Senior Design I: Initial Project Document
8 Sep. 2018

# Robotic Solar Farm Grass Cutting System Design Challenge


*University of Central Florida*

*Department of Electrical Engineering and Computer Science*

*Dr. Lei Wei*

*Sponsored by: OUC and Duke Energy*

**<u>Group 6</u>**

Max Seberger - Electrical Engineering
Anderson Kagel - Computer Engineering
Ali Hamdani - Electrical Engineering

# Project Narrative

The optimal location for PV panels for large generation of energy are normally in open areas like a grassy field. One of the downsides of these types of locations is the landscaping required from keeping grass and other vegetation cut so it does not hinder the ability of the solar panels and operation of the solar farm as a whole. Solar panels need to be in direct sunlight to run optimally, and that is variable with cloud cover, storms, etc. Thus removing the external factor of grass and plant growth hindering the operation of a PV panel is imperative when running a solar farm. Maintained grounds help with both the proper operation of solar panels and the easy maintenance of solar infrastructure. Properly maintained grounds will allow for easy replacement of a certain panel within an array is not functioning properly, from corrosion or other effects. There are a number of landscaping contractors that specialize in solar farm landscaping.As a result, solar energy is not entirely free and a major expense of solar farms is ground maintenance. There can also be risk with using ground services with possible damage of solar infrastructure which can be avoided if the AI-assisted, autonomous solar powered rover-based robot has good While there may be various approaches for providing ground maintenance service, the goal of this project is to minimize the monthly expense of cutting the grass by using AI-assisted, autonomous solar powered rover-based robots to articulate and guide electric weed whackers.

The main goal behind the eGOAT is to cut the costs and potential risks involved with human ground maintenance. The eGOAT must be autonomous, low cost, smart, and effective. An autonomous system like the eGOAT should be able to operate without frequent service or interference, while still providing an effective grass cutting service and ensuring the safety of solar infrastructure during operation. As the name suggests, the eGOAT will be powered electrically, drawing its energy from an array of integrated PV panels, unlike conventional, human-operated mowing equipment that run off of fossil fuels and need to be refilled frequently. This means that the eGOAT will be totally renewable, saving both the owner and environment the recurring costs associated with less eco-friendly options. The AI-guided task planning software of the eGOAT will be able to detect obstacles in the environment, identify locations and objects in need of trimming, and construct a sequences of tasks to accomplish mission objectives and avoids any potential damage to important infrastructure.

In the interest of generating many possible solutions to this challenging problem, this project will take the format of a design competition, where multiple interdisciplinary student teams will work in parallel to produce the best possible solution. There are at least three major elements to the project as follows:

- Rover-based Robot:  To provide the articulated sweeping motion needed to move the weed whacker across the terrain and cut grass.

- Navigation and Control:  To identify grass areas that need attention (i.e., cutting), avoid obstacles and provide overall motion control of the rover-based robot.

- Power Supply:  Grass cutting may take place at night and charge during the day. To accommodate such a scenario the system must use a defined battery storage technology with charging capability.

Successful design execution will require an interdisciplinary team with participation from students in the following disciplines: computer science, computer systems, electrical and mechanical engineering.  The optimal design will integrate state-of-the-art technology at the lowest cost.  Thorough and thoughtful consideration of safety, reliability and durability is an absolute requirement.

# Requirement Specifications

## Hardware/Electrical Requirements

1. The eGOAT shall be equipped with a remote kill switch that can turn off the cutting system and locomotion at a distance of approximately 50 feet.
2. The eGOAT shall be capable of navigating uneven terrain with an approximate terrain differential of 3 inches over a 2 foot span.
3. The eGOAT shall be able to maintain a grass height between 3 and 6 inches.
4. The eGOAT shall be charged through solar power.

## Software/Autonomous Requirements

1. The eGOAT shall be able to autonomously navigate its environment.
2. The eGOAT shall be able to sense objects in its surrounding environment and avoid damaging infrastructure, environment, and humans.
3. The eGOAT shall be capable of both cutting grass in large, open areas and trimming close to solar farm infrastructure.

