Introduction to URDF: Mobile Robot Design and Control

Install the necessary packages required
Execute in Terminal #1

```
sudo apt-get install ros-foxy-teleop-twist-keyboard
sudo apt-get install ros-foxy-joint-state-publisher*

sudo apt install gazebo11 libgazebo11-dev
sudo apt install ros-foxy-gazebo-ros-pkgs
sudo apt install ros-foxy-robot-state-publisher*
```

Execute in Terminal #1

```
cd ros2_ws/src
ros2 pkg create lab4 --build-type ament_python --dependencies rclpy
cd src/lab4/
mkdir urdf
mkdir launch
cd urdf
touch three_wheeled_robot.urdf
```

```
<?xml version="1.0" ?>

<robot name = "three_wheeled_robot">

  <link name="base">
    <visual>
    <geometry>
      <box size="0.75 0.4 0.1"/>
    </geometry>
    <material name="gray">
      <color rgba=".2 .2 .2 1" />
    </material>
    </visual>

    <inertial>
      <mass value="1" />
      <inertia ixx="0.01" ixy="0.0" ixz="0" iyy="0.01" iyz="0" izz="0.01" />
    </inertial>

    <collision>
    <geometry>
      <box size="0.75 0.4 0.1"/>
    </geometry>
    </collision>
```

```
</link>

<link name="wheel_right_link">
    <inertial>
            <mass value="2" />
            <inertia ixx="0.01" ixy="0.0" ixz="0"
            iyy="0.01" iyz="0" izz="0.01" />
    </inertial>

    <visual>
        <geometry>
          <cylinder radius="0.15" length="0.1"/>
        </geometry>
        <material name="white">
        <color rgba="1 1 1 1"/>
        </material>
    </visual>

    <collision>
        <geometry>
          <cylinder radius="0.15" length="0.1"/>
        </geometry>
      <contact_coefficients mu="1" kp="1e+13" kd="1.0"/>
    </collision>
</link>

<joint name="wheel_right_joint" type="continuous">
    <origin xyz="0.2 0.25 0.0" rpy="1.57 0.0 0.0"/>
    <parent link="base"/>
    <child link="wheel_right_link"/>
    <axis xyz="0.0 0.0 1.0"/>
</joint>



<link name="wheel_left_link">
    <inertial>
        <mass value="2" />
        <inertia ixx="0.01" ixy="0.0" ixz="0"
            iyy="0.01" iyz="0" izz="0.01" />
    </inertial>

    <visual>
      <geometry>
          <cylinder radius="0.15" length="0.1"/>
      </geometry>
      <material name="white">
        <color rgba="1 1 1 1"/>
      </material>
    </visual>

    <collision>
```

```
      <geometry>
        <cylinder radius="0.15" length="0.1"/>
      </geometry>
      <contact_coefficients mu="1" kp="1e+13" kd="1.0"/>
    </collision>
  </link>

  <joint name="wheel_left_joint" type="continuous">
    <origin xyz="0.2 -0.25 0.0" rpy="1.57 0.0 0.0"/>
    <parent link="base"/>
    <child link="wheel_left_link"/>
    <axis xyz="0.0 0.0 1.0"/>
  </joint>



  <link name="caster">
    <inertial>
        <mass value="1" />
        <inertia ixx="0.01" ixy="0.0" ixz="0"
        iyy="0.01" iyz="0" izz="0.01" />
    </inertial>

    <visual>
      <geometry>
        <sphere radius=".08" />
      </geometry>
      <material name="white" />
    </visual>

    <collision>
      <origin/>
      <geometry>
        <sphere radius=".08" />
      </geometry>
    </collision>
  </link>

  <joint name="caster_joint" type="continuous">
    <origin xyz="-0.3 0.0 -0.07" rpy="0.0 0.0 0.0"/>
    <axis xyz="0 0 1" />
    <parent link="base"/>
    <child link="caster"/>
  </joint>

  <link name="camera">
    <inertial>
        <mass value="0.1" />
        <inertia ixx="0.01" ixy="0.0" ixz="0"
        iyy="0.01" iyz="0" izz="0.01" />
    </inertial>
```

```
    <visual>
      <geometry>
        <box size="0.1 0.1 0.05"/>
      </geometry>
      <material name="white">
        <color rgba="1 1 1 1"/>
      </material>
    </visual>

    <collision>
      <geometry>
          <box size="0.1 0.1 0.05"/>
      </geometry>
    </collision>
</link>

<joint name="camera_joint" type="fixed">
