

ECE 4703

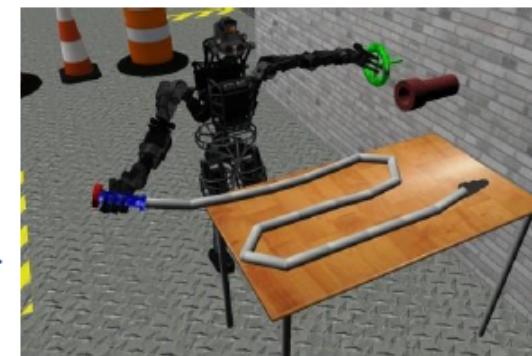
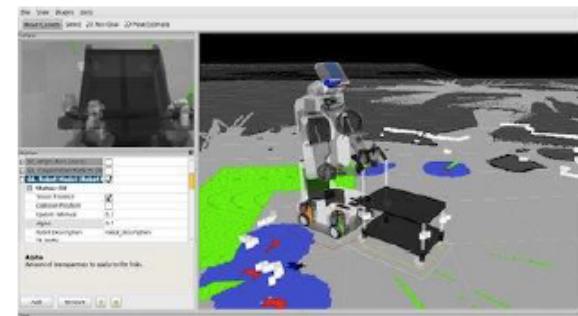
Mobile Autonomous Robots

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Various Development Tools for ROS

- Provides various development tools needed for robot development
- Improving the efficiency of robot development
- **Command-Line Tools**
 - Robot access only with commands provided by ROS without GUI & Use almost all ROS features
- **RViz**
 - Provides powerful 3D visualization tool
 - Visualizes sensor data such as laser, camera, etc.
 - Represents robot configuration and planned motion
- **RQT**
 - Provides Qt-based framework for developing graphic interface
 - Displays nodes and connection information between them (rqt_graph)
 - Floats encoder, voltage, or number that changes over time (rqt_plot)
 - Records data in message form and play back (rqt_bag)
- **Gazebo**
 - 3D simulator which supports physics engine, robot, sensor, environmental model, etc.
 - High compatibility with ROS

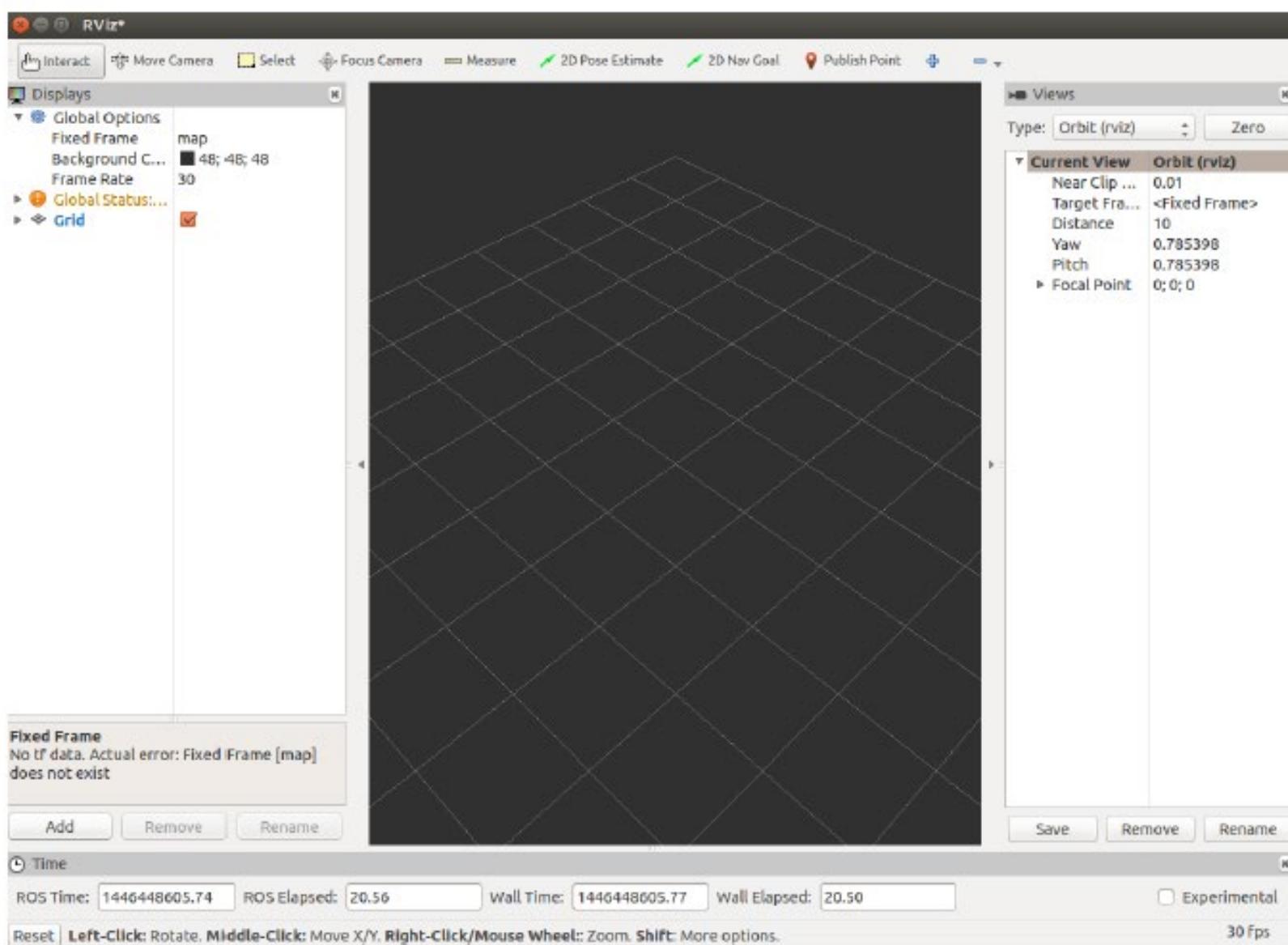


Rviz

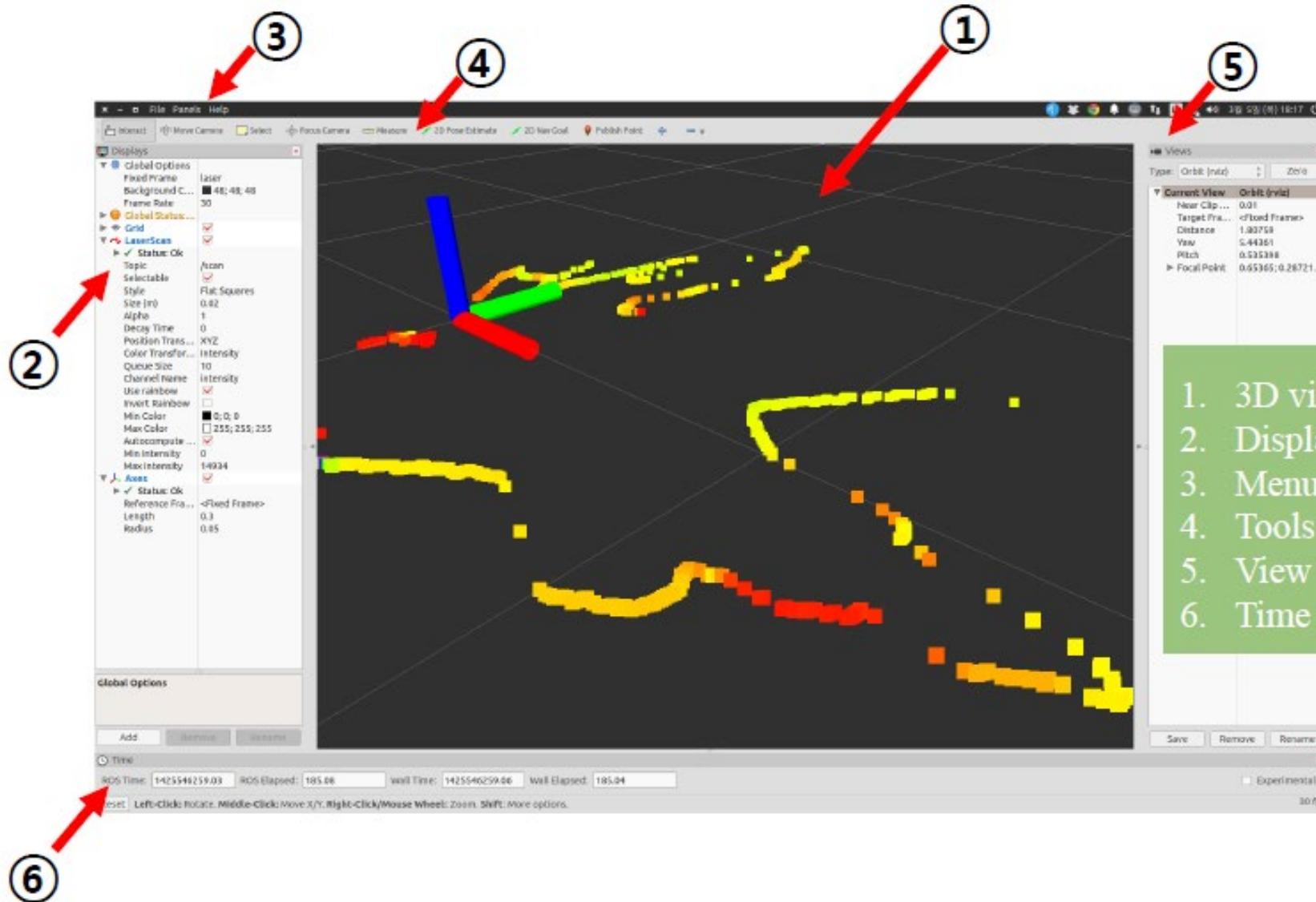
RViz(ROS Visualization Tool)

- 3D visualization tool for ROS
 - Visualization of sensor data
 - Distance data of LASER distance sensor(LDS)
 - Point cloud data from depth camera such as 'RealSense', 'Kinect', 'Xtion', etc.
 - Image data of camera
 - Inertia data of IMU sensor ...
- Represents robot configuration and planned motion
 - URDF (Unified Robot Description Format)
- Navigation
- Manipulation
- Tele-operation

RViz initial screen (not configured yet)

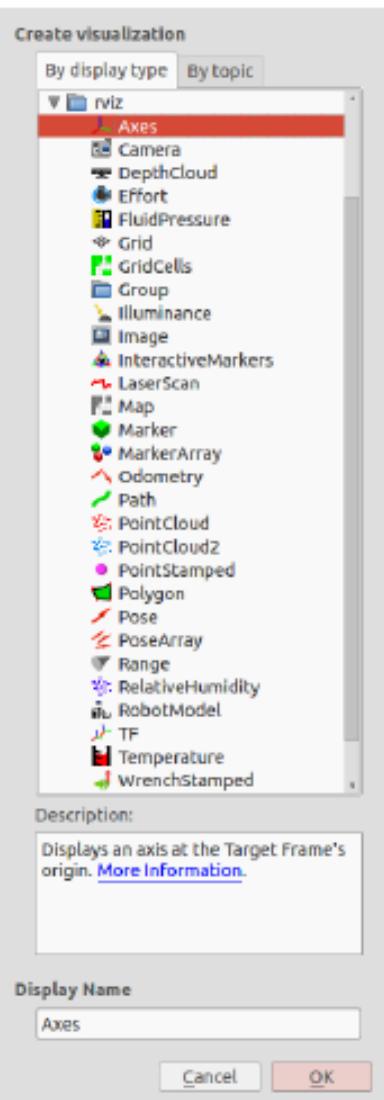


Screen Configuration of Rviz (for LDS)



1. 3D view
2. Display
3. Menu
4. Tools
5. View types
6. Time

Display type of RViz (Click 'ADD' in Display Menu)

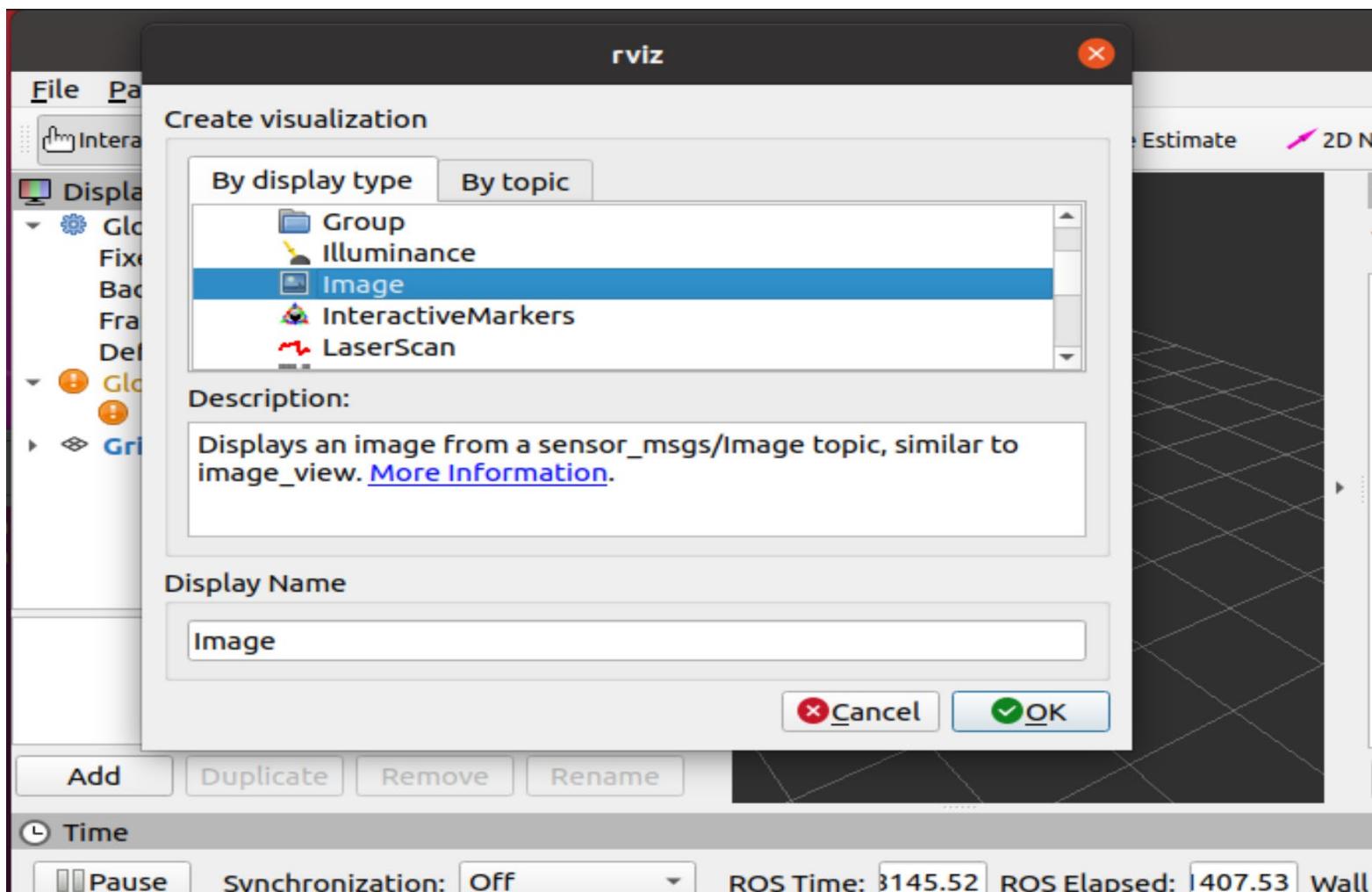


- Axes
- Camera
- Depth cloud
- Effort
- Fluid pressure
- Grid
- Grid cells (used for map)
- Group
- Illuminance
- Video
- Interactive marker
- Laser scan
- Map
- Marker
- Marker array
- Odometry
- Path
- Point cloud
- Point cloud2
- Point stamped
- Polygon
- Pose
- Pose array
- Range
- Temperature
- Robot model
- TF
- Relative Humidity
- WrenchStamped