# Constraints & Standards

## Constraints

1. The eGOAT must use an off-the-shelf, battery powered, string-based trimmer.

2. The eGOAT must use an off-the-shelf battery and charger.
3. The eGOAT must operate independently and have no attachments to solar farm infrastructure.
4. The eGOAT must not exceed an estimated budget of $1500 for total material and assembly cost.
5. The eGOAT must be limited to a size of 2 feet in each direction during grass cutting operations in order to fit between/under rows of solar arrays.
6. The eGOAT must not damage infrastructure, environment, or humans.

## Standards

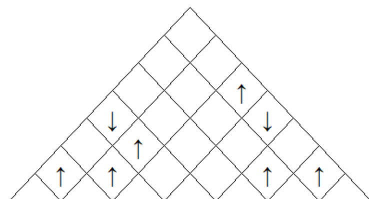
More research is needed.

# Diagrams

Figure 1: House of Quality

| Objectives | |
|---|---|
| To Maximize | + |
| To Minimize | − |

| Relationships | |
|---|---|
| Strong positive corelation | ↑↑ |
| Positive corelation | ↑ |
| Negative corelation | ↓ |
| Strong Negative corelation | ↓↓ |

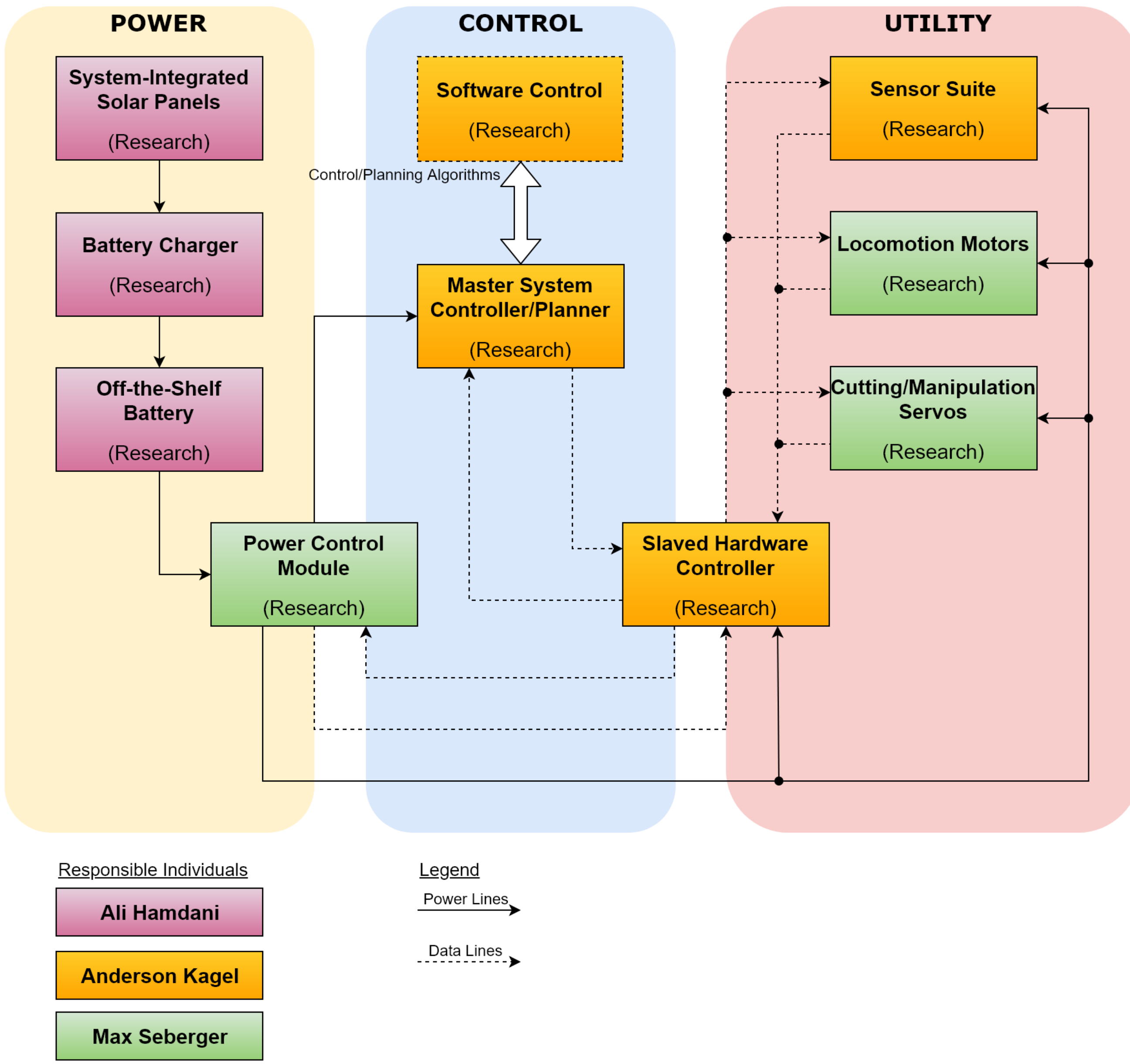


| | | | Column # | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction of Improvement | | + | − | + | + | + | − | − | |
| Row # | Customer Importance | Maximum Relationship | Functional Requirements / Customer Requirements (Explicit and Implicit) | Direction of Improvement | Effuciency | Cost | Enviromental Resistance | Battery life | Accuracy | Weight | Dimesnsions | Row # |
| 1 | 8 | | Cost | − | ↑ | | ↑ | ↑ | | | | 1 |
| 2 | 2 | | Size | − | ↓ | ↑↑ | | ↓ | | ↑ | ↑↑ | 2 |
| 3 | 4 | | Speed | + | ↓ | ↑ | | ↓ | ↓ | ↓ | | 3 |
| 4 | | | Charging time | + | ↓ | | | ↓ | | | | 4 |
| 5 | | | Duration | + | ↑ | ↑ | | ↑↑ | | ↑ | ↑ | 5 |