    <origin xyz="-0.35 0 0.01" rpy="0 0.0 3.14"/>
    <parent link="base"/>
    <child link="camera"/>
    <axis xyz="0.0 0.0 1.0"/>
</joint>

<link name="lidar">
    <inertial>
            <mass value="0.5" />
            <inertia ixx="0.01" ixy="0.0" ixz="0"
            iyy="0.01" iyz="0" izz="0.01" />
    </inertial>

    <visual>
      <geometry>
        <cylinder radius="0.1" length="0.05"/>
      </geometry>
      <material name="white">
        <color rgba="1 1 1 1"/>
      </material>
    </visual>

    <collision>
      <geometry>
          <box size="0.1 0.1 0.1"/>
      </geometry>
    </collision>
</link>

<joint name="lidar_joint" type="fixed">
    <origin xyz="-0.285 0 0.075" rpy="0 0.0 1.57"/>
    <parent link="base"/>
    <child link="lidar"/>
    <axis xyz="0.0 0.0 1.0"/>
```

```xml
</joint>

<!--http://wiki.ros.org/simulator_gazebo/Tutorials/ListOfMaterials-->
<gazebo reference="base">
   <material>Gazebo/WhiteGlow</material>
</gazebo>
<gazebo reference="wheel_left_link">
   <material>Gazebo/SkyBlue</material>
</gazebo>
<gazebo reference="wheel_right_link">
   <material>Gazebo/SkyBlue </material>
</gazebo>
<gazebo reference="caster">
   <material>Gazebo/Grey</material>
</gazebo>
<gazebo reference="lidar">
   <material>Gazebo/Blue</material>
</gazebo>
<gazebo reference="camera">
   <material>Gazebo/Red</material>
</gazebo>



<!-- differential robot-->
<gazebo>
   <plugin filename="libgazebo_ros_diff_drive.so" name="gazebo_base_controller">
     <odometry_frame>odom</odometry_frame>
     <commandTopic>cmd_vel</commandTopic>
     <publish_odom>true</publish_odom>
     <publish_odom_tf>true</publish_odom_tf>
     <update_rate>15.0</update_rate>

     <left_joint>wheel_left_joint</left_joint>
     <right_joint>wheel_right_joint</right_joint>

     <wheel_separation>0.5</wheel_separation>
     <wheel_diameter>0.3</wheel_diameter>
     <max_wheel_acceleration>0.7</max_wheel_acceleration>
     <max_wheel_torque>8</max_wheel_torque>
     <robotBaseFrame>base</robotBaseFrame>
   </plugin>
</gazebo>

<!-- camera plugin-->
<gazebo reference="camera">
  <sensor type="camera" name="camera1">
   <visualize>true</visualize>
   <update_rate>30.0</update_rate>
   <camera name="head">
     <horizontal_fov>1.3962634</horizontal_fov>
     <image>
```

```
          <width>800</width>
          <height>800</height>
          <format>R8G8B8</format>
        </image>
        <clip>
          <near>0.02</near>
          <far>300</far>
        </clip>
      </camera>
      <plugin name="camera_controller" filename="libgazebo_ros_camera.so">
        <alwaysOn>true</alwaysOn>
        <updateRate>60.0</updateRate>
        <cameraName>/camera1</cameraName>
        <imageTopicName>image_raw</imageTopicName>
        <cameraInfoTopicName>info_camera</cameraInfoTopicName>
        <frameName>camera</frameName>
        <hackBaseline>0.07</hackBaseline>
      </plugin>
    </sensor>
  </gazebo>

  <!--lidar plugin-->
  <gazebo reference="lidar">
    <sensor name="lidar" type="ray">
     <visualize>true</visualize>
      <update_rate>12.0</update_rate>
      <plugin filename="libgazebo_ros_ray_sensor.so" name="gazebo_lidar">
      <output_type>sensor_msgs/LaserScan</output_type>
      <frame_name>lidar</frame_name>
      </plugin>
      <ray>
        <scan>
          <horizontal>
            <samples>360</samples>
            <resolution>1</resolution>
            <min_angle>0.00</min_angle>
            <max_angle>3.14</max_angle>
          </horizontal>
        </scan>
        <range>
          <min>0.120</min>
          <max>3.5</max>
          <resolution>0.015</resolution>
        </range>
      </ray>
    </sensor>
  </gazebo>

</robot>
```

```
cd ..
cd launch
```

