SOLAR-BASED GRASS CUTTER MACHINE WITH LIGHT TRACKING SYSTEM

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Abstract

Currently, grass cutter machines are operated using fuel and electrical energy as power source which are costly and requires high maintenance. Hence, in this study, a solar-based operated machine for grass cutting was designed and fabricated by using locally available materials. Important aspects such as durability, strength, and portability were taken into design considerations for better performance characteristics. Due to continuous increase in the cost of fuel and the effect of emission of gases from the burnt fuel into the atmosphere, this necessitated the use of abundant solar energy from the sun as a source of power to drive grass cutter. This portable lawn mower can be used to maintain and trim grass in gardens, home, schools or yards. An improved cutter machine is capable to improve grass cutting process to become easier. It consists of obstacle avoidance, light tracking system and remote control principle.

Keywords: solar-based operated machine, obstacle avoidance, light tracking system, remote control principle

Lawn maintenance and landscaping remained one of the most important constraints from keeping a clean and fresh looking gardens and yards. Grass cutter machines have become very essential to daily living in maintaining the lawn. Furthermore, environmental awareness on usage of grass cutting machines has caught a great interest among consumers. As a result, consumers were searching for ways to reduce and solve their own carbon footprints. Moreover, environmental pollution keeps increasing and it can be experienced in everyday life.

As mentioned by Dongalo (2015), a lawn mower is a machine that uses one or more revolving blades to cut a grass surface to an even height. The blades can be powered by using hand, via pushing the mower ahead to function the mechanical blades, by means of an electric powered motor, or a small inner combustion engine to spin the blades. Some mowers also consist of other capabilities, such as mulching the cut grass or amassing their clippings in a bag. Different styles of blades were used in lawn mowers. Lawn mowers employing a single blade that rotates about a single vertical axis were known as rotary mowers, while those employing a multiple blade assembly that rotates about a single horizontal axis were known as cylinder or reel mowers. There were several types of mowers, each suited to a particular scale and purpose. The smallest type was pushed by a human user and was suitable for small residential lawns and gardens. Electrical powered or fossil-engine mowers were used for larger residential lawns. Riding mowers, which resembles small tractors, were larger than push mowers and were suitable for large lawns.

According to Dutta, P.P. et al. (2016), we may have energy sources by gasoline driven, electricity driven or hand driven lawn mower. Over the years, there were several developments in lawn mower generation. But with technological advancement there also arises the need to check the impact of machines on the environment as well as on man. Pollution was the major concern with the

conventional gas powered lawn mower. Due to the emission of gases it was responsible for pollution. Human effort was another factor that needs to be reduced.

Cutting grass cannot be simply accomplished by older, younger, or disabled people. Mowing the lawn with a standard motor-powered lawn mower was an inconvenience in terms of heavy weight and no one takes pleasure in it.

Motor-powered push garden mowers and riding lawn mowers create noise pollution because of the loud engine, and local air pollution because of the combustion of gasoline in the engine. Also, the electric lawn mower was corded which mowing could prove to be problematic and dangerous.

Therefore, the need arises to design a lawn mower that was able to cut grass automatically and make the whole landscaping process much convenient and easier for the user. This includes detecting and avoiding collisions in obstacles, navigating within a coverage mainly powered by solar energy. Herein, the researchers propose a model of the grass cutting machine powered through solar energy.

It is going to perform the grass cutting operation on its own and the design was meant to be an alternate green option to the popular and environmentally hazardous fuel-powered lawn mower. There's no oil and no pollution. Just clean air, less noise, and green grass.

One more important additional feature of the device was its Light or Solar Tracking System. Based on the article published by Yoshitake (2013), studies have shown that the angle of light affects a solar panel's power output. A solar panel that is exactly perpendicular to the sun produces more power than a solar panel that is not perpendicular. Solar trackers provide significant advantages for renewable energy. With sun tracking, electricity output can be expanded by about 30 to 40 percent. The increase in power output promises to open new markets for solar power.