Rviz

```
ab@ab-c:~$ roscore
```

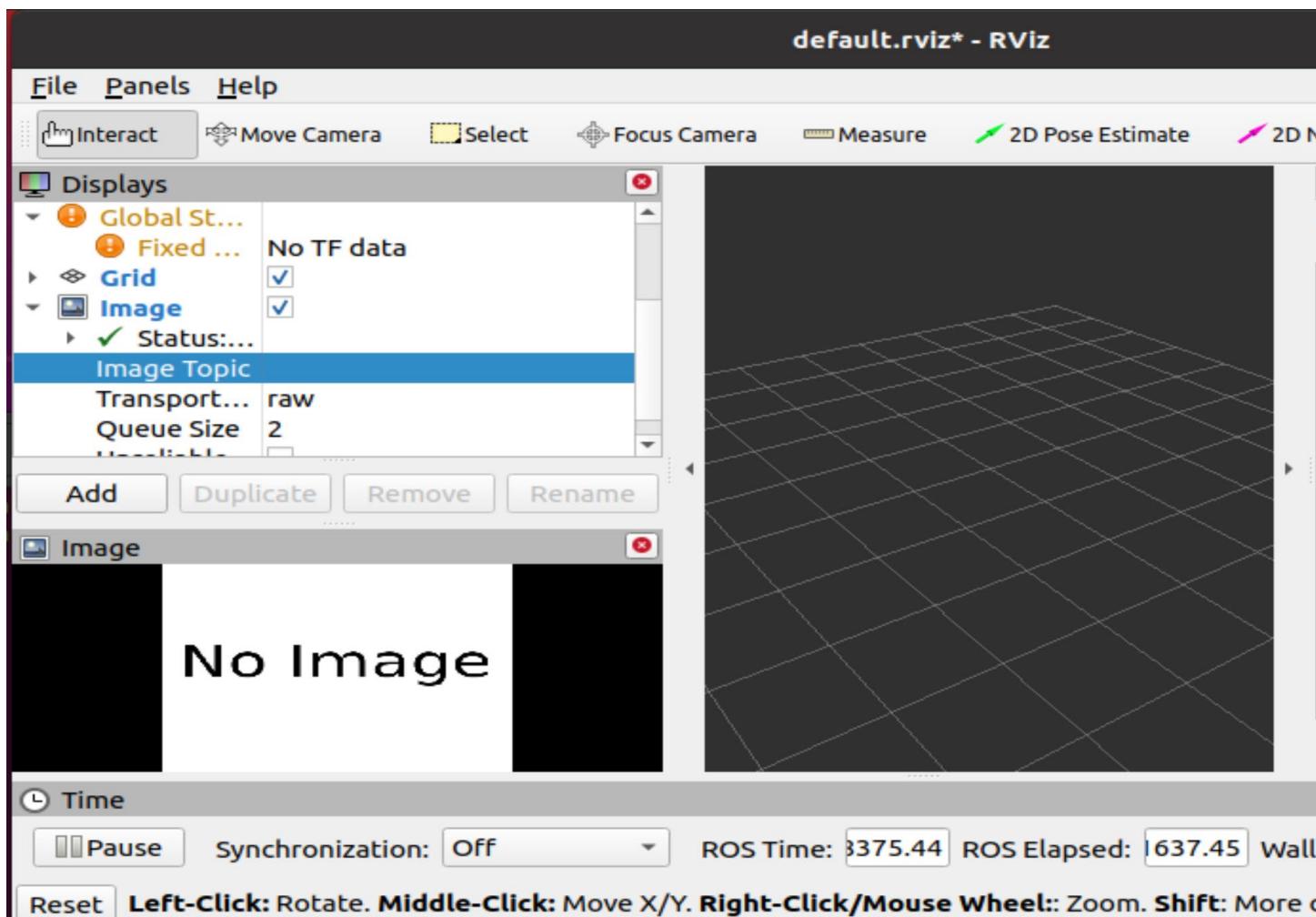
```
ab@ab-c:~$ rosrun rviz rviz
```



Rviz

```
ab@ab-c:~$ roscore
```

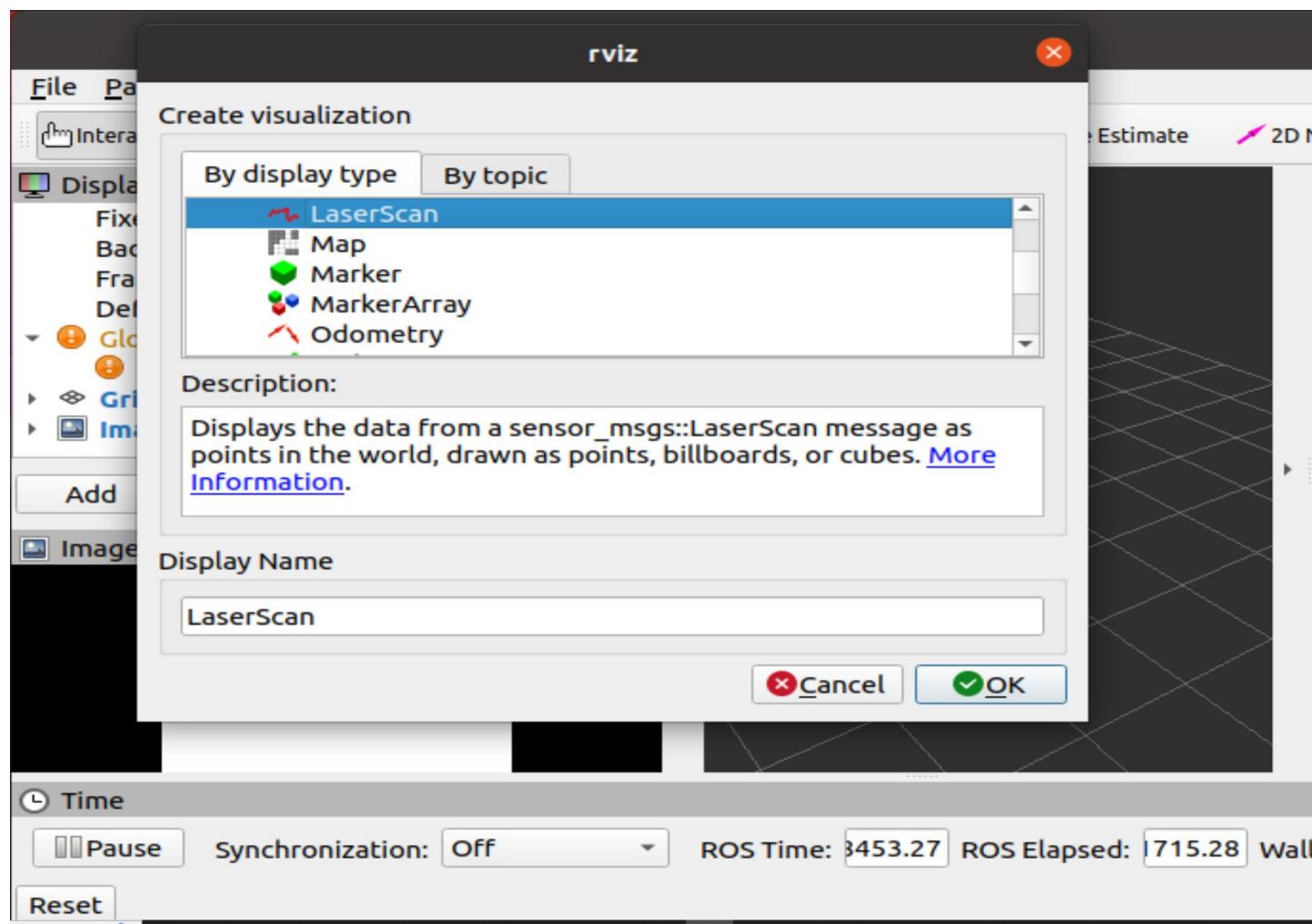
```
ab@ab-c:~$ rosrun rviz rviz
```



Rviz

```
ab@ab-c:~$ roscore
```

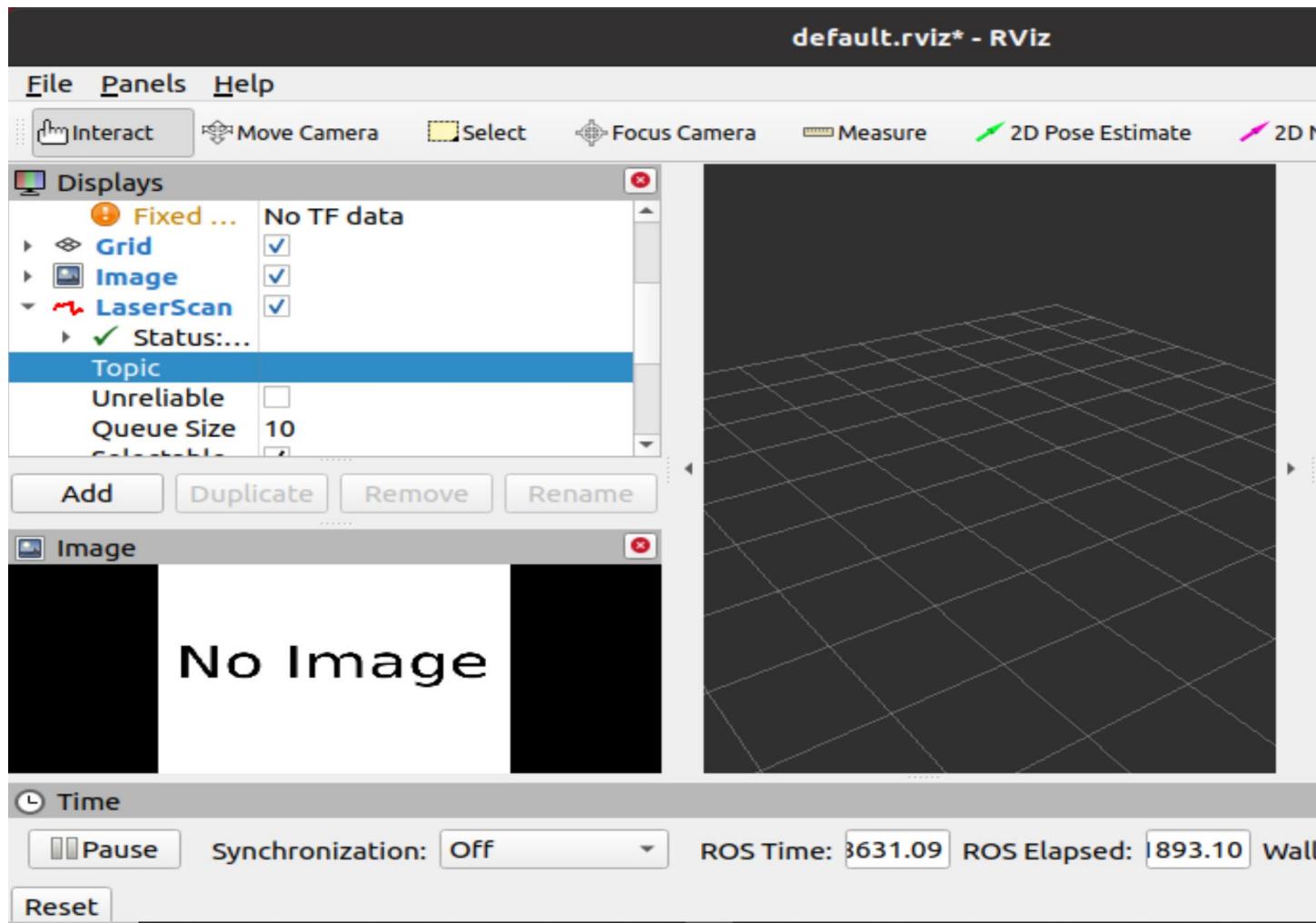
```
ab@ab-c:~$ rosrun rviz rviz
```



Rviz

```
ab@ab-c:~$ roscore
```

```
ab@ab-c:~$ rosrun rviz rviz
```



RQT

RQT: Plug-in Type Comprehensive GUI Tool for ROS

- Starting with the ROS Fuerte version, the existing 'rxbag', 'rxplot', 'rxgraph', etc. have been merged with 'rqt'. It is now available as **comprehensive GUI tool** for ROS with plug-ins such as 'rqt_bag', 'rqt_plot', 'rqt_graph', etc.
- Since 'rqt' is developed with 'Qt', users can freely add and develop **plugins**
- Let's take a look at '[rqt_image_view](#)', '[rqt_graph](#)', '[rqt_plot](#)', '[rqt_bag](#)' which are representative plugins of 'rqt'
- In addition, there are plugins such as
- rqt_action, rqt_gui, rqt_plot, rqt_runtime_monitor, rqt_bag, rqt_gui_cpp, rqt_pose_view, rqt_rviz, rqt_plugins, rqt_gui_py, rqt_publisher, rqt_service_caller, rqt_capabilities, rqt_image_view, rqt_py_common, rqt_shell, rqt_console, rqt_launch, rqt_py_console, rqt_srv, rqt_controller_manager, rqt_logger_level, rqt_reconfigure, rqt_tf_tree, rqt_dep, rqt_moveit, rqt_robot_dashboard, rqt_top, rqt_ez_publisher, rqt_msg, rqt_robot_monitor, rqt_topic, rqt_graph, rqt_nav_view, rqt_robot_steering, rqt_web, etc. (wow.. ---;;)

RQT Plug-in #1

1. Action

- Action Type Browser | Check the data structure of action type

2. Configuration

- Dynamic Reconfigure | Change the GUI setting value to change the setting value provided by the nodes
- Launch | GUI version of 'roslaunch'

3. Introspection

- Node Graph | Graph view showing relationship diagrams and message flow of running nodes
- Package Graph | Graph view showing node dependencies
- Process Monitor | Check CPU utilization, memory usage, and number of threads of running nodes

4. Logging

- Bag | ROS data logging
- Console | Check for messages such as warning, error that occur on the nodes
- Logger Level | Select and display logger information such as Debug, Info, Warn, Error, Fatal

RQT Plug-in #2

5. Miscellaneous Tools

- Python Console | Python console screen
- Shell | Activate shell
- Web | Activate web browser

6. Robot

- Depending on the robot, add a plug-in such as a dashboard

7. Robot Tools

- Controller Manager | Plug-in required to control the controller
- Diagnostic Viewer | Check robot device and error
- Moveit! Monitor | Check 'Moveit!' data used in robot arm planning
- Robot Steering | Robot adjustment GUI tool, used in remote control to steer the robot
- Runtime Monitor | Check for errors and warning on nodes in real time

RQT Plug-in #3

8. Services

- Service Caller | Connect to the running service server and request service
- Service Type Browser | Check the data structure of the service type

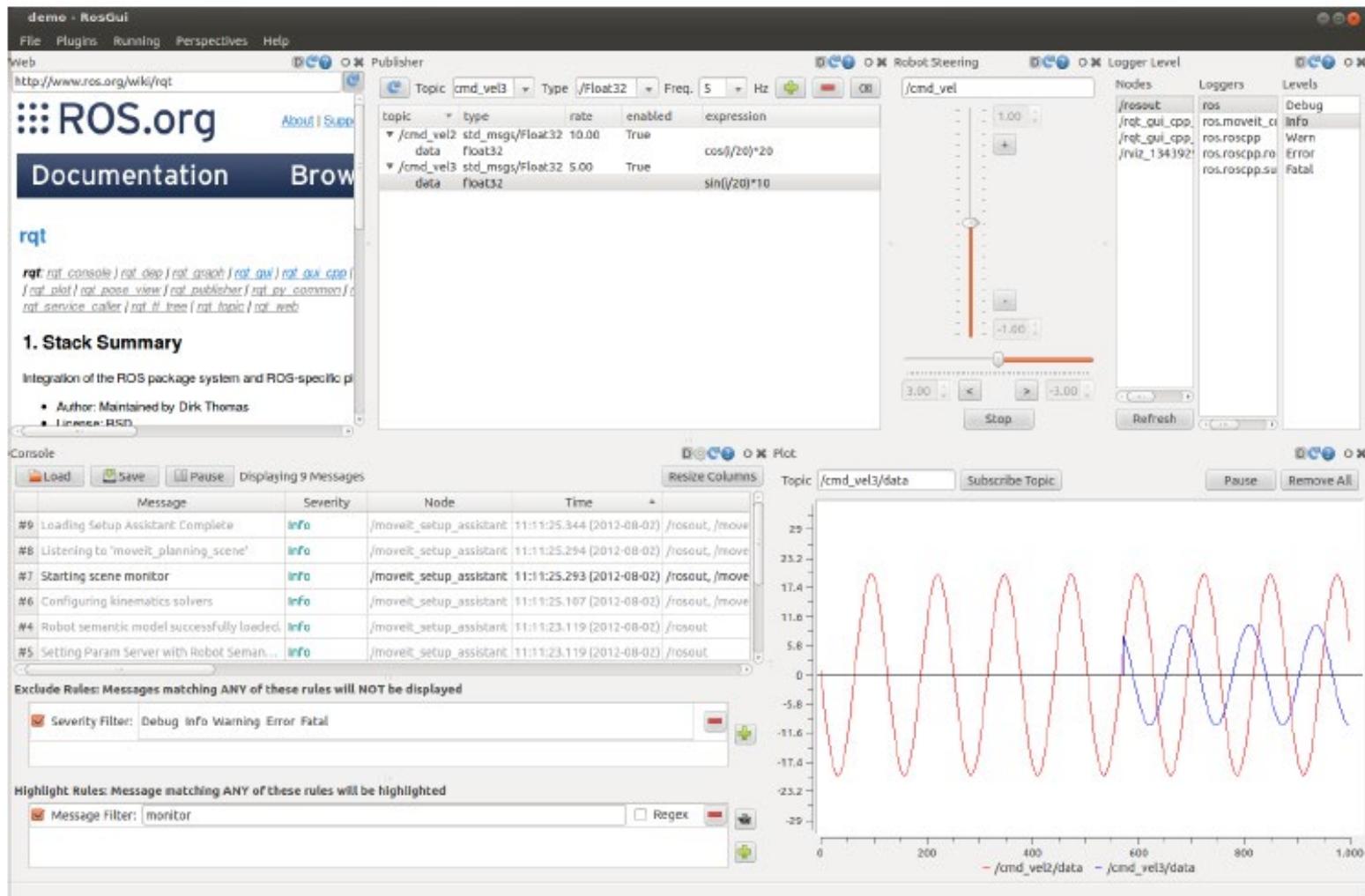
9. Topics

- Easy Message Publisher | Publish topic in GUI environment
- Topic Publisher | Create and publish topic
- Topic Type Browser | Check the data structure of the topic type
- Topic Monitor | Check the information of selected topic

10. Visualization

- Image View | Check image data of camera
- Navigation Viewer | Check location and target point of robot navigation
- Plot | 2D data plot GUI plug-in, 2D data plotting
- Pose View | Show current TF location and model location
- RViz | Rviz plug-in which is 3D visualization tool
- TF Tree | Graph view showing tf relation as a tree structure

RQT Example

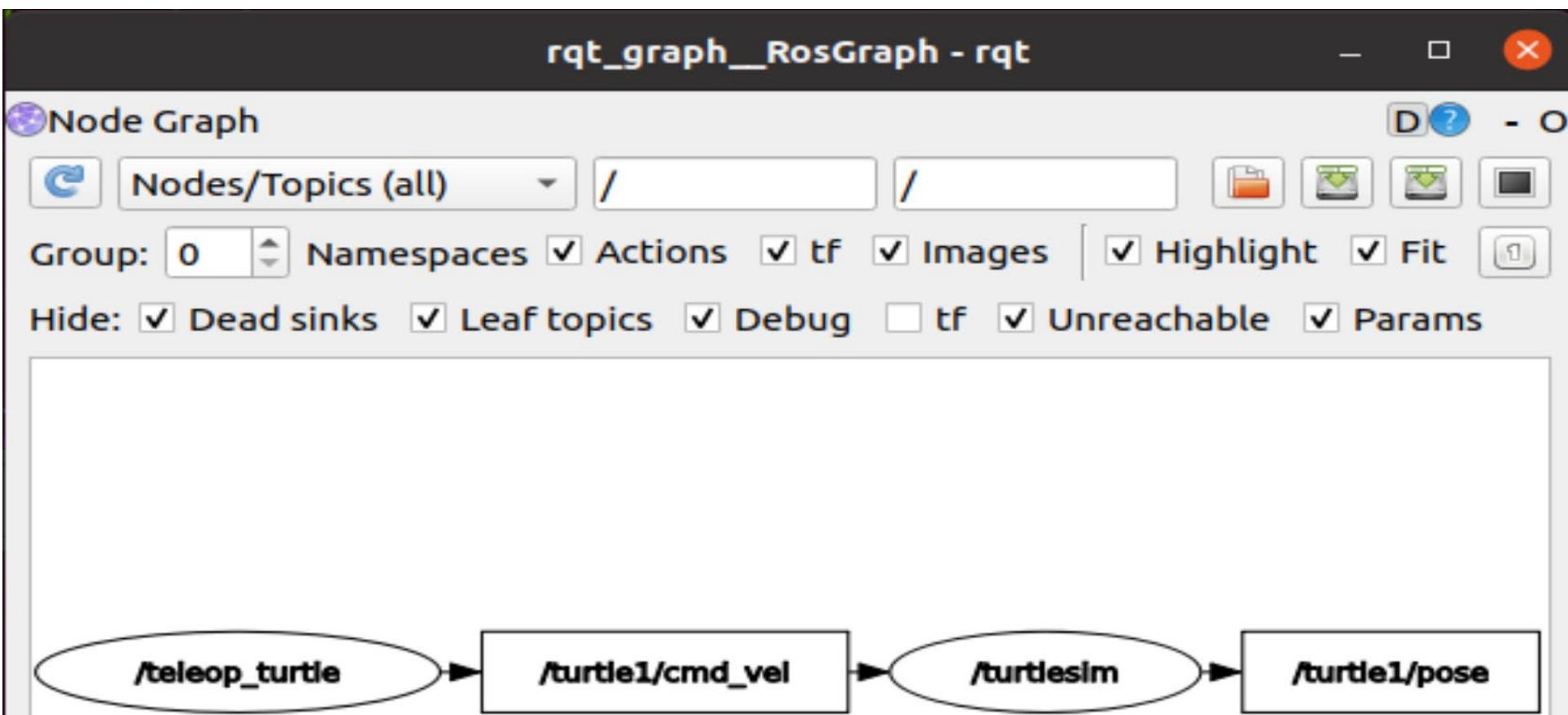


rqt_graph

```
ab@ab-c:~$ roscore
```

```
ab@ab-c:~$ rosrun turtlesim turtlesim_node
```

```
ab@ab-c:~$ rqt_graph
```

