Autonomous Lawn Care Unit

Project plan

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Revised: 3/23/2018 Version 2

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1 Introductory Material

1.1 Acknowledgement

If a client, an organization, or an individual has contributed or will contribute significant assistance in the form of technical advice, equipment, financial aid, etc, an acknowledgement of this contribution shall be included in a separate section of the project plan.

1.2 Problem Statement (2 paragraphs+)

The problem we intend to solve concerns the time and financial commitment required to upkeep a well-groomed lawn. There is a long list of reasons a certain individual may not be able to mow their own lawn, ranging from lack of time to physical incapabilities. Someone who falls into this category does not have many options to get the job done, without hiring expensive, third-party help.

We intend to solve this problem by designing a safe, functional, and affordable autonomous lawn mower. This will give lawn-owners a relatively inexpensive, low-effort means of maintaining their lawn effectively. Our autonomous lawn mower will be able to safely mow any predefined area with maximum accuracy and efficiency.

– This is included so that the reader will have the correct conception of the problem and the solution approach upfront. Each shall be written in a non-technical manner that a lay person would understand.

– Consists of two components, each separated and clearly identified:

-General problem statement – defines the general problem area

-General solution approach – defines the proposed solution approach

-This section should also highlight the purpose of the project, what you are trying to do.

1.3 Operating Environment (one paragraph +)

The general environment for our product will be a dry lawn. As with any lawnmower it, it would have trouble cutting wet grass. The wet lawn would also make it difficult for our lawnmower to retain traction and be able to travel up steeper terrain. Our mower will be spending most it's time outside, therefore, it must have some sort of water and dust resistance. The electrical components are very susceptible to water, and they must be kept dry. Lots of dust could cause static electricity to build up, which could kill the components. The next thing we would have to worry about is the mower overheating. We will need to keep the electronic components out of direct sunlight. When we

implement something to keep the components dry and dust free, it would also double as a shield from the sun.

– For any end product other than simply a calculation or simulation, it is essential to know the environment in which the end product will be used or to which it is expected to be exposed or experience. For example, will the end product be exposed to dusty conditions, extreme temperatures, or rain or other weather elements?

– This information is necessary in order to design an end product that can withstand the hazards that it is expected to encounter.

1.4 Intended Users and Intended Uses (two paragraph +)

Our intended users are anyone who need their lawn mowed. If you own a home, you most likely need to keep your lawn trimmed. There are many reasons why someone may not be able to do this. For example, some people do not have the time and some people have physical incapabilities.

The uses for our product would be to mow a lawn. We picture it being used by residents and not corporations. The primary goal of our product will be to make the lives of the user's a little bit easier.

– To properly design an end product that will provide the maximum satisfaction and perform in the most efficient manner, it is essential to understand the end user and the associated end uses.

1.5 Assumptions and Limitations

- Assumptions
    - Residential, non commercial use.
    - Battery Powered
    - ⅕ Acre Lawn
- Limitations
    - Steep Terrain
    - Dry Conditions
    - Grass must not be overgrown.

– Two separate lists, with a short justification as needed.

– Extremely important, as it can be one of the primary places where the client can go to determine if the end product will meet their needs.

– Examples of assumptions: The maximum number of simultaneous users/customers will be ten; Blue is the best background color and will be used; The end product will not be used outside the United States.

– Example of limitations: The end product shall be no larger than 5”x8”x3” (client requirement); The cost to produce the end product shall not exceed one hundred dollars (a market survey result); The system must operate at 120 or 220 volts and 50 or 60 Hertz (the most common household voltages worldwide).

– For limitations, include tests not performed, classes of users not included, budget/schedule limitations, geographical constraints, etc.

1.6 Expected End Product and Other Deliverables

- Safe and Affordable autonomous lawnmower.
    - Lawn mower can find and avoid hazards in lawn.
    - It is affordable compared to other mowers on the market.
- Android/iPhone App to control lawnmower.
    - This will tell the lawnmower when and where to mow. As well as view mower stats.

- List the end product and any other items, along with a brief description, that will be delivered to the client prior to the end of the project.

– If the end product is to be commercialized, the description shall be of the commercialized end product.

– It shall be in the form of a technical product announcement, as opposed to a product advertisement, and shall not include a list of technical specifications.

– Any other items that will be delivered to the client shall also be included and described unless their definition and description are obvious.

– Examples might include a household power supply to eliminate the need for batteries, a user’s manual, or other project reports.

