PhytoHome

TEAM 4: ECE 445 PROJECT PROPOSAL – FALL 2019

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1 Introduction

1.1 Objective

Many commercial aeroponic home systems do not include enclosed and controlled environments for the plant. This leaves the growth of the plant as a precarious exercise as the temperature and humidity preferences of home users vary and may not be optimal for plant growth. Moreover, as far as we have observed, all the systems use white-light LEDS resulting in inefficiencies. This is because plants only absorb specific wavelengths from the EM spectrum, particularly from the blue and red channels. The rest is reflected or dissipated as heat energy.

These inefficiencies will be resolved by providing an enclosed environment with temperature and humidity control and the integration of OLEDs that emit only the specific wavelengths that are absorbed by plants. With these new features and technologies, an optimal environment for plant growth can be achieved and lighting power input per kg of food will decrease, improving the overall efficiency of the system.

1.2 Background

With the world population projected to reach 10.9 billion by the year 2100 according to a statistical analysis of collected data by Our World In Data, a serious question to consider is whether traditional farming methods will suffice to provide the necessary produce for human flourishing, needless to say survival. In consideration of this question, many contemporary agriculturists are beginning to view traditional farming methods incapable of efficiently producing the food the future world will require. Instead, they are increasingly beginning to look at the concept of vertical farming, which is the idea of using enclosed and controlled environment vertical infrastructure to accommodate layers of food production, thus reducing the amount of horizontal space needed, which is far more limited on our earth. To support the production of food in vertical structures it is expedient to integrate technologies that will facilitate and optimize the process.

A particular method becoming popular in vertical farming is aeroponics, which uses a food/water system to feed and hydrate plant roots through injectors that disperse the nutrient-laden water as a spray. Using this system considerably reduces the amount of water needed to grow crops; to grow 1 kg of lettuce in traditional farming it would take 250L of water as opposed to 1L of water in aeroponics. The hopeful expectations of aeroponics in its ability to grow crops indoors has led to its commercialization, particularly for home production. However, many commercial models do not engineer the system to fully control the environment of the plants and therefore do not precisely maintain the conditions optimal for plant growth. With PhytoHome, the environment of the plant will be partially controlled in terms of its temperature and humidity, while a water/feed system will provide it with food and water.

1.3 High-Level Requirements

A list of at most three quantitative characteristics that this project must exhibit in order to solve the problem. Each high-level requirement must be stated in complete sentences and displayed as a bulleted list.

- PhytoHome RAS must be able to provide a temperature assisted environment that performs heating through either a small space heater or incandescent light, and provide minor cooling through a fan ventilation system and water misting. PhytoHome will not be able to provide significant cooling in extreme ambient heat conditions like a hot summer day.
- PhytoHome must be able to provide sufficient light to the plants through organic LED lighting, as well as monitor ambient sunlight to determine the amount of necessary operation time.
- PhytoHome must be able to provide intermittent or constant water misting directly to the roots of the plants to provide nutrients and sustain plant life.

2 Design

2.1 Block Diagram

A modular representation of the key entities in the system are represented by the block diagram below. The main control unit of the design is the microcontroller, which controls the habitat for the plants based off of information it receives from each of the three main sensors. For a more explicit correlation: photosensors indicate brightness, intensity, and duration of light in the lighting system, whilst temperate and humidity sensors indicate the necessary heating and cooling for best ambience under HVAC system. Water/feeding system is independent of sensors, and functions on the basis of each plant's unique nutrition schedule. All these subparts are essential to optimal simulated environmental conditions in the aeroponics chamber.

