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Special Issue
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This special issue is dedicated to Professor Onukwuli Okechukwu Dominic (FAS), marking his retirement and celebrating a remarkable career. His legacy of exemplary scholarship, mentorship, and commitment to advancing knowledge is commemorated in this collection of works.

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Development and evaluation of an autonomous solar lawnmower

Busayo Sunday Adeboye[1], Oluwaseyi Kolawole[1], Toyese Friday Oyewusi[2], Abideen Temitayo Oyewo[1*]
[1]Mechanical Engineering Department, Osun State University, Osogbo, Osun State, Nigeria
[2]Agricultural Engineering Department, Osun State University, Osogbo, Osun State, Nigeria
*Corresponding Author's E-mail: abideen.oyewo@uniosun.edu.ng

Abstract
The ongoing rise in fuel prices and environmental impact of petrol emissions necessitate the use of alternative energy sources. This study focuses on developing an autonomous solar-powered lawn mower, integrating solar panels and advanced control systems to minimize manual labour and emissions. The objectives include designing, fabricating, and evaluating a prototype that can efficiently cut grass across various lawn sizes, terrains, and vegetation types. The mower features two brushless motors, each rated at 2700 kV, powered by an 11.1-volt, 2-amp supply. The mower is designed with cutters positioned side by side, allowing it to cut grass beside obstacles while maintaining efficiency. This design improves obstacle navigation and addresses the limitations of traditional lawnmowers. Performance evaluations revealed that mower effectively cut various grasses and tender weeds. The integration of solar energy and automation introduces a sustainable, labour-saving solution that enhances lawn maintenance. The developed mower reduces manual effort, improves mowing efficiency, and maintains performance across diverse conditions. This innovation offers a practical and energy-efficient alternative to traditional models, opening the door to a new era of environmentally friendly lawn care.

Keywords: Autonomous, lawn mower, solar-powered, brushless motors, environmentally friendly lawn, sustainable technology

1. Introduction

Solar power, despite its historical underuse due to reliance on other energy sources, has become a significant renewable energy option through advancements in solar thermal and photovoltaic technologies. These developments enable innovative applications and support the transition from fossil fuels and wood fuels (Gonzalez-Aguirre et al., 2021; K Telli et al., 2023). The lawnmower, invented by Budding in 1830, replaced the scythe with a wheeled frame and rotating blades, revolutionizing grass-cutting efficiency. A lawnmower is a mechanical device used to cut grass or vegetation to an even height, commonly used in lawn maintenance. Cylindrical reel lawn mowers, with rotating blades, achieve precise cuts through a scissor-like action, interacting with a bed knife parallel to the ground. (Ivić et al., 2023; Karatayev et al., 2023; Leanza et al., 2023; Oyewo et al., 2024).

Inspired by a cloth-cutting machine, the design evolved over time from manual to horse-drawn, motorized, and steam-powered models, each overcoming earlier limitations (Theisen et al., 2022). Modern autonomous lawnmowers incorporate robotics, renewable energy, and artificial intelligence, allowing them to navigate, detect obstacles, and mow with precision while requiring minimal human intervention. Solar-powered systems enhance sustainability by reducing carbon footprints and costs, while Global Positioning System (GPS), Light Detection and Ranging (LiDAR), and machine learning optimize navigation and adaptability. These advancements support global sustainability goals, providing efficient, eco-friendly landscaping solutions (Gil et al., 2023). Rotary mowers, powered by internal combustion or electric motors, can be configured for different cutting heights and feature side openings for expelling cut grass. They have removable horizontal blades for easy sharpening or replacement, despite not being exceptionally sharp for precise cuts (Odetola et al., 2025; Oyewo, 2024; Khaled Telli et al., 2023). The concept of automation can be traced back to the Industrial Revolution, where mechanization began replacing manual labor in manufacturing processes. According to Groover, early automation primarily involved mechanical systems such as looms and conveyor belts. However, the advent of digital technology in the 20th century marked a significant shift toward programmable automation (Theisen et al., 2022). The introduction of computers and robotics further enhanced the precision and scalability of automated systems (Dada & Popoola, 2023).

The total efficiency and operating duration of autonomous solar lawnmowers may be limited by the significant power consumption of their communication systems, especially those used for remote control or monitoring. Typical communication methods used by current autonomous lawnmower systems include Wi-Fi and standard Bluetooth, both of which have high energy consumption (Akinyemi & Damilare, 2020). Nevertheless, there is still much to learn about the application of Low Energy RF communication, including Bluetooth Low Energy (BLE). When compared to conventional communication techniques, low energy radio frequency (RF) technologies have the benefit of substantially lower power usage. For example, BLE uses up to 100 times less power than standard Bluetooth, which makes it ideal for energy constrained systems like solar lawnmowers that run on their own (Thangavel et al., 2024). The mower's running time may be increased by implementing Low Energy RF, which reduces the overall energy consumption for communication. This is essential for solar-powered systems since it would enable them to operate for longer stretches of time without requiring regular recharging. The scalability of self-sufficient solar lawnmowers may also be enhanced via low energy radio frequency transmission (Onuabuchi et al., 2024).

Effective obstacle navigation, energy-efficient battery systems, and terrain adaption are hurdles in the development of autonomous solar-powered lawnmowers. Even with advancements in robotic systems, there are still a lot of unanswered questions that prevent these systems from reaching their full potential in practical settings. While traditional robotic systems primarily focus on wheel designs like differential and omni-wheels, which perform well on flat surfaces, they often struggle in more complex, uneven terrains such as gravel, sand, and slopes in the context of solar-powered lawnmowers, mecanum wheels, which are renowned for their improved maneuverability have not yet been thoroughly investigated. In order to maximize mobility across various surfaces and improve efficiency in actual outside settings, further study is required to fully understand the relationship between wheel types and different terrains (Ritwik & Patel, 2023). Apart from adapting to different terrain, battery system optimization is still a major obstacle. The efficiency of solar panels has increased, but to guarantee continuous, energy-efficient performance, the related battery systems need to be upgraded for longer operating hours, more storage capacity, and faster recharging.