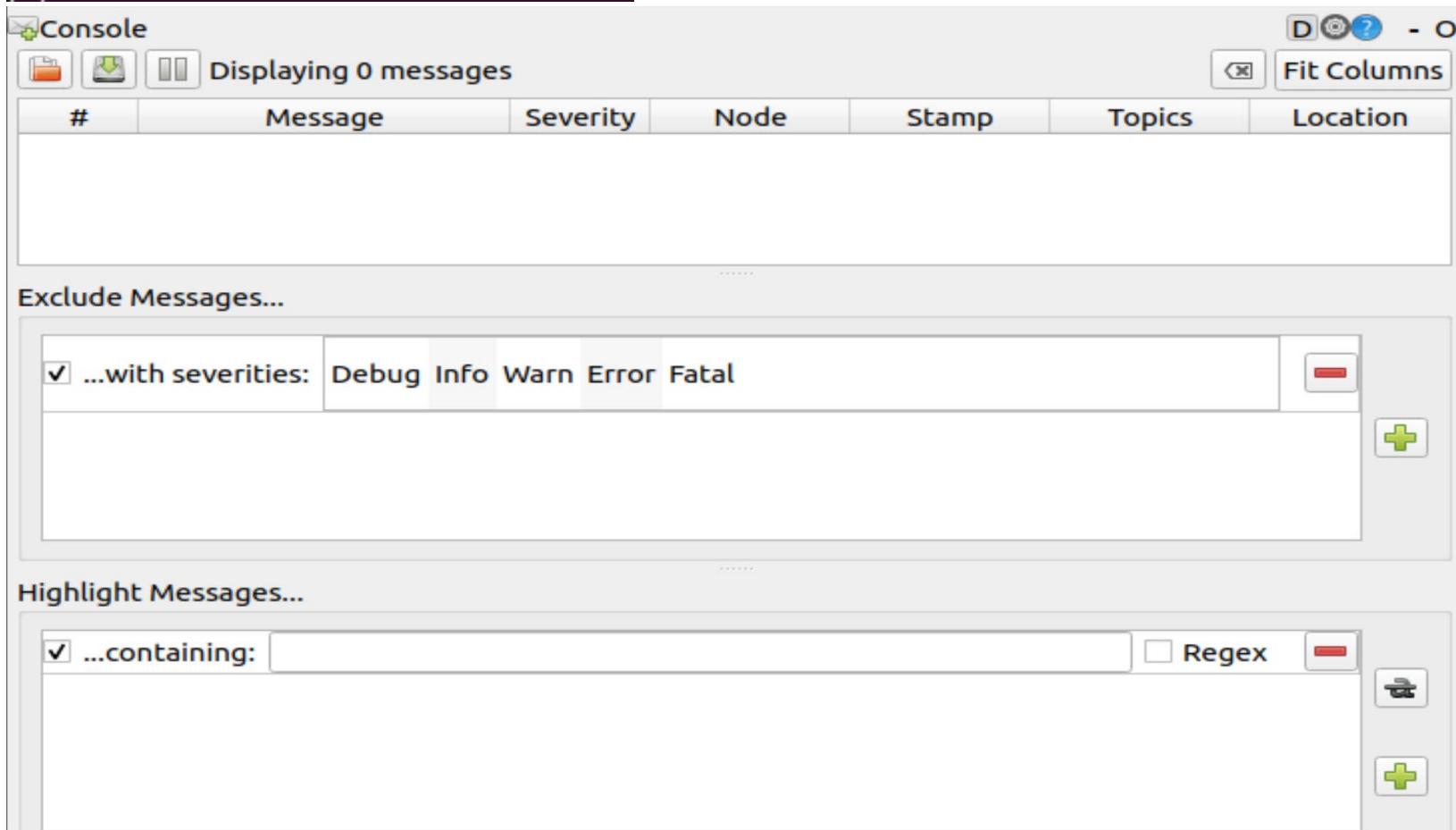


rqt_console

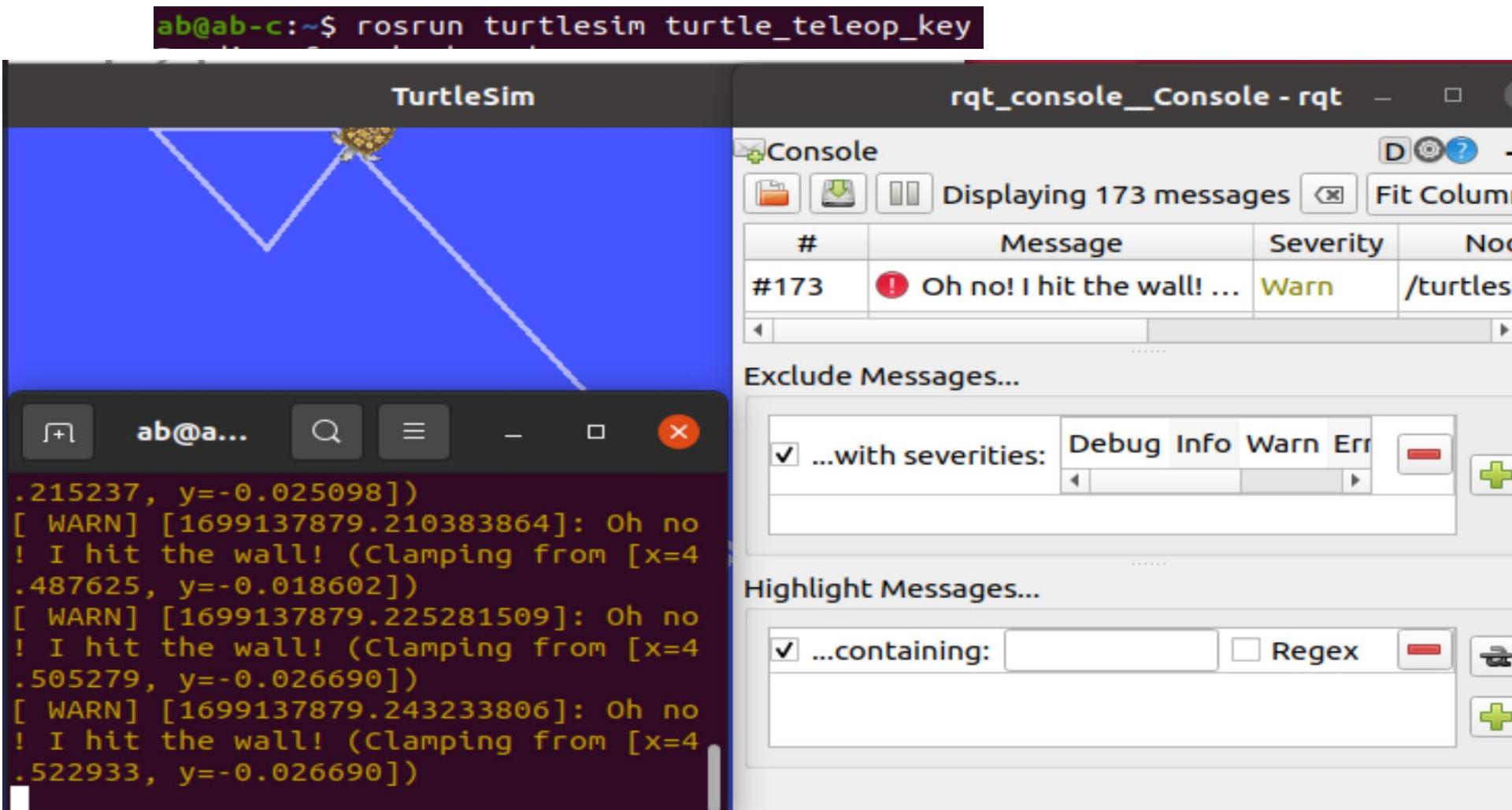
```
ab@ab-c:~$ roscore
```

```
ab@ab-c:~$ rosrun turtlesim turtlesim_node
```

```
ab@ab-c:~$ rqt_console
```



rqt_console

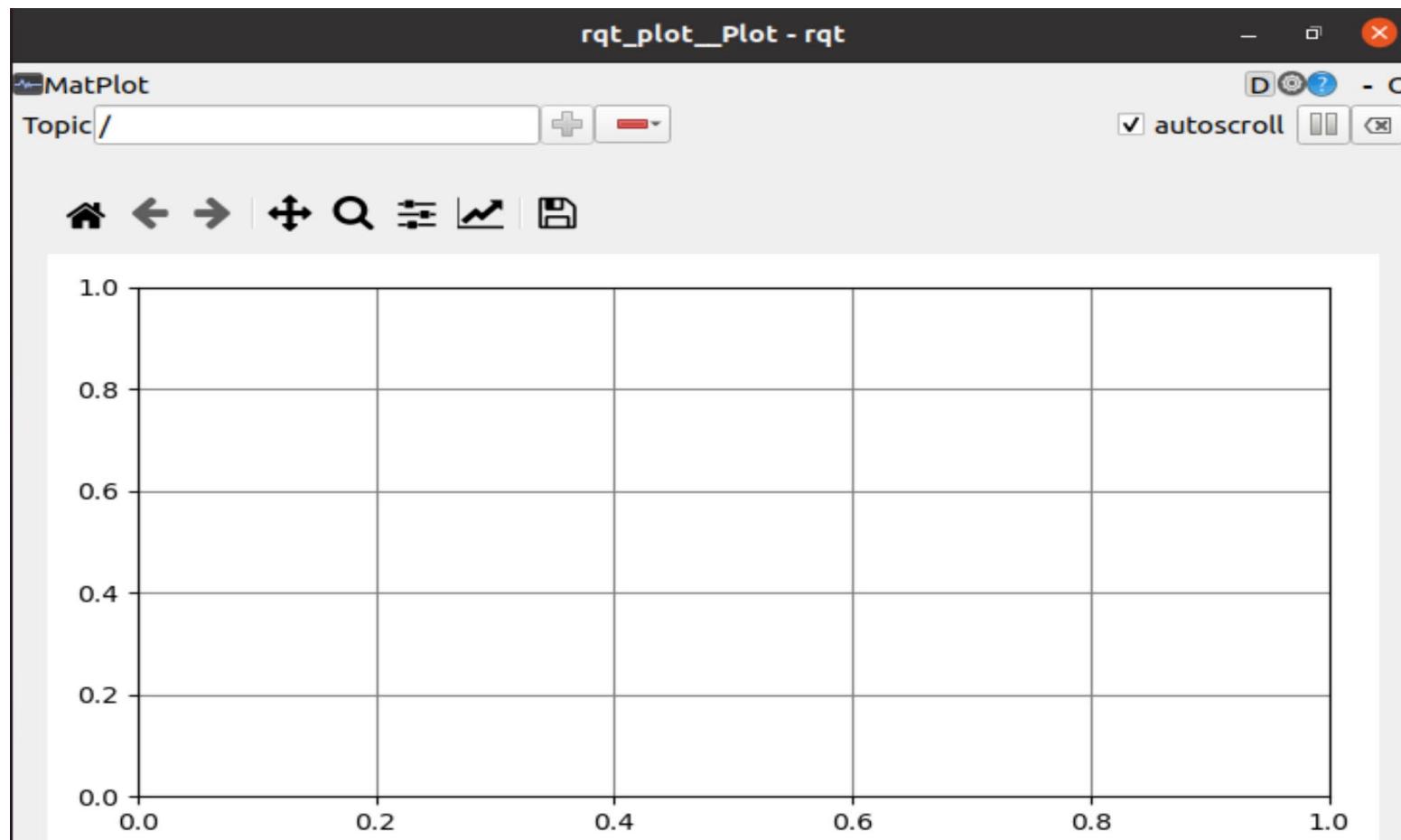


rqt_plot

```
ab@ab-c:~$ roscore
```

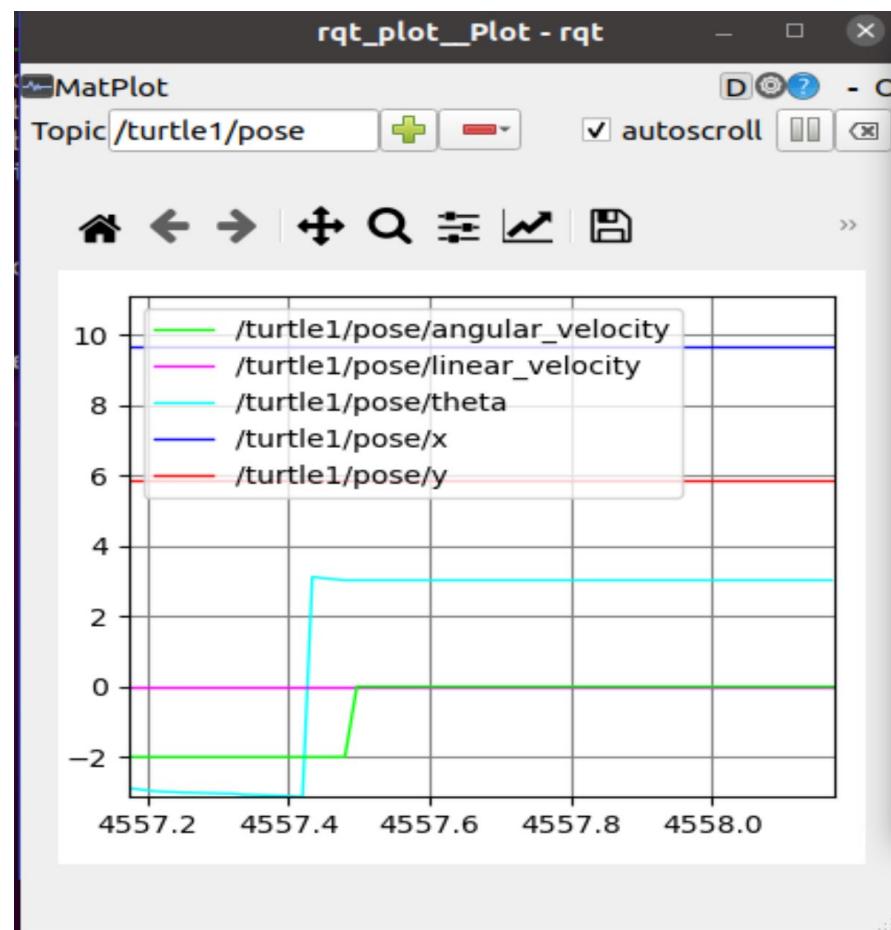
```
ab@ab-c:~$ rosrun turtlesim turtlesim_node
```

```
ab@ab-c:~$ rqt_plot
```



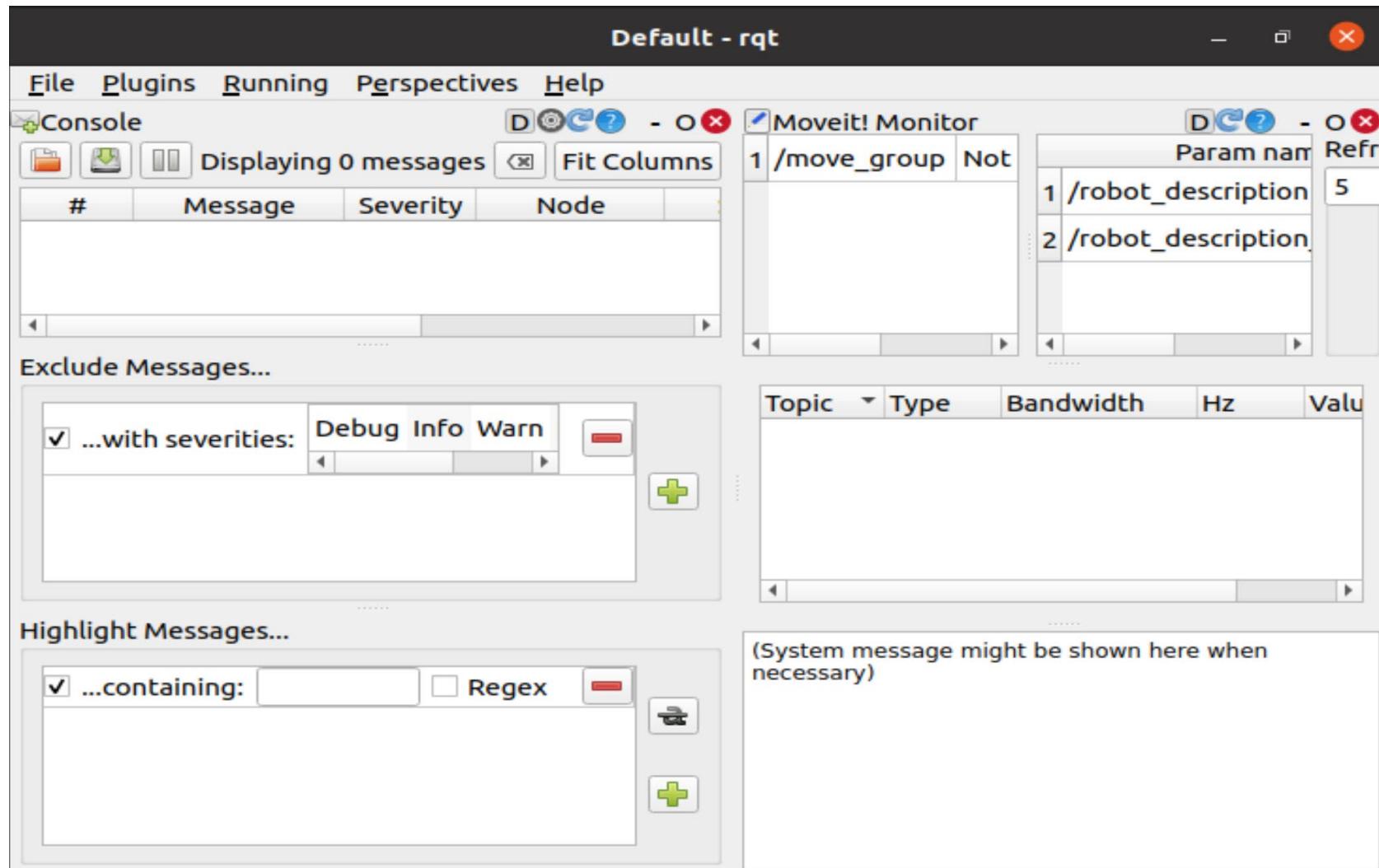
rqt_plot

```
ab@ab-c:~$ rosrun turtlesim turtle_teleop_key  
Reading from keyboard
```



rqt

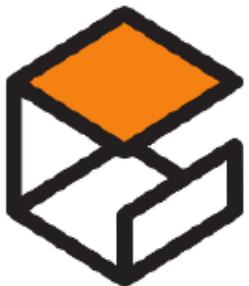
```
ab@ab-c:~$ rqt
```



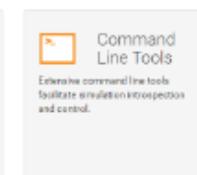
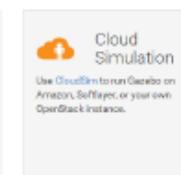
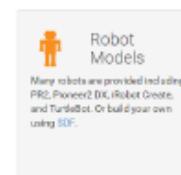
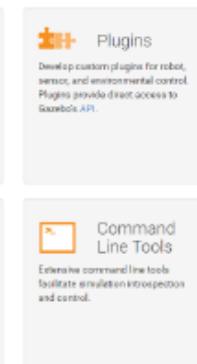
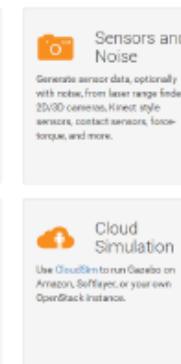
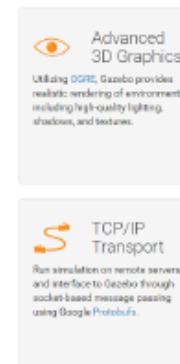
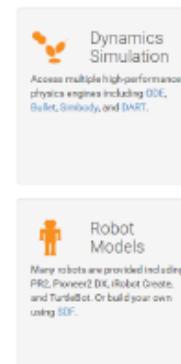
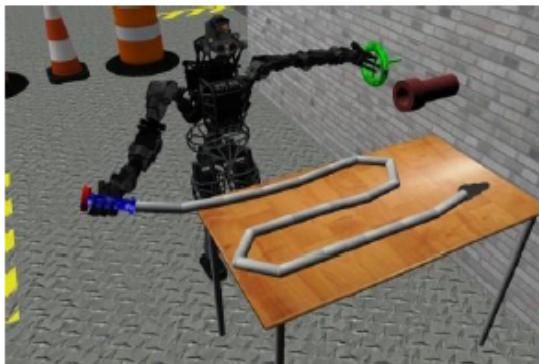
Gazebo

Gazebo

- Gazebo is 3D Simulator with Physics Engine, Robot model, Sensor, Environment model, and so on. It helps you to get data similar to the one in real environment.
- Gazebo is regarded as the best simulator among recently-introduced Open Simulator. In addition, it is selected as an **official simulator for DARPA Robotics Challenge**
- It is highly compatible with ROS.