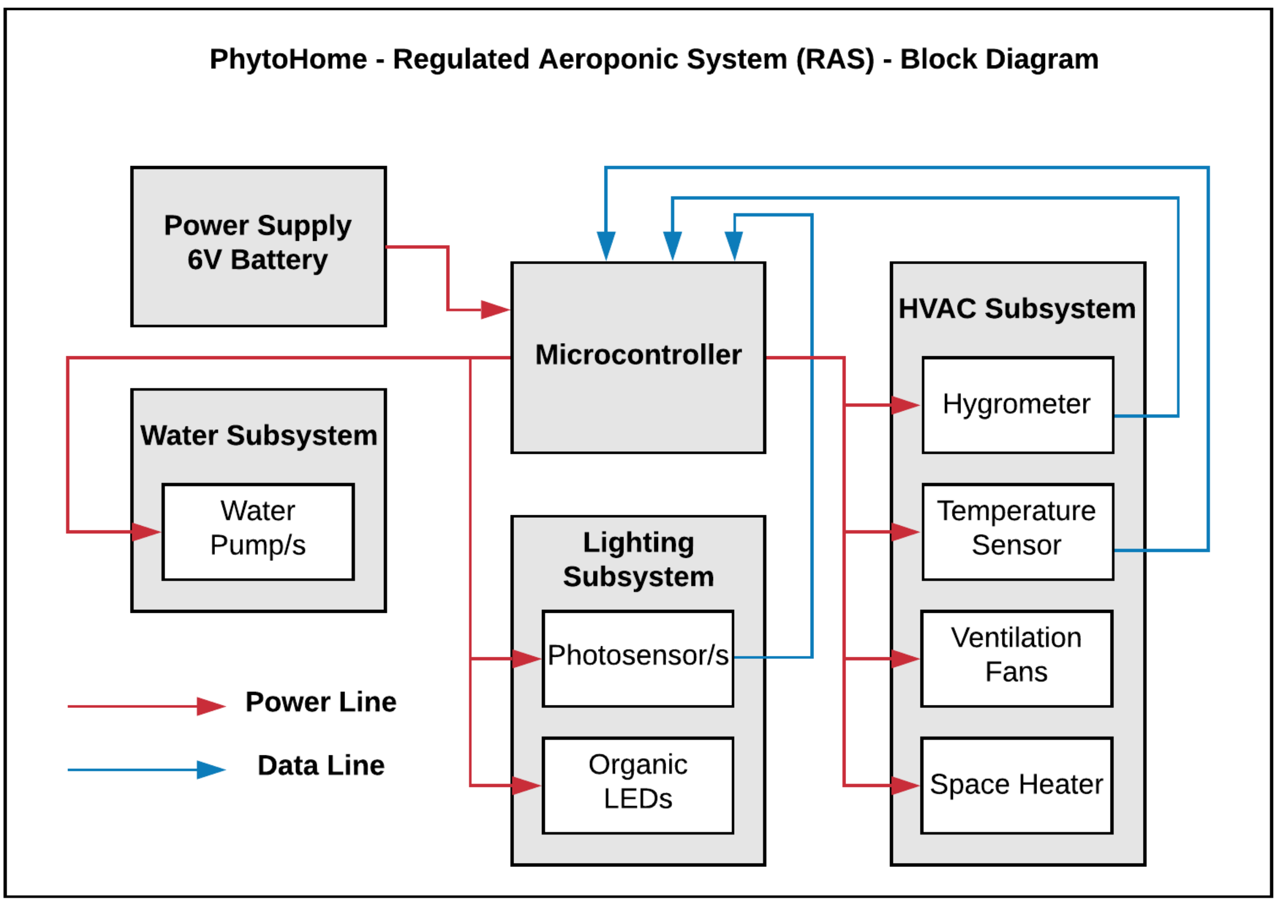

Figure 1. Block Diagram

2.2 Physical Design

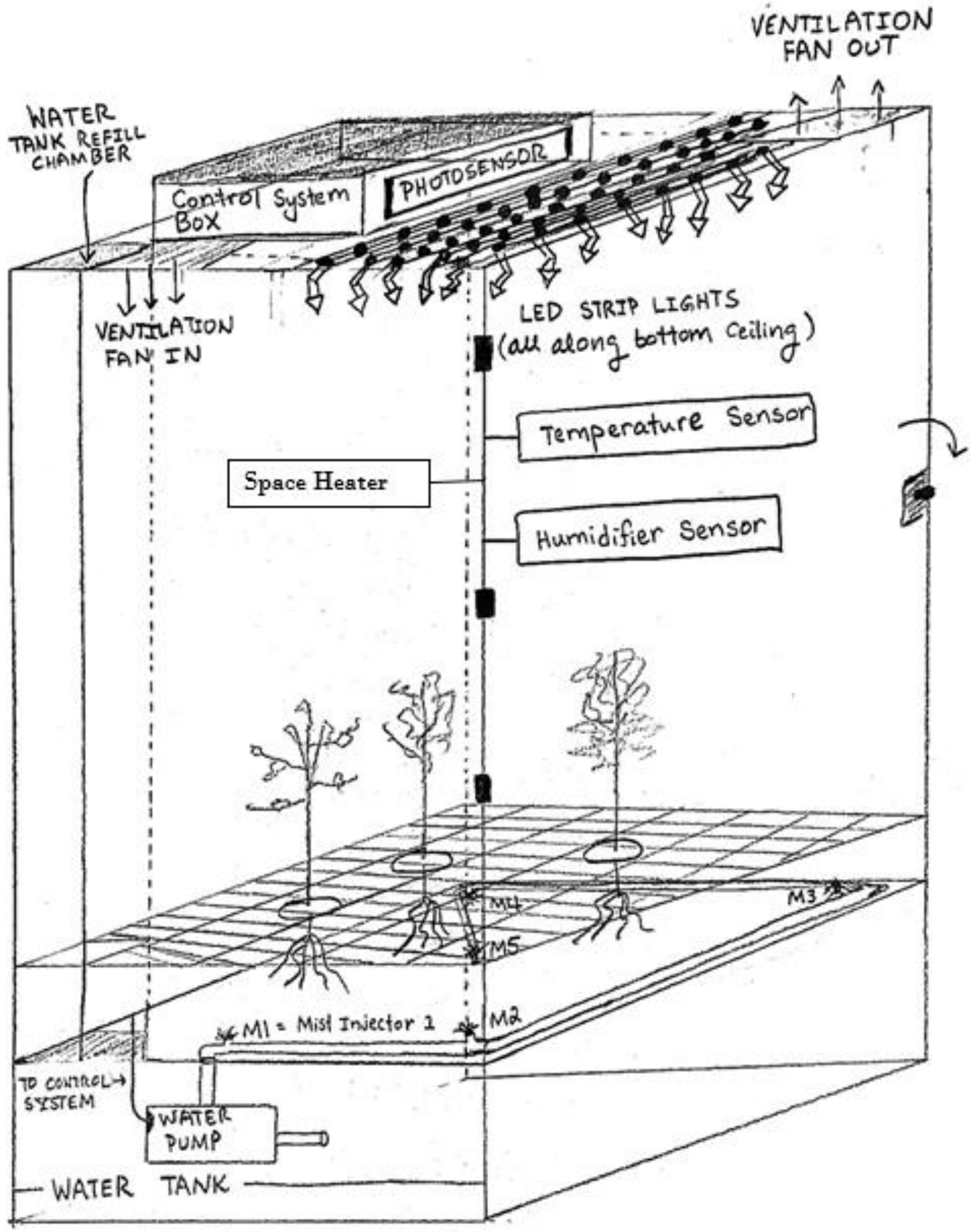

Figure 2. Physical Diagram

2.3 Functional Overview

2.3.1 Power Supply

The power supply has two primary tasks: the first is to supply the power to maintain constant data transfer from the temperature and humidity sensors to the microcontroller and accordingly operate the HVAC system; the second is to provide power to the intermittent systems like the water/feeding system and lighting system whenever necessary. Regarding the HVAC system, the power being supplied will be to drive a fan motor and current for a space heater. For the water/feeding system, power will be supplied to a pump motor to pressurize the water tubes that connect with the injectors.

2.3.2 Microcontroller

The microcontroller, ATmega328P, is the brains and will receive data from the sensors and compute this data to determine how to manage all the other subsystems. All sensors belonging to the lighting and HVAC subsystems will be connected as inputs to the microcontroller while its outputs will be used to power and control the remaining entities: water system pump, lighting subsystem OLEDs, HVAC space heater, humidifier, and ventilation fans.

2.3.3 Water Subsystem

The water subsystem consists of the water tank, pump, and injector positioned on the bottom of the PhytoHome system. It delivers nutrient-laden water to the roots of the plants in the feeding chamber by pressurizing the service tubes with a water pump (refer to **Figure 1**). This ensures that the amount of water and nutrients necessary for optimal plant growth is controlled efficiently. It is crucial that this subsystem be physically attached to the overall design because not only does it just hold the water, but also allows for ease of water transfer via the injectors, which distribute the water resourcefully.

