Team Hydro

Georgia Tech Grand Challenges

Proposal

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Problem Statement: How Might We

How might we improve the economic & operational efficiency of hydroponic systems in order to encourage the widespread implementation of sustainable agriculture?

Problem

Hydroponics is an agricultural method that depends solely on growing plants in mineral/nutrient-based solutions. As Team Hydro, our mission is to improve both the financial and operational efficiency of large scale/industrial hydroponic systems. Our team has defined financial efficiency to be the reduced cost of running of a functioning hydroponics system. Today, the cost of labour at a large or small scale hydroponics system is exorbitant and our team is confident that this cost can be greatly reduced by improving operational efficiency. Our team has defined operational efficiency to be the greatest output (crop growth and yield) to input (time, money, labor, nutrients, supplements) ratio. We firmly believe that by tackling the operational and cost efficiency of hydroponic systems, we can facilitate greater spread of sustainable farming.

Finally, we chose to implement our solution to industrial hydroponics systems because of their large scale. We wanted to devise a solution that would have the greatest and most varied outreach, and we believe that incorporating our solution in an industrial system will allow us to achieve this objective. In terms of time scale, we envision developing a solution that can be implemented in contemporary agricultural system and can be sustainable for years to come.

Significance

Agriculture is one of the most inefficient sources of resource use and one of the largest causes of pollution in the world. It is already insufficient to meet global food demands in some areas of the world (developed countries have massive food surpluses while poor and underdeveloped countries face crises of food shortage). According to the United Nations, "by 2030, food demand is predicted to increase by 50% (70% by 2050)." Agriculture "consumes 87% of the freshwater withdrawn in the world" (Bioscience) and "is a major use of land, accounting for around 51 percent of the U.S. land base" (USDA). This is due to the very resource-intensive methods of farming we've developed over the course of human history. In addition, many of the nutrients that are used in agriculture, i.e. the herbicides and pesticides, are causing significant damage. "Nitrogen compounds from Midwestern farms, for example, travel down the Mississippi to degrade coastal fisheries and create a large 'dead zone' in the Gulf of Mexico where aquatic life cannot survive" (U
CSUSA). In fact, according to National Geographic, this dead zone will likely soon be the size of New Jersey. Traditional agriculture is also very slow, taking months to produce a single harvest.

The problems of water, land, pollution, food distribution, and time can all be addressed by implementing hydroponics. For example, Podponics, a local hydroponic farm in Atlanta, has implemented a system that uses 10% of the water, 5% of the power, and 10% of the land in comparison to conventional agriculture (Podponics). In addition, the nutrients used in hydroponics are contained so the environmental effects are minimal. Water is recycled and no fertilizers (besides the basic nutrient solution), herbicides, or pesticides are necessary. Additionally, any pollutant waste can be disposed of safely.

Hydroponics have many significant benefits. Some include the following. Hydroponic facilities allow a greater number of crop cycles per year since plants can grow much faster (harvests can be ready in a matter of weeks, not months) and because crops can be produced year-round (Caldeyro-Stajano). Hydroponics can also be used to combat food distribution inequality, since these systems can be implemented in areas such as deserts, swamps, and rocky areas that currently can't produce food. Another advantage is that food can be produced closer to the point of consumption; even in large cities plants can be grown indoors and with much less space. This leads to fresher and more available food for millions of people all over the world.

The main problem with hydroponic systems, the reason they're not currently utilized at a level that could make a significant impact on these challenges, is the cost of startup and operation of the systems. Up to 70% of operational costs come from labor (Podponics). That is the issue we wish to address with this solution. The knowledge and methodology to conserve precious resources and feed the world's hungry are there, and we wish to make it easier than ever to implement this revolutionary technology.

Stakeholders

There are multiple individuals, communities, and organizations that would be interested and/or impacted by a solution that would improve the economic & operational efficiency of hydroponic systems. Here are four such stakeholders, and their likely viewpoints on the solution.

Entrepreneurs

An entrepreneur is anyone who starts of operates a business. For people looking into new areas for business, hydroponic farming is an ideal source. Hydroponics is a growing industry. It allows for areas where no traditional farming can take place to have thriving farms. For example, Freight Farms in Boston, MA has been receiving loads of press in the past few months. The farm uses shipping containers to grow food in Boston year round (Freight Farms). This is especially significant due to the continuous cold weather that has cause transportation to Boston to be limited. Deserts and places currently facing droughts can also have large hydroponics farms, which allow lettuce and other vegetables to be supplied. Hydroponic systems would allow business owners to set up in large cities, non-ideal climates, and take up less space. Any creation that would allow hydroponic systems to be easier to operate would make them more enticing for small businesses to use. Owners want to reduce costs, cut down the time it takes from initial setting up and planting to harvesting, while making sure the maximum amount of plants survive. This allows for the most profits and less risk when starting a business.

