Project Plan and Design Specifications

Robo-Weeder

Team #11

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Submitted to:

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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 and analysis of the electrical system as well as computer models of the Robo-Weeder concepts is underway.

Introduction:

Current methods of farming use technologically advanced cultivating tools and genetically modified crops. This method is the currently the most used to maximize the possible yield of the crops. However, these processes are not only destructive to the environment, but also destroy microorganisms along with ground insects which would further contribute to the development of high yielding soil. Another flaw in current industrial farms is that there is large scale production of one single crop on a parcel of land. Also known as monoculture, is main reason synthetic fertilizers and pesticides are used. Monoculture decreases the 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 chemicals. Therefore, the production of new chemicals to kill pests will need to be continuously developed. 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.

Project Definition:

Needs Statement

The current sponsor for the Robo-Weeder project, Jeff Phipps of Orchard Pond Organics, is a Mechanical Engineer and wants to develop a platform that will aid farmers in general crop care but mainly assist in the removal of 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. In order to aid Mr. Phipps on his organic farm, an effective, reliable, and well-functioning platform must be created.

Goal Statement and Objectives

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

Constraints

- “No-Till Shearing Design
- Not disturb one inch of soil
- Maximum 12 inch Width
- Splash proof

Expected Results

The expected result for this design (Robo-Weeder) is to have the ability to at least displace roots down to a depth of one inch below the surface of the soil, successfully removing grass at a rate of greater than 70% per square ft.

Methodology

After preliminary research was conducted on current, and traditional farming techniques as well as till designs, senior design team 11, constructed a House of Quality. The QFD within the HOQ, in Figure 1, relates key customer requirements to important engineering characteristics unique to the design by way of a relationship matrix in Figure 1 below.

Importance/Weight	Customer Requirements	Mass	Material	Durability	Stability	Strength of Components	# of Tires/Tracks	# of Motors	Operation Mode (Wired, Radio, etc…)	Battery 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: QFD detailing the Customer Requirements and the Engineering Characteristics.

The HOQ was created to help the team identify key design aspects that should be monitored during the design process. The three most important aspects as identified by the HOQ are stability, durability and strength of components. The complete HOQ can be viewed in Appendix A.

After completion of the HOQ brainstorming sessions, the mechanical engineers on team 11 presented several conceptual designs to the sponsor, as well as the faculty advisor. The final chassis design will be a combination of Steven Miller & Chris Murphy’s concepts.

Potential Designs:

The first design that was presented to the sponsors and advisors, was a design created by Steven Miller, Figure 2 below. This design consisted of two tires in the front which would be the source of steering and three tires in the back to spread the weight of the ROV over a larger area. The design has all-wheel drive, and the ability for vertical shearing adjustment.

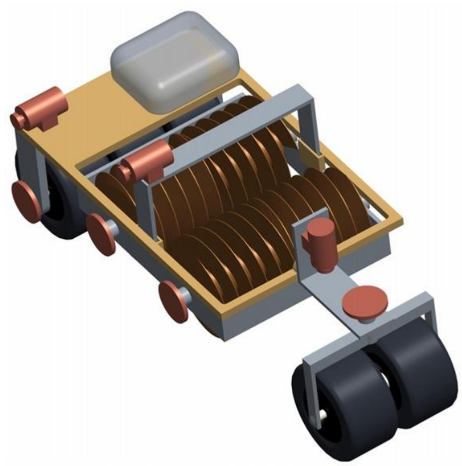


Figure 2: Design Idea proposed by Steven Miller.

The second design idea presented was by Christopher Murphy in figure 3 below. Chris' design consisted of four independently driven, independently steered wheels. It also includes a vertical shearing mechanism adjustment as well as the ability to pivot the shearing mechanism at a point above the augers.

