Robot & Drivetrain Analysis Report

MAE 3: Introduction to Engineering

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Team #39: Scuff Bot

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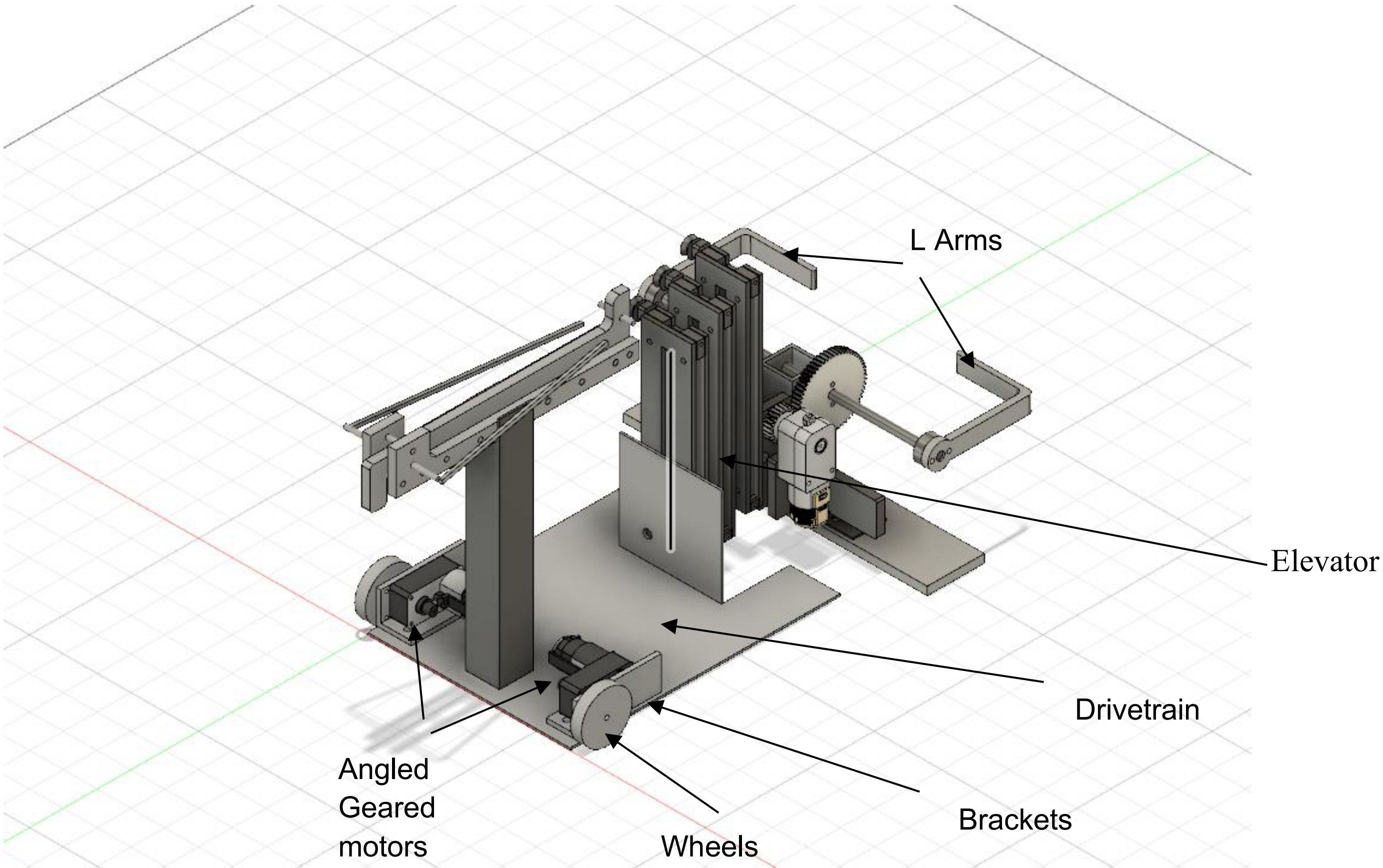
B04

Introduction

For the final project of the MAE 03 class, I worked mainly on the chassis/drivetrain of the robot that we were supposed to design and fabricate. The chassis I designed include two angled geared motors to power the drivetrain. This project mainly comprises of three powered components: Drivetrain (uses two motors), Elevator, and the L arms. The Drivetrain is a rear-wheel drive that runs on the Direct Drive principle, where the motors are directly attached to the wheels using a motor mount bracket between the chassis and the wheel.

