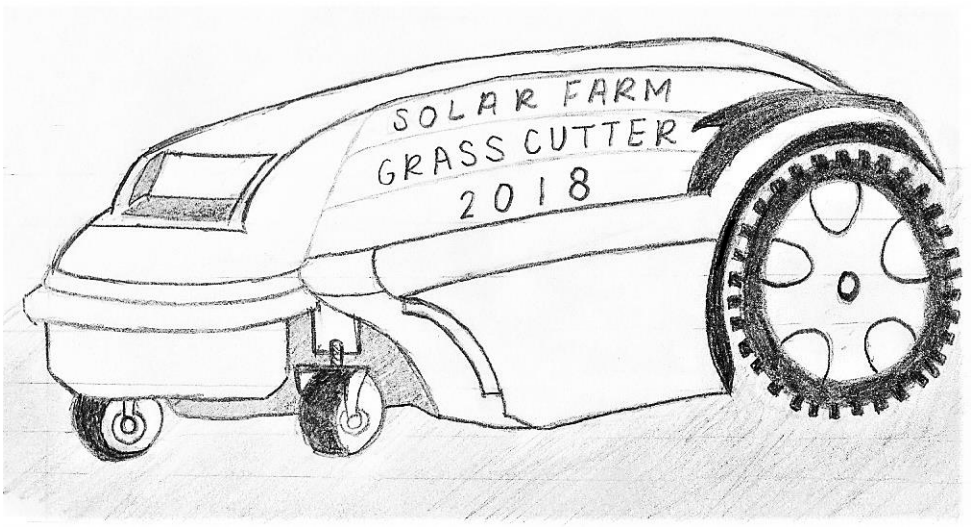
Articulated Autonomous AI-Assisted Solar Farm Grass Cutter



Department of Electrical Engineering and Computer Science

University of Central Florida

Dr. Lei Wei

Sponsors: OUC and Duke Energy

Senior Design I

Fall 2018

Group 19

Brandei Dieter	Electrical Engineering
Chris Entwistle	Electrical Engineering
Mario Mcclelland	Computer Engineering
Daniel Warner	Electrical Engineering

1.0 Project Narrative Description

As the rise of technology continues to grow, we are constantly seeking methods to improve the environment around us. Traditionally, lawn mowers are gas powered which inherently poses a threat generated by the carbon footprint left as a result. With solar farms becoming increasingly popular, using traditional lawn mowers to maintain them would mock the motivation behind renewable energy.

Many Solar Farms are constructed on top of a grass terrain. The problem that arises is the cost of labor to keep the grass maintained under the PV structures and surrounding area. We are going to solve this problem by creating an Articulated AI-Assisted Solar Farm Grass Cutter. Our device will be the solution that reduces labor costs while also increasing energy efficiency. Our project is sponsored by Duke Energy and Orlando Utilities Commission and will include interdisciplinary collaboration between fields of engineering.

This project will be developed in conjunction with a team of Mechanical Engineering and Computer Science students. The focus of our team will be the electrical design and power of the system, software algorithms for the hardware, power specifications of the solar panel and batteries, and the design and implementation of the Printed Circuit Board (PCB).

The grass cutter will have various technical requirements. An articulated sweeping motion is needed to move the string-based blade across the terrain to cut the grass to an acceptable height and identify the areas that need grooming. It will avoid all obstacles such as PV structures, humans, rocks, and objects. It will fit below and between the rows of PV panels, and have a remote kill switch that can turn off the cutting system. It will safely navigate through uneven terrain. Be capable of cutting the grass as close to the obstacles but not touching or damaging any objects. A rain detection system is required to detect rain and go back into the charging station. Being waterproof is ideal to prevent any damage to the internal system. A GPS system is required to provide boundary kill and navigation to the Solar Power Charging Station when it needs to be charged.

Another consideration for this project is to guarantee safety in the event of human interaction. This will be accomplished by assuring the necessary steps are taken to avoid collisions when the device is in operation. The Solar Power Charging Station should include a high wattage solar panel that will store energy for when the grass cutter needs to be charged and be waterproof to prevent any damage from weather.

