ASRL ROS 2 Tutorial - ROS 2 Basics

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Tutorial Contents

Table of Contents

Downloading Required Programs

- If on ubuntu computer, Install ROS 2 Jazzy, Follow steps for Ubuntu Installation
  - https://docs.ros.org/en/jazzy/Installation/Ubuntu-Install-Debs.html
- If on Windows computer, follow all steps above but first install the Ubuntu 24.04 VM.
  - Go to Microsoft Store, Search Ubuntu, Install Ubuntu 24.04.1 LTS.
  - IMPORTANT: It has to be the 24.04.1 LTS Version, Regular Ubuntu will not work.

Downloading Required Programs

- Optional Programs:
  - Visual Studio Code: Highly recommended
    - https://code.visualstudio.com/Download

General Ubuntu Info

- **Make sure you update packages before starting**
  - sudo apt update
  - sudo apt upgrade
- **Change working directory through cd**
  - Example: cd ws_tutorial
- **Make a new directory through mkdir**
  - Example: mkdir model
- **Make a new file through touch**
  - Example: touch main.xacro

Create a ROS 2 Package

- **Source ROS 2**
  - source /opt/ros/jazzy/setup.bash
- **Create the Workspace**
  - mkdir ws_tutorial/src
- **Create the C++ Package**
  - ros2 pkg create --build-type ament_cmake asrl_tutorial

Your structure should look like this

```
└── src
    └── asrl_tutorial
        ├── CMakeLists.txt
        ├── include
       |    └── asrl_tutorial
        ├── package.xml
       └── src
```

Creating The URDF

- **Rename the src folder inside asrl_tutorial to model**
- **Install Xacro, this will help with the creation of our model**
    - sudo apt install ros-jazzy-xacro
- **Create the model files**
    - Touch main.xacro chassis.xacro connector.xacro rim.xacro roller.xacro
- **Copy upcoming code into each file**

URDF Code Breakdown - Main

```
<?xml version='1.0'?>
<robot name="rome_urdf" xmlns:xacro="http://www.ros.org/wiki/xacro">
  <!-- Base -->
  <xacro:include filename="$(find asrl_tutorial)/model/chassis.xacro"/>


  <!-- World Link -->
  <link name="base_link" />
  <joint name="base_to_chassis" type="fixed">
    <parent link="base_link"/>
    <child link="chassis"/>
    <origin xyz="0 0 0" rpy="0 0 0" />
  </joint>
</robot>
```

URDF Code Breakdown - Chassis

```xml
<?xml version='1.0'?>
<robot xmlns:xacro="http://www.ros.org/wiki/xacro">
 <xacro:include filename="$(find asrl_tutorial)/model/connector.xacro"/>

 <!-- Chassis -->
 <link name="chassis">
  <visual>
   <origin xyz="0 0 0" rpy="0 0 0" />
   <geometry>
    <mesh filename="file://$(find asrl_tutorial)/meshes/chassis.stl" />
   </geometry>
   <material name="">
    <color rgba="1 1 0 1" />
   </material>
  </visual>
  <inertial>
   <origin xyz="0 0 0" rpy="0 0 0" />
   <mass value="16.004"/>
   <inertia ixx="0.3610" ixy="0.0" ixz="0.0" iyy="0.3610" iyz="0.0" izz="0.6749"/>
  </inertial>

 </link>

 <gazebo reference="chassis">
  <visual>
   <material>
    <ambient>0.9 0.9 0 1</ambient>
    <diffuse>0.9 0.9 0 1</diffuse>
    <specular>0.9 0.9 0 1</specular>
   </material>
  </visual>
 </gazebo>

 <!--Wheel Rims -->
 <xacro:connector name="1" parent="chassis" xyz="0.228 0.228 0.01" rpy="1.57 0 2.3562"/>  <!--Front Left-->
 <xacro:connector name="2" parent="chassis" xyz="0.228 -0.228 0.01" rpy="1.57 0 0.7838"/> <!--Front Right-->
 <xacro:connector name="3" parent="chassis" xyz="-0.228 -0.228 0.01" rpy="1.57 0 -0.7838"/>  <!--Back Right-->
 <xacro:connector name="4" parent="chassis" xyz="-0.228 0.228 0.01" rpy="1.57 0 -2.3562"/> <!--Back Left -->


</robot>
```

