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Design and Implementation of an Arduino-based Remote Controlled Solar Powered Lawn Mower

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Abstract
This research focuses on the design and construction of cost effective solar-powered lawn mower that can be operated remotely using an Arduino board.A lawn mower is a machine that cuts grass to a consistent height by rotating one or more blades (reel).The most common lawn mowers use an internal combustion engine, often with one cylinder, to power them. Mowers are typically self-propelled, which means that a human only needs to walk behind them and direct them; however, smaller mowers may lack self-propulsion and must be operated by a human to move across a surface.In this study, an Arduino-based remote controlled solar powered lawn mower was designed and constructed that does not require physical contact to push or direct it. The researchis divided into two parts: the first focuses on the mower frame, and the second on assembly and programming.The implemented mower is powered by a 12V lead acid battery and a 20W solar panel, which is used to recharge the battery. The lawn mower includes four 12V DC motors that synchronize with the L298N motor driver, which aids in motions and directions by decoding instructions from a NEC IR remote.The IR remote controls the lawn mower, which has a blade attached to a high torque (5000RPM) 12V DC motor that is likewise controlled by the IR remote. The 138B IR receiver takes signals from the IR remote and allows for all mower movements. An extra ultrasonic sensor automatically stops the mower when it is 20cm close to an impediment, preventing the mower from crushing into it if the user loses control.

Keywords
Lawn mower, Solar Panel, Arduino Uno R3 microcontroller, IR remote, Ultrasonic sensor

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I. Introduction

In the town of Stroud, Gloucestershire, England, Edwin Beard Budding invented the first lawn mower in 1830. A British patent for Budding's mower was issued on August 31, 1830. It was primarily intended to mow grass in large gardens and sports fields as an improvement over the scythe. An Arduino-based remote controlled solar powered lawn mower is a machine equipped with rotating blades that cut grass to a uniform height. The incorporation of the solar energy, enhances the use of ecofriendly free energy without the use of fossil fuel as a meansof powering the mower for the purpose of cutting lawns. The implemented lawn mower differs from conventional lawn mowers in that it employs an Arduino Uno R3 microcontroller board, which is based on the ATmega328P chip. The Arduino IDE allows instructions to be programmed onto the microcontroller.In this study, the lawn mower's motions are controlled by a NEC protocol IR remote and an SR04 ultrasonic sensor, which detects and stops movement when the mower approaches an impediment at a distance of 20 cm. The IR remote also controls the motor blade. The mower has a 12V battery that is charged by an 18V polycrystalline solar panel connected in series. Figure 1 depicts an overall block design of the Arduino-based remote control solar powered lawn mower.