touch gazebo.launch.py

```
from launch import LaunchDescription
from launch_ros.actions import Node
from launch.actions import  ExecuteProcess
def generate_launch_description():
    urdf = '/home/asha/ros2_ws/src/lab4/urdf/three_wheeled_robot.urdf'
    return LaunchDescription([

        Node(
            package='robot_state_publisher',
            executable='robot_state_publisher',
            name='robot_state_publisher',
            output='screen',
            arguments=[urdf]),
        Node(
            package='joint_state_publisher',
            executable='joint_state_publisher',
            name='joint_state_publisher',
            arguments=[urdf]),
#  Gazebo related stuff required to launch the robot in simulation
        ExecuteProcess(
            cmd=['gazebo', '--verbose', '-s', 'libgazebo_ros_factory.so'],
            output='screen'),
        Node(
            package='gazebo_ros',
            executable='spawn_entity.py',
            name='urdf_spawner',
            output='screen',
            arguments=["-topic", "/robot_description", "-entity", "lab4 "])
  ])
```

touch rviz.launch.py

```
from launch import LaunchDescription
from launch_ros.actions import Node

def generate_launch_description():
    urdf = '/home/asha/ros2_ws/src/lab4/urdf/three_wheeled_robot.urdf'
    # rviz_config_file=os.path.join(package_dir,'config.rviz')

    return LaunchDescription([
        Node(
            package='robot_state_publisher',
            executable='robot_state_publisher',
            name='robot_state_publisher',
            output='screen',
            arguments=[urdf]),
        Node(
            package='joint_state_publisher_gui',
            executable='joint_state_publisher_gui',
```

```
            name='joint_state_publisher_gui',
            arguments=[urdf]),

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


    ])
```

Edit the setup.py file as

```
from setuptools import setup
import os
from glob import glob
package_name = 'lab4 '

setup(
    name=package_name,
    version='0.0.0',
    packages=[package_name],
    data_files=[
        ('share/ament_index/resource_index/packages',
            ['resource/' + package_name]),
        ('share/' + package_name, ['package.xml']),
           (os.path.join('share', package_name), glob('urdf/*')),
           (os.path.join('share', package_name), glob('launch/*'))
    ],
    install_requires=['setuptools'],
    zip_safe=True,
    maintainer='asha',
    maintainer_email='asha@todo.todo',
    description='TODO: Package description',
    license='TODO: License declaration',
    tests_require=['pytest'],
    entry_points={
        'console_scripts': [
        ],
    },
)
```

