Choose a proper Servo Motor

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1 Usage of Servo Motors in the Mobile Robot

In our robot servo motors are used only to control the robot arm which we hope to use to lift the box which we need to inspect the color of the bottom side. To achieve this task we planned to use a robot arm consisting of three servo motors. Two of them are used to operate the arm and the gripper base while the remaining servo is used to control the gripper mechanism which holds the box.

1.1 Calculations for the required torques

Perpendicular distances to the lines of action of gravitational forces become maximum when the robot arm at the position depicted in the Figure 1. Therefore the maximum torque about the shafts of servo motors can be expected at this position. If a servo motor can overcome this maximum torque we can assume that it will definitely be able to handle any other torque it may come across during the operation.

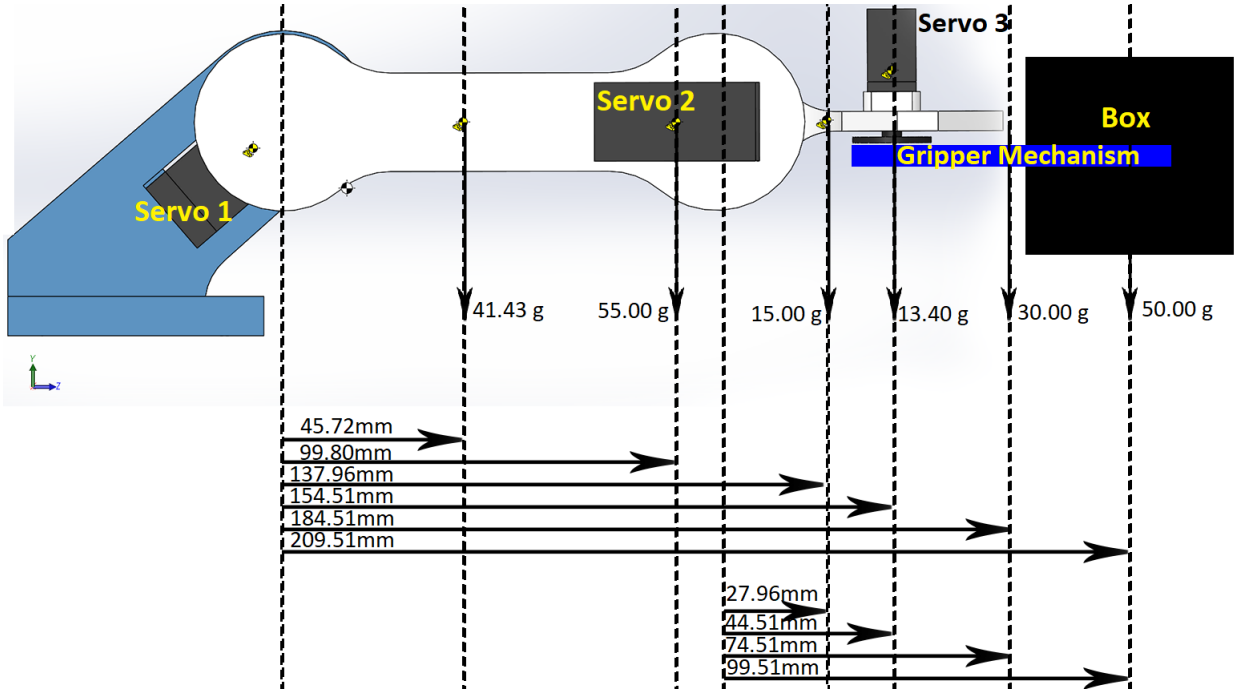


Figure 1: Free Force Diagram of the robot arm and approximated distances to the lines of action of gravitational forces

For the calculations, properties of one of the common 3D printing materials *Acrylonitrile Butadiene Styrene (ABS)* plastic is considered and mass of the following parts were taken through *Mass Properties* calculator in the *SolidWorks Application* and therefore 100% accuracy can not be guaranteed.

Mass of the gripper base	15.00 grams
Mass of the arm	41.43 grams

In addition to that mass of the gripper mechanism assumed to be 30.00 grams and mass of the box was taken as 50.00 grams which will possibly be less than that.