GAZEBO



Gazebo



GAZEBO

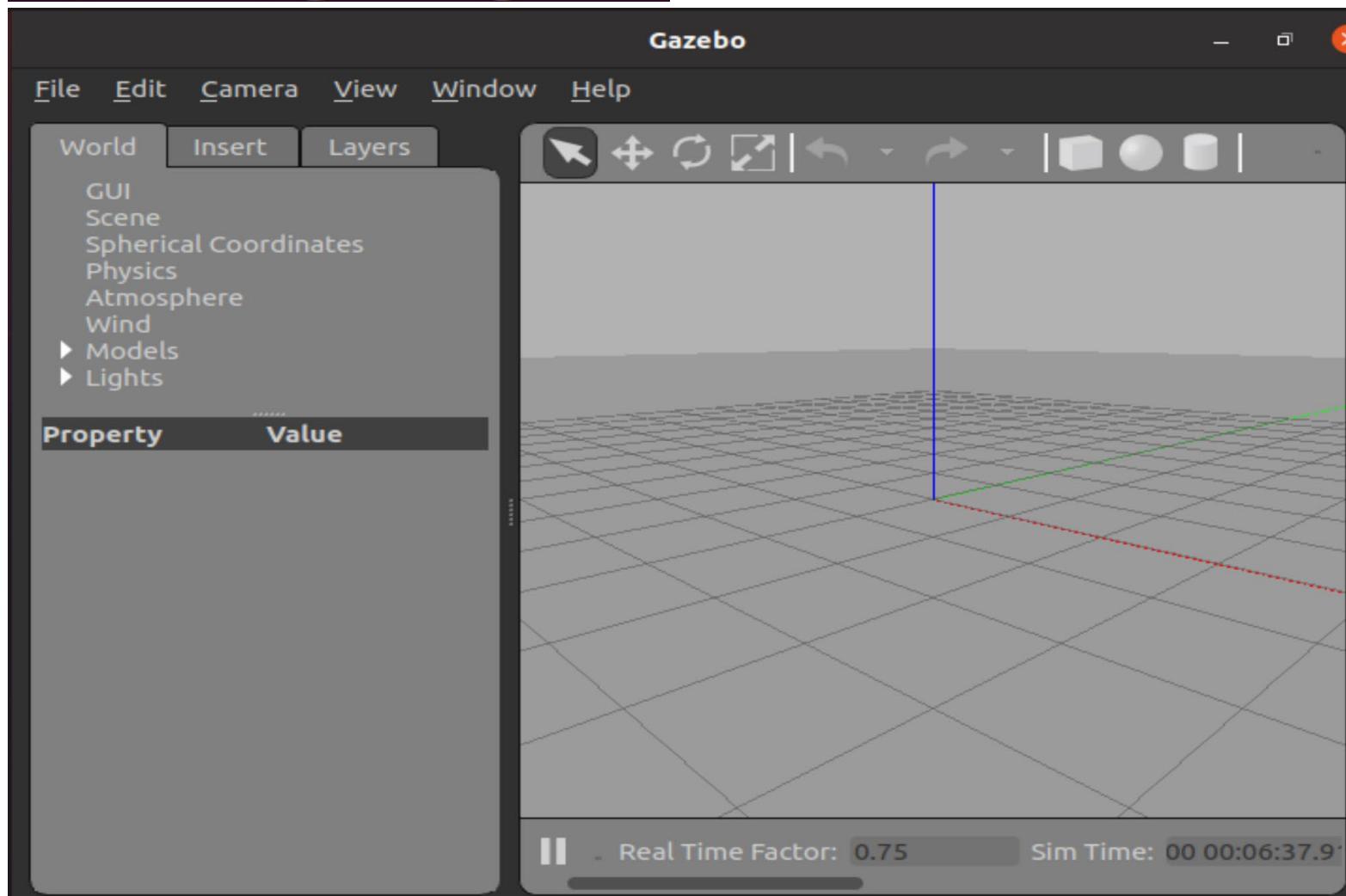
2016
Compilation

https://www.youtube.com/watch?v=R3xUKYcG_bc

Gazebo

```
ab@ab-c:~$ sudo apt install ros-noetic-gazebo-*
```

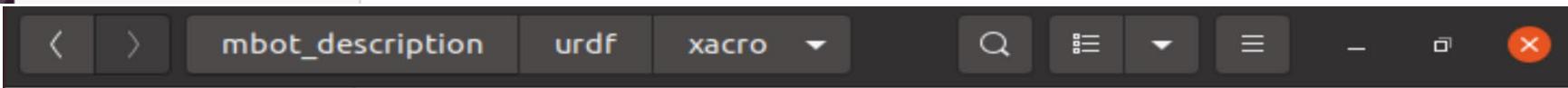
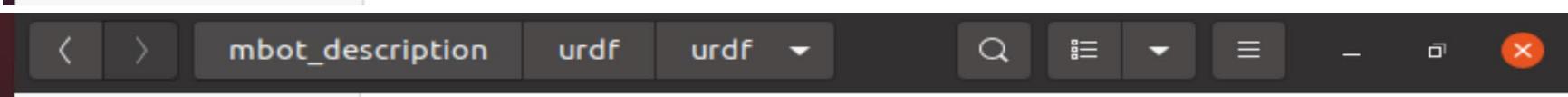
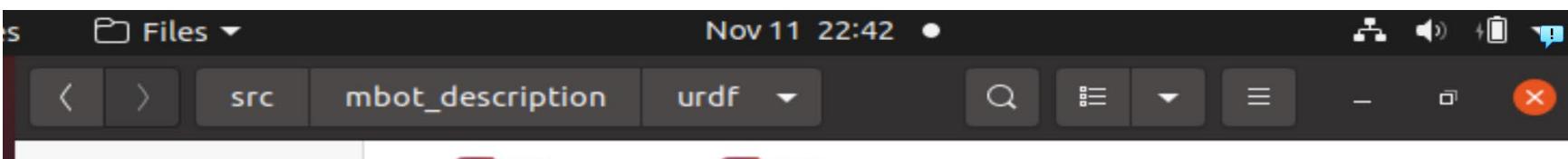
```
ab@ab-c:~$ gazebo gazebo
```



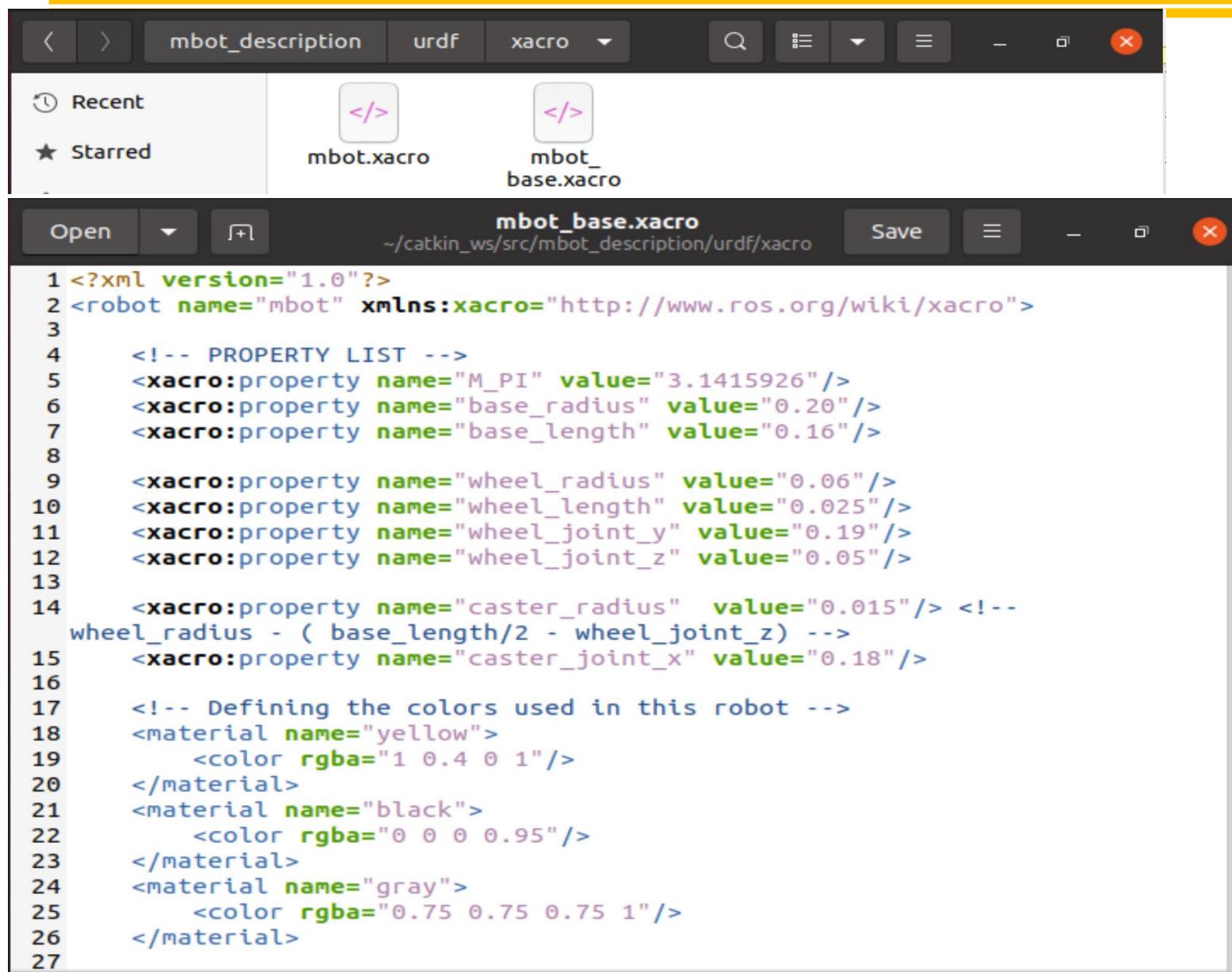
Lecture 16: URDF Model Optimization

Create New sub-Folders in urdf

Put files built in last class into sub-folder “urdf”, copy paste mbot.xacro, mbot_base.xacro into sub-folder “xacro”



Create mbot_base.xacro

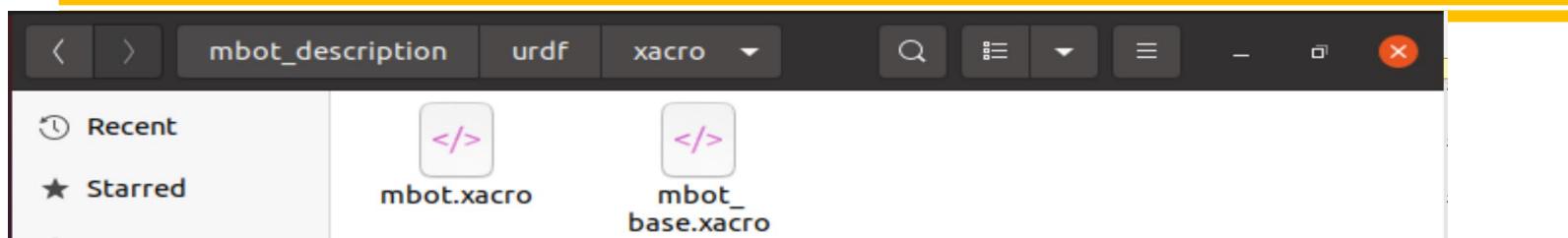


The screenshot shows a code editor interface with the following details:

- Toolbar:** Includes icons for back, forward, search, and file operations.
- Left Sidebar:** Shows "Recent" and "Starred" items, with "mbot.xacro" and "mbot_base.xacro" listed.
- Header:** Displays the file name "mbot_base.xacro", the path "~/catkin_ws/src/mbot_description/urdf/xacro", and standard window controls.
- Code Content:** The XML code for the robot definition, starting with the root element <robot> and defining properties like M_PI, base_radius, base_length, wheel_radius, wheel_length, wheel_joint_y, wheel_joint_z, and caster_radius, along with material definitions for yellow, black, and gray.

```
1 <?xml version="1.0"?>
2 <robot name="mbot" xmlns:xacro="http://www.ros.org/wiki/xacro">
3
4     <!-- PROPERTY LIST -->
5     <xacro:property name="M_PI" value="3.1415926"/>
6     <xacro:property name="base_radius" value="0.20"/>
7     <xacro:property name="base_length" value="0.16"/>
8
9     <xacro:property name="wheel_radius" value="0.06"/>
10    <xacro:property name="wheel_length" value="0.025"/>
11    <xacro:property name="wheel_joint_y" value="0.19"/>
12    <xacro:property name="wheel_joint_z" value="0.05"/>
13
14    <xacro:property name="caster_radius" value="0.015"/> <!--
15        wheel_radius - ( base_length/2 - wheel_joint_z ) -->
16        <xacro:property name="caster_joint_x" value="0.18"/>
17
18    <!-- Defining the colors used in this robot -->
19    <material name="yellow">
20        <color rgba="1 0.4 0 1"/>
21    </material>
22    <material name="black">
23        <color rgba="0 0 0 0.95"/>
24    </material>
25    <material name="gray">
26        <color rgba="0.75 0.75 0.75 1"/>
27    </material>
```

Create mbot.xacro



The code editor window title is 'mbot.xacro' and the path is '~catkin_ws/src/mbot_description/urdf/xacro'. The code content is:

```
1 <?xml version="1.0"?>
2 <robot name="mbot" xmlns:xacro="http://www.ros.org/wiki/xacro">
3
4     <xacro:include filename="$(find mbot_description)/urdf/xacro/->
   mbot_base.xacro" />
5
6     <xacro:mbot_base/>
7
8 </robot>
```

Create display_mbot_base_xacro.launch

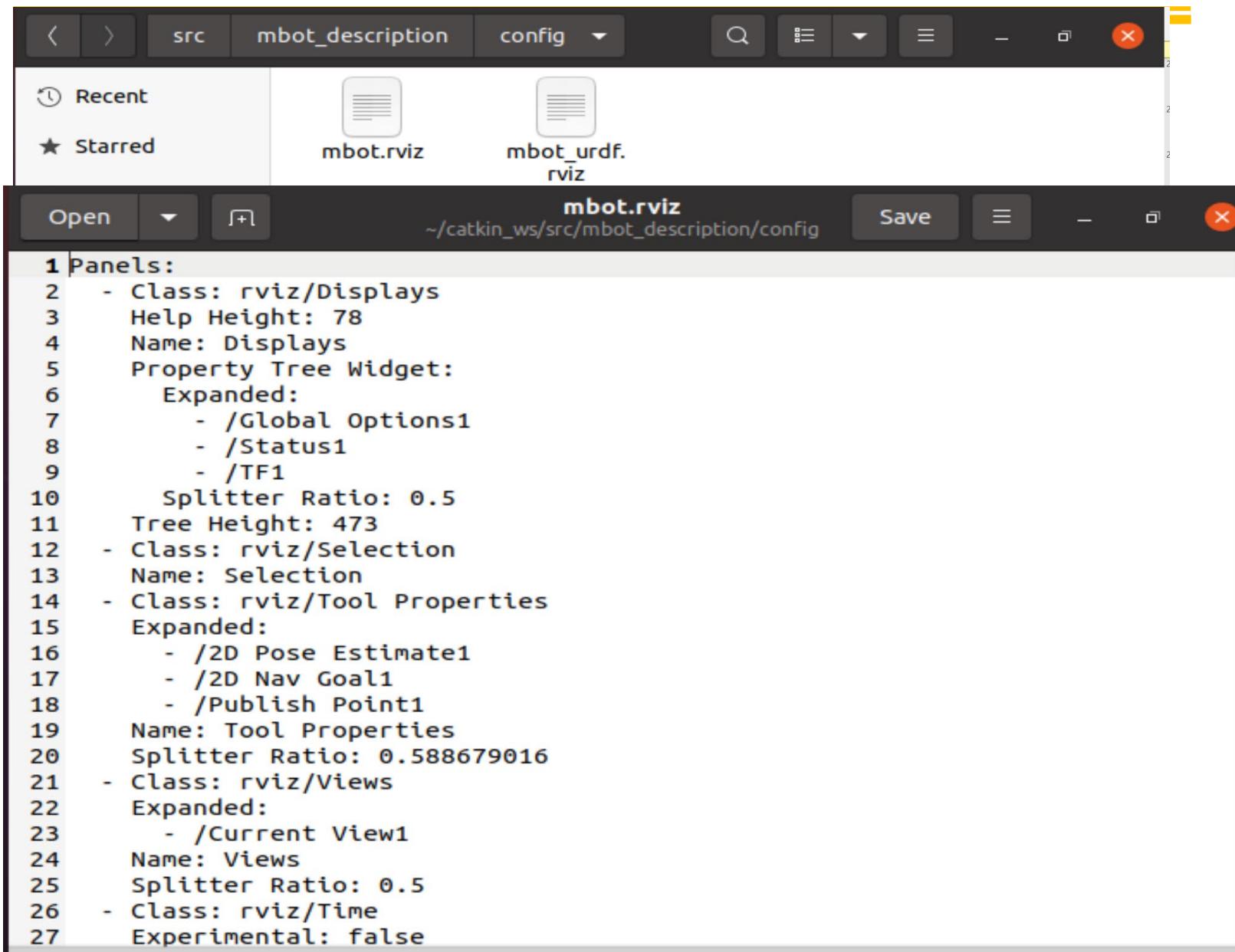
The screenshot shows a terminal window with two tabs open. The top tab is titled 'mbot_description' and contains the command 'cd mbot_description'. The bottom tab is titled 'mbot_description' and contains the command 'catkin_createLaunchFile launch/xacro'. The terminal output shows the creation of a new file named 'display_mbot_base_xacro.launch'.

```
cd mbot_description
catkin_createLaunchFile launch/xacro
[ 50%] display_mbot_base_xacro.launch
```

The resulting file 'display_mbot_base_xacro.launch' is displayed in the terminal window. It is a launch configuration file for ROS. The code is as follows:

```
1 <launch>
2     <arg name="model" default="$(find xacro)/xacro --inorder '$(find
mbot_description)/urdf/xacro/mbot.xacro'" />
3     <arg name="gui" default="true" />
4
5     <param name="robot_description" command="$(arg model)" />
6
7
8     <param name="use_gui" value="$(arg gui)"/>
9
10
11    <node name="joint_state_publisher" pkg="joint_state_publisher"
12      type="joint_state_publisher" />
13
14    <node name="robot_state_publisher" pkg="robot_state_publisher"
15      type="robot_state_publisher" />
16
17    <node name="rviz" pkg="rviz" type="rviz" args="-d $(find
mbot_description)/config/mbot.rviz" required="true" />
18
19 </launch>
20
```

Create mbot.rviz



The screenshot shows a code editor window with the following details:

- File Path:** ~/catkin_ws/src/mbot_description/config
- File Name:** mbot.rviz
- Content:** Configuration for the mbot.rviz viewer.

```
1 Panels:
2   - Class: rviz/Displays
3     Help Height: 78
4     Name: Displays
5     Property Tree Widget:
6       Expanded:
7         - /Global Options1
8         - /Status1
9         - /TF1
10        Splitter Ratio: 0.5
11        Tree Height: 473
12   - Class: rviz/Selection
13     Name: Selection
14   - Class: rviz/Tool Properties
15     Expanded:
16       - /2D Pose Estimate1
17       - /2D Nav Goal1
18       - /Publish Point1
19     Name: Tool Properties
20     Splitter Ratio: 0.588679016
21   - Class: rviz/Views
22     Expanded:
23       - /Current View1
24     Name: Views
25     Splitter Ratio: 0.5
26   - Class: rviz/Time
27     Experimental: false
```

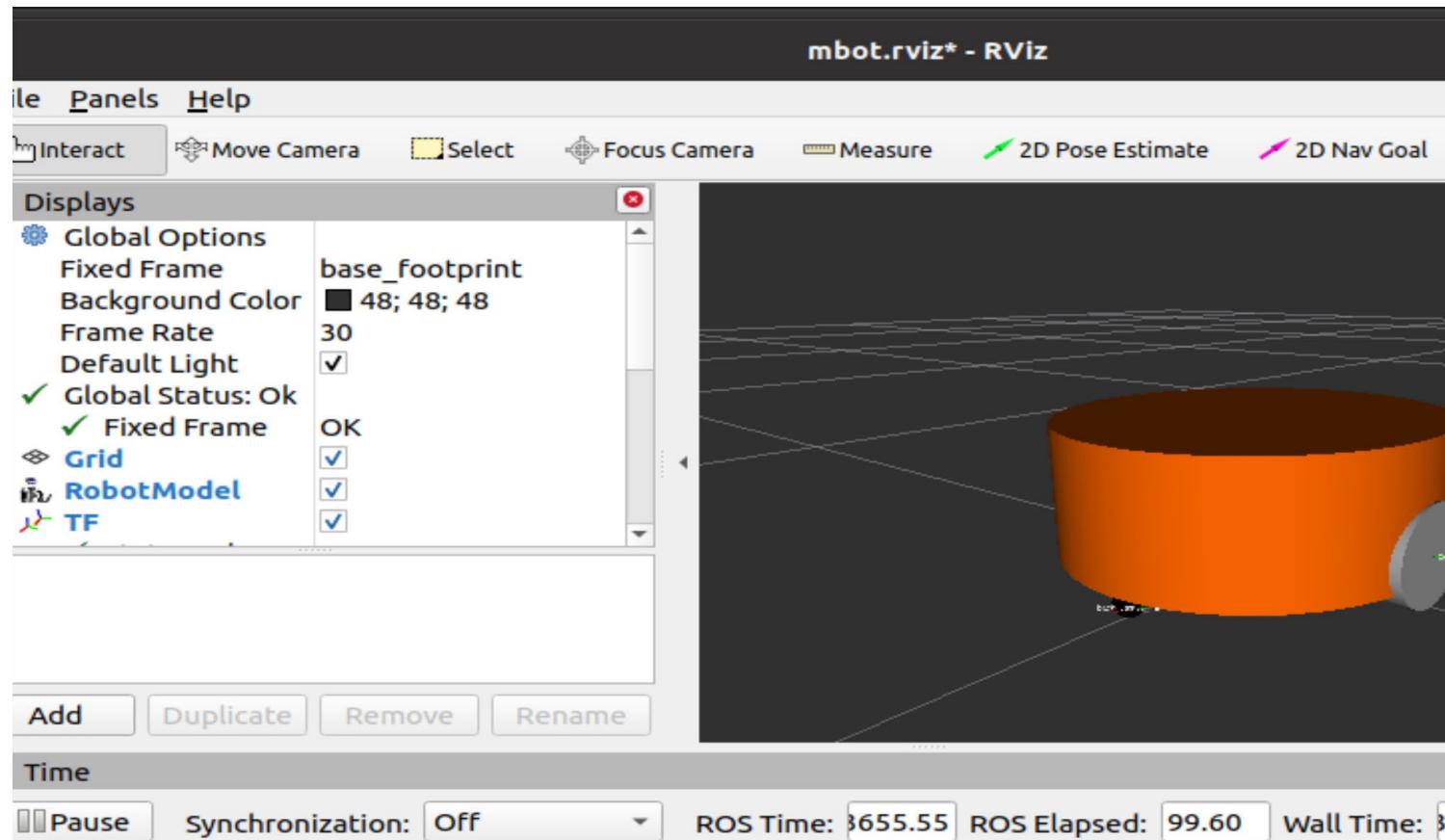
Display Model

Method 1:

```
ab@ab-c:~/catkin_ws/src/mbot_description/urdf/xacro$ rosrun xacro xacro xacro mbot.xa  
cro>mbot.urdf
```

