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Smart Solar Grass Cutter

Davik Edi Tan[1], Fatihah Zulaikha Ahmad Fauzi[1], Mahmod Abd Hakim Mohamad[1,2]*, Nurfarahin Onn[1]

[1] *Department of Mechanical Engineering, Centre for Diploma Studies, University Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600, Pagoh, Johor, MALAYSIA*

[2] *Sustainable Product Development (S-ProuD), Centre for Diploma Studies, University Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600, Pagoh, Johor, MALAYSIA*

*Corresponding Author: hakim@uthm.edu.my
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Abstract

The Smart Solar Grass Cutter project exemplifies a pioneering initiative at the intersection of sustainable technology and lawn maintenance, offering a transformative solution for urban and suburban landscapes. There a several issues with the current lawnmowers that users using right now. Grass-cutting technology in the past was manually operated using hand tools such as scissors, which required more human effort and time to complete the operation. Furthermore, in the traditional process, there is also a need for more consistency in the grass. Equipped with a variety of sensors, including infrared and ultrasonic, the mower ensures safe and efficient obstacle detection and avoidance. The algorithms optimize cutting patterns by considering dynamic variables such as grass growth rates $\frac{1}{8}$ to $\frac{1}{4}$ inch per day and specific lawn characteristics, thereby maintaining a well-groomed lawn while maximizing 15%-23% energy efficiency. By utilizing solar energy, the project significantly reduces carbon emissions, dependence on fossil fuels, and noise pollution associated with traditional gas-powered mowers, aligning with global trends toward eco-conscious practices. Additionally, a specialized mobile application enhances user convenience by enabling remote monitoring and control of the mower, including scheduling cutting sessions and receiving real-time updates. Overall, the Smart Solar Grass Cutter project represents a significant advancement in sustainable lawn maintenance, combining solar energy and user-friendly technology to offer a cost-effective and environmentally friendly alternative to traditional grass-cutting methods, thus positioning itself as a leader in the green revolution of urban landscape care.

1. Introduction

Grass-cutting machines, ranging from conventional lawnmowers to advanced robotic systems, have revolutionized landscaping and lawn care, making grass cutting more convenient and efficient. Covering up to 40% of the Earth's land surface, grass is a ubiquitous plant and maintaining it has been transformed by these devices [1]. This project introduces a grass cutter powered by a solar panel driving the motor that operates the blade, highlighting the use of renewable solar energy to aid household and agricultural tasks while reducing carbon footprints [2]. Emphasizing consistency in grass cutting, the smart solar grass cutter offers a sustainable

and efficient solution, promoting the transition to renewable energy sources and enhancing the reliability of lawn care.

Current lawnmowers have several issues, including high human effort and time, inconsistency in grass cutting, and significant environmental impact due to air and noise pollution from internal combustion engines. Traditional gasoline-powered mowers are not only noisy but also contribute to air pollution, necessitating alternatives that use renewable energy [3]. Additionally, maintenance costs for traditional mowers are high, with a tune-up costing between RM46 and RM1168 depending on the type and service method. To address these issues, this project aims to design a Smart Solar Grass Cutter with a microcontroller and obstacle sensor, providing an autonomous and eco-friendly solution that enhances efficiency and reduces labor [4]. The design includes essential components like the cutting mechanism, chassis, and solar panels for energy collection and storage [5].

A device called a solar grass cutter employs sliding blades to cut grass at a consistent length. Every area has access to ever more advanced technology. Power consumption becomes crucial going forward. The solar grass cutter is a very practical tool with an extremely straightforward design. It is employed to preserve gardens' lawns in good condition [6]. The rapid growth of various high-tech tools and equipment makes the jobs comfortable and sophisticated. The project aims to fabricate a grass-cutting machine system that makes the grasscutter-based motor run through solar energy. Power plays a great role wherever man lives and works. The cutting mechanism is made of a flat blade rigidly fixed to the frame behind the spiral arrangement which is configured to contact at least one reel bar of the spiral blades during the rotation of the spiral mechanism. The cutting effectiveness was achieved with a total power of 2500 watts at a rotary speed of 4000 rpm of shaft. This lawn mower employs a solar-powered energy source, which is more beneficial and simpler to operate than other energy sources especially when compared to gas-powered sources. However, the lawnmower is not powered by solar power due to its high cost and potential for operating complexity.

