Midterm I Report

Team #11: Robo-Weeder

10/30/15

Submitted to: Dr. Gupta (Faculty Advisor)
Jeff Phipps (Sponsor)

Authors: Steven Miller (ME)
Christopher Murphy (ME)
Arriana Nwodu (ME)
Aquiles Ciron (EE)
Steven Williamson (EE)
Zhang Xiang (ME)

Table of Contents:

Table of Figures:

Table of Tables

Abstract

The primary objective of the Robo-Weeder senior design project is to design and create a chassis with varying cutting attachments that will remove weeds from the rows of planted vegetables. Team 11 has contacted and met with Mr. Jeff Phipps, the project sponsor, and met weekly to discuss design objectives and constraints. Several designs have been suggested by the group and these designs were presented to the sponsor as well as the faculty advisor. The final chassis design has been approved by the sponsor as well as the faculty advisor, currently analysis of the electrical system as well as computer models of the Robo-Weeder concepts is underway.

1) Introduction

As a continuation of the previous year's Robotic Weeding Harvester, Team 11 has been tasked with improving upon or redesigning the final design prototype that was generated. Team 11's project, appropriately named "Robo-Weeder" has a primary function of aiding in the removal of unwanted weeds that plague the seed beds of Jeff Phipps' organic farm, Orchard Pond Organics.

Organic farming techniques do not rely on the traditional farming practices of tilling the soil and the application of herbicides to control the growth of weeds. Instead, the weed control is done through a less invasive means leaving the soil undisturbed. Currently, most organic farmers have resulted to having to remove weeds by hand to achieve the desired effect. Although from an organic standpoint, hand removal of the weeds is ideal, it is less than ideal when labor costs are considered.

The driving force for the Robo-Weeder will be to help facilitate the production of crops with high nutritional value. The Robo-Weeder will: be remotely operated, remove weeds through the application of a shearing force, have an interchangeable battery source as well as be equipped with video monitoring. The primary challenge that will be solved by team 11 is the amount of force to apply to the seedbed to achieve the desired amount of shear. The team dynamics include four mechanical engineers and two electrical engineers. The project is presented by the FAMU-FSU College of Engineering Department of Mechanical Engineering and is sponsored by Mr. Jeff Phipps, of the Orchard Pond Organics farm. The project is advised by Dr. Gupta and Dr. Hooker.

2) Project Definition

2.1) Background research

Current methods of farming use technologically advanced cultivating tools and genetically modified crops. This method is currently the most used in order to maximize the yield of crops with high nutritional value. However, these processes are not only destructive to the environment, but hurts crops by destroying microorganisms along with ground insects that would further contribute to the development of high yielding soil. Another flaw in conventional farming is that there is large scale production of one single crop on a parcel of land also known as monoculture. This cultivation method is main reason synthetic fertilizers and pesticides are used since there is a dramatic decrease in diversity of the crop on a land plot, eliminating the natural biological controls that would maintain pest levels, disease, and soil degradation [1].

Another negative attribute of using pesticides, herbicides, and insecticides, is many ‘pests’ have already evolved and will continue to evolve to resist new developing chemicals. These pesticides, herbicides, insecticides, and fertilizers are derivatives of fossil fuels which are a limited natural resource. In addition to being a natural resource; fossil fuels also contribute to water contamination which is problematic because farms require the use of vast water irrigation systems. Currently irrigation systems extract water from reservoirs faster than they can be replenished, rapidly depleting this resource.

Due to the known fact that traditional farming leads to the serious consequences, organic farming has become a growing trend around the world. One might ask, “What exactly is an organic farm?” The answer is organic farming is done without using any chemically derived fertilizers, pesticides, herbicides, or is grown with genetically modified organisms (GMO) [2]. There are many different methods to subsidize the effect of not using traditional fertilizers, pesticides, and herbicides. Some insecticides may be used such as rotenone and pyrethrin, which are both organic compounds. Another method of organic farming is using cover crops such as clover, a legume, to reduce unwanted weeds. Legumes also put nitrogen back in the soil once they are tilled out of the earth. That being said, legumes are natural fertilizers and promote healthy soil as well as improvements of antioxidant levels or a highly nutritious crop [3]. To combat the effect of pest while not using pesticides, organic farms do away with monoculture and diversify the crops. This variation in crops allows certain crops immunity to pests that target a particular crop. The final method used by organic farmers is crop rotation which enhances the quality of the soil by placing vital nutrients back into the soil.

However, the downside of organic farming is the precise removal of undesired plants that grow near crops, and pest control. There are many different ways to combat these efforts but none of which work well with monoculture. Existing weeding machines are heavy, bulky and use gasoline engines which can adversely affect the crop yield.

The previous team spoke with Jeff Phipps head farmer where he expressed concerns of technology completely replacing the farmers and creating an environment of ignorance when it comes to producing crops. This year Team 11 is taking this concern into consideration and creating a machine that will assist the farmer in their duties.

2.1.1) House of Quality

Early stages of project research required the Robo-Weeder design team to meet with the sponsor and identify key requirements that he would like to see implemented into the design process. These requirements could range from affordability to safety. At this time, Team 11 made use of a design tool known as the House of Quality (HOQ). The HOQ uses a correlation matrix to compare the sponsor's requirements to key engineering characteristics that affect the design. Based on the results obtained in Figure 1, Team 11 found that durability, stability, and strength were the most important features of the Robo-Weeder.

