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FABRICATION OF GUARDIAN LAWN INTEGRATED AI-POWERED SMART LAWN MOWING AND HOME SECURITY

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KEYWORDS

Fabrication, home security, autonomous lawn care, AI navigation, adjustable cutting systems, vacuum collection, Intel RealSense LiDAR, real-time monitoring

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ABSTRACT

The GUARDIAN LAWN project introduces a multifunctional robot for autonomous lawn care and enhanced home security. This initiative emphasizes the creation of a robust chassis that can navigate various terrains, a sophisticated suspension system, and a customizable grass-cutting mechanism. A notable feature of this robot is its vacuum system, which efficiently collects cut grass into a sump tank, keeping the lawn tidy and well-maintained. The construction process involves several tasks such as welding, cutting, and assembling components to build a durable structure capable of withstanding different environmental conditions. The robot has advanced electronics, including an Intel RealSense LiDAR for boundary detection. It is controlled by an Arduino Mega, enabling it to navigate and mow autonomously within set boundaries. Additionally, the GUARDIAN LAWN robot features a night-time security mode, using an onboard camera to monitor its surroundings and send alerts in case of unauthorized access. With the ability to operate in manual, semimanual, and automatic modes, the robot can seamlessly transition between lawn maintenance and security tasks, offering a versatile solution that combines advanced fabrication with smart automation technologies

INTRODUCTION

The Guardian Lawn project brings together automated lawn care and enhanced home security features. By using artificial intelligence, it provides efficient lawn maintenance while also offering real-time surveillance to improve safety. The objective is to create a fully autonomous machine that cuts grass effectively and includes motion detection and video monitoring to secure the residence. This groundbreaking solution harmonizes landscaping and security for homeowners. This initiative showcases a modern integration of automated lawn mowing technology with advanced security features. It utilizes artificial intelligence to ensure lawn maintenance is efficient and adaptable to different grass types and environmental conditions. Beyond its main function of mowing, the project prioritizes residential safety. The built-in surveillance system provides real-time monitoring and motion detection, allowing homeowners to oversee their property while keeping their lawns well-maintained. Ultimately, the goal is to develop a fully autonomous machine that ensures a pristine lawn while acting as a reliable security companion for the home. By merging these two critical aspects of property management—landscaping and security—Guardian Lawn seeks to provide homeowners with a practical, efficient, and unified solution for outdoor care and protection.

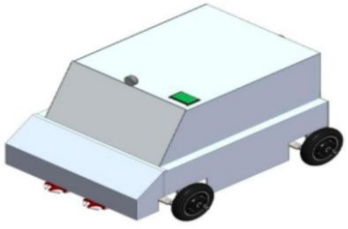

Figure 1: Cad Model of Guardian Lawn

DESIGN

THE MECHANICAL DESIGN OF THE GUARDIAN LAWN SYSTEM WAS CRAFTED USING SOLIDWORKS, ALLOWING FOR THE DEVELOPMENT OF INTRICATE 3D MODELS AND SIMULATIONS OF ITS VARIOUS COMPONENTS. THE ASSEMBLY CONSISTS OF SEVERAL KEY PARTS:

CHASSIS: THE CHASSIS IS DESIGNED TO SERVE AS THE SYSTEM'S FOUNDATION, PRIORITIZING DURABILITY AND STABILITY. IT ACCOMMODATES A RANGE OF

COMPONENTS, INCLUDING MOTORS AND SENSORS, TO FACILITATE SMOOTH MOVEMENT OVER VARIOUS TYPES OF TERRAIN.LITERATURE SURVEY

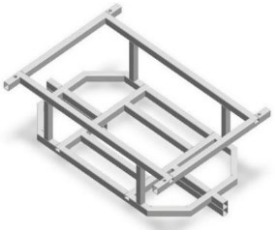

Fig 2.1 Chassis Design

Suspension System: The chassis is designed to serve as the system's foundation, prioritizing durability and stability. It accommodates a range of components, including motors and sensors, to facilitate smooth movement over various types of terrain.