URDF Code Breakdown - Connector

```
<?xml version='1.0'?>
<robot xmlns:xacro="http://www.ros.org/wiki/xacro">
<xacro:include filename="$(find asrl_tutorial)/model/rim.xacro"/>
<xacro:macro name="connector" params="name parent xyz rpy">
  <link name="C${name}">
    <inertial>
      <origin xyz="0 0 0.0286" rpy="0 0 0" />
      <mass value="0.092"/>
      <inertia ixx="4.8343e-05" ixy="0.0" ixz="0.0" iyy="4.8343e-05" iyz="0.0" izz="4.6517e-05"/>
    </inertial>

    <visual>
      <origin xyz="0 0 0.0286" rpy="0 0 0" />
      <geometry>
        <cylinder radius="0.0318" length="0.0572"/>
      </geometry>
    </visual>

  </link>

  <joint name="${parent}_C${name}_joint" type="continuous">
    <parent link="${parent}"/>
    <child link="C${name}"/>
    <origin xyz = "${xyz}" rpy = "${rpy}"/>
    <axis xyz = "0 0 1"/>
  </joint>

  <!-- Wheel Rims -->
  <xacro:rim name="wheel_${name}" parent="C${name}" xyz="0 0 0.0572" rpy="0 0 0"/>

  <gazebo reference="C${name}">
    <visual>
      <material>
        <ambient>0.7 0.7 0.7 1</ambient>
        <diffuse>0.7 0.7 0.7 1</diffuse>
        <specular>0.7 0.7 0.7 1</specular>
      </material>
    </visual>
  </gazebo>

</xacro:macro>
</robot>
```

URDF Code Breakdown - Rim

```xml
<?xml version='1.0'?>
<robot xmlns:xacro="http://www.ros.org/wiki/xacro">
<xacro:include filename="$(find asrl_tutorial)/model/roller.xacro"/>
<xacro:macro name="rim" params="name parent xyz rpy">
 <link name="rim_${name}_link">
  <inertial>
   <origin xyz="0 0 0.0182" rpy="0 0 0" />
   <mass value="0.20"/>
   <inertia ixx="6.3068e-04" ixy="0.0" ixz="0.0" iyy="6.3068e-04" iyz="0.0" izz="0.0012"/>
  </inertial>

  <visual>
   <origin xyz="0 0 0.0182" rpy="0 0 0" />
   <geometry>
    <cylinder radius="0.076" length="0.0381"/>
   </geometry>
  </visual>

 </link>

 <joint name="${parent}_rim_${name}_joint" type="fixed">
  <parent link="${parent}"/>
  <child link="rim_${name}_link"/>
  <axis xyz = "0 0 1"/>
  <origin xyz = "${xyz}" rpy = "${rpy}"/>
 </joint>

<xacro:roller name="1" parent="${name}"  xyz="0.068 0 0.0091" rpy="1.57 0 0"/>
<xacro:roller name="2" parent="${name}"  xyz="0.0647 0.021 0.0291" rpy="1.57 0 0.3142"/>
<xacro:roller name="3" parent="${name}"  xyz="0.055 0.04 0.0091" rpy="1.57 0 0.6283"/>
<xacro:roller name="4" parent="${name}"  xyz="0.04 0.055 0.0291" rpy="1.57 0 0.9425"/>
<xacro:roller name="5" parent="${name}"  xyz="0.021 0.0647 0.0091" rpy="1.57 0 1.2566"/>
<xacro:roller name="6" parent="${name}"  xyz="0 0.068 0.0291" rpy="1.57 0 1.5708"/>
<xacro:roller name="7" parent="${name}"  xyz="-0.021 0.0647 0.0091" rpy="1.57 0 1.8850"/>
<xacro:roller name="8" parent="${name}"  xyz="-0.04 0.055 0.0291" rpy="1.57 0 2.1991"/>
<xacro:roller name="9" parent="${name}"  xyz="-0.055 0.04 0.0091" rpy="1.57 0 2.5133"/>
<xacro:roller name="10" parent="${name}"  xyz="-0.0647 0.021 0.0291" rpy="1.57 0 2.8274"/>
<xacro:roller name="11" parent="${name}"  xyz="-0.068 0 0.0091" rpy="1.57 0 3.1416"/>
<xacro:roller name="12" parent="${name}"  xyz="-0.0647 -0.021 0.0291" rpy="1.57 0 3.4558"/>
<xacro:roller name="13" parent="${name}"  xyz="-0.055 -0.04 0.0091" rpy="1.57 0 3.7699"/>
<xacro:roller name="14" parent="${name}"  xyz="-0.04 -0.055 0.0291" rpy="1.57 0 4.0841"/>
<xacro:roller name="15" parent="${name}"  xyz="-0.021 -0.0647 0.0091" rpy="1.57 0 4.3982"/>
<xacro:roller name="16" parent="${name}"  xyz="0 -0.068 0.0291" rpy="1.57 0 4.7124"/>
<xacro:roller name="17" parent="${name}"  xyz="0.021 -0.0647 0.0091" rpy="1.57 0 5.0265"/>
<xacro:roller name="18" parent="${name}"  xyz="0.04 -0.055 0.0291" rpy="1.57 0 5.3407"/>
<xacro:roller name="19" parent="${name}"  xyz="0.055 -0.04 0.0091" rpy="1.57 0 5.6549"/>
<xacro:roller name="20" parent="${name}"  xyz="0.0647 -0.021 0.0291" rpy="1.57 0 5.9690"/>




<gazebo reference="rim_${name}_link">
 <visual>
  <material>
   <ambient>0.2 0.2 0.2 1</ambient>
   <diffuse>0.2 0.2 0.2 1</diffuse>
   <specular>0.2 0.2 0.2 1</specular>
  </material>
 </visual>
</gazebo>

</xacro:macro>
</robot>
```

