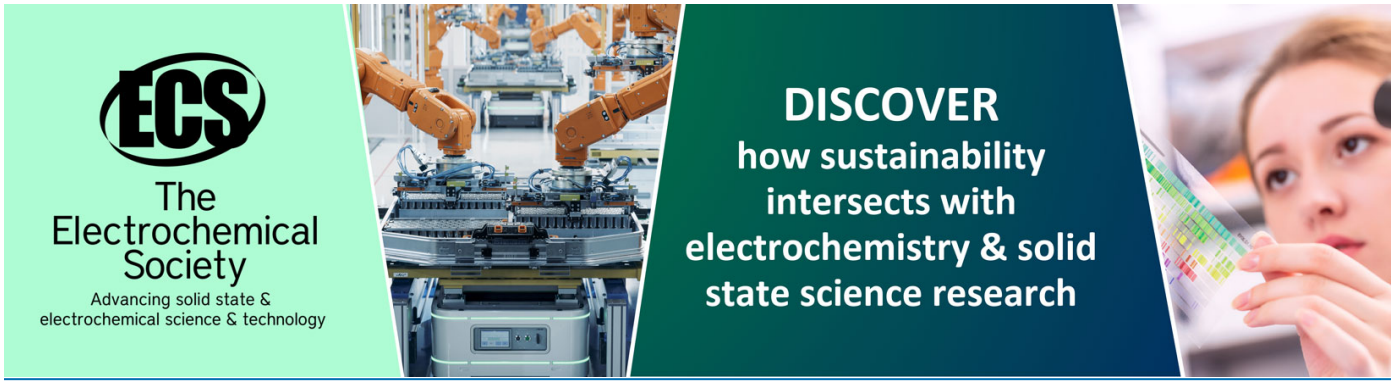
Design and Fabrication of Grass Cutting and Water Spraying Rover



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Design and Fabrication of Grass Cutting and Water Spraying Rover

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Abstract: In this age of robotics and automation, it comes as a surprise to us that the most basic dull tasks such as gardening are still done in majority by humans. Even the simplest jobs of trimming the grass have become only faux-automated - there are machines, but you always need a person to run around the field with that. We believe that humans should naturally move on to tasks that utilize their potential the most - tasks that involve creativity, imagination and innovation. Considering these aspects and came up with the automatic trimming and water spraying rover. Combination of both cutting grass and water spraying makes the project more interesting, moreover both the tasks can be performed simultaneously or both operations can be done at different situations according to the operator. Input will be given through Arduino and accordingly the rover moves. Trimming and irrigation of fields and gardens are among the most mundane, monotonous tasks known to man. Along with being boring and uninspiring to the doers, these separately conducted tasks also increase the total time of execution, and the costs involved. Not only do they kill the creativity of the people, they also cost a fortune given the increasing costs of manual labour, not to forget all the imperfections and errors that are induced in the project.

Keywords: Grass Trimming Rover, Water Spraying Rover, Faux-Automation.

1. Introduction

Gardening, as we know it, is a tedious, time taking process. It requires a lot of manual labour, therefore investment (8). Club the added task and responsibility of watching over the gardeners at all times to ensure they do their job properly - and we have a complete headache in place (5). Not to mention that all their work is naturally prone to human errors of all kinds. Robots are machines which are capable in performing more complex and boring jobs, dull tasks like gardening should be left to the machines and reduce in manual intervention (1). At the same time, another problem exists thanks to the faux-automation - sprinkling of fields and gardens (10). The current sprinklers are fixed at a spot in the garden, and try to irrigate the whole field by rotating their nozzle around the spot and hoping that water reaches all regions of the field evenly (7). It must come as no surprise that this system is highly inefficient (2). The sprinkling is often not uniform - leading to some areas of the field being over-irrigated, and the other areas not receiving enough water for sustenance (9). There are many successful projects in the market which are capable to sense moisture level in the soil and other operations but the major disadvantage is they are costly and are not compatible for most of the users (6).