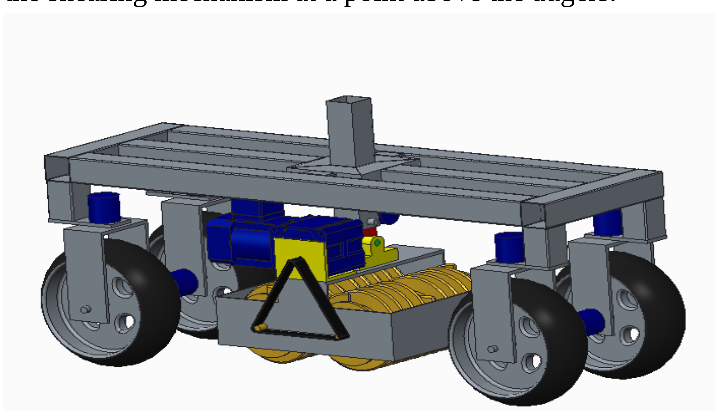


Figure 3: Design idea proposed by Chris Murphy.

The third conceptual design presented by Arriana Nwodu, introduced and focused on a new method of shearing. The sponsor had already committed to a cutting implement that could cause for material buildup within the machine over time. With the proposed implement, the chances of material build up are cut down due to the nature of how the implement removes roots.

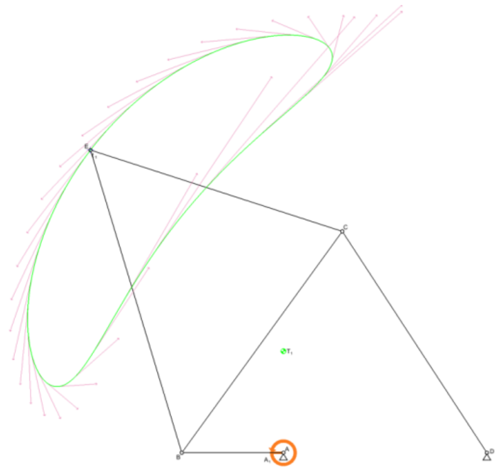


Figure 4: Design Idea proposed by Arriana Nwodu.

Figure 4 shows the position, velocity and acceleration analysis of the four-bar coupler introduced by Arriana Nwodu. The downward cutting stroke is slow however the return stroke is quick keeping material build up and slippage to a minimum

The final design presented was a reiteration of the previous year's weeding robot and was presented by Xiang Zhang. Xiang's design housed a side mounted weeding mechanism which improved upon last year's design by adding a spring damper system to account for uneven shear surfaces. His design also used tracks instead of tires to improve traction and reduce ground surface pressure.

The sponsor chose a final conceptual design that incorporates attributes of both Steven Miller and Christopher Murphy's designs. The sponsor couldn't figure out a quick way to implement Arriana's 4-Bar Coupler and has decided to put that idea to the side. Team 11 will use the 4-Bar as a shearing alternate and will be presented as an exciter.

Product Specifications:

Team 11 was challenged with developing a remotely operated mechanical platform, The Robo-Weeder, capable of aiding Mr. Jeff Phipps in the removal of undesired plants in Orchard Pond Organics. During the course of identifying the needs and expectations for the Robo-Weeder project, team 11 constructed lists of specifications that outline both the design parameters as well as the performance capabilities.

Design Specifications:

- 12/24 Volt Operation:
    - Exact system voltage requirements is yet to be determined.
- 4"/6" Diameter Auger Housing:
    - Auger diameter is pending due to analysis of forces and torques.
- Overall width less than 12":
    - Shorter auger length translates to lower motor torques.
- Wireless Remote Operation:
    - Gives the operator the ability to operate from longer distances.
- Video Monitoring Capability:
    - Allows operator to monitor the exact location and efficiency of the ROV from extended distances.