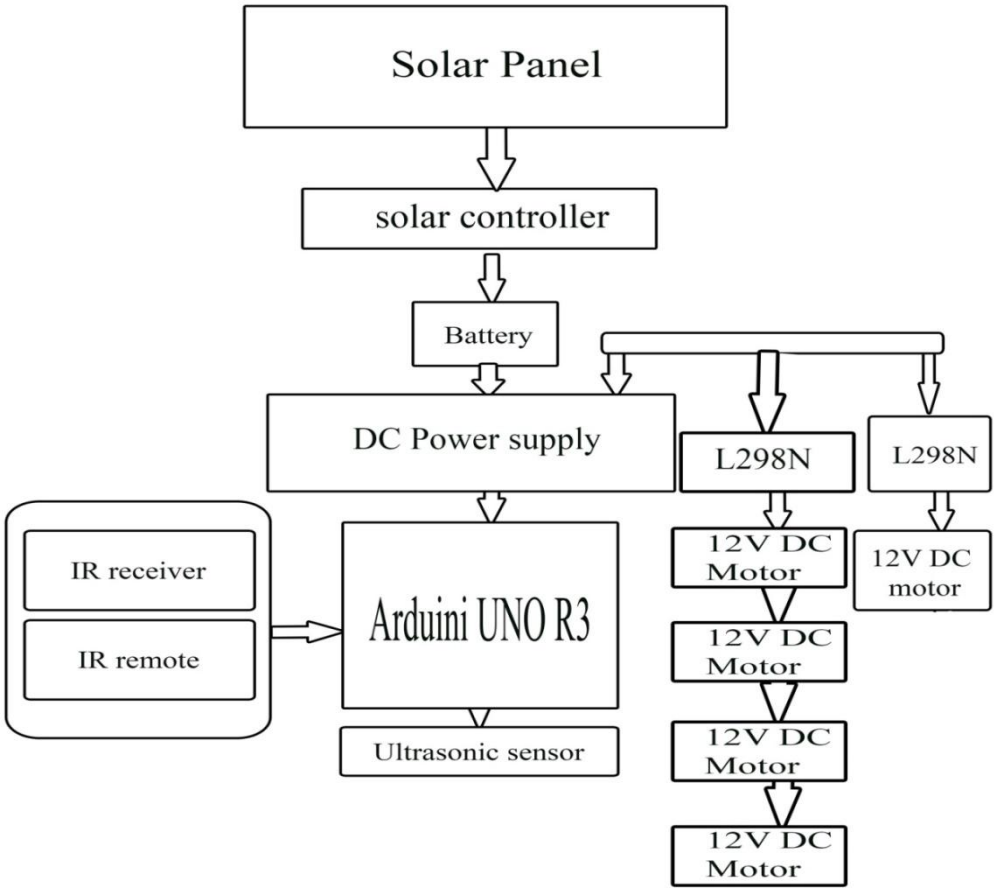


Figure 1: Block Diagram of the Arduino-based remote controlled solar powered lawn mower

II. Methodology

2.1 System Elements

The remote controlled solar-powered lawn mower system consists of various key components. Polysilicon Solar Panel: A 12V lead-acid battery was charged by a polycrystalline solar panel that was synchronized with a solar charge controller. This renewable power source enables cost-effective continuous operation of the lawn mower while reducing its environmental impact. The lead-acid battery is an energy storage device that powers the lawn mower's motors and other components.

The battery is charged by the solar panel via a charging system, they serve as the main power source for the system. Two L298N motor drivers are utilized in the system. Generally, two motor drivers and five (5) 12 V DC motors were employed in this study. One motor driver powers the four (4) 12V DC motors that were utilized to propel the lawnmower; the other motor driver controls the other 12V DC motor that is attached to the grass-cutting blade. The preprogrammed instructions to operate the lawnmower are carried out by the microcontroller of the Arduino UNO R3 board.Arduino UNO R3 board acts as the system's central processing unit, coordinating all of its operations and reacting to human input. The 1383B IR receiver is employed to receive signals from an NEC protocol IR remote. This allows for controlling the lawn mower remotely and enabling users to start, stop, and change directions of the mower from a distance. An ultrasonic sensor is utilized to detect obstacles in the path of the lawn mower. When an obstacle is detected at a distance of 20cm, the sensor sends a signal to the Arduino board, triggering the mower to stop and prevent collisions.

2.2 System Operation

The remote control solar-powered lawn mower operates as follows: The polysilicon solar panel captures sunlight and converts it into electrical energy, which charges the 12V lead-acid battery. The charged battery powers the Arduino board, motor drivers, and other components of the lawn mower. The Arduino board executes the programmed instructions, thereby controlling the movement of the lawn mower by sending appropriate signals to the L298N motor driver connected to the four 12V DC motors. The blade motor is also controlled by the Arduino board through the second L298N motor driver. The 1383B IR receiver receives

commands from the NEC protocol IR remote, allowing users to remotely control the lawn mower's operations. The ultrasonic sensor continuously scans the surroundings and detects obstacles in the pathway of the lawn mower. If an obstacle is detected within 20cm, the sensor triggers the Arduino board to stop the motors, preventing any potential collisions.

