Autonomous AI-Assisted Solar Farm Grass Cutter

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***Abstract* – The objective of this project is to design and implement a power efficient, functional and prestige Autonomous AI-Assisted Solar Farm Grass Cutter for Duke Energy and Orlando Utility Commission. The solution is expected to improve the accuracy and cost effectiveness with respect to maintaining the land of solar farms while reducing the carbon footprint compared to conventional methods. Using conventional methods, our sponsors have reported that it is very expensive to maintain their solar farms every year. By producing a low-cost solution, they will save a tremendous amount of money and cut down on maintenance and labor costs.**

***Index Terms* – Artificial Intelligence, Autonomous Systems, DC Motors, Laser Radar, Motor Drives, Robot Control, Ultrasonic Transducers**

I. INTRODUCTION

According to Duke Energy and Orlando Utility Commission (OUC), maintaining the property of the Solar Farms costs roughly 150-200 thousand dollars per year to maintain about 500 acres of land. Our sponsors have given us a budget of $1,500 to design and create a prototype of an Articulated Autonomous AI-Assisted Solar Farm Grass Cutter in order to reduce solar farm maintenance and labor costs. The motivation behind this project is to reduce the carbon footprint when compared to conventional methods while creating a power efficient and low-cost solution. Along with a budget, the sponsors agreed upon certain design specifications that include a rechargeable off the shelf battery for the grass cutter to be recharge in a timely manner, a remote-controlled kill switch capable of communicating from a 50 ft range and robot dimensions peaking at a 2-foot cube. These constraints including IEEE and ABET constraints created the foundation for our engineers to begin planning and researching products and applications for the grass cutter design to effectively maneuver throughout solar panel farms. The grass cutter robot should not damage any of the panel structures located in the farms, the dimension and blade constraints are specified for the robot to accurately get in between solar panel structures. Overall, the farm grass cutter should never damage anything on the property and be able to cut grass at a rate of 500 square feet per 15 minutes. Consequently, the design will save money to promote the use of future solar farms.

II. SYSTEM COMPONENTS

The AI-Assisted Farm Grass Cutter project is best presented in terms of system components. Together, each component and module were used to create the final product. This section provides a description and purpose of each of these components.

A. Microcontrollers

The heart of the project is an ATMEGA2560 and ATMEGA16U2 microcontroller operating at 16MHz. The ATMEGA2560 contains 256KB of programmable flash memory operating at the same rate as the ATMEGA16U2 microcontroller that is used as a USB to serial converter. The main purpose of the ATMEGA2560 is to operate on inputs and outputs being inputted from the outer input/output pins along with the received data through the USB and serial ports. These microcontrollers were integrated off the Arduino Mega Rev3 development board and used on the final Printed Circuit Board (PCB) design. All of the data from the incoming and outgoing data from the connected pins are processed in combination through these chips.

B. Development Boards

The development boards used for this project were the Arduino Mega Rev3 and the Odroid-XU4. The Arduino Mega Rev3 was used for testing purposes as the final PCB design integrated the microcontrollers used on this board. The Odroid-XU4 was used to implement the synthesis of software algorithms for the lidar and camera. This includes all the software for image segmentation, mapping, self-localization and overall control. The Odroid-XU4 communicates with the ATMEGA2560 on the PCB via serial communications. This allows the Odroid to receive and transmit data for the necessary control of the overall grass cutter system. Originally the Raspberry Pi development boards were considered for this project; however, the Odroid-XU4 computes roughly 7 times faster with the Cortex-A7 processor built with an efficient 8-stage pipeline to process video inputs more quickly.

C. Ultrasonic Sensors

The ultrasonic sensors used for this project were the HC-SR04 Ultrasonic Sensors. They were used for obstacle detection and avoidance at short distances at a range of 2cm-4m. It will be used to detect objects at close distances at a set tolerance of 10cm. When an object is detected by these sensors, the robot will activate the necessary protocols to avoid those objects.

D. Lidar

The lidar system used for this project was the SLAMTEC RPLidar A2M8 360º Laser Scanner. This was used in conjunction with the Odroid-XU4, programmed by the computer science team, for self-localization, object avoidance and mapping. The lidar system has a range of 0.15 to 8-meters that was used to map the entire area that is inside the boundary system. This is helpful in path planning, avoiding obstacles, self-localization and mapping. The robot has an accurate virtual map that it can follow and aide in the necessary operations to avoid the obstacles that the lidar picked up in its virtual map.