2.3.4 HVAC Subsystem

The HVAC System is responsible for monitoring and controlling the temperature and humidity of the plants environment. This is achieved through sensors, ventilation fans, and a space heater.

The hygrometer is a sensor that is used to continuously record humidity data of the environment and provide it to the microcontroller to maintain optimal humidity levels for plant growth.

The temperature sensor will constantly provide temperature readings to the microcontroller to maintain optimal temperature levels for plant growth. The ventilation fans are used cool the environment whenever temperatures reach levels that are detrimental to the plants growth.

Last but not least, the space heater will work to provide heat to the environment any time that the temperatures rise too high and obstructs the development of the plants.

2.3.5 Lighting Subsystem

The lighting subsystem is purposed in providing the necessary radiation for the plants to undergo photosynthesis. In particular, OLEDs will be used to deliver the proper blue and red wavelengths that are best absorbed by plants, eliminating any unnecessary waves. To determine just how much OLED light is needed by the system, photosensors will be used to detect natural light entering the PhytoHome. Based off its feedback, the OLEDs will adjust accordingly to just how bright they need to be.

2.4 Block Requirements

Block	Requirements
Power Supply	• For proper functionality of entire system, the total power supplied should be 6 V with a tolerance of ± 0.5 V • Given than a 6 V battery is being used to power the entire system, the PhytoHome should be able to stay turned on for at least 1 week straight without having to replace the batteries • In the case of a short/high amperage, a fuse will be installed downstream of source with an LED to signal that such has occurred, and will open to prevent any physical, harmful malfunctions • An invertor will be placed as well to monitor that no voltage sags occur and that microcontroller is always supplied 6 V ± 0.5 V
Microcontroller	• Provides voltage to water, lighting, and HVAC subsystem for the entire time system remains “on” • Takes feedback data from water, lighting, and HVAC system to determine settings for space heater, ventilation fan, and water pumps • In case microcontroller fails to properly read/send data for any subsystem, that subsystem will shut off and that will serve as a visual indicator that there is a fault

Water Subsystem	• Will have a timer controlled via microcontroller to regulate what times injectors must set off to "feed" the plants • A visual black line on glass water tank will dictate how much the tank should be filled up to • A visual red line on glass water tank will dictate that it needs to be refilled once tank water reaches below this line • The intensity/pressure in which the injectors will shoot out water will be controlled through pump, which is then controlled through microcontroller • The wiring for pump motor must physically be separated from water to prevent any fatal hazards in case of contact
Lighting Subsystem	• Microcontroller needs to be outputting 5 V ± 0.1 V the entire time it is "on" to ensure correct functionality of LEDs • One photosensor will measure how much natural light is coming into chamber, and will send signal to microcontroller to adjust brightness of LED lights • A second photosensor will be measuring total (artificial + natural light) in system to make sure it remains just approximately 40 W ± 5 W for sufficient photosynthesis to take place

HVAC Subsystem	• Will use a hygrometer to measure humidity in chamber to ensure humidity remains between 40%-70% for vegetative plant growth • If humidity falls out of desired range, then injectors will spray water in chamber to increase, or run ventilation fans to decrease. This is controlled via microcontroller • Temperature sensor will send data to microcontroller if environment is either too hot or too cold • Since herbal plants will be used for testing, desired temperature range to be set is between 55-70 degrees F • If temperature sensor detects environment is too cold, will send signal to microcontroller to turn on space heater until desired temperature of at least 55 degrees is reached • If temperature sensor detects environment is too hot, will send signal to microcontroller to turn on ventilation fans until desired temperature of at least 70 degrees is reached

2.5 Risk Analysis

For PhytoHome to perform as desired, the necessary radiation, food, water, temperature and humidity must be provided. This firstly depends on correct data regarding the quantities of each of the above parameters, which is obtained through the respective research. Inherently involved in this is the possibility of inaccurate, incompetent or dishonest sources which misrepresent the facts regarding the specifics of the variables important to plant growth. To circumvent this to some extent, a broad research initiative must be undertaken to obtain multiple sources, mitigating the risk of planning sole on single faulty source, but rather assimilating a general consensus among the surveyed sources.