Obstacle navigation is one area where autonomous solar lawnmowers have a lot of room for development. This study offers a novel alternative by moving the cutters to cut next to barriers, whereas conventional methods depend on obstacle detection and avoidance systems. The mower can effectively trim regions around obstacles like rocks, trees, and garden furniture thanks to its design, which also does away with the need for complicated detecting methods. In situations where conventional mowers would leave parts uncut or need many passes, the ability to rotate cutters offers a major benefit. These mowers are more effective, versatile, and self-sufficient in outdoor settings because to the utilization of Mecanum wheels for enhanced terrain adaptation, a unique cutter design for obstacle navigation, optimized battery systems, and low energy communication technologies. This study has the potential to further the area of autonomous solar-powered lawnmowers by tackling these important problems and providing a more workable and efficient solution for real-world applications.

2. Materials and Methodology

2.1. Design considerations

The design in this work focused on the development of a remote-controlled motorized ground vehicle with a cutting system, utilizing Low Energy Radio Frequency communication. The design of the autonomous solar lawnmower prioritizes ease of maintenance through a modular structure with durable, easily replaceable components. It is built with weather-resistant materials to ensure durability in diverse environmental conditions and features a compact, lightweight design for easy storage, transportation, and operation. The lawnmower is scalable and adaptable to future advancements, such as GPS, Internet of Things (IoT), and Artificial Intelligence (AI) integration. Solar power serves as the primary energy source, complemented by electric charging options and energy-efficient components for optimized performance. The design ensures functionality, sustainability, and adaptability while addressing current and future user needs.

2.2. Design conceptualization

The lawnmower features two strategically positioned motors beneath the body to drive the cutting blades, ensuring balanced and efficient performance. The design optimizes component placement for efficiency, durability, and usability while minimizing maintenance requirements and enhancing overall functionality. **Figure 1** presents the design conceptualization of the study.

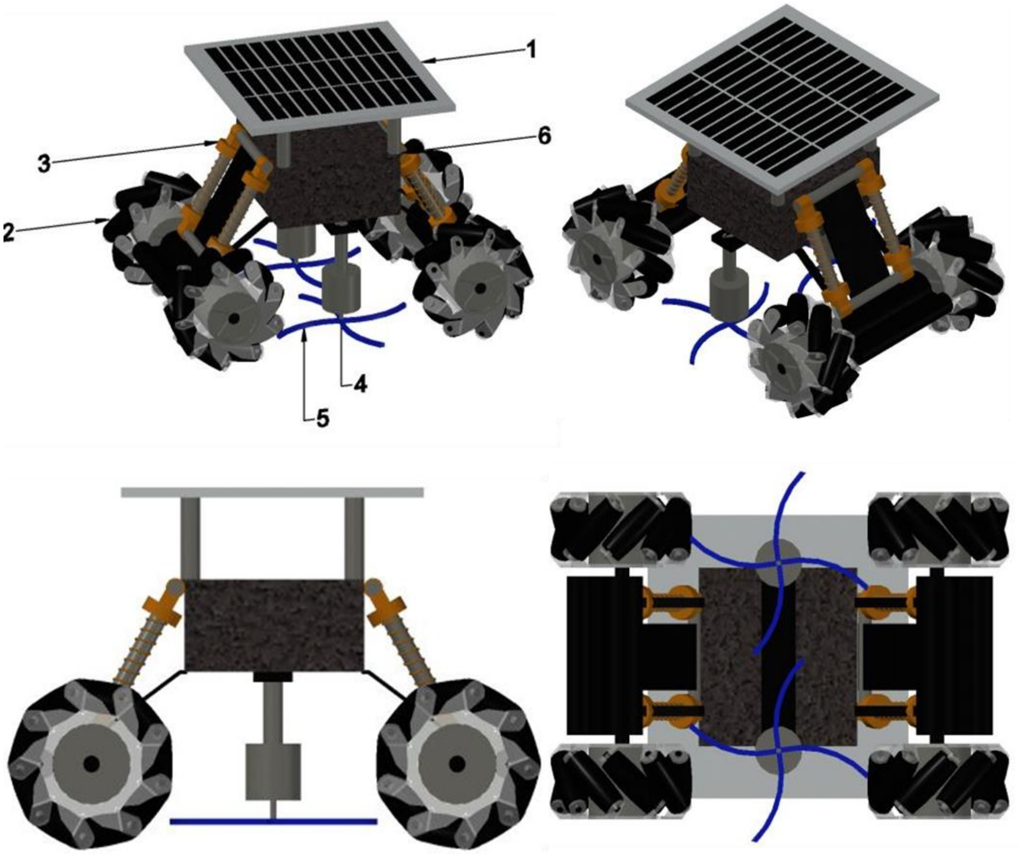

Figure 1: Design Conceptualization

2.3. Design calculations

The calculation of the system was divided into two, the first was based on calculation of the speed, power, torque of the cutter and the second calculation was based on the power requirement for the motor to move.