The grass cutter will be portable, have low power consumption and easy to maintain. The grass cutter will be shock proof to prevent internal damage from outside contributing factors. It will have DC motors that can provide enough power to the wheels to navigate through uneven terrain. The wheels will be able to provide a full range of motion. The wheels will be designed to have proper traction to be able to operate in conditions that include inclined or declined terrain.

In conclusion, a microcontroller will be designed to interface the electrical components that will satisfy the customer's requirements. Many of the inputs will be received by the sensors to communicate with the motors that will navigate the device. One stretch goal will include optimizing the blade motor control by turning the blade off when it drives over grass that does not require attention.

2.0 Project Requirement Specifications

The goal of this project is to use the components listed in the table below to design a fully functional, Articulated AI-Assisted Solar Farm Grass Cutter. The project has to contain a development board, Microcontroller, Motor Control Drivers, a GPS module, a Bluetooth module, and a DC-to-DC Conversion Circuit. The grass cutter will use low voltage and power consumption. It will include a Rechargeable Lithium Ion Battery. It will charge the battery via Solar Power through the Solar Power Charging Station.

Table 1: Legend for Project Requirement Specifications Table

ORS	Overall Requirement Specifications
PRS	Project Requirement Specifications
BRS	Billing Requirement Specifications

Table 2: Project Requirement Specifications

Designation	Description	Value	Related Standards
ORS-1	Dimensions of Device	≤2x2x2 ft.	None, typical competitive size
ORS-2	Dimensions of PCB	To be determined	None, typical competitive size
ORS-3	Weight	Less than 50 pounds	None, typical competitive size
PRS-1	Microcontroller	Compatible with the development board	IEEE Standard
PRS-2	Development Board	Compatible with C and high level functions	IEEE Standard
PRS-3	Bluetooth Module	Compatible with the microcontroller	IEEE Standard
PRS-4	Motor Control Driver Chips	Compatible with the microcontroller	IEEE Standard
PRS-5	Rechargeable Lithium Ion Battery	High battery capacity	IEEE Standard
PRS-6	Resistors	Variety	None, typical competitive size
PRS-7	Capacitors	Variety	None, typical competitive size
PRS-8	Dc-to-DC Converter	Be able to boost up or step down voltages	IEEE Standard
PRS-9	Obstacle Avoidance Sensor	>6 inch range detection	IEEE Standard
PRS-10	Solar Panel	High Power Output	IEEE Standard
PRS-11	GPS Module	>than 3feet accuracy	IEEE Standard
PRS-12	Obstacle Detection Sensor	>2 feet range detection	IEEE Standard
BRS-1	Project Cost Ceiling	$2000	None, typical competitive size

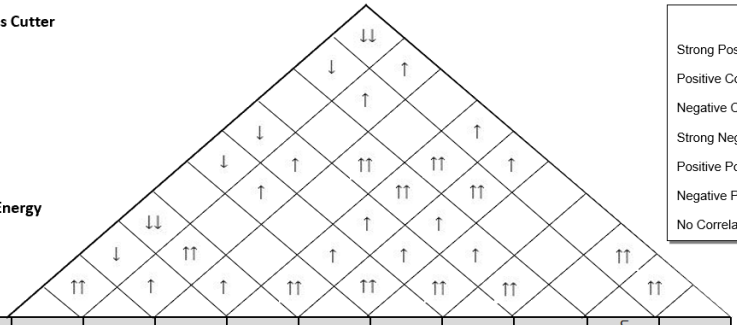
3.0 Engineering Market House of Quality Trade-Off Table

Group 19: Autonomous AI-Assisted Solar Farm Grass Cutter

House of Quality (ECE)

Engineers: **Brandei Dieter**
Chris Entwistle
Mario Mcclelland
Daniel Warner

Customer: **Orlando Utility Commission & Duke Energy**



Legend

Strong Positive Correlation	↑↑
Positive Correlation	↑
Negative Correlation	↓
Strong Negative Correlation	↓↓
Positive Polarity	+
Negative Polarity	-
No Correlation is BLANK	

