CS 6301 Introduction to Robot Manipulation and Navigation Homework 1

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In this homework, write down your solutions for problem 1 and finish the coding problem 2. Upload your solutions and code to eLearning. Our TA will check your solutions and run your scripts to verify them.

Problem 1

(3 points)

Grübler's Formula. Exercise 2.7 in Lynch and Park, Modern Robotics.

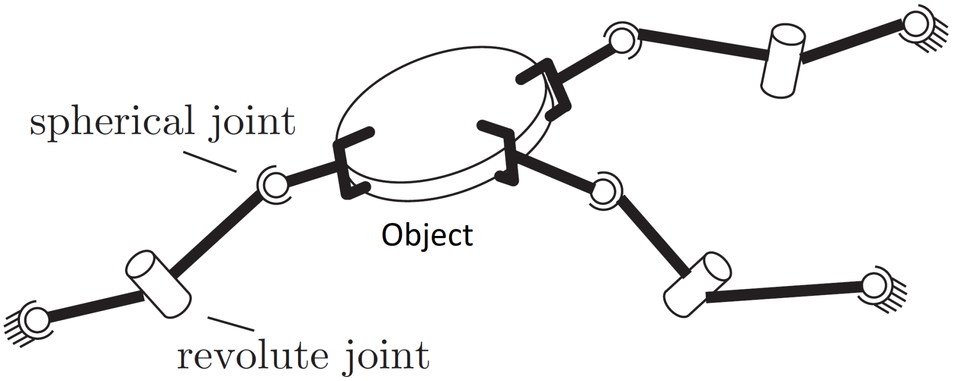


Figure 1: Three cooperating SRS arms grasping a common object.

Three identical SRS open-chain arms are grasping a common object, as shown in Figure 1. Find the number of degrees of freedom of this system using Grübler's formula. Write down how you apply Grübler's formula to this system.

Problem 2

(7 points)

ROS programming and Rviz.

In this problem, you will learn how to build a ros workspace and visualize a Fetch mobile manipulator robot in Rviz. **You can directly use Ubuntu, or Docker or virtual machine to install ROS according to your own set up**. Refer to the ROS wiki page if needed `http://wiki.ros.org/`.

(2.1) **(For Docker users)** First, build a docker image with ros following the instructions in the lecture. Test your ros installation by running the rviz command. Before we start on building the ROS workspace, Let's learn how to mount a host folder into Docker. Usually, your code will be stored in your host folder. You can use the "-v" option of the Docker run command to mount a folder into the Docker environment. For example, the following command will mount a folder in Windows "C:\data" as a folder "/data" in Docker:

- docker run -it -v C:\data:/data ubuntu:ros

In this way, you can save all your code in the host machine and use them in the Docker environment.

(2.2) Creating a ROS workspace. A ROS workspace is a place to store your own ROS packages. Following the link here to create a ROS workspace `http://wiki.ros.org/catkin/Tutorials/create_a_workspace`. You should create the ROS workspace in the mounted folder from the host machine.

(2.3) Adding package to your ROS workspace. We are going to use two existing ROS packages to visualize the Fetch mobile manipulator. Download them from the following links to add to your workspace, i.e., add the packages to the src folder:

- fetch_description. `https://github.com/fetchrobotics/fetch_ros/tree/melodic-devel/fetch_description`
- urdf_tutorial. `https://github.com/ros/urdf_tutorial`

You can read this page about ROS packages `http://wiki.ros.org/ROS/Tutorials/CreatingPackage`.

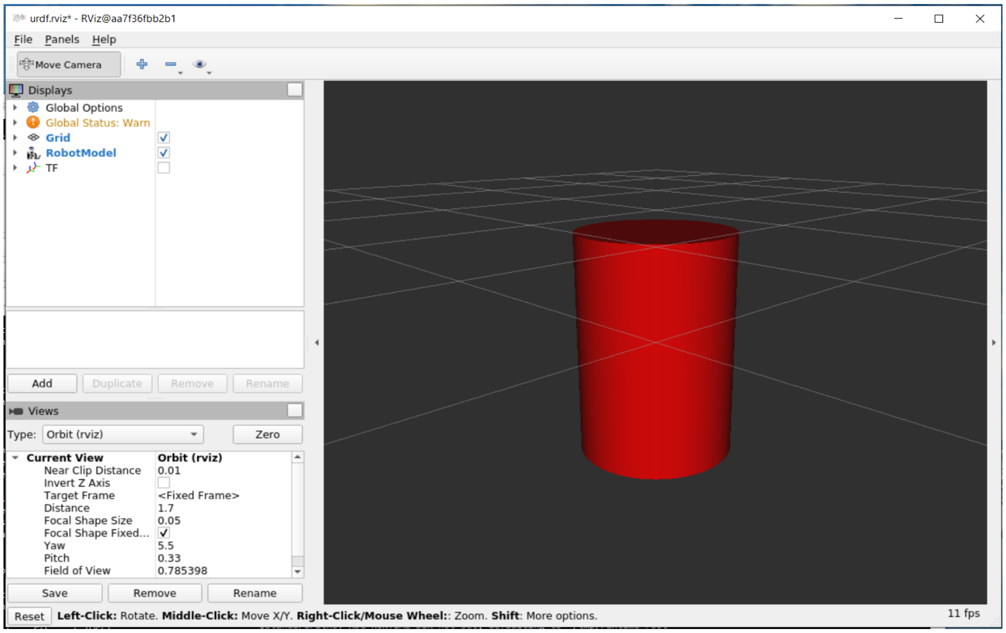
(2.4) Building and testing your ROS workspace. You can build the packages in the ROS workspace by running