2.3.1. Speed, power and torque calculations

The speed, power and torque calculations of the cutter are shown below, for a brushless motor rated at 2700 KV (RPM per volt) and operated at a voltage of 11.1 volts and 2 Amps, the speed (RPM), power, and torque are calculated using the following steps:

i. Speed (RPM): the speed of the motor was calculated using the KV rating and the voltage.

$$Speed\ (RPM) = KV \times Voltage$$

$$= 2700 \times 11.1 = 29{,}970\ RPM$$

ii. Power: The power output of the motor was calculated as:

$$Power\ (Watts) = Voltage \times Current\ (Amps)$$

Where:

F is the force exerted by each motor, calculated based on the torque needed to move the lawn mower's weight, and V is the velocity at which the mower needs to move

$$= 11.1\,V \times 2\,A = 22.2\,Watts$$

So, the ideal motor's power output while cutting grass was approximately 22.2 watts.

iii. Torque: the torque was calculated as:

$$Torque\ (Nm)\ =\ (Power\ /(2\pi\ \times\ Speed))$$
$$=\ (333\ Watts\ /\ (2\pi\ \times\ 7400\ RPM))\ =\ 0.106\ Nm$$

To calculate the power P needed by each motor, we use the basic formula:

P = F × v

We already have the velocities for each wheel, and now we need to calculate the Fore F acting on each wheel.

The robot weighs 5 kg

Gravity is 9.81 m/s^2

F (total)=Weight=mg= 5kg × 9.81m/s^2 = 49.05N

Since the force is evenly distributed among the four wheels, the force acting on each wheel is:

$F_{Wheel}\ /F_{Total}$=

49.05N /4=12.26N

2.3.2. Calculate power for each wheel

Now that we know the force on each wheel (12.26N), we can use the velocity values for each wheel to calculate the power.

i. Power for Wheel 1 (Front Left)**:**
   Velocity V_1=1.19 m/s
   P_1=F_{Wheel}× V_1= 12.26N × 1.19m/s=14.60W
ii. Power for Wheel 2 (Front Right)**:**
   Velocity V_2=−0.19 m/s^2
   P_2=F_{Wheel} × V_2=
   12.26N×0.19m/s = 2.33W
iii. Power for Wheel 3 (Rear Left)**:**
   Velocity V_3=0.59 m/s
   P_3=F_{Wheel} × V_3
   12.26N×0.59m/s=7.23W
iv. Power for Wheel 4 (Rear Right)**:**
   Velocity P_4=0.41 m/s
   P_4=F_{Wheel}× V_4=12.26N×0.41m/s=5.03W
   P_{Total}=P1+P2+P3+P4
   Total power needed P1=14.60 W+ P2=2.33 W+ P3=7.23 W+ P4=29.03 W

$$Power_{Wheel}\ +Power_{cutter}$$
$$P(total) = 29.03W + 22.2W = 51.23W$$

Expected runtime using the 24.42 Wh battery:

$$\text{Runtime} = \frac{Battery\ capacity\ (Wh)}{Total\ Power\ Consumption(W)}$$
$$\text{Runtime} = \frac{24.24}{51.23} \quad = 28.6 \text{ Minutes}$$

2.4. Materials and their specifications

Table 1 lists all the hardware components used in this project alongside their respective use.

Table 1: Material Selection

S/N	Component	Quantity
1.	Robot Car Chassis	1
2.	Mecanum wheels	4
3.	Motor driver module	1
4.	ATMEGA328P (in Arduino Nano)	2
5.	433MHz Radio Frequency Module	1
6.	3S LiPo Battery	2
7.	Li-ion Batteries	2
8.	LM2596 DC-DC Buck Converters	1

9.	Brushless Motor	2
10.	Electronic Speed Controllers	2
11.	Relays	2
12.	Joysticks	2
13.	2N2222 Transistors	2
14.	Resistors	1
15.	Capacitors	1
16.	Vero board	1
17.	Connecting Wires	-

2.5. Functions of the components and elements

2.5.1. Chassis

This serves as the foundation of the mobile platform for the system as shown in Figure 2 (a). It provides the structure to support the wheels, motors, motor drivers, and other essential components.

2.5.2. Mecanum wheels

Figure 2b shows the Mecanum wheels. This is a special type of wheel designed to enable omnidirectional movement, making them ideal for mobile robots, such as a remote-controlled lawn mower. Unlike traditional wheels, mecanum wheels feature rollers arranged at 45-degree angles around the wheel's circumference.

2.5.3. Motor driver module:

Figure 2c presents the L298 motor driver module responsible for controlling the direction and speed of the DC motors. As a dual H-bridge motor driver, it can independently manage two motors, which is crucial for controlling the wheels of a lawn mower robot.

2.5.4. ATMEGA328P

Figure 2d describes the ATmega328 widely known for its use in the popular Arduino Uno and Nano boards. The ATMEGA328P MCU requires a clock circuit and a reset pull-up circuit to be built around it for it to function properly.

2.5.5. 433MHz radio frequency module

Figure 2e presents the 433MHz Radio Frequency (RF) module wireless communication device that enables data transmission at 433MHz, making it well-suited for remote control applications with moderate range need.

2.5.6. LM2596 buck converter

Figure 2f presents the 2.5.6. LM2596 buck converter which is highly efficient DC-DC buck converter module designed to step down input voltages ranging from 5V to 80VDC to a stable, lower output voltage. Its compact size and versatile design make it an ideal choice for various electronic applications, particularly in situations where a stable lower voltage is needed.

2.5.7. RS360 high-torque DC motor

As shown in Figure 2b, the RS360 high-torque motor is a compact and durable motor renowned for its ability to deliver substantial torque, making it well-suited for applications that require strong, consistent rotational force.

2.5.8. Electronic speed controller

Figure 2 (h) presents the electronic Speed Controllers (ESCs) devices that regulate the speed, direction, and braking of electric motors by controlling the amount of power delivered.

