Introduction to Robotics
Lab 3 - Sensing and actuation for the arm

Names: Hamad Abdul Razzaq & Muhammad Ali Siddiqui
IDs: hr06899 & ms06875

Lab Report

Task 3.1

Part (a)

Sensors

- Camera - Will be used to get the information about the ARM Hardware and/or the object(s).
- Potentiometer inside servo motor - Used as a shaft position sensor.

Actuators

- Servo Motor - Responsible for the rotation of ArmLink(s).

Part (b)

We can use potentiometer as a position sensor in such a way that the resistance of the potentiometer can be mapped to the position of the shaft. So, even if we power off the circuit, the value of the potentiometer will not return to 0, infact, it will stay where it was. As a result, Potentiometer can be used to measure the **absolute** position of an object. In the servo motor attached to our Robot, the same principle can be used to determine the absolute position of the shaft. Based on potentiometer readings, we can decide where the shaft is currently at and then rotate it, as specified by the user.

References:

1. https://www.directindustry.com/industrial-manufacturer/potentiometer-position-sensor-148672.html

Task 3.2

Part (a)

- **Angle rotation limits** - The Angle rotation limits are specified to be from 0 to 1023 with a step size of 0.29^o. This means that our motor can rotate from 0^o to 300^o approximately.
- **Resolution** - 0.29^o
- **Speed Limit** - 114 rpm (rotations per minute). However, if the maximum rpm of motor is higher than 114, then the speed limit can be as high as the maximum rpm of the motor.
- **Torque Limit** - 1.5 Nm

Part (b)

Yes, it will indeed limit the possible cartesian resolution of the end effector. The reason could be explained with the help of an example. Consider we want to move the end-effector from position a to position b. For such movement, one of the motors have to rotate by a value less than 0.29^o. Since, the motor cannot take a step smaller than 0.29^o, as a result we cannot arrive exactly at position b but we arrive at the closest possible position to b which would be $b + \delta$ where δ is a very small value. As a result, our cartesian coordinate resolution limited by the motor resolution limit.

Task 3.3

The Camera was set up as instructed. The *Intel RealSense Viewer* tool was used to get both the RGB and depth streams. Different features of the software were explored such as different depth color schemes, the coordinates at a certain position, etc.

Task 3.4

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Progress Report

Name: Hamad Abdul Razzaq

Course: Image Processing Onramp

Progress: **70%** complete (as of 23 January 2023)

Chapters

1. Introduction **100%**
2. Images in MATLAB **100%**
3. Image Segmentation **100%**
4. Preprocessing and Postprocessing Techniques **100%**
5. Classification and Batch Processing **0%**
6. Conclusion **0%**

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6. Conclusion **0%**

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Task 3.5

The following segment in the file extracts a color frame and displays it:

```
% Select color frame
color = fs.get_color_frame();

% Get actual data and convert into a format imshow can use
% (Color data arrives as [R, G, B, R, G, B, ...] vector)
data = color.get_data();
img = ...
    permute(reshape(data',[3,color.get_width(),color.get_height()]),[3 ...
    2 1]);

% Display image
figure;
imshow(img);
title(sprintf('Color frame from %s', name));
```

Task 3.6

The takeways about the vision-based pick and place robotic system are that the task is to pick and object using a robot arm and place it at a certain location using the camera. We were familiarized with the movement and picking up of the object in Lab 2 and then we were introduce to capturing the rgb and depth frames using the camera in this Lab. The expectations ahead are that we will process the image obtained from the camera to determine the position of the object that we want to pick. And then we will command our robot arm to move to that location, pick the object and place it at our desired location.

Task 3.7

We have the following information:

$$
\begin{aligned}
L_1 &= 0.125m \\
L_2 &= 0.125m \\
L_3 &= 0.12m \\
\tau &= 1.5Nm \\
M_1 &= 0.0535kg \\
M_2 &= 0.0535kg \\
M_3 &= 0.0535kg \\
m1 &= 0.0528kg \\
m2 &= 0.0528kg \\
m3 &= 0.0366kg
\end{aligned}
$$

The Stall Torque for wrist is given by:

$$\tau = M_L g \left(L_1 + L_2 + L_3\right) + m_3 g \left(L_1 + L_2 + \frac{L_3}{2}\right) + M_3 g \left(L_1 + L_2\right) + m_2 g \left(L_1 + \frac{L_2}{2}\right) + M_2 g L_1 + m_1 g \frac{L_1}{2}$$

Arranging the equation for M_L, we get:

$$M_L = \frac{\tau - m_3 g \left(L_1 + L_2 + \frac{L_3}{2}\right) - M_3 g \left(L_1 + L_2\right) - m_2 g \left(L_1 + \frac{L_2}{2}\right) - M_2 g L_1 - m_1 g \frac{L_1}{2}}{g \left(L_1 + L_2 + L_3\right)}$$

After plugging in the values, we get:

$$\boxed{M_L = 293.1g}$$

Which is roughly close to the provided value, i.e., 250 g. The error in the calculations is because of the assumptions that we made in our calculations such as, locating the center of mass at the center of the link, fictional and dynamic effects, etc.