E. Camera

The camera used for this project was the oCam 5MP USB 3.0 Camera. This was used in conjunction with the Odroid-XU4, programmed by the computer science team. The camera was used for image segmentation. This fulfills the requirement from the sponsors to be able to detect the grass areas that need attention. Using OpenCV and Robot Operating System (ROS), the camera is able to successfully determine the areas of grass that need attention and avoid areas that do not need to be cut.

F. GPS Module

The GPS Module used for this project was the Holybro Micro M8N GPS Module. The Holybro Micro M8N GPS Module includes an industry leading -167 dBm navigation sensitivity, navigation update rate up to 10Hz, rechargeable 3 Volt lithium backup battery, low noise 3.3V regulator, power and fix indicator LEDs, 15cm PIXFALCONμAPM compatible 6-pin cable, 25x25x4mm ceramic patch antenna. This new design incorporates the HMC5983L digital compass that uses the Ublox latest 8series module providing a convenient method of mounting the compass away from source of interferences from surrounding devices. This chip was used to aid in the use of location, positioning, mapping and odometry for the software. To improve efficiency, the GPS will only be polled for data when needed. In this case, we're only interested in learning the position of the robot when the battery is low.

G. Wheel Motors

The Wheel Motors used for this project was the 12-Volt, 23RPM, 4166.2oz-in HD Premium Planetary Gearmotor. Two of these motors were used for the two front wheels of the robot. These motors have the necessary torque, force, speed and bi-directional specifications to fulfill the sponsor set requirements and further derived requirements. Each motor powers the movement of a 10-inch diameter wheel. At a maximum torque of 4166.2oz-in or 260.39lb-in, each motor can handle about a maximum of 52 pounds per motor with a 5-inch radius wheel. This provides a positive power margin of approximately 30%.

A weight limit requirement of 40 pounds for the entire grass cutting assembly was set by the mechanical engineering team associated with this project. Using equation (1) below with the radius of the wheel, it was found that each wheel motor needs to be able to handle at least 200lb-in of torque. The calculations are shown in equations (2) and (3).

$$\frac{T}{2} = F * L \tag{1}$$

$$\frac{T}{2} = 40lb * 5in \tag{2}$$

$$\frac{T}{2} = 200lb \tag{3}$$

Since common outside ground surfaces provide a widely varying coefficient of friction, the 30% positive margin provides assurance that the motors will be strong enough to overcome situations where extra torque is required. Specifically, this positive power margin can be used to verify the sponsor requirement that the grass cutter assembly must be able to navigate a terrain differential of a max of 3 inches within in a 2-foot span. This terrain differential is shown below in Fig. 1.

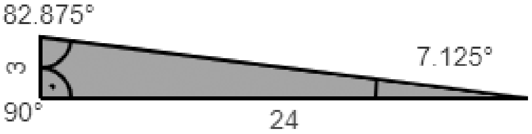

Fig. 1. Robot Incline Diagram

The equations and calculations used to solve for required power on an incline are shown below in equations (4), (5) and (6).

$$F_{Incline} = F_N + F_S \tag{4}$$

$$F_{Incline} = W * \sin(\theta) + W * \mu_S \cos(\theta) \tag{5}$$

$$F_{Incline} = 4.96 + 36.69 = 44.65lb \tag{6}$$

Coefficient of friction is equal to 1 for highest demand of torque. The motors still provide a 16.5% positive margin when considering the incline requirement.

H. Encoders

The encoders included with the selected wheel motors are critical for the grass cutter to have precise and synchronized movement. The encoders will act as inputs and will connect to the ATMEGA2560 processor chip pins. The encoders utilize quadrature phase shift keying (QPSK) modulation in order to provide 17,712 discrete values for one rotation of the wheel. Since wheel size will affect calculations, a series of tests were conducted to find the ration between the amount of discrete value change per degree of rotation in both standard turning and zero point turning. Synchronization using the discrete values from the encoders in conjunction with the PWM inputs to the motor drivers enables straight and reverse movement without any drifting bias towards either side. The encoders were used to aide in odometry by having the discrete values sent from the ATMEGA2560 processor chip to an Odroid XU4 running a Robot Operating System (ROS) via serial to USB conversion. Having these encoders effectively allows ROS to control movement of the robot by providing a reference.