URDF Code Breakdown - Roller

```
<?xml version='1.0'?>
<robot xmlns:xacro="http://www.ros.org/wiki/xacro">
 <xacro:macro name="roller" params="name parent xyz rpy">
 <link name="roller_${name}_rim_${parent}_link">
  <inertial>
   <origin xyz="0 0 0" rpy="0 0 0" />
   <inertia ixx="1e-6" ixy="0.0" ixz="0.0" iyy="1e-6" iyz="0.0" izz="1e-6"/>
   <mass value="0.01"/>
  </inertial>
  <visual>
   <origin xyz="0 0 0" rpy="0 0 0" />
   <geometry>
    <cylinder radius="0.01" length="0.03"/>
   </geometry>
  </visual>

  <collision>
   <origin xyz="0 0 0" rpy="0 0 0" />
   <geometry>
    <cylinder radius="0.01" length="0.03"/>
   </geometry>
  </collision>
 </link>

 <joint name="roller_${name}_rim_${parent}_joint" type="continuous">
  <parent link="rim_${parent}_link"/>
  <child link="roller_${name}_rim_${parent}_link"/>
  <axis xyz="0 0 1"/>
  <origin xyz="${xyz}" rpy="${rpy}"/>
 </joint>

 <gazebo reference="roller_${name}_rim_${parent}_link">
  <mu1 value="100"/>
  <mu2 value="100"/>
  <visual>
   <material>
    <ambient>0.6 0.6 0.6 1</ambient>
    <diffuse>0.6 0.6 0.6 1</diffuse>
    <specular>0.6 0.6 0.6 1</specular>
   </material>
  </visual>
 </gazebo>

 </xacro:macro>



</robot>
```

Creating The URDF

- **Create the Meshes folder in correct directory**
  - cd ws_tutorial/src/asrl_tutorial
  - mkdir meshes
- **Download this STL file and place in folder**
  - https://github.com/UCF-ASRL/ROS-2-Tutorial/blob/main/asrl_tutorial/meshes/chassis.stl

Your structure should look like this

```
└── src
    └── asrl_tutorial
        ├── CMakeLists.txt
        ├── include
        │   └── asrl_tutorial
        ├── meshes
        ├── model
        │   ├── chassis.xacro
        │   ├── connector.xacro
        │   ├── main.xacro
        │   ├── rim.xacro
        │   └── roller.xacro
        └── package.xml
```