Customer's Desires	**Technical Requirements**	Power System Capabilities	Power Distribution	Bluetooth Implementation	Control Implementation	Navigation Implementation	Object Recognition	Object Distinction	Safety Protocols	GPS Implementation	Boundary System
		+	+	+	+	+	+	+	+	+	+
Maintain Grass Height Under 6in	+	↑	↑		↑↑		↑↑	↑↑	↓		
Maintain Area the Size of Solar Farm	+	↑↑	↑↑		↓	↑↑	↑	↑	↑	↑↑	↑↑
Fit Under/Between PV Structures	+			↓	↓	↓			↑↑	↓	↓
Avoid Damaging Infrastructure/Environment/Humans	+		↑	↑	↑↑	↑	↑↑	↑↑	↑↑	↑	↑
Utilizes Solar Power Charging Station	+	↑↑	↑↑			↑↑	↑	↑		↑	↑
Have Kill Switch at least 50 ft	+	↑	↑	↑↑							↑
Capable of Navigating Uneven Terrain	+	↑	↑	↓	↑↑	↑	↑	↑	↑		
Integrated Off the Shelf Battery and Charger	+	↑↑	↑								
Independently Powered Location Beacon	+	↑↑	↑↑							↑↑	↑
Low Cost	+	↓↓	↓	↓	↓	↑	↓	↓	↑	↓	↓↓
Target		**> 50x10 ft range**	**< 75% charge/cycle**	**> 50x10 ft range**	**> 50x10 ft/15mins**	**> 3 in delta in terrain**	**> 2 ft**	**> 6 in**	**No damage**	**> 2 ft accuracy**	**> 50x10 ft boundary**
Technical Difficulty (1-5, 5 hardest)		**2**	**4**	**1**	**4**	**5**	**2**	**3**	**4**	**3**	**2**