III. Design Consideration and Experimental Result

3.1 Arduino and motor driver control circuit boardsystem

The Arduino microcontroller with ATmega328P core is used as the brain for the circuit. The ATmega328P microcontroller makes it easily to communicate with the motor drivers and the sensors. Figure 2 shows circuit board connections of the remote controlled solar powered lawn mower. Figure 3 shows lower frame and upper of the lawn mower with a solar panel. Figure 4 shows final assembly of the research product.Table 1 displays materials used for the frames.

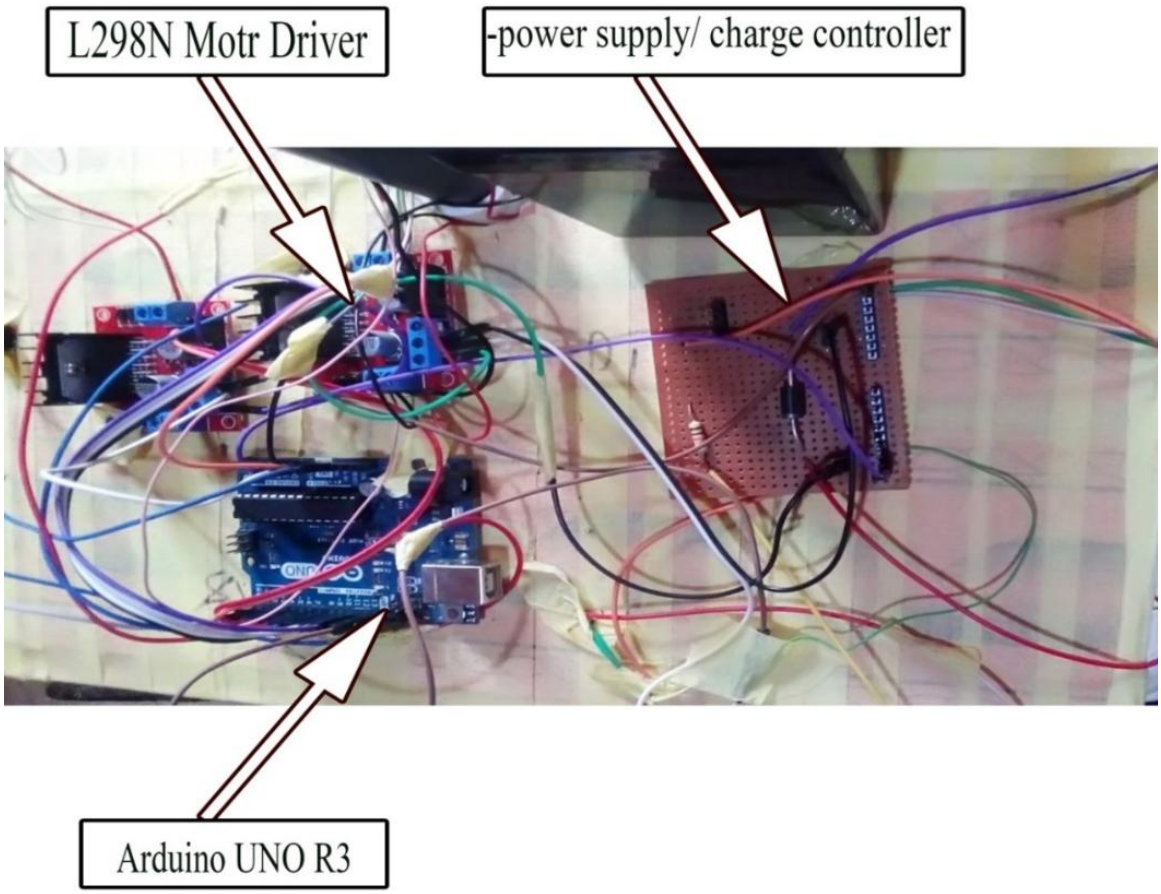
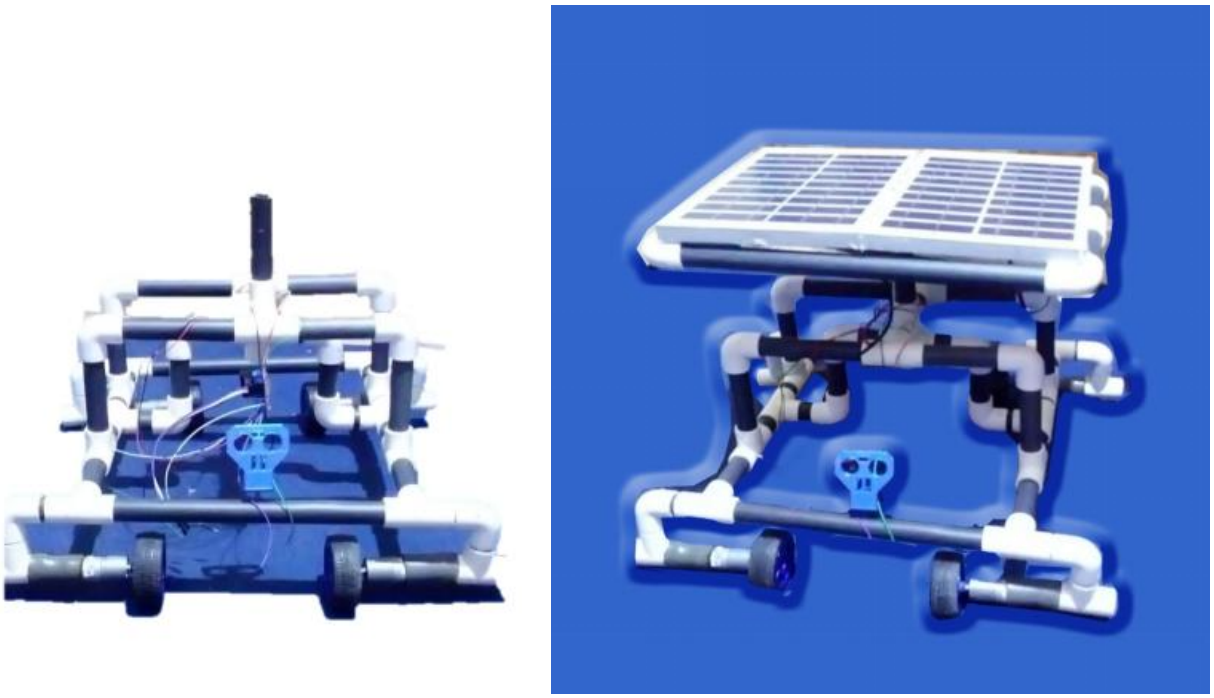