To solve this dual-problem of irregular irrigation and tiring-boring-dull-gardening, we are coming up with AuTIRo. The Automated Trimming and Irrigation Rover (AuTIRo) is a 4-wheeled device designed to go around fields, smartly irrigating the lands and trimming the grass. The first-of-its-kind robot that solves both grass trimming and uneven irrigation issues - AuTIRo is designed and built around the tenets of automation and smart robotics.

2. Design and Fabrication

Design of grass cutting and water spraying rover starts with the 3D modelling and followed by analyse of rover (chassis) and material selection, it is the essential part of the process since it has to sustain the entire load acting. On the other hand, selection of electronic and mechanical components such as, chassis and axial material to be used, motor to drive the rover and for cutting grass, power supply, sensors and Arduino, wheels and the other components. At the end all parts are assembled, then finally trails and calibration are being done.

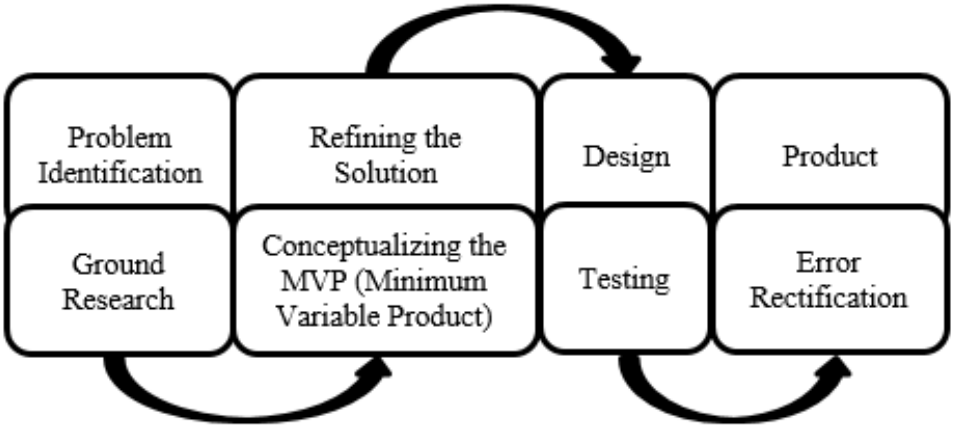

Figure 1. Overview of the Project Methodology.

Figure 1, gives the information of overview of the project methodology, process that leads to well defined solution and at minimum cost. Initially Problem has been identified then brainstorming multiple solutions related to problem, cost efficiency and then design, testing and error rectification and at the last calibration and calculations has been justified.

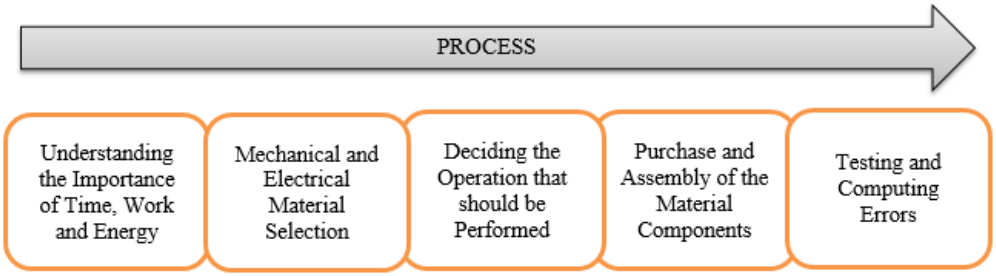

Figure 2. Design Methodology for the Project.

Figure 2, gives a brief idea of the how the design of grass cutting and water spraying is done. It begins with the design and ends with the calibration and errors rectification has been done.

2.1 Orthogonal 3D View of the Rover

The bottom part of the robot contains the water tank, driver (Motor) and the driven is present bellow the chassis, the drive is transmitted through the chain and sprockets. Water container consists of the approximately 5 litres.

The following figures show the design and fabrication of the rover.