Statement of the Problem

This research attempts to build and design a "Solar-Based Grass Cutter Machine with Light Tracking System" by the use of renewable energy. More specifically, it seeks to find the answers to the following questions:

1. What are the existing lawn mowing equipment and conditions available in the market?
2. What are the hardware and software requirements needed in the development of the Solar-Based Grass Cutter Machine with Light Tracking System?
3. What are the design features and working principles of the Solar-Based Grass Cutter Machine with Light Tracking System?
4. What is the level of acceptability of the device in terms of the following criteria?
    a. Functionality;
    b. Reliability;
    c. Usability;
    d. Maintainability;
    e. Portability;
    f. Workability; and
    g. Safety

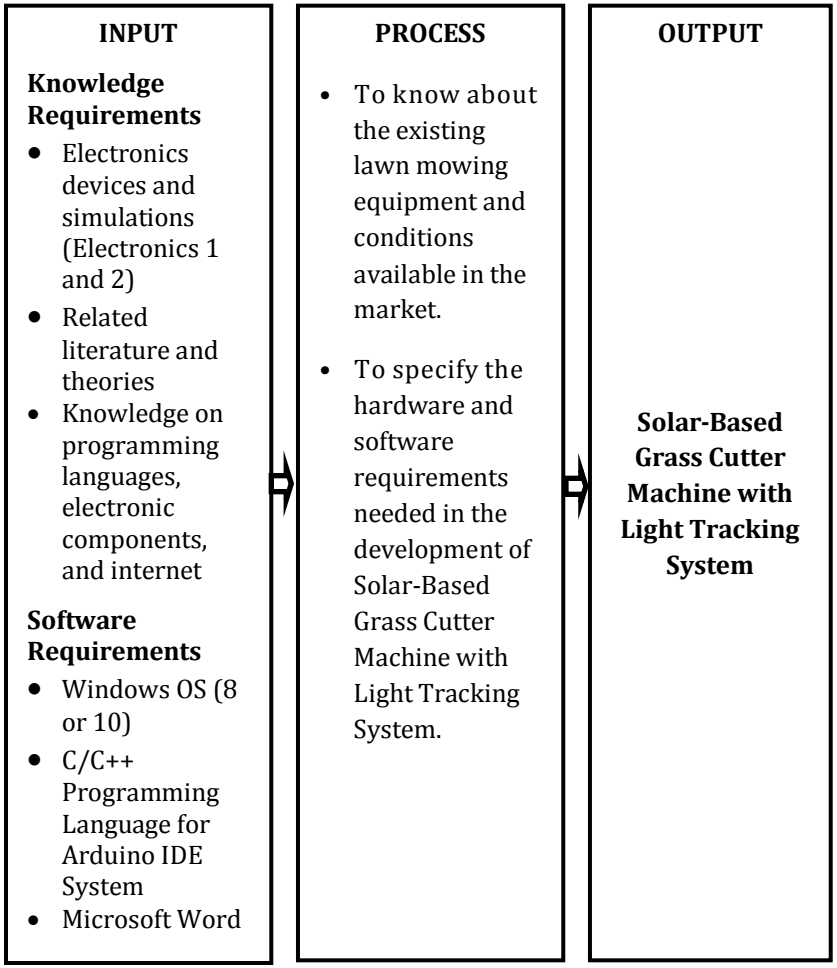
Method

The blend of two research methods, descriptive and developmental study involved the production of knowledge with the ultimate aim of improving the processes of instructional design, development, and evaluation of the project. Through a process of data collection in several related literature and studies, journals, researches and internet, the researchers enabled to analyze and interpret the source materials to describe and come up with the idea of Solar-Based Grass Cutter Machine with Light Tracking System. The researchers described and interpreted the

phases of the study. It includes design components, specifications, system design, block diagrams, activity flowchart and project cost.

Conceptual Framework

The IPO model provided the general structure and guide for the researchers understanding of how the particular variables in the studies are connected with each other.