Performance Specifications:

- All Wheel Drive:
  - Improved traction and control in loose dirt and high litter environments.
- Front and Rear Steering:
  - Gives the operator superior control over the position of the ROV. Also allows for tighter turning radiuses.
- Independent Shearing Mechanism Speed Control (2 Auger):
  - Fine tuning of the auger systems angular velocity will improve shearing efficiency.
- Vertical adjustment of Shearing Mechanism :
  - Adjustment of the vertical position of the shearing mechanism will allow for the operator to improve the effectiveness of the shearing mechanism.
- Interchangeable Shearing Mechanism:
  - Alternate shearing mechanisms may be developed or existing mechanisms may be improved upon. The ability to interchange gives the operator total control over the R.O.V.'s capabilities.

Shearing Mechanism:

The Robo-Weeder mechanical weeding platform houses a very unique shearing mechanism that includes a horizontally positioned auger type design that lies in contact with the seed bed. This particular design uses the helical fins around the auger to apply a shear force normal to the direction of motion to the top one inch of the soil. The particular auger system housed on board of the Robo-Weeder will consist of 2 augers in parallel with a slight offset between the front and rear augers. The front auger helical fin will be "right handed" whereas the rear auger helical fin will be "left handed". The purpose of the opposite fin direction and the offset between the front and rear augers is to reduce material build up on either side of the mechanism.

Assigned Responsibilities

ME Department Students

- Shear Force Analysis of the auger weeding mechanism:
  - Steven Miller will conduct analysis of the auger mechanism. He will make reasonable assumptions based on the final design concept. This will aid in material selection as well as the selection of the electrical components.
- Final Design Concept CAD Drawings:
  - Christopher Murphy will begin detailed CAD drawings of all components of the final concept. This will aid in the estimation of the final size and weight of the ROV.
- Material Selection:
  - Xiang Zhang will conduct calculations to ensure the proper materials are used. This task is dependent on the CAD drawings as well as the shear force calculations.
- Alternate Shearing Mechanism Analysis:
  - Arriana Nwodu has already begun to conduct a detailed analysis of the 4-Bar Coupler shearing mechanism which includes force, velocity, and acceleration analysis. The sponsor wants to try new shearing implements and will the 4-Bar Coupler will included as an exciter.

EE Department Students

- Motor Analysis and Selection:
  - Aquiles Ciron will conduct analysis of the motor system to include motor drivers. This task is dependent upon the shear force analysis and final concept CAD drawings.

- Website Design:
    - Steven Williamson will design and implement Team 11's senior design website in addition to assisting Aquiles Ciron in analyzing motor and microcontroller systems.

In addition to mechanical and electrical drawings and calculations, everyone will take part in conducting shelf engineering in search of the optimal combination of microcontrollers, linear actuators, motors, etc. for the best price possible.

Project Schedule:

Figure 5 describes in detail, the projected schedule for Team 11 through the end of fall semester 2015. Team 11 is currently completing the introductory phase of the project, and is initiating Product Development. Identifying the Need has gone through a series of refinements and was solidified after the last meeting with the sponsor. The Faculty Advisor directed Team 11 to look for electrical based actuators that will accommodate the environment that the machine will be operating in. Conceptual Analysis and Material Selection will continue until the beginning of November where the rest of the semester will be dedicated to Final CAD Drawings Prototyping and Fabrication.