Figure 1: House of Quality Trade-Off Table

4.0 Block Diagrams

4.1 Hardware Block Diagram for Grass Cutter

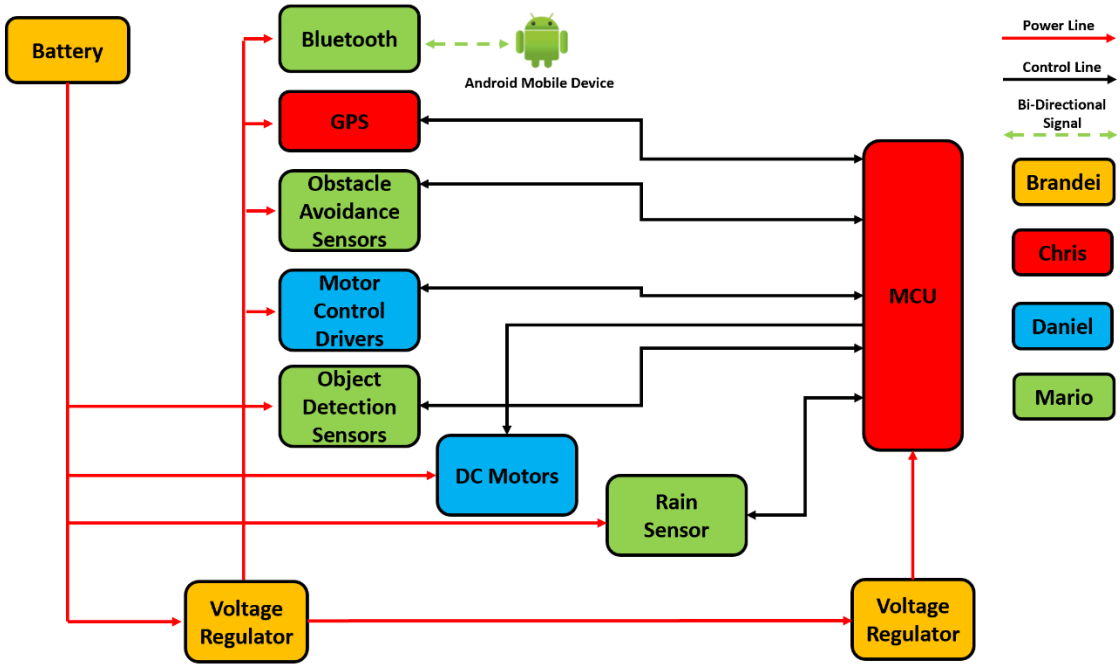


Figure 2: Hardware Block Diagram for Grass Cutter

4.2 Hardware Block Diagram for Charging Station

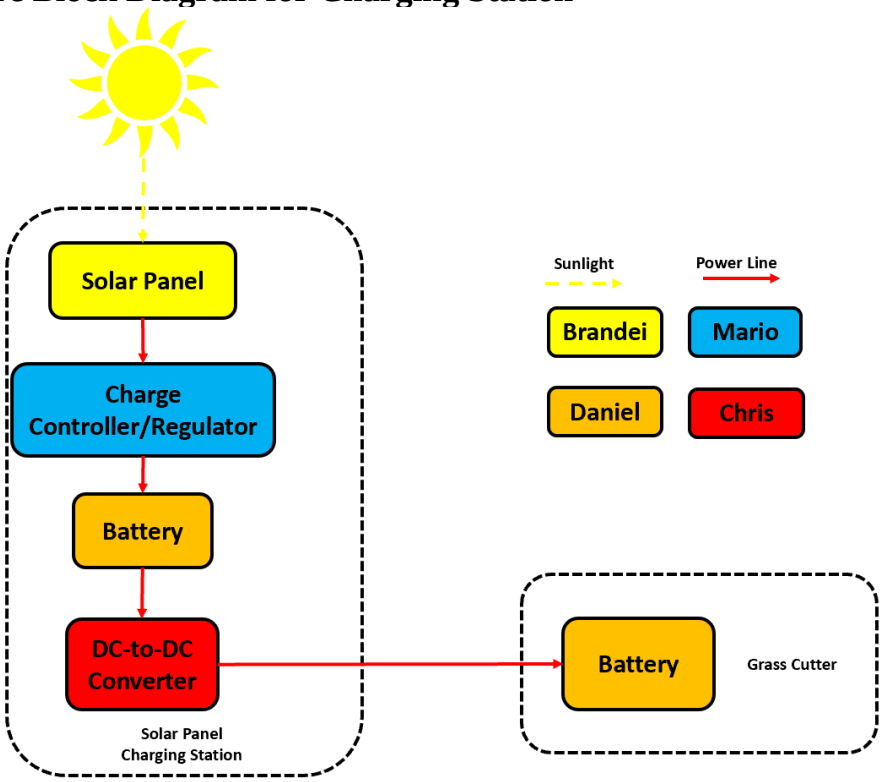


Figure 3: Hardware Block Diagram for Charging Station

4.3 Software Block Diagram for Grass Cutter

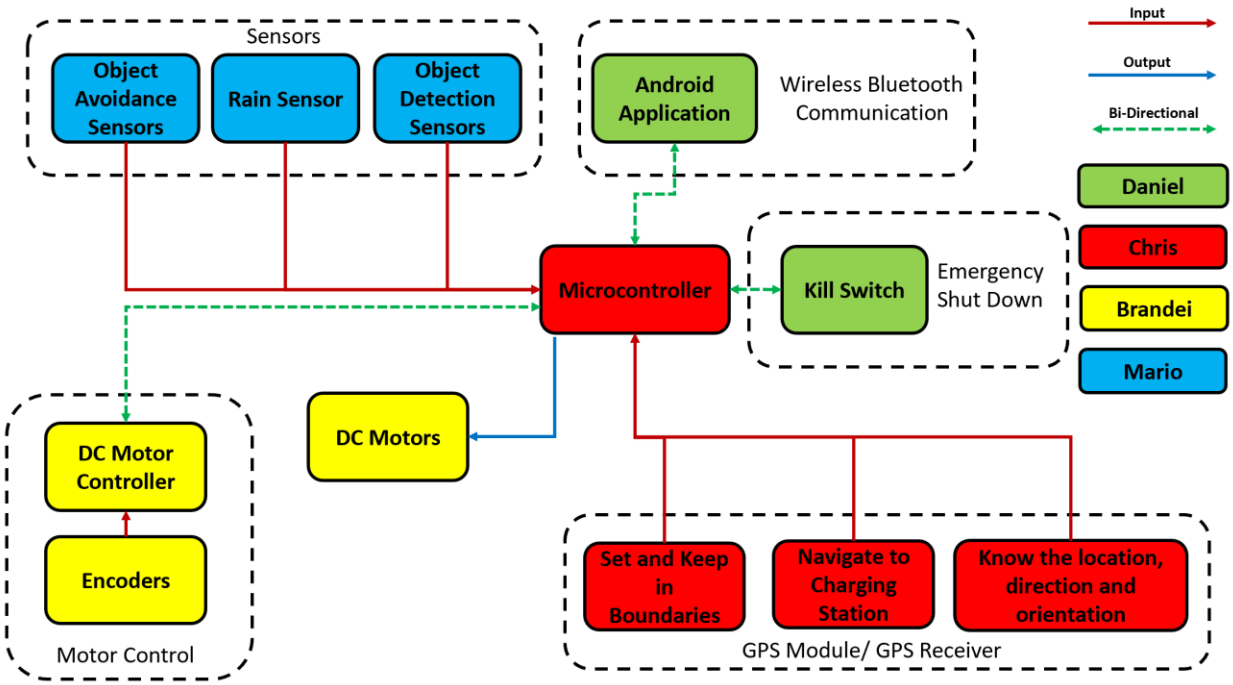


Figure 4: Software Block Diagram for Grass Cutter

5.0 Project Budget and Financing

Table 3: Project Budget and Financing

Item	Description	Quantity	Price ($)
Development Board	Able to program and debug the software	1	20.00
Microcontroller	Compatible with development board	2	4.40
IC dip Sockets	16-pin	3	0.75
IC dip Sockets	28-pin	1	0.33
Female Headers	Variety	As Required	3.00
Male Headers	Variety	As Required	3.00
Bluetooth Module	Compatible with microcontroller	1	3.90
GPS Module	Geolocalization applications	1	20.00
Capacitors	Variety	As Required	5.00
Resistors	Variety	As Required	5.00
Crystal Oscillator	16MHz	1	0.69
Motor Control Drivers	Compatible with microcontroller	3	12.00
DC Motors	At least 12 Volt 30000 RPM	3	40.00
Pins	Variety	As Required	3.00
Pin Sockets	Variety	As Required	3.00