Creating The Launch File

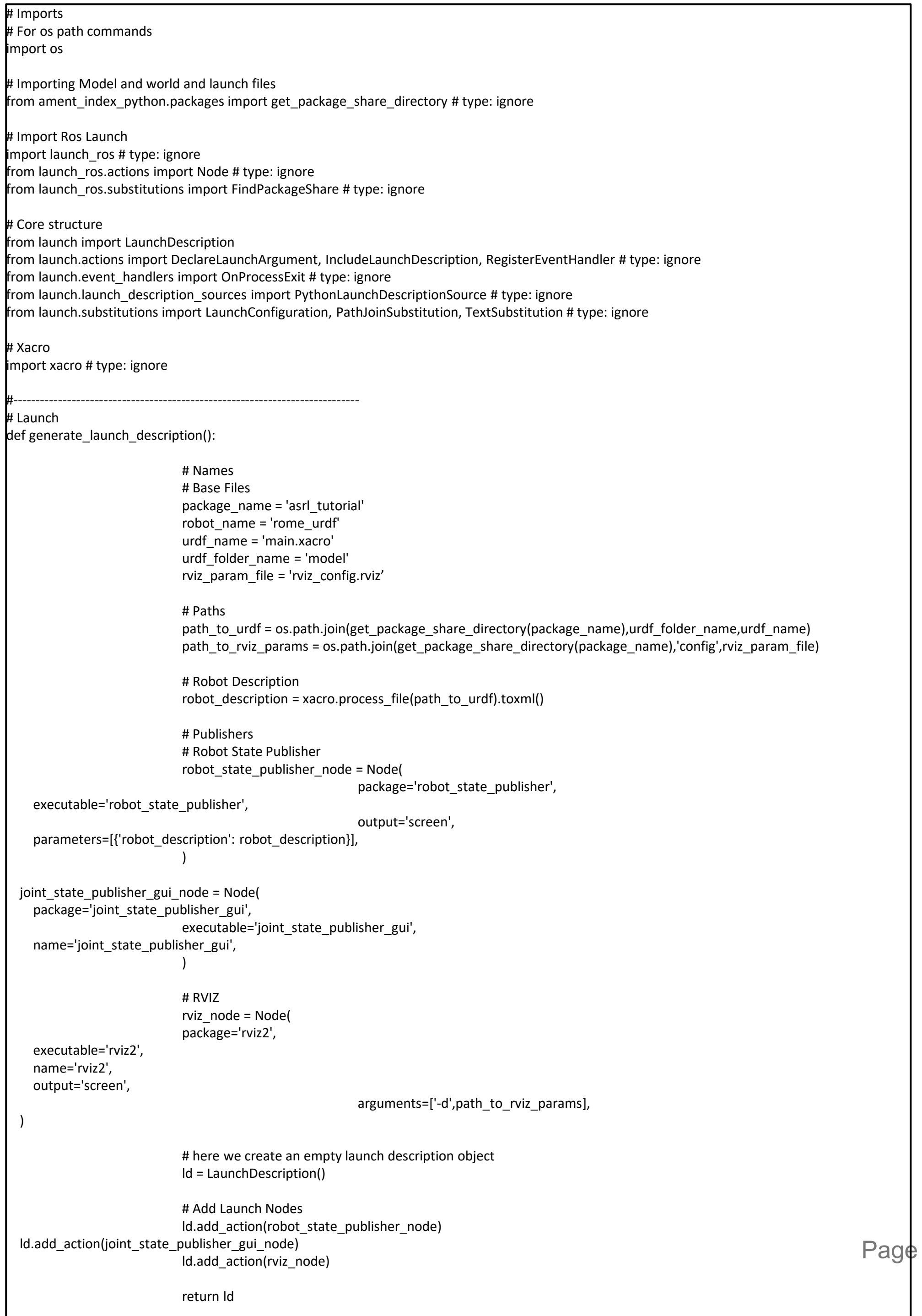
- **Create a new folder**
  - cd ws_tutorial/src/asrl_tutorial
  - mkdir launch
- **Create the Launch File**
  - touch tutorial.launch.py