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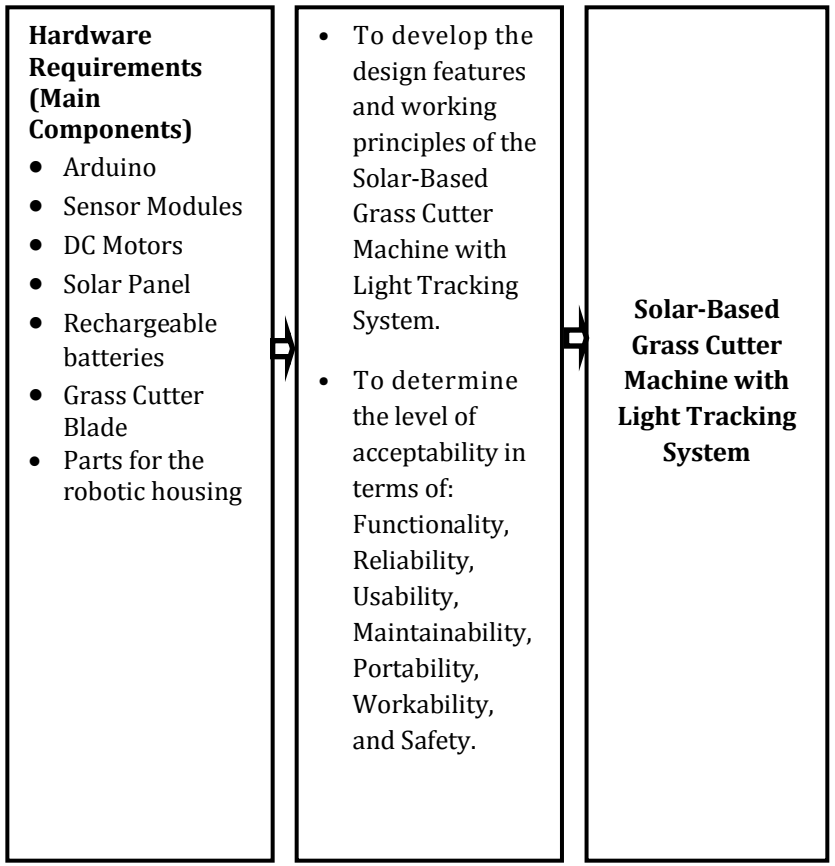


Figure 1. The IPO model of Solar-Based Grass Cutter Machine with Light Tracking System

System Design

The purpose of the System Design process was to provide sufficient detailed data and information about the system. A block diagram is a chart or diagram that use labeled blocks connected by lines or arrows to represent the relationship of parts or phases, as the steps in a data-processing application.

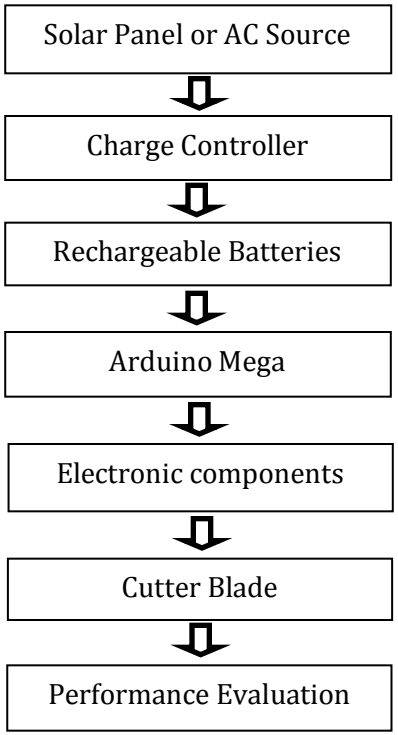


Figure 2. Block Diagram for Solar-Based Grass Cutter Machine With Light Tracking System

Figure 2 shows the block representation of the project for the system design. It contained several blocks such as Solar Panel, Microcontroller, Batteries, and Motor Driver. The source was driven from the solar energy using photovoltaic panel or by AC source which charges the battery and was utilized for powering operation of the system through the use of charge controller. The system's overall function was done by the Arduino UNO Mega.

The grass cutter and DC motors were interfaced to Arduino that controls the working of all the motors. All of the electronic components used in the system were powering up the working of the device. It is also fitted with two ultrasonic

sensors in the front for object detection. The Arduino moved the vehicle motors in forward direction in case no obstacle was detected. If obstacle detection is monitored by the device, the ultrasonic sensor will send a signal to the motor driver to stop and rotate in order to avoid collision that may cause damage to the object, human, or animal. The battery recharges through the solar charging controller. After the testing, performance evaluation of the developed machine was carried out.

Project Technical Description

The Solar-Based Grass Cutter Machine with Light Tracking System which also includes remote control and obstacle avoidance features needed hardware requirements to be implemented. The lists of hardware required in order for the system to work properly were stated in Table 1 that covers the minimum hardware requirements.

