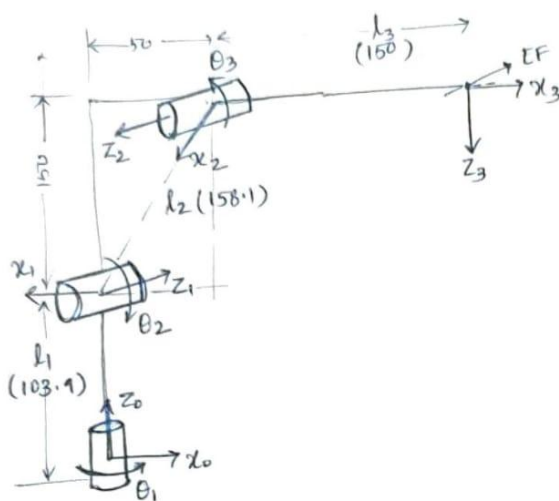


## ROS Assignment 2 Report

The forward kinematics of the Interbotix RX-150 manipulator were calculated after carefully studying the schematic diagram for lengths, angles and RViz for determining the correct z-axis for joint angles of the shoulder and elbow. The following image shows the derivation of the DH parameters on the basis of which the *forward\_kinematics.py* script works.

Forward kinematics for wrist of Interbotix RX-150.



$x_0 \rightarrow x_1$   $z_0$   
 $z_0 \rightarrow x_1$   $z_0$   
 $z_0 \rightarrow x_1$   $x_1$   
 $z_0 \rightarrow z_1$   $x_1$

$x_1 \rightarrow x_2$   $z_1$   
 $z_1 \rightarrow x_2$   $z_1$   
 $z_1 \rightarrow x_2$   $x_2$   
 $z_1 \rightarrow z_2$   $x_2$

$x_2 \rightarrow x_3$   $z_2$   
 $z_2 \rightarrow x_3$   $z_2$   
 $z_2 \rightarrow x_3$   $x_3$   
 $z_2 \rightarrow z_3$   $x_3$

$i$	$\theta$	$d$	$a$	$\alpha$
1	$\pi + \theta_1^*$	$l_1$	0	$\pi/2$
2	$2\pi - \tan^{-1}(3) + \theta_2^*$	0	$-l_2$	$-\pi$
3	$\pi - \tan^{-1}(3) + \theta_3^*$	0	$l_3$	$\pi/2$

