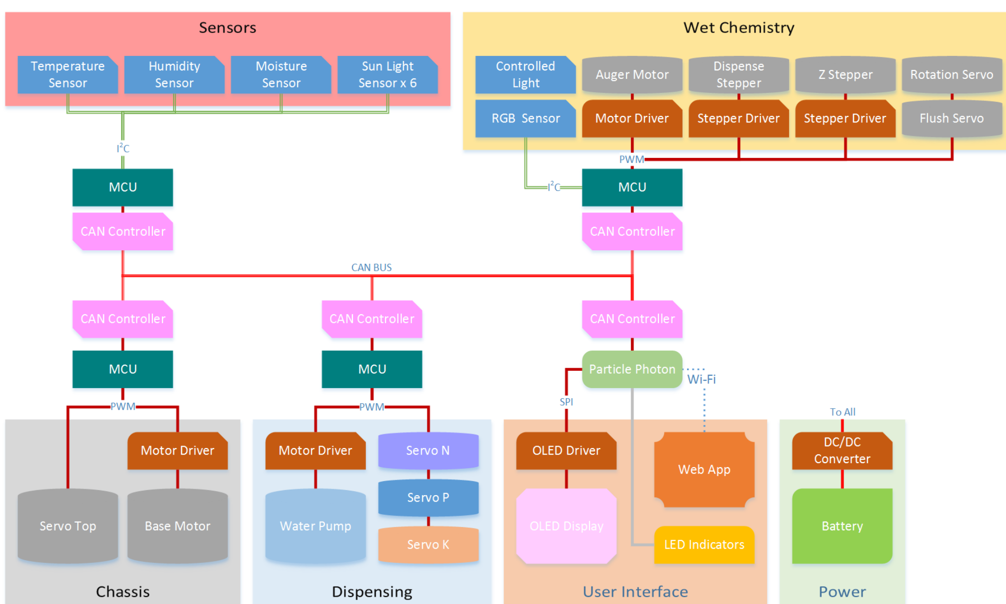
The base structure of the project should ideally be able to be applied to different types and sizes of pots. All of the different structures considered for the project included a rotating base for the pot in order to satisfy the even sunlight requirements. However there were considerations for where all of the other subsystems resided. The designs being considered were: (A) a circle attached on top of the rim of the pot, (B) a contraption that hangs off of the pot, (C) all subsystems built inside of the pot, and (D) all subsystems attached to the base but with expandable width and height. Design A does not allow for different pots being used since there are different rim sizes for each pot. Design B also restricts the usage of pots since different pots also have different shapes and rim sizes. Design C is the most limited since it needs to be able to fit in current pots and there are complications when connecting all of the components together. Design D is the one that allows the most usability and would allow for the most different pots used.

4.6 Plant Display

The plant display must be able to show possible emotions or other visual cues. Different considerations for this display included having a LCD or OLED display or an eInk display. eInk displays have no glare in the sunlight so the display can be easily seen and deciphered when in the sun and the eInk displays draw less power than LCD or OLED displays so they last longer. eInk displays also provide more detail in their displays. However, the eInk displays have a slower refresh rate so that leads to a slower response time to possible triggers. eInk displays are also just black and white whereas LCD or OLED displays have a wider range of colors. Since eInk displays are more complex to control and harder to see in the dark as well as the slower refresh rate, LCD or OLED displays are more preferable. Between LCD displays and OLED displays, OLED displays are more efficient and have a higher contrast.

5 System Description/Depiction

5.1 Block Diagram



5.2 Sensors

Responsible for gathering information from the environment and passing it along to the microcontroller in order to interact with the dispensing systems and rotating base. Our product will include a temperature, humidity, moisture, and light sensor and utilize the information gathered from these sensors.

5.3 Wet Chemistry

The wet chemistry module is responsible for conducting NPK tests to determine whether or not fertilizer needs to be added. The process involves using a syringe to add water to dirt collected by an auger and letting it sit until it separates, taking the sample of water to another container and adding a reagent for N, P, or K, letting the water change color and then measuring it. Once the sample has been tested, a servo motor will take out the used dirt and place it back in the pot.

5.4 Chassis

Base structure of the project should be able to rotate in order to allow for sunlight to reach all parts of the plant equally. The pot should also be able to extend up and down in order to accomodate different plant heights.