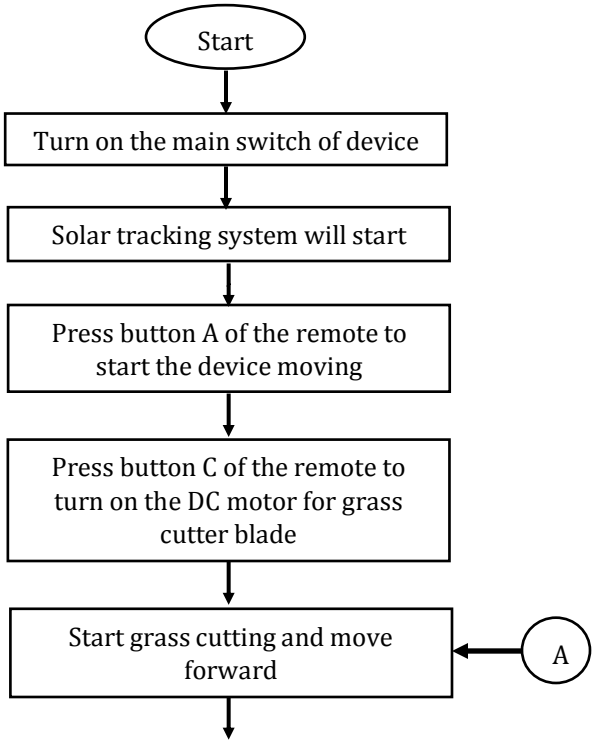
Table 1. Minimum Hardware Requirements

Category	Specification
Solar Panel	6 V 1.2 W 0.2 A
Arduino UNO	Microcontroller ATmega328
Servo motor	0.1 sec/60 degrees (4.8 V)
L298N Module	Motor Shield Driver
Ultrasonic sensor	5 V DC 20 cm detection distance
Rechargeable Batteries	Standard Charging Time: 3 hours Maximum Charge Current: 3000 mA
Motor locked-rotor torque for wheels	4.5 kg·cm
555 DC motor	6000 rpm

Table 1 shows the minimum hardware requirements for successful deployment of the device. The hardware components needed the following, the minimum requirement for the processor is the Arduino ATmega328. The minimum requirement for the servo motor is with initial weight of 9g and initial speed is 0.1 sec/60 degrees.

The DC motors should have a module which is the L298N motor shield driver to give a task for its different directions. Its ultrasonic sensor uses 5 volts and 20 cm for detection distance. There are 3 rechargeable batteries with each of 3000 mA current capacity and the DC motor's rated speed is at 6000 rpm.

Activity Flowchart



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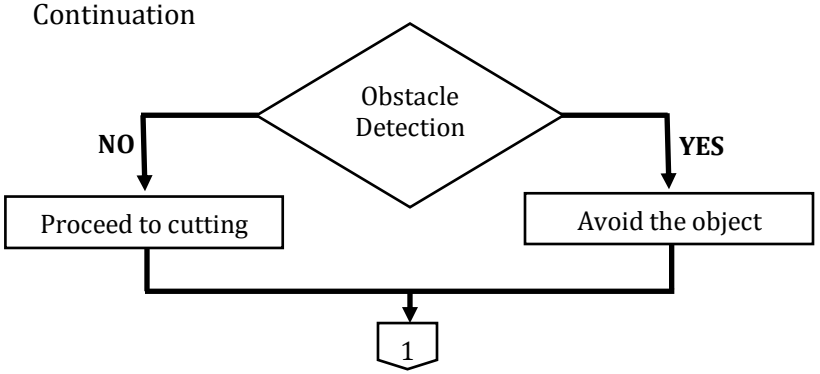


Figure 3. Activity Flowchart for Solar-Based Grass Cutter Machine With Light Tracking System - Part 1

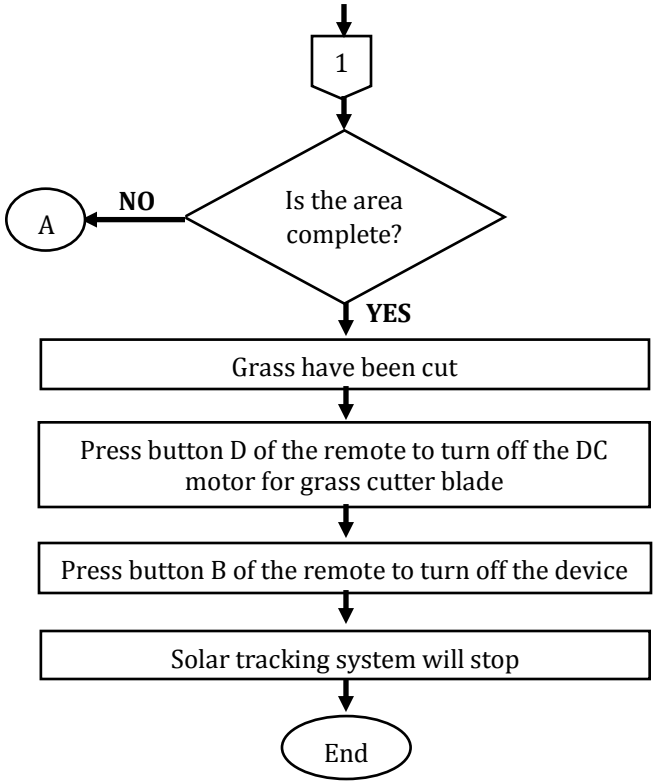


Figure 4. Activity Flowchart for Solar-Based Grass Cutter Machine With Light Tracking System - Part 2

The flowchart was used primarily to organize the researchers' thoughts about various movements and events in the project. The working of solar powered grass cutter has panel mounted on the top of the device with four pieces of photoresistors in such a way that it can receive solar radiation with high intensity easily from the sun.

