



MCT344- Industrial Robotics

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ABSTRACT

This report presents the development and simulation of a 6 degrees of freedom (DOF) manipulator using the MoveIt framework, a powerful tool for motion planning in robotics. The primary objective is to demonstrate MoveIt's capabilities in generating collision-free paths and visualizing these movements in virtual environments, specifically through RViz and Gazebo. The report details the planning pipeline, implementation steps, and the advantages of using MoveIt for efficient and reliable manipulator planning. Additionally, a Python script is introduced to facilitate motion planning using MoveIt, showcasing its flexibility and simplicity in defining robot models, planning paths, and executing motions. The successful execution of complex motion plans and the visualization of the manipulator's behavior underscore the effectiveness of this approach for a wide range of robotics applications, from industrial automation to service robots.

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1.INTRODUCTION

The field of robotics has seen significant advancements in motion planning, particularly with the development of sophisticated frameworks like MoveIt. This report explores the application of MoveIt for planning and simulating the movements of a 6 degrees of freedom (DOF) robotic manipulator. Motion planning is a critical component of robotic systems, enabling robots to navigate complex environments and perform precise manipulations. By leveraging MoveIt's comprehensive suite of tools for motion planning, collision detection, and trajectory execution, we aim to demonstrate the framework's effectiveness in generating and visualizing collision-free paths. The simulation of these movements is carried out in RViz and Gazebo, providing a virtual environment to observe and refine the manipulator's behavior.

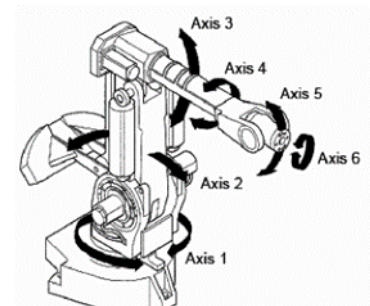


Figure 1 6 DOF Robot

In addition to the overall planning process, the report introduces a Python script designed to simplify motion planning tasks using MoveIt. This script exemplifies the framework's flexibility, allowing users to easily define robot models, plan paths, and execute motions across a variety of robotic applications, from industrial automation to service robots. The subsequent sections detail the implementation steps, highlight the advantages of using simulation tools, and showcase the successful execution of complex motion plans, ultimately demonstrating the robust capabilities of MoveIt in real-world robotics scenarios.

2.MoveIt Configuration

2.1. Launching MoveIt

```
File "src/salma_moveit/scripts/robot_control.py", line 48, in main
  rospy.sleep(1)
File "/opt/ros/noetic/lib/python3/dist-packages/rospy/timer.py", line 165, in sleep
  raise rospy.exceptions.ROSInterruptException("ROS shutdown request")
rospy.exceptions.ROSInterruptException: ROS shutdown request
hossam_torky@Torkyy:~/catkin_ws$ roslaunch salma_moveit setup_assistant.launch
WARNING: Package name "robot_arm_urdf_Lab5" does not follow the naming conventions. It should start w
ith a lower case letter and only contain lower case letters, digits, underscores, and dashes.
WARNING: Package name "ROBOTIC_ARM_URDF_1" does not follow the naming conventions. It should start wi
th a lower case letter and only contain lower case letters, digits, underscores, and dashes.
... logging to /home/hossam_torky/.ros/log/6f974220-5fd7-11ef-951f-253f781abe01/roslaunch-Torkyy-4857
.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

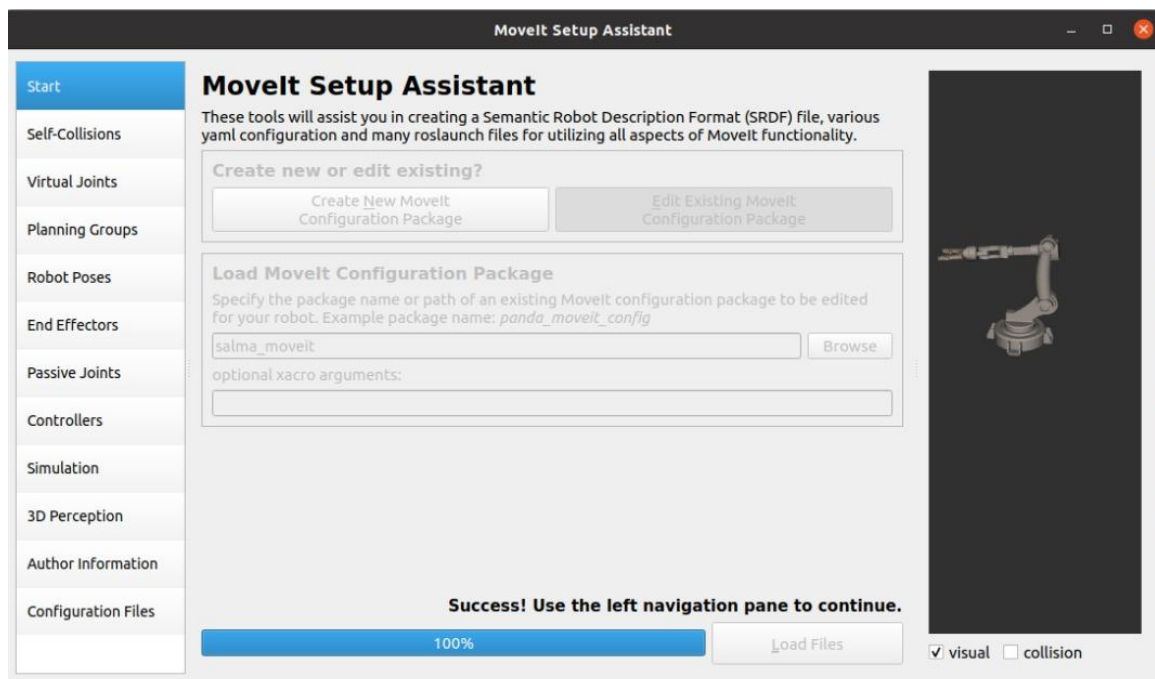
started roslaunch server http://Torkyy:36749/

SUMMARY
=====
```

Figure 2 MoveIt launch

2.2. Edit in MoveIt

- We created a new moveit package inside of our project workspace.



2.2.1. Self-collision

- This step prevents the links from collision so it disables any possibility that they can collide with each other

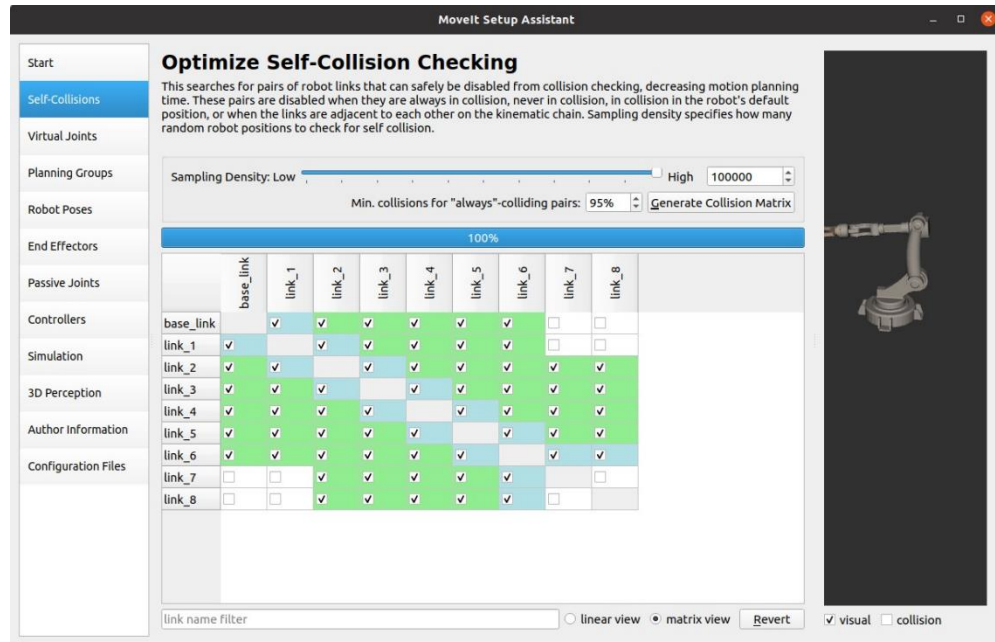


Figure 3 Self collision

2.2.2. Planning Groups

- We divided our joints into two groups, the arm group which represents from our first to our fourth link and the hand group which represents our fifth & sixth group for the end effector