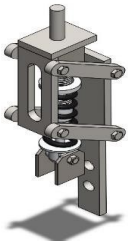

Fig 2.2: Suspension System and Shock Absorber

Grass Cutter Blades: The blades come with adjustable height settings to suit different lengths of grass. Additionally, a vacuum system is integrated to gather the cut grass into a storage container, reducing the need for cleanup after use.

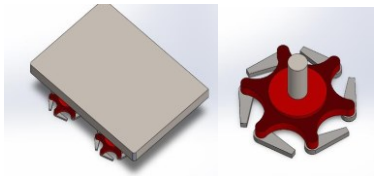

Fig 2.3. Grass Cutter Blades

Wheels And Motors: The wheels, combined with a BLDC motor assembly, enable smooth movement while powering both the cutting and vacuuming functions. These components are firmly attached to the chassis, ensuring efficient operation.

Fig 2.4: Wheels Attached with Hub Motors

ANALYSIS

The Guardian Lawn system's design was carefully examined using SolidWorks and Ansys to assess its structural integrity, performance, and efficiency in real-world scenarios.

Chassis Analysis

The chassis design underwent stress analysis to confirm its ability to endure mechanical forces during operation. Finite Element Analysis (FEA) in SolidWorks helped pinpoint high-stress areas, allowing for optimization of material choices and thicknesses to enhance durability.

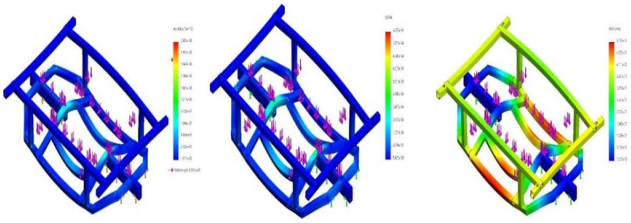

Fig 3.1 Chassis Analysis

Suspension Analysis

An analysis using Ansys was conducted on the suspension system to verify its capability to absorb shocks andnavigate uneven terrains without compromising the stability orintegrity of the chassis.

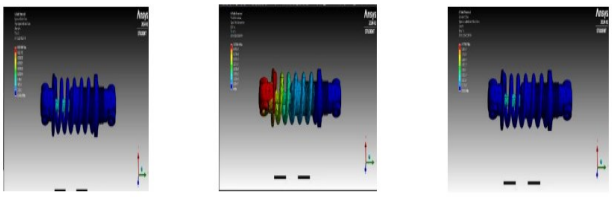

Fig 3.2 Shock Absorber Analysis

FABRICATION

The creation of the Guardian Lawn system involved several important steps, each crucial for ensuring the finalproduct's performance, durability, and strength. This process included producing essential componentslike the axles and chassis and utilizing advanced techniques and materials to satisfy the system's functional andenvironmental requirements.

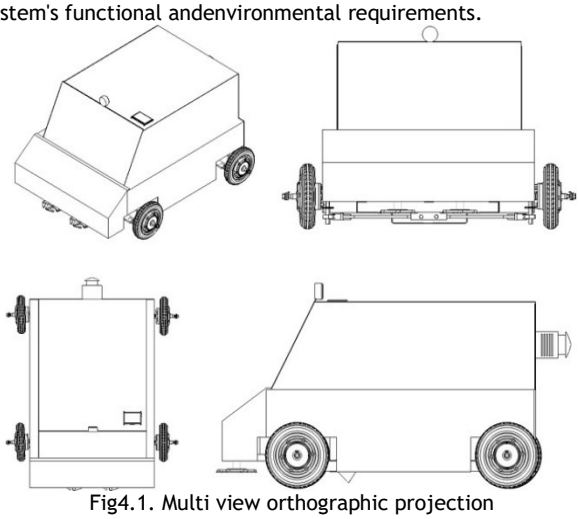

Fig4.1. Multi view orthographic projection

Fabrication of axles

The axles, vital for the smooth operation and mobility of the Guardian Lawn system, were made from high-speed steel (HSS). HSS was chosen for its exceptional durability, strength, and wear resistance, making it an excellent option for components that experience continuous operational stress.

