Department of Electronic & Telecommunication Engineering

University of Moratuwa

Assignment – 5

EN2532 - Robot Design and Competition

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Robot Weight Calculation

The list of chosen components that add a significant weight to the robot are as follows,

- Battery: 250 g
- Raspberry-Pi 3B+ with clear case: 64 g
- MG995 Servo Motor (x2): 110 g
- Gripper: 100 g
- Robot Chassis with wheels: 330 g
- Motor Driver: 26 g
- Motor (x2): 202 g
- Caster Wheel (x2): 80 g

Therefore, the total weight of the robot accounts to,

$$\text{Total weight} = 1162 \text{ g}$$

Requirements

1. Qualitative Requirements

- Since this robot is made for the EN2532 module, we only require the robot to last for six months.
- The motor should be affordable to align with the budget of the project.
- Medium level of accuracy is sufficient for the application.

2. Quantitative Requirements

- The distance the robot needs to traverse was estimated to be 20 m. We intend to complete the task within 5 minutes. Therefore, we chose the maximum velocity of the robot as 11 cms^{-1}.
- The motors need to be able to provide enough torque to propel a weight of 1119 g on a 20° slope.
- The motor should run at 30% of its stall torque to operate with low current draw to ensure minimize losses.

Considering the above qualitative requirements, the Brushed DC motor seems the most suitable motor type for our application. Therefore, the following calculations are done in order to determine the quantitative requirements for the Brushed DC motors.

Calculations

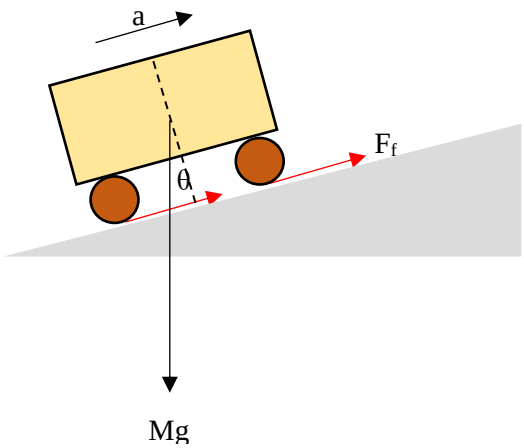

Figure: Free Body Diagram

1. Speed

$$\omega = v/r$$

$$\omega = 0.11 \times \frac{1}{\left(\frac{0.065}{2}\right)}$$

$$\underline{\omega = 3.38\, rad\, s^{-1}\ (32.32\, rpm)}$$

2. Torque

Acceleration of the motor is calculated to obtain the desired velocity withing a second.

$$\tau = M(a + gsin\theta\ )$$

$$\tau = M(a + gsin\theta\ )r$$

$$\tau = 1.162 \times (0.11 + 9.81 \times \sin(20)) \times (\frac{0.065}{2})$$

$$\tau = 0.139 \text{ Nm}$$

Required torque after adding safety margin to account for losses due to practicalities:

$$\tau = 0.139 \text{ Nm} \times 2$$

$$\underline{\tau = 0.278 \text{ Nm}}$$

It is a best practice to run a motor at 30% of its stall torque. Therefore, the stall torque required can be calculated as below.

$$\text{Stall torque} = \frac{0.278Nm}{30} \times 100 = 0.9266 \text{ Nm}$$

Required Specifications for the DC motor

Motor type	Brushed DC Motor
Operational toque	0.278 Nm (39.368 oz.in)
Operational speed	3.38 rad s^{-1} (32.32 rpm)
Stall torque	0.9266Nm (131.22 oz.in)

Specifications of suitable DC motors

34:1 Metal Gearmotor 25Dx64L mm HP 12V with 48 CPR Encoder (No End Cap)	
No Load RPM	290 rpm
Stall torque	120 oz-in

The above motor has a stall torque of 120 oz-in which is close to the required value of 131.22 oz-in. Furthermore, the No Load RPM is 290 rpm. Therefore, this motor aligns with all the boundary requirements.

According to the torque speed graph, we can calculate the operational speed at our required torque.

Operational speed = $\left(\frac{290}{120}\right) \times (120 - 39.368) = 194.86$ rpm

The above calculation indicate that the motor can accommodate the required operational speed at the operational torque.

34:1 Metal Gearmotor 25Dx52L mm HP 12V	
No Load RPM	300 rpm
Stall torque	150 oz-in

The above motor has a stall torque of 150 oz-in which is greater than 120 oz-in. The No Load RPM of the motor is 300 rpm which can easily accommodate our requirements.

According to the torque speed graph, we can calculate the operational speed at our required torque.

Operational speed = $\left(\frac{300}{150}\right) \times (150 - 39.368) = 221.26$ rpm

The above calculation indicate that the motor can accommodate the required operational speed at the operational torque.

Conclusion

After considering the above calculations and the qualitative requirements, we have selected 34:1 Metal Gearmotor 25Dx64L mm HP 12V with 48 CPR Encoder (No End Cap) as it is both suitable for our application and provided by the university.