– There shall be at least a one-paragraph description for each item to be delivered.

– Delivery dates shall also be specified.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

The ultimate goal of our project is to deliver a safe, affordable autonomous lawn mowing system. The system includes the lawnmower device, perimeter mapping device, and software to control both of these.

2.2 Functional Requirements

- Algorithm to efficiently mow entirety of area given a mapped perimeter
    - Intelligent routes will ensure straight lines
- System to map perimeter of the lawn
    - Easy installation
    - Low power
- Object detection and avoidance
    - Use various sensors to accurately detect and avoid objects
    - Navigate around hazardous areas in a lawn
- Mobility through standard lawns
    - Drive up 30% grade
    - Lightweight
- Algorithm to detect and avoid safety concerns
    - Easy shutoff consistent with sensor stimuli
    - Indicate current state
- Power efficiency
    - Auto-charging feature
    - Charge and mowing time to fall between 60-90 minutes
- Streamlined interfacing
    - Android app for communication and diagnostics
- GPS module for directional guidance

2.3 Constraints Considerations

- Battery life to complete job or return to charging station
- Lightweight enough to be easily moved by hand
- Algorithm execution rate of 100Hz
- Design consists of affordable parts, and is reasonable for the domestic market

- 15% incline maximum
- 3.5 inch maximum grass height
- The motors will shut off if the mower is lifted off the ground
- Bump sensors to prevent mowing living things

IEEE Standards:

We will be following all the IEEE ethics standards

2.4 Previous Work And Literature

There are several autonomous lawn mowers sold by lots of different companies available on the market. The majority of these lawn mowers are above $2000 dollars and resemble roombas. These lawn mowers use boundary wire and the mower mows in random directions that are within the boundary wire perimeter. Our group has a market research put in an excel sheet which compares lots of these lawnmowers and its different functionalities. We believe that our project will be cheaper than the majority of these products. Another thing our project will try to improve on is the mowing algorithm we will try to cut in an organized way and avoid cutting already cut grass rather than random movements within the wire perimeter.

Example mower which is expensive and uses a random mowing algorithm:

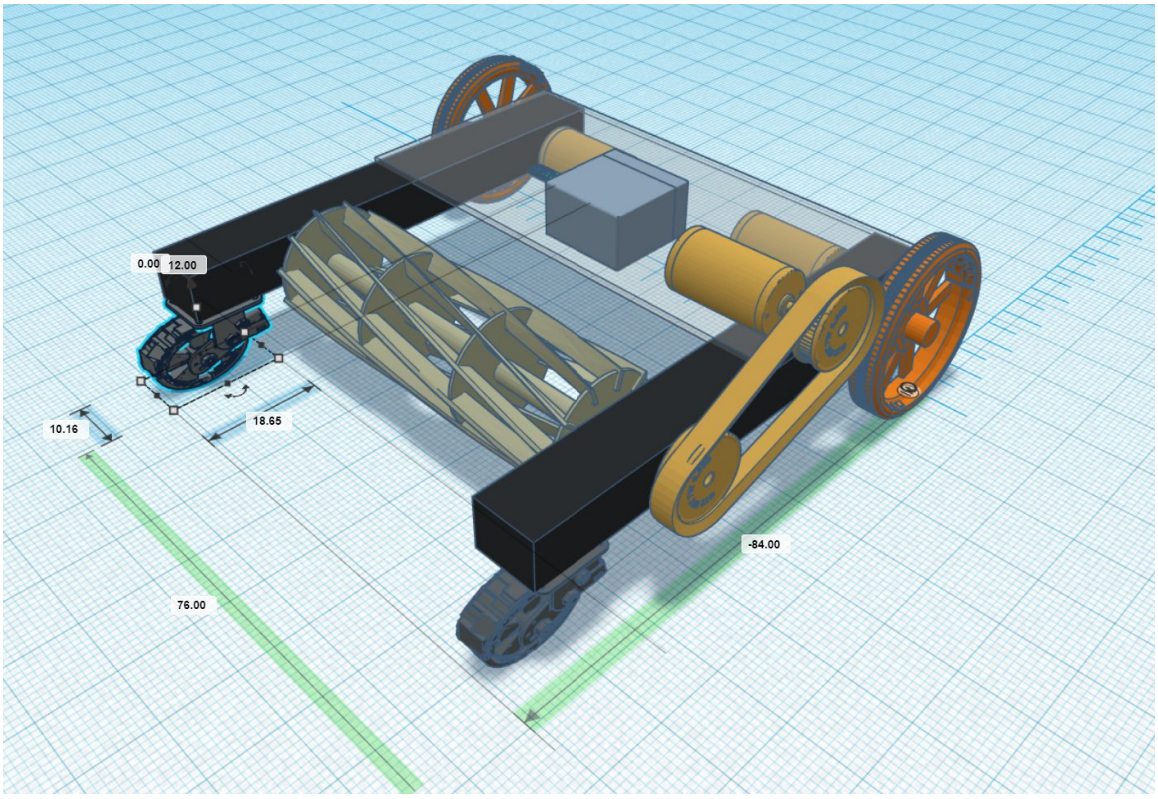
https://www.robomow.com/en-GB/platform/rs/

