Lab 1 Report

Methods

Formulation

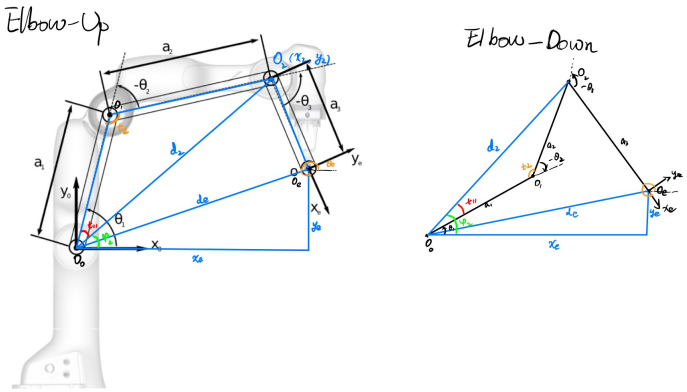
(TODO)

FK

(TODO)

IK

- Compute position of $O_2(x_2, y_2)$
- Compute d_2, d_e, ϕ_2
- Draw the elbow-up and elbow-down solutions
    - Compute intermediate angles t_{11}, t_2 using law of cosines
    - Compute θ_1, θ_2 for each solution using the intermediate ϕ_2, t_{11}, t_2:



- Compute $\theta_3 = \theta_e - \theta_1 - \theta_2$

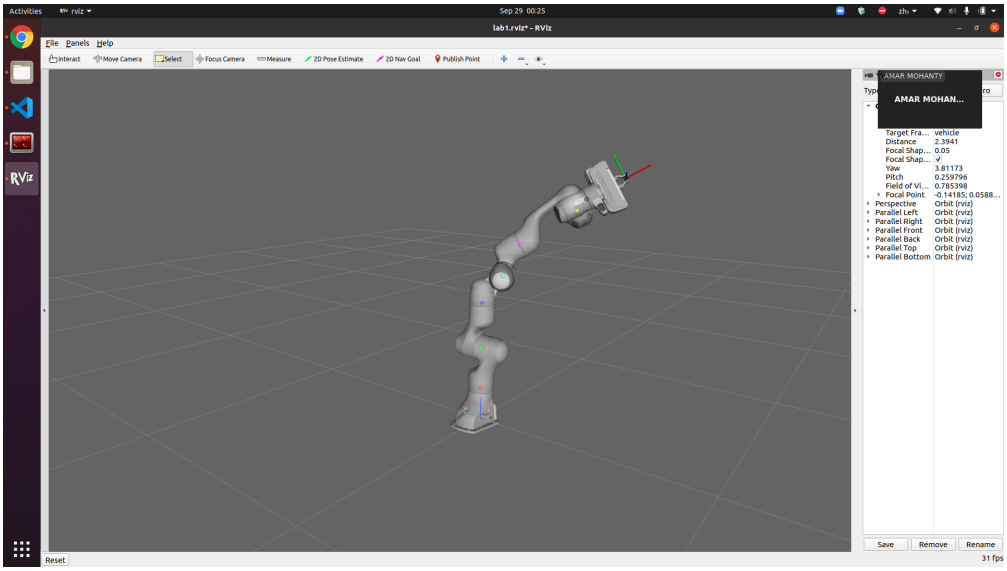
Evaluation

FK

If the joint points and end effector frame are glued to the robot as it moves, then the FK solution is correct