Fig 4.2: Axle

The process of fabricating the axles included several key steps:

• Material Preparation: High-strength steel (HSS) was sourced in standard lengths, and precise measurements were marked out based on the design specifications.
• Plasma Cutting: Plasma cutting was utilized for its accuracy and efficiency in slicing through thick metal. The cutting machine was set to the exact dimensions, ensuring that the axles were cut with minimal heat-affected zones to avoid any deformation of the material.
• Finishing: After the cutting process, the axles were refined to eliminate sharp edges for improved assembly quality.

Chassis Fabrication

The chassis, constructed from zinc-coated steel square tubing, supports all components of the Guardian Lawn system. The zinc coating protects against corrosion from moisture and environmental elements, ensuring durability over time.

Fig 4.3. Square Tubes

The process of creating the custom chassis included several key steps:

Material Sourcing: Zinc-coated square tubes were obtained based on the necessary dimensions to fit the wheels, motors, and sensors. The specifications of the material were selected to guarantee optimal durability while preserving structural integrity.

Cutting and Shaping: The tubes were meticulously cut to the required lengths and shaped into the desired framework using saws. Custom brackets and joints were designed and welded in place to enhance reinforcement and provide extra support to the structure.



Fig 4.4: Cutting

Welding:

Arc welding was used to join the chassis components, resulting in strong bonds between the zinc-coated tubes. To improve corrosion resistance and joint strength, stainless steel filler rods were incorporated. Maintaining precision during the welding process was vital for keeping the chassis aligned and structurally sound.

Fig 4.5: Welding

Assembly: The various parts of the chassis were welded together to create a strong and sturdy structure. Ensuring precise alignment and secure fastening was crucial for making sure that all components fit together perfectly.

Fig 4.6: Chassis assembly

The suspension system of the Guardian Lawn has been carefully crafted to provide outstanding stability and maneuverability on a variety of terrains. Designed with attention to detail, this specialized suspension framework is built to tackle the challenges of outdoor environments while ensuring a smooth ride over uneven surfaces.

Suspension System Fabrication

Key Steps in the Suspension System Development:

Material Selection and Preparation: High-strength steel was chosen for the components of the suspension system to withstand operational stresses and ensure long-lasting durability.

Plasma Cutting: The steel components were shaped using state-of-the-art plasma cutting techniques, selected for their precision and efficiency. This approach allowed for the creation of custom parts that fit perfectly with the Guardian Lawn chassis, resulting in clean cuts that maintain the integrity of the material by reducing heat-affected zones.

the chassis was assessed through fatigue analysis. Vibration transfer path analysis identified weak points in the chassis.

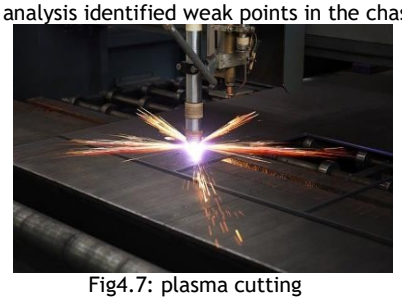

Fig4.7: plasma cutting

Bolt Assembly:

After cutting, the components were put together using high-quality bolts. This method was chosen for its ease of maintenance and the flexibility it provides for future modifications. The bolts were tightened to strict standards to ensure strong connections and minimize potential vibrations during operation. Shaft and Motor Assembly: The 12mm stainless steel rod acts as the primary shaft connecting the cutting blade to the motor. Precision holes were drilled using a lathe for secure attachment, while radial drilling machines created matching holes in the motor shaft. This setup allows for secure fastening with nuts and bolts, ensuring stability during high-speed operations. Blade Attachment: Stainless steel discs are designed to support grass-cutting blades effectively. Each disc includes two blades positioned for optimal cutting efficiency and reduced vibrations, ensuring smooth operation. The stainless-steel construction prevents rust and wear, guaranteeing long-lasting durability and reliable outdoor performance.

Fig 4.8: shock absorbers

Wheel and Suspension System The grass cutter bot features four BLDC wheel hub motors with center shafts, allowing for efficient and responsive movement. Its wheels and suspension system are crafted to ensure stability and smooth operation across different terrains.