I. Blade Motors

The Blade Motors used for this project was the Guang Wan XD-3420 Permanent Magnet DC Motor. Three of these motors were used for the three string-based blades of the cutting system. High rotations per minute (RPMs) and torque were required to cut the grass as precisely and efficiently as possible. These motors are rated at 3000rpm at 12-Volts and are bi-directional. The rated torque of these motors are 1kgf-cm or 0.868lb-in at 12-Volts. The three motors will operate simultaneously underneath the aluminum base of the robot.

J. Motor Drivers

The Motor Drivers used for this project were the VNH7100AS Automotive Fully Integrated H-Bridge Motor Drivers. These H-bridge drivers control speed and rotational direction of bidirectional motors. Four of these motor drivers were used to control and regulate five DC motors in conjunction with the ATMEGA2560 and PCB. They operate at 12-Volts to distribute the needed power to the motors. They are capable of handling up to 20A in current outputs per channel. Each of the front wheel motors has their own motor driver. Two of the blade motors has one motor driver and the third blade motor has its own motor driver. The front wheel motors have bidirectional control to fulfill the operations of forward, reverse, and turning using zero point or standard. The blade motors only need to go in one direction.

K. Voltage Regulators

Three voltage regulators were used for this project. The LMZ31506 Power Module DC-DC Converter was used to regulate the power from a 12-Volt battery to 5-Volts to power the Odroid-XU4. The LD1117S50CTR Linear Voltage Regulator was used to regulate the power from a 12-Volt battery to 5-Volts to power the Atmega2560 and related components through a DC power jack. The LP2985 Linear Voltage Regulator was used to regulate the 5-Volt power input to 3.3-Volts output to power the components that require lower voltages.

L. Batteries

Five batteries were used for this project. Four Ovonic 11.1-Volt LiPo Batteries were used to power the motors, overall grass cutter system and components, Odroid-XU4, lidar and camera. One 3.7-Volt MXJO Lithium Ion Battery was used to power the perimeter generator circuit.

M. Power Switches and Relays

There are four power switches connecting the batteries to the proper component. These are used as the manual power switches to each of the four batteries. There are four relays that are connected between the batteries and the proper component. These are used as a remote kill switch to meet the requirements of the sponsors to have a remote kill switch with a range of at least 50 feet. The relays used in this project contain programmable channels that can link to a remote control. Each channel is capable of linking to its own individual relay. The relays contain a max amp rating. Since the blade motors can pull an abundant amount of current, more than one relay will be used for controlling blade motor operations. The wheels motors will require one relay. The Grass-Cutter drive sub-system components can be independently shut off and on vie remote control.

N. Perimeter Wire Receiver Sensors

The perimeter wire receiver sensors consist of two inductor coils. These will be placed at the front of the robot at 45-degree angles. They are used to detect the signal given off by the perimeter wire. If it does detect the signal, the signal is routed through an operational amplifier to two analog pins on the ATMEGA2560 and then the proper action is taken to stay inside of the boundary wire.

O. Perimeter Wire Timer

The timer used is the NE555P IC Timer designed and manufactured by Texas Instruments. This timer generates a square wave through a wire surrounding a desired perimeter for our team. If the solar panel farm property perimeters can be maintained within a marginal error of 3 feet, then our GPS module may be used to keep the grass cutter in range as a second option for the sponsors. However, a timer is used for this project generating a 32-42kHz frequency ranging square wave signal. Inductive sensors can pick up the signal reporting data to the Atmega2560 microprocessor.

III. SYSTEM CONCEPT

The system's concept will be demonstrated in this section. To further understand the system's concept, the flowchart, diagrams and state machines are used below. All the software was implemented by the electrical engineering, computer engineering and computer science teams.

A. System Software Class Diagram

The system software class diagram is shown below in Fig. 2. This shows the outline of the software programming that was implemented. It includes all the sensors, technology and overall control of the system.