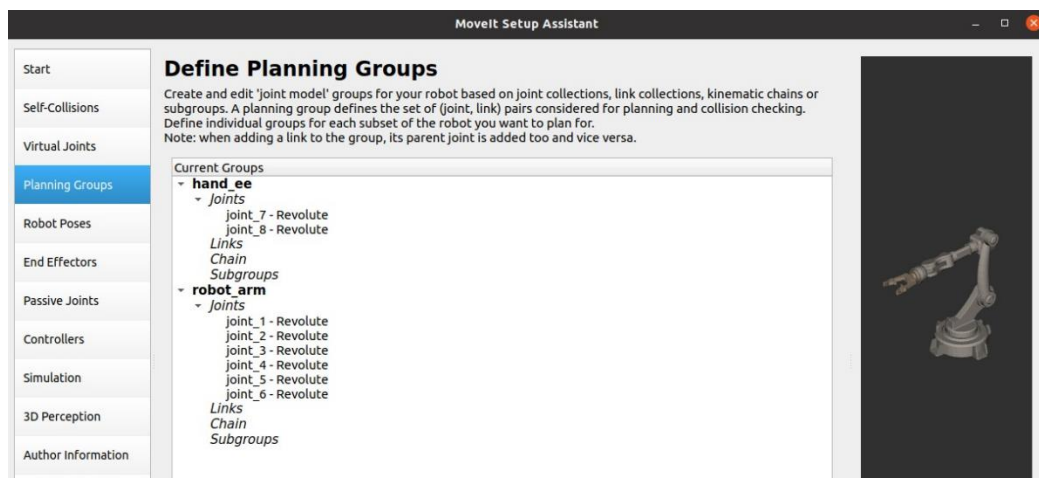


Figure 4 planning groups

2.2.3. Robot Poses

- Hand close position

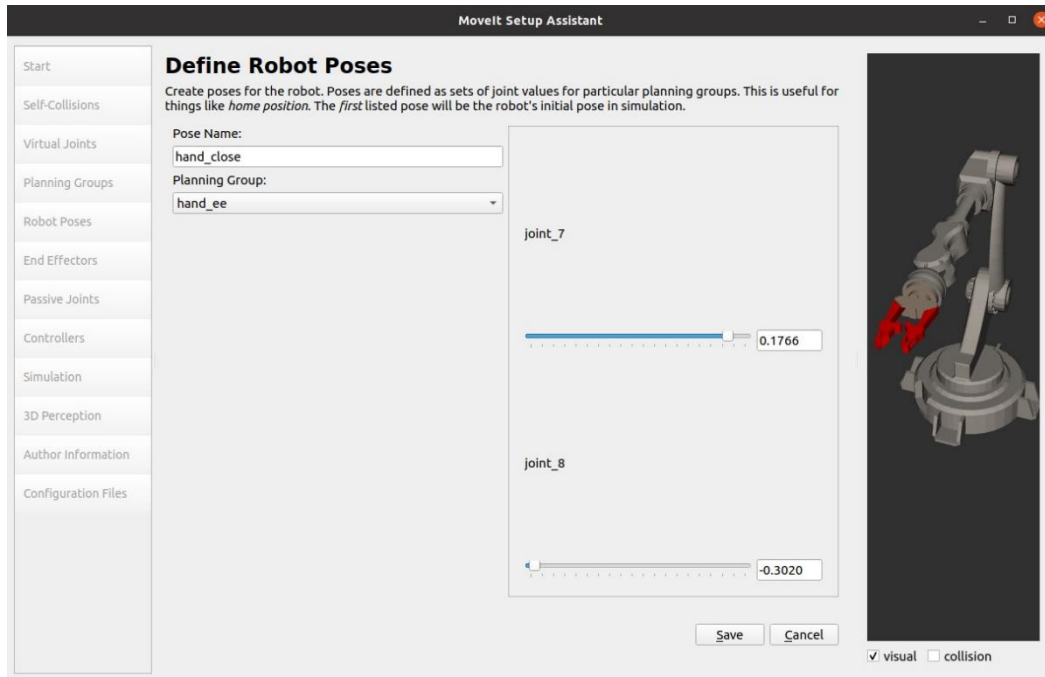


Figure 5 Hand close

- Hand Open position

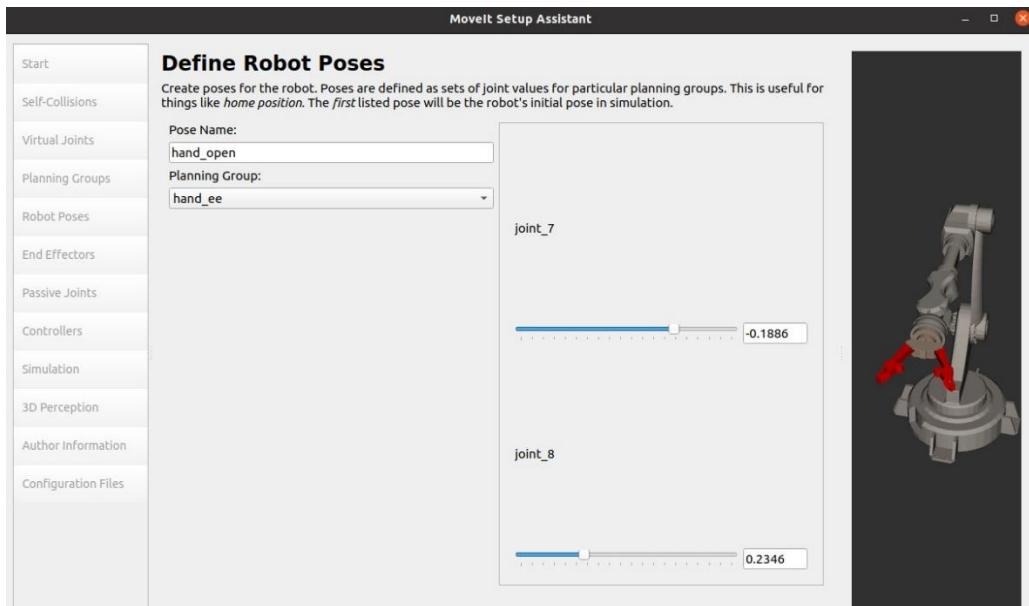


Figure 6 Hand open

- Pose 1

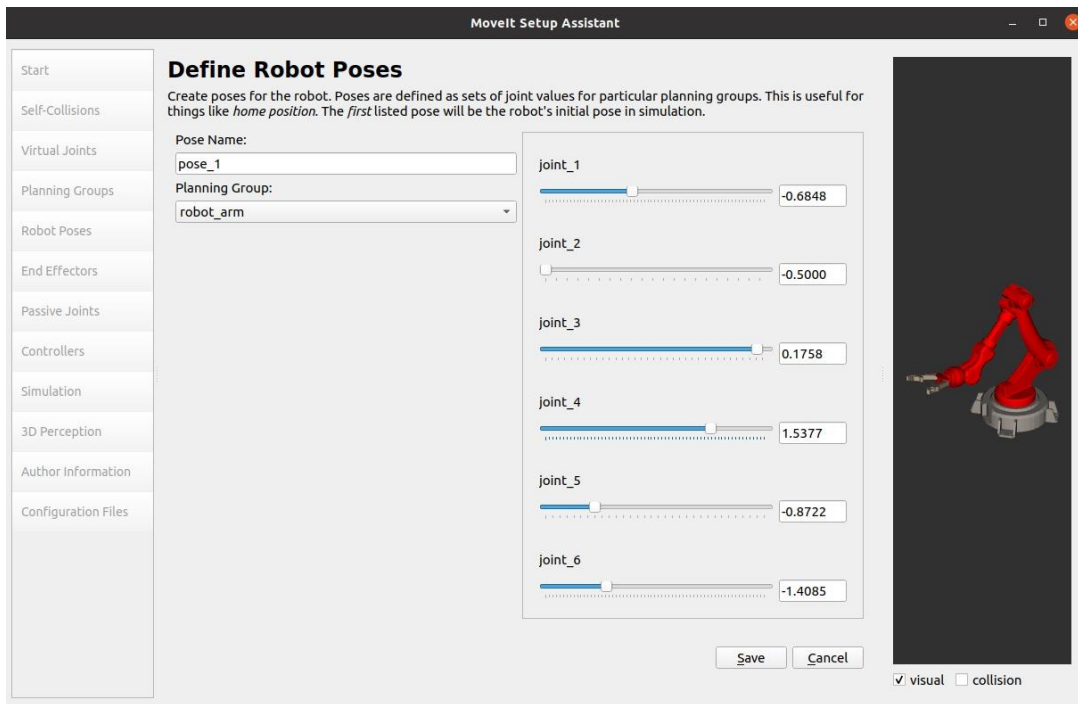


Figure 7 Pose 1

- Pose 2

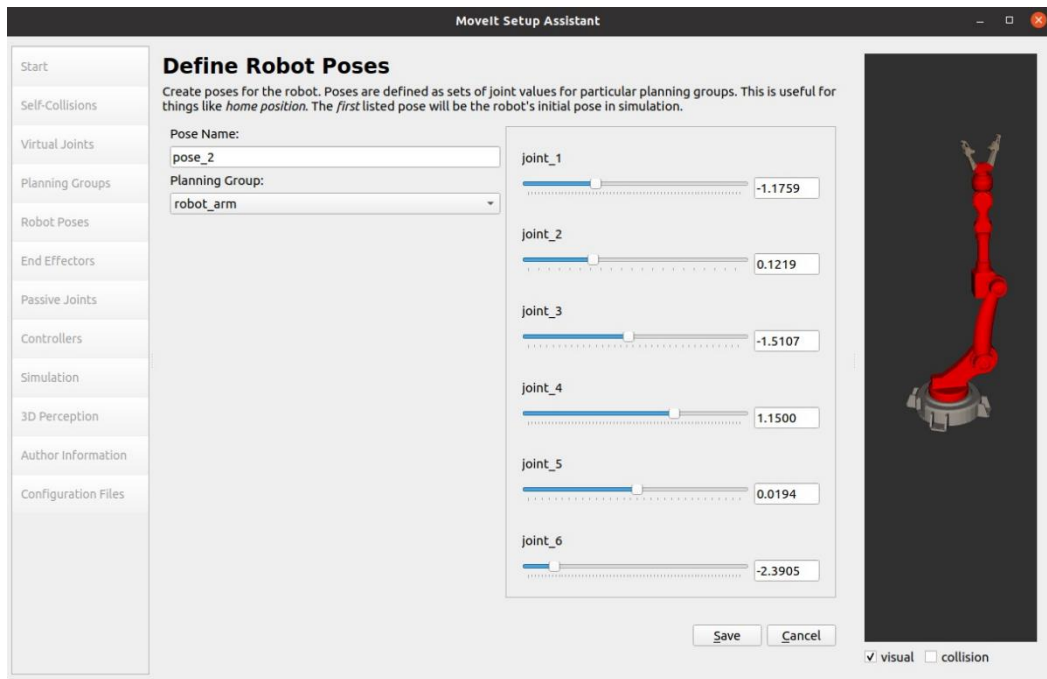


Figure 8 Pose 2