Figure 2: Circuit connection of the remote controlled solar powered lawn mower

3.2 Hardware Frame requirement

Table 1:Materials used for the frames

Component of the mower frame	**Desired length/number**
1/2´´ PVC pipe	30 feet
½´´ PVC bend	24
½´´PVC 'Tee'	19
T&G	1.5 feet
¾´´ PVC pipe	1.5 feet



(a) (b)

Figure 3: (a) Lower Frame (b)Upper and lower Frame of the Lawn Mower with a Solar Panel

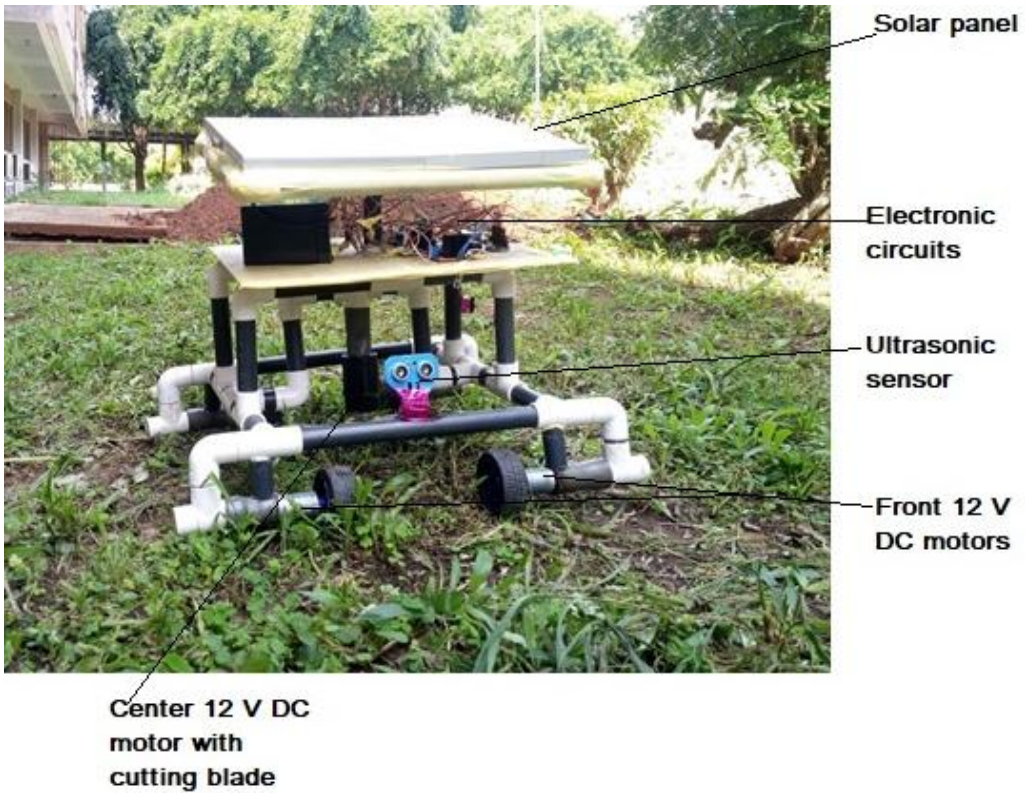


Figure 4: Final Assembly of the Arduino-based remote controlled solar powered lawn mower.

3.3 Software implementation

The flow chart for the execution is displayed in Figure 5. When the mower is turned on, it waits for a command from the IR remote before moving. When in operation, it will immediately stop moving if it detects an impediment at a distance of 20 cm. Figure 6 showsArduino IDE Serial monitor interface.