Execute in Terminal #1

colcon build --packages-select lab4
ros2 launch lab4 rviz.launch.py

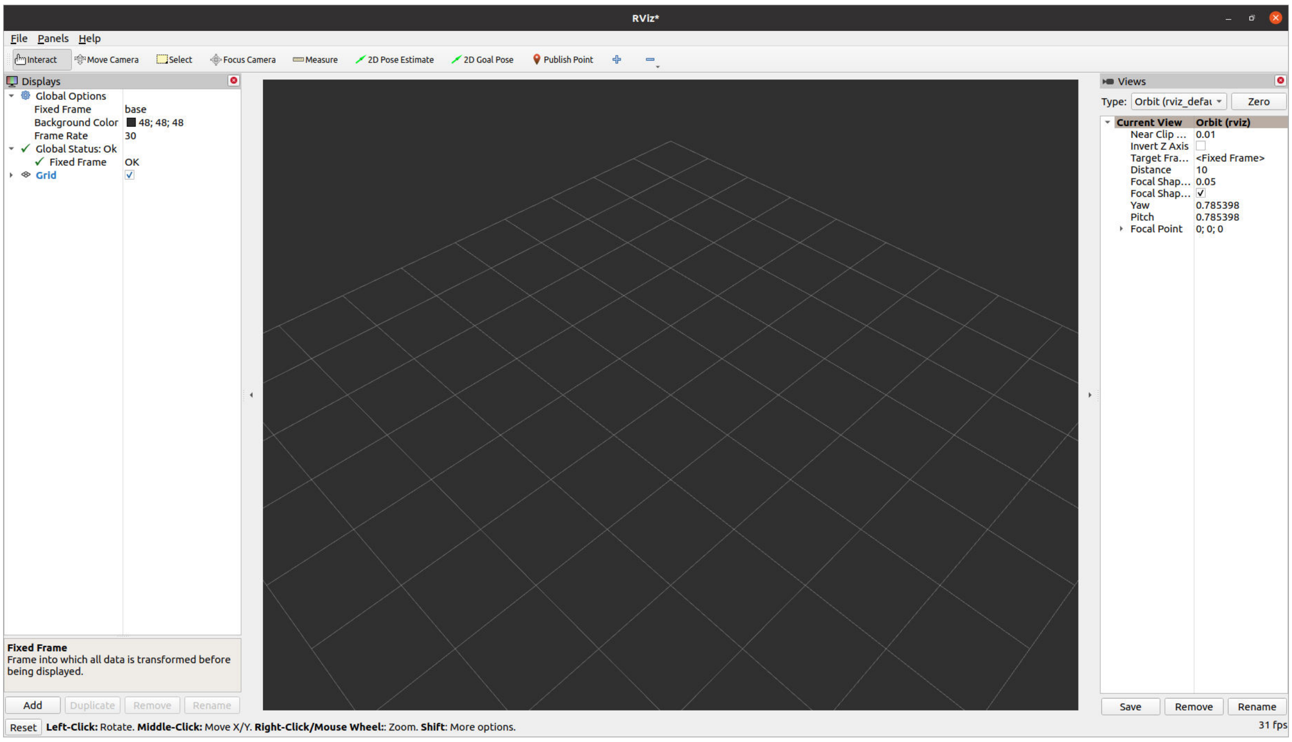
Execute in Terminal #2

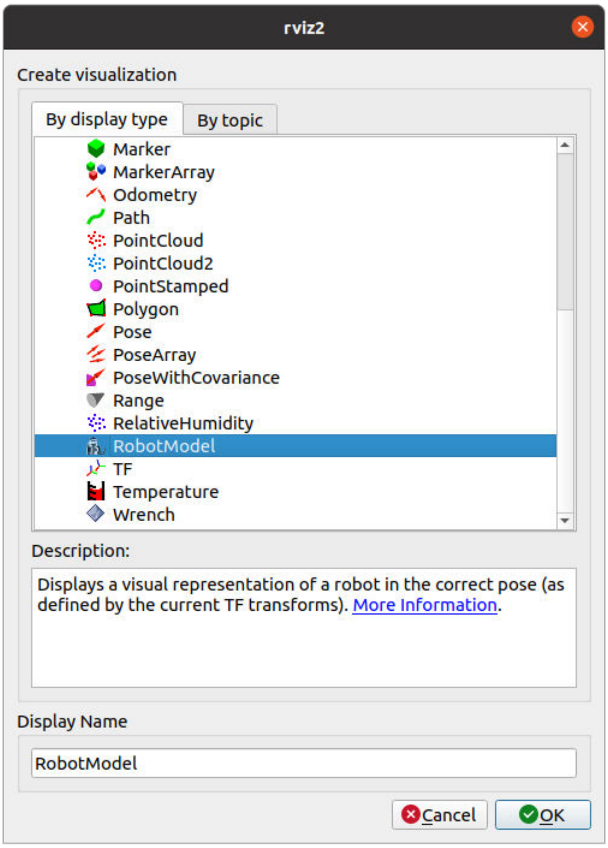
killall gzserver
ros2 launch lab4 gazebo.launch.py