1.1.1 Torque about shaft of Servo 1

$$\begin{aligned} MAX(\tau) &= 41.43 * 45.72 + 55.00 * 99.80 + 15.00 * 137.96 + 13.40 * 154.51 + 30.00 * 184.51 + 50.00 * 209.51 \\ &= 2.7534 * 10^4 \ g\ mm \\ &= 2.7534 \ Kg\ cm \end{aligned}$$

1.1.2 Torque about shaft of Servo 2

$$\begin{aligned} MAX(\tau) &= 15.00 * 27.96 + 13.40 * 44.51 + 30.00 * 74.51 + 50.00 * 99.51 \\ &= 8.2266 * 10^3 \ g\ mm \\ &= 0.82266 \ Kg\ cm \end{aligned}$$

1.2 Selection of Servo Motors

Calculations were done assuming the ideal conditions and 100% efficiency can not be expected form motors in real world application and therefore servo motors are selected in a way that they can handle at least twice the above calculated torques easily.

For the Servo 1 and 2 TowerPro MG996R servo motor was chosen which has following characteristics

Weight	55g
Dimension	40.7*19.7*42.9 mm^3
Stall torque	**9.4kg/cm (4.8v); 11kg/cm (6.0v)**
Operating speed	0.19sec/60degree (4.8v); 0.15sec/60degree (6.0v)
Operating voltage	4.8- 6.6v
Gear Type	Metal gear
Dead band width	1us

Table 1: Characteristics of TowerPro MG996R servo [2]

For the Servo 3 which is use to operate the gripper mechanism which is not mass critical, TowerPro MG90S micro servo motor was chosen which has following characteristics.

Weight	13.4g
Dimension	22.8*12.2*28.5mm
Stall torque	**1.8kg/cm (4.8V); 2.2kg/cm (6.6V)**
Operating speed	0.10sec/60degree (4.8V); 0.08sec/60degree (6.0V)
Operating voltage	4.8V
Gear Type	Metal gear
Dead band width	1us

Table 2: Characteristics of TowerPro MG90S servo [1]

1.3 Modified Initial Protype

Note : The gripper mechanism is not shown in the following models

(a) TowerPro MG90S servo

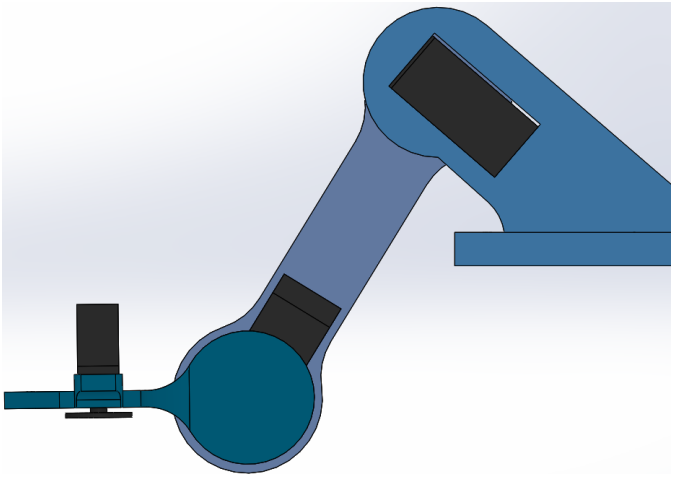
(b) TowerPro MG996R servo

Figure 2: Selected servo

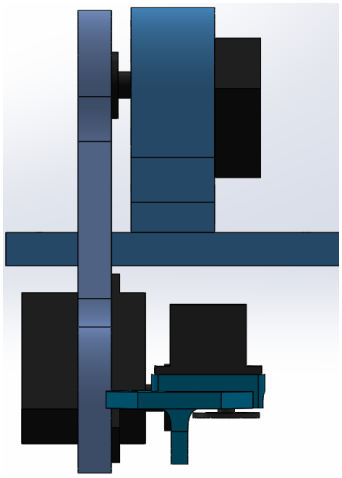
Bibliography

[1] admin. MG90S | Tower Pro. http://www.towerpro.com.tw/product/mg90s-3/.