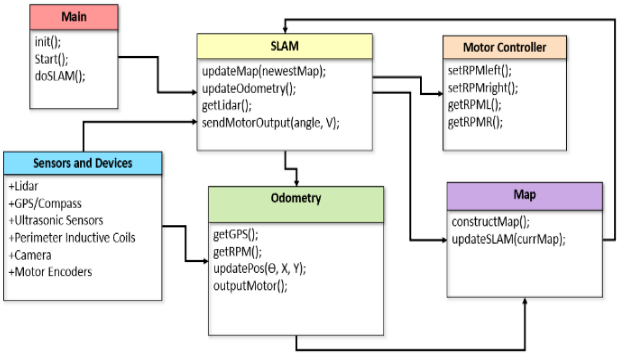

Fig. 3. System Software Class Diagram

B. System Robot State Machine

The system robot state machine is shown in Fig. 3. Figure 3 shows that there will be four main states; Forward, Follow Planned Path, Roll (Left/Right), and Stop. The "Forward" state can be thought of as an "all clear" scenario where none of the sensors prompts movement action. The "Follow Planned Path" state is where some type of autonomous movement is required by the ROS, for example, when moving around a stationary object such as a solar panel structure. The "Roll (Left/Right)" state is one of two avoidance protocols. The Roll state is where the robot maintains movement in a standard or zero-point turn, to avoid a close object not detected by ROS's LIDAR and Camera inputs. The last state "Stop" is used as a last resort measure when the autonomous grass cutter assembly has determined that an object is within immediate vicinity for impact. The robot will stop all movement until the object has moved away. This is shown below in Fig. 3.

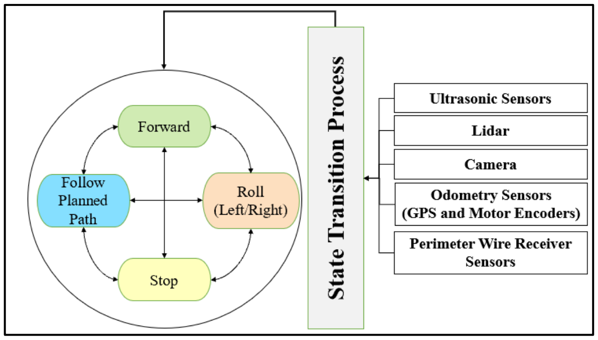

Fig. 2. System Robot State Machine

C. System Software Flowchart

The system software flowchart is shown in Fig. 4. This shows how the overall software operates. After start-up, the system checks whether the surrounding perimeter area has been mapped or not. If the system has determined that a map of the area is not currently available, it will go forward and attempt to find the nearest perimeter wire. Once a perimeter wire is found, the autonomous grass cutter will traverse the entire perimeter wire to gain a mapping of the outside. After mapping the outside perimeter, a mapping of the inside is done while simultaneous cutting. If the system detects that the area is already mapped, it will cut on a set schedule in order to maximize the effective area one autonomous grass cutter can cover. Once initially mapping is solved, the autonomous grass cutter enters its normally closed loop operations until ROS determines that the autonomous grass cutter has finished cutting its area of responsibility. During normal operations, the flowchart reads similarly to the System Robot State Machine in Fig. 3. The system will cut along its planning path or in forward mode and if an object has been detected by ROS, ROS will attempt to control the wheels using the encoders to avoid the object. Shown in the System Software Flowchart, the ultrasonic sensors are maintaining priority over ROS's decisions. This decision was implemented by the programmers because there are bundles of software and algorithms running on ROS that could possibly fail, where the ultrasonic sensors are analog and simplistic and because of this, are much more reliable. Depending on which threshold of the ultrasonic sensors has been broken, the system will either stop or roll as described in the previous section. Once ROS has determined that the area of responsibility has been cut, the system will power off. This is shown below in Fig. 4.

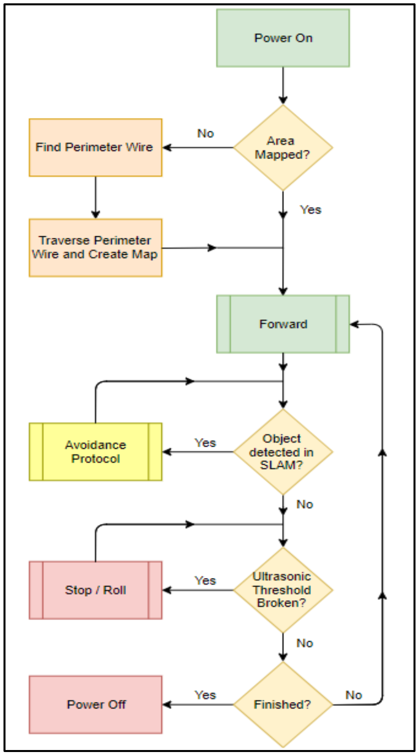

Fig. 4. System Software Flowchart

D. System Hardware Block Diagram

The system hardware block diagram is shown below in Fig. 5.