- catkin_make

If the workspace has been built successfully, run the following command to test the urdf_tutorial package:

- source devel/setup.bash #source your workspace
- roslaunch urdf_tutorial display.launch

The second command will launch the display.launch file in the urdf_tutorial package in your workspace. You should see the Rviz interface as shown in Figure 2.



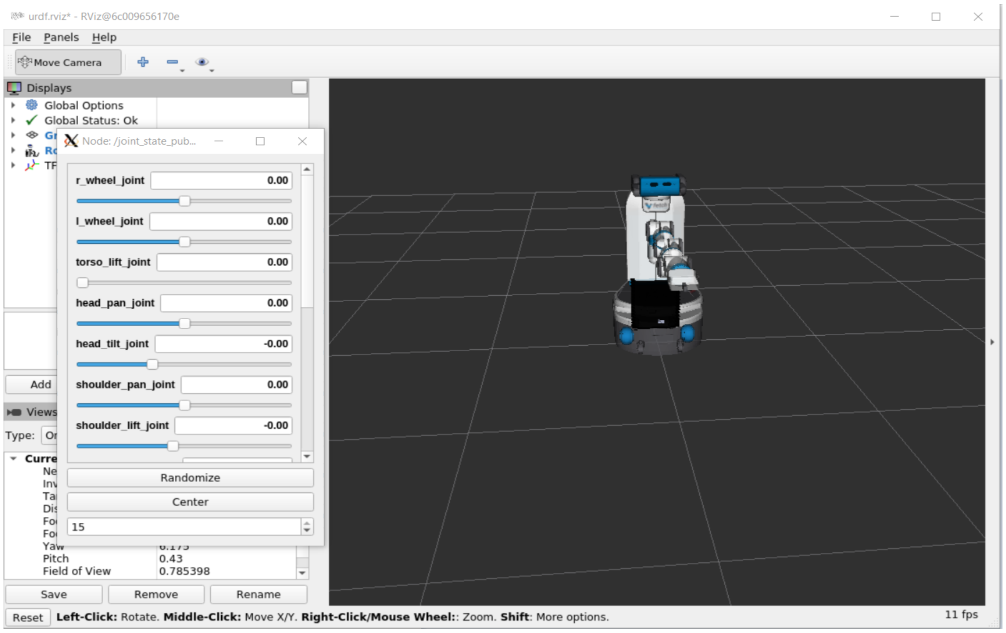
Global Options
Global Status: Warn
Grid ☑
RobotModel ☑
TF □

Type: Orbit (rviz)

Current View	Orbit (rviz)
Near Clip Distance	0.01
Invert Z Axis	□
Target Frame	<Fixed Frame>
Distance	1.7
Focal Shape Size	0.05
Focal Shape Fixed...	☑
Yaw	5.5
Pitch	0.33
Field of View	0.785398

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:**: Zoom. **Shift**: More options.

Figure 2: Rviz interface by running “roslaunch urdf_tutorial display.launch”.



Global Options
Global Status: Ok

r_wheel_joint	0.00
l_wheel_joint	0.00
torso_lift_joint	0.00
head_pan_joint	0.00
head_tilt_joint	-0.00
shoulder_pan_joint	0.00
shoulder_lift_joint	-0.00

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Yaw	6.175
Pitch	0.43
Field of View	0.785398

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:**: Zoom. **Shift**: More options.

Figure 3: Rviz visualization of a Fetch mobile manipulator.

(2.5) Visualizing Fetch robot model. Create a new launch file named display_fetch.launch in urdf_tutorial/launch by coping the display.launch file. Modify the content of the new launch file to display the Fetch robot. The definition of the robot is the urdf file under fetch_description/robots/fetch.urdf. Run the following command for testing:

- roslaunch urdf_tutorial display_fetch.launch

You should see the visualization as in Figure 3.

(2.6) Tuning the robot joints. Use the /joint_state_publisher window to set the following joints of the robot arm to the corresponding values:

- shoulder_pan_joint: -1.32
- shoulder_lift_joint: 0.7
- upperarm_roll_joint: 0.0
- elbow_flex_joint: -2.01
- forearm_roll_joint: 0.0
- wrist_flex_joint: -0.56
- wrist_roll_joint: 0.0

You can keep the other joint values as the default ones. Capture a screenshot of the robot in Rviz for this homework submission.

Submission guideline: Zip your src folder in your workspace and submit the zip file to eLearning. Make sure you have a screen capture included for (2.6). Our TA will build your workspace and run commands to verity it.