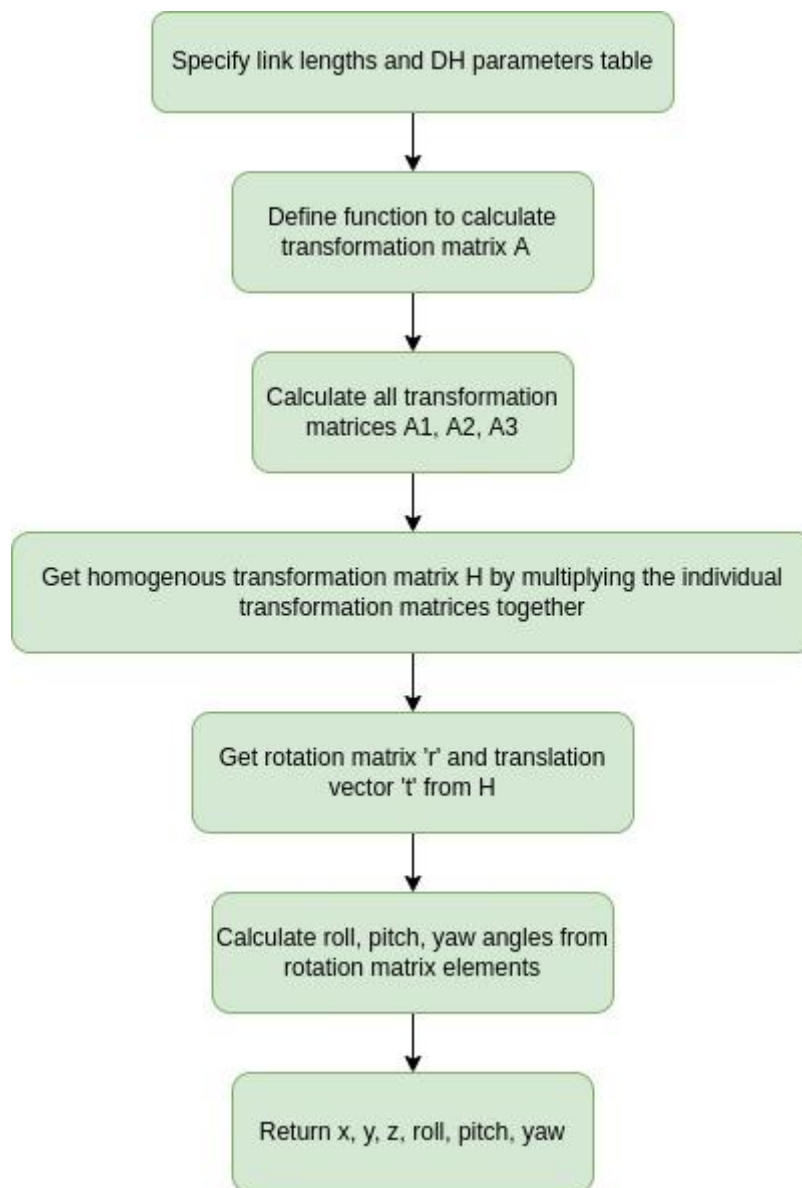
$$l_1 = 103.9$$

$$l_2 = 158.1$$

$$l_3 = 150$$

$$\tan^{-1}(3) = \left\{ \tan^{-1}\left(\frac{150}{50}\right) \right\}$$

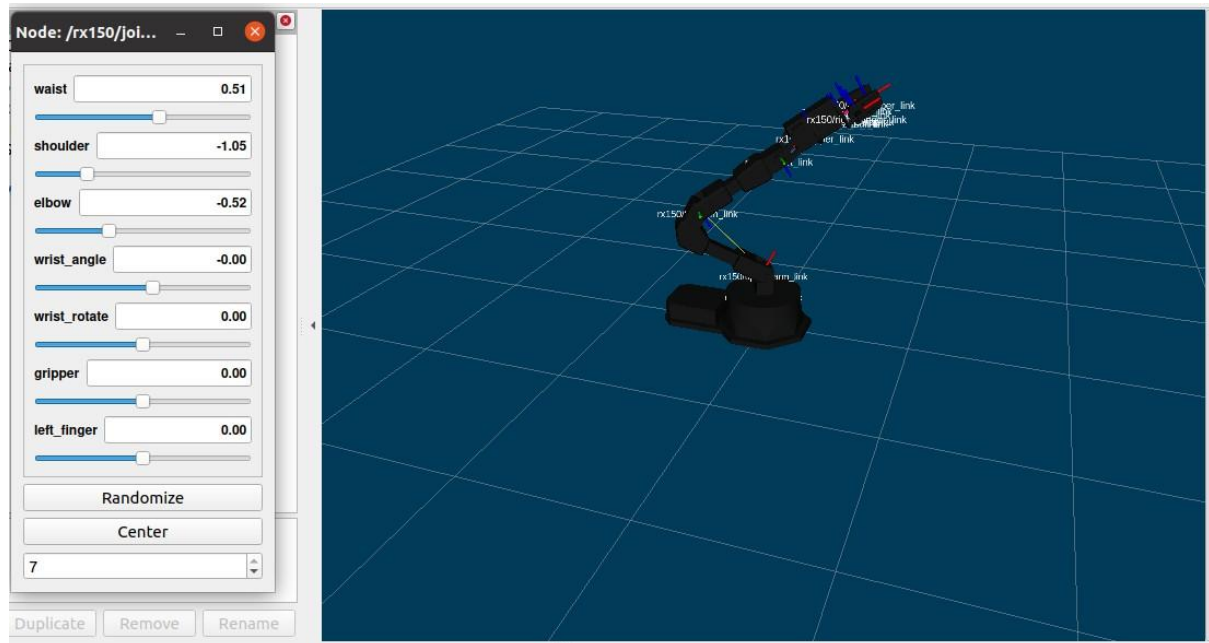
The flowchart below depicts the logic of the script '*forward\_kinematics.py*'



**Note:** The screenshots of results for the various test cases have been attached in the pages to follow.

## Test case 1:

rviz:



tf:

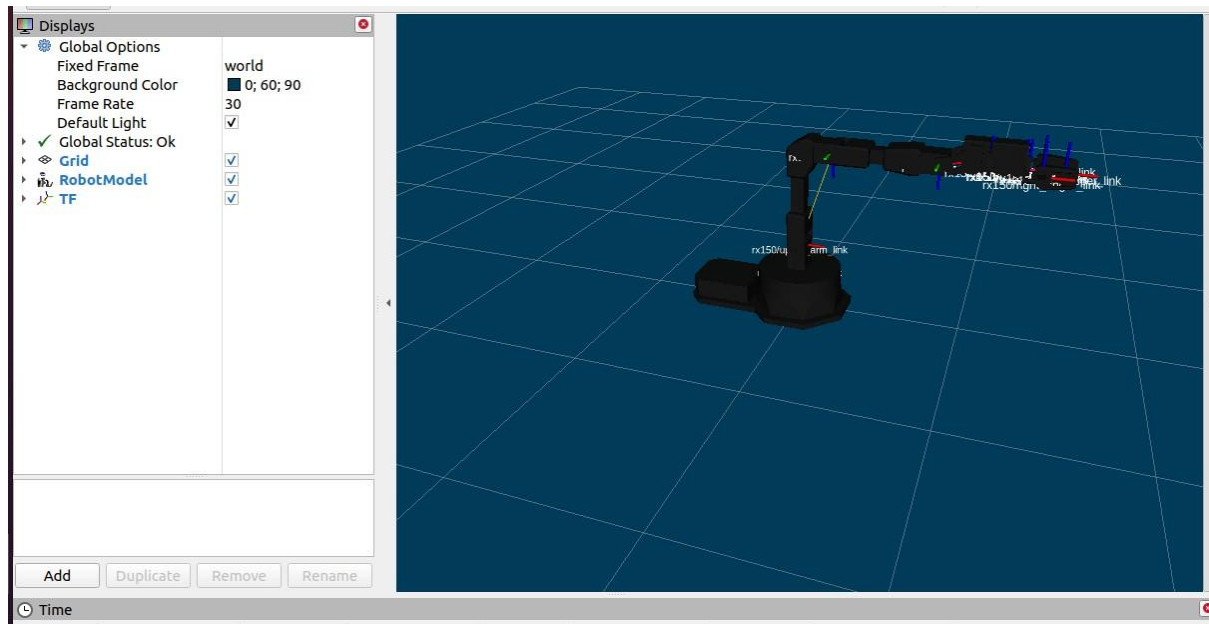
```
At time 1644634233.066
- Translation: [0.021, 0.012, 0.298]
- Rotation: in Quaternion [0.934, 0.244, 0.254, -0.066]
           in RPY (radian) [3.142, -0.530, 0.512]
           in RPY (degree) [180.000, -30.393, 29.340]
At time 1644634234.067
- Translation: [0.021, 0.012, 0.298]
- Rotation: in Quaternion [0.934, 0.244, 0.254, -0.066]
           in RPY (radian) [3.142, -0.530, 0.512]
           in RPY (degree) [180.000, -30.393, 29.340]
```

script:

```
joint angles = [ 0.524 -1.047 -0.524]
x y z = [0.022 0.013 0.297]
r p y (deg) = [-180. -30. 30.]
Traceback (most recent call last):
```

## Test case 2:

rviz:

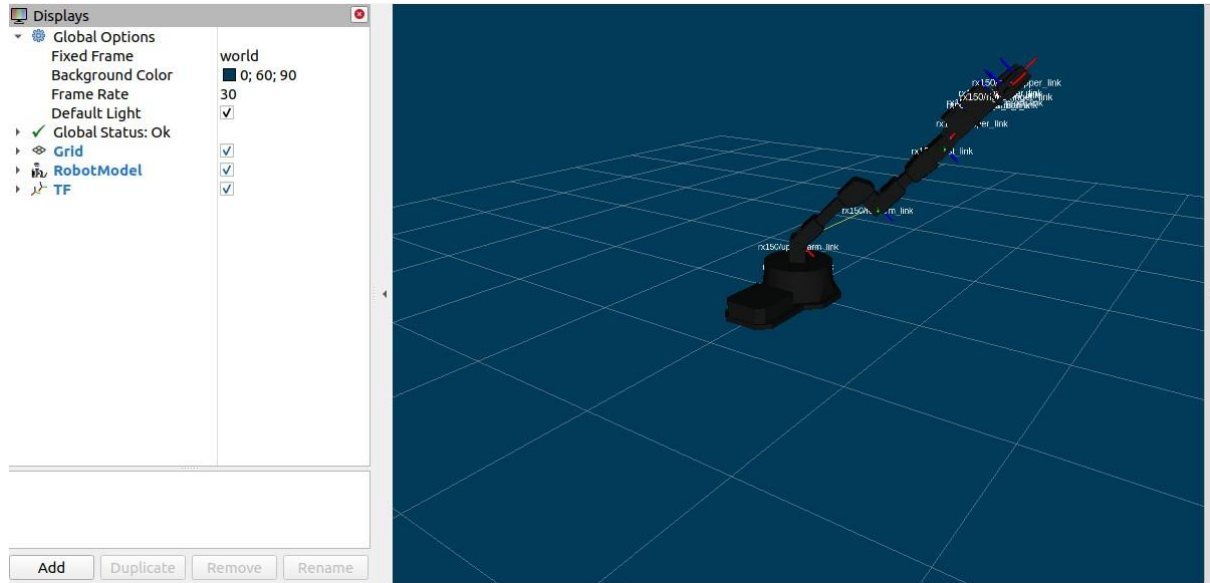


tf:

```
At time 1644634012.067
- Translation: [0.200, -0.000, 0.254]
- Rotation: in Quaternion [1.000, -0.000, -0.000, 0.000]
           in RPY (radian) [3.142, 0.000, -0.000]
           in RPY (degree) [180.000, 0.009, -0.000]
At time 1644634013.067
- Translation: [0.200, -0.000, 0.254]
- Rotation: in Quaternion [1.000, -0.000, -0.000, 0.000]
           in RPY (radian) [3.142, 0.000, -0.000]
           in RPY (degree) [180.000, 0.009, -0.000]
```

script:

```
joint angles = [0 0 0]
x y z = [ 0.2  -0.  0.254]
r p y (deg) = [180. -0. -0.]
```