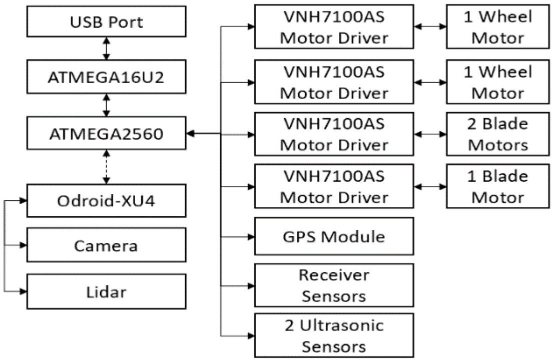

Fig. 5. System Hardware Block Diagram

This shows the major hardware components used in the grass cutter system. The block diagram illustrates the USB port communicating data from source and processing it using the ATMEGA16U2. From there, the data is handled by the ATMEGA2560, transferring all data back and forth between motor drivers, GPS module and obstacle avoidance sensors. The Odroid, camera and Lidar sub-system signals are also handled by the ATMEGA2560. Wheel motors and blade motor decisions are all determined by the programmed ATMEGA2560. In the software, each input device controlling motor speeds have independent priority.

IV. HARDWARE DETAILS

Each of the major sub-systems outlined in previous sections will now be explained with further details in this section.

A. Object Avoidance Sub-System

Located on the main PCB are 54 I/O pins with inputs being processed by the Atmega2560 microcontroller. For the object avoidance subsystem, these inputs are processed and sent to the H-bridge motor drivers for wheel motor control. Using the Lidar system and camera video streaming on the Odroid-UX4 for image segmentation, inputs will come from the Odroid-UX4 to turn wheels in order to avoid an object. After avoidance, the cutter proceeds to its Lidar mapped path. Nevertheless, supersonic and inductive sensors input warning signals if an object's closeness has been miscalculated by the path planning unit. If an object exists less than 4 cm ahead of the grass cutter, the entire unit will stop and perform a zero-point turn, or "roll" until it has avoided the near accident. After returning to the forward path plan, the robot will make appropriate turning adjustments. This process is repeated while the Lidar system maps out the territory within the perimeter wire. If the inductive sensor finds the perimeter wire while path planning, the Lidar system keeps the mapped section of the territory and the robot proceeds mapping while following the perimeter. After mapping around the perimeter, if the entire enclosed area is not fully mapped, the lidar system will then only focus on obstacles within the already mapped perimeter.

Consequently, the design is programmed to plan future paths using the Odroid-UX4 with inputs from the camera and Lidar application. The reason for the ultrasonic sensor inputs are to not hit any obstacles in case of miscalculated path radiuses when avoiding objects. Nonetheless, ultrasonic sensors are useful to get close to objects after a path is chosen. A distance between the ultrasonic sensors and an object is held within a designated distance between 4 cm and 8 cm (4 being too close and 8 being too far away). By retrieving this calculated data as the robot moves around an obstacle, a new path is distinguished closer to the obstacle. USB connections link the Odroid-UX4 directly to the PCB for signaling between the path planning unit and the Object avoidance unit.

B. Boundary Sub-System

The boundary sub-system operates using a perimeter boundary wire system. The perimeter wire is wired around the set boundary to a generator circuit. In this circuit, the NE555P timer and respective components produces a square wave throughout the perimeter wire. This signal will be detected by the receiver sensors on the grass cutter system. The signal received through the receiver sensors are then routed through an LM324M operational amplifier to the respective analog pins on the ATMEGA2560. After the signal is received by the processor, the boundary protocols are activated to take the necessary actions to stay inside the boundary. During startup, the robot will traverse the perimeter wire to map the whole area using the lidar system. Afterwards, the robot will start cutting inside the area of the perimeter wire.

C. Drive Sub-System

The drive system operates using H-bridge motor drivers controlled by PWM pins. By allowing current to pass through the motors bidirectionally, the two front wheels are provided the ability to turn both directions. The drive sub-system uses two 12-Volt, 23RPM, 4166.2oz-in HD Premium Planetary Gear motors. While the grass-cutter is turned on, the motors receive the 12-Volt directly from one of the four 12-Volt batteries used for powering this project. The same potential is used to power the H-bridge motor drivers. Once the wheel motors have received power and the software startup has finished, the software will control the motor driver outputs for wheel rotation. The software block diagram in section A of this document describes how the motor driver outputs can be interrupted by ultrasonic sensors, video and Lidar inputs for essential turning. All of which signals are being processed through PWM pins. Additionally, the motor encoders provide feedback in regard to angular speed of each wheel. The encoder feedback within the drive sub-system keeps both wheel speeds equivalent. If a wheel speed is slightly faster than the other causing the robot to turn, the alternate wheel will speed up.

