Design and Development of an Autonomous Hybrid Lawn-mower

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Introduction:

A Lawn Mower is a device that trims grass to maintain it at a uniform height. Traditionally available, commercial lawn mowers are purchased at high initial investment & manual labour is required to operate, it is also bulky & difficult to maneuver. To overcome human efforts, the goal is to engineer an electric Autonomous Hybrid Lawn Mower, which performs trimming of grass without any human assistance. Though many automated lawn mowers are available commercially, they partially require human monitoring and assistance. This system is made autonomous using Computer Vision & Artificial Intelligence. The implementation of an autonomous trait to such a model eliminates the need for human monitoring and intervention in operations. This model also comprises various modes of operation with an automatic cutting height adjustment, thus making it a hybrid system. The goal of this project is to design and engineer an autonomous hybrid mower which uses the applications of Artificial Intelligence and machine vision to help maximize the efficiency of mowing and further reduce the amount of human intervention. Instead of using boundary wires and basically, any other physical constraints, this system would use image processing to learn and understand its surroundings including grass edges and mow lawns efficiently, while avoiding obstacles, with the help of a dedicated camera and a Jetson Nano AI Developer kit.

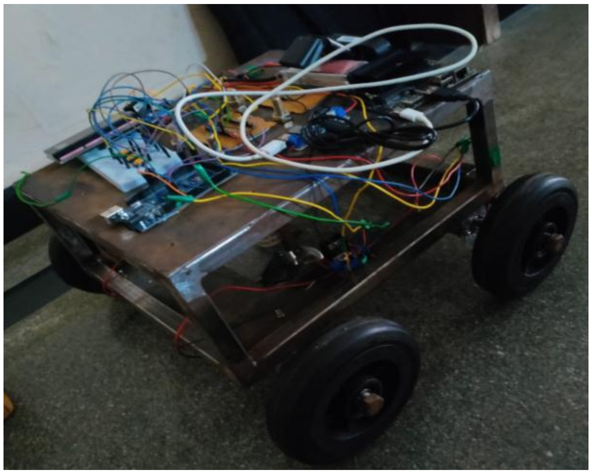

Fig 1: A model of the Autonomous Hybrid Lawn-mower

Fig 2: Procured cutting blade.

Methodology:

1. Selection of a problem statement: Amidst an array of existing problem statements found over the course of a wide survey, we opted to pursue a solution to the problem of designing and developing an autonomous lawn mower with hybrid operating modes.
2. Procurement of a cutting blade available in the market: After perusing through numerous materials, it was found that the design process for our mower must be initiated with the cutting blade. We have opted to not design the blade from scratch due to time constraints and have hence chosen to select a suitable blade available in the market.
3. Design calculations and fixing dimensions: With the dimensions of the blade in hand, we implemented dimensioning to the movable platform which is responsible for holding the cutting motor and blade. After which, the dimensioning of the wheels followed. This enabled us to ascertain the positioning of the drive motors with respect to the chassis. A required chassis dimensioning was performed and the gross vehicular weight inclusive of the weights of all the components and structures was taken into account.

   There were a few parameters that demanded calculation in order to feasibly design our mower. Some of which included:

   - Total Tractive Effort
   - Rolling Resistance
   - Acceleration Force
   - Grade resistance
   - Maximum Tractive Torque

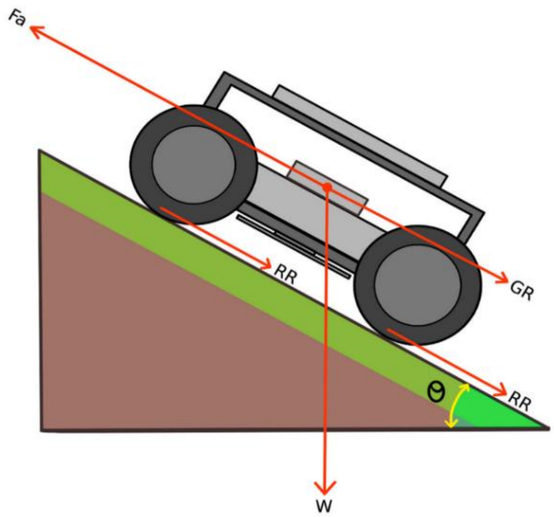

Fig 3: Forces acting on the embodiment.

4. Selection of motors required: By ascertaining the torque required by the drive wheels to propel the mower, a suitably powered motor was selected for each of the drive wheels. Similarly, the motor for the cutting blade was chosen as well. It was found that the motor torque required per wheel to drive the mower was 162.34 N-cm. The blade motor to be selected for our purpose is supposed to have a minimum power output of 0.136hp or 101.61W and a minimum running speed of 3000 rpm. A commercially available motor fitting the specifications is selected.

Fig 4: Procured motors for the wheels and the cutting blade.

Fig 5: 2200 mAH LIPO battery pack.

5. Selection of batteries: After the required motors are selected, the amount of power they consume at maximum working conditions are calculated. According to their power

consumption, a suitable battery pack is chosen for our mower to run for a specified time on full charge. A LiPo battery was considered for this purpose.