Fig 4.9: Wheel and Suspension System

Wheel and Motor Specifications:

➢ BLDC Wheel Hub Motors:

• The bot uses BLDC (Brushless DC) motors in the wheel hubs, delivering direct torque for smooth movement. Positioned on the central shafts of each wheel, these motors ensure balanced power distribution.

➢ Wheels:

• The wheels measure 10 × 2.5 inches, providing a broad surface area for enhanced traction and stability during use.

• This wheel size allows the bot to navigate smoothly over uneven or rough terrain, increasing its adaptability for various lawn types.

➢ Independent Suspension System:

• Each wheel features an independent suspension system that allows for individual movement and shock absorption. This ensures stability and smooth operation, even on uneven terrain. The system minimizes vibrations and enhances handling during movement.

➢ Axle and Suspension Integration:

• The suspension system connects to axles, providing essential support for the wheels and managing torque from the BLDC hub motors. An independent suspension system is vital for keeping all four wheels in contact with the ground, evenly distributing weight, and improving the robot's ability to navigate tough terrains.

Grass Cutter Blade Assembly with Adjustable Height Feature

This grass cutter blade assembly features a motor-driven rotary cutting system that effectively transfers power to the blades through a torque shaft. A notable aspect is the adjustable height mechanism, allowing you to set the cutting height anywhere from 2 inches to 10 inches. This real-time height adjustment facilitates tackling various grass lengths and adapting to different terrain conditions.

Vacuum System Integration

Suction Blower Integration in Grass Cutter: The grass cutter bot includes a manually operated suction blower for collecting the cut grass, ensuring a clean finish after mowing. Since lawn mowing is not a daily activity, this design provides a practical solution using a robust, high-speed blower system. The specifications of the blower are as follows:

• Engine Type: 2-stroke engine
• Displacement: 27cc
• Air Speed: 241 km/h

Fig 4.10: suction blower

Sump Tank Integration

The sump tank is strategically located next to the suction blower, with a direct duct connection from the blower's outlet to the tank's inlet for effective grass collection. The blower's position determines where the sump tank is placed, ensuring airflow from the blower flows directly into the tank without blockages. A hinged door at the back of the tank allows for easy removal of collected grass when the tank reaches capacity. This configuration enhances smooth operation while preserving the bot's suction and cutting functionality. Sump Tank Fabrication: Volume Calculation, and Placement The sump tank, intended to gather grass from the suction blower, is constructed from sheet metal. The fabrication process includes accurate cutting, welding, and assembly to guarantee effective grass collection and disposal.

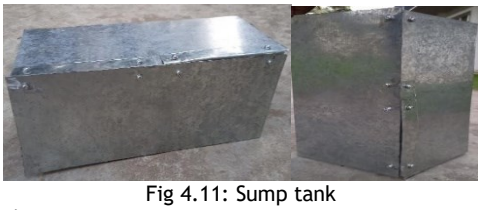

Fig 4.11: Sump tank

Fabrication process

Cutting the Sheet Metal: The components of the tank were cut using straight snips, ensuring that the cuts were clean and precise. The dimensions of both the rectangular and triangular sections were carefully marked before cutting.

• Two rectangular sections were cut to the following dimensions:
• Rectangular 1: 140 mm height × 180 mm width × 250 mm length
• Rectangular 2: 120 mm height × 180 mm width × 400 mm length
• The triangular section was cut with a base of 120 mm, a height of 200 mm, and a length of 120 mm.

Volume Calculation: The volume of the sump tank is determined by adding the volumes of the two rectangular sections and the triangular section.

Section 1 volume (V1): 140 mm x 180 mm x 240 mm = 63 x 105 mm^3

Section 2 volume (V2): 120 mm x 180 mm x 400 mm = 86.4 x 105 mm^3

Section 3 volume (V3): 1/2 x 120 mm x 200 mm x 120 mm = 14.4 x 105 mm^3

Conversion from mm^3 to Liters: Total volume = V1 + V2 + V3 = 163.8 x 105 mm^3 $1mm^3$ = 1 x 10^-6 Liters Total Volume of the tank in Liters = 16.38 Liters

Thus, the total volume of the sump tank is 16.38 Liters, providing ample capacity for grass collection.