- **Pose 3**

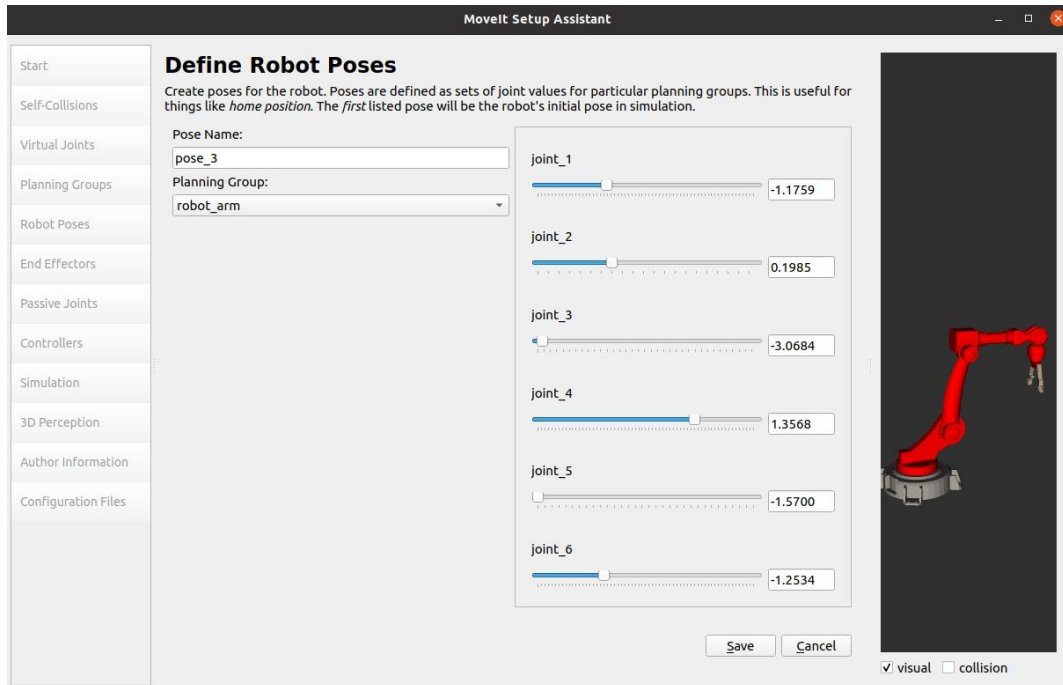


Figure 9 Pose 3

2.2.4. End Effectors

- This represents our end effectors' definition where we assign it a name, a group, and a parent link

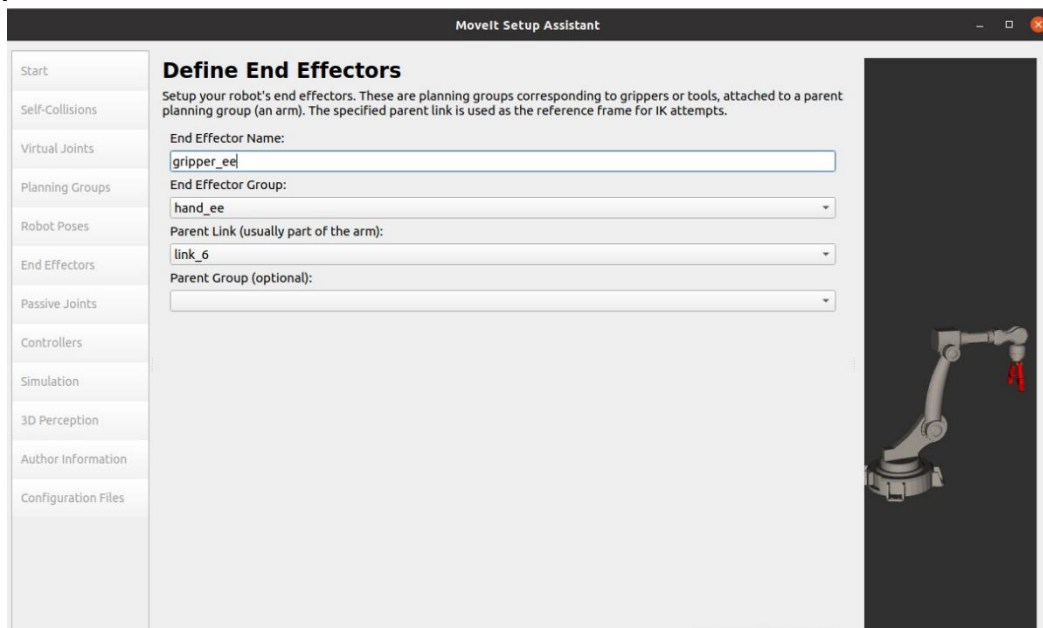


Figure 10 Define end effector

2.2.5. Controllers

- We defined a controller for each group, and we named them as in the .yaml file as well as defining their type

