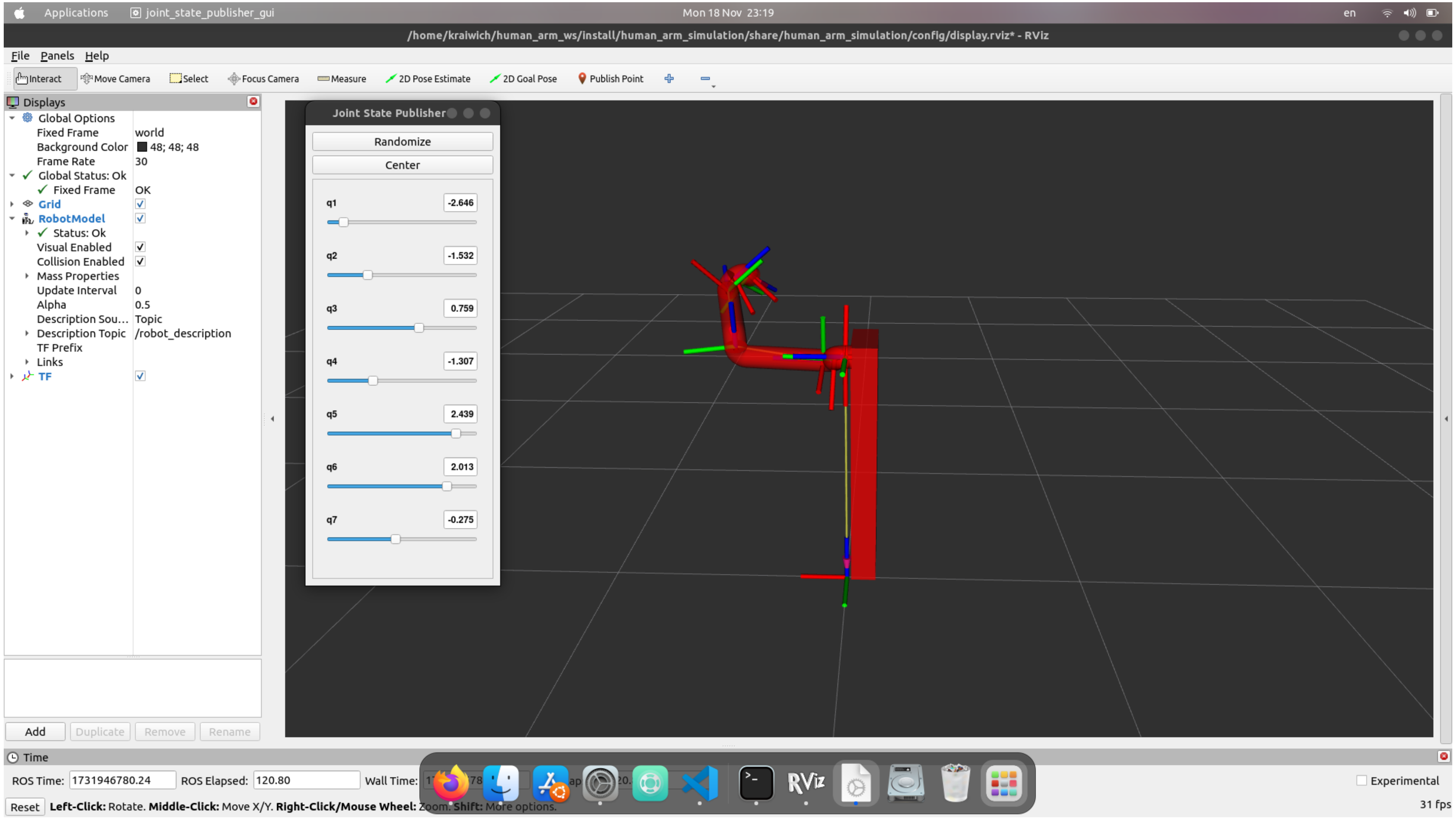
Progress Update

7 DOF MANIPULATOR SIMULATES THE JOINT PATTERN OF A HUMAN ARM KINEMATICS SIMULATION

Group 24

7 DOF MANIPULATOR MODEL



MATH AND KINEMATICS CONCEPT

MDH – Parameter of 7 DOF 3R – R – 3R

DHRobot: Human Arm, 7 joints (RRRRRRR), dynamics, modified DH parameters

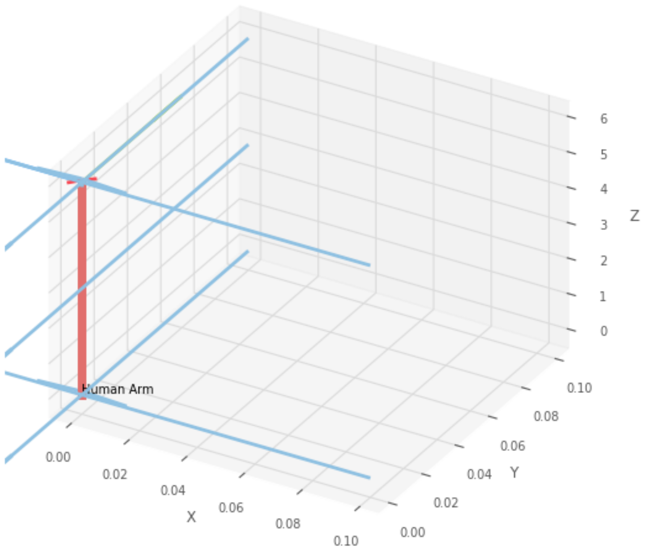
a_{j-1}	α_{j-1}	θ_j	d_j
0.0	0.0°	q1	0.0
0.0	90.0°	q2 + 90°	0.0
0.0	-90.0°	q3	0.0
3	90.0°	q4 - 90°	0.0
0.0	-90.0°	q5	3
0.0	90.0°	q6 + 90°	0.0
0.0	-90.0°	q7	0.0

```python
# 3R-R-3R
human_arm = rbt.DHRobot([
        rbt.RevoluteMDH(), #joint 1
        rbt.RevoluteMDH(alpha = pi/2, offset = pi/2), #joint 2
        rbt.RevoluteMDH(alpha = -pi/2), #joint 3
        rbt.RevoluteMDH(a = l1, alpha = pi/2, offset = -pi/2), #joint 4
        rbt.RevoluteMDH(alpha = -pi/2, d = l2), #joint 5
        rbt.RevoluteMDH(alpha = pi/2, offset = pi/2), #joint 6
        rbt.RevoluteMDH(alpha = -pi/2), #joint 7
    ],
    name = "Human Arm"
)
human_arm
```

MATH AND KINEMATICS CONCEPT

MoveJ Mode

Forward Kinematics

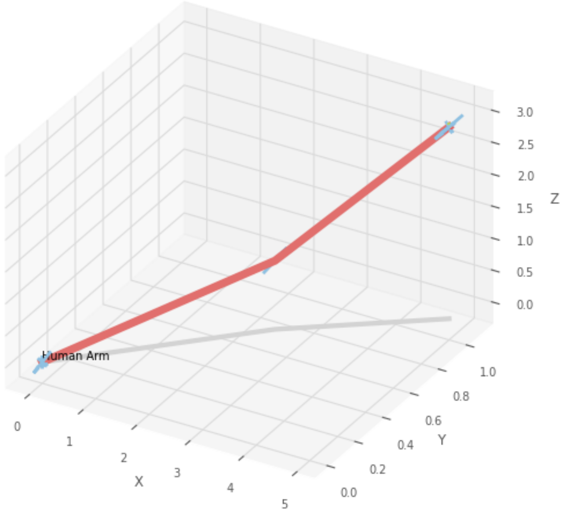



```
q = [0,0,0,0,0,0,0]
```

```
T_0e = human_arm.fkine(q)
T_0e
```

```
  0    0   -1    0
  0    1    0    0
  1    0    0    6
  0    0    0    1
```

Invert Kinematics




```
T_goal = SE3(5,1,3) @ SE3.Rx(pi/2)
T_goal
```