Fig 4.12: top view of sump tank

ELECTRONIC COMPONENTS

1.Wi-Fi Module (NodeMCU):

The NodeMCU Wi-Fi module facilitates wireless communication, allowing for remote control of the bot. This module enables the operator to manage the vehicle's movement and various functions via a mobile or web-based interface, making manual operation more convenient.

Fig 5.1: node MCU

2. Motor Controllers:

A BLDC motor controller regulates the speed and direction of the bot's wheels, ensuring smooth and efficient movement. It receives signals from the Arduino and converts them into the necessary power for the BLDC motors that drive the wheels.

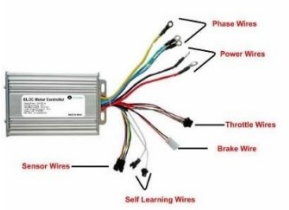

Fig 5.2: BLDC motor driver

3. Microcontroller (Arduino Mega):

The Arduino Mega acts as the main control unit for the system. It handles inputs from the Wi-Fi module (NodeMCU) and oversees the functioning of the BLDC motor controller for the wheels, along with other components such as the suction blower and cutting blades. Additionally, the Arduino ensures that the motor controller and battery system run within safe limits, avoiding issues like overloading or under-voltage situations.

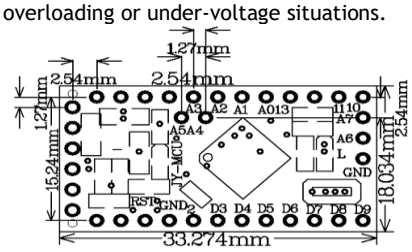

Fig 5.3: Arduino Mega

4. Power Supply: The vehicle runs on two 36V, 30A batteries, which deliver plenty of energy for the motors, suction blower, and cutting tools. These robust batteries guarantee extended operational time before a recharge is necessary. The batteries provide the necessary power to the BLDC motors, enabling continuous operation even during demanding cutting and suction activities.

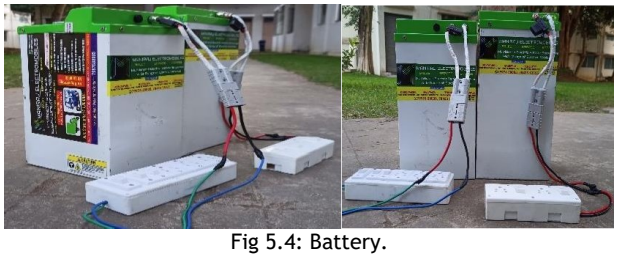

Fig 5.4: Battery.

5. Intel real sense lidar camera: This camera helps map the lawn and identify boundaries, offering Realtime information for autonomous navigation.

Fig 5.5: Lidar Sensor

6.BLDC motor: This motor powers the mower's movement, enabling efficient cutting and precise maneuvers.

Fig 5.6: BLDC Motor

7. JETSON NANO: This AI computer improves the robot's functions through real-time data processing, allowing for image recognition and better navigation, which enhances its mowing and security capabilities.

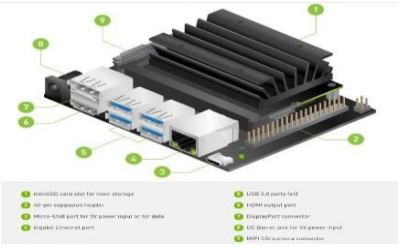

Fig 5.7: Jetson Nano

8. RASPBERRY PI: The Guardian Lawn system uses a Raspberry Pi to manage sensors and devices, enabling remote control through a smartphone app. Its integration with the Jetson Nano improves AI functionality, enhancing lawn care and security features.