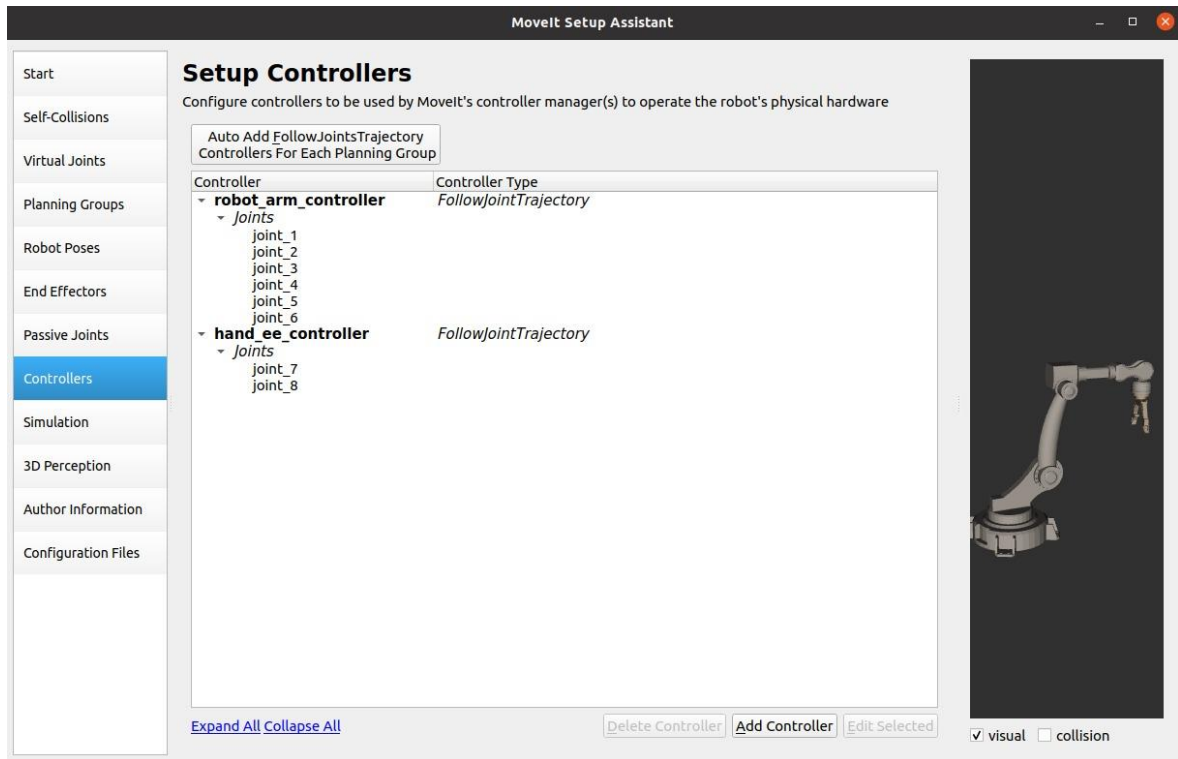
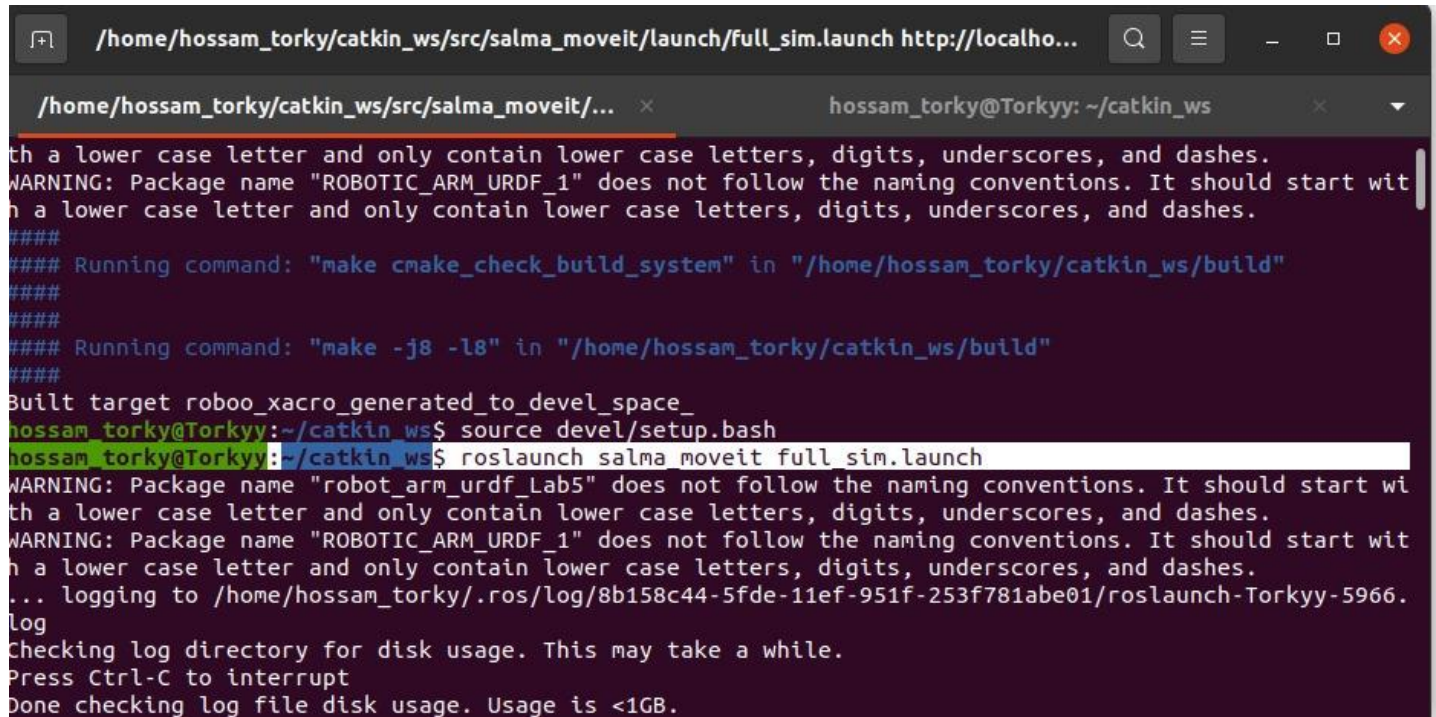