2.5.9. Joystick module

Figure 2 (i) presents a joystick input device used to control movement by translating hand motions into directional commands. In this lawn mower project, the joystick allows the operator to intuitively guide the mower, making it move forward, backward, sideways, or diagonally based on the joystick’s position.

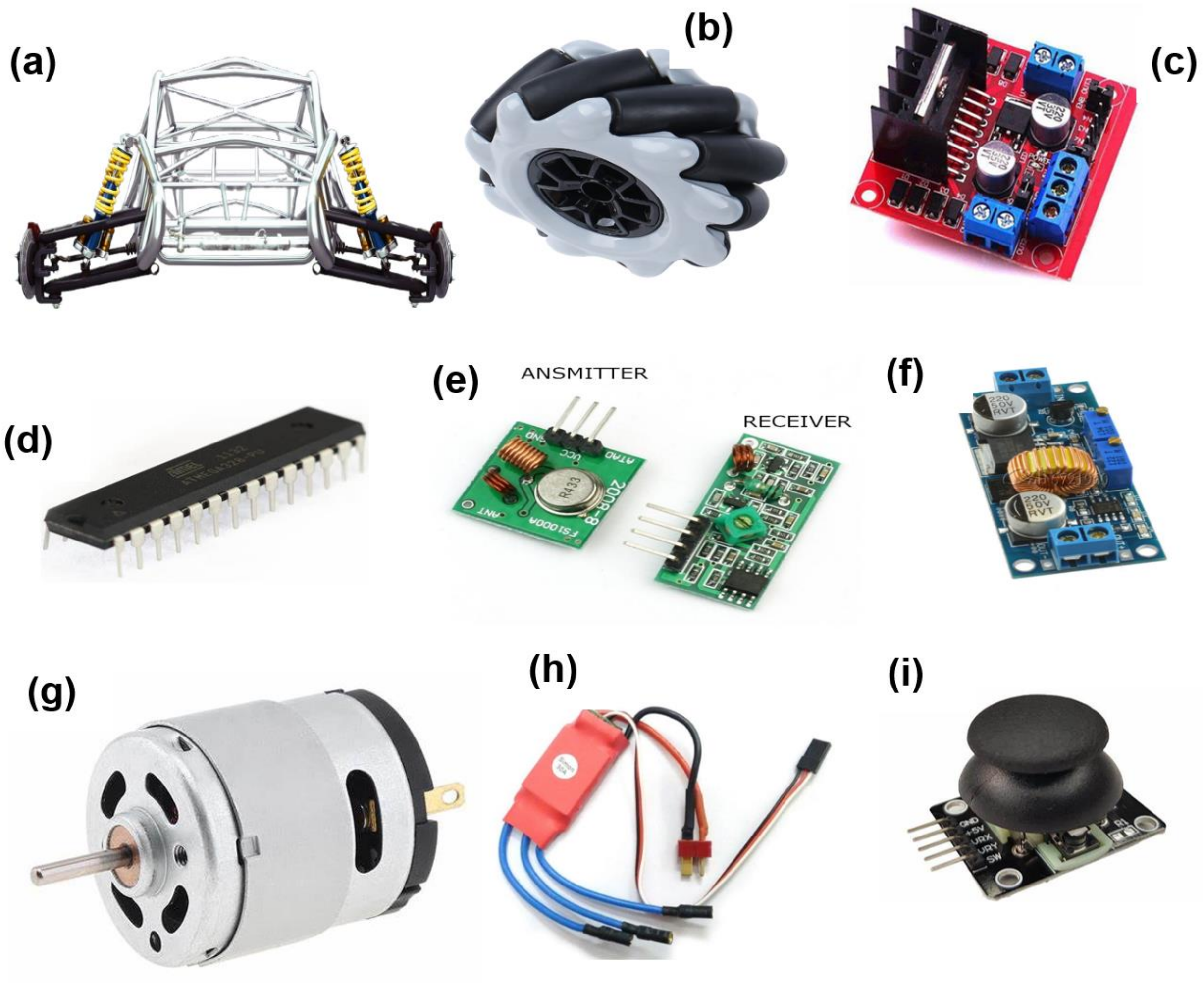

Figure 2: (a) Off-road Car Chassis (b) Mecanum wheel (c) L298N motor driver module (d) ATMEGA328P (e) 433MHz RF Module Pair (f) XL7015 DC-DC Buck (g) RS360 High-Torque DC Motor (h) Electric Speed Controller (i) Joystick module

2.6. Development of the autonomous solar powered lawnmower

The development consists of two segments: the movement segment, which enhances the movement of the mower, and the cutting segment, which is responsible for the cutting process. Figure 3 shows the development of the system detailing the movement (a) and cutting segment (b), respectively.