Fig 5.8: Raspberry Pi

Fabrication Process Flow for Autonomous Grass Cutter Bot

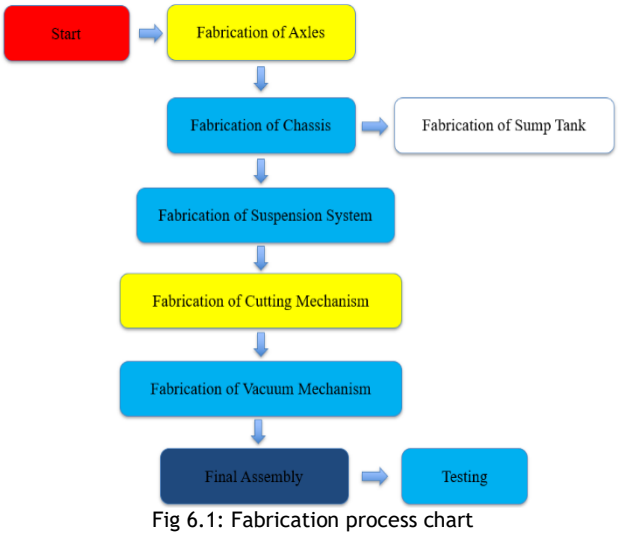

Fig 6.1: Fabrication process chart

METHODOLOGY

This methodology outlines a systematic approach to designing, developing, and integrating technologies for an autonomous lawn mower that incorporates home security features. The process is divided into several stages: research and design, hardware integration, software development, system integration, and testing. Each stage is crucial for ensuring the functionality and efficiency of the final product.

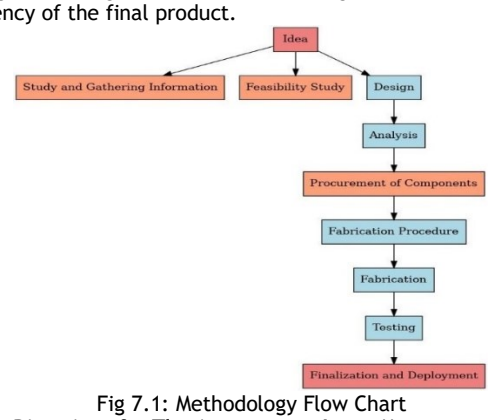

Fig 7.1: Methodology Flow Chart

Future Directions for The Autonomous Lawn Mower

1. Incorporation of AI and machine learning: AI algorithms for self-directed navigation, impediment recognition, and topographical surveying can be incorporated to considerably improve the automaton's effectiveness, helping to save energy and time.
2. Autonomous recharging and docking: An auto-recharging function that enables the bot to autonomously return to a charging station when its battery level is becomes low, significantly enhancing the bot's response sentence. Investigating photovoltaic cells as an extra sustainable energy option for exterior applications might be advantageous as well.
3. Advanced sensors, like LiDAR and computer vision systems, play a crucial role in enhancing safety by providing real-time environmental scanning to detect and navigate obstacles such as pets or uneven terrain. These monitoring devices could also discern various kinds of turf and modify the trimming apparatus accordingly.
4. You can change the cutting blades for different grass or the waste vacuum system to fit different cleanup needs, making the bot more useful. This modularity would be especially attractive to commercial clients with varied lawn care needs.
5. Remote Supervision and Control: Upgrading the wireless component to enable distant monitoring, planning, and governance through a specialized mobile platform could enhance operational ease. This improvement would allow users to track battery duration, working conditions, and grass buildup in real time. Implementing sophisticated energy regulation frameworks can ensure that the automaton functions persistently without impairing efficiency.

RESULTS

This design ensures efficient grass collection after each mowing session, utilizing the strong airflow of the 2- stroke blower while remaining user-friendly for regular lawn care. Sump Tank Fabrication, Volume Calculation, and Placement The sump tank, intended to gather grass from the suction blower, is constructed from sheet metal. The fabrication process includes accurate cutting, welding, and assembly to guarantee effective grass collection and disposal.

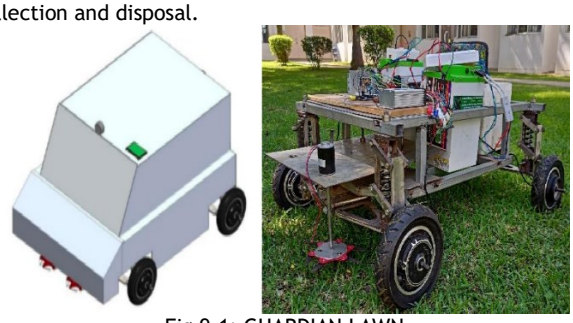

Fig 9.1: GUARDIAN LAWN

CONCLUSION

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