Figure 11 setup controllers

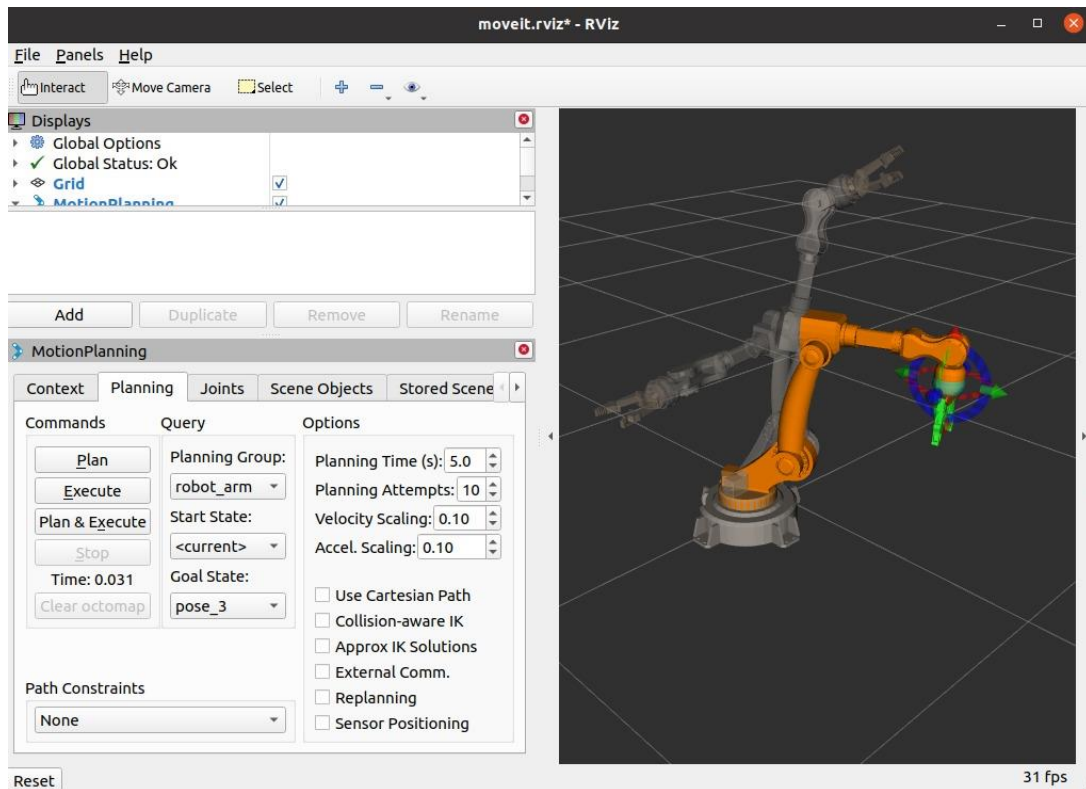
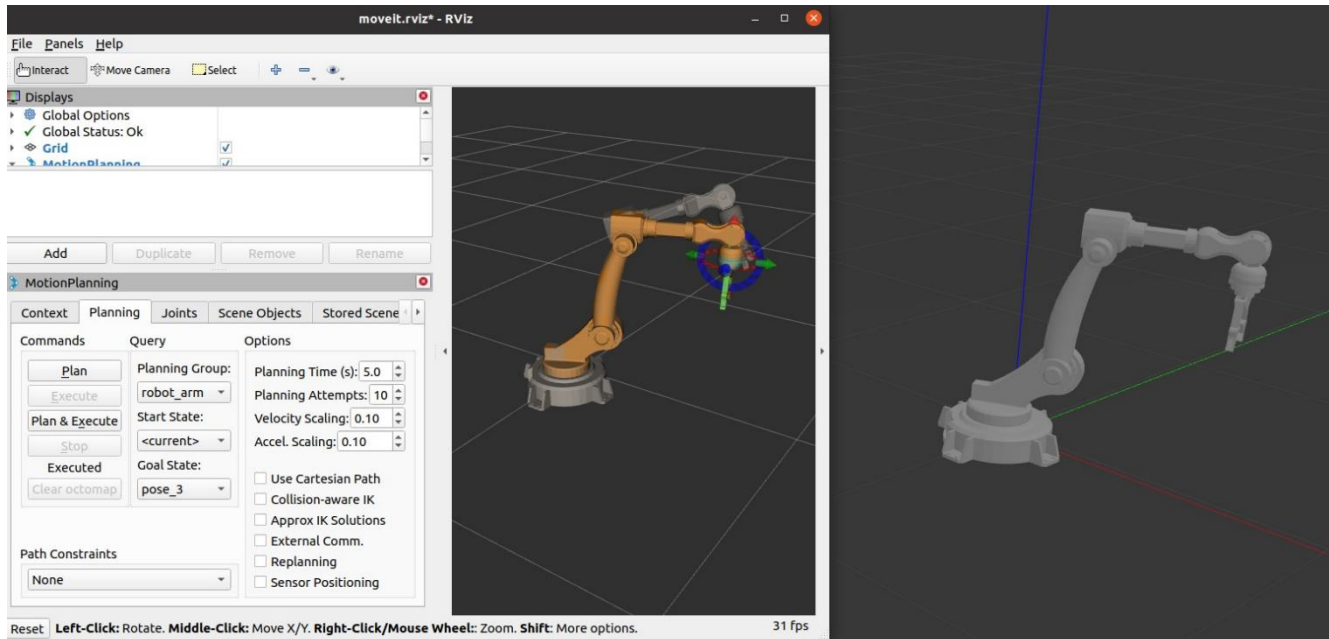
3.Launching Gazebo & RVIS