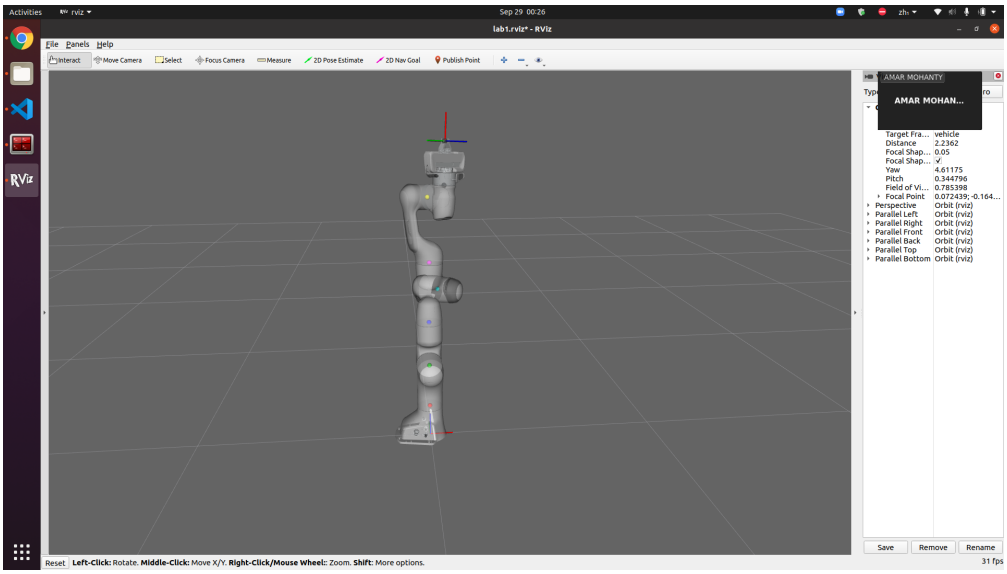
Config 1

```
np.array([ 0, 0, -pi/3, -pi/3, pi/3, pi, pi/3 ])
```



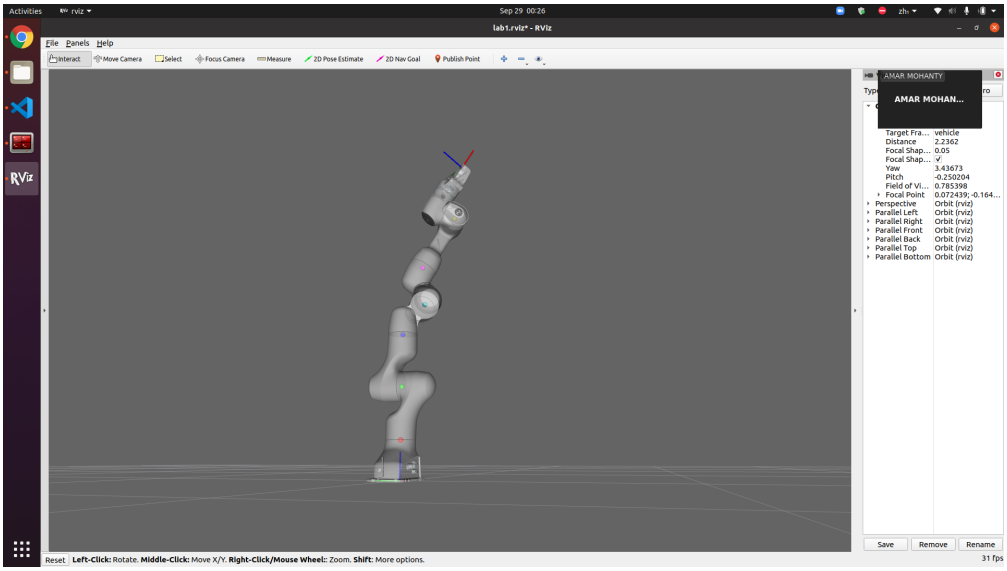
Config 2

```
np.array([ 0, 0, pi/3, pi/3, pi/3, pi, pi/3 ])
```