D. Power Sub-System

Four 11.1-Volt LiPo batteries and one 3.7-Volt MXJO Lithium Ion battery were used in this project in the power sub-system. One of the 12-Volt batteries powers the Odroid-XU4, Lidar and Camera. There is one voltage regulator to regulate the power to 5-Volts for the Odroid. One of the 12-Volt batteries powers the printed circuit board, GPS module, ultrasonic sensors and related components. There are two voltage regulators on the PCB that outputs 5-Volts and 3.3-Volts. One of the 12-Volt batteries powers three of the blade motors and motor drivers. The last 12-Volt battery powers two of the wheel motors and motor drivers. The 3.7-Volt battery powers the perimeter generator circuit. Each of the four 12-Volt LiPo batteries have a manual power switch between the power connections to the specified part. The power sub-system block diagram is shown below in Fig. 6.

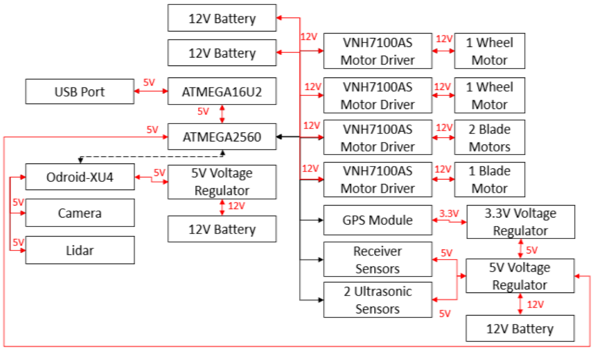

Fig. 6. Power Block Diagram of Grass Cutter System

The power sub-system of the perimeter wire generator circuit is shown below in Fig. 7.

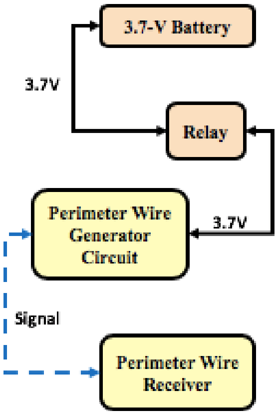

Fig. 7. Power Block Diagram of Boundary System

Another aspect of the power system other than the voltage distributions and to further explain the diagram illustrations focus concerns on the amount of electrical current each component in capable of handling. The Arduino Mega Rev3 development board components were used in the PCB design to help implement correct outputs. Consequently, the PCB allows a maximum current output of 40mA per pin, and a total limitation of 200 mA regarding the entire limit. The motor drivers used for this project have a maximum current limit of 15A, therefore the motor drivers must be split up. One 11.1-Volt LiPo battery is sent to a motor driver that has the capability to provide current for 2 blade motors at a time. Additionally, only one battery is used as VCC for the control of the motor drivers. Since the blade motors require the most current, this battery will be the one monitored. When at low charge the robot must be charged.

The Odroid-XU4 requires 4A and 5V. Therefore one 111.1 LiPo battery alone is used for the LMZ31506 Power Module DC-DC Converter that converts the 12V to 5V while allowing the required current for communication between the subsystems. These details explain why the power system is set up as is.

E. Camera Sub-System

The camera subsystem is responsible for extracting critical information from its environment. The lidar provides great data for navigation and object avoidance, however combining this technology with the camera ensures the robot will cut the grass areas that need attention. This makes the system smarter and more efficient. Using OpenCV and ROS algorithms it transforms sequential image data into a reliable source of information. Some of the algorithms being used to process the image data are converting the live feed into the HSV color space, as well as using gaussian blurs that smoothens the frames taken. Once these filters are applied, shadows are removed that improves the result of segmenting the images to the associated colors and the quality of the frames are improved and used with more accuracy and precision. For simplicity, grass or green objects will be superimposed with white, and other objects will be blacked out. This will incite three unique cases that the robot will encounter.