Importance/Weight	Customer Requirements	Weight	Material	Durability	Stability	Strength	Traction	# of Motors	Communication	Power System
4	Safe to Operate	4	20	20	40	20	4	4	4	4
1	Cost Efficient	5	10	5	5	5	10	10	5	5
5	Effective	5	25	50	5	25	25	5	25	25
5	Reliable	5	25	50	50	50	5	5	5	25
2	Simple to Operate	2	2	2	2	2	2	2	10	2
2	Interchangable Implements	20	10	10	20	10	2	2	2	2
3	Weight	30	30	30	30	30	30	30	3	15
2	Marketability	2	2	20	20	10	2	2	10	2
4	Irregular Terrains	4	4	20	40	4	40	4	4	4
Totals		**77**	**128**	**207**	**212**	**156**	**120**	**64**	**68**	**84**
Rank		**7**	**4**	**2**	**1**	**3**	**5**	**9**	**8**	**6**

Figure 1: House of quality for team 11 relating the sponsor's design requirements with the key engineering characteristics.

2.1.2) Soil Analysis

Due to the Robo-Weeder constantly interacting and moving soil during its operation, it was necessary for Team 11 to gain a better understanding of the soils mechanical properties. Of these mechanical properties, the shear force was the most important. To investigate the mechanical properties, team 11 consulted with the Department of Civil Engineering's professor of Soil Mechanics, Professor Sal Arnaldo, P.E, as well as chairman and professor Kamal Tawfiq, Ph.D., P.E. After consultation, both professors advised the team to conduct in depth soil tests to fully understand the actual forces needed.

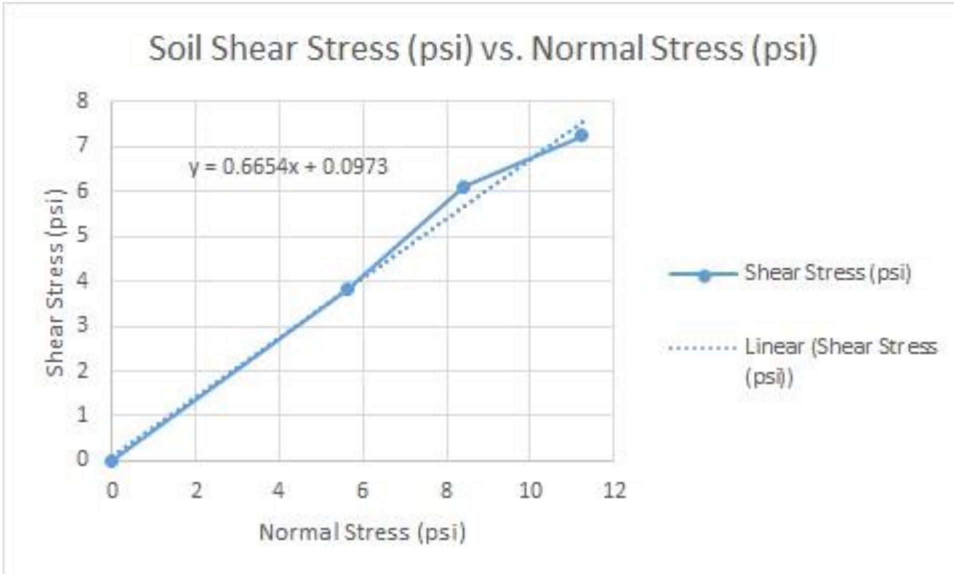

Figure 2: Preliminary Graph depicting the needed shear stress given a normal stress. Additional testing is needed to validate data and ensure shear stresses are accurate.

After conducting the first round of soil tests, Figure 2 above shows the relationship of the needed shear stress to the applied normal stress on the soil sample. The near linear relationship is modeled by the trend line and allows Team 11 to calculate the needed auger forces to move the soil in question. Due to Figure 2 displaying the preliminary data gathered from the first round of testing, team 11 is waiting on additional testing results before concluding the auger forces needed, Although more testing is needed, it gives Team 11 a good understanding of what is to be expected.

2.2) Need Statement

The current sponsor for the Robo-weeder project, Jeff Phipps of Orchard Pond Organics, is a Mechanical Engineer and wants to develop a remotely operated platform that will aid farmers in general crop care, by removing weeds on his organic farm. The chassis desired must be robotic in nature, and must apply an adequate shear force to the roots of undesired plants without disturbing adjacent crops. The platform must be able to accommodate future cutting implements that the sponsor develops and must be safe, easily maintained and user friendly. In order to aid Mr. Phipps on his organic farm, an effective, reliable, and well-functioning remotely controlled platform must be created.

2.3) Goal Statement and Objectives

Thus far, the established goals for Team 11 is to create a remotely operated machine that effectively eliminates unwanted plants by the root, be splash proof, and have an option to interchange weeding implements.

2.4) Constraints

The established constraints for the mechanism are as follows:

- Function in “No-Till” fashion
- Must be mobile
- Must be remotely operated
- Must use Auger style shearing mechanism
- Not disturb more than one inch in depth of soil
- Width shall not exceed 12 inches
- Must be tolerant to minimal water (splash proof).
- Must shear undesired plants on an acre of land per day

3) Design

3.1) Functional Analysis

3.1.1) Chassis

The chassis of the Robo-Weeder ROV is the central support system which will house all of the components necessary for the ROV to carry out its designed function. Throughout the planning of the chassis design, several details need to be considered in order to effectively create a working chassis for the Robo-Weeder. The details to consider include the mode of connecting the individual elements of the chassis, the stresses that will be experienced by the chassis due to normal operation and the materials in which to construct the chassis from.

3.1.1.1) Connection Methods

Before each element of the chassis can be drawn in detail within Pro-e, team 11 needs to determine the method in which the individual elements of the chassis are connected. The two main methods of connection considered by the team are welding and fastening by way of bolts. Welding of the elements is a permanent bond and can be difficult to achieve depending on the materials selected to create the chassis. Welding of the elements would provide a method of connection that requires less face area and can attach unconventional geometries such as curved edges. Fastening by way of bolts offers the team a non permanent method to attach elements but needs adequate face area. The face area is needed so that bolt heads, washers and nuts seat firmly on flat surfaces as well as to allow clear access for tooling. Also, bolting would allow the team to freely change portions of the chassis as the prototype is developed if changes occur.