The Makita cordless lawnmower in is a robust tool, reflecting Makita's expertise in producing high-quality equipment. Its adjustable cutting height and solid construction make it suitable for medium to large lawns. However, its large size and limited battery life may pose challenges for households with smaller yards or extensive lawn areas. For such scenarios, it is advisable to consider lawnmowers with higher voltage batteries or more compact designs [7]. The next lawn machine is a push lawn mower created by the EGO company. The company started in China and is known for high-quality machines worldwide. Push mowers and cordless lawn mowers are built almost the same. However, push mowers need more effort to cut grass. This push mower weighs between twenty-three pounds [8]. The advanced 4-wheeled Husqvarna robotic lawn mower, suitable for medium-sized areas up to 1500 m^2 and slopes with a 40% incline, features smart technology for adaptive mowing, spot mowing, and navigation through narrow passages, with an intuitive menu and optional snap-covers in various colors [9]. The John Deere X126 Riding Lawnmower powered by a 10.65 KW petrol engine, features a durable welded steel frame, cast-iron front axle, ergonomic operator station, quality headlights, infinite ground speeds, weighs 210 kg, and offers a 1070 mm cutting width, making it easy to own, operate, and maintainClick or tap here to enter text.. The compact which is 1200W Hover Mower model BEMWH551-QS, with a 30 cm deck, glides on air for easy, multidirectional mowing, features adjustable cutting heights of 20, 30, and 40 mm, includes a 10 m cable and 10 replacement blades, and has a folding handle for space-saving storage.

The Smart Solar Grass Cutter aims to achieve several key objectives: firstly, to design a solar-powered grass cutter equipped with a microcontroller and obstacle sensor, thereby saving electricity and reducing labor in lawn maintenance; and secondly, to develop a machine that offers high system efficiency compared to traditional grass cutting models. The project scope must be precisely specified before implementation to ensure alignment with its original objectives and proper functionality. This project adheres to its objectives by focusing on the use of renewable solar energy to ease household tasks and agricultural work. The product's compact size of 32 cm x 32 cm x 32 cm facilitates easy storage. The solar grass cutter can trim grass to a height of 3 inches and is suitable for outdoor use due to its monocrystalline solar panels, which have a 15% to 23% efficiency and a lower temperature coefficient. Additionally, this machine is designed to support the typical parameters of a house garden.

2. Methodology

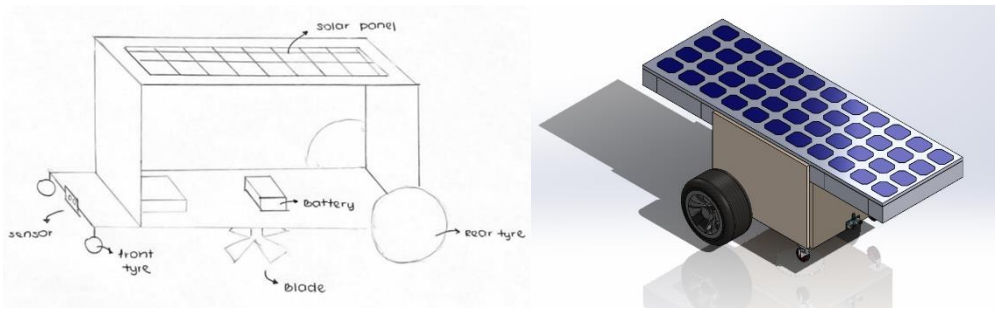
The research focuses on design improvements and software simulation for fast fault detection and correction. SolidWorks 2023 facilitates the meticulous planning and creation of forms and sizes for design projects, enabling modifications to existing parts and designs to suit certain requirements. The sensor's form makes it possible to calculate the peak driving duration with accuracy. Using Google Forms to collect insightful feedback and insights from emergency vehicle drivers can assist identify areas for development and address driver challenges. The project framework, influencing factors, conceptual design, project costs, materials, and sensor types used for best performance will all be covered.