Hydroponic Farmers

Hydroponic farmers are farmers who use hydroponic systems to grow their produce as a profession. Hydroponic farms and farmers range in type and size; a hydroponic farm could be as simple as a greenhouse with basic hydroponic systems, or large warehouses with stacked pods in an industrial setting. Podponics, founded in 2010, is a local producer of various plants such as lettuce and kale grown using hydroponic methods. Podponics, like many other hydroponic farms, are concerned with the 3 p's (people, produce and profit) (Rich, S.). They would be interested in a more cost efficient method that could easily be integrated to their existing farming methods. There is massive demand for automation in hydroponic systems. All growers are after the same thing: optimum crop performance with minimal effort and expense. (Automation - Optimum Crop Performance | American Hydroponics. (n.d.).) The next opportunity hydroponic farmers would invest in is physical automation of their hydroponic systems to reduce operational costs and improve profits.


Podponics

Consumers

Consumers are the people who will purchase the fresh produce and are the largest group out of the stakeholders. If a business does not do well it will not hurt them financially, but there are many reasons why a consumer would be invested in our idea. One is the number of food deserts around the world. This has been a consistent theme in justifying the projects' importance. In Montreal, for example, 40% of people without a car do not have access to fresh produce (Larsen, 2009). This lack of fresh food has been proven to result in more purchases of processed food and generally more expensive food. Processed foods are generally designed to have a high calorie value in order to be filling, but have less nutrients (Chin, 2013). A low cost or easy to implement hydroponics system would allow for cheaper, more nutritious food to exist in areas where none does now. A resident in a food desert would be happy to have a farm set up closer to their house. Consumers were surveyed to see how important certain aspects of growing food is ranked when purchasing. Over 80% of people said freshness was most important, and other key needs are safe to eat, support local economy, and environmentally friendly (Yue 2009). For these reasons, hydroponic systems would be popular, as they take up little land, and require little transportation since they can be set up anywhere.

Traditional Farmers

Traditional farmers use "traditional" methods to grow produce as their main income. Traditional farms are focused on expansive plots of extensively-tilled land that grow plants to sell for profit. Traditional farming includes methods used today that include floodwater farming or irrigated gardening. All these methods require soil to grow crops, and are used by the vast majority of farmers today. Farmers prioritize profit, and turn to traditional farming as it currently has a higher crop value yield than hydroponics (Hoagland, D., & Arnon, D).

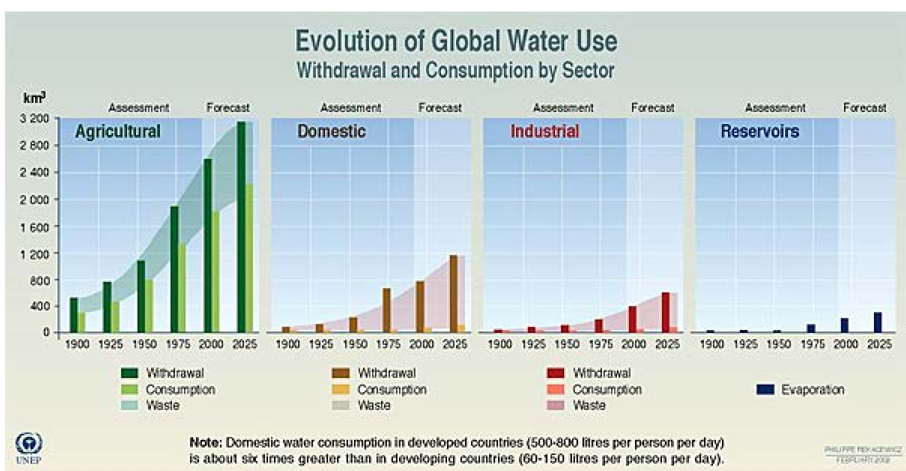
Therefore, farmers would be open to more a profitable farming technique. Additionally, farmers are becoming more and more concerned about water conservation and soil degradation (Bruening, T. H., and T. J. Rollins.) and therefore would be very interested in a technique that could increase their water efficiency without decreasing their profits. For example, the California Farmers' Markets Association is heavily concerned with more sustainable agricultural practices after the recent droughts risking their profits and recent government bills placing restrictions on water usage. A cost-efficient hydroponic system would alleviate their worries and bring economic and environmental sustainability.

Context & Existing Solutions

Hydroponic systems are showing massive potential for large-scale application all around the world. There are many improvements and automation systems available from small-scale hydroponic farms all the way to industrial-scale hydroponic facilities. Identifying a niche improvement in hydroponics is the core purpose of our team. By working on a niche technological improvement, we further optimize hydroponic systems and encourage their widespread implementation. Looking at past, present, and future work in sustainable and traditional agriculture helps us provide context to identify this niche. In this section, we define the background information to the problem and see how current solutions address the problem. We look at Podponics, an Atlanta-area hydroponic facility, and their automation efforts and operational improvements. Then, we look at open-source, smaller-scale efforts. Finally, we look at efforts in traditional agriculture and their application in hydroponic systems.