Your structure should look like this

```
└── src
   └── asrl_tutorial
      ├── CMakeLists.txt
      ├── include
      │   └── asrl_tutorial
      ├── launch
      │   └── tutorial.launch.py
      ├── meshes
      │   └── chassis.stl
      ├── model
      │    ├── chassis.xacro
      │    ├── connector.xacro
      │    ├── main.xacro
      │    ├── rim.xacro
      │   └── roller.xacro
      └── package.xml
```

Launch File Code Breakdown

- **Install Packages used in the launch file**
    - sudo apt install ros-jazzy-joint-state-publisher-gui
    - sudo apt install ros-jazzy-rviz2



```
# Imports
# For os path commands
import os

# Importing Model and world and launch files
from ament_index_python.packages import get_package_share_directory # type: ignore

# Import Ros Launch
import launch_ros # type: ignore
from launch_ros.actions import Node # type: ignore
from launch_ros.substitutions import FindPackageShare # type: ignore

# Core structure
from launch import LaunchDescription
from launch.actions import DeclareLaunchArgument, IncludeLaunchDescription, RegisterEventHandler # type: ignore
from launch.event_handlers import OnProcessExit # type: ignore
from launch.launch_description_sources import PythonLaunchDescriptionSource # type: ignore
from launch.substitutions import LaunchConfiguration, PathJoinSubstitution, TextSubstitution # type: ignore

# Xacro
import xacro # type: ignore

#---------------------------------------------------------------------------
# Launch
def generate_launch_description():

                    # Names
                    # Base Files
                    package_name = 'asrl_tutorial'
                    robot_name = 'rome_urdf'
                    urdf_name = 'main.xacro'
                    urdf_folder_name = 'model'
                    rviz_param_file = 'rviz_config.rviz'

                    # Paths
                    path_to_urdf = os.path.join(get_package_share_directory(package_name),urdf_folder_name,urdf_name)
                    path_to_rviz_params = os.path.join(get_package_share_directory(package_name),'config',rviz_param_file)

                    # Robot Description
                    robot_description = xacro.process_file(path_to_urdf).toxml()

                    # Publishers
                    # Robot State Publisher
                    robot_state_publisher_node = Node(
                                        package='robot_state_publisher',
   executable='robot_state_publisher',
                                        output='screen',
   parameters=[{'robot_description': robot_description}],
                    )

 joint_state_publisher_gui_node = Node(
   package='joint_state_publisher_gui',
                    executable='joint_state_publisher_gui',
   name='joint_state_publisher_gui',
                    )

                    # RVIZ
                    rviz_node = Node(
                    package='rviz2',
   executable='rviz2',
   name='rviz2',
   output='screen',
                                        arguments=['-d',path_to_rviz_params],
 )

                    # here we create an empty launch description object
                    ld = LaunchDescription()

                    # Add Launch Nodes
                    ld.add_action(robot_state_publisher_node)
 ld.add_action(joint_state_publisher_gui_node)
                    ld.add_action(rviz_node)

                    return ld
```

Rviz Configs

- **Create a new folder**
  - cd ws_tutorial/src/asrl_tutorial
  - mkdir config
- **Download this file into the config folder**
  - https://github.com/UCF-ASRL/ROS-2-Tutorial/blob/main/asrl_tutorial/config/rviz_config.rviz

Your structure should look like this

```
└── src
    └── asrl_tutorial
        ├── CMakeLists.txt
        ├── config
        │   └── rviz_config.rviz
        ├── include
        │   └── asrl_tutorial
        ├── launch
        │   └── tutorial.launch.py
        ├── meshes
        │   └── chassis.stl
        ├── model
        │   ├── chassis.xacro
        │   ├── connector.xacro
        │   ├── main.xacro
        │   ├── rim.xacro
        │   └── roller.xacro
        └── package.xml
```