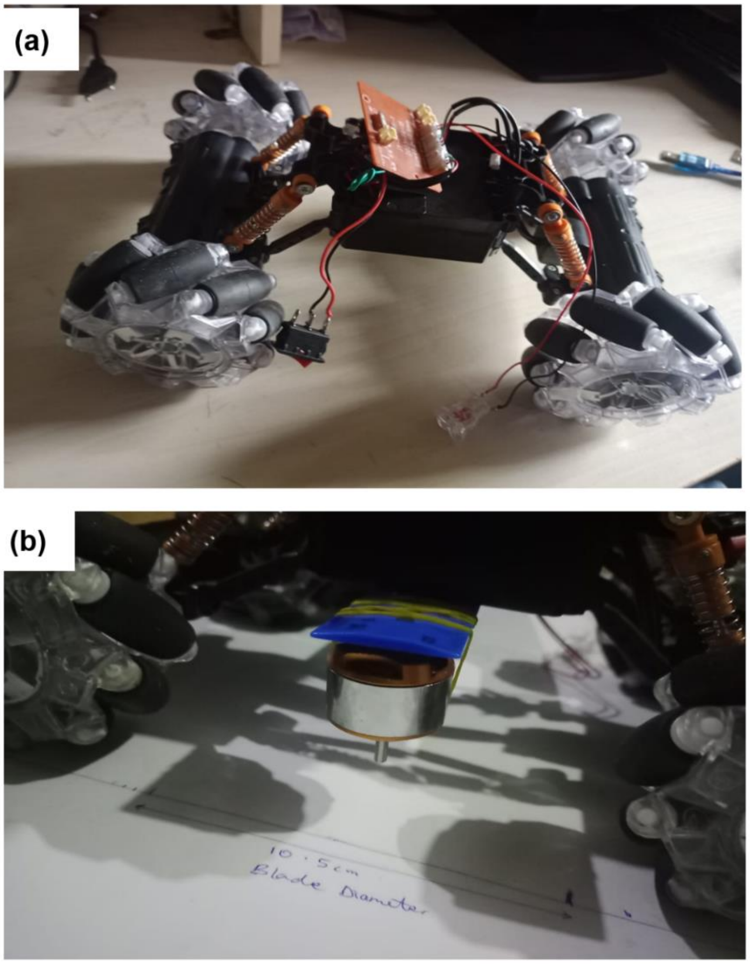

Figure 3: (a) movement segment and (b) cutting segment of development process of the Mower Performance evaluation for autonomous solar lawnmower

The performance evaluation of the autonomous solar lawnmower was conducted on both even and uneven terrain. The testing was conducted on each type of terrain following complete battery charging. The evaluation took into account important factors such movement speed, cutting depth, and the effect of cutting speed on time consumption and battery drain. Through an analysis of how differences in surface smoothness influenced the lawnmower's overall functionality and energy efficiency, the assessment sought to ascertain the lawnmower's efficiency and adaptability under various terrain circumstances.

3. Results and Discussion

3.1. Results obtained from the cutter of the mower

The mower was equipped with two cutters positioned side by side. Both cutters share the same power rating, ensuring balanced performance and the results for the cutting were presented in **Table 2**.

Table 2: Results obtained from the cutter of the mower

Power	Value	Unit
Battery capacity	2.2	Ah
Battery Voltage (Normal)	11.1	V
Battery Voltage (Fully Charge)	12.6	V
Maximum Continuous Discharge Current	77	A
ESC Maximum Current	30	A

Motor Rating	2700	KV
Speed	29970	RPM
Power	333	W
Motor Current Drawing	30	A
Runtime Estimate	28.6	Minute
Torque	0.133	Nm
Total Energy Capacity	24.42	Wh

3.2. Developed autonomous lawnmower

The mower features two strategically placed brushless motors, each driving the cutting blades, ensuring a smooth and efficient operation. The cutting blades were housed in a low-profile, modular structure, enabling the mower to easily navigate and mow under obstacles. The solar panels were seamlessly integrated into the top of the mower, providing a sustainable power source for extended operation. The final look of the developed autonomous lawnmower is shown in **Figure 4**.

3.3. Performance evaluation

Table 3 and 4 present the results obtained from the even and uneven terrain. The performance evaluation of the mower conducted on different grass heights across various site grounds and Figure 5 shows a detailed graph of efficiency evaluation. Time and battery discharge required to cut grass was slightly greater in uneven terrain than even terrain. This can be attributed to more roughness along the path of uneven terrain. Several studies have investigated the effect of terrain type on the performance of autonomous lawnmowers. For example, a study by Akinyemi and Damilare (2020) found that the time taken to cut grass in even terrain was slightly higher than in uneven terrain. This may seem counterintuitive, as one might expect that uneven terrain would require more time to navigate. However, the authors suggest that the lawnmower's navigation system was able to adapt more efficiently to the uneven terrain, resulting in faster cutting times.

In contrast, the same study found that the battery discharge rate was higher in uneven terrain compared to even terrain. This is likely due to the increased energy required to navigate the uneven terrain, which can involve more frequent changes in direction and speed. The authors suggest that this highlights the importance of optimizing the lawnmower's navigation system and energy management strategy for different terrain types. Another study by Daniyan et al. (2020) also investigated the effect of terrain type on the performance of an autonomous lawnmower. The authors found that the lawnmower's energy consumption was significantly higher in uneven terrain compared to even terrain. This was attributed to the increased energy required to operate the lawnmower's motors and navigation system in the uneven terrain. In terms of the time taken to cut grass, the authors found that the lawnmower performed slightly better in uneven terrain compared to even terrain. However, this difference was relatively small, and the authors suggest that other factors such as the lawnmower's navigation system and energy management strategy may have a greater impact on its performance**.** Overall, the literature suggests that the performance of autonomous solar lawnmowers can vary depending on the terrain type. While uneven terrain may require more energy to navigate, it can also result in faster cutting times. In contrast, even terrain may require less energy to navigate, but can result in slightly longer cutting times**.**

Table 4: Results obtained from even terrain

S/N	Area (m²)	Initial Grass Height (cm)	Final Grass Height (cm)	Time (min)	Battery Discharge (%)
1	4	8	3	2	3.5
2	4	6	3	1.30	3
3	4	7	3	1.50	3.2
4	4	5	3	1.20	2.8

Table 4: Results obtained from uneven terrain

S/N	Area (m²)	Initial Grass Height (cm)	Final Grass Height (cm)	Time (min)	Battery Discharge (%)
1	4	6	3.3	2	8
2	4	4	3.2	1.30	5
3	4	5	3.2	1.50	6
4	4	7	3.2	2	4