The solar panel converted solar energy into electrical energy and the power will be transmitted to the mechanism. This electrical energy will be stored in batteries by using a solar charge controller. Pressing button A of the remote controller will turn on the power of the device.

It will also power on the solar tracker which will directly points on the highest light intensity coming from the sun, then will start its charging condition until the work is finished. All of the electronic parts inside of the case were connected and electrically supplied by the solar panel and rechargeable batteries. The motor driver sends signal to the motors of the wheels when to start, stop or change the direction. Two ultrasonic sensors were used for the project. One for the detection of solar tracker on top and one for the detection on the bottom. Once the device start cutting the grass and there is an object in front of it, it will automatically avoid it by rotating and moving forward to another place until it completes its mowing. By pressing button D, the grass cutter blade will stop then followed by button B which stops the device, the last step in the process.

Design Components

This part displayed the functions and specifications of each of the electronics equipment used.

Mini Polycrystalline Solar Panel. A panel designed to absorb the sun's rays as a source of energy for generating electricity or heating.

Figure 5. Mini Polycrystalline Solar Panel

Table 2. Mini Polycrystalline Solar Panel

Specifications	Description
Materials	Polycrystalline silicon
Interface	5.5 mm
Maximum Power	1.2 W
Working Current	0.2 A
Short-Circuit Current	0.22 A
Working Voltage	6 V
System Voltage	6 V
Open-Circuit Voltage	7.2 V
Size	Approx. 130 x 84 x 10 mm / 5.11 x 3.3 x 0.39 inch
Weight	Approx. 107 g

Arduino UNO. The Arduino Uno board is a micro-controller based on the ATmega328. It has 14 digital input/ output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button.

Figure 6. Arduino UNO Mega 2560

Table 3. Arduino UNO Mega 2560

Specifications	Description
Operating Voltage	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limit)	6-20 V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

L298N Motor Driver Module. The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time.

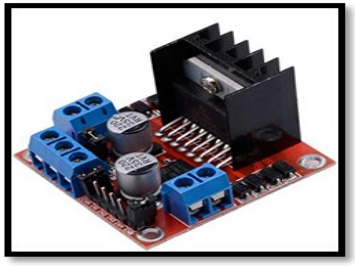


Figure 7. L298N Motor Driver Module

LM2596 Step Down Power Module. It is monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation.

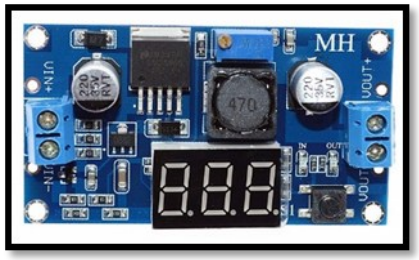


Figure 8. LM2596 Step Down Power Module

Relay Module. A relay is an electrically operated switch that can be turned on or off.

Figure 9. 1 Channel 5V Relay Module

Lithium Battery Protection Board. It will protect Lithium battery pack from overcharging, over-discharging and over-drain, therefore it is a must to have to avoid Lithium battery pack from explosion, fire and damage.

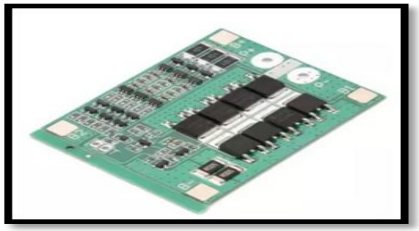


Figure 10. Lithium Battery Protection Board

Direct Current Motor (DC Motor). A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy.

Figure 11. DC Motor

HC-SR04 Ultrasonic Sensor. Ultrasonic sensor measures distances based on transmitting and receiving ultrasonic signals.

Figure 12. HC-SR04 Ultrasonic Sensor

4-Channel Wireless Remote Controller. The four switches will have each functions that correspond directly on the Solar -Based Grass Cutter Machine depending on the situation.