Method 2:

```
ab@ab-c:~$ roslaunch mbot_description display_mbot_base_xacro.launch
```



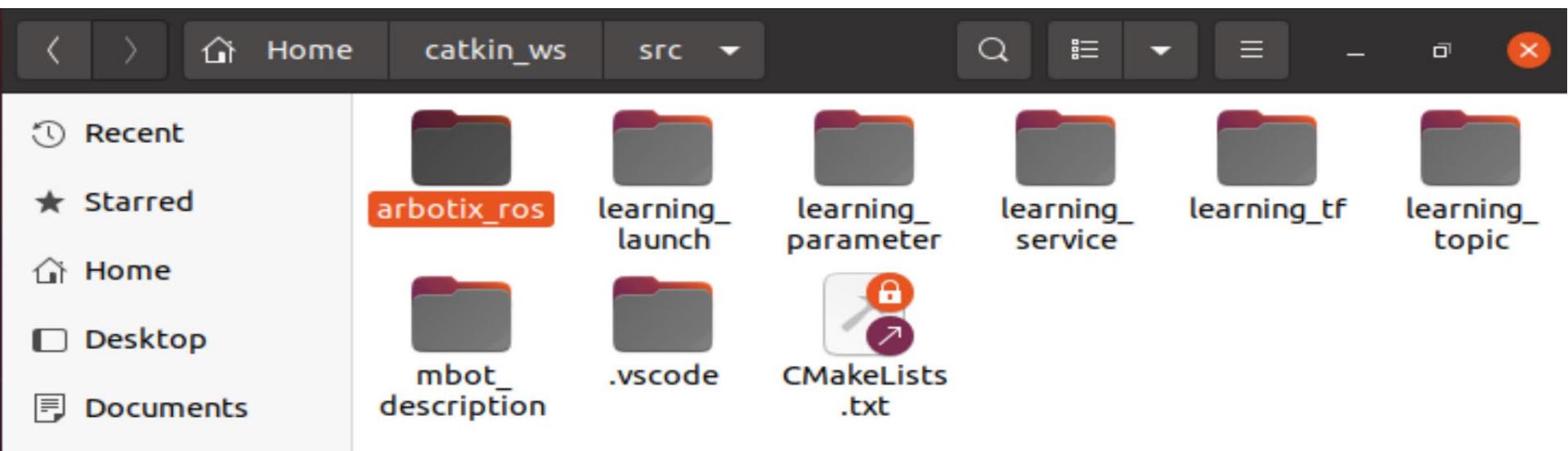
Lecture 17: ArbotiX & Rviz

Install ArbotiX

```
ab@ab-c:~/catkin_ws/src$ sudo apt install git  
ab@ab-c:~/catkin_ws/src$ git clone https://github.com/vanadiumlabs/arbotix_ros.git
```

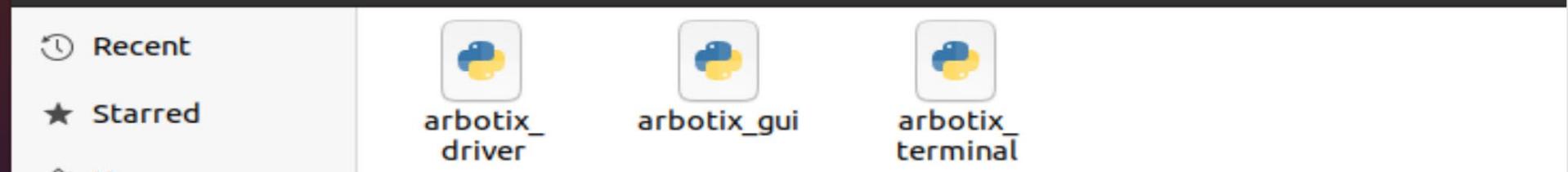
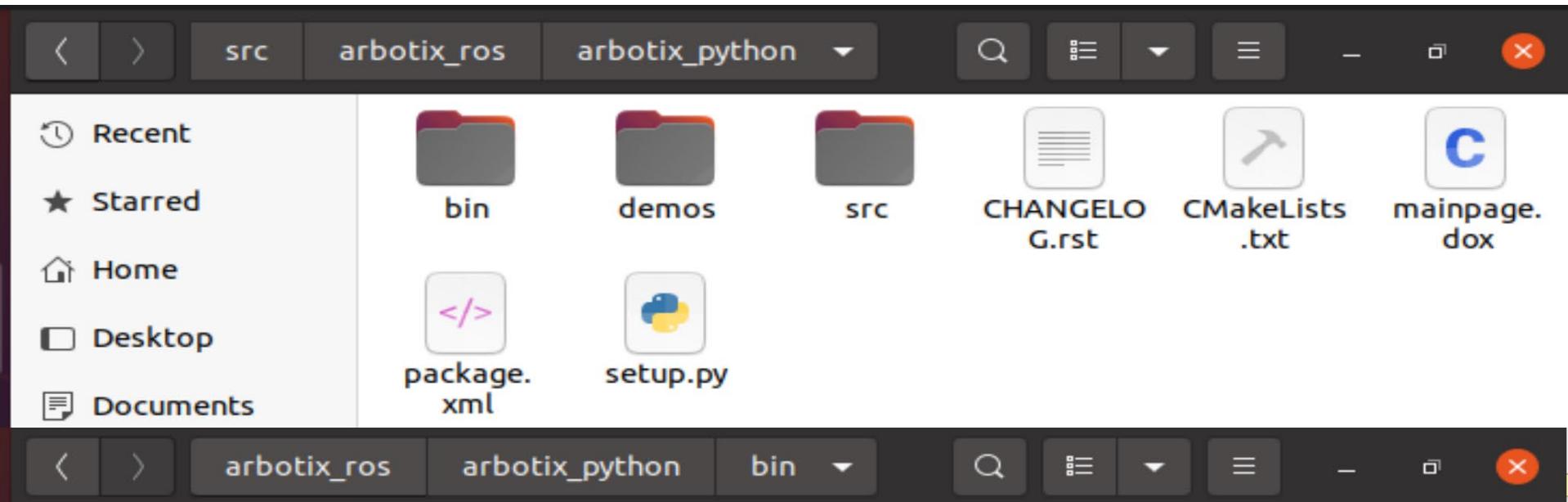
```
ab@ab-c:~/catkin_ws$ catkin_make
```

```
ab@ab-c:~/catkin_ws$ source devel/setup.bash
```

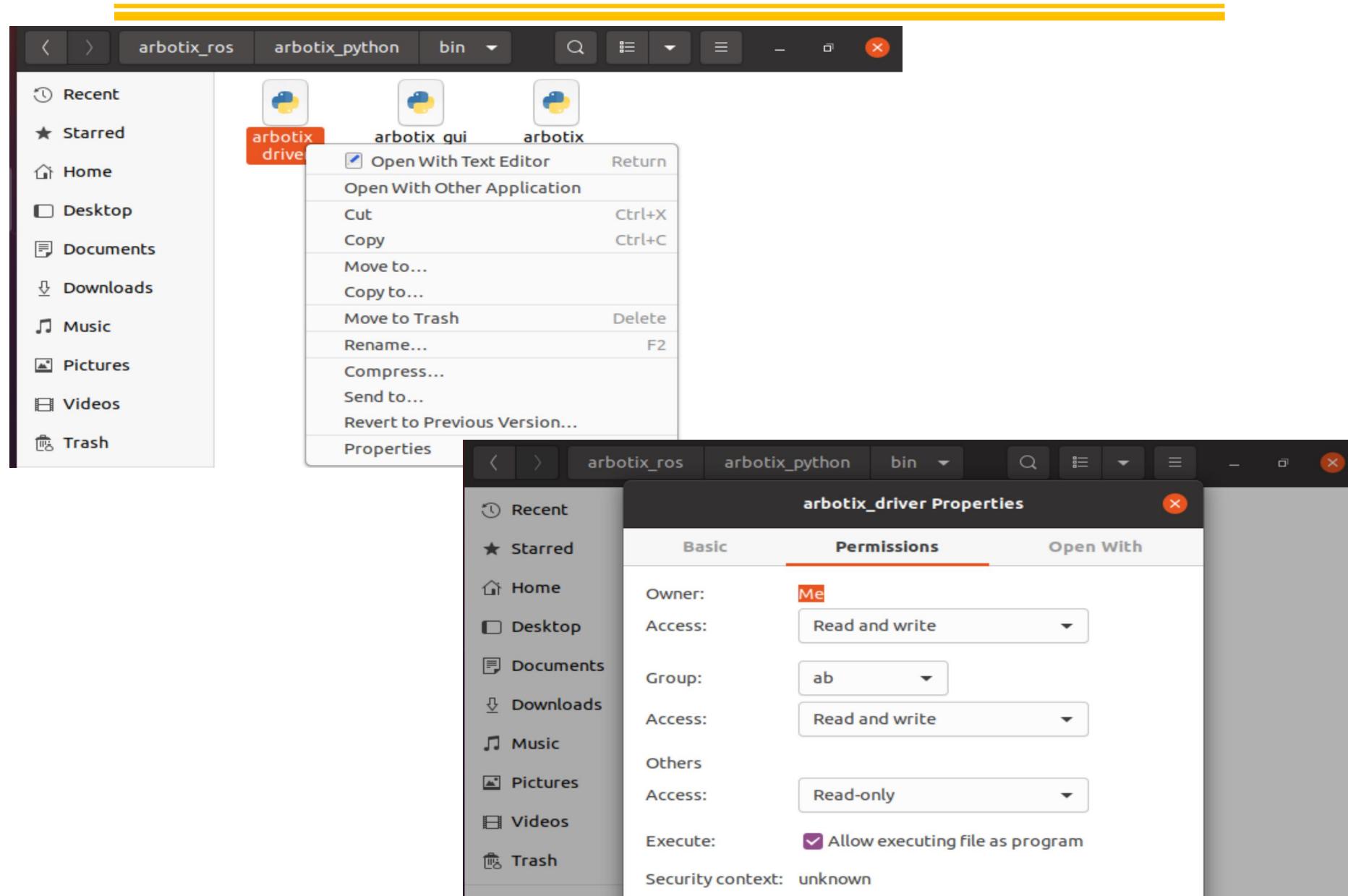


arbotix_python

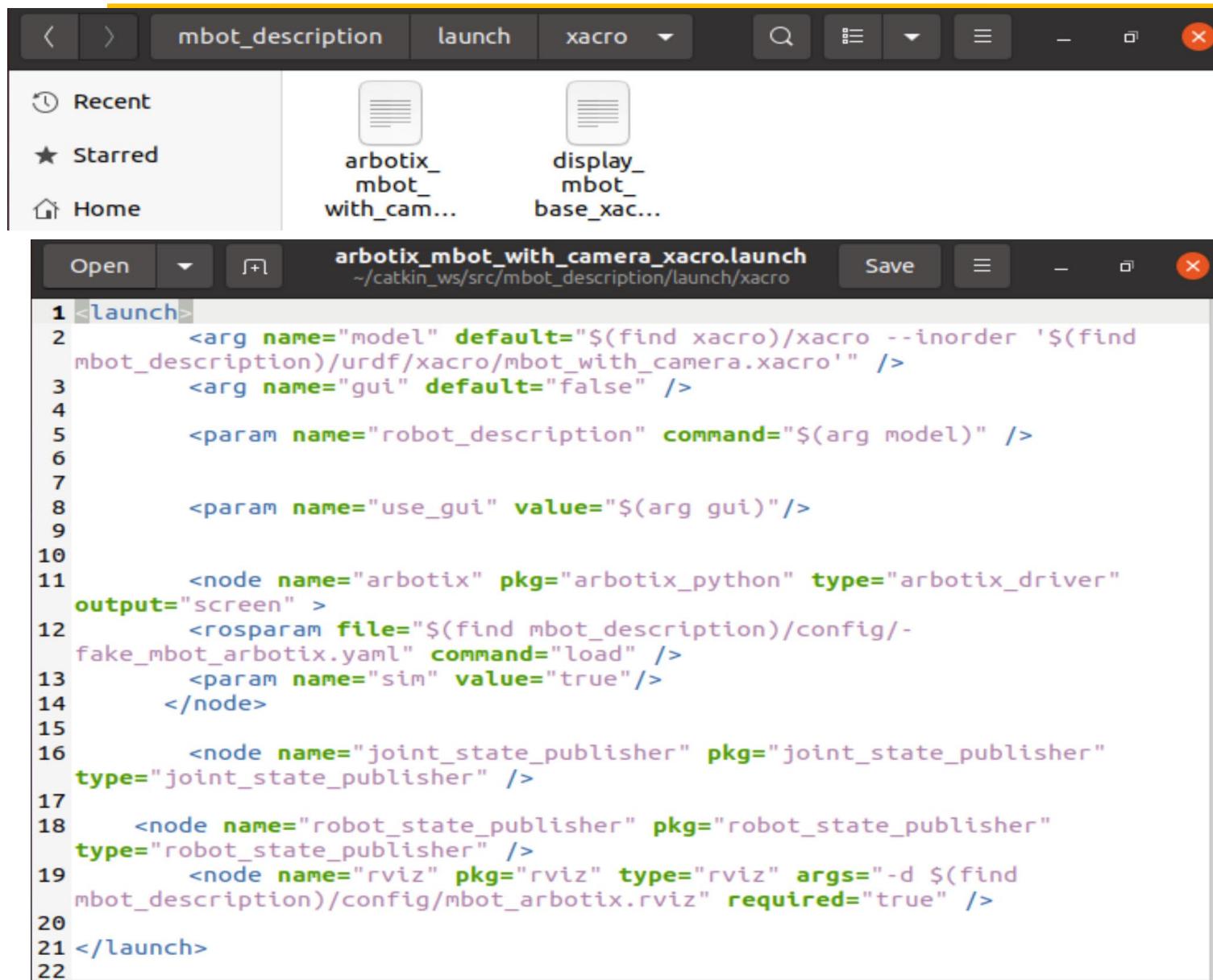
Allow executing file as program



arbotix_python



Create arbotix_mbot_with_camera_xacro.launch



The screenshot shows a code editor window with the following details:

- File Explorer:** Shows two files: "arbotix_mbot_with_camera_xacro.xacro" and "display_mbot_base_xac...".
- Title Bar:** Displays the file name "arbotix_mbot_with_camera_xacro.launch" and its path "~/catkin_ws/src/mbot_description/launch/xacro".
- Code Area:** Contains the XML configuration for launching the robot. The code is numbered from 1 to 22.

```
1 <launch>
2     <arg name="model" default="$(find xacro)/xacro --inorder '$(find
    mbot_description)/urdf/xacro/mbot_with_camera.xacro'" />
3     <arg name="gui" default="false" />
4
5     <param name="robot_description" command="$(arg model)" />
6
7
8     <param name="use_gui" value="$(arg gui)"/>
9
10
11    <node name="arbotix" pkg="arbotix_python" type="arbotix_driver"
12        output="screen" >
13        <rosparam file="$(find mbot_description)/config/-fake_mbot_arbotix.yaml" command="load" />
14        <param name="sim" value="true"/>
15    </node>
16
17    <node name="joint_state_publisher" pkg="joint_state_publisher"
18        type="joint_state_publisher" />
19
20    <node name="robot_state_publisher" pkg="robot_state_publisher"
21        type="robot_state_publisher" />
22        <node name="rviz" pkg="rviz" type="rviz" args="-d $(find
    mbot_description)/config/mbot_arbotix.rviz" required="true" />
23
24 </launch>
```

Create fake_mbot_arbotix.yaml

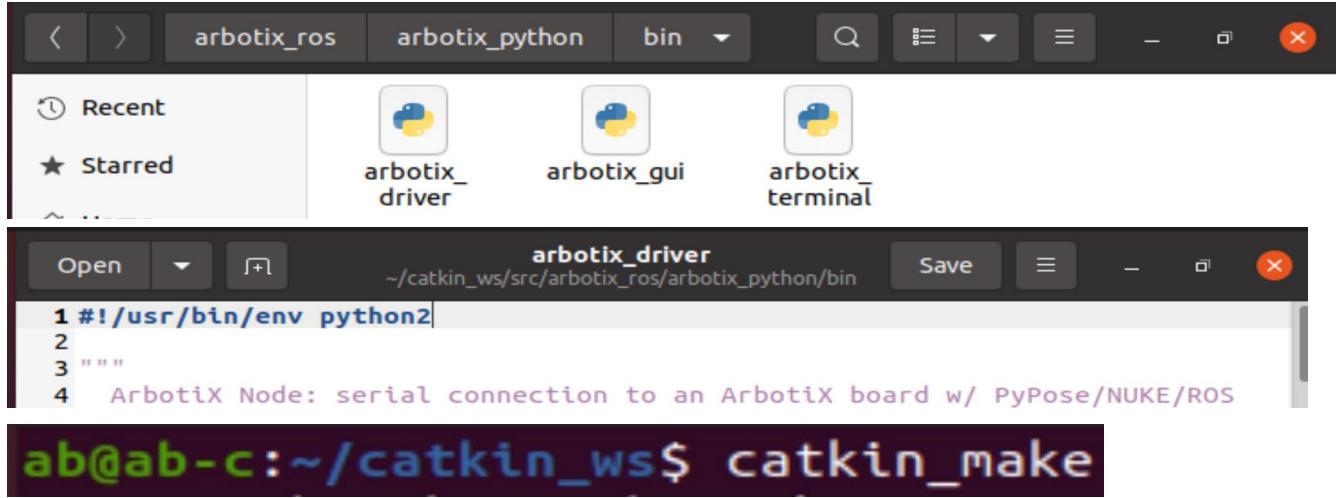
The screenshot shows a code editor interface with the following details:

- Toolbar:** Includes icons for back/forward, search, and file operations.
- Sidebar:** Shows "Recent", "Starred", and "Home" items.
- File List:** Displays files: "fake_mbot_arbotix.yaml" (selected), "mbot.rviz", and "mbot_urdf.rviz".
- Editor Area:** Title bar says "fake_mbot_arbotix.yaml" and "Save".
- Code Content:** The "fake_mbot_arbotix.yaml" file contains the following YAML configuration:

```
1 controllers: {
2     base_controller: {
3         type: diff_controller,
4         base_frame_id: base_footprint,
5         base_width: 0.26,
6         ticks_meter: 4100,
7         Kp: 12,
8         Kd: 12,
9         Ki: 0,
10        Ko: 50,
11        accel_limit: 1.0
12    }
13 }
```