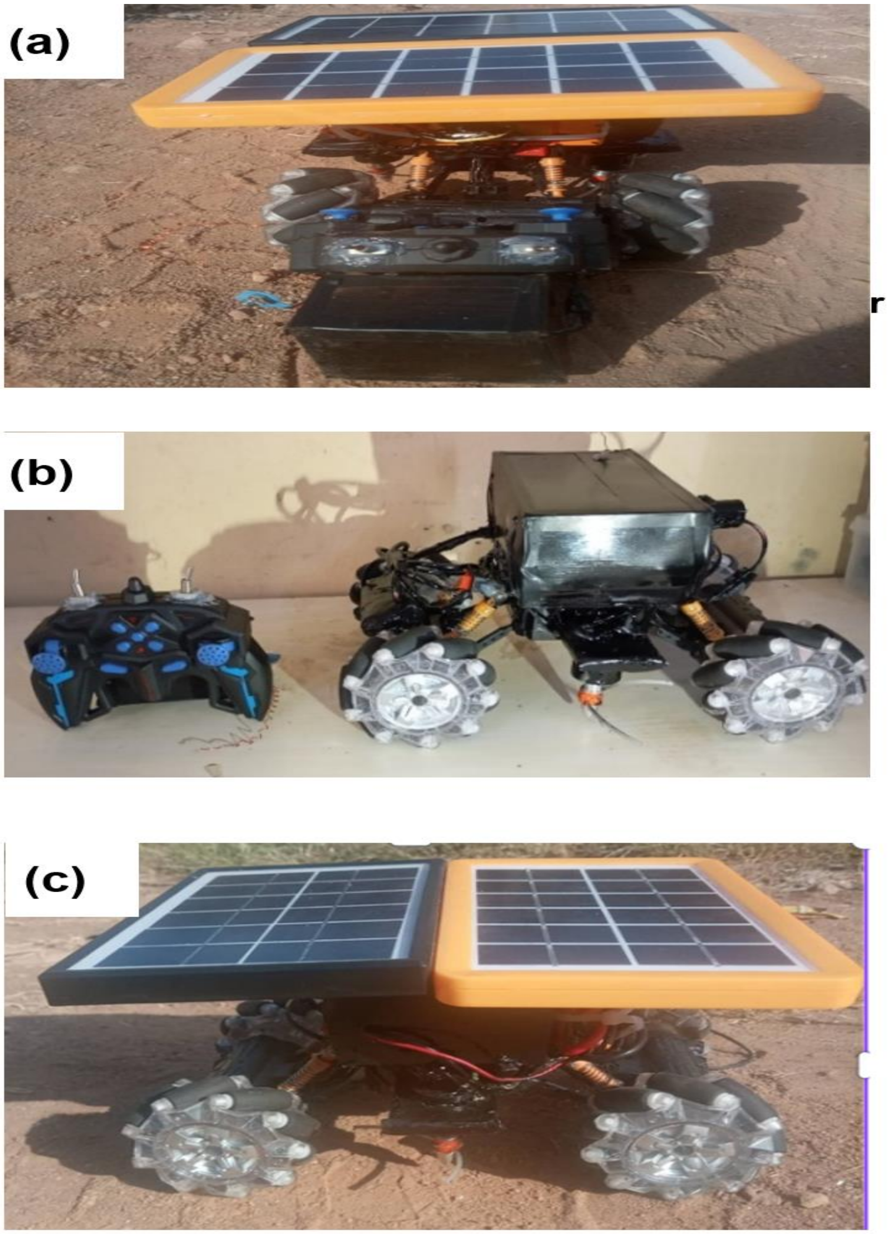

Figure 4: Stages a, b and c during the development of Autonomous Lawnmower

3.3.1. Effect of height of grass on battery depletion

According to our research, taller grass resulted in longer mowing times and higher battery depletion. For example, the mower used up to 8% of the battery in a matter of minutes when mowing thicker grass (about 7 to 8 cm). On the other hand, just 3% to 5% of the battery was consumed when mowing shorter grass (around 4 cm). This trend held true for both equal and uneven terrain testing, suggesting that the mower's energy efficiency is significantly influenced by the height of the grass. Grass height and battery usage are directly correlated; the higher the grass, the more energy the mower must need to cut it to a manageable height. Taller grass also took longer to mow, and the battery usage rose. Battery depletion increased according to the length of time it took the lawnmower to cut through regions with thicker grass (6 cm to 7 cm). For instance, the mower took around two minutes to finish a 4 m² area in places with thicker grass, resulting in an 8% battery consumption. On the other hand, it only took 1.30 minutes to mow areas with shorter grass (about 4 cm), using just 3% to 5% of the battery. These findings imply that when grass height grows, the mower's energy efficiency declines since it takes more time and energy to cover the same area.

Our study's results are consistent with those of Leanza et al. (2023) and Gil et al. (2023) when compared to previous studies. According to Leanza et al. (2023), a solar-powered lawnmower's energy usage climbed with the height of the grass, using an average of 7% more battery every session. They also discovered that in order to cut higher grass, longer mowing durations were needed. The tendency shown in our investigation was further supported by Gil et al. (2023), who emphasized the higher battery depletion rate while mowing taller grass. By offering more precise information about the connection between battery usage and grass height, including the resulting increase in mowing time, our study expands on previous findings.

In conclusion, our analysis confirms earlier studies showing that mowing time and battery depletion increase with grass height. Taller grass can limit the mower's overall performance since it uses more energy, requires more time to mow, and is less efficient. This is a crucial factor in raising the effectiveness of solar-powered robotic lawnmowers, and our findings offer more information on how controlling grass height and refining mowing techniques might reduce battery usage.