2.1 Design Identification

This smart solar grass cutter machine has a very simple design that optimizes the use of materials in the machine. This machine uses three motors: two motors are used for the tires, and one motor is used to move the blade. The rubber rotating wheel is used as a rear tyre to control whether the machine moves or not if there is an obstacle in front of it. Design is very cost-effective when building a new product. It will start with a hand sketch and a fully designed prototype using SolidWorks software. The dimensions of a product are very important to maintain the safety factor of the machine. This can be explained in more detail in Table 1.

Photovoltaic (PV) panels offer the primary electricity for the Arduino microcontroller-powered Smart Solar Grass Cutter prototype. PV panels generate power from solar radiation, which is subsequently stored in batteries with the help of a solar charge controller. This controller aids in maintaining battery performance in addition to preventing overcharging. When the lawnmower is operating independently, the ultrasonic sensor finds obstructions in its path. The sensor detects obstacles and relays that information to the microprocessor, which then modifies the cutter's direction to avoid the obstruction. When required, the microcontroller is configured to make sure that the two back wheel motors run at the same speed.

Fig.1 depicts a solar-powered machine, likely designed for tasks such as mowing or automated movement. The first image shows a 3D model with a solar panel on top to capture sunlight and generate power, a main body that likely houses the battery and motor, a large rear wheel for driving, and smaller front caster wheels for easy turning. The second image is a hand-drawn sketch labeling the key components, including the solar panel, battery, blade (possibly for cutting), wheels for mobility, and a sensor for detecting obstacles. This machine seems to be a simple, eco-friendly device powered by sunlight, potentially for automated tasks like lawn mowing.



(a) **(b)**

Fig. 1 *Drawings of Smart Solar Grass Cutter (a) Sketch (b) 3D Design using SolidWorks*

This Fig.2 below shows a solar-powered system controlled by an Arduino Uno. A solar panel charges a 12V battery, which powers the Arduino and connected components. An ultrasonic sensor provides input to the Arduino, which controls two motors and a motor blade through motor drivers.

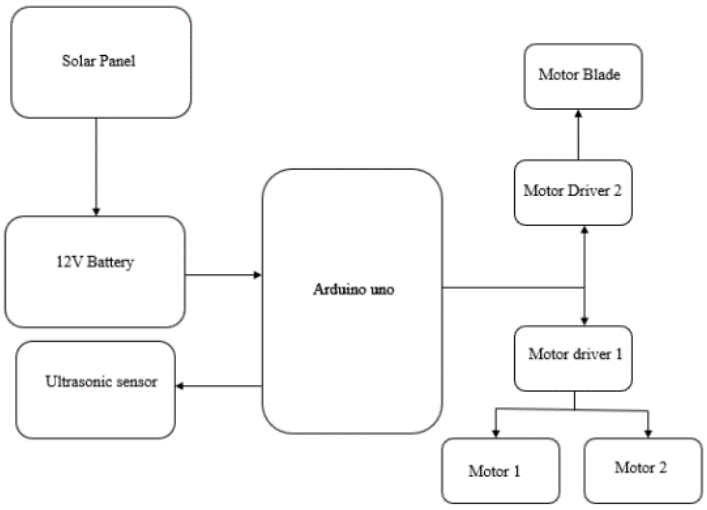


Fig. 2 *Block diagram of Smart Solar Grass Cutter*

2.2 Characteristic of Smart Solar Grass Cutter

The table describes the main characteristics of the Smart Solar Grass Cutter. It is a solar-powered, self-operating device designed to detect obstacles during use. Its compact size makes it easy to store, and while the initial cost is high, it requires low maintenance, making it economical over time. The device is made from durable plywood, which is environmentally friendly due to its long lifespan and low carbon footprint.