3.1.1.2) Stress analysis

During the operation of the ROV, the chassis will be influenced by a number of forces and torques. These forces and torques will be generated by the shearing device as well as the act of maneuvering the ROV through the soil. As a direct consequence, these forces and torques could have the potential to damage connections between the shearing mechanism as well as the steering components. Once detailed drawings of the different elements of the chassis have been completed, a detailed analysis of the stresses will be done.

3.1.1.3) Material Selection

Once the chassis forces are known and a solid understanding of the chassis geometry is gathered by team 11, the team can begin looking at the materials that will be needed to construct the different chassis elements. Common materials that will be strongly considered are metals such as aluminum and steel. Aluminum has a high strength to weight ratio making it a favorable choice to keep the weight of the ROV at a minimum. Whereas steels introduce a much larger weight but are capable of sustaining greater stresses and strains before experiencing failure.

3.1.2) The Weeding Mechanism

The main component housed on the Robo-Weeder ROV is the shearing device that will be used to remove weeds from the seed bed. The sponsor for the Robo-Weeder project wants to use an auger style shearing system in which the auger will contact the ground horizontally. During rotation of the auger, the helical teeth that revolve around the auger will apply a shear force to the surface of the seed bed. This shear force will in turn remove or severely damage any weeds that are affected by the shearing component. Team 11 is tasked with trying to make the shearing component both safe to operate and safe to interact with during routine maintenance or cleaning procedures. The team will also develop a variable position system that will allow the operator to apply variable pressure to the ground by the shearing component as well as lift the component off the ground when not in use.

3.1.2.1) Variable Position System

During the operation of the Robo-Weeder, there may be times during transport in which the auger being in contact with the ground could impede the movement of the ROV. Also, there may be times in which a larger contact pressure needs to be applied to the ground to achieve the desired amount of shear force. Both of these situations gave way to the imminent development of a system in which the operator could control the height of the shearing system as well as the pressure that it applied to the ground. Possible methods being discussed by Team 11 include the use of a rack and pinion gear installed in a vertical manner. The user would then have the ability to control the position either by manual input through a hand crank or through the use of a drive motor if a more automated method is desired. Alternate methods for lifting the shearing system are actively being researched but currently the rack and pinion system is the only effective method determined by Team 11.

3.1.2.2) Safety of Component

The Robo-Weeder ROV will house an auger style shearing mechanism. This shearing mechanism could potentially pose a risk of serious bodily harm if the operator interacts with the shearing mechanism while the Robo-Weeder is operational. The main cause of injury from the shearing components is a direct result of the rotating nature of the augers. Being that the chance of injury is the greatest by the shearing mechanism, a protective housing will need to be developed to protect the operator from the rotation machinery.

Although the primary cause of injury is due to the rotation of the augers, other injury threats could arise as the variable position lift system is developed. The exact nature of these injuries is currently unknown due to the lift system being in a conceptual phase. A full threat analysis will be conducted once a prototype is developed to ensure the operator is protected from any source of harm.

3.1.3) Electrical Components

3.1.3.1) Microcontroller

A-Star 32U4 Prime LV vs. Arduino Mega 2560 R3

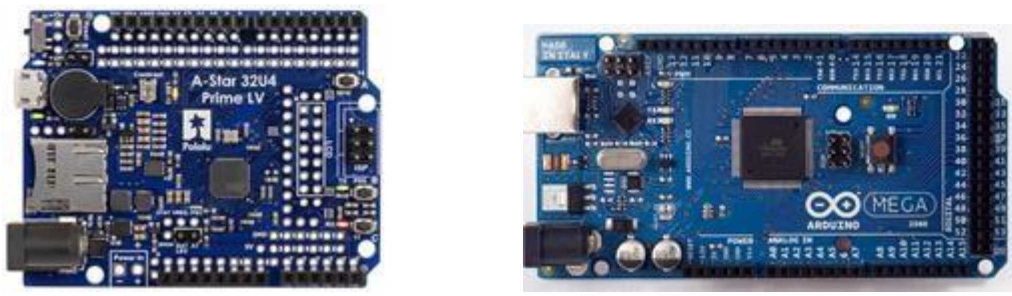

Figure 3: A-Star 32U4 Prime LV microSD (left) and Arduino Mega 2560 (right)

Table 1: A-Star 32U4 Prime LV and Arduino Mega 2560 R3 specification

Models	A-Star 32U4 Prime LV	Arduino Mega 2560 R3
Price	$28.95	$45.95
Operating Voltage	5.5V	5V
Input Voltage (recommended)	2.7V to 11.8V	7-12V
Input Voltage (limits)	-------	6-20V
Digital I/O Pins	26	54
Analog Input Pins	12	16
DC Current per I/O Pin	100mA	40mA
DC Current for 3.3V Pin	300mA	50mA
Flash Memory	32KB	128KB
SRAM	2.5KB	8KB
EEPROM	1KB	4KB
Clock Speed	16MHZ	16MHZ
PWM outputs	7	15
Processor	ATmega32U4	ATmega2560

Figure 3 shown above is the microcontroller that Team 11 will be using in order to control all the electrical components on the Robo-Weeder. Table 1 provided is the spec sheet of the microcontroller, the Arduino Mega.

3.1.3.2) Motor Control

Figure 4: 10-36V DC Motor Speed Controller Reversible PWM Control Forward

The above image is of a dual motor control with high efficiency, and torque all while generating low heat. It requires an input voltage ranging from 10 to 36 volt from a direct current. It has a maximum output of 150 watts and has pulse width modulator range of 10 to 95%. The maximum current this motor controller can withstand is 8 amps within 30 seconds. The features included with this motor controller is an external speed control knob and a reversible control that's equipped with a reversing switch.