The Need for Sustainable Agriculture

The overarching issue in sustainable agriculture is defining *why* there is a need for sustainable agriculture. Without defining a need for hydroponics, we cannot suggest why the systems need improved at all. Hydroponics is attractive for numerous economic and environmental reasons. Hydroponics is known for extreme resource-efficiency, typically using 10% of the water and 10% of the land in comparison to traditional agriculture (Skip Menu. (n.d.)). Agriculture currently accounts for about 70% of the world's water use, so reducing water consumption with sustainable agriculture would have a truly massive impact. As the world becomes more and more urbanized and our population density increases, hydroponics becomes even more attractive for its land usage. We can grow food anywhere--on skyscrapers, in backyards, in deserts, on Mars. Looking into the future, the United Nations estimates that the world will need 30% more water and 50% more food, and they estimate that water scarcity will affect 50% of the world's population within the next 25 years. The world *needs* sustainable agriculture, which is why sustainable agriculture and hydroponic technology are so important.



Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational Scientific and Cultural Organisation (UNESCO, Paris), 1999.

Contemporary Hydroponic Implementations

If hydroponics is so promising and revolutionizing, then why has it not been applied on a large scale? The reason is that the required capital for startup, maintenance, and labor are enormous. In some areas of the world, cost has had little impedance to hydroponics, like the Netherlands, which, despite its size, is the second-largest exporter of agricultural products in the world (Statistics Netherlands (CBS)). The image on the right shows one of their indoor production facilities. Facilities like these in the Netherlands provide massive evidence for improving the cost-effectiveness of hydroponic systems and making them more attractive to more countries and businesses.

For a successful business model and implementation of hydroponics, however, facilities do not need to be built in spotless warehouses managed by European scientists in white lab coats. Podponics LLC is a hydroponic facility that provides lettuce and kale to local Atlanta supermarkets. Podponics grows 100 acres of produce in less than 1 acre of stacked shipping containers, and they have mastered several key components of hydroponic automation with their own proprietary technology. For water delivery, Podponics developed their own computer chips for automating when water is delivered to the plants. For energy, Podponics runs 480 volts from Georgia Power and has developed an API for detecting when energy is cheapest (2-4 AM) and running their facility at its peak at this time. The LED lights are also ran at 480 volts and the frequency of their flickering (which is not noticeable to the human eye) is modulated. Despite this amazing system, Podponics has not automated any labor expenses: maintenance, planting, and harvesting are still their main expenses. They also must flush their water every so often due to pH issues, which is obviously inefficient. We have the opportunity to tackle these issues and hope to partner with Podponics in the near future.

However, not all hydroponic automation and maintenance technologies are proprietary business technologies. The open-source community has embraced hydroponics and its potential for automation and maintenance improvements. The Robotic Urban Farming System (RUFS) is an open-source system whose components and instructions are available online for free and integrate Raspberry Pi & Arduino, two popular versatile computer chips. This system has the ability to monitor and correct temperature, humidity, lighting, water cycles, nutrients, and pH. However, the system is not very large and key labor components are not automated (as with Podponics, however this is a much smaller operation). Perhaps this system could be expanded to a larger scale (like a Podponics shipping container). Using open-source technology is very attractive because it thrives on community involvement. If we develop an automation system that can be applied on many scales, it should be available to everyone because doing so is more conducive to widespread implementation.

The Effect of Automation on Production

But how do automation and robotic system improve hydroponic systems? Hydroponics is much like a factory; it's a biological assembly line in which the plants are the products. Automation and robotics have been shown to increase productivity. The study "Automation, labor productivity and employment – a cross country comparison" found:

> *If countries increase the degree of automation to the same level as in the corresponding industries in the most automated country, the countries in our sample may increase aggregate productivity in the manufacturing sector between 8 percent in Germany and Japan and 22 percent in UK. Further, long run employment would tend to increase between 3 percent in Germany and Japan and 7 percent in UK.*

Automation has massive economic potential, especially in sustainable agriculture has not been completely implemented. However, improving hydroponic technology through automation is not just through making automation systems; it's also about making the components of automation easier to manage. The growth medium is one such component that heavily impacts the pH of hydroponic systems. For example, rockwool, a popular growth medium, must be pH-neutralized before use and many mediums need significant periodic cleaning, which is inefficiency and expensive (Home Hydro Systems) . By developing a new growth medium, we can reduce the need for pH automation and resource use. However, Team Hydro is headed towards automation & control systems because improvements in the growth medium and pH management are only marginal, and are largely offset by a well-designed control system.