6. 3D Modeling and 2D drafting: Once the dimensions and necessary details of design were acquired, the mower's chassis was modelled and the final assembly was created in an appropriate 3D modeling software package called CATIA V5.
7. Procurement of materials: Once the dimensions of the design and selective materials were finalized, procurement of the required mild steel was done from scrap yards and sent for fabrication.
8. Fabrication: The process involved the machining and joining of the necessary parts and assembling them by the usage of various machining techniques inclusive of welding, brazing, drilling, tapering, turning, etc.
9. Programming the Arduino Mega and training the Jetson nano: Once the assembly and the necessary wiring had been completed, the Arduino Mega microcontroller board was programmed to help interface with the front-mounted ultrasonic sensors for detecting any sudden or unforeseen obstacle in the mower's path. There were 5 probable obstacles chosen as potential obstacles typically found on lawns, whose several different orientations were visually captured by a camera and were fed to the Jetson nano developer board to recognize the said obstacles when encountered in real time. The probable obstacles chosen were a flower pot, a block of concrete, a stone, a brick and a shoe.

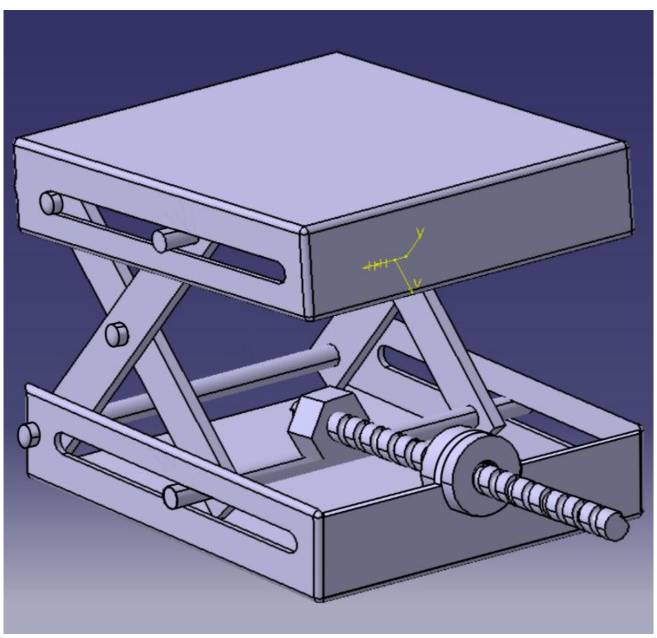

Fig 6: 3D model of the cutting height adjustment mechanism.

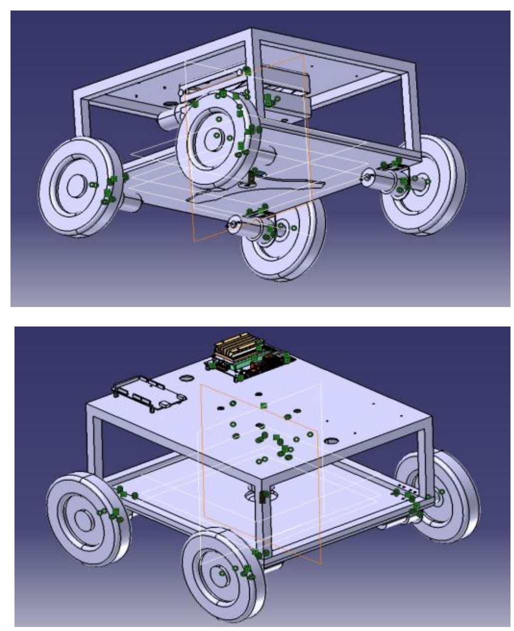

Fig 7: 3D models (isometric views) of the proposed embodiment.