Figure 5: Sabertooth dual 10A motor driver for R/C

This Sabertooth dual 10A motor driver for R/C has a required input voltage of 6 to 25 volts. The amperage this motor controller can handle ranges from 10A per motor to 15A per motor. It has a built in 5 volt BEC that provides power to a microcontroller or R/C receiver.

Figure 6: Pololu Simple Motor Controller 18v7

The above is an image of a simple motor controller 18v7. It contains a simple bidirectional control of one DC brush motor and can requires a voltage ranging from 5.5 to 30 volts. The maximum current this motor controller can withstand ranges from 7 to 25 amps for a continuous current output without a heat sink. This devices also has four communications or control options:

1. USB interface connection to a PC.
2. Logic-level (TTL) serial interface connection to a microcontrollers.
3. Radio control (RC) connection to an RC receiver.
4. Analog voltage interface (joystick or potentiometers) at 0–3.3 V

These three motor drivers are potential motor drivers that we may use based on their specifications. Depending on our final motor selection, only one, or two, of these motor drivers may be selected for implementation.

3.1.3.3) Power System

The power system that Team 11 will implement to run this ROV will be a rechargeable battery system. The sponsor would like to be able to run the ROV for a period of time until the battery is drained, and then be able to easily replace the battery with a new, freshly charged one. It was decided that a 12V battery system will be used rather than a 24V system. The criteria to be looked at when selecting which type of battery to be used are the battery's run time, life-cycle, charge time, and weight. There were many types of batteries considered, but the list has been narrowed down to three: nickel cadmium, nickel metal hydride, and lithium ion.

Nickel Cadmium

Nickel cadmium batteries are the most common type of rechargeable battery. They are used for portable electronics as well as toys. The advantages and disadvantages of these types of batteries are:

- Advantages:
  - Low self-discharge shelf-life
  - Moderate life-cycle
  - Has no voltage drop near discharged levels
  - Performs optimally down to 20°F

- Disadvantages:
  - Heavy
  - May suffer from "Memory Effect"
  - Large in size

Nickel Metal Hydride

Nickel metal hydride is similar to Nickel cadmium with a few advantages over it. However, with those advantages come disadvantages that need to be considered when comparing the two.

- Advantages:
  - Lighter weight than nickel cadmium
  - Longer run times than nickel cadmium batteries of same size

- Small
- Does not suffer from “Memory Effect”

· Disadvantages:
  - Few life cycles
  - Performs poorly in cold weather
  - High self-discharge shelf-life
  - Has a voltage drop when nearly discharged
  - Cannot handle a high rate charge (slow charge time)

Lithium Ion

Lithium ion batteries are the most technologically advanced of the three battery types listed above. The advantages and disadvantages of lithium ion batteries are:

· Advantages:
  - Light weight (lightest of the three)
  - Higher life cycles than that of nickel cadmium and nickel metal hydride
  - Quick recharge time
  - High performance in cold weather
  - Low self-discharge shelf life

· Disadvantages:
  - Newest technology, expensive
  - Capable of erupting/exploding in high heat

Based on the above criteria and advantages/disadvantages, the following table compared the 3 types of batteries numbering them 1-3 with 1 being the best in that category and 3 being the worst.

Table 2: Battery Assessment

Type of Battery	Run Time	Life-Cycle	Charge Time	Weight
Nickel Cadmium	3	2	2	3
Nickel Metal Hydride	2	3	3	2
Lithium Ion	1	1	1	1

When looking at the table it looks like lithium ion batteries are the clear-cut best option. However, when the time comes to purchase batteries and if budget is an issue, it may not be an option. A glaring disadvantage of lithium ion batteries that needs to be addressed is their volatile properties in high heat.
Due to our machine being operated outside in the direct sunlight, a battery housing may have to be designed in order to keep the temperature down.

3.1.3.4) Communications (Transmitter/receiver)

Figure 7: Spektrum R5520 DX5e DSMX Transmitter (left) and Turnigy TGY-i6 AFHDS Transmitter (right).

Table 3: Spektrum R5520 DX5e DSMX vs.Turnigy TGY-i6 AFHDS Transmitter and Receiver specification

Model	Spektrum DX5e	Turnigy TGY-i6
Price	$89.99	$49.00
Frequency	2.4GHZ	2.4GHZ
Channels	5	6
Voltage	1.5v x 4 AA	1.5v x 4 AA
Current	-------	100mA
Receiver	AR 610	Turnigy iA6
Modulation	DSM2, DSMX	GFSK

Option	Telemetry	Optional telemetry

The two transmitters shown in Figure 7 are two potential transmitters we may select. For the Robo-Weeder, a 6-channel transmitter will be required for all of its designated functions. These functions will include driving (2 channels), steering (2 channels), and auger power (2 channels).

3.2) Design Concepts

3.2.1) Electrical Design Concepts

The Electrical design concept is nearing its final design phase. The choices of parts to choose from and the potential for any modifications are nearing its final stages. Any efforts in finalizing the design will all depends on the choices of motors that will power the drive train, steering and the augers. The heart of the electrical design will be the microcontroller, any choices will be based on the capability of the microcontroller in terms of having enough pins for any expansion of the design or the adaptability of the board to handle changes in the programming. The choices for the motor-controller will be based on the voltage and amperage rating of the dc motor, ensuring that each motor-controller will not overheat due to the excess load requirement of the dc motor will be the design criteria that needs to be met, in able to avoid any design failure. The power system for this design will have to provide the necessary system requirements in terms of the operating voltages and current, in addition to being able to maintain an acceptable amount of charge for a given length of operational use in between charging. The transmitters that will be available are almost identical in its operational requirements, leaving very few choices left to choose from, any decision in choosing the right transmitter might be made in terms of the economy of the price of each available transmitter. This electrical design concept will be a working progress until its final completion and operational readiness.