Config 3

```
np.array([ 0, 0, -pi/3, -pi/6, 0, pi, pi/3 ])
```

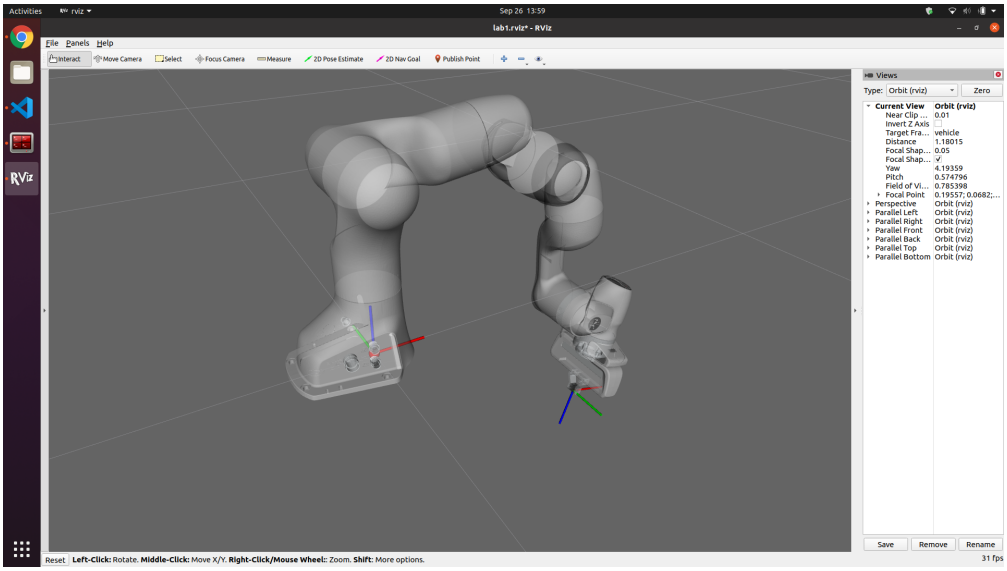


IK

If the end effector can reach the target with desired position and orientation, then the IK solution is correct.

Target 1

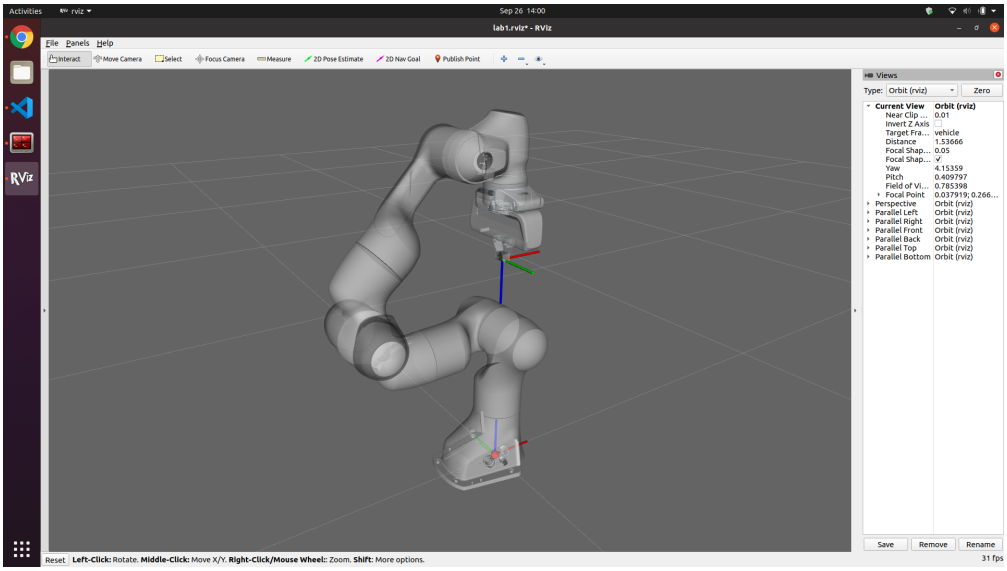
```
{ # IK target 1
    'o': np.array([0.5, -0.3]),
    'theta': pi/2+0.3
}
```