The Smart Solar Grass Cutter is a fully self-operated device powered by solar energy derived from sunlight. It is designed with the ability to detect obstacles during operation, ensuring efficient and safe use. Compact in size, it is easy to store and does not occupy much space. While the initial cost may be high, the maintenance expenses are minimal, making it economical in the long run. Constructed with plywood, the grass cutter is both durable and long-lasting, reducing the need for frequent replacements. Additionally, plywood contributes to a lower carbon footprint compared to other building materials, enhancing its environmental sustainability.

2.3 Calculation of Smart Solar Grass Cutter

The Smart Solar Grass Cutter calculation is designed to enable analysis to understand how each component of the system interacts with the others. First, the model needs to be designed. Therefore, the design calculations are directed and applied to the machine to complete the fabrication.

(1)

$$W = mg$$
$$W = (0.4)(9.81)$$
$$W = 3.92N$$

(2)

$$P = T\omega = (Fd)\left(\frac{2\pi N}{60}\right)$$
$$T = Fd$$
$$T = (3.92)(0.11)$$
$$T = 0.43Nm$$
$$P = (Fd)\left(\frac{2\pi N}{60}\right)$$
$$P = (0.43)\left(2\pi\left(\frac{4000}{60}\right)\right)$$
$$P = (0.43)(418.88)$$
$$P = 180.13W$$

(3)

$$P = IV$$

The dimensions of the blade are very important because the calculation of weight requires volume, as in Eq. 1 [10]. Based on Eq. 1 [10], it requires a mass value and a gravity value. The mass value of the blade is 0.4 kg, while the gravity value is 9.81m/s^2. Calculating the weight of the blade is important to determine its power. The power of the blade is obtained by multiplying the torque and the angular velocity, with the weight of the blade being important to calculate the torque. These calculations are important for evaluating power consumption and selecting the appropriate motor. The power of the motor must be higher than the power of the blade to ensure that the motor can rotate the blade effectively during use. To calculate the torque, it must use the formula T = Fd as in Eq.2 [11]. The diameter of this blade is 0.11 m. Meanwhile, the speed used to move the blade is 4000 rpm.

According to Eq. 1 and 2, the calculated blade weight is 3.92 N and the blade power is 180.13 W. This value is used to determine the total power consumption. Eq. 3 [12] is used to calculate the power consumption of both the rear motor and the power supplied by the solar panel, as well as the 6V and 12V batteries. The value for current to move one rear tyre is 1.5 A, while the voltage value is 6 V. The rear tyre used on the machine has 2, so it needs to be multiplied to get the total for both rear tires. The blade uses a single motor only, and the current value is 2 A

and the voltage is 12 V. The total power value needs to be calculated to know how much power will be used to move all the motors when the machine is turned on.

Table 1 *Calculation for total power consumption*

Components	Current (A)	Voltage (V)	Power (W)
Single Motor Rear Tyre	1.5	6	9
Dual Motor Rear Tyre	9	2	18
Single Motor Blade	2	12	24
		Total Power (W)	42

The table shows the power consumption of three components: a single motor for the rear tire, a dual motor for the rear tire, and a single motor blade. The single motor rear tire operates at 6 V and 1.5 A, consuming 9 W of power. The dual motor rear tire runs at 9 V and 2 A, consuming 18 W of power. The single motor blade operates at 12 V and 2 A, consuming 24 W of power. The total power consumption of the system is calculated as 42 W.

The single rear wheel motor is rated at 6V with a current of 1.5A. Using Eq.3, the power consumption of one motor is calculated to be 9 W. Consequently, the total power consumption for both rear wheels is 18 W. Thus, the overall power consumption of the entire system is 42 W. However, the most crucial aspect of any project's design and development is system efficiency. Efficiency is essential to demonstrate the reliability of the system. In summary, it is important to highlight the improvements of the new prototype compared to previous studies. Calculating efficiency requires determining both the power used and the power supplied by the system.