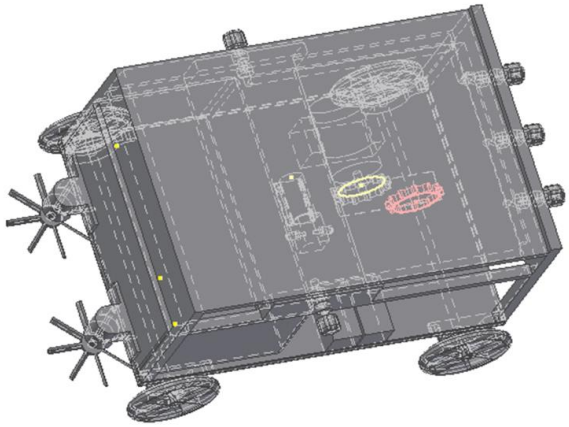

Figure 3. 3-D CAD Model of the Rover.

Figure 3, shows the CAD model of the rover designed in Autodesk inventor 3D modelling software.

Figure 4. Mist Sprinkler for Water Spraying.

Figure 5. Multi Grass Cutting Blades.

Figure 4 and 5, shows the mist sprinkler and multi cutting single blade used in the rover. The water is pumped from the reservoir to sprinklers and grass cutter is driven by the motor. Trimmer blade has multi cutting edges for cutting the grass. The wings of the blade are tilted at approximately 45° which looks similar to a propeller. When the grass comes in contact with the blade, the grass gets trimmed and thrown into grass collector.

Table 1. List of Components used for Chassis Assembly.

Name of the Components	Specifications and Units
Stainless Steel Shaft	400 x Dia. 100 mm
Galvanized Iron Sheet	500 x 350 mm
Nuts, Bolts & Grub Screws	As Required
Aluminium Bushes	4 Nos.
Sprockets	2 Nos.
C-clamps	4 Nos.
Bearings	4 Nos.

Table 1, enlists all the components that are used in assembly of chassis. This includes all the mechanical components and their specifications.

3. Construction and Working

Rover activates on pressing the power button on the Arduino, for manual mode the mobile is paired to the Bluetooth module which is connected to the circuit and for automatic mode the movement is programmed initially. Grass cutting and water spraying operations done by the rover can be both simultaneously or it can perform at different conditions in which the operator wants to perform the task.

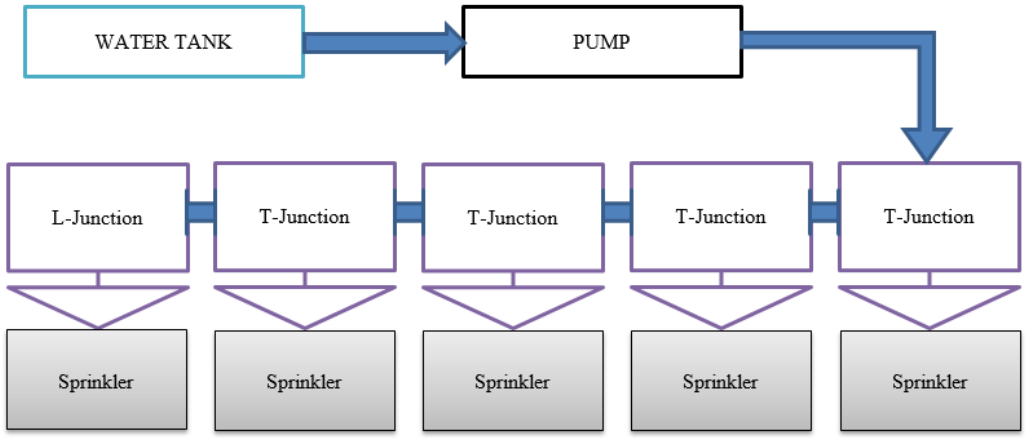

Figure 6. Arrangement and Connections of the Sprinkler.

Figure 6, shows arrangement of the sprinklers and connections from the water tank to sprinklers through L & T junctions via using pump.