5.5 Dispensing

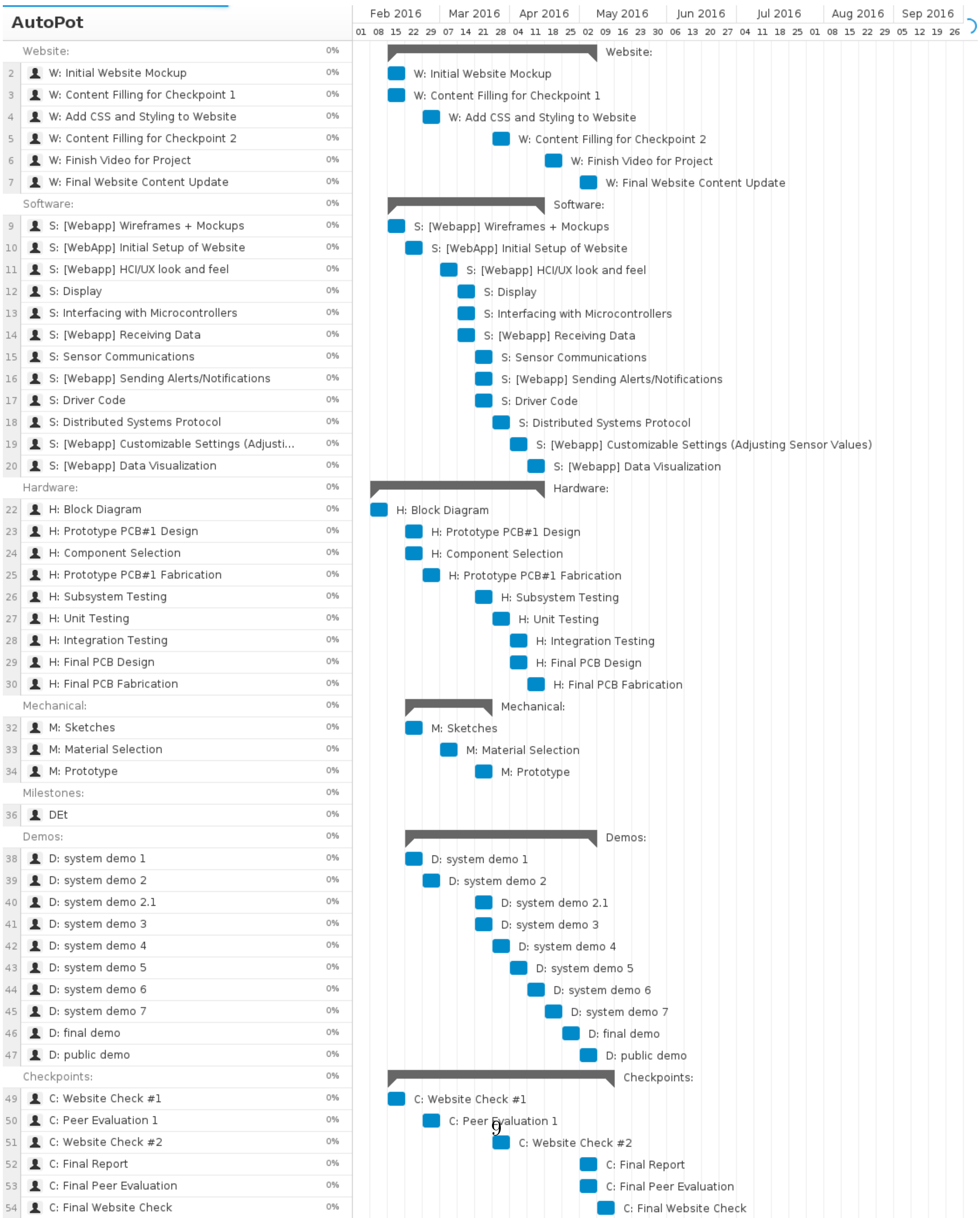
Subsystem responsible for dispensing the water and fertilizer to the plant through the use of servos and a water pump paired with a motor driver. The water tank will need to be refilled by the user whenever it runs low, and this is facilitated by the notification system through the web app. The fertilizer would also have to be refilled by the user, but the dispensing is all automatic whenever the system detects low fertilizer or moisture levels.

5.6 User Interface

Provides a way for the user to interact with their product through the use of a web app and an OLED Display on the pot itself. The LED display will show something like a smiley face to demonstrate that your plant is currently fine, or a frowny face in order to indicate that something is wrong if for example, the temperature conditions were not suitable for the plant. Additionally, the display will show what is wrong with the plant and what the user should do to fix it. The web app sends email notifications to the user regarding the status of their plant and any important notices the user would be interested in, such as if the water tank needed a refill or the temperature of the room was unsuitable for the plant. Users will also be able to select different settings regarding the care of their plant, so if an experienced plant grower wanted to, they could have minimal assistance. The web app will also include a database for different plant profiles that would help users take care of different types of plants. These profiles would include information such as optimal room temperatures, moisture content, fertilizer content, and watering amounts.