Updating CMakeLists.txt

- Update the CMakeLists.txt file to include your folders

```
cmake_minimum_required(VERSION 3.8)
project(asrl_tutorial)

if(CMAKE_COMPILER_IS_GNUCXX OR CMAKE_CXX_COMPILER_ID MATCHES "Clang")
  add_compile_options(-Wall -Wextra -Wpedantic)
endif()

# find dependencies
find_package(ament_cmake REQUIRED)
# uncomment the following section in order to fill in
# further dependencies manually.
# find_package(<dependency> REQUIRED)

#Install file to share
install(
  DIRECTORY model meshes launch config
  DESTINATION share/${PROJECT_NAME}
)

if(BUILD_TESTING)
  find_package(ament_lint_auto REQUIRED)
  # the following line skips the linter which checks for copyrights
  # comment the line when a copyright and license is added to all source files
  set(ament_cmake_copyright_FOUND TRUE)
  # the following line skips cpplint (only works in a git repo)
  # comment the line when this package is in a git repo and when
  # a copyright and license is added to all source files
  set(ament_cmake_cpplint_FOUND TRUE)
  ament_lint_auto_find_test_dependencies()
endif()

ament_package()
```

Updating package.xml

- Update package.xml to include important packages

```
<?xml version="1.0"?>
<?xml-model href="http://download.ros.org/schema/package_format3.xsd" schematypens="http://www.w3.org/2001/XMLSchema"?>
<package format="3">
  <name>asrl_tutorial</name>
  <version>0.0.0</version>
  <description>ASRL Tutorial ROS 2 Basics</description>
  <maintainer email="bastian.weiss@ucf.edu">Bastian Weiss</maintainer>
  <license>TODO: License declaration</license>

  <buildtool_depend>ament_cmake</buildtool_depend>

  <test_depend>ament_lint_auto</test_depend>
  <test_depend>ament_lint_common</test_depend>

  <depend>xacro</depend>
  <depend>robot_state_publisher</depend>
  <depend>joint_state_publisher_gui</depend>

  <export>
    <build_type>ament_cmake</build_type>
  </export>
</package>
```

Launching our Package

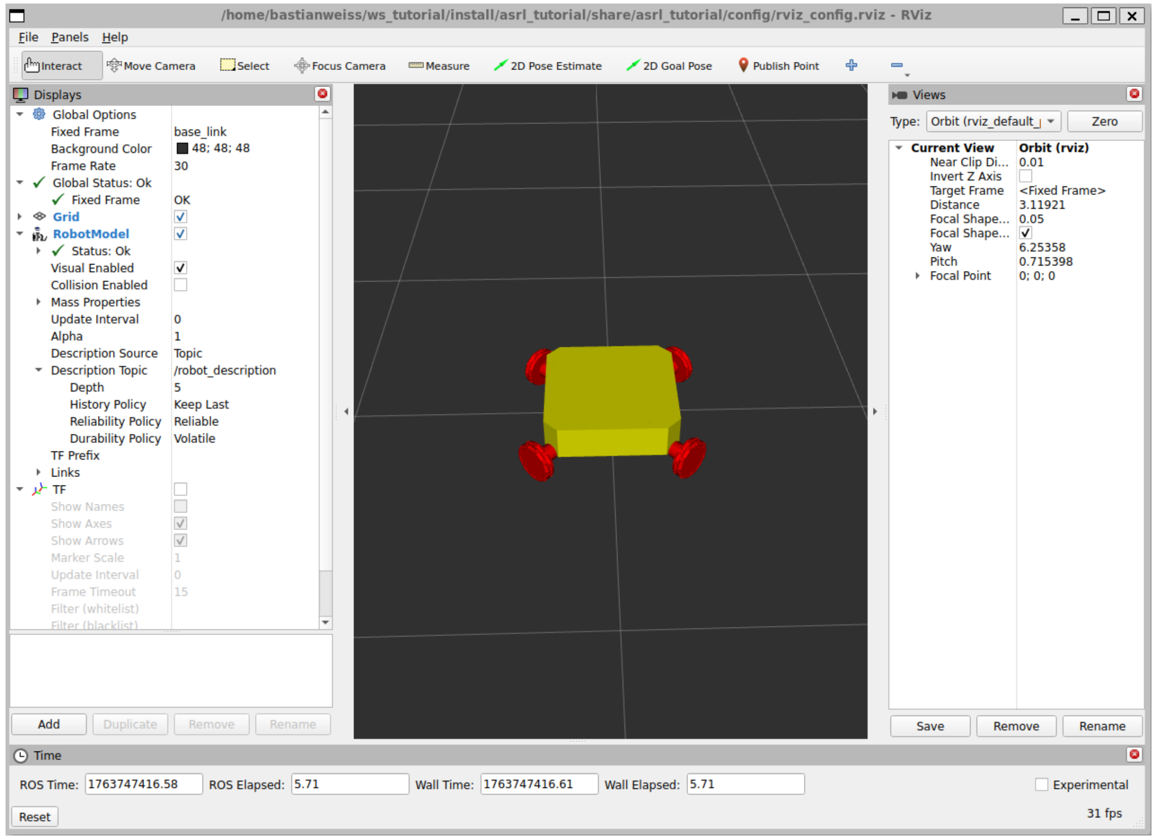
- **Make sure ROS 2 is sourced**
  - source /opt/ros/jazzy/setup.bash
- **Make sure you are in correct directory**
  - cd ws_tutorial
- **Build the package**
  - colcon build
- **Source the Install Folder**
  - source install/setup.bash
- **Launch the Package**
  - ros2 launch asrl_tutorial tutorial.launch.py