3.2.1.1) Microcontroller Design

For communication between the user and the ROV, a remote control will be used to transmit a signal to the receiver. Connected to the receiver will be our microcontroller(s) that will relay the transmitted signal to three motor controllers. Each motor controller will be connected to 2 motors with 6 motors in total for the overall design. The breakdown of the function of the 6 motors are as follows:

- 1 motor for front steering
- 1 motor for rear steering
- 2 motors to drive the ROV (front and rear wheel drive)
- 1 motor for each auger (2 augers in total)

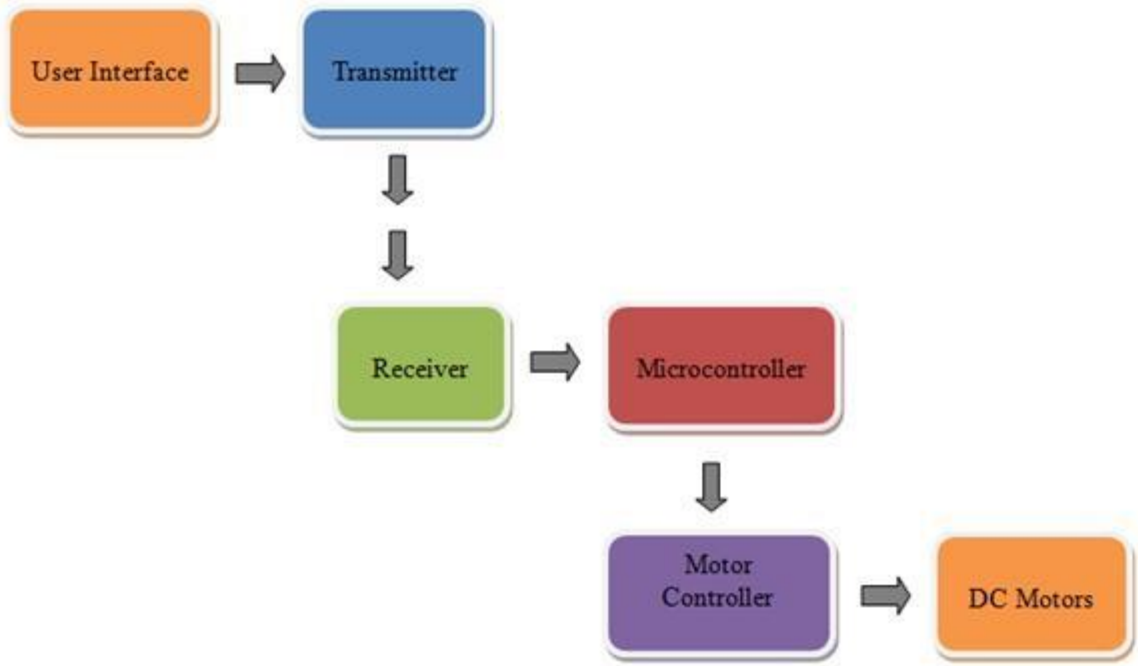

Figure 8: User to ROV Signal Flow

3.2.1.2) Motors

As described above, 6 motors will be required to power the ROV. The exact motors that are to be used for the final design have yet to be determined. There are two factors preventing the motors from being selected. Exact measurements, such as weight and size, have yet to be determined for the augers. Whichever motor is selected will need to be powerful enough to spin the auger blades as well as being strong enough to move the vehicle with all the attachments.

To achieve desired speeds for the augers as well as the machine, encoders will be used. Encoders are mounted to an electric motor and provide feedback of the speed or position of the motor shaft. There are two general types of encoders: incremental and absolute. An absolute encoder seems to be the better option due to its ability to retain position information when power is removed. The encoder of choice will be selected once the desired motor has been chosen.

3.2.2) Mechanical Design Concepts

During the conceptual design phase of the Robo-Weeder project, team members were were tasked to develop multiple design concepts. These concepts would eventually steer the team towards a final design concept with the aid of input from the faculty advisors as well as the team's sponsor. The team members were asked to include as many aspects of the design as possible in their conceptual drawings.

3.2.2.1) Design Concept 1

The first design concept introduced was one that employed the auger style shearing device that was prefered by the sponsor. The housed augers each had a chevron patterns but of opposite hand threads. The opposite chevron patterns allowed the front auger to move dirt out from the center to the edges of the ROV and the rear auger to pull material back to the center. The concept was designed with the idea of having 180 degree of motion from the front steering system as well as having drive motors attached to both the front and rear wheels. To increase traction for the design, the rear drive wheels were the entire width of the device adding more contact area.

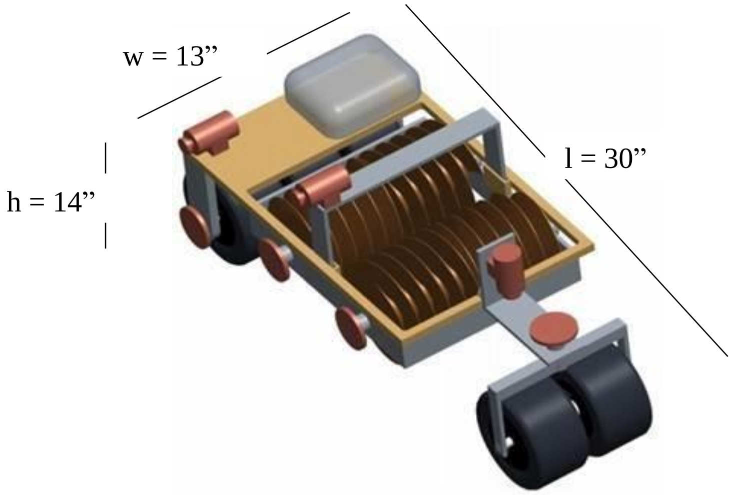

Figure 9: Design Concept 1

3.2.2.2) Design Concept 2

The second design concept that was presented by team 11 had a few similarities to the first design. The main similarity is the auger style shearing mechanism which also displayed the chevron pattern. To drive concept 2, the design was all wheel drive and independent front and rear wheel steering to allow superior maneuverability. The shearing mechanism housed on concept 2 also had a pivot point at the top most connection that would allow the shearing mechanism to twist when uneven ground was traversed.