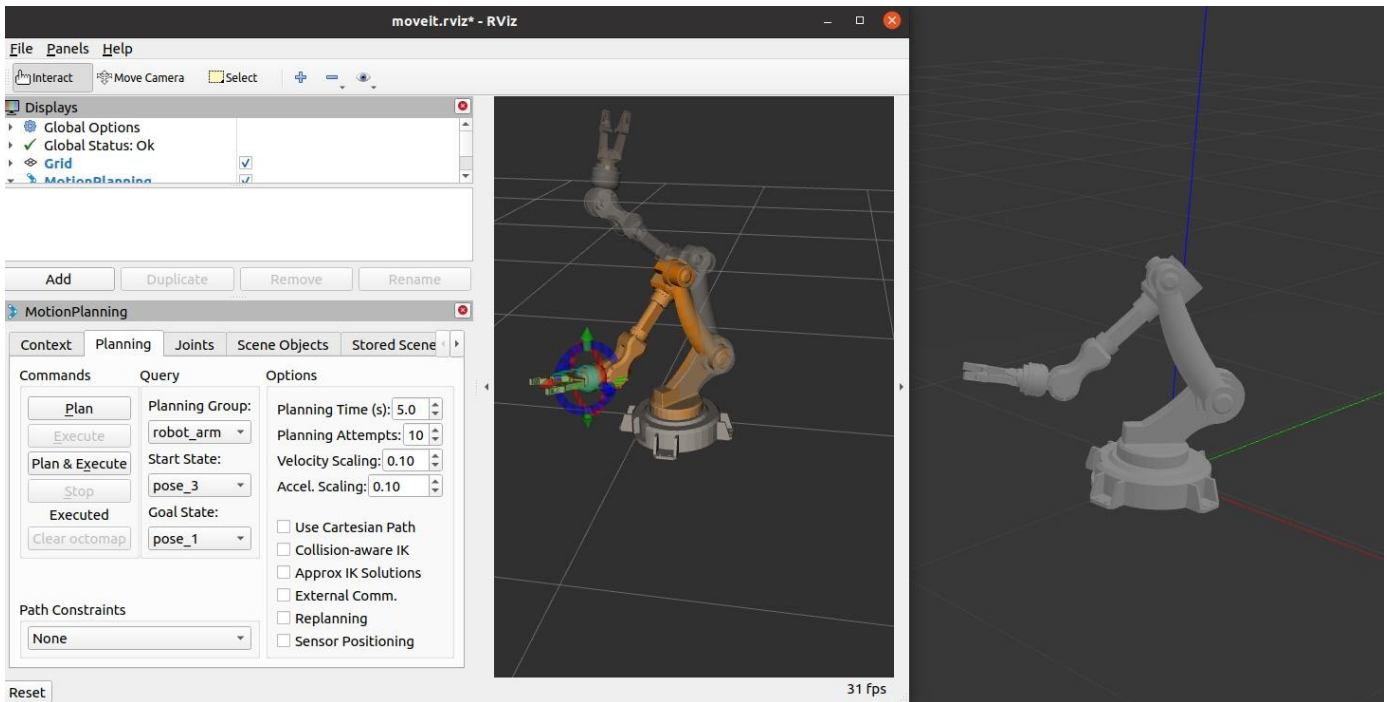
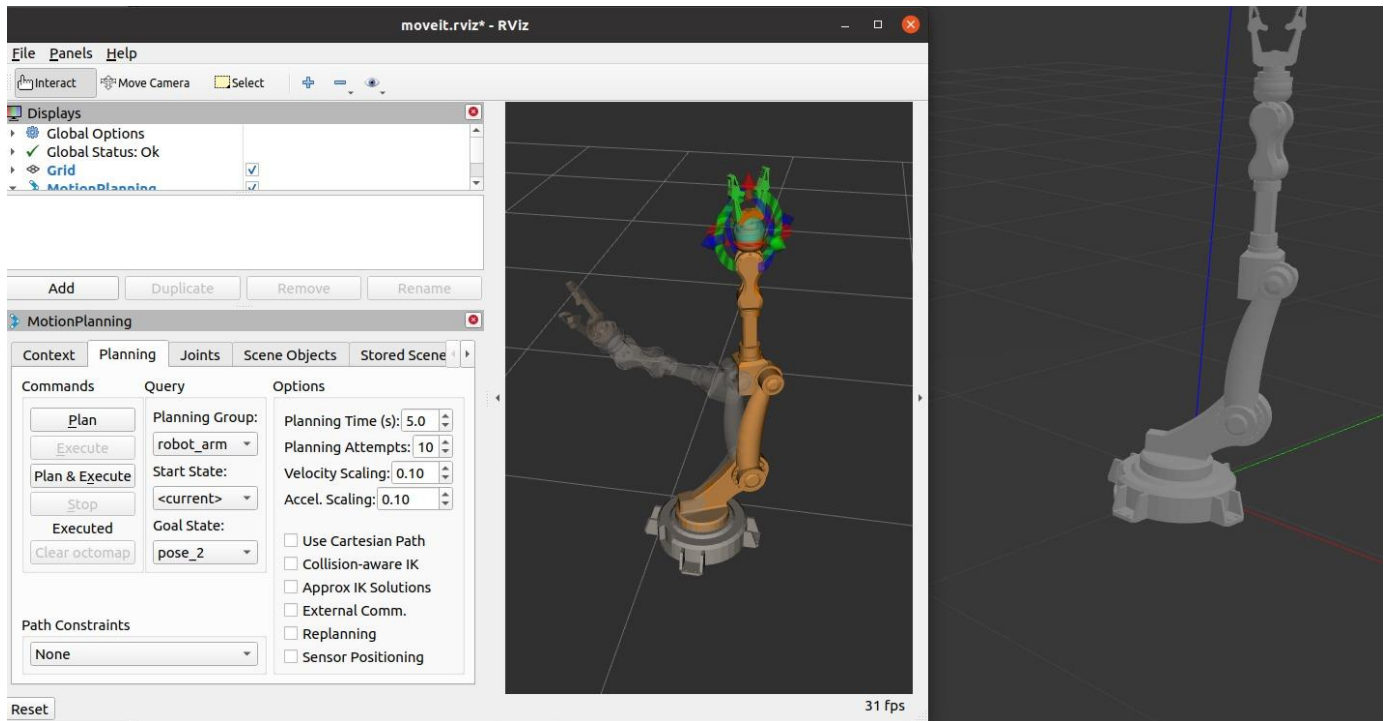


```
/home/hossam_torky/catkin_ws/src/salma_moveit/launch/full_sim.launch http://localho...
/home/hossam_torky/catkin_ws/src/salma_moveit/... x  hossam_torky@Torkyy: ~/catkin_ws
th a lower case letter and only contain lower case letters, digits, underscores, and dashes.
WARNING: Package name "ROBOTIC_ARM_URDF_1" does not follow the naming conventions. It should start wit
h a lower case letter and only contain lower case letters, digits, underscores, and dashes.
####
#### Running command: "make cmake_check_build_system" in "/home/hossam_torky/catkin_ws/build"
####
####
#### Running command: "make -j8 -l8" in "/home/hossam_torky/catkin_ws/build"
####
Built target roboo_xacro_generated_to_devel_space_
hossam_torky@Torkyy:~/catkin_ws$ source devel/setup.bash
hossam_torky@Torkyy:~/catkin_ws$ roslaunch salma_moveit full_sim.launch
WARNING: Package name "robot_arm_urdf_Lab5" does not follow the naming conventions. It should start wi
th a lower case letter and only contain lower case letters, digits, underscores, and dashes.
WARNING: Package name "ROBOTIC_ARM_URDF_1" does not follow the naming conventions. It should start wit
h a lower case letter and only contain lower case letters, digits, underscores, and dashes.
... logging to /home/hossam_torky/.ros/log/8b158c44-5fde-11ef-951f-253f781abe01/roslaunch-Torkyy-5966.
log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.
```