Front Wheels	Caster Wheels	2	20.00
Rear Wheels	Plastic Wheels	2	10.00
Wheel Screws	Variety	As Required	5.00
Wheel Screw Nuts	Variety	As Required	5.00
Axles	Metal Axles	As Required	5.00
Spacers	Variety	As Required	5.00
Gears	Variety	As Required	5.00
Motor Screws	Variety	As Required	5.00
Screws	Variety	As Required	5.00
Screw Terminals	2-pin	4	2.28
DC to DC Converter	Regulator Voltage from Solar Panel Battery to Grass Cutter Battery	1	15.00
Charge Controller/Regulator	Regulate Voltage from Solar Panel to battery	1	2.35
Connection Wires	Variety	As Required	5.00

Battery	Rechargeable Lithium Ion Battery with at least 12V	1	200.00
Battery	Deep Cycle Battery with at least 50Ah 12V	1	500.00
String-Based Blades	Tough and Durable String-Based Blades	1	20.00
Solar Panels	At least 100 Watts for the Charging Station	1	300.00
Obstacle Avoidance Sensors	Ultrasonic Module	5	6.84
Human Detection Sensor	Human Body Sensor Module	1	11.59
Rain Detection Sensor	Arduino Weather Detect Sensor	1	2.15
PCB	Copper based	2	0.80
USB to TLL Serial Cable	Windows Supported USB Programming	1	6.99
Soldering Kit	Soldering Kit with Soldering wire and rosin	1	17.99
		Sub-Total	**1280.06**
		Shipping	**40.00**
		Total Cost	**1320.06**
		Projected Cost Ceiling	**2000**