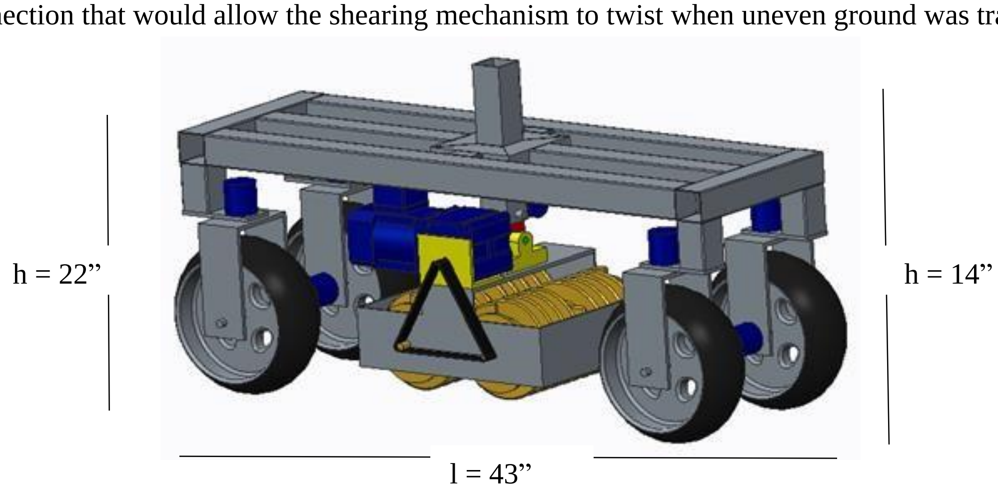

Figure 10: Design Concept 2

3.3) Evaluation of Mechanical Designs

As seen in the previous sections, team 11 produced multiple mechanical design concepts and introduced each to the team's sponsor, Mr. Jeff Phipps. After each mechanical concept was evaluated in detail, the team consulted again with its sponsor and decided how to proceed to the project's final mechanical design concept. It was determined that instead of using an individual conceptual design developed by the team in its entirety for the final mechanical design concept, the team would extract favorable components from each of the individual mechanical design concepts and develop the final mechanical concept in this fashion. Components that were considered were the wheel housings, main chassis designs and the auger housing.

3.4) Final Mechanical Concept

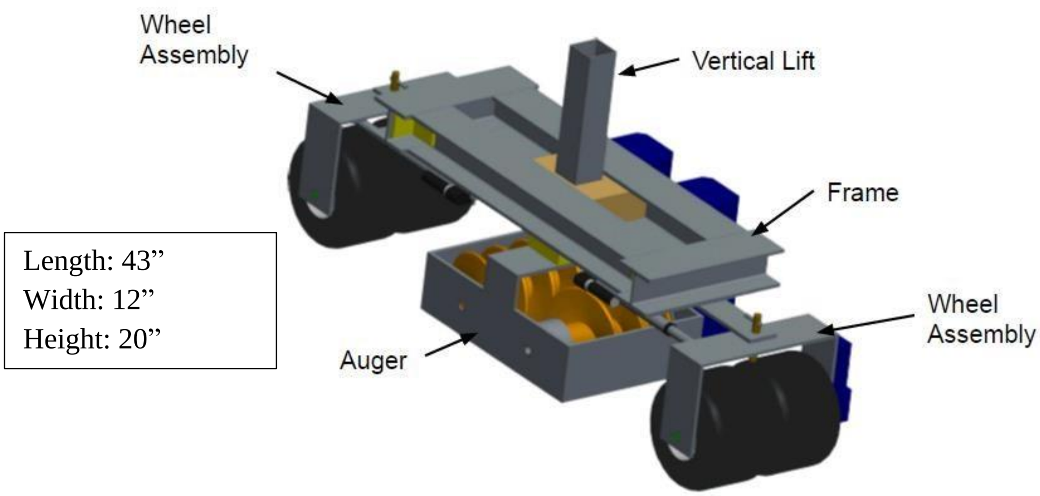

Figure 11: Overall View of the Final Concept

The final design is a combination of different components from both Design Concept 1 and Design Concept 2. These components include all-wheel drive, vertical lift adjustment, steering using linear actuators, helical shearing mechanism, and variable speed adjustments of the augers. The final design of these requirements can be found in Figure 11. These components were selected by both the sponsor as well as the team as being the best viable solution to developing the Final Design Concept.

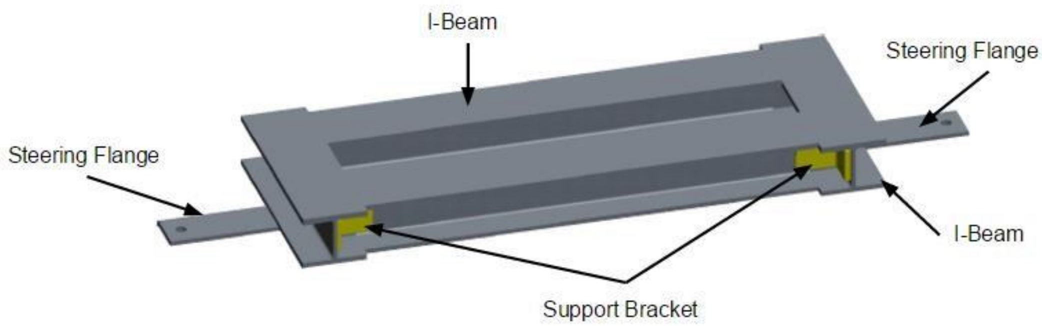

Figure 12: Frame Design of the Final Concept

The frame for the Final Design Concept in Figure 12 was developed with simplicity in mind. A Ibeam design was utilized to ensure that the frame would be able to handle the torques and weight that the Final Design Concept will encounter. Support Brackets with bolts were used to connect the frame components together to give a variability in the frame size and future maintenance of the machine. Flat plates were used to design a steering flange in which the driving assembly will connect.