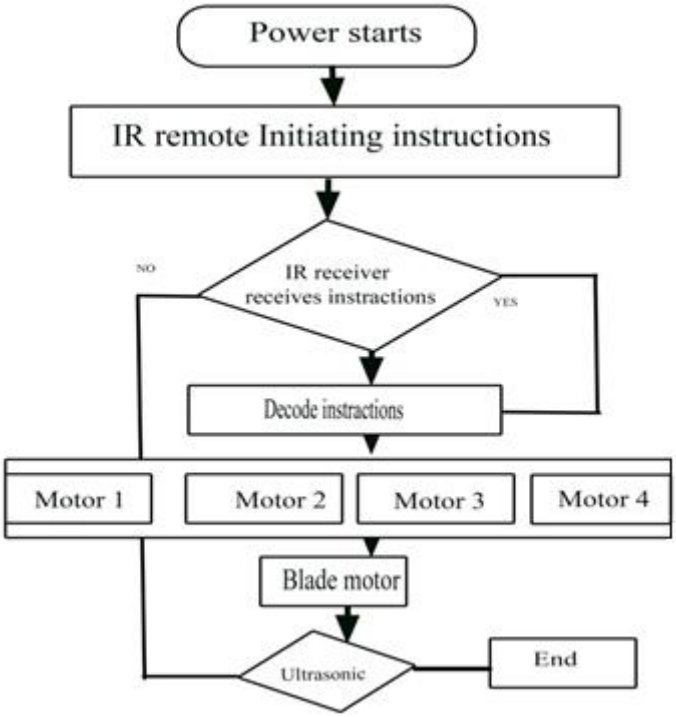


Figure 5: Flowchart implemented for the programming of the lawn mower

3.4 Arduino program for the motor control, the IR remote and the Ultrasonic sensor

The Arduino Uno R3 controller controls the device's whole operation. It is powered by the second L298N motor driver's 5V output. The Infrared Sensor (1838B) manages remote communication between the gadget and the user, and it is powered by the Arduino's 3.3V supply. The signal pin is connected to the Arduino's pin 2. The HC-SR04 sensor (SONAR) measures the distance between itself and obstructions. The ultrasonic frequency used is 40 kHz.The ultrasonic sensor's trigger pin is set high for 10µs, while the echo pin measures the bounced-back sound. The ultrasonic sensor is linked to the Arduino Board's 5V output, which is grounded to the Arduino.

The Trigger pin is also connected to pin 7, while the Echo pin is attached to pin 8 on the Arduino. The Motor Drivers (L298N) control the speed and direction of DC motors utilizing PWM and an H-Bridge driver. Two motor drivers are utilized for various motors. The first driver's VCC is connected to the 12V everlasting power supply, GND to Arduino, and specialized control pins (IN1, IN2, IN3, IN4) are attached to pins 9, 10, 11, and 12, respectively, to control four geared DC motors for the wheels.The Second Driver is connected to an external power source and the Arduino's GND, with particular control pins (IN3, IN4) attached to pins 4 and 5, which control the ON/OFF of the Blade motor. When button 2 on the IR remote is pressed, the mower will move forward; button 4 will move it to the left; button 6 will move it to the right; button 8 will cause the mower to move backward; and button 5 will immediately stop all motions.The PLAY/PAUSE button and the BACK button switch on and off the blade motor, respectively. Figures 7 and 8 depict the NEC IR remote and the experimental texting of the mower control system on the Arduino IDE serial monitor, respectively.

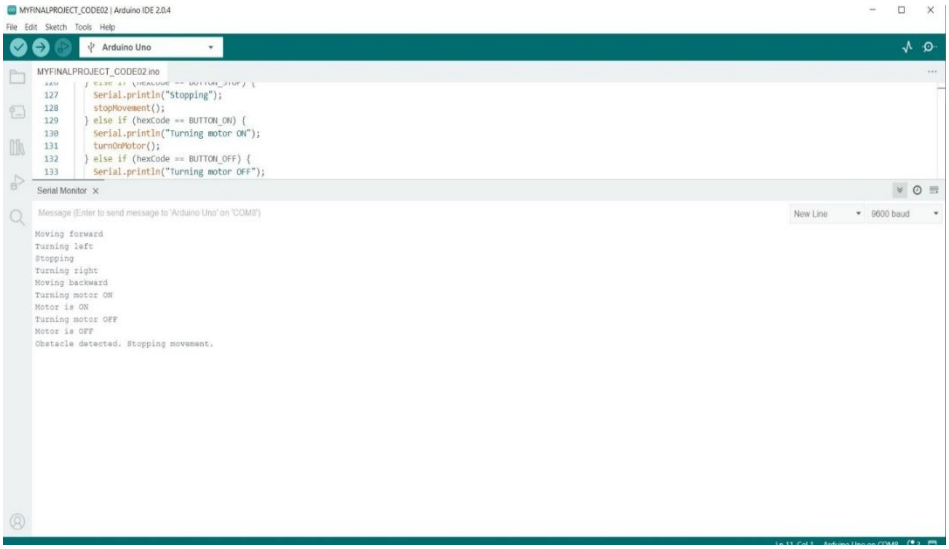


Figure 6: The programmed control system working on the Arduino IDE Serial monitor