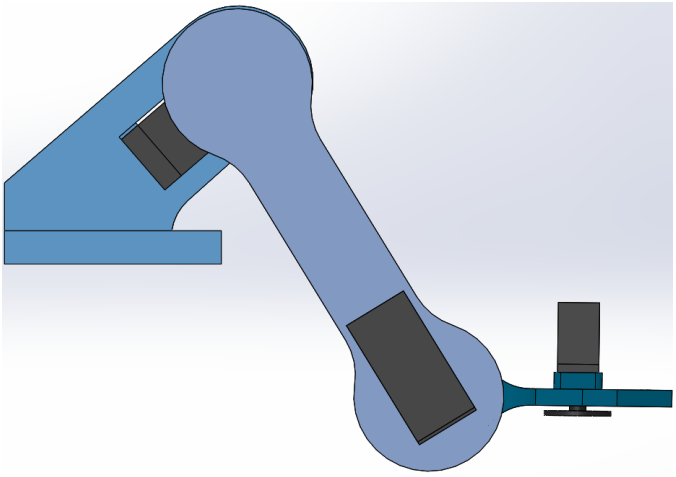
[2] admin. MG996R | Tower Pro. http://www.towerpro.com.tw/product/mg996r/.



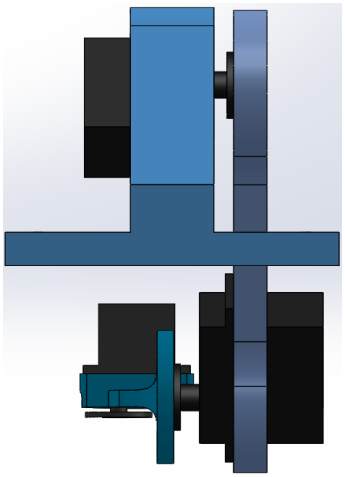
(a) Side View 1



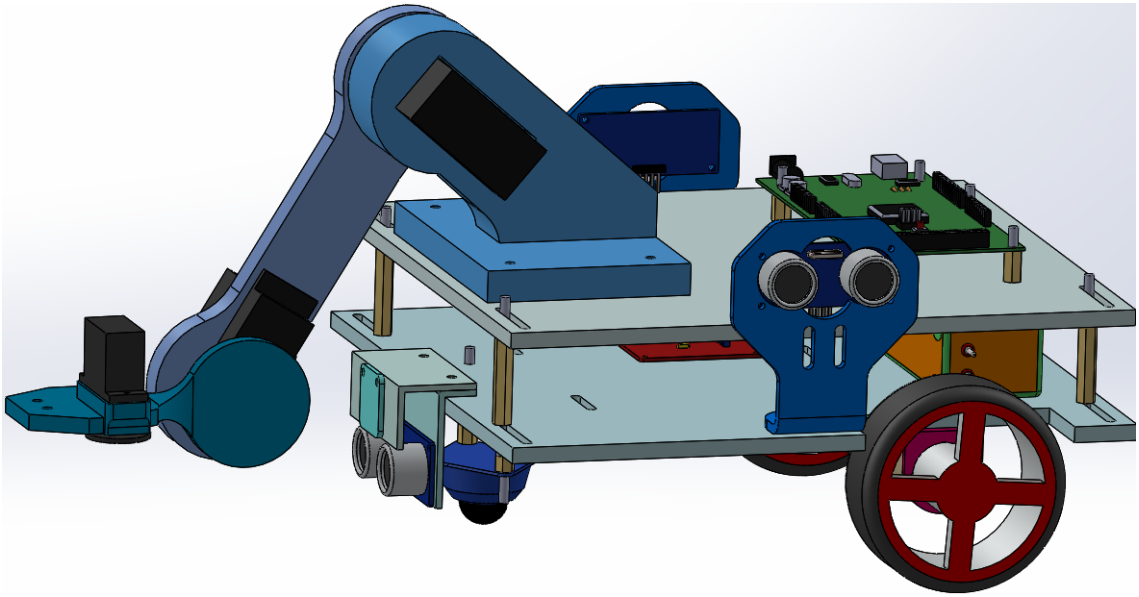
(b) Front View



(c) Side View 2



(d) Back View



(e) Overall View Of the Mobile Robot

Figure 3: Servo Motors in the Robot Arm