| 6 | | | Ease of Installation | + | | | | | | | | 6 |
| 7 | | | Safety | + | | | | | | | | 7 |
| | | | Target | | >75% | <1500$ | Resist 45 mph wind,water proof | >3 hr | >80% spent over grassy area | <30lbs | <2 feet in all directions | |
| | | | Column # | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |

$$Efficiency = \frac{\sum_i \eta_i(L_i)}{L_{system}},\ where\ \eta_i\ is\ the\ efficiency\ of\ the\ i^{th}\ component\ and\ L\ is\ a\ resistive\ load$$

## Block Diagrams

Figure 2: System Level Block Diagram



# Budget and Financing

Table 1: Budget and Financing

| Item | Price |
|---|---|
| Solar Panels | $300 |
| PCB | $150 |
| Microcontrollers | $150 |
| Battery/Charger | $200 |
| Sensors | $200 |
| Electric Motors/Servos | $200 |
| Cordless Weed Wacker | $200 |
| Mechanical Materials | $600 |

Total: $2,000

# Milestones

Table 2: Milestones and anticipated schedule

| Senior Design 1 (2018) | |
|---|---|
| **Description** | **Due Dates** |
| Project selection | August 31st |
| Divide and conquer | September 14th |
| Research | October 10th |
| 60 Page | November 2nd |
| 100 Page | November 16th |
| Finalizing the paper | November 24th |
| Final document | December 3rd |
| **Senior Design 2 (2019)** | |
| **Description** | **Due Dates** |
| Order PCB #1 | January 8th |
| Finalize PCB#1 Testing | January 18th |
| Order PCB #2 and Testing ( If necessary ) | January 25th |
| Build prototype | February 1st |
| Testing | February 4th - February 18th |
| Finalize prototype | March 22nd |
| Peer presentation | TBA |
| Final report | TBA |
| Final presentation | TBA |