2.4 Circuit Connection

To operate, the Smart Solar Grass Cutter requires a circuit connection. Fritzing is a software used for designing connections. Wire connections must be made using software to prevent damage to electrical equipment. After that, it must be simulated to prevent circuit failure.

Fig. 3 shows the circuit where the power supply, consisting of solar panels and batteries, ensures continuous power for the system. Solar panels and batteries that power the Arduino, motor drivers, and other components. The Arduino Uno is a central microcontroller that is connected to an ultrasonic sensor via a dedicated pin to measure distance. This data helps in navigation or avoiding obstacles. The Arduino also sends control signals to the L298N motor driver, which, powered by the battery, drives the connected DC motor. These motors, managed by signals from Arduino through motor drivers, perform tasks such as moving robots or rotating parts in a system.

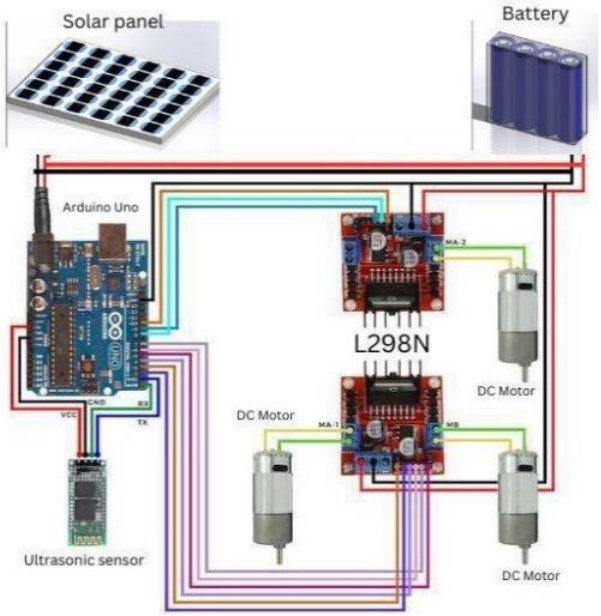


Fig. 3 *Overall cicuit connection*

Circuit functionality includes power management, sensor operation, control logic, and motor control. A solar panel and battery that power the Arduino, motor driver, and motor ensure continuous operation. The ultrasonic sensor measures the distance to nearby objects and sends this data to the Arduino for processing. The Arduino, based on the received sensor data and its programmed logic, sends the appropriate control signal to the L298N

motor driver. The motor driver then controls the speed and direction of the DC motor according to these instructions. This integrated system, powered by a combination of solar energy and batteries, is ideal for applications such as mobile robots that require precise distance measurement and motor control.

The source code implemented in the Arduino serves to give instructions to the motor on the machine for how much speed is required for the motor. All these things are written in the source code to ensure that the motor of the Smart Solar Grass Cutter machine can move according to the suitability of the machine.

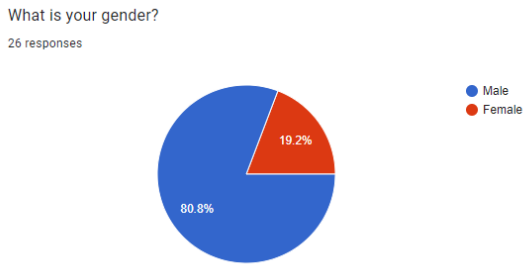
3. Results and Discussion

It discusses the results and findings from implementing the Smart Solar Grass Cutter project, based on the previously discussed methodology. The project includes manufacturing the machine through steps such as measuring, cutting, grinding, and welding and collecting data through a Google Form survey to understand the needs of households and improve the relevance of the machine for future use. Additionally, this section covers engineering analysis of power and load values to ensure optimal performance and machine reliability. The results of the test phase are important to verify the functionality of the machine, in line with the goals and scope of the project.