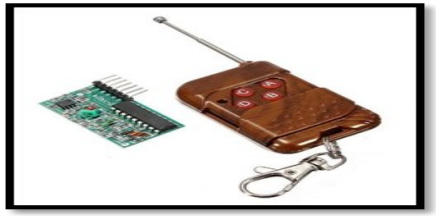


Figure 13. 4-Channel Wireless Remote Controller

Servo Motor. A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.

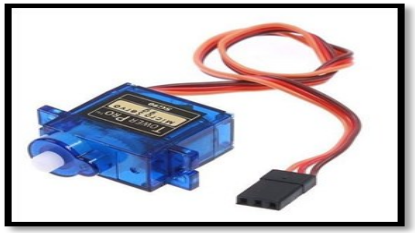


Figure 14. Servo Motor

Rechargeable Batteries. A rechargeable battery is a type of electrical battery which can be charged, discharged into a load, and recharged many times.

Figure 15. Rechargeable Batteries

Devastator Tank Mobile Platform. The robot platform itself has multiple mounting holes that allow users to add various sensors, servos, turntables and controllers.

Figure 16. Devastator Tank Mobile Platform

Cutter Blades. A blade is that portion of a tool, which was used to cut the grass.

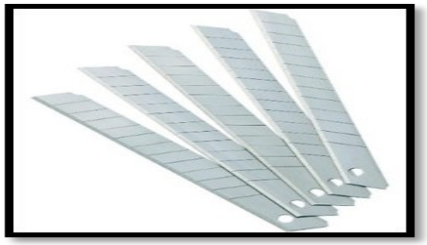
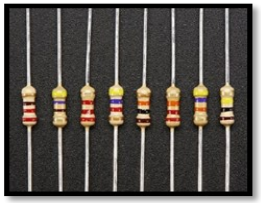


Figure 17. Cutter Blades

Battery Holder

Jump Wires

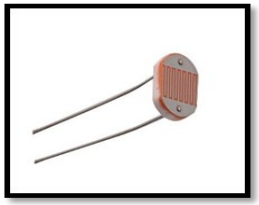
Toggle Switch



Resistors

RGB LED

Stranded Wires



Photoresistor

Acrylic glass

Cable Sleeve

Ultrasonic sensor bracket

Shrink tube

DC Motor Coupling Shaft

Figure 18. Other Equipment Used for the Project Study

Wiring Diagram of Solar-Based Grass Cutter Machine with Light Tracking System

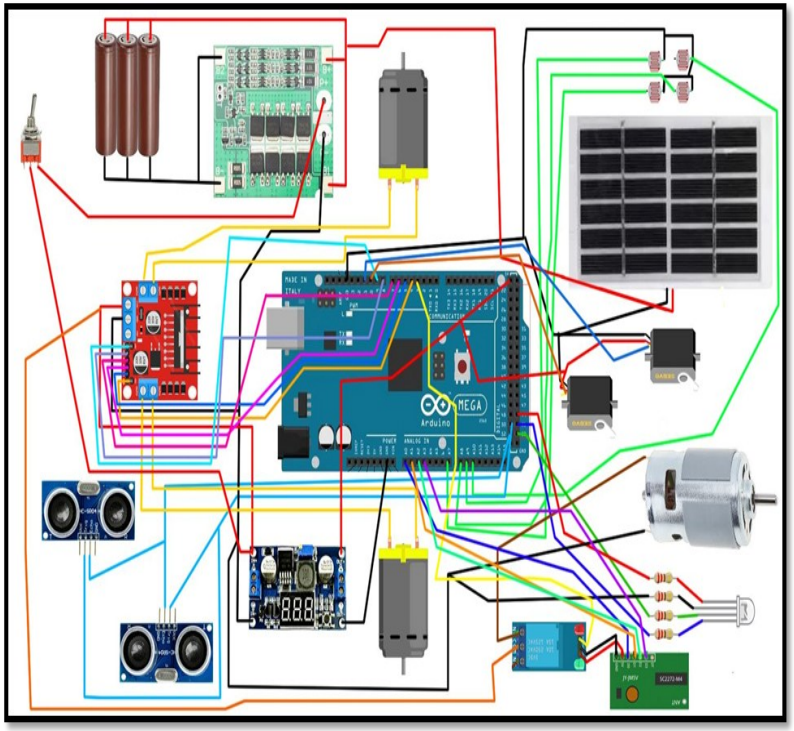


Figure 19. Wiring Diagram of Solar-Based Grass Cutter Machine with Light Tracking System

Figure 19 shows the schematic diagram for the Solar-Based Grass Cutter Machine. All of the electronic components were interconnected with each other especially to the brain of the device which is the Arduino. The wiring configuration for the solar tracking system and four channel remote control were also showed.