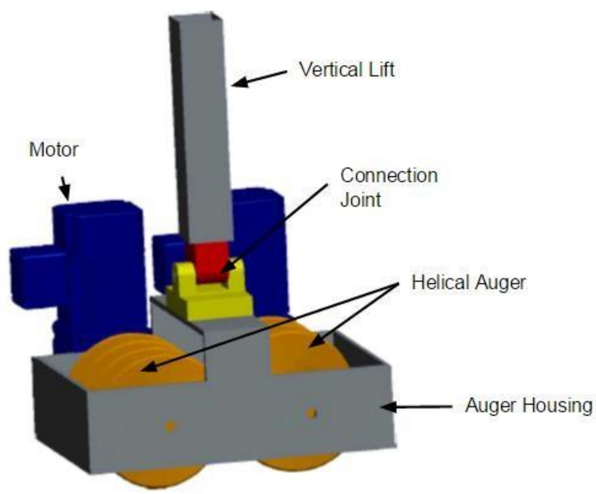

Figure 13: Auger Design of the Final Concept

The Auger Design of the Final Concept is seen in Figure 13. This auger will be used for shear the first inch of the ground to remove weeds. It features a vertical auger lift, two independently operated augers via two motors, auger housing, two helical augers, and a connection joint to connect the vertical lift to the auger housing.

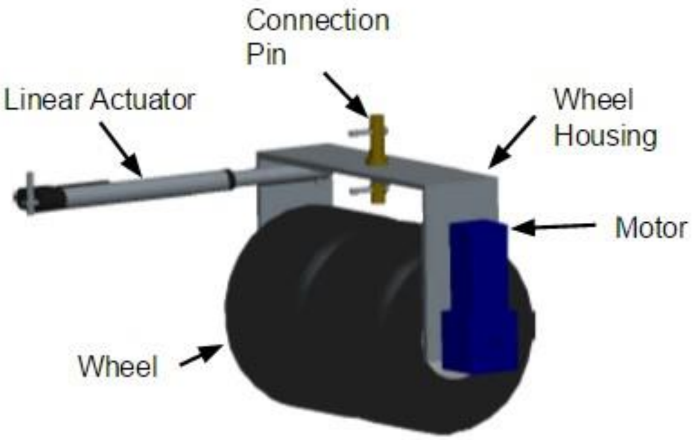

Figure 14: Drive Assembly and Steering of the Final Design

The Drive Assembly and Steering of the Final Design can be found in Figure 14. The drive system provided via two drive assemblies. Each assembly has two wheels on one common axial, which is driven with one motor, and the wheel housing attaches to the axial using bearings. Two linear actuators will be used to provide linear steering of the machine. The connection pin will be used to allow pivoting of the entire the drive assembly. The drive assembly connects to the steering flange.

4.0) Methodology

To accomplish the Robo-Weeder project in a timely manner team 11 separated the design into several parts and phases: Mechanical Design, Electrical Design and Final Design. Mechanical design includes the design of the chassis and connected components to include the auger shearing mechanism and the drive system. The chassis should be of a simple design and be as light as possible. The drive system needs allow the ROV to be capable of traversing multiple terrain types to include both uneven and muddy conditions. The auger shearing mechanism focuses on effectively removing the weeds and a minimum disruption of the soil. The Electrical Design includes the design of the electrical components to include the microcontroller, motor controllers and the transmitter/receiver for communication. The final phase of the design includes the development of the Final Design. The final design phase combines the results of both the Mechanical Design and Electrical Design phase to create a final operational ROV.

4.1) Schedule

To allow the team to stay on schedule, Team 11 developed a Gantt chart in which all of the project activities were input and given a set amount of time for completion. Team 11's Gantt chart is broken down into three phases. The first phase is an introductory phase to the project. During this phase the team took time to understand the project. This included meeting with our sponsor and conducting background research. During the introduction phase of the project, team 11 went to the sponsors farm to conduct field research to get a better understand about the working situation. The next phase in the schedule is the project planning phase. During this phase, members developed initial design concepts to present to our sponsor. The final design concept as well as electrical concepts are also developed during this phase. The final part of the project is the Final Design phase. During this phase the team develops detailed CAD designs, begins fabrication of parts and if time permits during the fall semester, prototyping. The full Gantt chart can be seen below in Figure 15.