Through Podponics and open-source designs, it is clear that maintenance improvements are very attractive from a business and community standpoint. The two pieces of hydroponic automation that are open to Team Hydro are scalable automation systems and labor automation. There has been work into labor automation of traditional agriculture. Next, we look at these systems and how they can be applied to hydroponic systems.

Automation in Traditional Agriculture

The labor automation of traditional agricultural systems has been a widely accepted tactic in an attempt to increase the sustainability of agricultural methods. Sustainability in agriculture is becoming more and more prominent as the world population continues to increase. In order to become more sustainable, alternative agricultural practices are becoming more widely used. These practices focus on increasing agricultural output without affecting the environment, increasing crop yields, increasing the efficiency of nutrients and implementing ecologically based management practices. In order to accomplish these goals, automation has been growing in popularity in agricultural practices. Some of these automation ideas include the use of robots to analyze and harvest crops, and Farm Management Information Systems (FMIS). Combining these automation ideas with hydroponics (which already increases sustainability) has the potential to further promote the health of the environment while improving agriculture (Tilman).

Robotic Implementations

The use of robots in agriculture has been slowly growing in popularity as technology is becoming more accessible. These robots include the use of GPS-navigated tractors and other machinery to help prepare the farm for planting and actually plant the seeds. More recently there have been strides to increase the use of robots in farming by expanding their uses to include other farming procedures. Research has been taking place in Australia as the farm industry there is growing rapidly due to their increased role in providing food for Asian countries.

Professor Sukkarieh, a professor at Sydney University, has been exploring these possibilities of expanding the role of robots in agriculture. Their focus is in creating robots that have the ability to take in data of the surroundings and create an outline/map of the farm to use in the robot's navigation of the farm. Furthermore, these robots have the ability to collect, analyze and present information about the quality of the soil. Using this information, farmers will be able to more accurately water, fertilize and put pesticide their crops. In addition, it will cut down on the time commitment of farmers allowing them more time to produce more crops. The combination of increasing plant health and providing them with more time will allow for the increase in crop yield.

Furthermore, Professor Sukkarieh hopes to apply this technology to tractors and allow them to directly process the data rather than going through the farmer. This will allow the tractor to directly fertilize, place pesticide, mow, or sweep the crops depending on the data received from the robot implemented into the tractor.

In addition, this technology can also be used to implement automation in the harvesting of crops; there has been success in creating robots that have the ability to identify individual fruit on trees and determine its ripeness relatively accurately. Using this technology and the ability to learn the map of the orchard, they are working on creating a robot that can harvest crops and replace the hand-labor necessary to do the task otherwise. Professor Sukkarieh believes that they are 80% done with successfully developing such a robot and is currently working with farmers on the implementation of the technology. These farmers will be the first field test of the robot and, if successful, he hopes to begin widespread implementation of the harvesting robots.

Though this research is in the field of traditional agriculture, it also is very applicable to use in hydroponic systems. Currently, there is no technology that has the capabilities of harvesting crops and the labor necessary is one of the higher costs (in time and money) of having a hydroponic system. Using some of the same technology to be able to analyze plant health such as identifying the edible part of the plant and its ripeness, a robot could be developed with the same capabilities to harvest as a robot in a traditional agricultural setting.

The only difference would be the robot would be harvesting in a more enclosed space, in a stacked system which could be taught to the robot through the same learning algorithms that allow the robot to outline and map a traditional farm. Once taught when and where to harvest, a robot would have the potential to successfully harvest a hydroponic system. Furthermore, the technology could further increase the water efficiency as the robot could tell the system what row of plants do and do not need water on that particular cycle of watering. This would result in an even greater cost-efficiency of the system and continue the push for sustainability in agriculture (Hollick).

Why is it still a problem?

The root of any problem can almost always be boiled down to finances, and hydroponic agriculture is no exception. The reason the high cost of implementing hydroponics systems persists seems to be a multifaceted dilemma. The crux of the problem seems to lie in the fact that the technological capabilities and infrastructure to make hydroponics relatively inexpensive has not been developed and implemented on a large scale. This again raises the question, “why not?” The answer is demand. Less economically developed countries (LEDCs) such as Uruguay have developed low cost and “easy-to-learn” techniques that use pvc pipes, wooden crates, and coconut husks. While these type of techniques are not feasible for our target market of large scale industrial systems, these LEDCs saw the advantages of hydroponics early on and the demand for relevant low cost technology developed. In the United States however, the field of hydroponics is relatively new and emerging, but is simultaneously quickly growing. As this trend quickly develops within the United States, we are confident that the demand for low cost hydroponics will emerge as well. When it does, the only gap that will remain is the need for the technology and expertise, which we as Team Hydro hope to fill.

Secondly, this is also a “perceived” problem. The sticker cost of setting up a hydroponics system may be alarming, but many fail to see the return on investment of establishing a hydroponics system over time. The next steps to combating this part of the problem would be would be to justify the high cost of hydroponics by outlining the various benefits a successful hydroponics system would bring such as improved resource efficiency and a more nutritious and productive crop yield.