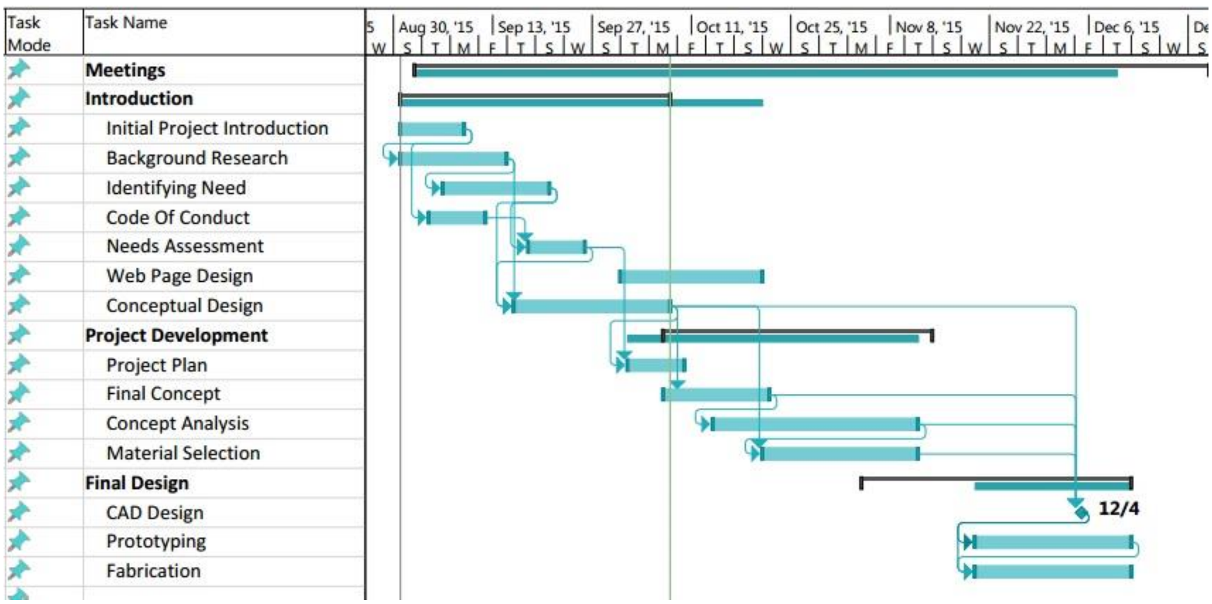


Figure 5: Gantt Chart for the Robo-Weeder project.

Conclusion:

The traditional farming methods that have been implemented on a large scale are having a detrimental effect on the environment and the quality of today's crops. These negative effects range from the widespread use of herbicides, pesticides and fertilizers, to the massive amounts of water being drained to provide the needed water demand of large scale farms. These less than environmentally friendly farming practices have been the driving force behind the rise of the organic farm.

The sponsor and Team 11 had a series of meetings to discuss conceptual designs with a final chassis design chosen. After the final decision was made the team discussed the conceptual design with the faculty advisor, Dr Gupta to attain direction on how to proceed with the focus being on shelf engineering electrical linear actuators and the best combination of motors, microcontrollers etc. The mechanical engineers of Team 11 will further expound on the final conceptual design with detailed CAD drawings accompanied by force and velocity analysis of each component of the machine. Arriana will create detailed drawings of the alternate shearing mechanism to present to the sponsor at a later date as an exciter.

References:

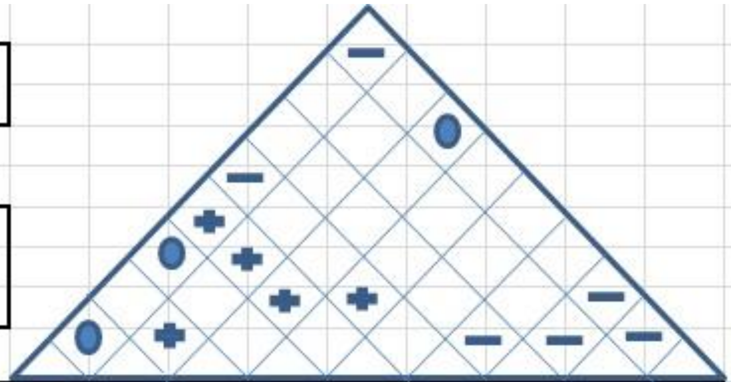
[1] http://12.000.scripts.mit.edu/mission2014/problems/ineffectiveinadequate-agricultural-practices

[2] http://www.ofrf.org/organic-faqs

[3] https://www.ocf.berkeley.edu/~lhom/organictext.html

Appendix A:

House of Quality



+	Posivite Relation
●	Nuetral Relation
–	Negative Relation

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Figure 6: Team 11 House of Quality