Excel Sheet:
https://docs.google.com/spreadsheets/d/1waZLEHPhGPK-LqDRXmTi1eaSke41UbJOGqoiGLr6axQ/edit#gid=0

2.5 Proposed Design

Our lawn mower design is have a RC chassis made of C channels 2 caster wheels in the front and 2 fixed wheels in the back which will be powered by 2 motors. We plan on using a microcontroller to control the sensors and movement. As for the blades we plan on using a Reel blade which will be attached to the front of the mower which will also be powered by a motor. To make this mower autonomous we will have boundary wire surrounding the portions of the lawn which need mowing. The mower will sense for the wire and cut within the designated perimeter.

Prototype Cad Design:



2.6 Technology Considerations

Arduino Mega

- Easy to program
- Many I/O ports
- Inexpensive (<$40)
- Prior team experience with Arduino
- Easy integration with GPS

Deck:

Adapt an existing electric lawn mower

Pros

- Larger cutting radius

Cons

- Controller and wheels will draw power from battery
- Hard to move around and work on
- Larger mechanical component
- Add motors and caster wheels
- Bulky/ hard to navigate

DIY deck

Pros
- Inexpensive
- Wire, blade, or disk
- More leeway with size/ power
- Lightweight

Cons
- Less refined

Adapt trimmer

Pros
- Inexpensive
- Lightweight
- Low power

Cons
- Larger mechanical component
- Harder to integrate

Drivetrain:

Electric wheelchair wheels ($80-$200)

Pros
- Powerful (24V)
- Relatively inexpensive

Cons
- Better for full sized mower
- More current draw
- Heavier

RC wheels / tracks ($40-$150)

Pros
- Inexpensive
- More options
- Possibly include chassis
- Zero turn radius (tracks)

Cons
- Less powerful (9 - 12v)

Based on our collective research, We believe the best direction for this project is a combination of Grant's 3D printed proposal and an RC chassis and wheels. Though creating the device from scratch requires some initial mechanical engineering, it will ultimately require much less of a mechanical component than adapting an existing mower, since there really aren't any available mowers that meet a lot of our specifications.

A 3D printed or custom deck will be very inexpensive, lightweight, and provide us with more options. We can make this device very mobile and light, which will make testing much easier. An RC-scaled product gives us the ability to use less power, cut intricately, and realize the idea at a very low cost.

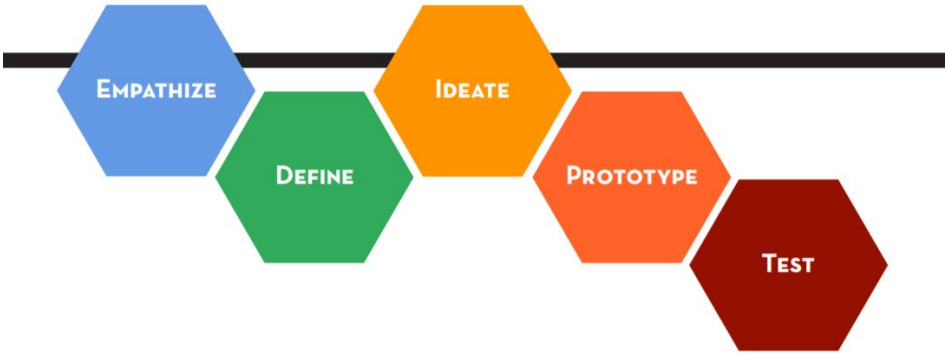
2.7 Safety Considerations

There are several safety concerns that should concern the consumer:

1. Young children should stay away from the mower at all times while running.
2. Stones, debris, and other large objects should be removed from the lawn prior to mowing to prevent injuries.

2.8 Task Approach

One of the methods that we will use for the mower is a design method thinking shown by the chart below.