The drivetrain was initially modeled to move half the weight of the robot kit (2.679 kg) at 5 cm/s. Towards the end of the project, the drivetrain is able to perform a whopping 9.14 cm/s.

Figure 1: Scuff Bot



Two brackets are fixed on to the chassis as shown in figure 1. Brackets are designed to fix the motors and provide a housing for them. The motor mount is inserted into a designed hub which is attached to the wheel using three screws. A 4-40 round-head screw is used in the middle of the wheel to fix the wheel firmly onto the chassis so that it doesn't wobble around. That screw goes into the 4-40 tapped hole in the motor mount. I also fixed a Delrin to the back end of the chassis to reduce the friction.

Functional Requirements for the drivetrain

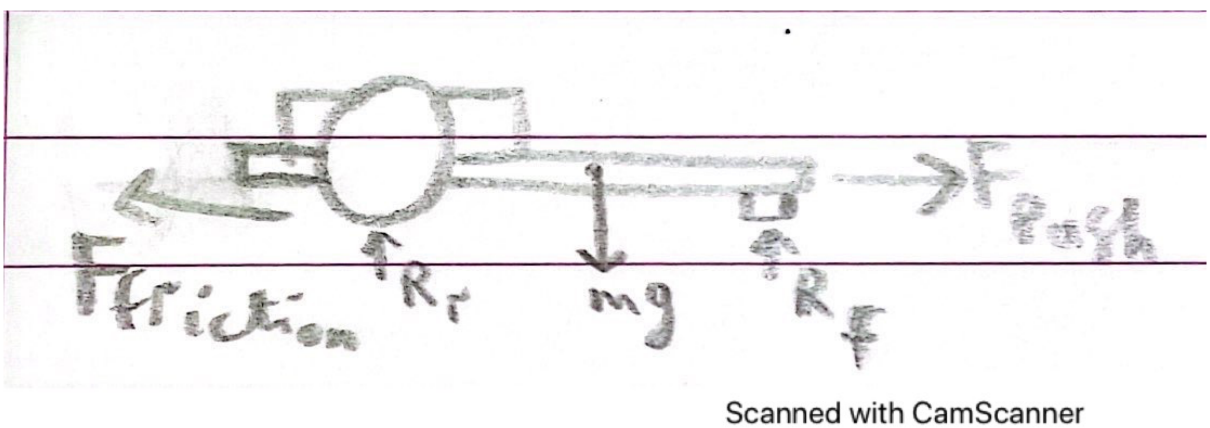
- Carry the weight of all the other components (approximately 2.375 kg).
- Reduced friction between the drivetrain and the surface.
- Should maneuver up to the boxes and back to the Geisel in about 10 seconds.

<u>Objective</u>

In this analysis, I am trying to calculate the maximum pushing force that the motors can provide to move the robot. This force analysis will allow me confirm how much weight can our robot bear at maximum and how fast will it be able to move during the competition.