CASE 1: cutting on grass – here, the robot will be in its most ideal position. As it traverses through the field, we want to make sure that it stays on grass as much as possible. If it is on the grass, it will plan a sufficient path according to lidar inputs.

CASE 2: partial grass – in this case, the robot will see white in its field of view and will simply attempt to maneuver in its direction to put it back in its ideal position of CASE 1.

CASE 3: no grass – in this case the robot will not have any grass in its field of view, so it will simply rotate until it can locate the grass.

F. Lidar Sub-System

The lidar subsystem is responsible for mapping the area. The lasers are constantly spinning 360 degrees and updating the map of all the obstacles and objects in the path of the robot. The map is used to accurately path plan through the area of the solar farm that needs attention. It aides in obstacle avoidance and data to properly navigate through the solar farm without damaging any solar farm infrastructures, obstacles and objects in its line of sight.

V. SOFTWARE DETAILS

Before the software portion of the system can be explained in detail, a full understanding of the design hierarchy must be explained. The overall system can be viewed as a series of inputs and outputs, where the outputs are simply responses to the respective inputs. The inputs, or stimuli, have been tiered out in terms of importance where ultrasonic sensors are top tier, or of most importance, and the LIDAR and Camera are to be considered auxiliary. While every sensor plays an important part, the more reliant and simplistic sensors are used to set the absolute maximum thresholds allowed. Having the ultrasonic sensors connected to the same processor chip that has control to the wheel motors means that the ultrasonic sensors inputs are the most reliant and will be treated as a highest priority. A hierarchical approach provides the best means for minimizing risk towards accidents. Although the combination of the LIDAR and Camera provide high fidelity inputs, they require a vast amount of computing and reliance on algorithms to produce desired outputs. Since the LIDAR and Camera have a high reliance on

Autonomous decisions will be programmed by the Computer Science personnel onto the Odroid-XU4 board in which the stimuli will be from the sensors. Once autonomous decisions are made, commands will be sent from the Odroid-XU4 to the ATMEGA2560 chip to be carried out.

VI. BOARD DESIGNS

The Printed Circuit Boards (PCBs) were designed using EasyEDA. They were ordered through JLCPCB. The main system PCB has 6 layers and a 1 oz copper weight. The perimeter wire generator PCB has 2 layers and a 1 oz copper weight. Copper is an excellent thermal and electric conductor which increases thermal resistant and current-carrying capacities. This improves the reliability of the PCB operating in higher temperatures. Having multiple layers helps improve the heat transfer along and across the PCB which reduces the damaging stress that may be caused by uneven heating of the PCB. Having more layers comes at a higher cost but weighing the advantages out, it is worth it to have a more reliable and efficient PCB design considering the high temperatures it will be operating in. The main system's PCB cost $176.81 for a quantity of ten. The generator PCB cost $2.00 for a quantity of five.

VII. CONCLUSION

In summation, the Autonomous AI-Assisted Solar Farm Grass Cutter is an innovative way to cut down on maintenance costs of cutting grass at solar farms. In the future, this lower cost design can be applied to many difference applications such as residential and businesses grass areas and lawns. The Articulated AI-Assisted Solar Farm Grass Cutter project is developed in conjunction with a team of Computer Science, Electrical Engineering, Computer Engineering, and Mechanical Engineering students. The prototype that is created will participate in a competition between other prototype from UCF and USF.

THE ENGINEERS

Brandei Dieter is a 23-year old graduating Electrical Engineering student. Brandei hopes to pursue a career in designing electrical components for automobiles. After graduating, Brandei plans to move to Los Angeles, California and study under a professional engineer to become a professional licensed engineer.

Christopher Entwistle is a 27-year old graduating Electrical Engineering student. Christopher currently works at Lockheed Martin. After graduation, he will be pursuing a career in Cyber Security and plans to further his education after settling into his new career.

Mario Mcclelland is a 26-year old graduating Computer Engineering student. Mario currently works as a technical assistant teaching labs and tutoring students. He is interested in completing his master's in electrical engineering. Mario would eventually like to work as a firmware engineer to develop new technologies through circuit instrumentation.

Daniel Warner is a 25-year old graduating Electrical Engineering student who is interested in power distribution and the electrical power industry. Daniel hopes to build more efficient voltage distribution networks that incorporate greener energy sources such as solar and wind farms. Daniel also plans to achieve a professional engineering license post-graduation after settling into a career.

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