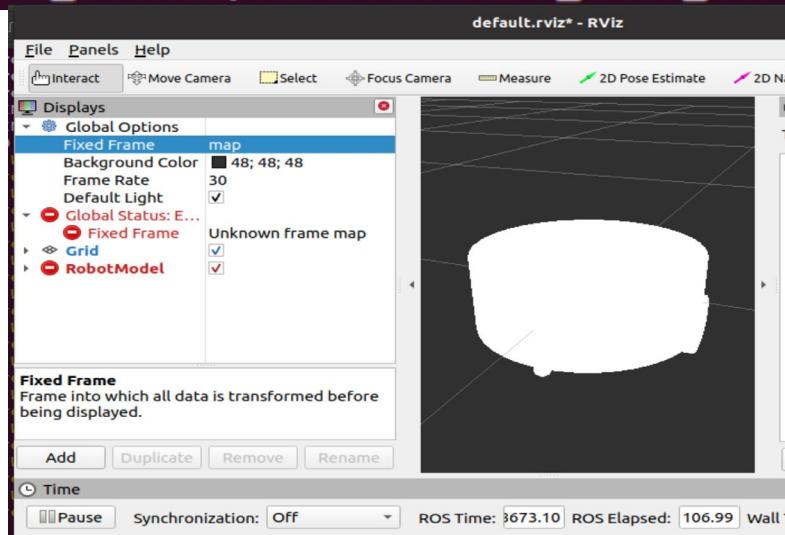
roslaunch

Change arbotix_python 3 to python2

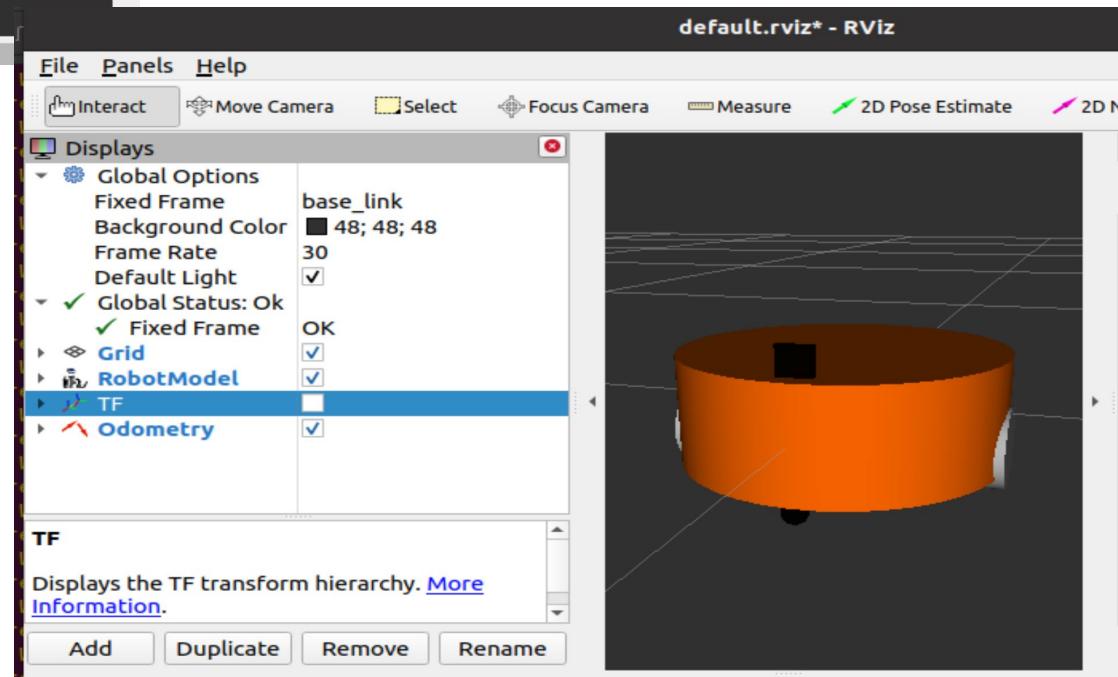
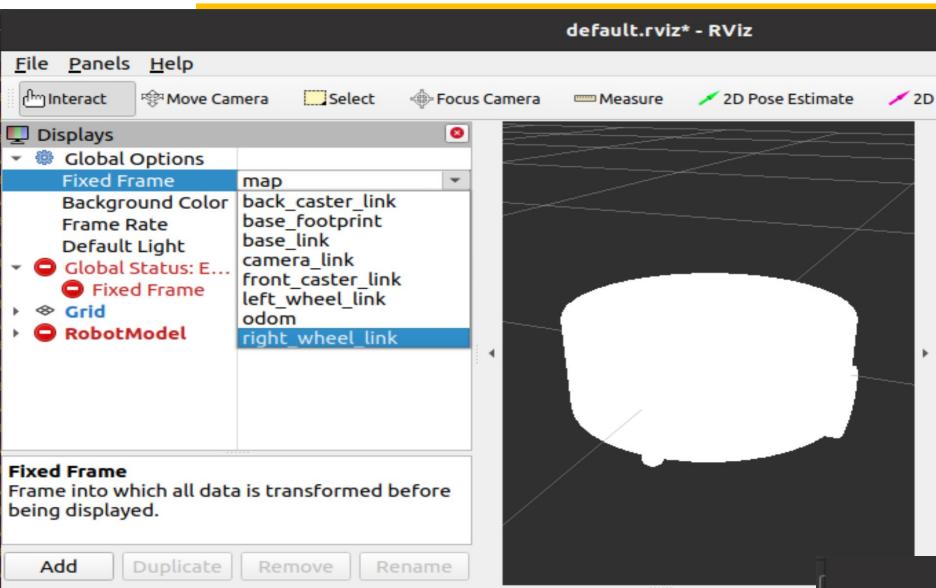


ab@ab-c:~/catkin_ws\$ catkin_make

ab@ab-c:~\$ roslaunch mbot_description arbotix_mbot_with_camera_xacro.launch

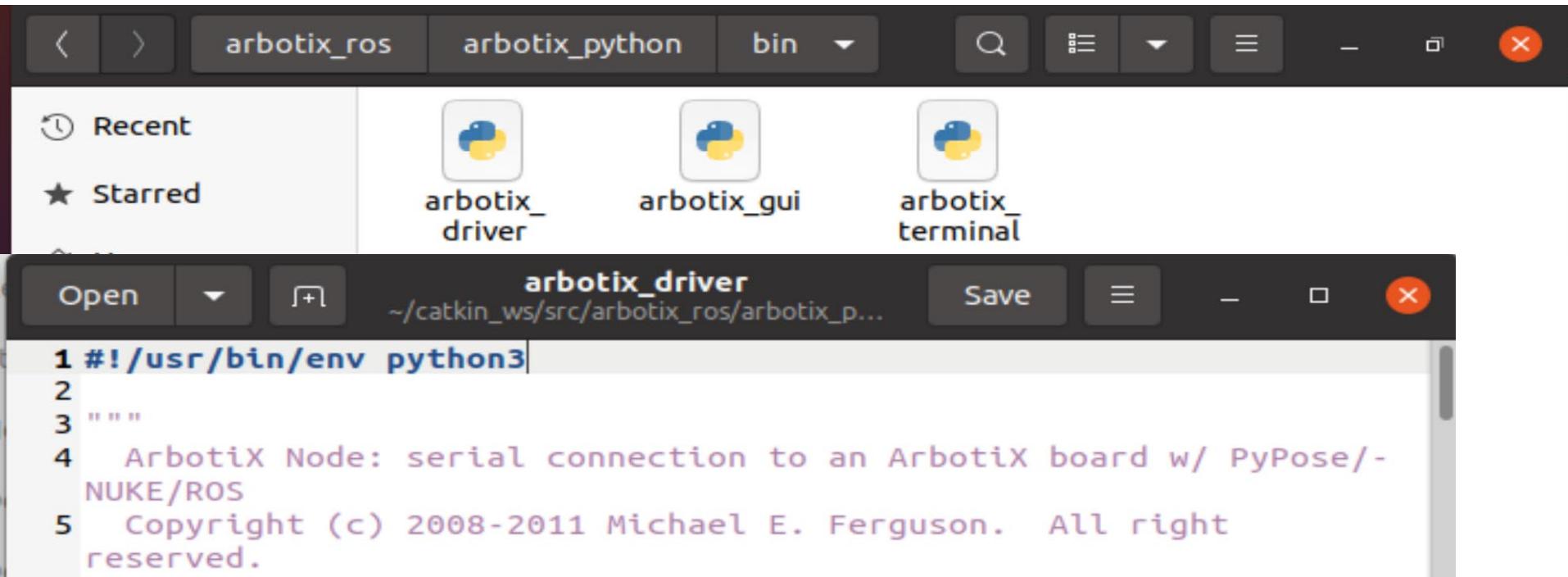


Trouble shooting #1: Rviz ->fixed frame -> “base_link”



Trouble shooting #2: Arbotix_python -> bin -> python 3

Change python3 to python2



Recent

Starred

arbotix_driver

arbotix_gui

arbotix_terminal

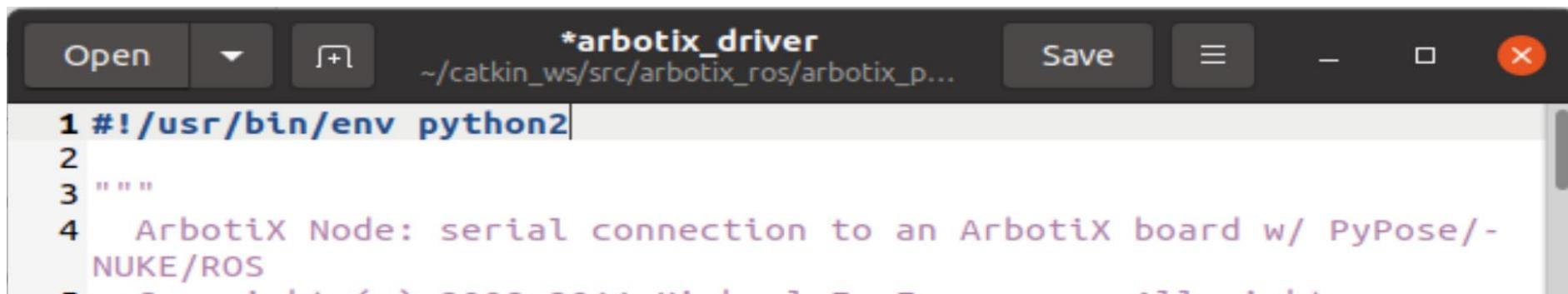
Open

arbotix_driver

~/catkin_ws/src/arbotix_ros/arbotix_p...

Save

```
1 #!/usr/bin/env python3
2
3 """
4 ArbotiX Node: serial connection to an ArbotiX board w/ PyPose/-
NUKE/ROS
5 Copyright (c) 2008-2011 Michael E. Ferguson. All right
reserved.
```



Open

*arbotix_driver

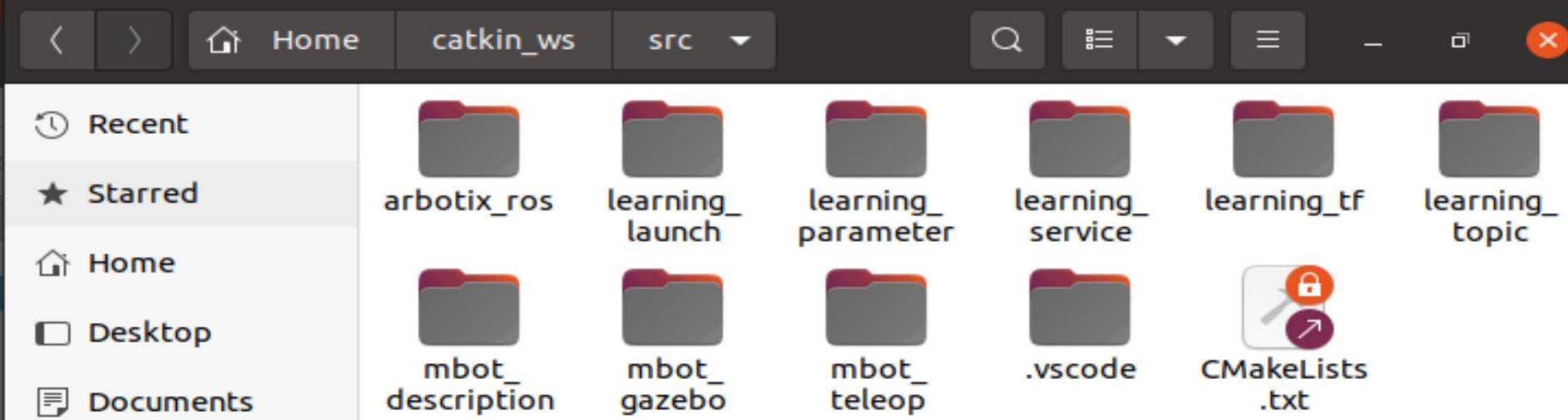
~/catkin_ws/src/arbotix_ros/arbotix_p...

Save

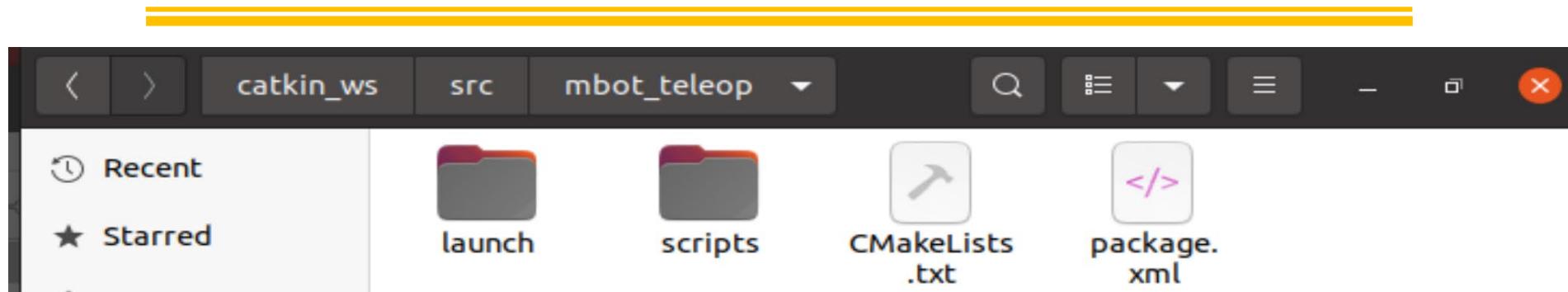
```
1 #!/usr/bin/env python2
2
3 """
4 ArbotiX Node: serial connection to an ArbotiX board w/ PyPose/-
NUKE/ROS
```

Create mobot_teleop Package

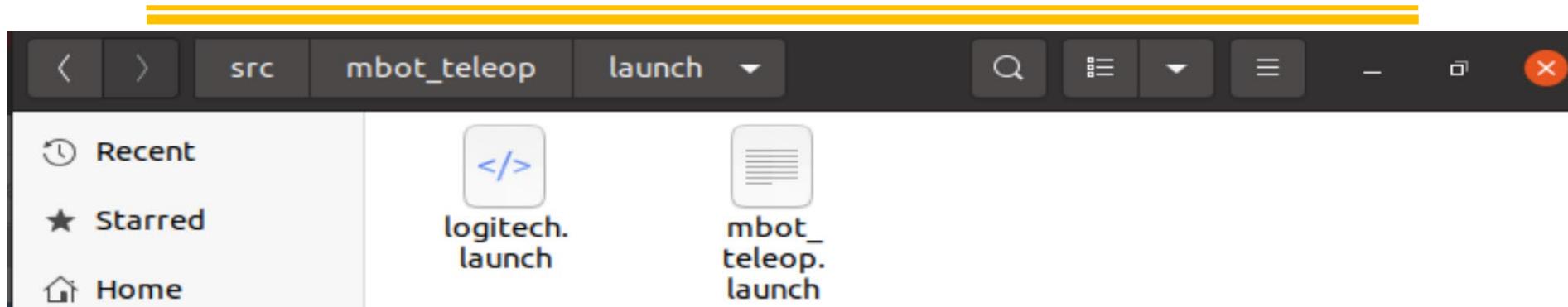
```
ab@ab-c:~/catkin_ws/src$ catkin_create_pkg mobot_teleop urdf xacro
```



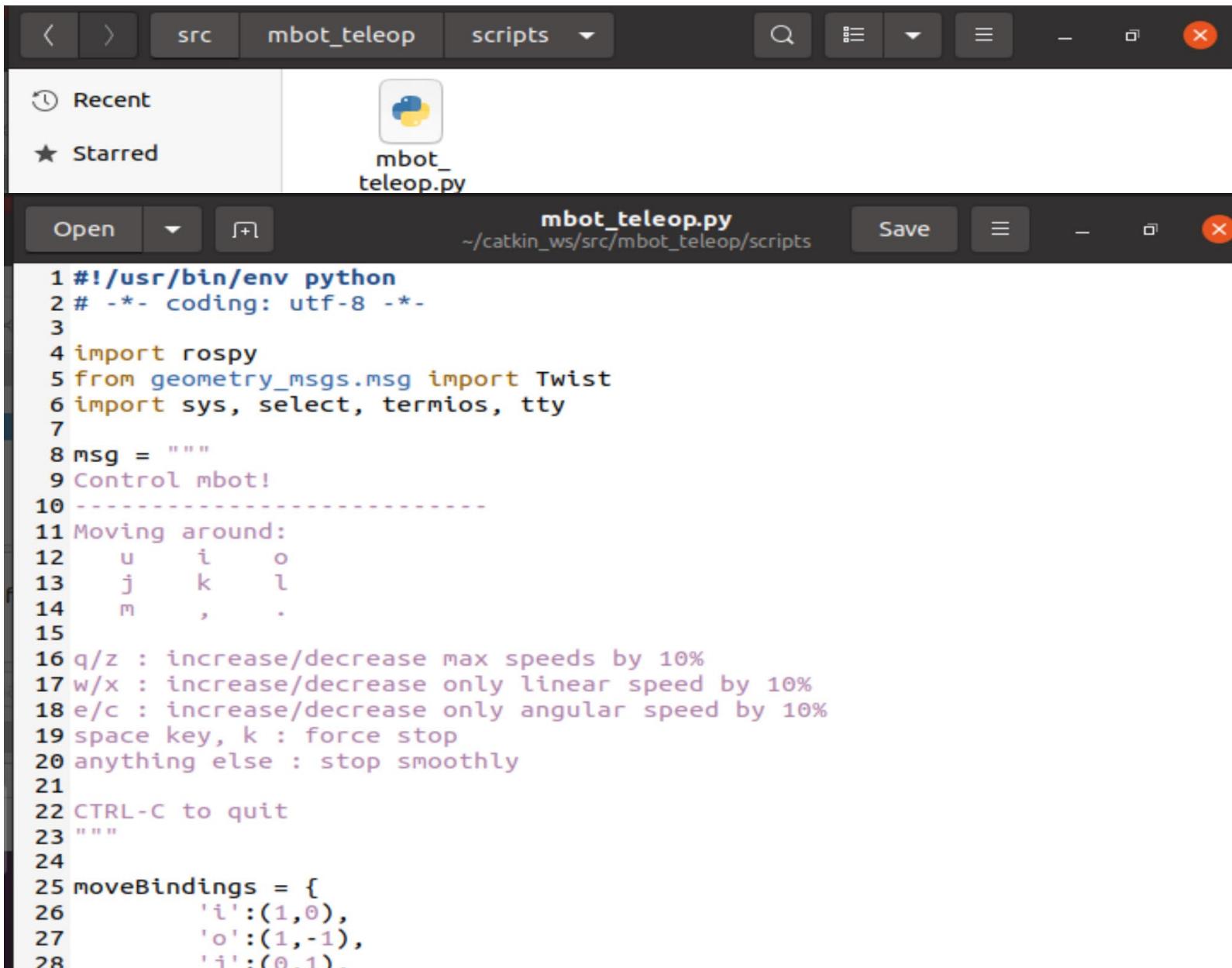
Create New Folders



Create mbot_teleop.launch



Create scripts

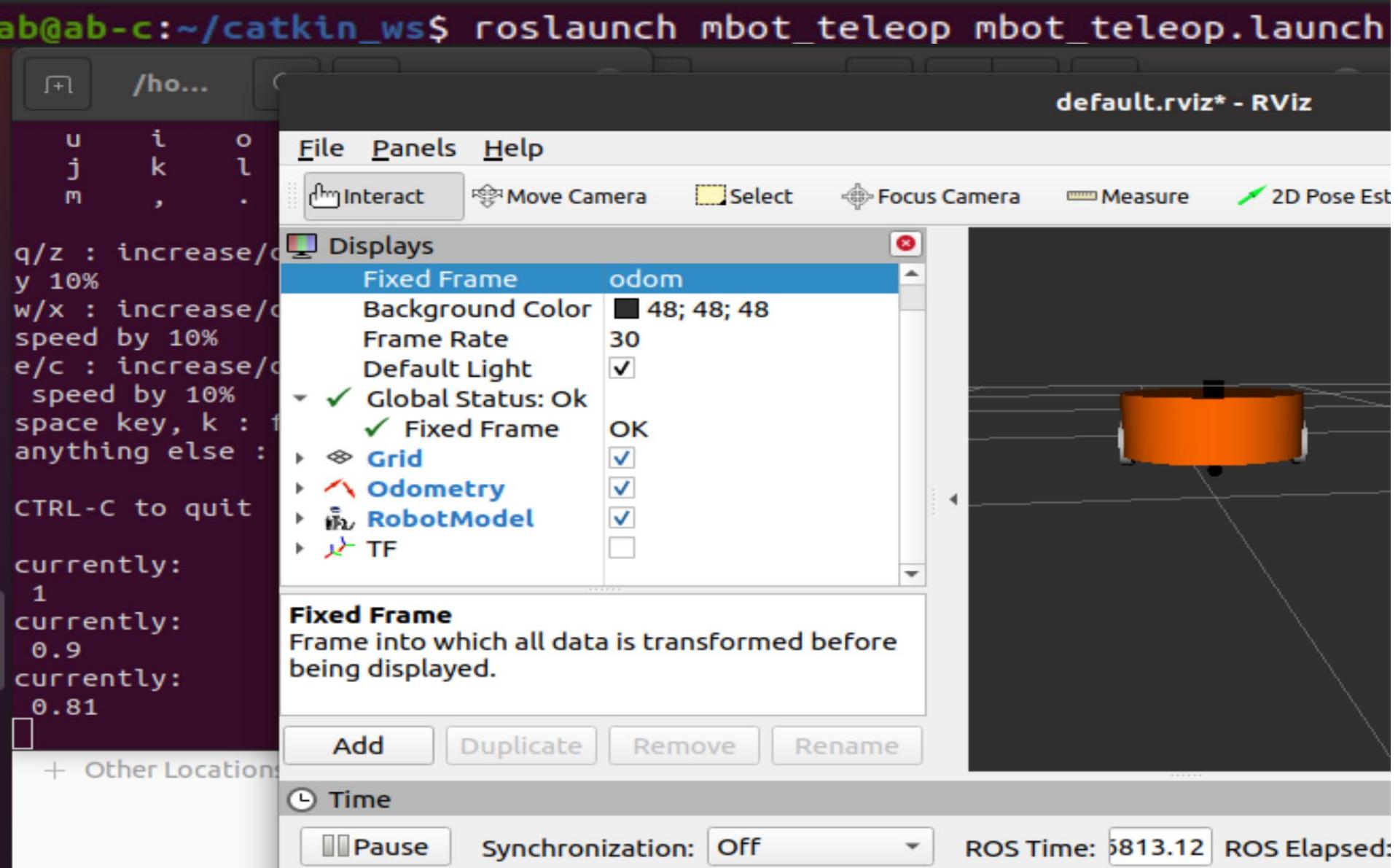


The screenshot shows a code editor interface with the following details:

- Toolbar:** Includes back/forward buttons, a search icon, a refresh icon, and a close button.
- Left Sidebar:** Shows "Recent" and "Starred" sections, and a Python icon.
- Title Bar:** Displays the file name "mbot_teleop.py" and its path "~/catkin_ws/src/mbot_teleop/scripts". It also includes "Open", "Save", and other window control buttons.
- Code Area:** Contains the following Python script:

```
1 #!/usr/bin/env python
2 # -*- coding: utf-8 -*-
3
4 import rospy
5 from geometry_msgs.msg import Twist
6 import sys, select, termios, tty
7
8 msg = """
9 Control mbot!
10 -----
11 Moving around:
12     u    i    o
13     j    k    l
14     m      ,    .
15
16 q/z : increase/decrease max speeds by 10%
17 w/x : increase/decrease only linear speed by 10%
18 e/c : increase/decrease only angular speed by 10%
19 space key, k : force stop
20 anything else : stop smoothly
21
22 CTRL-C to quit
23 """
24
25 moveBindings = {
26     'i':(1,0),
27     'o':(1,-1),
28     'j':(0,1),
```

roslaunch

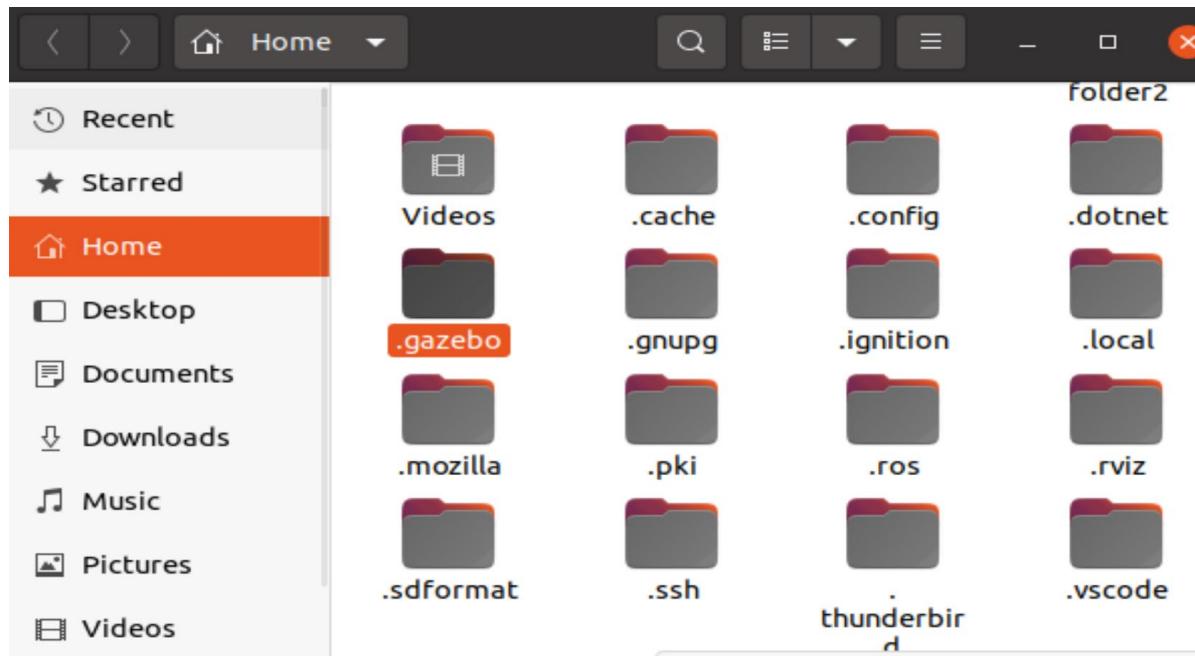


Lecture 18: Gazebo

Install Gazebo_models

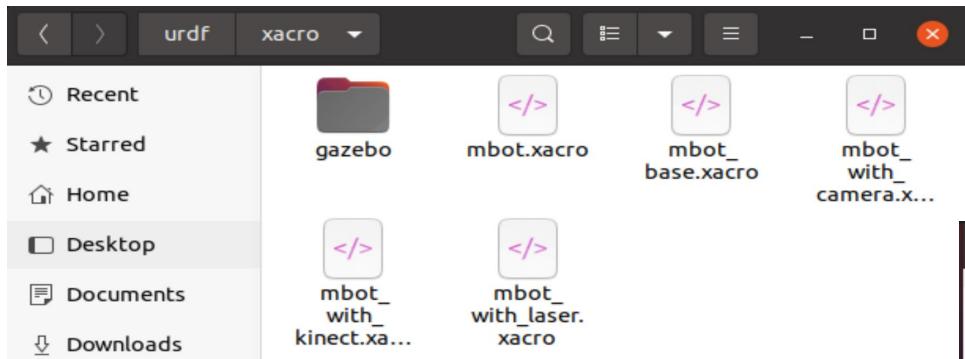
Download:

https://github.com/osrf/gazebo_models

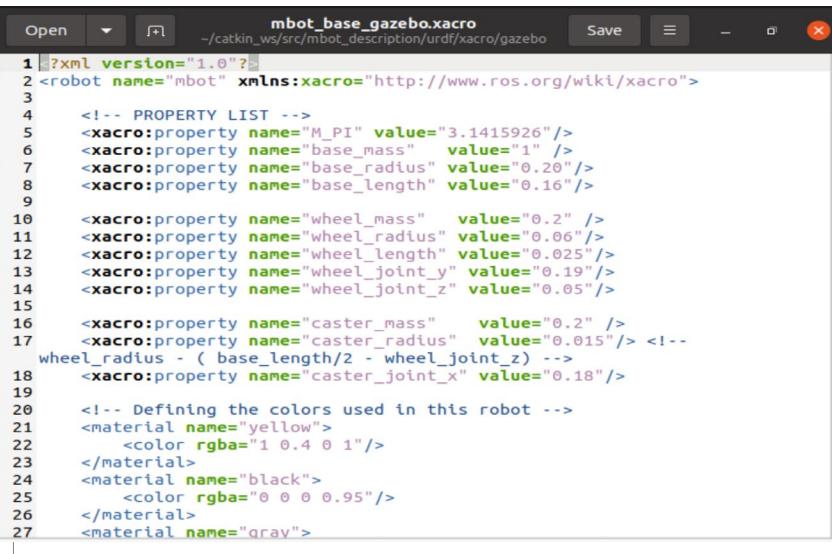


Create the Physical Simulation Model

mbot_base_gazebo.xacro



The image shows a file manager interface with two panes. The left pane lists recent and starred files under categories like Home, Desktop, Documents, and Downloads. The right pane displays several XACRO files for a robot named 'mbot'. The files include 'gazebo', 'mbot.xacro', 'mbot_base.xacro' (selected), 'mbot_with_camera.xacro', 'mbot_with_kinect.xacro', 'mbot_with_laser.xacro', and 'mbot_with_kinect_gazebo.xacro'. The 'mbot_base.xacro' file is highlighted with a red border.



```
1 <?xml version="1.0"?>
2 <robot name="mbot" xmlns:xacro="http://www.ros.org/wiki/xacro">
3
4   <!-- PROPERTY LIST -->
5   <xacro:property name="M_PI" value="3.1415926"/>
6   <xacro:property name="base_mass" value="1" />
7   <xacro:property name="base_radius" value="0.20"/>
8   <xacro:property name="base_length" value="0.16"/>
9
10  <xacro:property name="wheel_mass" value="0.2" />
11  <xacro:property name="wheel_radius" value="0.06"/>
12  <xacro:property name="wheel_length" value="0.025"/>
13  <xacro:property name="wheel_joint_y" value="0.19"/>
14  <xacro:property name="wheel_joint_z" value="0.05"/>
15
16  <xacro:property name="caster_mass" value="0.2" />
17  <xacro:property name="caster_radius" value="0.015"/> <!--
18    wheel_radius - ( base_length/2 - wheel_joint_z ) -->
19    <xacro:property name="caster_joint_x" value="0.18"/>
20
21  <!-- Defining the colors used in this robot -->
22  <material name="yellow">
23    <color rgba="1 0.4 0 1"/>
24  </material>
25  <material name="black">
26    <color rgba="0 0 0 0.95"/>
27  </material>
28  <material name="gray">
```

Create the Physical Simulation Model

1. Add link of “collision” and “inertial”

```
<collision>
    <origin xyz="0 0 0" rpy="${M_PI/2} 0 0" />
    <geometry>
        <cylinder radius="${wheel_radius}" length = "$-
{wheel_length}" />
    </geometry>
</collision>
<cylinder_inertial_matrix m="${wheel_mass}" r="$-
{wheel_radius}" h="${wheel_length}" />
</link>

        <!-- Macro for inertia matrix -->
<xacro:macro name="sphere_inertial_matrix" params="m r">
    <inertial>
        <mass value="${m}" />
        <inertia ixx="${2*m*r*r/5}" ixy="0" ixz="0"
            iyy="${2*m*r*r/5}" iyz="0"
            izz="${2*m*r*r/5}" />
    </inertial>
</xacro:macro>

<xacro:macro name="cylinder_inertial_matrix" params="m r h">
    <inertial>
        <mass value="${m}" />
        <inertia ixx="${m*(3*r*r+h*h)/12}" ixy = "0" ixz = "0"
            iyy="${m*(3*r*r+h*h)/12}" iyz = "0"
            izz="${m*r*r/2}" />
    </inertial>
</xacro:macro>
```

Create the Physical Simulation Model

2. Add “gazebo” tag

```
<gazebo reference="${prefix}_wheel_link">
    <material>Gazebo/Gray</material>
</gazebo>

<gazebo reference="base_footprint">
    <turnGravityOff>false</turnGravityOff>
</gazebo>
```

Create the Physical Simulation Model

3. Add transmission to link the joints and the controller

```
<!-- Transmission is important to link the joints and the
controller -->
<transmission name="${prefix}_wheel_joint_trans">
    <type>transmission_interface/SimpleTransmission</type>
    <joint name="${prefix}_wheel_joint" >
        <hardwareInterface>hardware_interface/-
VelocityJointInterface</hardwareInterface>
    </joint>
    <actuator name="${prefix}_wheel_joint_motor">
        <hardwareInterface>hardware_interface/-
VelocityJointInterface</hardwareInterface>
        <mechanicalReduction>1</mechanicalReduction>
    </actuator>
</transmission>
```

Create the Physical Simulation Model

3. Add controller

```
<!-- controller -->
<gazebo>
    <plugin name="differential_drive_controller"
            filename="libgazebo_ros_diff_drive.so">
        <rosDebugLevel>Debug</rosDebugLevel>
        <publishWheelTF>true</publishWheelTF>
        <robotNamespace>/</robotNamespace>
        <publishTf>1</publishTf>
        <publishWheelJointState>true</publishWheelJointState>
        <alwaysOn>true</alwaysOn>
        <updateRate>100.0</updateRate>
        <legacyMode>true</legacyMode>
        <leftJoint>left_wheel_joint</leftJoint>
        <rightJoint>right_wheel_joint</rightJoint>
        <wheelSeparation>${wheel_joint_y*2}</wheelSeparation>
        <wheelDiameter>${2*wheel_radius}</wheelDiameter>
        <broadcastTF>1</broadcastTF>
        <wheelTorque>30</wheelTorque>
        <wheelAcceleration>1.8</wheelAcceleration>
        <commandTopic>cmd_vel</commandTopic>
        <odometryFrame>odom</odometryFrame>
        <odometryTopic>odom</odometryTopic>
        <robotBaseFrame>base_footprint</robotBaseFrame>
    </plugin>
</gazebo>
```

Create launch

The image shows three terminal windows side-by-side, illustrating the creation of a launch file for an Mbot robot.

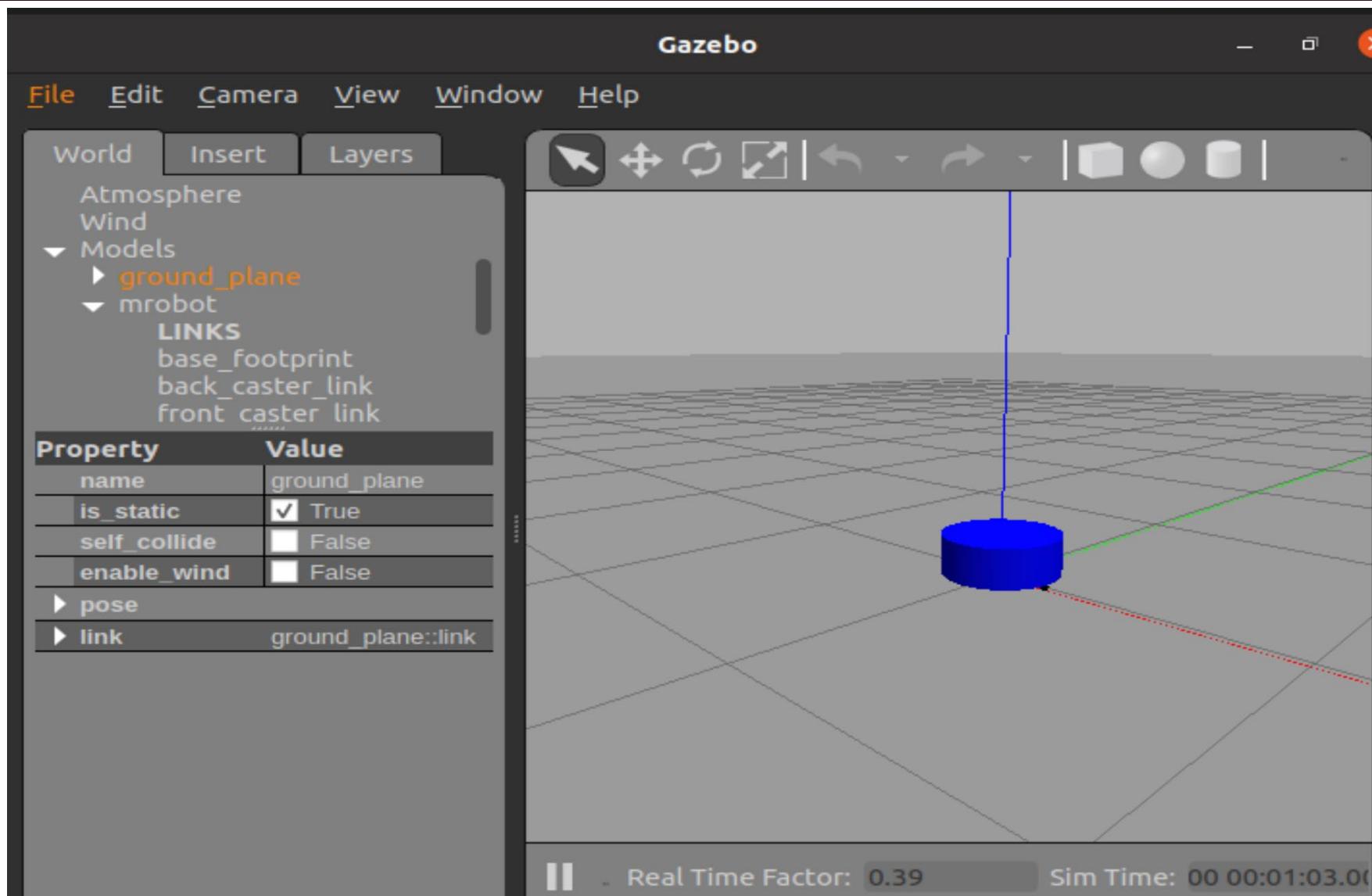
- Top Terminal:** Shows the root of the `catkin_ws/src` directory. It contains several packages: `arbotix_ros`, `learning_launch`, `learning_parameter`, `learning_service`, `learning_tf`, `learning_topic`, `mbot_description`, `mbot_gazebo`, `mbot_teleop`, and `.vscode`. A `CMakeLists.txt` file is also present.
- Middle Terminal:** Shows the `mbot_gazebo` package directory. It contains `launch`, `worlds`, `CMakeLists.txt`, and `package.xml`.
- Bottom Terminal:** Shows the `mbot_gazebo/launch` directory. It contains several launch files: `mbot_kinect_nav_gazebo.launch`, `mbot_laser_nav_gazebo.launch`, `view_mbot_gazebo_empty_world.launch` (which is highlighted with a red box), `view_mbot_gazebo.launch`, `view_mbot_gazebo_r.launch`, `view_mbot_with_cam.launch`, `view_mbot_with_kine...`, and `view_mbot_with_lase...`.

Code Content (view_mbot_gazebo_empty_world.launch):

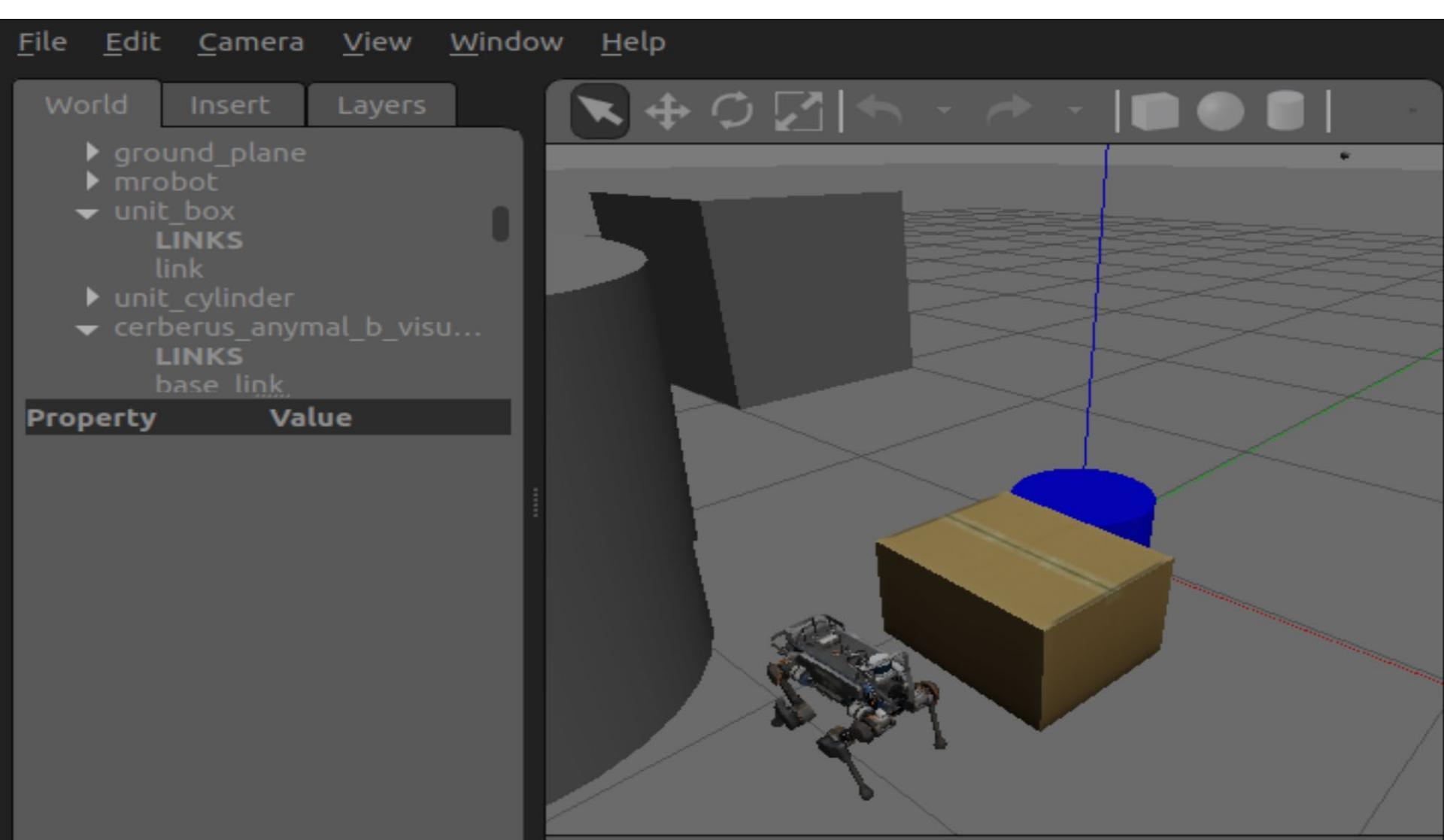
```
1 <launch>
2
3
4   <arg name="paused" default="false"/>
5   <arg name="use_sim_time" default="true"/>
6   <arg name="gui" default="true"/>
7   <arg name="headless" default="false"/>
8   <arg name="debug" default="false"/>
9
10
11   <include file="$(find gazebo_ros)/launch/empty_world.launch">
12     <arg name="debug" value="$(arg debug)" />
13     <arg name="gui" value="$(arg gui)" />
14     <arg name="paused" value="$(arg paused)" />
15     <arg name="use_sim_time" value="$(arg use_sim_time)" />
16     <arg name="headless" value="$(arg headless)" />
17   </include>
18
19
20   <param name="robot_description" command="$(find xacro)/xacro --inorder
'$(find mbot_description)/urdf/xacro/gazebo/mbot_gazebo.xacro'" />
21
22
23   <node name="joint_state_publisher" pkg="joint_state_publisher"
type="joint_state_publisher" ></node>
24
25
26   <node name="robot_state_publisher" pkg="robot_state_publisher"
```

roslaunch

```
ab@ab-c:~/catkin_ws$ rosrun mbot_gazebo view_mbot_gazebo_empty_world.launch
```