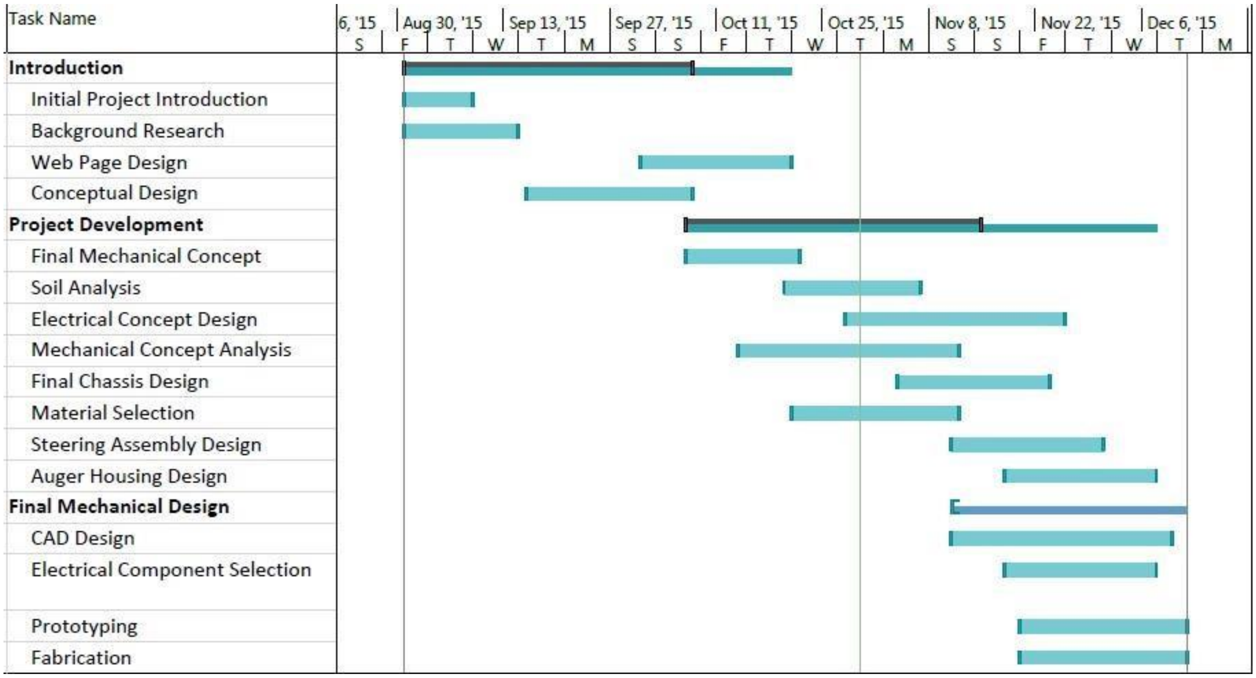

Figure 15: Gantt chart detailing the current and future tasks for the Robo-Weeder project.

4.2) Resource Allocation

Until the completion of the detailed design, Team 11 will borrow a microcontroller and motor controllers from Dr Gupta's laboratory in the AME building adjacent to the college of engineering. Team 11 must address one of the main constraints placed by the sponsor Jeff Phipps to use an auger style shearing mechanism, due to the foreseen difficulty of manufacturing. Team 11 will discuss the possibility of obtaining an auger locally from the Harbor Freight store located in Tallahassee, Florida.

Once the soil analysis has been completed by the civil engineering department, Team 11 will have an accurate value for the torque required that the machine will need to traverse in dry and wet conditions. This value will determine what type of motor will be required that will narrow down the combination of motor & micro controller that will be necessary. The Team will then look for the items that will provide the required functionality.

It is estimated that ~50% of the budget will go towards electronics such as motors, motor drivers, controllers, etc. About 35% will be towards mechanical equipment such as materials and the remaining 15% will be used for unexpected expenses.

4.3) Risk Assessment

During the duration of the Robo-Weeder senior design project, it is a necessity for team 11 to plan for risks and hazards that the team will encounter throughout the design and fabrication process. Several major risks that are being addressed during the fabrication process include electrical burns from welding and serious injury from the machining process used to form the different elements of the final mechanical design.

After fabrication of the final prototype, team 11 will begin testing of the product. During the testing phase a completely different set of risks and hazards is presented to the team. The major risks present to the team is the chance for serious bodily harm through the rotating augers and electrical burn due to the electrical components and the power system. Other risks that are present during the design and testing phases are detailed more accurately in the attached risk assessment document.

5.0) Conclusion

To summarize, after several meetings with project sponsor Jeff Phipps, a final mechanical conceptual design has been chosen. This design will have independent front and rear wheel steering a chevron style auger pattern that will displace soil one inch to the side and one inch backwards. The required electrical components will have to have communications such that each feature can operate independently as well as efficiently. Currently soil analysis is being conducted by the Civil Engineering Department of the FAMU FSU College of Engineering where the results given will determine what type of motor will be required in order to facilitate the production of the ROV Robo-Weeder. Once the motor has been chosen the compatible micro and motor controllers will be purchased and further development of the machine will continue. Team 11 is on schedule and will continue on with detailed CAD design prototyping this semester where weight and balancing must be studied and optimized.

6.0) References

[1] Bernardes, A. M., Denise Crocce Romano Espinosa, and JA Soares Tenório. "Recycling of batteries: a review of current processes and technologies."*Journal of Power Sources* 130.1 (2004): 291-298.

[2] "Dynapar - Motor Encoder Speed & Position Control Overview." Dynapar. N.p., n.d. Web. http://www.dynapar.com/Technology/Encoder_Basics/Motor_Encoders/

[3] ArduinoBoardMega https://www.arduino.cc/en/Main/arduinoBoardMega

[4] A-Star 32U4 Prime LV https://www.pololu.com/product/3108/specs

[5] 10-36V DC Motor Speed Controller Reversible PWM Control Forward http://www.thanksbuyer.com/10-36v-dc-motor-speed-controller-reversible-pwm-control-forwardreverse-switch-34561#tab-description

[6] Pololu Simple Motor Controller 18v7 https://www.pololu.com/product/1372

[7] Sabertooth dual 10A motor driver for R/C https://www.dimensionengineering.com/products/sabertooth2x10rc

[8] Spektrum R5520 DX5e DSMX 5-Channel Transmitter and Receiver http://www.superdroidrobots.com/shop/item.aspx/spektrum-dx5etransmitter-with-ar610receiver/992/

[9] Turnigy TGY-i6 AFHDS Transmitter and 6CH Receiver http://www.hobbyking.com/hobbyking/store/__62710__Turnigy_TGY_i6_AFHDS_Transmitter_and_6CH_Receiver_Mode_2_.html