Figure 7:*The NEC IR remote for controlling the mower movement*

3.5 Experimental Results

(a) BEFORE (b) AFTER

Figures 8: (a) Lawnmower in operation, before cutting (b)Lawnmower in operation, after cutting weeds

Figures 8 (a) and (b) depict the mower before and after cleaning weeds. When developing the cutting blade, both the force required to cut the lawn and the force acting on the blade were taken into consideration. Any sharp object that impacts grass should have a force of at least 10 Newton.It also depends on the object's height, density, and surface area. As a result, when developing the blade of a solar-powered lawn mower, the force required for effective mowing was determined to be 15 Newton.The component of any net force that induces circular motion is known as centripetal force. When the net force equals the centripetal force and the magnitude is constant, uniform circular motion occurs. Centripetal force, like centripetal acceleration, is directed toward the center of rotation.According to Newton's second law of motion, a net force causes the acceleration of mass (m),$F_{net} = ma$. For uniform circular motion, the acceleration is centripetal acceleration: $a = a_c$. Therefore, the magnitude of centripetal force, F_c, is F c =m a c. A stainless steel is used in theconstruction of the cutting blade because of its strength and weight which can transmit same speed as that of the DC motor or a little less cause of friction. The mower was testedon several types of grass in order to determine its viability. For instance, elephant grass (Cenchruspurpureus), stubborn grass (Sidaacuta), and spear grass. Additionally, the performance on various slopes and grounds. Lawn conditions, grass density, moisture content, grass length, and cut height all affect the area of cut (battery time).Frequently turning the product on and off while cutting will result in less efficient cutting.Table 2 compares the parameters to the traditional mower and the final mower used in this study.Table 3 displays the mower's output statistics during operation.

$$\mathbf{F}_{net} = m\mathbf{a} \qquad (1)$$

$$F\ c = m\ a_{\ c} \qquad (2)$$

Table 2:*Some parameters compared to the Traditional mower and the final mower for this work*

Parameter	Traditional lawn mower	Arduino Automated solar powered mower
Pollution	Causes more pollution	Clean and pollution free
Effort	more	less
Remote control	Not available	available
Noise	More	less
Fuel	Uses fuel	No fuel
Free energy	No	Yes

Table 3: Some data gathered as the mower operates

Parameter	Result
The maximum cutting height	1.5 inches
Type of weeds/grass for efficient cutting	'Light'grass
Voltage input (DC motors)	12V
12V DC motor running currunt	60mA
12v DC Motor stall current	1120mA
Blade motor running current	85mA
Blade motor stall current	100mA
Mower weight	7.35KG
Working distance for the IR remote	25 feet
Working Distance for the Ultrasonic sensor	20cm

IV. Conclusion

The objective of this project was to build an Arduino-based remote operated solar lawn mower.This lawn mower was constructed with an Arduino UNO R3 microcontroller, an IR receiver module, and an ultrasonic sensor. The 1383B IR receiver connected to the Arduino allows the UNO R3 to read input signals from the IR remote and control the mower's movement and direction.This project demonstrated the feasibility of using free solar energy, an Arduino UNO R3 board, an IR remote, and an ultrasonic sensor to automate complex tasks that would otherwise be physically demanding or impossible. While this design must be refined before mass production, increasing the cutting frequency is recommended to improve the cut area. The highest cutting height is 1.5 inches.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding this publication of the paper.

Author Contribution

The *authors confirm contribution to the paper as follows:* ***study conception and design:***Benjamin Oteng, DwamenaFosu Gideon, BordohEdwardTsiah*;* ***data collection:***Benjamin Oteng, DwamenaFosu Gideon, BordohEdwardTsiah*;* ***analysis and interpretation of results:***Benjamin Oteng, DwamenaFosu Gideon, BordohEdwardTsiah*;* ***draft manuscript preparation:***Benjamin Oteng, DwamenaFosu Gideon, Bordoh EdwardTsiah. *All authors reviewed the results and approved the final version of the manuscript*.

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