The method has five parts to it: Empathize, Define, Ideate, Prototype and Test. For the empathize portion, we came up with a list of people which would need the mower. We had to understand why they needed an autonomous mower and what specific tasks the mower should perform. In terms of defining, we decided that an autonomous mower which is affordable and easy to use. The Ideate will help us think outside the box in our brainstorming and come up with more options that we see nothing like in the market. We looked at several competitors and mixed and matched their strengths. We currently have a model of our prototype which met with the goals we wanted to achieve. The final part is Test which gives us feedback on how the prototype did and how it can be improved. After our prototype is built we will begin testing on the mower.

2.9 Possible Risks And Risk Management

- Finding the best components for our mower with the smaller scale design that we have for our mower.

- Having a lack of knowledge on the mechanical side of creating the mower
- Cost could be high with the niche components that we are looking for
- Purchasing and receiving the various components could take longer than expected

2.10 Project Proposed Milestones and Evaluation Criteria

- Research and all options weighed
- Selection and purchase of parts for the mower
- Mower drivetrain is finished
- Have the microcontroller and sensors attached to the mower base
- Control the mowers movements using a remote
- Have the mower move autonomously
- Let the mower mow a lawn without human guidance

2.11 Project Tracking Procedures

We will be using gitlab issues to keep track of our project throughout the two semesters.

2.12 Expected Results and Validation

The desired outcome for our project is to provide a safe and affordable autonomous lawn mower. Our goal is to have this lawn mower sell for under 1500$ and cover about ⅛ of an acre and be able to go on an incline up to 15%.

To validate our results we will keep track of how far the mower has moved on one charge and calculate the total area covered. We will also test the mower on a grassy hill to make sure it has the power and traction necessary to move up an incline. Currently with all our parts combined we are at 1100$ which is well under the 3000$ budget we were given.

2.13 Test Plan

Testing types:

Software:

1. Make sure that there is a solid connection between the microcontrollers and the motors of the mower
2. Make sure that the mower is moving in the correct direction
3. Test if the arduino and the raspberry pi have a solid connection

Hardware:

1. All parts of the mower are connected securely and safely
2. All the sensors are receiving accurate data
3. The mower is operating at the correct speeds
4. Battery is charging correctly
5. The mower should be able to withstand certain conditions

Mobile:

1. The app should be connected to the mower correctly
2. Data from the mower should be shown to the user
3. Server for logging in should be working correctly

Parts that will be testing:

Great States 204-14 Hand Reel 14 Inch Push Lawn Mower
PG71 Gearmotor
30" C Channel
8" Plaction Wheel with Wedgetop Tread (am-0514)
PG Series Mounting Bracket (am-2197)
500 Hex Hub (am-0096a)
3/8" diameter external retaining ring (am-1253)
M4-0.7 x 10mm SHCS [Qty-10] (am-1269)
10-24x1/2 Thread Forming Screw [Qty-25] (am-1361)
1/4-20 x 2" SHCS - Bulk Qty (am-1012)
1/4-20 Nylock Nut - Bulk Qty (am-1015)
Cheap and Dirty Radio Control System (am-2520)
8 Ganged ATC Fuse Block for Snap Action Breakers with Ground Terminal (am-3136)
5 ft of bonded red/black wire (buy 25 ft)
30 Amp Snap Action Breakers (am-0290)
12V 17Ah Battery
Connector, Female, 12-10 AWG, Tab .032"x.250", Yellow, Qty 10