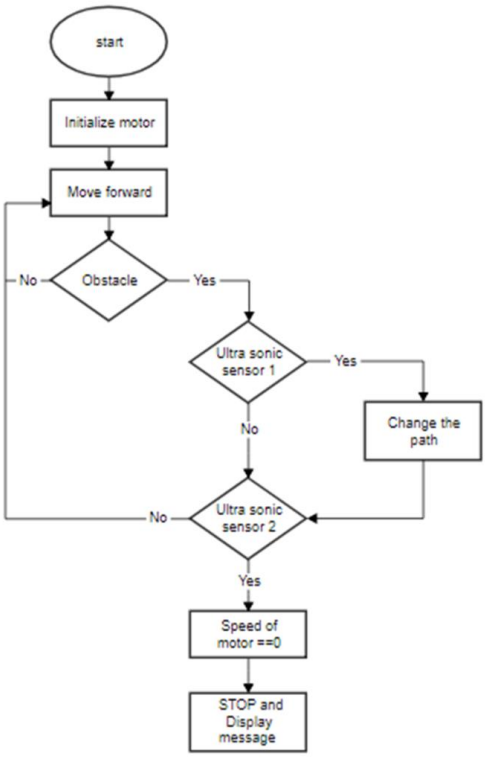

Figure 7. Flowchart of the Working of Rover.

Figure 7, defines a simplified flowchart of the working of the rover. The operation of the rover starts with the movement, in the first condition, if the rover will encounter any obstacles then it will calculate the distance and it will change the path and in the second loop ultrasonic sensor 2 sensor checks for the human presence. Ultrasonic sensor 1 is located between the grass cutters and ultrasonic sensor 2 is placed at the top, and when there is any signal in sensor 2 which is detected less than 20 cm the rover comes to static condition.

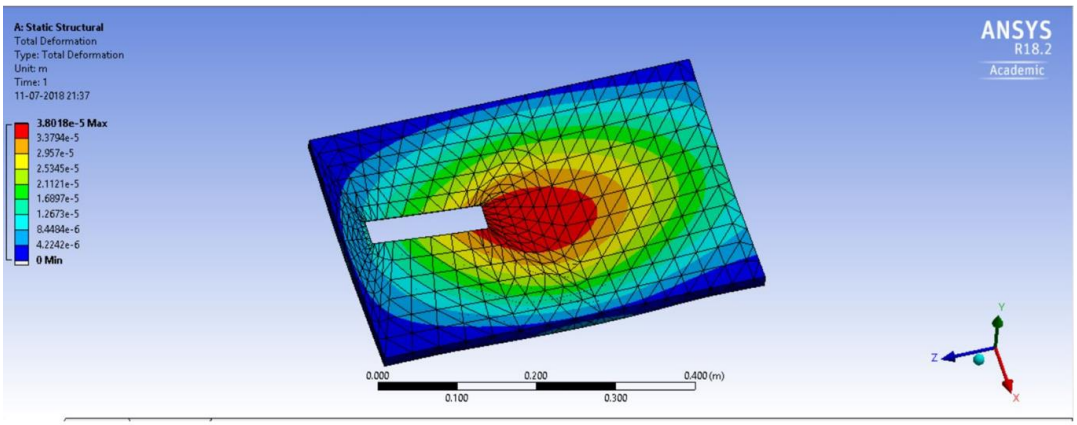

Figure 8. Total Deformation Analysis of Chassis.

Figure 8, describes total deformation after the load is applied. Analysis of chassis has been done in Ansys workbench R18.2, the minimum load is 0 N and maximum load is 3.8018e-5, in the above figure the front half of portion is subjected to 19.6 N and the rare end portion is subjected to 49 N. Finally, through deformation analysis it can be concluded that it can sustain the applied load.

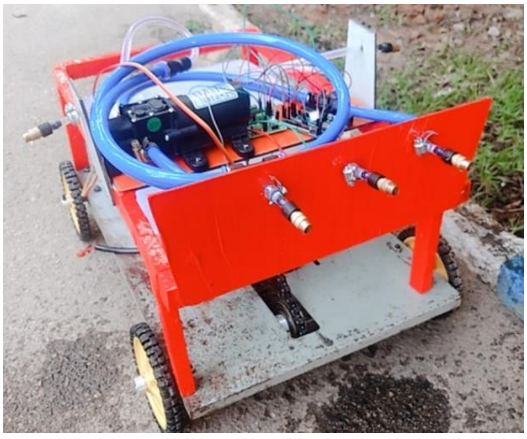

Figure 9. Assembled View of Rover (Rear).