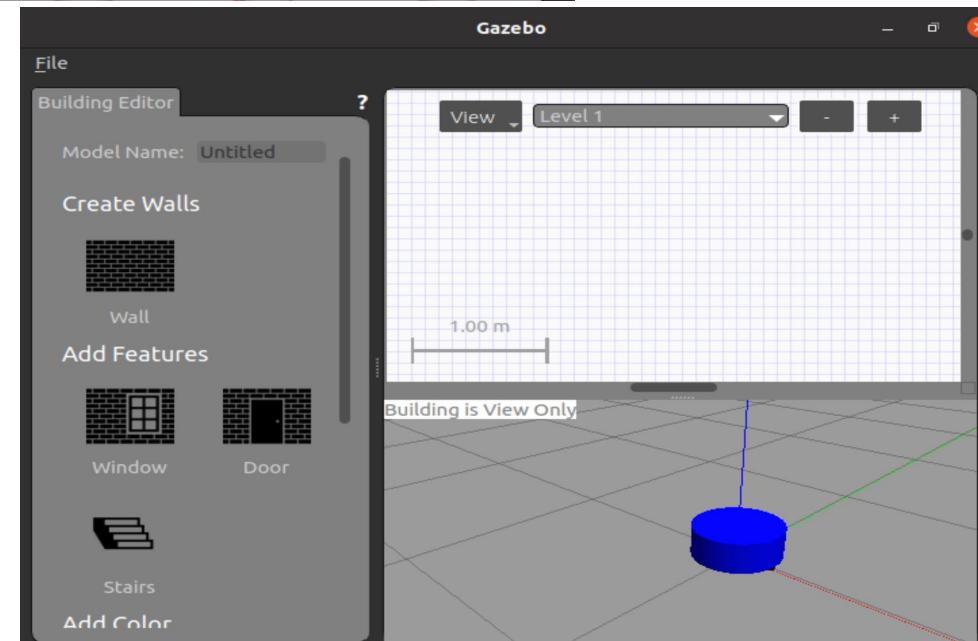
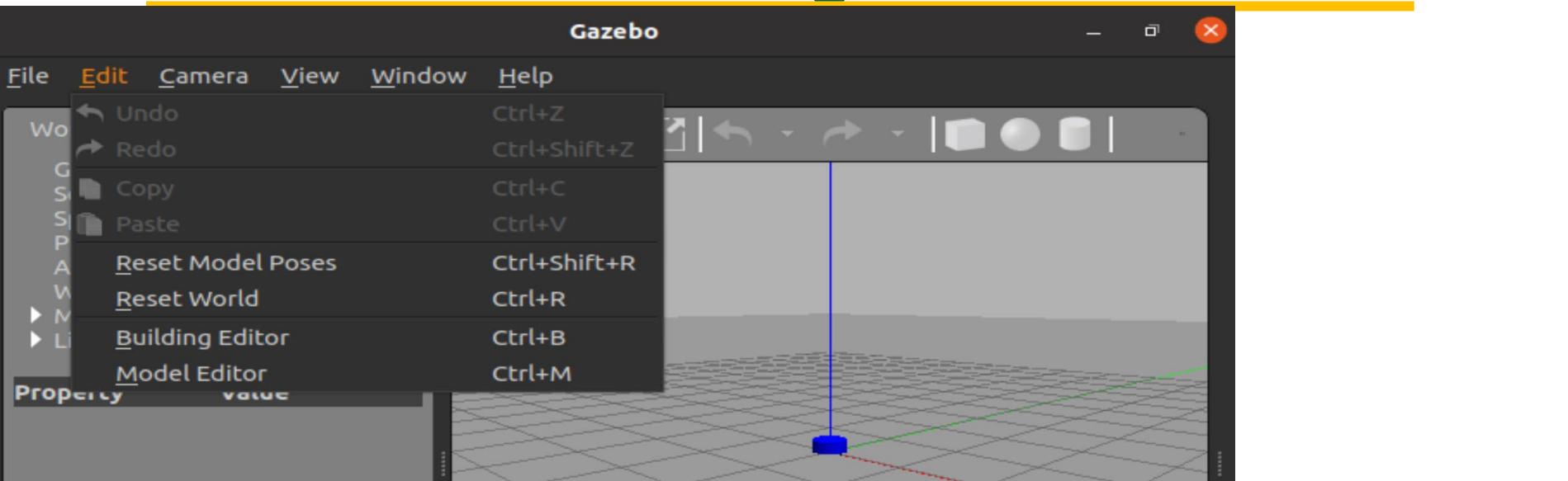


Create Simulation Environment



Create Simulation Environment

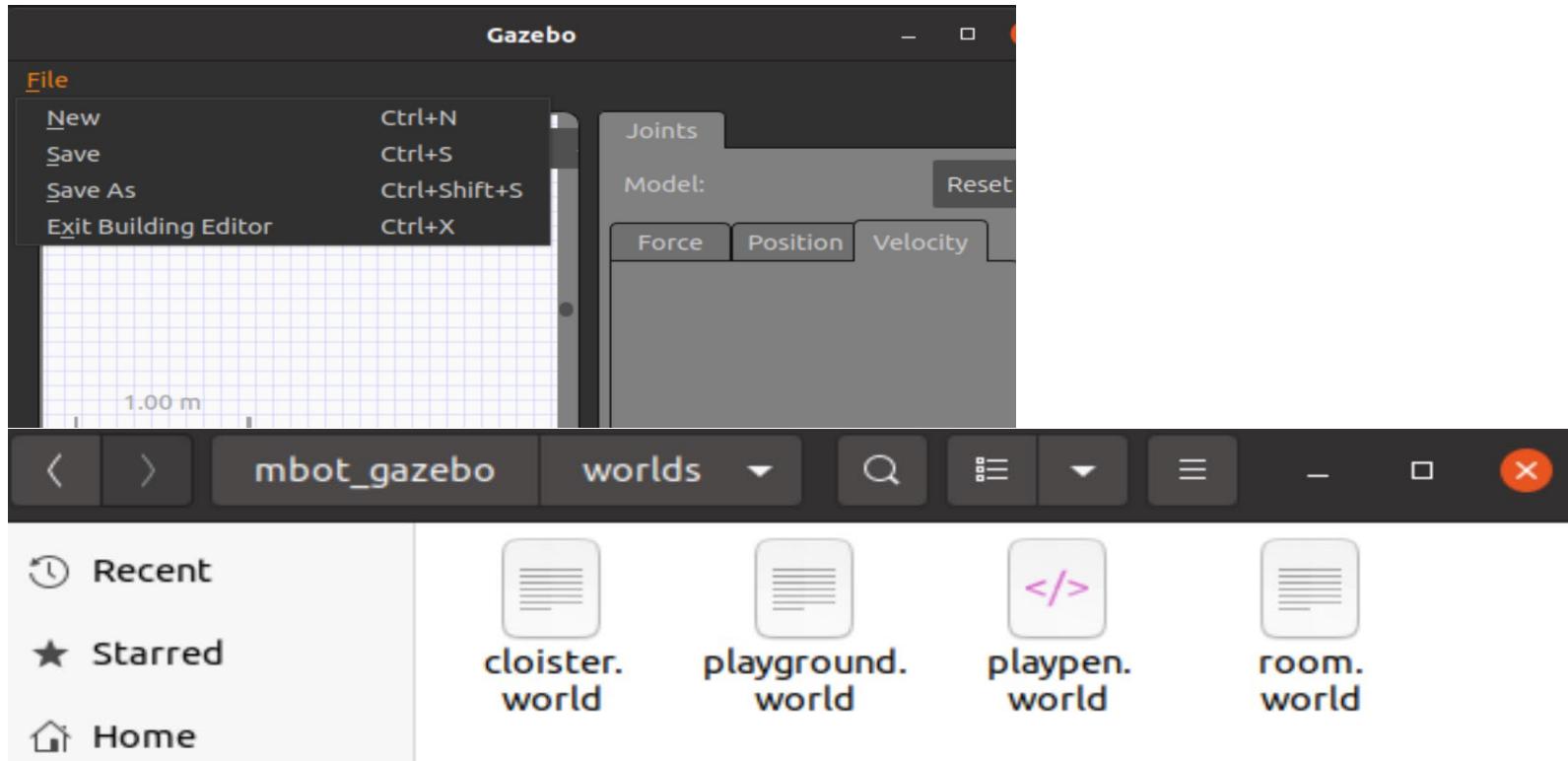
Building editor



Create Simulation Environment

Building editor

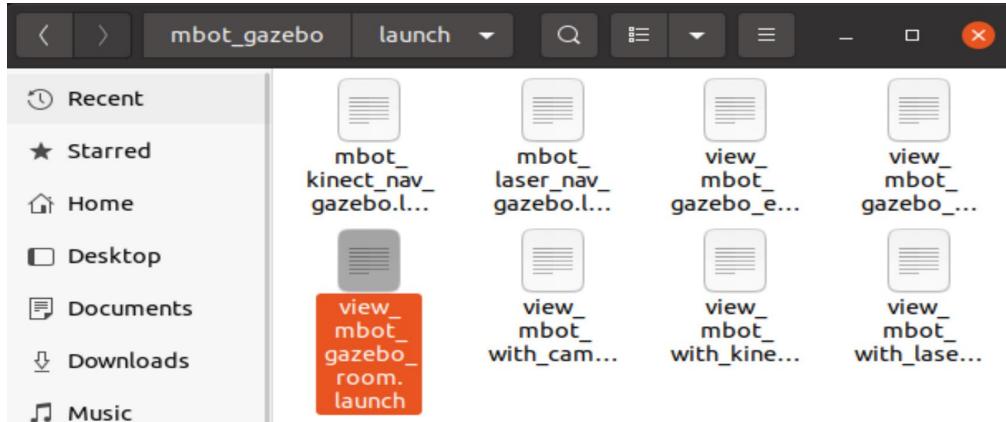
Save: room.world



Create Simulation Environment

Building editor

Save: room.world



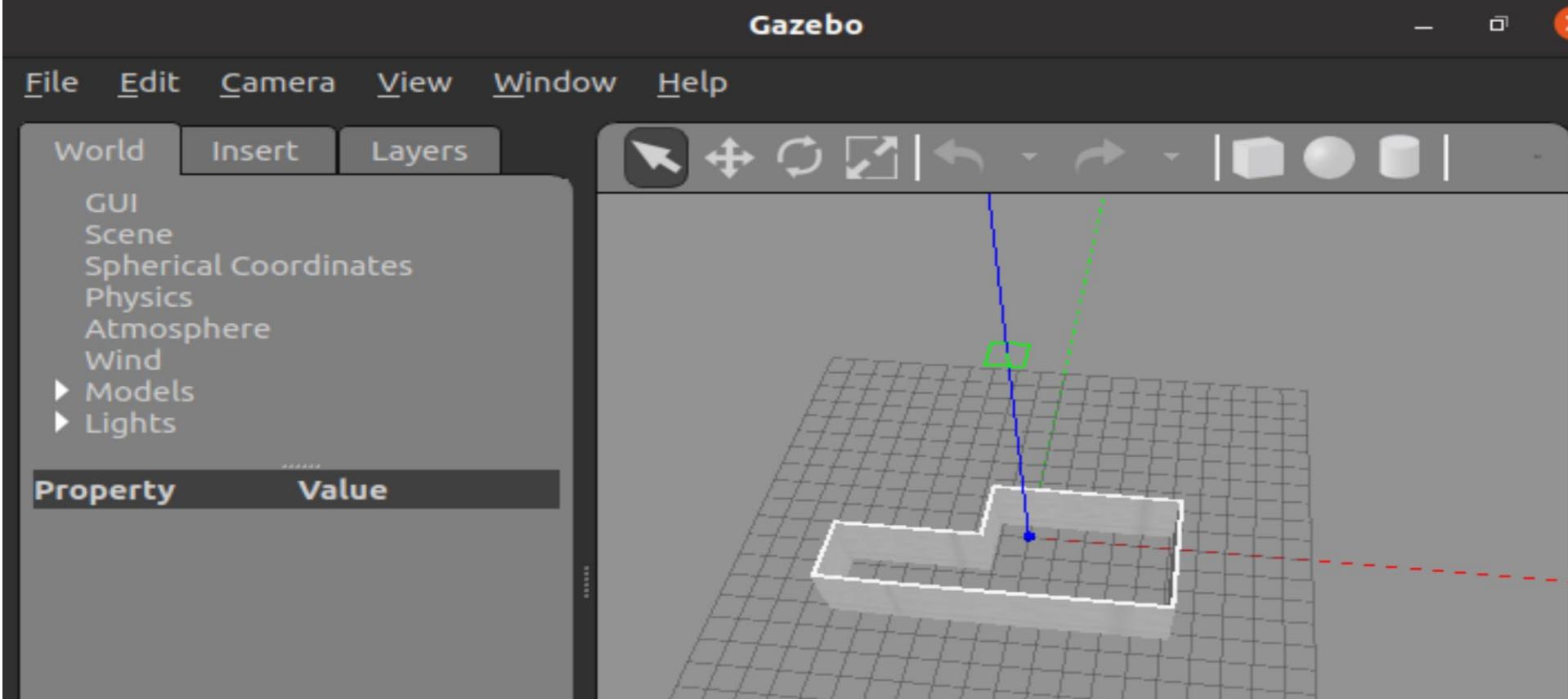
Create Simulation Environment

Building editor

```
ab@ab-c:~/catkin_ws$ catkin_make
```

```
ab@ab-c:~/catkin_ws$ source devel/setup.bash
```

```
ab@ab-c:~/catkin_ws/src/mbot_gazebo/launch$ roslaunch mbot_gazebo view_mbot_gazebo_room.launch
```

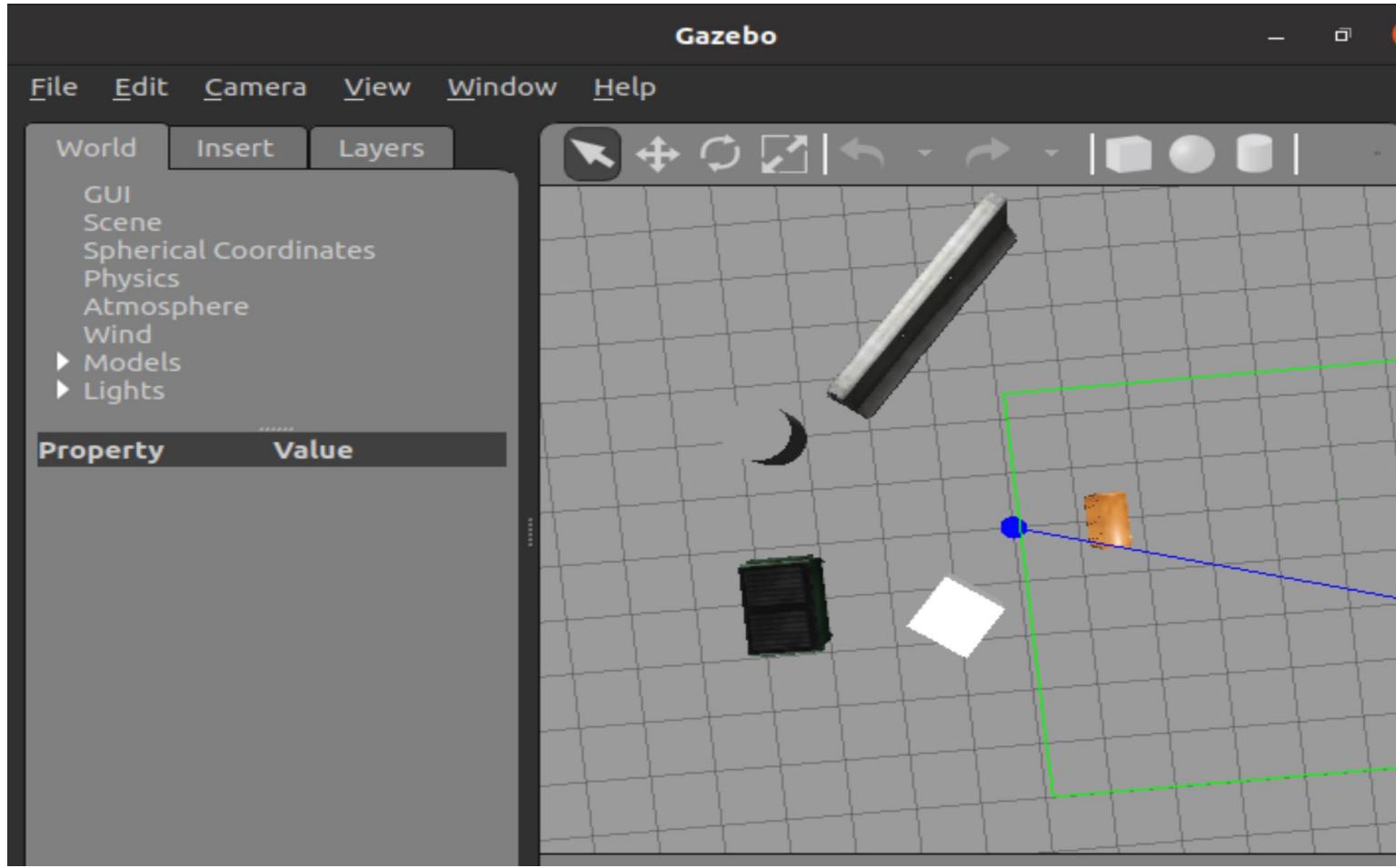


Simulation

```
ab@ab-c:~/catkin_ws$ catkin_make
```

```
ab@ab-c:~/catkin_ws$ source devel/setup.bash
```

```
ab@ab-c:~/catkin_ws/src/mbot_gazebo/launch$ rosrun mbot_gazebo view_mbot_gazebo play ground.launch
```



Simulation



```
ab@ab-c:~$ rostopic list
/clock
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/performance_metrics
/gazebo/set_link_state
/gazebo/set_model_state
/joint_states
/rosout
/rosout_agg
/tf
/tf_static
ab@ab-c:~$
```

Simulation

```
ab@ab-c:~$ roslaunch mbot_teleop mbot_teleop.launch
/home/ab/catkin_ws/src/mbot_t...
mbot_teleop (mbot_teleop/mbot_teleop.py)
ROS_MASTER_URI=http://localhost:11311
process[mbot_teleop-1]: started with pid [33708]

Control mbot!
-----
Moving around:
 u   i   o
 j   k   l
 m   ,   .

q/z : increase/decrease max speeds by 10%
w/x : increase/decrease only linear speed by 10%
e/c : increase/decrease only angular speed by 10%
space key, k : force stop
anything else : stop smoothly

CTRL-C to quit

currently:      speed 0.2      turn 1
```

Reference



✓ [Download link](#)

✓ Language:
English, Chinese, Japanese, Korean



"ROS Robot Programming"

A Handbook is written by TurtleBot3 Developers

Reference

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- **J. O’Kane,** **A Gentle Introduction to ROS,**
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