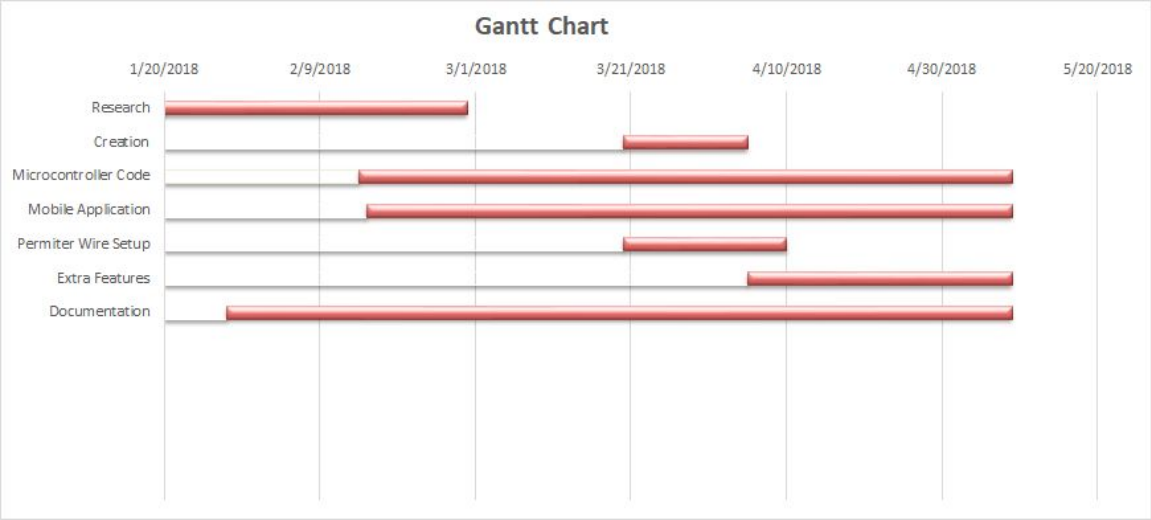
Powerpole Kit
Talon SRX Speed Controller (am-2854)
Power Converter 12/24VDC to 5VDC
3-wire PWM cable
6 gauge Robot Side Power Cable Kit
6 Gauge Battery Cable
Battery Charger
Houseables Caster Wheels

3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

Spring Semester

February	March	April	May
Hardware: Research the mower design **Software:** Order the arduino **Mobile:** Start App	**Hardware:** Find the parts needed for the lawn mower **Software:** Start testing the the basic functions of our microcontroller **Mobile:** Begin writing the ui for the app	**Hardware:** Order the parts needed for the lawn mower **Software:** Test the microcontroller on a dummy mower **Mobile:** Connect the app with the microcontroller	**Hardware:** Combine and test the parts of the lawn mower **Software:** Test the microcontroller on the mower **Mobile:** Connect the mower with the app



Fall Semester

September	October	November	December
Hardware: Test our mower and make adjustments Software: Continue improving our autonomous code Mobile: Connect a camera on the mower with the app	Hardware: Refine our mower Software: Continue improving our autonomous code Mobile: Move the mower with the app	Hardware: Make adjustments if needed Software: Continue improving our autonomous code Mobile: Add more functionality to the app	Hardware: Put finishing touches on the mower Software: Put finishing touches on the autonomous code Mobile: Put finishing touches on the app

Our project has 3 main parts to it so each month we should try to set goals for all 3 parts. Obviously some parts will be more important than others at different stages of our design process. These goals set in our timeline allows us to have a basic idea of where to proceed in the future. During the spring semester the projected goal of this project is to have a working prototype of a the lawn mower. We hope that our mower can move by itself and maybe cut a few rows of grass. During the fall semester we hope to have the mower mow a small lawn by itself without error. On the mobile side of the project, we hope to have the app connect with the mower's camera and allow it to control the mower wirelessly.

3.2 Feasibility Assessment

The end goal of this project is to have a mower mow a small residential lawn without breaking down. Some challenges that may appear will be combining all the hardware parts

and connecting it with the microcontroller. Another challenge which may arise would be the autonomous and sensor code.

3.3 Personnel Effort Requirements

Creating the mower	40 hours
Controlling the mower with a microcontroller	15 hours
Controlling and connecting the sensors	10 hours
Researching the what parts to use	15 hours
Autonomous mower code	80 hours
Mobile application	30 hours
Perfecting and adding possible changes	60 hours

This is a rough estimate of the basic things we need to accomplish with our project.

3.4 Other Resource Requirements

Parts and their cost spreadsheet:
https://docs.google.com/spreadsheets/d/1CgmDwK05UuJ-vxxP7mH8zM6wpVNLLWAvFZ_a-7ijMqk/edit#gid=0

3.5 Financial Requirements

This project will have an estimated cost of between $1000-$1500 USD. Our client has agreed to this number and will be providing our group with the funds.

4 Closure Materials

4.1 Conclusion

Mowing the lawn is something the majority of homeowners need to do on a semi- weekly basis. Sometimes they may not have the time or ability to mow it. With our project we aim to solve this problem in a affordable and effective way. We think that with our approach we should be able to make a device that is much cheaper than what the current market has to offer. Our mower will also have extra features such as a mobile app, weed killers, and auto charging which should make it even more helpful to the consumer. Our end goal is to create a product that the every-day homeowner can

4.2 References

TBD

4.3 Appendices

TBD