6.0 Project Milestones

6.1 Fall 2018 Senior Design I Milestones

Table 4: Fall 2018 Milestones

Fall 2018- Senior Design I					
Number	**Task**	**Start**	**End**	**Status**	**Responsible**
1	Group Members Established	08/22/18	08/22/18	Completed	Group 19
2	Research Project Idea	08/22/18	09/14/18	Completed	Group 19
3	Project Idea	08/22/18	08/29/18	Completed	Group 19
4	Group Meeting	08/26/18	08/26/18	Completed	Group 19
5	Group Meeting	09/09/18	09/09/18	Pending	Group 19
6	Initial Document – Divide & Conquer	09/10/18	09/14/18	Initiated	Group 19
7	Prepare Questions for Meeting	09/03/18	09/14/18	Initiated	Group 19
8	SD1 Half Hour Meeting	09/17/18	09/19/18	Pending	Group 19
9	Sponsor Meeting	09/20/18	09/21/18	Pending	Group 19
10	Cover Page	09/01/18	09/01/18	Completed	Group 19
11	Table of Contents	09/01/18	11/28/18	Pending	Group 19
12	Project Description	09/01/18	09/03/18	Pending	Group 19
13	Research	09/01/18	11/28/18	Pending	Group 19
14	Related Standards and Design Constraints	09/01/18	09/07/18	Pending	Group 19
15	Hardware Design	09/20/18	10/01/18	Pending	Group 19
16	Software Design	10/01/18	11/01/18	Pending	Group 19
17	Update Project Milestones and Project Budgets	11/01/18	11/02/18	Pending	Group 19
18	Conclusion	11/15/18	11/28/18	Pending	Group 19
19	Copyright Permissions	11/15/18	11/28/18	Pending	Group 19
20	Datasheets	11/16/18	11/23/18	Pending	Group 19
21	Citations	11/16/18	11/30/18	Pending	Group 19
22	Table of Figures and Table of Tables	11/16/18	11/30/18	Pending	Group 19
23	Final Document Draft	11/20/18	11/21/18	Pending	Group 19
24	Group Progress Check	11/20/18	11/21/18	Pending	Group 19
25	Prepare Questions for Meeting	11/21/18	11/21/18	Pending	Group 19
26	SD1 Half Hour Meeting	11/23/18	11/23/18	Pending	Group 19
27	Revision of Final Document	11/30/18	11/30/18	Pending	Group 19
28	Final Document Due	12/03/18	12/03/18	Pending	Group 19
29	Order Components	09/28/18	12/01/18	Pending	Group 19
30	Build Prototype	10/15/18	11/30/18	Pending	Group 19
31	Test Prototype	11/30/18	11/30/18	Pending	Group 19

6.2 Spring 2019 Senior Design II Milestones

Table 5: Spring 2019 Milestones

Spring 2019- Senior Design II					
Number	**Task**	**Start**	**End**	**Status**	**Responsible**
1	Verify committee members	01/19/19	TBD	Pending	Group 19 and committee members
2	Group Meeting	01/20/19	TBD	Pending	Group 19
3	Prototype Equipment Bought	01/22/19	1/22/19	Pending	Group 19
4	PCB Board schematic for prototype trial #1	01/30/19	02/03/19	Pending	Group 19
5	Ordered trial #1 PCB Board from Manu.	02/03/19	02/04/19	Pending	Group 19
6	Initial Wheel Motors in Operation	02/10/19	02/09/19	Pending	Group 19
7	Sensor on Microcontroller initiated	02/20/19	02/22/19	Pending	Group 19
8	Operation of wheels and Sensors for Trial #1 prototype complete	02/28/19	02/28/19	Pending	Group 19
9	Group Meeting In regard to Trial #1	03/01/19	03/01/19	Pending	Group 19
10	Improve Prototype With third, swinging motion, Motor	03/02/19	03/10/19	Pending	Group 19
11	Test Prototype Trial #2	03/11/19	03/11/19	Pending	Group 19
12	Finalize Prototype (Final Trial #3)	03/15/19	04/01/19	Pending	Group 19
13	Peer Report	TBD	TBD	Pending	Group 19
14	Final Documentation	01/01/19	05/03/19	Pending	Group 19
15	Final Presentation	TBD	TBD	Pending	Group 19 and committee members