Your structure should look like this

```
└── src
    └── asrl_tutorial
        ├── CMakeLists.txt
        ├── config
        │   └── rviz_config.rviz
        ├── include
        │   └── asrl_tutorial
        ├── launch
        │   └── tutorial.launch.py
        ├── meshes
        │   └── chassis.stl
        ├── model
        │     ├── chassis.xacro
        │     ├── connector.xacro
        │     ├── main.xacro
        │     ├── rim.xacro
        │   └── roller.xacro
        └── package.xml
```

Launching our Package

- You should now see Rviz open with the Joint State Publisher GUI
- You can rotate the joints to test using the GUI



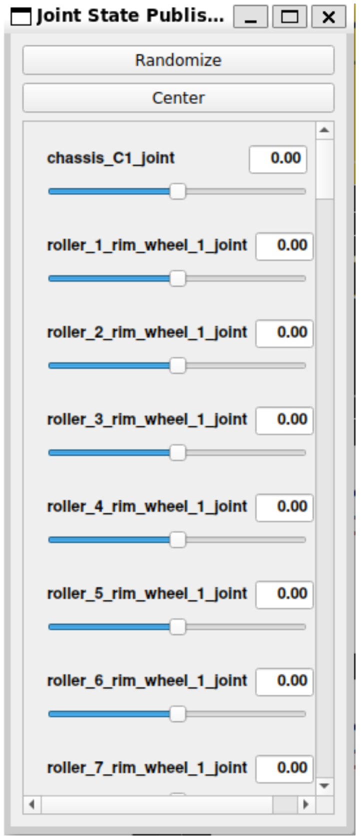
Global Options	
Fixed Frame	base_link
Background Color	■ 48; 48; 48
Frame Rate	30
✓ Global Status: Ok	
✓ Fixed Frame	OK
Grid	✓
RobotModel	✓
✓ Status: Ok	
Visual Enabled	✓
Collision Enabled	☐
Mass Properties	
Update Interval	0
Alpha	1
Description Source	Topic
Description Topic	/robot_description
Depth	5
History Policy	Keep Last
Reliability Policy	Reliable
Durability Policy	Volatile
TF Prefix	
Links	
TF	☐
Show Names	☐
Show Axes	✓
Show Arrows	✓
Marker Scale	1
Update Interval	0
Frame Timeout	15
Filter (whitelist)	
Filter (blacklist)	

Type: Orbit (rviz_default_| Zero

Current View	**Orbit (rviz)**
Near Clip Di...	0.01
Invert Z Axis	☐
Target Frame	<Fixed Frame>
Distance	3.11921
Focal Shape...	0.05
Focal Shape...	✓
Yaw	6.25358
Pitch	0.715398
Focal Point	0; 0; 0

ROS Time: 1763747416.58 ROS Elapsed: 5.71 Wall Time: 1763747416.61 Wall Elapsed: 5.71 ☐ Experimental

31 fps



chassis_C1_joint	0.00
roller_1_rim_wheel_1_joint	0.00
roller_2_rim_wheel_1_joint	0.00
roller_3_rim_wheel_1_joint	0.00
roller_4_rim_wheel_1_joint	0.00
roller_5_rim_wheel_1_joint	0.00
roller_6_rim_wheel_1_joint	0.00
roller_7_rim_wheel_1_joint	0.00

UCF

End of Tutorial