FBD:

Figure 1



Assumptions:

- The Drivetrain is at quasi-static motion
- No friction is lost
- Negligible air resistance
- The weight of the robot is evenly distributed on the wheels

Equations:

$$\Sigma F_x = 0 \qquad F_{push} - F_{friction} = Driving\ force$$

$$\Sigma F_y = 0 \qquad R_r + R_f - mg = 0$$

Where $F_{friction} = \mu N = \mu mg$

Where μ = friction coefficient

Force Analysis:

Force exerted on the robot by each motor = Torque/ (Distance of motor shaft and wheel)

We have the max torque provided by the motor which is 0.322 N.m and we also have the length of the shaft on which motor and the wheel will be attached which is 0.13m.

$$Max\ Force\ provided\ by\ each\ geared\ motor = \frac{Max\ Torque}{Length}$$

$$= \frac{0.322}{0.13} = 2.477\ N$$

$$Total\ Max\ Force\ available = 2.477 * 2 = 4.95\ N$$

$$Force\ needed = m.a = 2.375\ kg * 2\frac{m}{s^2} = 4.75\ N$$

Here, we know the mass of the robot and we took the acceleration of the robot to be 2 m/s^2

$$Factor\ of\ safety = F_{available}/F_{needed} = \frac{4.95}{4.75} = 1.042$$

This means that our robot can easily move around with an acceleration of $2 m/s^2$.

Conclusion

The drivetrain of the robot gives the desired results in terms of the speed and is also able to lift the weight of the whole robot and the objects that we pick. Our whole design was built around the idea of uniqueness and efficiency. The two L arms are able to scoop in two objects at the same time as their width is set as so they can reach two objects in the boxes at the same time. But, there’s a limitation with this unique design. The biggest limitation of this design is that it cannot reach the Ipad as the L-arms cannot extend to the length of the Ipad.

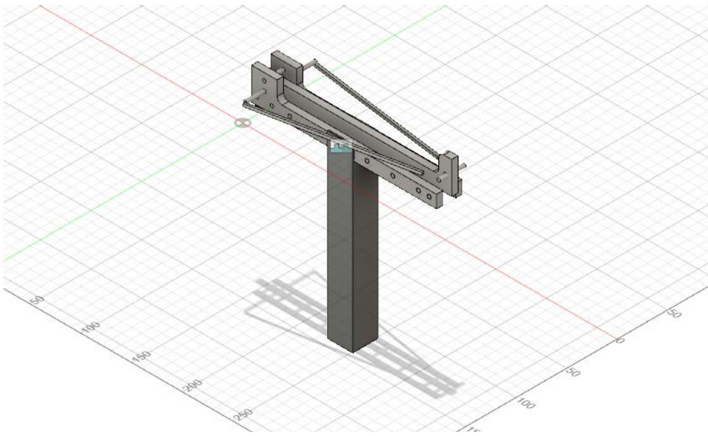
If I were to be a given a second chance with the robot design, I would replace the L-arms with a grabbing mechanism such as a claw as I came to a realization that even though L arms work fine, but it is not as efficient as a claw. L arms can be a bit difficult to use and navigate around but a claw provides with flexibility with regards to the position of the robot. One other change that I would consider is that I will use a shaft to connect the two wheels with one motor, because when they are powered with two different motors, sometimes the motors give different output so instead of going in the direction we want, the robot tend to move more towards the direction where it is getting more torque from.

Overall, this robot project taught me a lot and I think I gained a lot of experience and skills by being a part of this project. The biggest lesson I learned being part of this project was that I learned how to be more creative to come to the solutions and to overcome the problems we face while working on a planned design. I also learned how to manage a project with a team and how to be a team-player.

Design Process Essay

As I mentioned earlier that our robot was not able to get to the Ipad, we generated further ideas to overcome this limitation. We all were having a hard time figuring out how we can be able to score the Ipad. With creative thinking, we came up with an idea of a crossbow spring shooter design which would be able to knock down the Ipad. The essential idea is that an arm will be attached to the robot with rubber band stretching it inwards to store the elastic potential energy. A small rope was used to tie one end of it to the arm and the other end to a screw which will be screwed to one of the holes in the play area. When we reverse the robot, the rope will be slacked off from the screw, deploying the arm which could reach to the Ipad. By using this mechanism, we were one step ahead to winning the competition as we could now reach all of the objects, including the Ipad.

Figure 2 Crossbow



Here’s a CAD of this design to give a better picture of the idea.