Figure 12 Gazebo and RVIS launch

3.1. Simulation





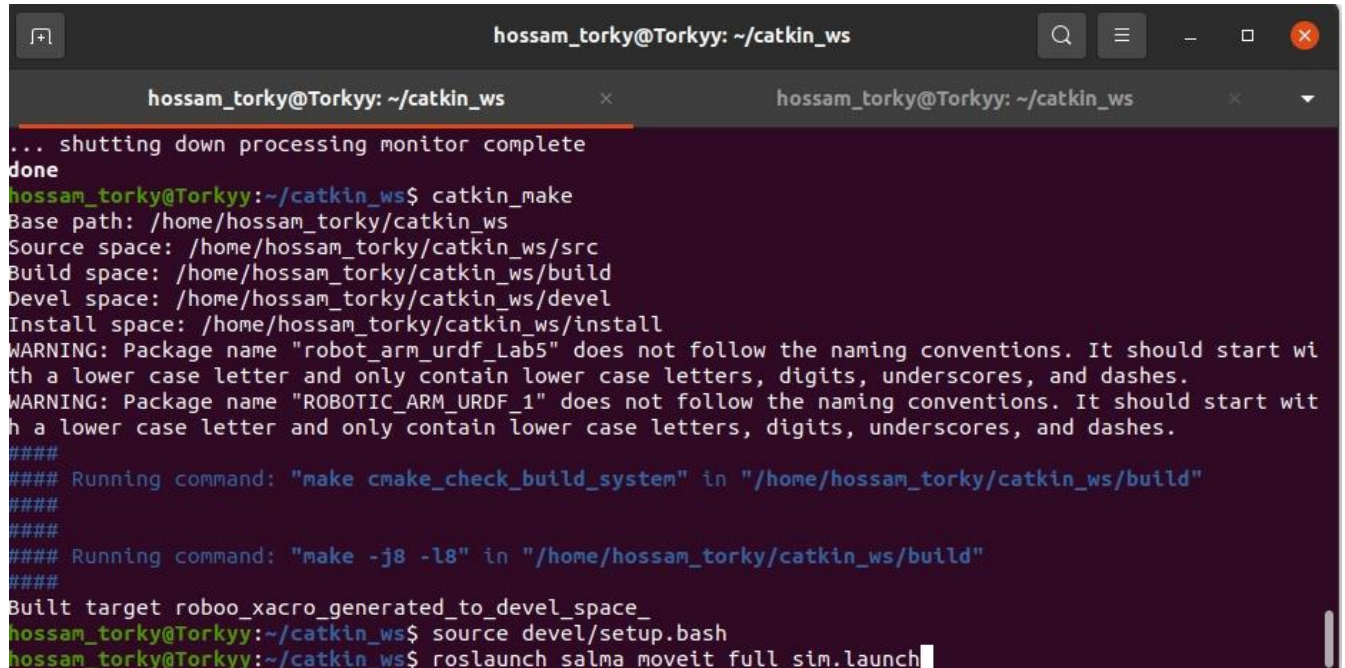
4. Python Script

```
robot_control.py  x  salmaeltohfaa_urdf.srdf  x  salmaeltohfaa_urdf.srdf
1 import sys
2 import rospy
3 import moveit_commander
4 import moveit_msgs.msg
5 from math import pi
6
7 moveit_commander.roscpp_initialize(sys.argv)
8 rospy.init_node('move_robot', anonymous=True)
9
10 robot = moveit_commander.RobotCommander()
11 scene = moveit_commander.PlanningSceneInterface()
12
13 def move_robot_arm(joint1, joint2, joint3, joint4, joint5, joint6):
14     group_name = "robot_arm" # Replace with your arm's group name
15     group = moveit_commander.MoveGroupCommander(group_name)
16
17     joint_goal = group.get_current_joint_values()
18     joint_goal[0] = joint1
19     joint_goal[1] = joint2
20     joint_goal[2] = joint3
21     joint_goal[3] = joint4
22     joint_goal[4] = joint5
23     joint_goal[5] = joint6
24
25     group.go(joint_goal, wait=True)
26     group.stop()
27
28 def move_end_effector(joint1, joint2):
29     group_name = "hand_ee" # Replace with your end effector's group name
30     group = moveit_commander.MoveGroupCommander(group_name)
31
32     joint_goal = group.get_current_joint_values()
33     joint_goal[0] = joint1
34     joint_goal[1] = joint2
35
36     group.go(joint_goal, wait=True)
37     group.stop()
38
39
40 def main():
41     move_end_effector(-0.1243, 0.2075)
42     rospy.sleep(1)
43     move_robot_arm(-0.6849, -0.5, 0.1758, 1.5377, -0.8722, -1.4085)
44     rospy.sleep(1)
45     move_end_effector(0.2709, -0.2501)
46     rospy.sleep(1)
47     move_robot_arm(-1.1759, 0.1219, -1.5107, 1.15, 0.0194, -2.3905)
48     rospy.sleep(1)
49
50 if __name__ == '__main__':
51     while True:
52         main()
53
```

Figure 13 python script

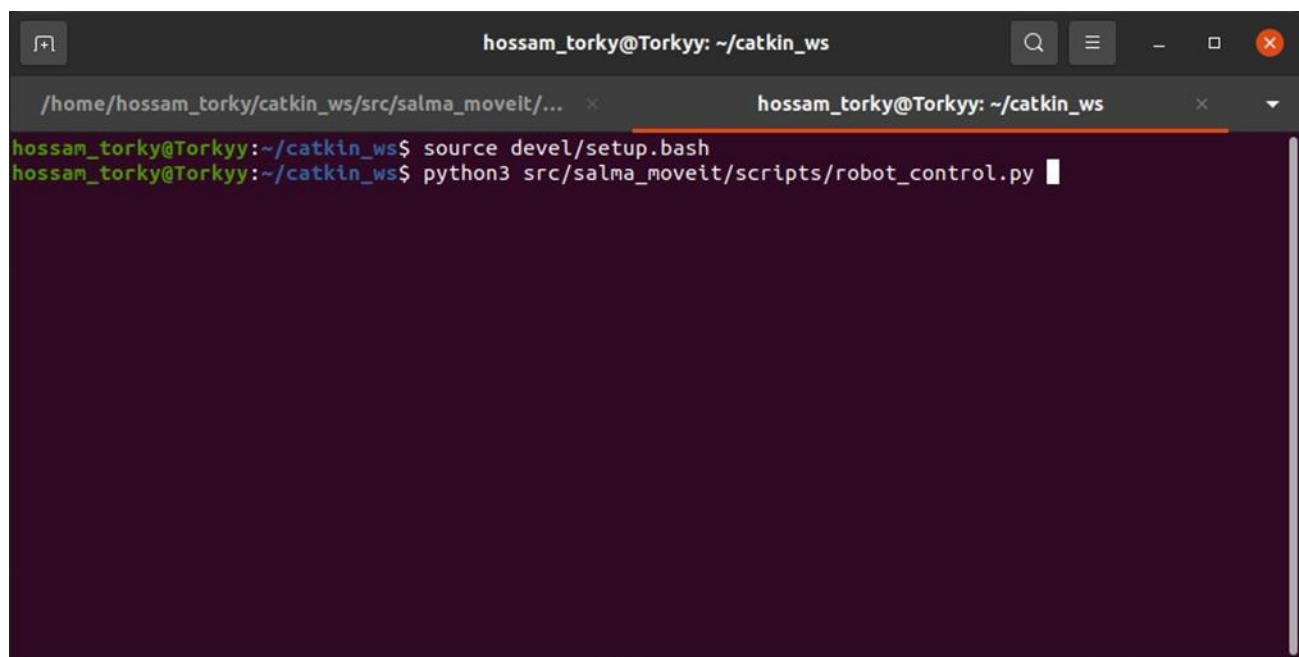
5. Gazebo & Rviz

5.1. Launching Gazebo & Rviz

A terminal window titled 'hossam_torky@Torkyy: ~/catkin_ws' with two tabs. The first tab shows the output of 'catkin_make', including warnings about package naming conventions and the execution of 'make cmake_check_build_system' and 'make -j8 -l8'. The second tab shows the execution of 'source devel/setup.bash' and 'roslaunch salma_moveit full_sim.launch'.

```
hossam_torky@Torkyy: ~/catkin_ws
... shutting down processing monitor complete
done
hossam_torky@Torkyy:~/catkin_ws$ catkin_make
Base path: /home/hossam_torky/catkin_ws
Source space: /home/hossam_torky/catkin_ws/src
Build space: /home/hossam_torky/catkin_ws/build
Devel space: /home/hossam_torky/catkin_ws/devel
Install space: /home/hossam_torky/catkin_ws/install
WARNING: Package name "robot_arm_urdf_Lab5" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
WARNING: Package name "ROBOTIC_ARM_URDF_1" does not follow the naming conventions. It should start with a lower case letter and only contain lower case letters, digits, underscores, and dashes.
####
#### Running command: "make cmake_check_build_system" in "/home/hossam_torky/catkin_ws/build"
####
####
#### Running command: "make -j8 -l8" in "/home/hossam_torky/catkin_ws/build"
####
Built target roboo_xacro_generated_to_devel_space_
hossam_torky@Torkyy:~/catkin_ws$ source devel/setup.bash
hossam_torky@Torkyy:~/catkin_ws$ roslaunch salma_moveit full_sim.launch
```

5.2. Launching Python Script

A terminal window titled 'hossam_torky@Torkyy: ~/catkin_ws' with two tabs. The first tab shows the execution of 'source devel/setup.bash'. The second tab shows the execution of 'python3 src/salma_moveit/scripts/robot_control.py'.