 Displ

```
At time 1644634403.066
- Translation: [0.122, -0.214, 0.282]
- Rotation: in Quaternion [0.798, -0.462, 0.335, 0.194]
           in RPY (radian) [3.142, -0.794, -1.051]
           in RPY (degree) [180.000, -45.495, -60.192]
At time 1644634404.066
- Translation: [0.122, -0.214, 0.282]
- Rotation: in Quaternion [0.798, -0.462, 0.335, 0.194]
           in RPY (radian) [3.142, -0.794, -1.051]
           in RPY (degree) [180.000, -45.495, -60.192]
```

epcs7

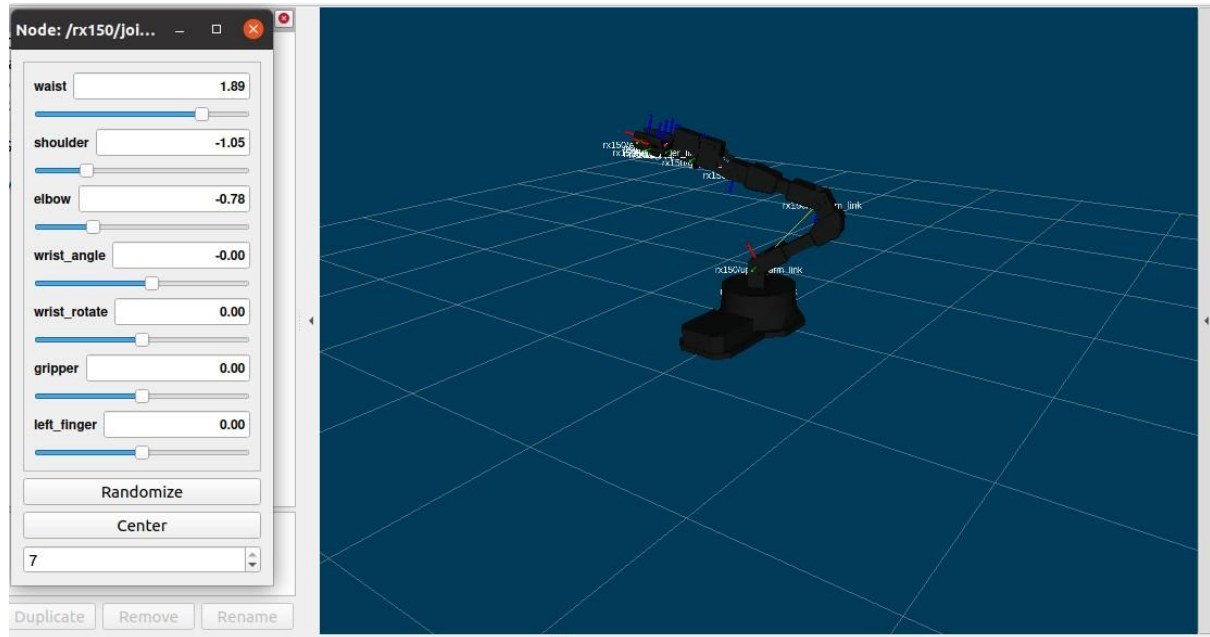
```

tpcs/test_forward_kinematics.py
joint angles = [-1.047  0.785  1.571]
x y z = [ 0.124 -0.214  0.281]
r p y (deg) = [180. -45. -60.]
Traceback (most recent call last):

```

## Test case 4:

rviz:



tf:

```
At time 1644634556.066
- Translation: [-0.012, 0.037, 0.262]
- Rotation: in Quaternion [0.580, 0.804, 0.078, -0.108]
           in RPY (radian) [3.142, -0.267, 1.891]
           in RPY (degree) [180.000, -15.326, 108.360]
At time 1644634557.066
- Translation: [-0.012, 0.037, 0.262]
- Rotation: in Quaternion [0.580, 0.804, 0.078, -0.108]
           in RPY (radian) [3.142, -0.267, 1.891]
           in RPY (degree) [180.000, -15.326, 108.360]
```

script:

```
joint angles = [ 1.885 -1.047 -0.785]
x y z = [-0.012 0.038 0.261]
r p y (deg) = [-180. -15. 108.]
Traceback (most recent call last):
```