```
  1    0    0    5
  0    0   -1    1
  0    1    0    3
  0    0    0    1
```

```
q_sol = human_arm.ikine_LM(T_goal)
```

```
q_sol
```

```
IKSolution(q=array([ 0.59176464,  1.96060021, -2.7990761 , -0.33489993, -1.84468853,
        0.1264097 , -0.70394593]), success=True, iterations=16, searches=1, residual=3.899056967795112e-07, reason='Succes
s')
```

MATH AND KINEMATICS CONCEPT

MoveL Mode

Target direction

Target_pos – Current_pos = Diff_pos

Diff_pos → **Unit vector**

x 0.5

Velocity (x,y,z,roll,pitch,yall)

```
target_direction = [
    target[0] - current_pos.x,
    target[1] - current_pos.y,
    target[2] - current_pos.z,
    target[3] - current_pos.rpy()[0], # roll
    target[4] - current_pos.rpy()[1], # pitch
    target[5] - current_pos.rpy()[2] # yall
]
target_direction
```

```
unit_target_direction =[
    target_direction[0] / linear_size,
    target_direction[1] / linear_size,
    target_direction[2] / linear_size,
    target_direction[3] / angular_size,
    target_direction[4] / angular_size,
    target_direction[5] / angular_size,
]
unit_target_direction
```

```
vel = [
    unit_target_direction[0] * 0.5,
    unit_target_direction[1] * 0.5,
    unit_target_direction[2] * 0.5,
    unit_target_direction[3] * 0.5,
    unit_target_direction[4] * 0.5,
    unit_target_direction[5] * 0.5,
]
```