Development of the Study

The researchers decided to make its protective case by assembling the Devastator Tank Mobile Robot Platform.

Also, the following photos shows the adjustment of height of the case by adding acrylic glass and creating division inside for the proper placement of electronic devices was done, making and testing of wiring connection for solar panel's light tracker, customizing the blade cutter then testing and evaluation of the grass cutter machine.

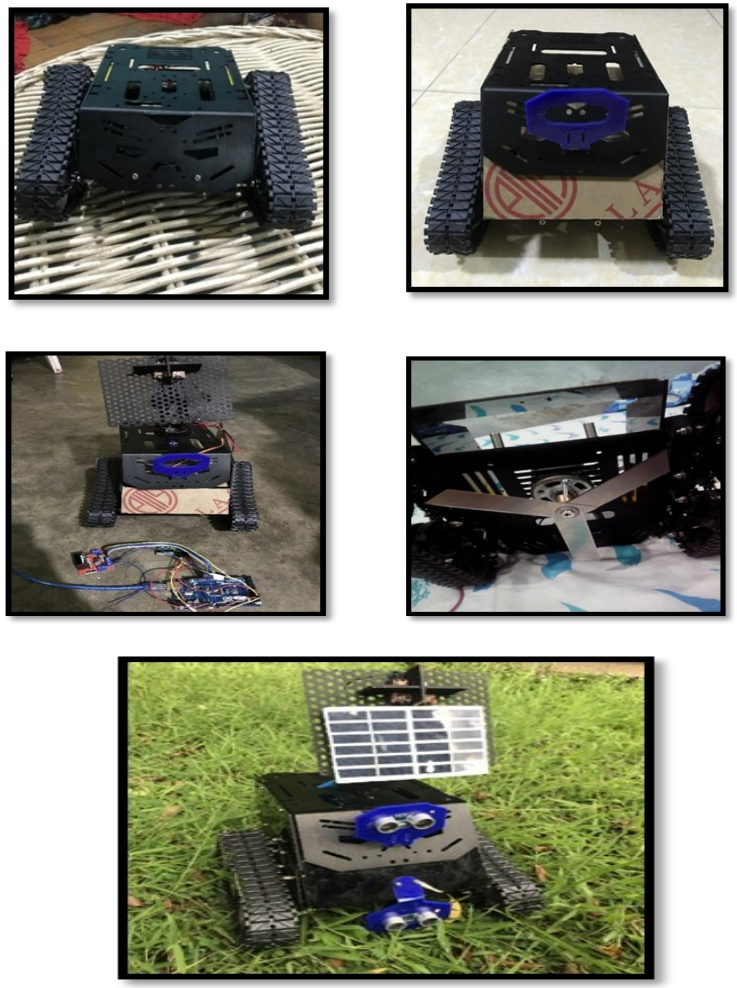


Figure 20. Photos Showing the Actual Making of the Device

Table 4 presents the actual cost of the Solar-Based Grass Cutter Machine with Light Tracking System.

Project Cost

Table 4. Project Cost of Solar-Based Grass Cutter Machine with Light Tracking System

Item	Quantity	Amount	Total
Mini Solar Panel	1	₱236.00	₱236.00
Arduino Mega 2560	1	700.00	700.00
L298N Motor Driver Module	1	150.00	150.00
LM2596 Step Down Power Module	1	150.00	150.00
1 Channel 5V Relay Module	1	70.00	70.00
Lithium Battery Protection Board	1	183.00	183.00
555 DC Motor	1	550.00	550.00
HC-SR04 Ultrasonic Sensor	2	69.00	138.00
4-Channel Wireless Remote Controller	1	347.00	347.00
Servo Motor	2	120.00	240.00
Rechargeable Batteries	2 pairs	449.00	948.00
Battery Holder	5 pcs.	169.75	169.75
Devastator Tank Mobile Platform	1	4,385.00	4,385.00
Cutter Blades	10 pcs.	65.00	65.00
Jump Wires	30 pcs.	7.00	210.00
Resistors	7 pcs.	1.00	7.00
Stranded Wires (#22 AWG black)	10 m	8.00	80.00
Stranded Wires (#22 AWG red)	10 m	5.00	50.00