6 Project Management

6.1 Schedule



6.2 Individual Responsibilities

- Anny Ni
  - Primary: Web app software
  - Secondary: Low level programming
- Edwin Cho
  - Primary: PCB design and assembly, mechanical design and manufacturing, system integration
  - Secondary: Driver code
- Grace Lee
  - Primary: Web app software
  - Secondary: Low level programming
- Raymond Xu
  - Primary: Embedded Programming
  - Secondary: communication between sensors and MCU

6.3 Budget

Model	Description	Unit Cost	Units	Total Cost
PT100 RTD	Temp. Probe	$9.99	1	$9.99
MAX31865	RTD to Digital Converter	$3.47	2	$6.94
YTBD	Humidity Sensor	$3.00	1	$3.00
YTBD	Moisture Sensor	$10.00	1	$10.00
TSL2591	Sun Light Sensor	$1.81	6	$10.86
Particle Photon	Wireless MCU	$19.00	1	$19.00
YTBD	Microcontroller	$20.00	5	$100.00
MCP2515	CAN Controller	$1.99	6	$11.94
NHD-1.69-160128ASC3-ND	OLED Display, 1.69", w/microSD	$24.35	1	$24.35
HS-485HB	Top Servo	$21.00	1	$21.00
HXT500 Micro Servo	Dispenser Servos, Flush Servo	$2.49	4	$9.96
YTBD	Motor Drivers	$5.00	3	$15.00
3pcs Micro stepper motor	Stepper Motors, 68mm, 10mm	$8.99	1	$8.99
YTBD	Stepper Driver	$5.95	3	$17.85
YTBD	RGB Sensor	$7.00	1	$7.00
YTBD	LEDs	$8.00	1	$8.00
YTBD	DC/DC Converter	$10.00	1	$10.00
YTBD	NPK Reagents	$30.00	1	$30.00
YTBD	Miscellanious Connectors, etc.	$50.00	1	$50.00
Bay Area Circuits	PCB #1, 2-Layer, 5 Day	$30.00	1	$30.00
YTBD	PCB #2	$275.00	1	$275.00
				$678.88

6.4 Risk Management

6.4.1 Design Risks

- Sensors are not accurate enough
  - Carefully research different sensors and alternatives for them in case they don't operate according to expectations
- Too much power usage
  - Let sensors sleep longer/update less frequently
  - Search for low power component alternatives

6.4.2 Schedule Risks

- Plants take a long time to grow so testing is difficult
  - Start testing on plants earlier in the development cycle or find plants that grow very quickly.
- Underestimate time required to complete tasks
  - Utilize stretch goals to keep track of features that aren't necessary and better focus on the most fundamental and important ones
  - Reestimate the effort required to complete the project by meeting regularly. This will ensure each person stays on task until the deadline.
  - Produce a basic prototype as quickly as possible so that there is more time to test and add new features

6.4.3 Resource Risks

- Sensors/fragile parts may break or malfunction
  - Order duplicates of parts in case of failure.
- Plants might die as we begin testing with a prototype version
  - Order lots of seeds as they're relatively cheap.
- People get sick, fall behind, lazy, etc.
  - Have overlapping responsibilities so team members can pick up the slack for other members.
  - Constant communication among team members so that we know when somebody is falling behind.

7 Related Work (Competition)

7.1 Parrot Pot

One similar product, called the Parrot Pot, is slated to be released in April 2016. It is being marketed as an automatic intelligent watering system because while it does have sensors, it does not actually interact with the plant outside of watering it. Parrot also has a plant database of over eight thousand different plant profiles to provide plant specific information. In addition, they plan to provide alerts and notices regarding their plant to users through a smartphone app. While it would be difficult to compete with Parrot's large database, our product offers a few advantages over the Parrot Pot. Specifically, the Parrot Pot can only water the plant, and does not automatically add fertilizer or rotate the plant to evenly spread sunlight. Additionally, we plan to monitor more soil elements than the Parrot Pot.

7.2 DIY Automatic Plant Waterers

Several different types of DIY automatic plant waterers can be found. These designs are generally very basic and involve users buying various parts and constructing the plant waterers themselves. Creation of these products is done individually, and requires both a substantial amount of effort and technical knowledge that most users would not care to use. Additionally, most designs are quite basic and lack any sensory information or user interaction.

References

[1] Adafruit. Chirp! the plant watering alarm.

[2] Kelly Hansen. Is full-spectrum light necessary for plant growth? *Horticultural LED lighting*, 2003.

[3] Heliospectra. What light do plants need?

[4] Chris Hoffman. E ink vs. lcd: Which screen is best for reading? *How-To-Geek*, 2014.

[5] Jungseed.com. 3-way digital soil analyzer.