Proposed Work

Goal

Our overall goal is to make hydroponics easier to implement and maintain at a cost-efficient level. We believe this could be done through automation. If our solution is successful, a cheaper hydroponics system would be available for public use. Based on our improved hydroponics system, more people would see hydroponics as a viable replacement to traditional farming. If we make hydroponics more accessible and less expensive, hydroponics would be more appealing to new businesses. We have seen many start ups focus on hydroponics and build hydroponic farms close to cities. Many variations of hydroponics systems exist and their appeal is growing for these reasons we want to focus on improving hydroponics.

Objectives

Find a space/place to work

In order to proceed with the development of our solution, our first step is to find or create a space where we have the ability to work on our project. Since our solution involves the creation of a prototype robot, we need to have a hydroponic system available to us in order to test our final product. Therefore, this space must be big enough to store our materials for the creation of the prototype as well as have a hydroponic system for us to use in conjunction with the prototype. Without having space to set up a hydroponic system, it would be impossible to test our robot and check if our solution was actually successful.

The actions necessary to achieve this objective consist of contacting information groups that already have hydroponic systems established and checking to see of the possibility of us using their systems. Two groups we are currently looking to contact about using their systems are Engineers for a Sustainable World and Podponics. Both of these groups have systems within driving distance that would be highly useful for us. It would be ideal if both groups were willing to let us use their systems for testing as it would provide a test to make the robot applicable to multiple systems. After contacting the organizations, we need to arrange a meeting about the possibilities of using our robot for testing on their systems as well as determine the measurements of their systems. In addition to the space needed for the hydroponic system, we would need to locate a place to store our robot during its developmental stages as well as a place to work on it. Ideally, this would be close to the testing facilities but we may need to be flexible.

The success of this objective can be easily determined by our ability to acquire a hydroponic system (ideally one already set up) that we can test our prototype on as well as locating storage and workspace for our prototype. If we find a space to set up a hydroponic system on a small scale, or manage to find a hydroponic system already set up that we could use for testing, we would consider this objective as a success.In addition, finding a space to work on our prototype and a place to store the robot would be an another measure of success.

One obstacle would be the inability to find a system that is already set up and have to create our own system. This would not be extremely difficult but would require more resources in both time and money than using a system already established. Furthermore, having to set up our own system even though it would be on a very small scale would take up space which is one of the most difficult resources to acquire especially since we are based in a city. We might have to forgo the complete establishment of a hydroponic system and instead, only create the few necessary parts needed for testing and set up the pieces in someone’s dorm room. The difficulty to acquire space may also result in the obstacle that the robot must be stored entirely in one person’s room or may have to be transported many times as we work on our project.

Find a partner

Along with finding a space to work, we would need to find a partner who is willing to work with us and collaborate us as we move forward with our solution direction. We need to have someone willing to push us toward a solution as well as give us insight on what the industry wants/needs in our solution direction; for example, what specific style of planting robot is preferred? This partnership would be vital in providing us with knowledge of robotic design as most of our expertise within automation is only on the surface level. We want to find a partner who can help guide us along the design process and provide a basic analysis of whether they believe our design is practical and feasible to build.

The steps to accomplish this task begin with contacting outside organizations with experience in the field who have either worked with hydroponics or robotics, ideally both. Currently, we are communicating with several contacts who are involved in agricultural robotics/ robotics in general and some contacts who are involved purely in hydroponics. We are continuing to explore further partnership possibilities in hopes of locating a partner with experience in both fields. Since this is unlikely, we may be looking to keep in contact with multiple organizations and have more than one partner organization for different aspects of our solution. Following the contact, we need to arrange a meeting with the organizations to state our interest in partnering with them in our project and sell them the idea of working with us to complete the project. Finally, we need to close the deal with the partnership by officially declaring our interest to work with the organization and/or company and discovering whether they would be interested in assisting us in our solution process. This may involve getting an officially signed document stating our commitment to help the organization and their commitment to assist us as we proceed with our project; it would also clarify what information would be shared between the two parties.

Success can be most accurately measured by the relationship we develop with our partner/s as we move through the solution process. We would like to stay in constant contact with our partner, keeping them up to date on what we are proposing in our prototype and getting feedback on its applicability and design feasibility. We want to make sure we receive input at our multiple stages of design, implementation and testing in order to ensure our prototype successfully accomplishes its task in a way that is appealing and applicable to current consumers. Through a constant relations with our partner, we hope to ensure the development of a meaningful solution with real-world applications.

One obstacle to establishing successful relations with a partner would be the possibility of working with a business. Since their main goal is to turn a profit, it would be difficult to define the role of each of the groups as we work toward our solution. This would most likely be overcome by official negotiations and a document being signed clarifying each group's role in the partnership. In addition, there is a chance we would be working with multiple partners so we would need to be organized and make sure that we interact appropriately with both parties and make sure that each realizes we are receiving assistance from the other.