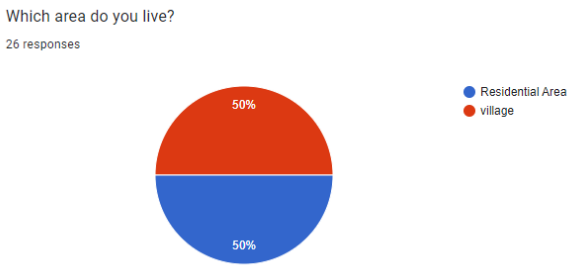
3.1 Data Collection

Fig.4 illustrates the findings from a survey on public perception and acceptance of smart solar grass cutters. Most respondents were male (88.9%), while females made up 11.1% of the participants. The residential background of the respondents was evenly divided, with 50% living in residential areas and 50% living in villages. Regarding current lawn maintenance practices, 34.6% of respondents used a manual push mower, another 34.6% used a gas-powered mower, while 15.4% relied on electric mowers and another 15.4% used robotic or autonomous mowers. In terms of familiarity with smart solar grass cutters, more than half (51.9%) were not familiar at all, while 24.8% indicated they were somewhat familiar.

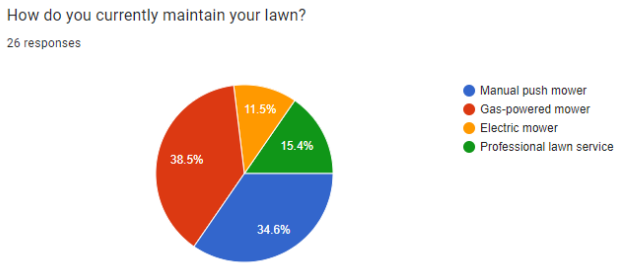
Eco-friendliness was an important consideration for many respondents, with 61.5% rating it as extremely important and 25.6% considering it moderately important. When asked about essential features for smart solar grass cutters, respondents prioritized autonomous operation (92.3%), safety features (80.8%), solar charging capability (76.9%), and battery longevity (73.1%), with durability and warranty also being significant considerations (65.4%). Concerning the amount, they were willing to spend, half of the participants (50%) preferred a budget range of RM500–RM1000, while 42.3% favored spending less than RM500. Finally, major concerns about switching to smart solar grass cutters included the high initial cost (61.5%), limited functionality during cloudy days (53.8%), and potential maintenance difficulties (38.5%), alongside worries about reliability and durability (23.1%). Overall, the survey results show a positive interest in smart solar grass cutters, especially if the products can address cost, reliability, and eco-friendliness issues.



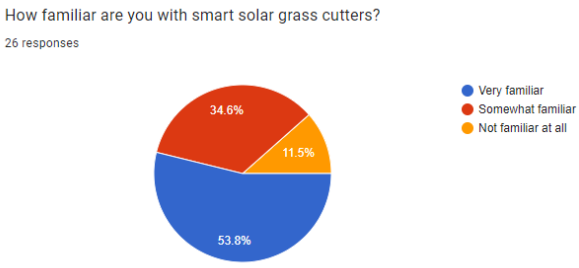
(a)



(b)



(c)



(d)