MATH AND KINEMATICS CONCEPT

MoveL Mode

Jacobian

$$J^{\dagger} = J^{T}\left(JJ^{T}\right)^{-1}$$

```
J = human_arm.jacob0(current_q)
J
```

```
array([[-1.83697020e-16, -6.00000000e+00, -3.67394040e-16,
        -3.00000000e+00,  0.00000000e+00,  0.00000000e+00,
         0.00000000e+00],
       [ 1.83697020e-16, -2.46519033e-32,  6.00000000e+00,
        -1.23259516e-32,  0.00000000e+00,  0.00000000e+00,
         0.00000000e+00],
       [-3.03535178e-49,  1.83697020e-16, -1.83697020e-16,
         1.23259516e-32,  0.00000000e+00,  0.00000000e+00,
         0.00000000e+00],
       [ 0.00000000e+00,  0.00000000e+00, -1.00000000e+00,
         0.00000000e+00,  0.00000000e+00,  0.00000000e+00,
        -1.00000000e+00],
       [-3.74939946e-33, -1.00000000e+00, -6.12323400e-17,
        -1.00000000e+00, -3.74939946e-33, -1.00000000e+00,
        -6.12323400e-17],
       [ 1.00000000e+00,  6.12323400e-17,  6.12323400e-17,
         6.12323400e-17,  1.00000000e+00,  6.12323400e-17,
         6.12323400e-17]])
```

```
J_new = np.dot(Jt,Jit)
J_new
```

```
array([[-5.10269500e-18,  5.10269500e-18,  9.24197836e-17,
         4.59242550e-17,  4.59242550e-17,  5.00000000e-01],
       [-5.55111512e-17,  1.66666667e-01,  5.44374645e+15,
        -1.95431051e-16,  1.11022302e-16, -1.53080850e-17],
       [-1.37130180e-16,  1.66666667e-01, -1.56393174e+00,
        -1.11022302e-16,  1.41150633e-16, -1.53080850e-17],
       [-3.33333333e-01, -3.33333333e-01, -1.08874929e+16,
         3.90862102e-16, -5.55111512e-16,  6.16297582e-33],
       [ 5.10269500e-18, -5.10269500e-18,  1.54609491e-16,
         1.53080850e-17,  1.53080850e-17,  5.00000000e-01],
       [ 3.33333333e-01,  1.66666667e-01,  5.44374645e+15,
        -1.34198711e-16, -1.00000000e+00,  1.53080850e-17],
       [ 1.34198711e-16, -1.66666667e-01,  4.38326254e+00,
        -1.00000000e+00, -1.34198711e-16,  1.53080850e-17]])
```

MATH AND KINEMATICS CONCEPT

MoveL Mode

Calculate q_dot

$$\dot{q} = J^{\dagger}(q)\dot{x}$$

```
q_dot = np.dot(J_new,vel)
q_dot
```

```
array([-1.19410199e-17, -1.38024164e+15,  4.10614973e-01,  2.76048328e+15,
       -3.95670221e-17, -1.38024164e+15, -1.12544580e+00])
```

Calculate joint effort

$$\mathbf{t} = J^{\mathrm{T}}(q)w$$

```
w = [1.0, 1.0, 1.0, 1.0, 1.0, 1.0]
w
```

```
[1.0, 1.0, 1.0, 1.0, 1.0, 1.0]
```

```
t = np.dot(J.transpose(),w)
t
```

```
array([-2.57405257, -6.9258615 ,  1.35180893, -4.31208182,  1.06741805,
       -0.39815702, -1.3046416 ])
```

MATH AND KINEMATICS CONCEPT

MoveL Mode

Find Singularity (not sure in math detail)

USE Singular Value Decomposition (SVD)

```python
import numpy as np
from scipy.linalg import svd

# Compute singular values
U, S, Vh = svd(J)
print("Singular values:", S)

# Check for near-zero singular values
if np.any(S < 1e-6):
    print("Jacobian is near singular.")
else:
    print("Jacobian is non-singular.")
```

```
Singular values: [6.84451016e+00 6.08504366e+00 1.41421356e+00 1.07362968e+00
 9.86024149e-01 4.09684666e-17]
Jacobian is near singular.
```

Thank You