Develop a design

Our next step is to design our robot. After further research and thoroughly brainstorming ideas from all team members we will decide on one solution. We know we will be working with planting seeds at this point, but still have a some variables to decide. As of now we have a few ideas for the functionality and looks of the robot that will be presented to robotics professors to see what is plausible and most likely to succeed.

There are generally two hydroponics systems that exist. One set up is to have the plants vertically stacked in a closed environment and the other is long trays with plants spread out in a greenhouse and only contain one level. We will need to decide which method our first robot will be designed for. It could be stationary and the trays are brought to the robot, it could move along a preset track, or the robot could have wheels and move on its own.

We will have a few methods of seeding to pick from for our design. We have already researched a few products that exist for transferring seeds. Almost every method we saw used a vacuum to pick up seeds and place them in trays. Other processes involved spreading seeds over a metal surface with holes and a vacuum seal which allowed the seeds to drop through. This operates entirely based on human control and would not reduce labor cost. Only one solution was found which used belts to funnel seeds in a tray and vibrates the seed holder in order to move them down the line. This prototype is small scale and not designed specifically for a hydroponics system. It is also stationary which as of now is not part of our design. However, this prototype offers us a decent starting point.

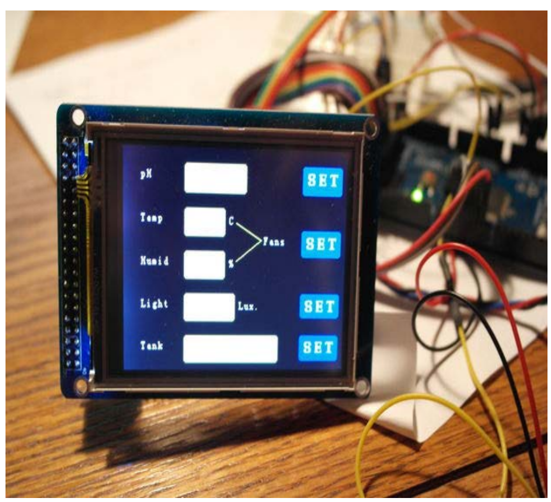
Another aspect of the design is how to put the seeds in the foam medium. Foam is used at Podponics and many hydroponics farms, so that will be used for testing. It is also a similar design to most of the mediums used and should be adaptable. The robot can either try to place the seed into the hole in the foam that is sitting in the tray or pick up foam put the seed in it and place the entire thing in the tray. The mediums could also move through the robot to pick one foam cube from a pile and set it up under the seed. The seed should be in the exact same place each time. If the mediums are already in the trays the robot can move similar to a 3D printer to drop the seed in each opening and move down the line. The amount of spots and length of the tray should be a variable in the program, in order to adjust size and be scalable.

Implement the design in the creation of a prototype

Once we have a firm grasp on our design we will have to start making prototypes. This will be challenging but will allow us to make concrete progress on our idea. In order to create the prototype we will use resources around campus. This is includes the Invention Studio and Student Competition Center. In order to stay on task well creating the prototype we plan on having check-ins at our weekly meetings. Due to the different majors of our team we will be split up into a hardware and software and be in constant communication with both sides.

Software team will decide which programming languages we want to use and work with, making sure the robot can recognize positioning of the trays, and where to drop the seeds. This will take a lot of time and will need to be worked on throughout next year.

Hardware will be in charge of the physical aspects of the robot. This team will have to work more quickly at the beginning of the year to give the software team time to work with the robot. Hardware team with make a 3D model of our prototype and keep it updated with any changes we make.



Some anticipated issues with the prototype are lack of technical knowledge or simply not working. We would consult professionals on campus who are working in programming and robotics. Our team has already had a meeting with a team working on automating poultry operations at the Food Processing Technology Center. If our initial design idea is not compatible with the hydroponics system we have multiple design ideas and can go back to make necessary changes. It will also be good practice for us to document design changes and testing results.

Test our prototype

After successfully creating our prototype from the design we created, we will need to test our prototype to ensure its capabilities and check to make sure it is in working order. It is important to test our prototype constantly, so there will be testing including within the creation of the prototype as it comes together. Testing will allow us to ensure our prototype is working properly and can successfully complete the tasks we set out to accomplish in the creation of our robot.