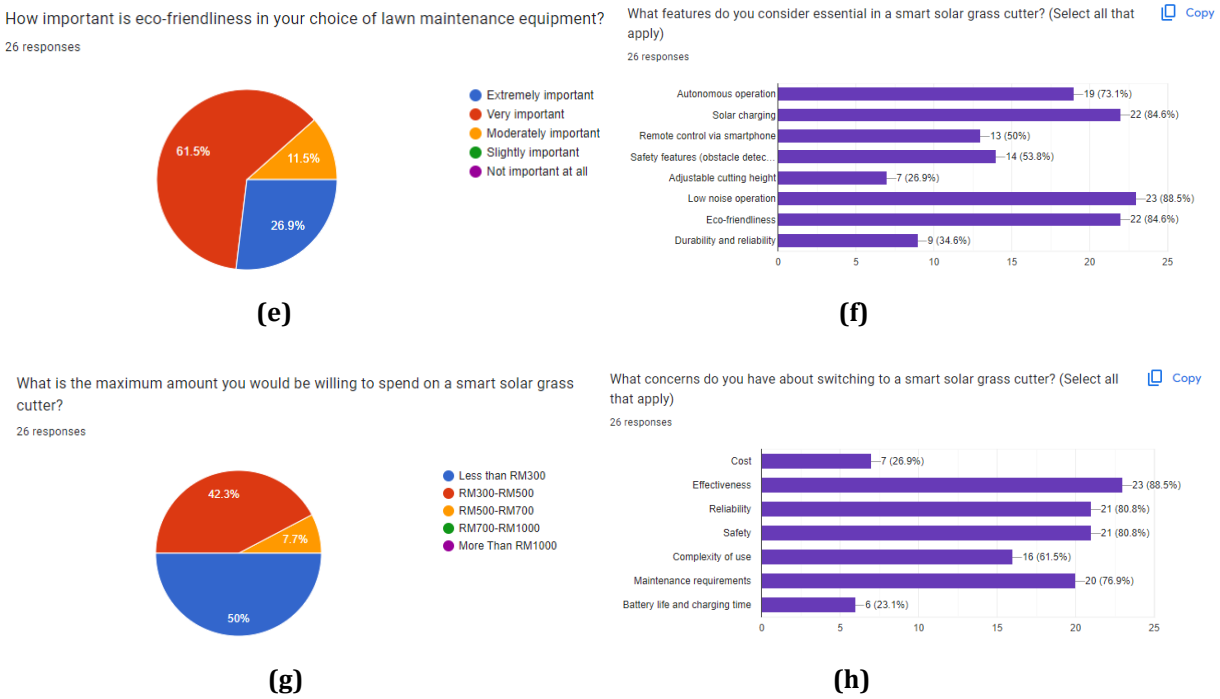


Fig. 4 *Result based on google form (a) Gender (b) Place (c) Mower type (d) Familiarness of smart solar grass cutter (e) Awareness of lawn maintenance equipment (f) Features in smart solar grass cutter (g) Maximum amount to spend on smart solar grass cutter (h) Concern regarding switching to smart solar grass cutter*

3.2 Final Product of Smart Solar Grass Cutter

The innovative development of Smart Solar Grass Cutter using solar-powered systems marks a significant advancement in addressing the specific needs of homes and establishments with grass areas unsuitable for traditional tractor mowers. This cutting-edge machine is distinguished by its impressive capabilities, positioning itself as a viable and efficient alternative to the conventional gasoline mowers commonly found on the market. The intentional use of renewable energy sources tailored to the machine's power requirements highlights a strategic commitment to sustainability, providing users with a cost-effective and eco-friendly solution. Under the project titled "Smart Solar Grass Cutter" as shown in Fig.5, this forward-thinking approach aims to address current needs while also offering ease of use and potential for future modifications.

The economic benefits of Smart Solar Grass Cutter make them particularly suitable for the average consumer, aligning with modern sustainability goals. By eliminating fuel costs and significantly reducing the pollution associated with traditional lawn mowers, this machine emerges as an environmentally friendly alternative. Notably, the machine can operate in two modes—using either solar energy or batteries. This innovative feature enhances its usability, enabling extended operation even at night, thus catering to a wide range of users.

(a) (b)

Fig. 5 *Final product of Smart Solar Grass Cutter (a) Side view (b) Front view*

The Smart Solar Grass Cutter minimal operating expenses present this device as a useful and environmentally friendly lawn care option by combining a solar-powered system with a long-lasting, robust build. In keeping with the global trend towards more ecologically friendly behaviours, consumers can profit from both decreased environmental effects and economic benefits. In essence, Smart Solar Grass Cutter are a harmonious fusion of functionality and innovation. This machine is a living example of how cutting-edge technology and environmental responsibility can exist together as it continues to navigate the landscape of sustainable solutions. With its environmentally friendly operation, cost-effective design features, and forward-thinking approach, the Smart Solar Grass Cutter is poised to revolutionise lawn care by offering users dependable, effective, and eco-friendly equipment.