Figure 10. Assembled View of Rover (Front).

Figure 9, shows the rare end of the rover where five sprinklers are arranged to cover the entire 180 degrees so that the equal amount of water can be sprayed.
Figure 10, shows the front end of the rover where the ultrasonic sensor and the cutters are fitted for detecting the obstacles and cutting the grass respectively.

4. Calculations

The following are all the calculations that are done for the robot.

4.1 Calibration of Dimensions

Table 2. Design Details of Rover Body.

Design Consideration	Specifications
Length of the Rover	500 mm
Width of the Rover	340 mm
Height of the Rover	330 mm
Ground Clearance	70 mm
Material used for Chassis	Galvanized Iron
Diameter of the Cutter	110 mm

Table 2, shows the design details of the rover and the material used for the construction.

4.2 Rover Components Used

Table 3. List of Components Used.

Name of the Component	Number of Units
Wheel	4
Battery 12V	2
Arduino	1
Motor Driving Module	2
DC Motor 120 Watt	1
DC Motor	2
Ultrasonic Sensor	1
Pump 100 PSI	1

Table 3, enlists all the components that are used in the fabrication of Grass Cutting and Water Spraying Rover which includes all the Sensors, Controllers, pump and the Motors.

4.3 Calculating the Speed of Robot

- Length of field (Assumption) = 2.5 m (L)
- Breadth of field (Assumption) = 2.5 m (B)
- Number of drive motors = 1
- Radius of drive wheel (R) = 0.06 m
- RPM of each drive motor (N) = 50 RPM
- Speed (V) = R*ω
- ω = (2*π*N)/60
- ω = 5.236 radians/second
- V = 0.314 m/s
- Considering efficiency of power delivered to motor = 80%

- Speed delivered or Speed of Rover(Vr) = V ∗ 0.8 = 0.25 m/s
- Time taken by the rover to cover the field length once (t) = L / Vr = 2.5/0.25 = 10 seconds.

5. Results and Discussions

The rover developed, facilitates both grass cutting and water spraying automatically. It works in both manual and automatic modes. The fabrication started after approximating weight of the rover. Based on the weight, the torque required for the rover was estimated and the market survey was done to get to the motor which has a required Torque for DC motor to drive the rover. The shape and size of the rover were decided and 3D modelling was done using Autodesk inventor. On the other side, the hand power supply to the rover is to be selected, keeping in mind the voltage supply and the current capacity. Lead Acid Batteries were chosen to reduce the cost for power supply to the rover. The IR Sensors which were in use by most of the existing robots were replaced by the Ultrasonic sensors which were more accurate. Many challenges had been addressed during every stage of the development. These include positioning of the components, wheel alignment, sensor positioning, motor drive, sprinklers, pump positions and water container.

The robot was able to cover 80% to 90% of the area. The bluetooth controller is used to move the rover in the complicated areas, which was not facilitated by the automatic mode. The bluetooth controller also enables the ability to cover the difficult areas and assist the rover to do the repetitive tasks in these areas.

The rover attains a speed of maximum 1.3 km\hr and minimum of 1.0 km\hr. For cutting the grass, grass cutter blades are fixed at the front end of the rover. The cutter is flexible to adjust at different heights. Grass cutting and water spraying can be done simultaneously and also operation can be done one after the other i.e. initially grass cutting can be done followed by water spraying.

6. Conclusion and Future Scope

These days the importance of automation is been drastically increasing, there are so many machine used in agricultural field for different operations that need to be performed. There are machines or robots for grass cutting but only some of them are affordable and economical. There are very few robots which can accurately perform multiple tasks. In this project, both the grass cutting and water sprinkling is being collaborated together.

This project has immense scope of improvement in the future. The results demonstrated at this prototype stage are unparalleled, while leaving a lot of room for further incremental updates. The robot speed is 1.2 km/hr. and it can be easily increased to 2 km/hr. by changing the velocity ratio and wheels, and a battery with a larger current output. Using a wider action area, the field area covered per unit time can also be increased. Finally, at a minimal cost of initial investment, the developed model can be used for irrigation and trimming of fields and gardens is more viable than most others.

Acknowledgements

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