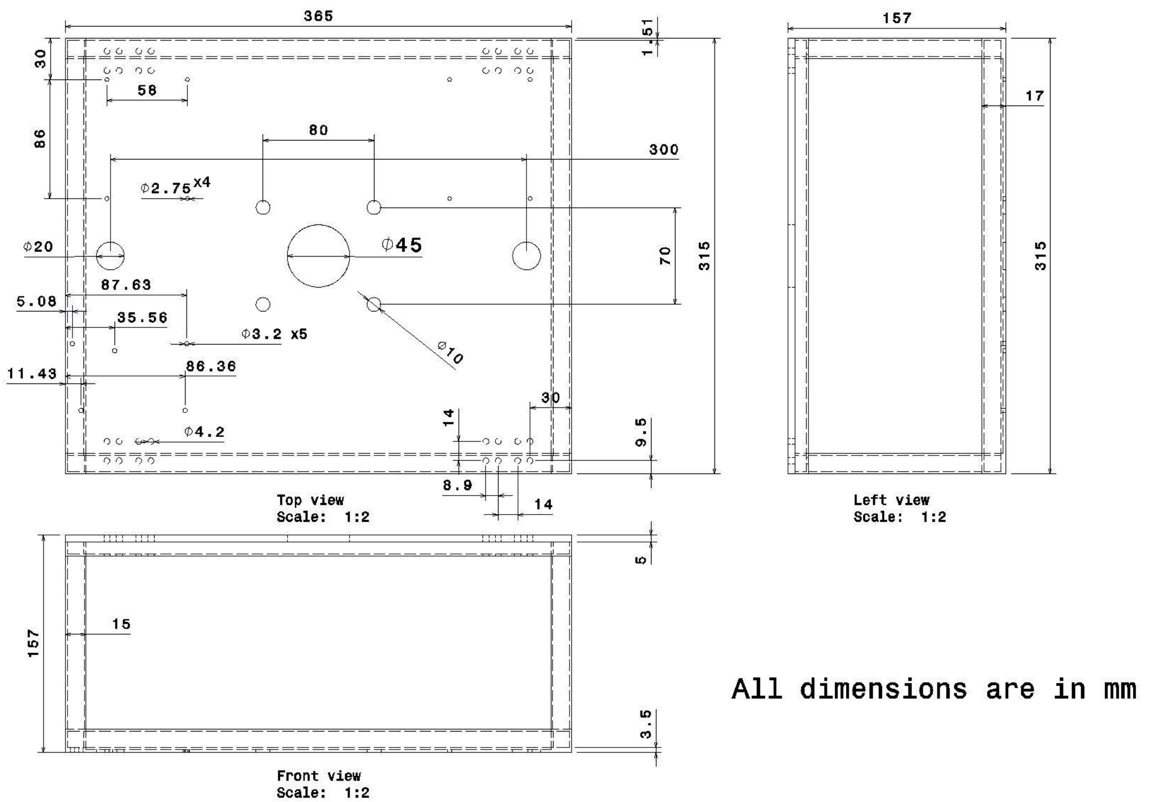

Fig 8: 2D draft of the chassis.

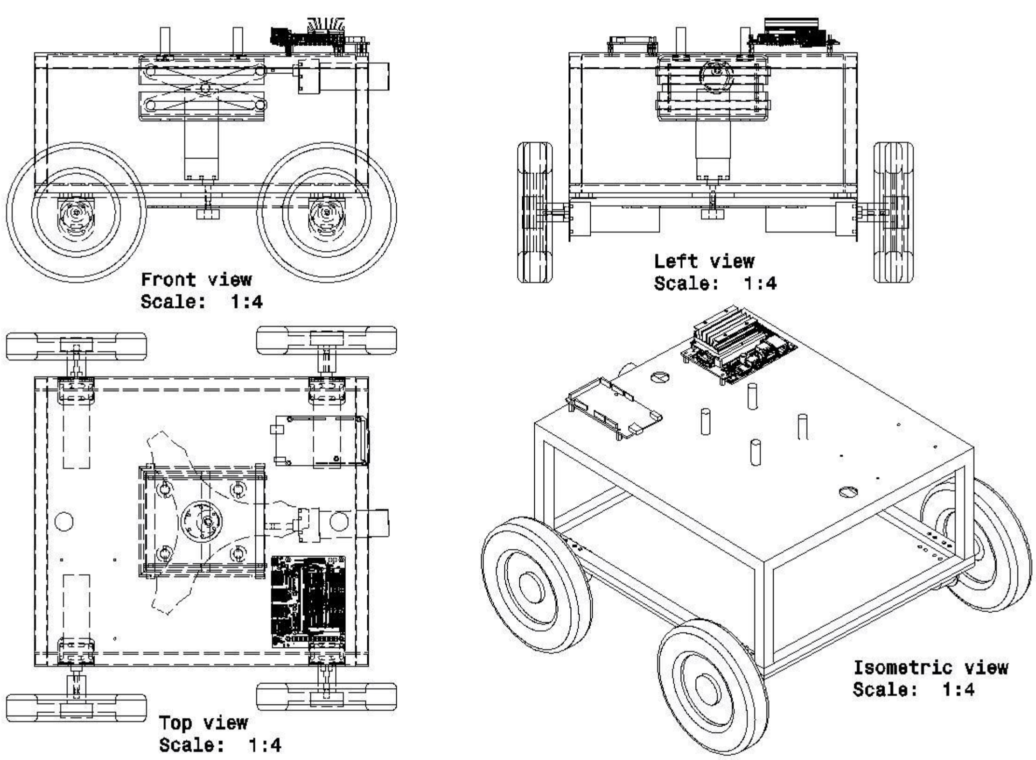

Fig 9: 2D draft of the embodiment.

Conclusion:

This project involved the design and development of an automated lawn mower that runs without the help of boundary wires by using the principles of artificial intelligence and computer vision. The training of the AI model for the proposed embodiment has proved to be fruitful in avoiding obstacles whilst mowing lawns and has also successfully eliminated the requirement of constant human monitoring and has also implemented the use of an automatic cutting height adjustment system.

Scope for future work:

1. Auto-docking
   - This feature is used to navigate the proposed embodiment from its current location to the charging dock.
   - The mower, when reaches a threshold charge level of the battery pack, runs from its location to the location of the remote charging station or charging dock.
   - This process further boosts the concept of autonomous behavior applied to the proposed embodiment and reduces human efforts for having to monitor the charge level of the batteries.
2. Solar charging
   This feature is used to charge the battery by solar power to include hybrid power supply and to save charge time by charging during operation.