Assuming the proper, accurate data has been obtained to serve as the subsystem performance requirements, an improper selection of subsystem components can result in the failure of meeting these requirements. The main components to consider are the water pump motor, LEDs, space heater, and humidifier. The water pump must be chosen to provide the necessary PSI to the water service tubes so that an effective spray results ejected from the injectors. This is a vital role since it's through the injectors by which water and food reach the roots of the plants.The LEDs must be chosen so that they emit the specific blue and red wavelengths that the plants absorb. Emission of wavelengths considerably away from the desired ones can result in reflection or dissipation as heat energy, resulting in death of the plant. Both the space heater and humidifier must be able to effectively change the temperature and humidity of the environment within a reasonable timeframe. In other words, if the temperature in a room is low, say 65 degrees, then the space heater should be able within minutes to bring the temperature of the environment up by ten to fifteen degrees. This is for the reason that if the heating process takes too long, permanent damage can be incurred on the plant depending on how low the temperature is. On the side of humidity, the major concern is to be able to reduce the environment's humidity, for the reason that too much humidity can facilitate the growth of mold and bacteria on the plant and its environment. The dehumidifying will be possible by fans that ventilate the plant space.

3 Ethics & Safety

In IEEE Code of Ethics statement #7 mentions undertaking “technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations” [1]. A legitimate safety issue is that the task of creating PhytoHome is being undertaken by engineering students with limited professional experience. Thus, here it is ethically necessary to fully disclose our pertinent limitations, namely lack of experience that increases the risk of accident and warrants additional measures of technical review and criticism.

There are two safety issues relevant to our project. The first is that of potentially misdesigning our circuit so as to cause electrical failure in such a way that increases the risk of electrical shock, burns, and fire hazard. The second is the danger of having electronics operating in and/or near water sources. While considering these two safety issues that may arise during the development of our project, it is important to consider the ethical obligation to avoid harm that is set forth in section 1.2 of the ACM Code of Ethics and Professional Conduct, part of which says, “Well-intended actions, including those that accomplish assigned duties, may lead to harm” [2]. Thus, even though our team has set forth to embark on a process of well-intended actions in order to solve a problem we consider serious to the bettering of our world, these actions may unintentionally lead to harm, and we are, as the ACM code goes on, “obliged to undo or mitigate the harm as much as possible” [3].

Intentional or accidental misuse of our product is foreseen if the mechanical design is altered in such a way the safety precautions which involve separation of circuitry from water, and tampering with the location of the heat source to place it in an area of PhytoHome that increases user risk of burns. Additional misuse that our current design would not have control could come from using PhytoHome for a process that facilitates the growth of plants used in the production of illegal drugs.

We will thus seek to avoid ethical these and other potential ethical breaches and safety issues by disclosing any obligated ethical information, consulting superior technical support when deemed necessary, and through careful design to limit device alterability and testing of PhytoHome in order to ensure sufficient safety measures. In addition, since, as the Illinois General Assembly Professional Engineering Practice Act of 1989 states, “The practice of professional engineering in the State of Illinois is hereby declared to affect the public health, safety, and welfare and to be subject to regulation and control in the public interest" [4], we will take our project seriously and work towards a deliverable that is safe and benefits the public welfare.

4 References

[1] “IEEE Code of Ethics,” IEEE - Advancing Technology for Humanity. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html [Accessed: 09-15-2019]

[2] “ACM Code of Ethics and Professional Conduct,” ACM - Association for Computing Machinery. [Online]. Available: https://www.acm.org/code-of-ethics [Accessed: 09-15-2019]

[3] “ACM Code of Ethics and Professional Conduct,” ACM - Association for Computing Machinery. [Online]. Available: https://www.acm.org/code-of-ethics [Accessed: 09-15-2019]

[4] “Professions, Occupations, and Business Operations (225 ILCS 325/) Professional Engineering Practice Act of 1989 Sec. 1,” Illinois General Assembly. [Online]. Available: http://ilga.gov/legislation/ilcs/ilcs3.asp?ActID=1344&ChapAct=225%26nbsp%3BILCS%26nbsp%3B325%2F&ChapterID=24&ChapterName=PROFESSIONS+AND+OCCUPATIONS&ActName=Professional+Engineering+Practice+Act+of+1989%2E [Accessed: 09-15-2019]

[5] “Population of the World Today” – Our World in Data. [Online]. Available: https://ourworldindata.org/world-population-growth [Accessed: 09-17-2019]