In order to test our robot, we will first need to make sure we have our test environment available and ready for testing. Hopefully, we will have multiple environments available for testing so we can see if we have created a design that is applicable to multiple systems since own of our goals is to create a robot that is applicable to multiple systems. Depending on the final design of our robot, our testing phase will differ depending on which aspects on the robot need significant testing. The testing process will consist of us looking into the mobility of the robot whether it is free standing or moving along a track to ensure that it can successfully move through the hydroponic system. In addition, we will have multiple dimensions of seed pods for the robot to plant in to test our input mechanisms of the locations of the holes and how many holes are there. Finally, we will test the growth of the plants after the robot plants them in the system to ensure they are taking root and healthy young plants on their way to adulthood. We will have multiple testing cycles and take random data from each cycle to look at the success of our robot. We need to determine its successful germination rate to prove that it is capable of accomplishing the seeding task.

Success will be defined by putting the robot through many different scenarios and testing all the human input aspects of our robot. While the testing process may result in many failures, this can actually be seen as success. A failure means we have located a problem within the robot and know what to be focusing on in order to improve our robot and come closer to the overall success of our project. Ultimate success will result in overcoming all failed tests to produce multiple successful scenarios in which at least 95% of the seeds planted germinate and begin growing into healthy plants.

Some obstacles to a successful testing phase include setting up multiple scenarios to run our robot through as well as finding all the errors in our prototype before presenting our design to the user. It will be a difficult task to attempt to break our robot and find all the holes in our prototype so that later a consumer will not have to deal with the issue. In addition, the time commitment to the testing phase will be massive as many scenarios will need to be run in countless settings in order to get accurate readings and determine results that truly represent the capabilities of our robot.

Research Team

Team Hydro Future Expectations

We expect to have 7 team members in Team Hydro the next academic year. The caliber and role of these team members is organized as follows:

We expect a team member to be a mediator of our discussions, providing the delicate touch to ease the decision process and ensure our meetings are quick yet productive. In addition, this team member can provide useful advice on the non-technical aspects of our project, for example policies of hydroponic industries or agricultural practices. The desired attributes that make this team member suitable for these roles is the public policy major, which brings to the table the best in education Georgia Tech has to offer. This is absolutely necessary because every technical solution must take into account non-technical factors, because ultimately it is the combination of both that yields a 'successful' project. In addition, a constant reminder of what is feasible or not is useful to the project.

We expect a team member to be heavily involved with the design and creation process of our solution. This includes research (for example, other techniques to aid our design phase) and working on the 3D-modelling and prototyping of our solution. The skills this team member has includes majoring in Mechanical Engineering and extensive experience with robotics that will be invaluable during our design and creation processes. Also, this team member has run through the protocol of modelling, prototyping and other important steps in designing a technical solution. This would assist us greatly in accomplish our project faster and to a higher quality. In addition, this team member is dedicated, passionate and able to apply their experience to new projects, such as our own.

We expect a team member to be an analyst, researcher and constructor for the team. The skills that this team member possess include a plethora of coding and hardware experience. This is invaluable as these attributes are highly relevant to our project and would assist in the process that would make our project a successful one. In addition, a computer engineering major ensures a constant education of additional materials that could assist us in developing our solution.

We expect a team member to be involved with the ideation and the more creative aspects of our project, such as graphics, websites etc. The skills this team member has includes previous website design experience, other coding experience and previous robotics experience. This would be important in the processes we will be addressing in our solution. In addition, a computer engineering major ensures a constant education of additional materials that could assist us in developing our solution. Also, this team member is able to communicate to various members of faculty directly, and that would assist in obtaining advice tailored to our project.

We expect a team member to be involved with the ideation and the implementation of our project. This person has extensive experience in the overlap of technical and non-technical factors that would be invaluable to the team. This includes prototyping award-winning projects in disciplines similar to our project's. In addition, this team member is able to research elements that our crucial to our project, and provide insight on challenges we may face in the future. This is highly necessary because foresight is one of the key ideas to developing a successful project.