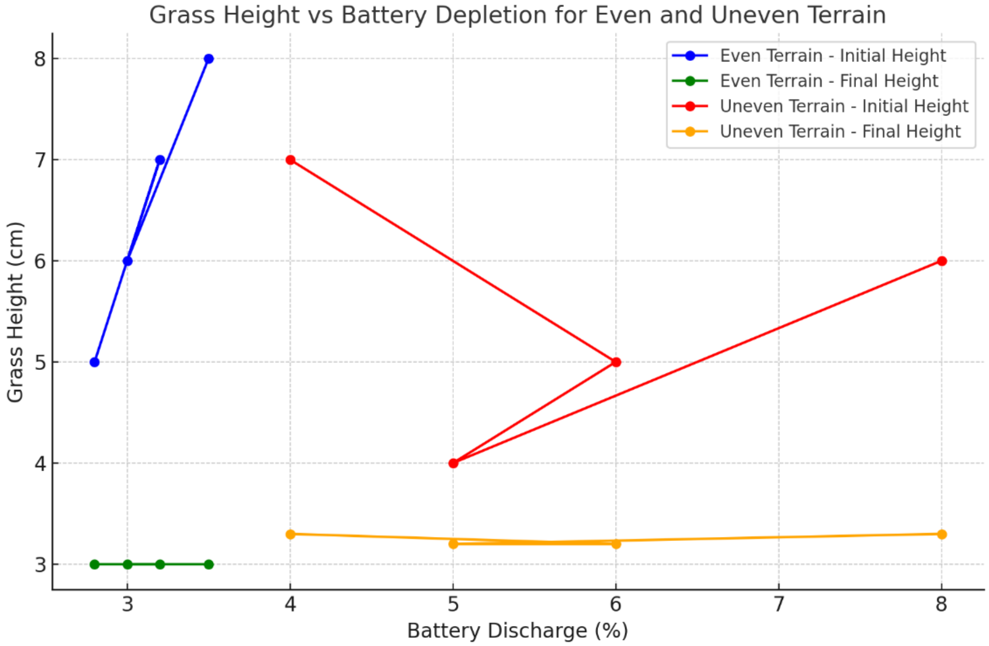

Figure 5: Effect of height of grass on battery depletion

3.3.2. Efficiency analysis of the lawnmower

This research assessed an autonomous solar lawnmower's performance in a range of topographical situations and grass heights. The findings, derived from tests carried out on both level and irregular surfaces, provide important new information on how these variables affect battery life and overall effectiveness. Grass height significantly impacts lawnmower efficiency, with taller grass requiring more energy and causing faster battery depletion. Experiments showed a direct correlation between initial grass height and battery discharge. Even on even terrain, higher grass heights resulted in higher efficiency, while uneven terrain led to higher energy consumption due to rougher terrain. The results of this study are consistent with other investigations on the energy efficiency of lawnmowers, especially those that run on solar power. According to Akinyemi and Damilare (2020), a greater voltage drop was produced when mowing higher, more difficult grass, suggesting that more energy was needed to run the mower. This result is in line with the present study's findings that higher battery drain was caused by taller grass. Additionally, Iqbal and Khan (2017) observed that softer grass, which is simpler to cut, led to a reduced energy consumption (0.17 V), which is consistent with the current study's finding that efficiency is increased by shorter grass.

When Saidani et al. (2021) compared autonomous solar lawnmowers to conventional gasoline-powered rotary mowers, they found that the former used a little less energy—4.80 kWh per week as opposed to 12.60 kWh per week for the latter. This bolsters the claim that significant energy savings may be obtained by solar-powered autonomous mowers that are tuned for frequent mowing and effective terrain management. These results are further supported by the current study, which shows that the mower may use less energy while cutting shorter grass and perform better on level ground. Regular mowing is crucial for autonomous systems to have the best possible energy efficiency, according to Daniyan et al. (2020). They discovered that when autonomous mowers were used on well-kept lawns, they used less energy, which supports the notion that routinely cutting the grass to a reasonable height increases the mower's overall efficiency and prolongs its battery life. By demonstrating how cutting grass shorter led to more effective energy utilization in both flat and uneven terrain, this study bolsters that conclusion

3.3.3. Limitation of the study and future outlook

The development and evaluation of an autonomous solar lawnmower is a complex task ’hat involves overcoming various limitations. One of the primary limitations of autonomous solar lawnmowers is power constraints. Solar panels have limited energy harvesting capabilities, which can restrict the lawnmower’s operating time and range. The energy generated by solar panels is dependent on various factors such as sunlight intensity, panel efficiency, and temperature (Dada & Popoola, 2023). This means that the lawnmower’s performance can be affected by weather conditions, time of day, and season. Another significant limitation of autonomous solar lawnmowers is terrain adaptability. Autonomous lawnmowers can struggle to navigate uneven terrain, such as slopes, obstacles, and rough grass, which can reduce their efficiency and effectiveness. Gil et al. (2023) found that the lawnmower’s navigation system was unable to adapt to complex terrain, resulting in reduced performance and increased energy consumption. Furthermore, the lawnmower’s sensors and perception systems can be affected by environmental factors such as weather, lighting, and vegetation, which can reduce their accuracy and reliability.

In addition to power constraints and terrain adaptability, autonomous solar lawnmowers also face limitations in terms of communication and control. The lawnmower’s communication range can be limited, making it difficult to transmit data and receive commands from remote locations. Iqbal and Khan (2017) found that the lawnmower’s communication system was unable to maintain a stable connection with the remote server, resulting in reduced performance and increased energy consumption. Moreover, the lawnmower’s control systems can be complex and challenging to develop, particularly in terms of managing the lawnmower’s movements, navigation, and energy consumption. Summarily, the development and evaluation of an autonomous solar lawnmower require careful consideration of various limitations, including power constraints, terrain adaptability, communication, and control. Addressing these limitations is crucial for the development of efficient, effective, and reliable autonomous solar lawnmowers.