Table 4. Continuation

Item	Quantity	Amount	Total
Toggle Switch	1	30.00	30.00
RGB LED	1	12.00	12.00
Photoresistors	4 pcs.	5.00	20.00
Acrylic glass	1	400.00	400.00
Ultrasonic sensor bracket	2 pcs.	80.00	160.00
Cable ties	1 pack	83.00	83.00
Cable Sleeves	50 ft. (2 packs.)	950.00	1,900.00
Shrink Tube (#3 mm)	50 in.	3.00	150.00
DC Motor Coupling Shaft	1	35.00	35.00
		Total	***₱11,468.75***

Results and Discussion

Solar-Based Grass Cutter Machine is a hardware prototype that helps the user to make their lawn mowing easier and convenient. With the use of the electronic components, all the related duties regarding the services are to be managed efficiently and more wasted time prevented. This hardware provides helps by cutting the grass in respective area.

It also has an added feature in which the user of the hardware could be able to turn on/off the device using a remote control and has a solar tracker for easy detection of light intensity for its charging function.

To discuss further, listed are the detailed functionalities and capabilities of Solar-Based Grass Cutter Machine with Light Tracking System:

1. It can avoid obstacle through an ultrasonic sensor.
2. The device can easily charge through direct pointing of solar tracker towards the highest light intensity coming from the sun.
3. It can cut grass automatically.
4. The user can control the on/off of the device by using a remote control with different functions. It also comes with a RGB LED for the indicator of working principle of device.

Although the study was reviewed several times, cited were some limitations in the hardware and software such as:

1. Setting of coverage cutting area not included.
2. Setting of required time for cutting not included.
3. The device cannot move on grass areas that have rough and rocky surfaces.
4. There is no charging and discharging indicator.
5. Applicable to small area lawns.
6. It cannot operate on rainy days.
7. The remote controller must operate near the device because it only has short range distance.
8. The maximum rotation of the device when it sense an obstacle is 180°.
9. The obstacle detection distance of the device is set at 20 cm.
10. There must be an obstacle in front of the device in order to complete its random pattern for cutting the whole lawn area with defined dimensions.
11. The two ultrasonic sensors can only detect objects that are visible and whole in piece.

The researchers gathered studies about the features of the traditional lawn mower and compared its conditions to the improved device. It was proved that the Solar-Based Grass Cutter Machine was improved because it is pollution-free, reduces human efforts, low maintenance, availability of remote controller, less noise, power sources are renewable energy and ac source, less expensive, and applicable for small area.

Table 5 shows the testing of the developed system in which the researchers listed down the specifications of the device.

Table 5. Testing of the Developed System

Parameters	Values
Charging time (AC-powered)	3-4 hours
Charging time (Solar-powered)	10-12 hours
Minimum discharging time	20-30 minutes
Type of surface lawn area	Flat and smooth grass surface, applicable for small area
Motor wheel speed	150 rpm
Distance of obstacle avoid-ance	20 cm
Maximum Height of Grass to cut	3-6 inches
Level of grass cut	0.5 inches
Cutting pattern	Random

Conclusion

The project study entitled “Solar-Based Grass Cutter Machine with Light Tracking System” was successfully completed and the results obtained were very good. This project is more suitable for a common user as it is having much more advantages such as no fuel cost, no pollution and no fuel residue, less number of moving components and this can be operated by using solar energy. It consumes renewable source of energy so total energy received from sun far exceeds energy demand. This system is capable of charging the batteries while the solar powered grass cutter is in motion. Integrating features of all the hardware components used have been developed in it. Presence of

every module has been reasoned out and placed carefully, thus contributing to the best working condition of the unit. By using simple switches or by predetermined programming, it can be easily handled and controlled within less time span. It also performed well because it detected the obstacle and changed the direction or stopped functioning as per the instruction given. Using the help of growing technology and highly advanced Arduino, the project has been successfully implemented. The Solar-Based Grass Cutter Machine meets the challenge of environmental protection and low cost of operation. The project has been developed for the use of residences and establishments that have lawns where tractor driven mowers could not be used.

Recommendations

In light of the findings and conclusion of the study, the following recommendations were drawn and can be used by future researchers who want to develop similar kind of study:

1. Use of display indicator for the solar charging and discharging.
2. Use of high end sensor mechanism that can sense the entire finished route so it will not repeat mowing the area mowed already and can also sense all the damaged possibilities on the hardware.
3. Installation of additional software requirements for setting a required area dimensions and time given.
4. Use of higher specifications in materials to give better output results.
5. Make the unit heavier for effective grass cutting.
6. Adjustment of detection distance of the two ultrasonic sensors for better obstacle avoidance.

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