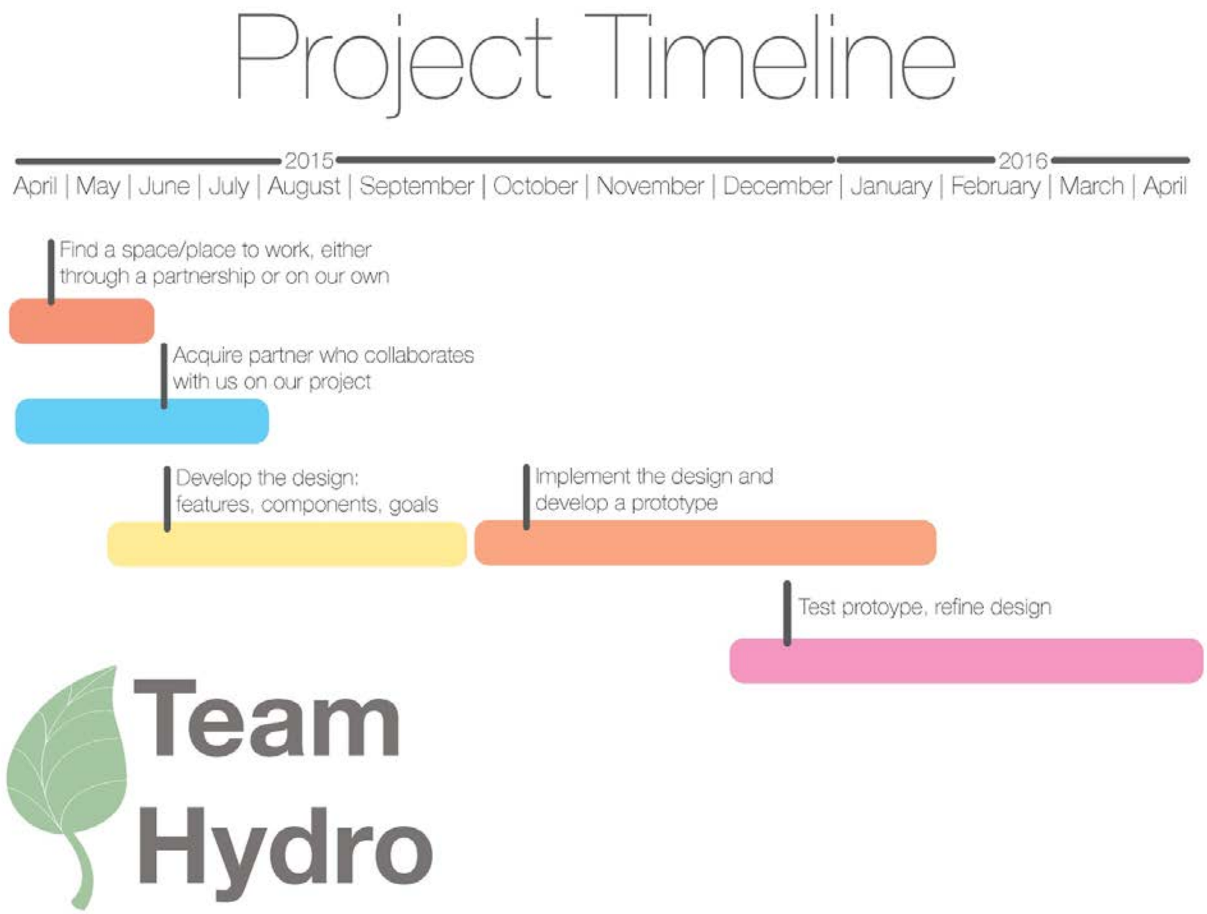
We expect a team member to be involved with additional information gathering such as field trips, as well as the design phase. The skills this team member has include previous field trip organizational skills and extensive research know-how. This is important as external advice is critical to developing our project.

We expect a team member to be involved with construction, communications and organizational areas of our project. The skills this team member has are extensive team based experience, communication techniques, robotics knowledge, and project development. This is necessary as previous experience in these areas ensures our project runs smoothly and we are able to create a higher quality product.

Team Hydro Outside Assistance

Our most helpful outside mentor has been John Davidson of Podponics, Inc. He has been a wealth of knowledge and helped us decide on which direction to pursue in our project. He even shared with us some non-sensitive internal documents from his company to assist us in information-gathering. We have visited him twice at Podponics' facility, taking photos and videos of the operation, and he has been very welcoming and we will be returning soon to work with him further. Although we have not asked him to be our formal advisor, we know that he is more than happy to help our team make an improvement on sustainable agriculture.

Timeline


Project Timeline
2015
2016
April | May | June | July | August | September | October | November | December | January | February | March | April
Find a space/place to work, either through a partnership or on our own
Acquire partner who collaborates with us on our project
Develop the design: features, components, goals
Implement the design and develop a prototype
Test protoype, refine design
Team Hydro

Budget

Item	Price (USD)	Quantity	Total (USD)
Motor	100	6	600
Wiring	100	1	100
Sensors	100	15	1500
Pneumatics	400	1	400
Other robotic components	1000	1	1000
Facility	100 per month	15	1500
Travel	10.50	10	105
Website Hosting	40	1	40

Total Requested: $5245

Expected Outcomes & Future Directions

Our main goal for this project is to figure out a way to further automate the process of hydroponic growing and to implement such a solution on a small scale, in hopes that the technology could then be implemented in hydroponics facilities of all sizes all over the world. Ideally, after two years of work, we would like to have developed and proved our solution physically so that we can focus on disseminating that solution throughout the world at large. However, it is possible that our solution will take several years of development so we are keeping our options open.

Our strongest relationship currently and moving forward is with Podponics, Inc. and they will continue to be a source of information and real-world knowledge that will greatly aid us in our endeavors. Our main source of funding will most likely continue to be Grand Challenges, but since the entire focus of our project is cost reduction, we will be easy to accomodate. Engineers for a Sustainable World is another interested organization and may allow us to use their hydroponic facility to implement our solution, which will make our project even more financially sustainable.

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