4. Conclusions

This study provides several innovative answers to the problems that independent solar lawnmowers encounter. Mecanum wheels provide the mower more versatility on a range of surfaces, guaranteeing easy mobility even in difficult situations. The innovative cutter design reduces manual involvement and increases productivity by enabling cutting alongside obstructions. Longer operating hours are guaranteed by optimized battery systems, and the mower's total energy efficiency is improved by low-energy communication technology. This study, by addressing these critical areas—terrain adaptability, obstacle navigation, energy efficiency, and autonomy holds great potential to advance the field of autonomous solar-powered lawnmowers by addressing these issues, the study offers a more practical and effective alternative, increasing the viability of solar-powered lawnmowers for practical uses and laying the groundwork for next advancements in energy-efficient, self-sufficient outdoor equipment.

References

Akinyemi, A. O., & Damilare, A. S. 2020. Design and fabrication of a solar operated lawnmower. International Journal of Innovative Science and Research Technology (IJISRT), 5(10).

Dada, M., & Popoola, P. 2023. Recent advances in solar photovoltaic materials and systems for energy storage applications: a review. Beni-Suef University Journal of Basic and Applied Sciences, 12(1), 1-15.

Daniyan, I., Balogun, V., Adeodu, A., Oladapo, B., Peter, J. K., & Mpofu, K. 2020. Development and performance evaluation of a robot for lawn mowing. Procedia Manufacturing, 49, 42-48.

Gil, G., Casagrande, D. E., Cortés, L. P., & Verschae, R. 2023. Why the low adoption of robotics in the farms? Challenges for the establishment of commercial agricultural robots. Smart Agricultural Technology, 3, 100069.

Gonzalez-Aguirre, J. A., Osorio-Oliveros, R., Rodriguez-Hernandez, K. L., Lizárraga-Iturralde, J., Morales Menendez, R., Ramirez-Mendoza, R. A., Ramirez-Moreno, M. A., & Lozoya-Santos, J. d. J. 2021. Service robots: Trends and technology. Applied Sciences, 11(22), 10702.

Iqbal, J., & Khan, Z. H. 2017. The potential role of renewable energy sources in robot's power system: A case study of Pakistan. Renewable and Sustainable Energy Reviews, 75, 106-122.

Ivić, S., Crnković, B., Grbčić, L., & Matleković, L. 2023. Multi-UAV trajectory planning for 3D visual inspection of complex structures. Automation in Construction, 147, 104709.

Karatayev, M., Gaduš, J., & Lisiakiewicz, R. 2023. Creating pathways toward secure and climate neutral energy system through EnergyPLAN scenario model: The case of Slovak Republic. Energy Reports, 10, 2525-2536.

Leanza, A., Galati, R., Ugenti, A., Cavallo, E., & Reina, G. 2023. Where am I heading? A robust approach for orientation estimation of autonomous agricultural robots. Computers and Electronics in Agriculture, 210, 107888.

Odetola, A. O., Oyewo, A. T., & Adegbola, J. O. 2025. Electrochemical Studies of Hybrid Botanical Extracts on Mild Steel Corrosion in Hydrochloric Acid Medium. UNIZIK Journal of Engineering and Applied Sciences, 4(1), 1497-1503.

Onuabuchi, E., Ekeopara, J., Sule, R., Ayanbisi, O., Akinwumi, S., Olawole, O., & Ogunwale, E. (2024). Development and Evaluation of Efficient Smart Solar Lawn Mower. IOP Conference Series: Earth and Environmental Science,

Oyewo, A. T. 2024. Predictive Model for Estimating the Tensile Strength of Biodegradable Banana Pseudostem Fiber Composite Through the Utilization of Taguchi Optimization Technique. Materials Circular Economy, 6(1), 55. https://doi.org/10.1007/s42824-024-00145-6

Oyewo, A. T., Oluwole, O. O., Ajide, O. O., Omoniyi, T. E., & Hussain, M. 2024. A summary of current advancements in hybrid composites based on aluminium matrix in aerospace applications. Hybrid Advances, 5, 100117. https://doi.org/https://doi.org/10.1016/j.hybadv.2023.100117

Ritwik, P., & Patel, N. 2023. Autonomous Lawn Mower–A Comprehensive Review. International Research Journal on Advanced Science Hub, 5(12), 420-428.

Saidani, M., Pan, Z., Kim, H., Wattonville, J., Greenlee, A., Shannon, T., Yannou, B., Leroy, Y., & Cluzel, F. 2021. Comparative life cycle assessment and costing of an autonomous lawn mowing system with human-operated alternatives: Implication for sustainable design improvements. International Journal of Sustainable Engineering, 14(4), 704-724.

Telli, K., Kraa, O., Himeur, Y., Ouamane, A., Boumehraz, M., Atalla, S., & Mansoor, W. 2023. A comprehensive review of recent research trends on unmanned aerial vehicles (uavs). Systems, 11(8), 400.

Telli, K., Kraa, O., Himeur, Y., Ouamane, A., Boumehraz, M., Atalla, S., & Mansoor, W. 2023. A Comprehensive Review of Recent Research Trends on Unmanned Aerial Vehicles (UAVs). Systems 2023, 11, 400. In.

Thangavel, B., Chitra, V., Immanuel, S., Raja, E., & Chua, W. C. 2024. Design and Development of Automated Solar Grass Trimmer with Charge Control Circuit. International Journal on Robotics, Automation and Sciences, 6(1), 36-45.

Theisen, A., Kiesling, L., & Munger, M. 2022. From Airbnb to solar: electricity market platforms as local sharing economies. Public Choice, 193(3), 141-162.