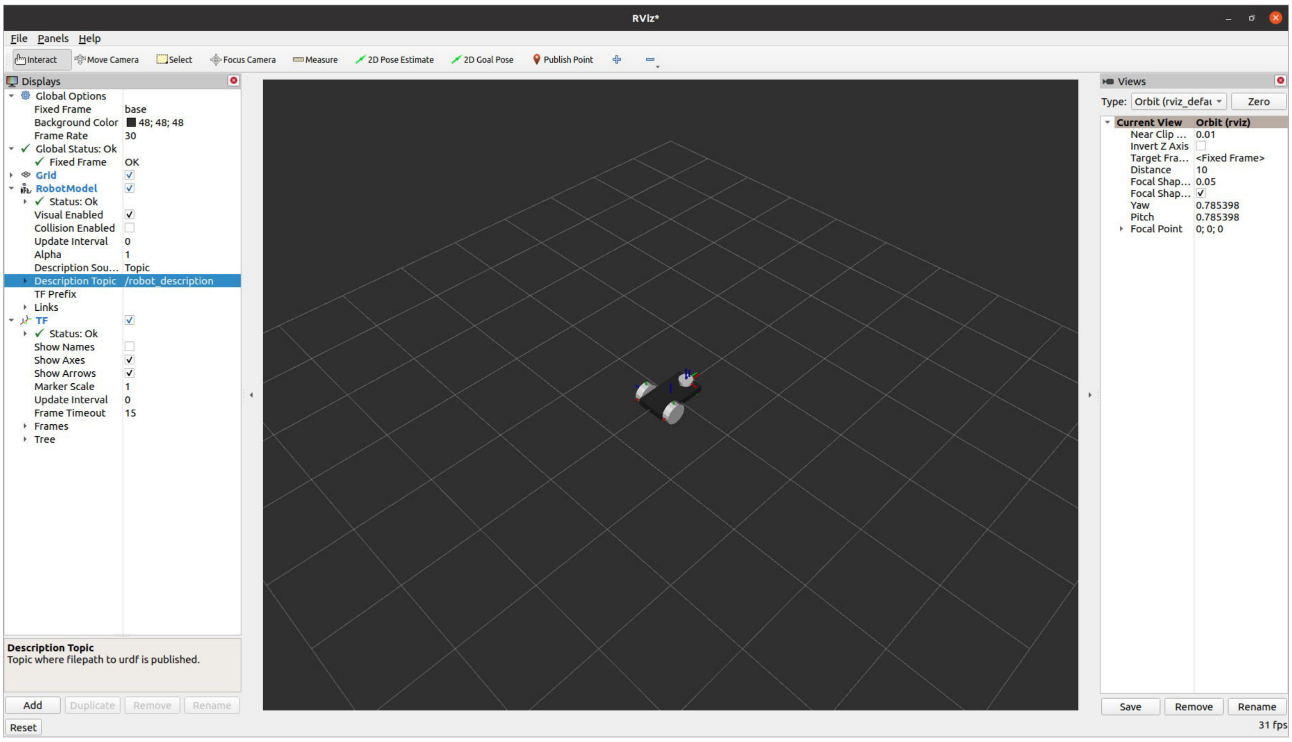
Execute in Terminal #3

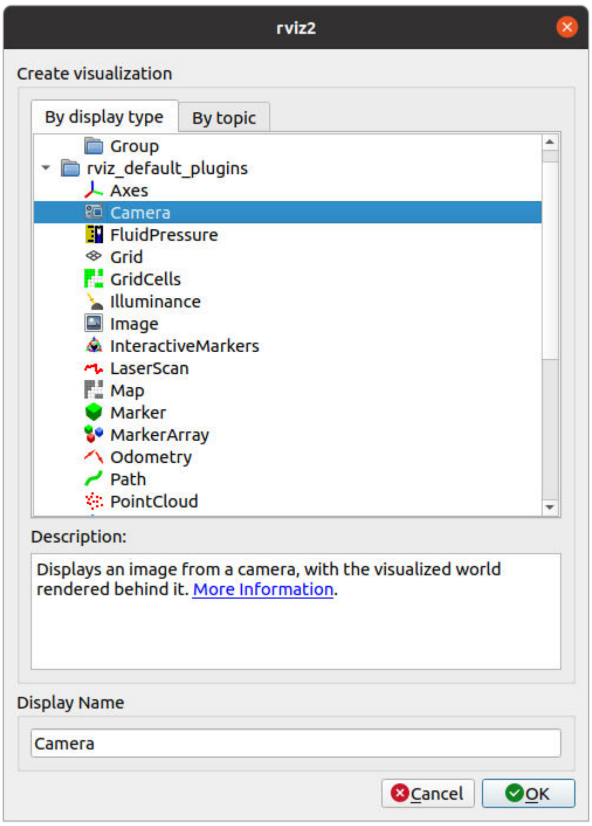
ros2 run teleop_twist_keyboard teleop_twist_keyboard