3.3 Testing Results for Smart Solar Grass Cutter Machine

The Smart Solar Grass Cutter represents a significant advance in automated lawn maintenance technology, integrating solar power to improve sustainability and efficiency. This innovative device combines a smart navigation and cutting system with an environmentally friendly energy source, promising a cost-effective and environmentally friendly solution for lawn care. The test will demonstrate the potential for widespread adoption in both residential and commercial settings, offering a glimpse into the future of smart green landscaping solutions.

Table 2 *Tests of grass cutting*

Average Grass Height (cm)	Observation		
	Test 1	Test 2	Test 3
0.5	✗	✗	✗
1.0	✓	✓	✓
1.5	✓	✓	✓
2.0	✓	✓	✓
2.5	✓	✓	✓
3.0	✓	✓	✓
3.5	✓	✓	✓
4.0	✓	✓	✓
4.5	✓	✓	✓
5.0	✗	✗	✓
5.5	✓	✗	✓
6.0	✗	✗	✗
7.5	✗	✗	✗
8.0	✓	✗	✗
8.5	✗	✗	✗
9.0	✗	✗	✗
9.5	✗	✗	✗
10.0	✗	✗	✗

*✓ Machine cut the grass ✗ Machine did not cut the grass

Table 2 provides a detailed comparison of the machine's performance based on grass height measurements, showcasing the outcomes when the machine successfully cut the grass and when it did not cut the grass various observation levels from 0.5 cm to 10.0 cm. The machine has trouble cutting grass that is 5 cm or taller on average. When it comes to grass cutting, the machine's performance is greatly affected by variations in grass width and thickness, which causes the results from all the data to become inconsistent. The machine's inefficiency is further compounded by its height, blade position, and ultrasonic sensor. Because of its low height, the machine frequently breaks down when it encounters dense grass because it can't get enough ground through the dense patches. The issue is made worse by the blade's elevated position, which makes it difficult for the machine to properly cut the grass at its base and leaves uneven and partial cuts. Additionally, insufficient adjustments are made because of the ultrasonic sensor's inability to precisely detect the height and density of the grass, which lowers cutting efficiency overall. When dealing with grass that is thicker or exceeds 5 cm in height, the machine's performance becomes unreliable and inconsistent due to the combined effect of these sensor limitations.

4.0 Conclusion

The primary energy source for wearable Smart Solar Grass Cutter has been successfully constructed with good work efficiency, therefore prototypes are concentrated on renewable energy. Thus, it can be said that the primary goal of the suggested Smart Solar Grass Cutter design has been met, and industry development can continue. The Smart Solar Grass Cutter is an easy-to-use gadget that can also help cut down on air pollution. Because they require less time to operate, grass cutters are appropriate for modest applications; however, they are not appropriate for high-altitude grass. A few ideas for future research to create better gadgets are listed below. The machine's tyres should be spring-loaded to improve mobility and enable the machine to go even on uneven surfaces. Furthermore, it might be able to install a battery that can be charged solely with solar energy, eliminating the need to replace the battery when it runs out of power.

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Conflict of Interest

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

Author Contribution

The authors have contributed to this past of the paper as follows: **study conception and design:** *Davik Edi Tan;* **data collection:** *Fatihah Zulaikha;* **analysis and interpretation of results:** *Davik Edi Tan and Fatihah Zulaikha;* **draft manuscript preparation:** *Mahmod Abd Hakim Mohamad, Nurfarahin Onn and Fatihah Zulaikha. All authors reviewed the results and approved the final version of the manuscript.*

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