Target 2

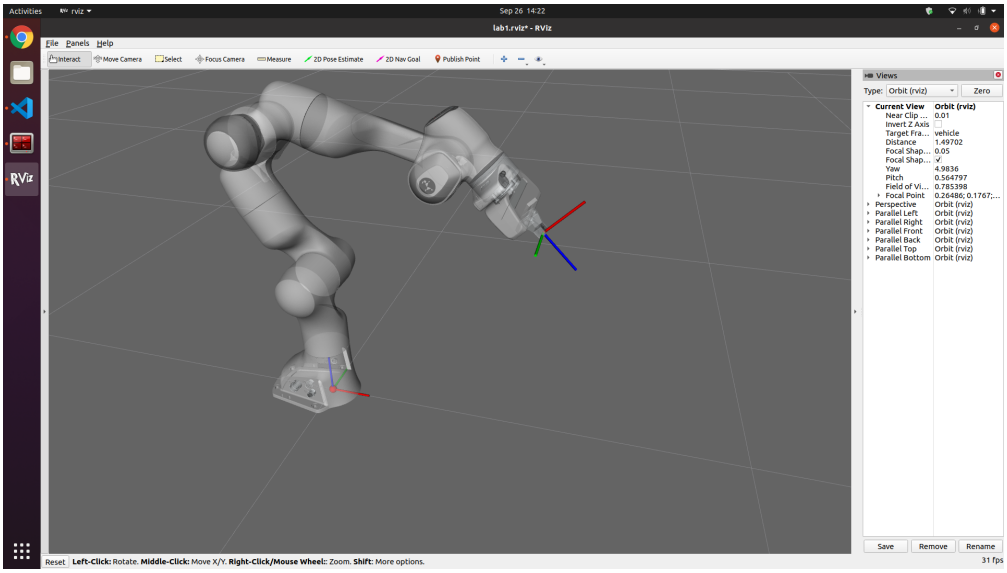
```
{ # IK target 2
    'o': np.array([0, 0.5]),
```

```
    'theta': pi/2
}
```



Target 3

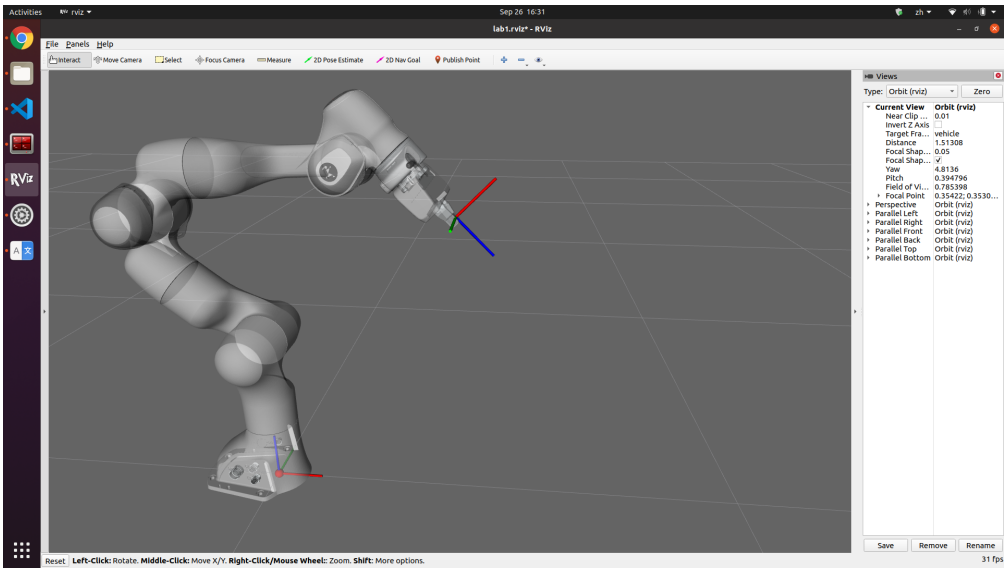
```
{ # IK target 3
    'o': np.array([0.5, 0.5]),
    theta': 1/4 * pi
}
```



Analysis

Gravity

With gravity, the manipulator tends to move faster and will have a little shake when reaching the target. The final posiiton of the end effector might be a little below the target.



The reason might be with gravity, the joints cannot reach the exact computed values because of the external gravity force.

Reachable workspace

(TODO)

Extending Inverse Kinematics to 3D

Panda does have a spherical wrist. However, kinematic decoupling does not work on the full Panda robot because it has 7 dofs, and you have to solve the first 4 joint variables with only 3 equations (the position of the wrist center). The appropriate way I can think of is to use geometric approach to solve the first 4 joint variables, and then the 3 joint variables of the wrist can be solved using Euler angles. The challenge with the 7 dof arm is that both numerical and geometric approach will be more complicated because of the one more redundant dof, and methods like kinematic decoupling will be inapplicable.