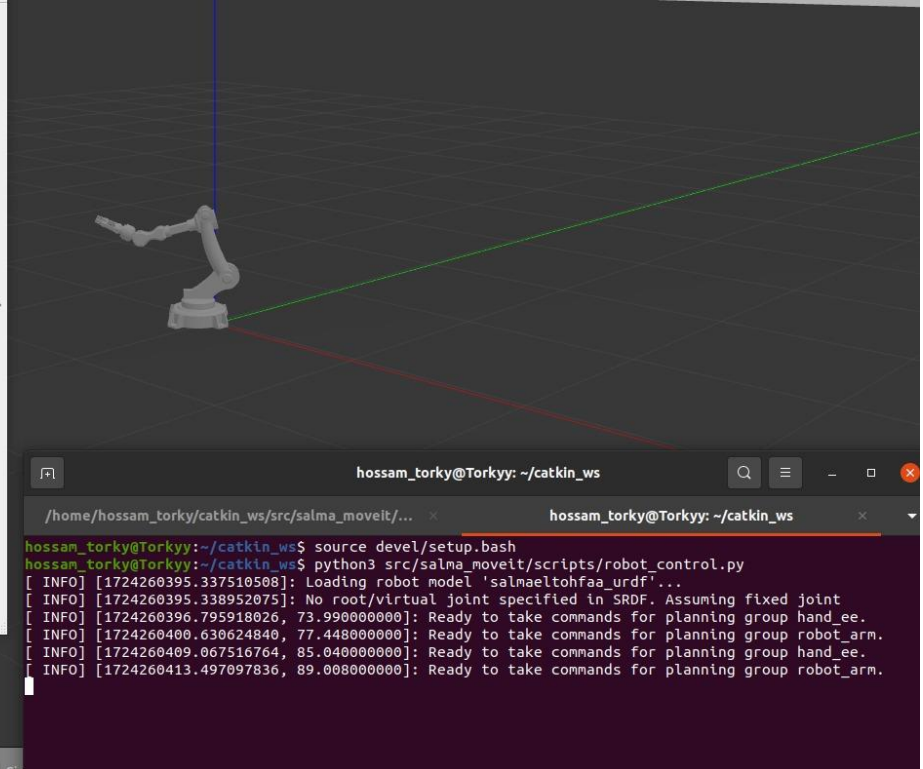
```
hossam_torky@Torkyy: ~/catkin_ws
/home/hossam_torky/catkin_ws/src/salma_moveit/...
hossam_torky@Torkyy:~/catkin_ws$ source devel/setup.bash
hossam_torky@Torkyy:~/catkin_ws$ python3 src/salma_moveit/scripts/robot_control.py
```

5.3. Motion in Gazebo & Rviz



l: Zoom. Shift: More options.

31 fps

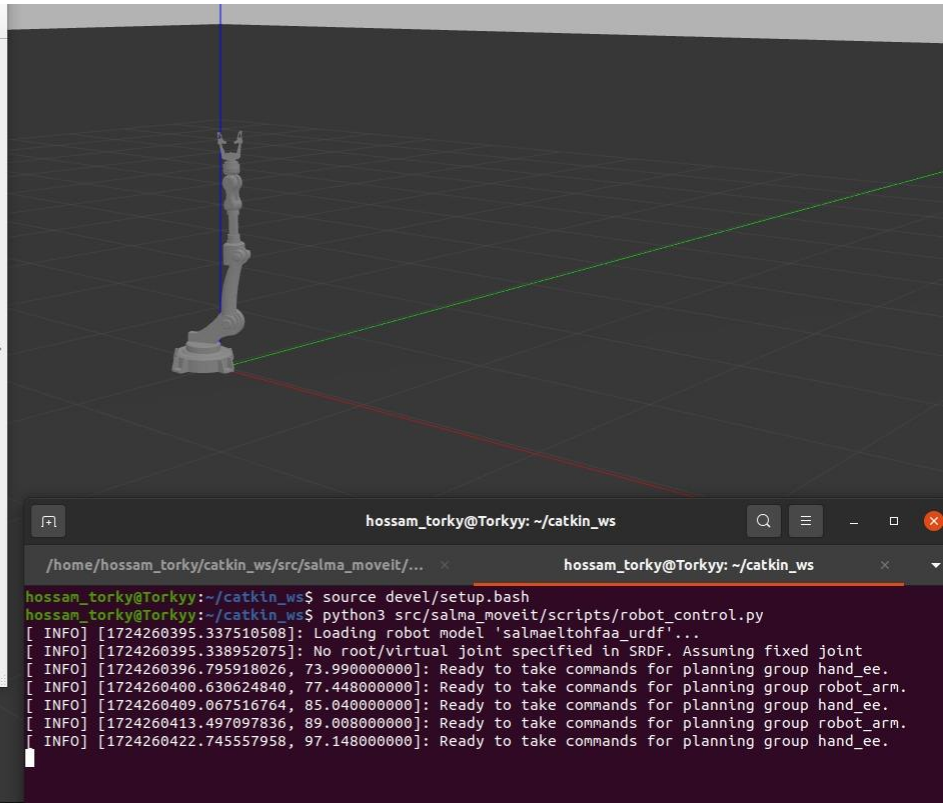


```
hossam_torky@Torkyy: ~/catkin_ws
/home/hossam_torky/catkin_ws/src/salma_moveit/...  hossam_torky@Torkyy: ~/catkin_ws
hossam_torky@Torkyy:~/catkin_ws$ source devel/setup.bash
hossam_torky@Torkyy:~/catkin_ws$ python3 src/salma_moveit/scripts/robot_control.py
[ INFO] [1724260395.337510508]: Loading robot model 'salmaeltohfaa_urdf'...
[ INFO] [1724260395.338952075]: No root/virtual joint specified in SRDF. Assuming fixed joint
[ INFO] [1724260396.795918026, 73.990000000]: Ready to take commands for planning group hand_ee.
[ INFO] [1724260400.630624840, 77.448000000]: Ready to take commands for planning group robot_arm.
[ INFO] [1724260409.067516764, 85.040000000]: Ready to take commands for planning group hand_ee.
[ INFO] [1724260413.497097836, 89.008000000]: Ready to take commands for planning group robot_arm.
```



Zoom. Shift: More options.

31 fps



```
hossam_torky@Torkyy: ~/catkin_ws
/home/hossam_torky/catkin_ws/src/salma_moveit/...  hossam_torky@Torkyy: ~/catkin_ws
hossam_torky@Torkyy:~/catkin_ws$ source devel/setup.bash
hossam_torky@Torkyy:~/catkin_ws$ python3 src/salma_moveit/scripts/robot_control.py
[ INFO] [1724260395.337510508]: Loading robot model 'salmaeltohfaa_urdf'...
[ INFO] [1724260395.338952075]: No root/virtual joint specified in SRDF. Assuming fixed joint
[ INFO] [1724260396.795918026, 73.990000000]: Ready to take commands for planning group hand_ee.
[ INFO] [1724260400.630624840, 77.448000000]: Ready to take commands for planning group robot_arm.
[ INFO] [1724260409.067516764, 85.040000000]: Ready to take commands for planning group hand_ee.
[ INFO] [1724260413.497097836, 89.008000000]: Ready to take commands for planning group robot_arm.
[ INFO] [1724260422.745557958, 97.148000000]: Ready to take commands for planning group hand_ee.
```

6. CONCLUSION

In conclusion, this report has demonstrated the robust capabilities of the MoveIt framework in planning, simulating, and executing motion plans for a 6 degrees of freedom (DOF) manipulator. Through the integration of RViz and Gazebo, we were able to visualize and refine the manipulator's movements in a virtual environment, ensuring collision-free and efficient path generation. The Python script introduced further exemplifies the ease with which users can leverage MoveIt for various robotic applications, highlighting its flexibility and simplicity in defining models, planning trajectories, and executing complex motions.

The successful execution of these tasks underscores the effectiveness of MoveIt as a tool for reliable and efficient motion planning in robotics. By utilizing this framework, engineers and researchers can streamline the development process, reduce the likelihood of errors, and enhance the overall performance of robotic systems. This approach holds significant potential for advancing industrial automation, service robotics, and other applications where precise and adaptive motion planning is essential.

7.VIDEO & FILES LINK

https://drive.google.com/drive/folders/1jlefrTKn2qO3F6AWT4i6yDSPL_JSHrBE?usp=drive_link