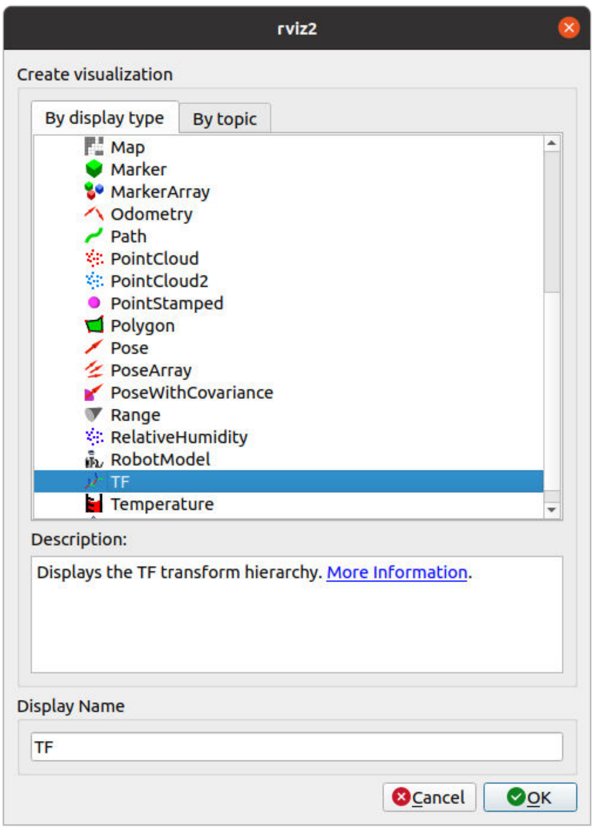
Do these changes in the rviz window:

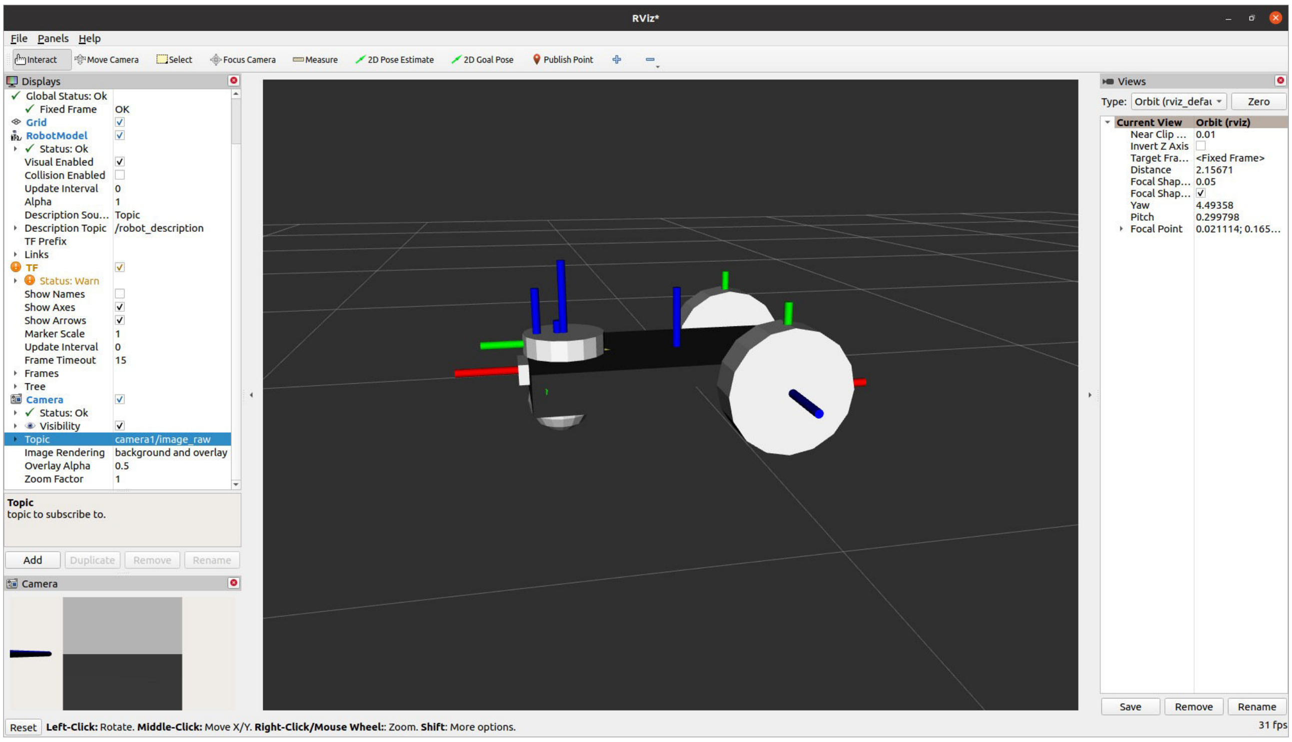


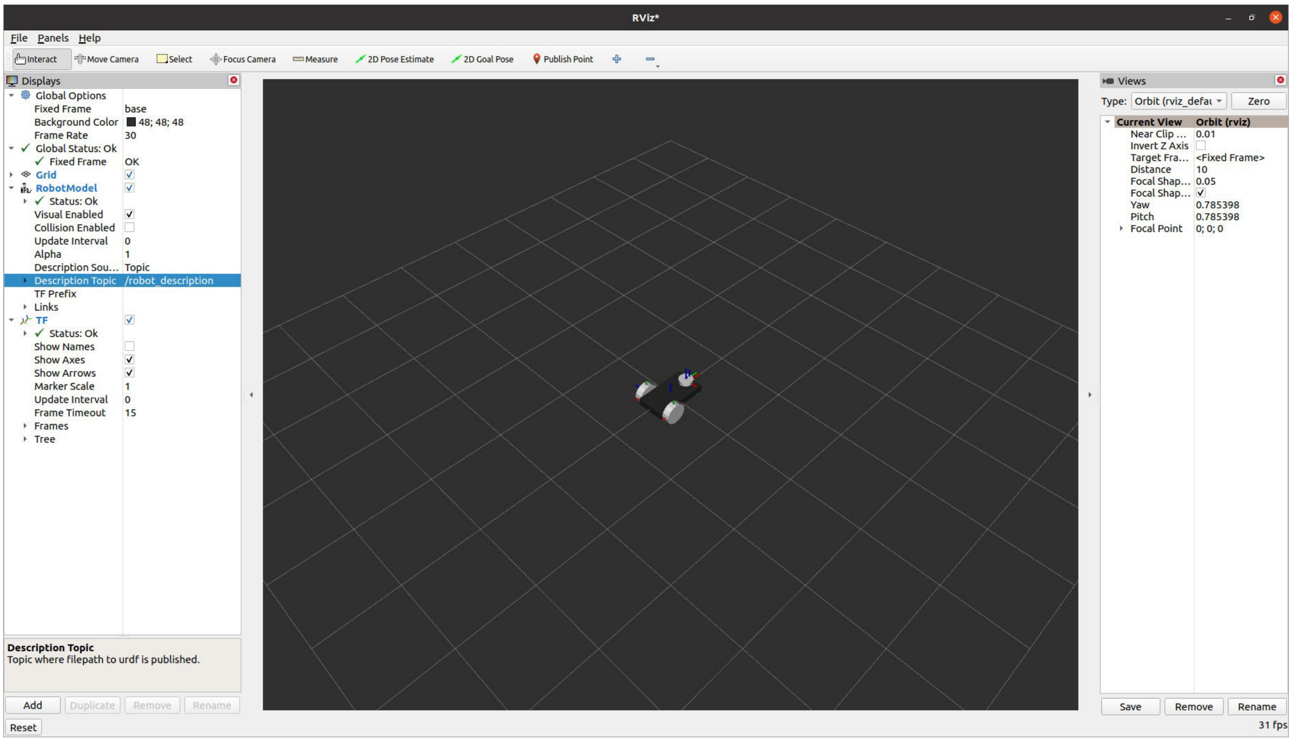


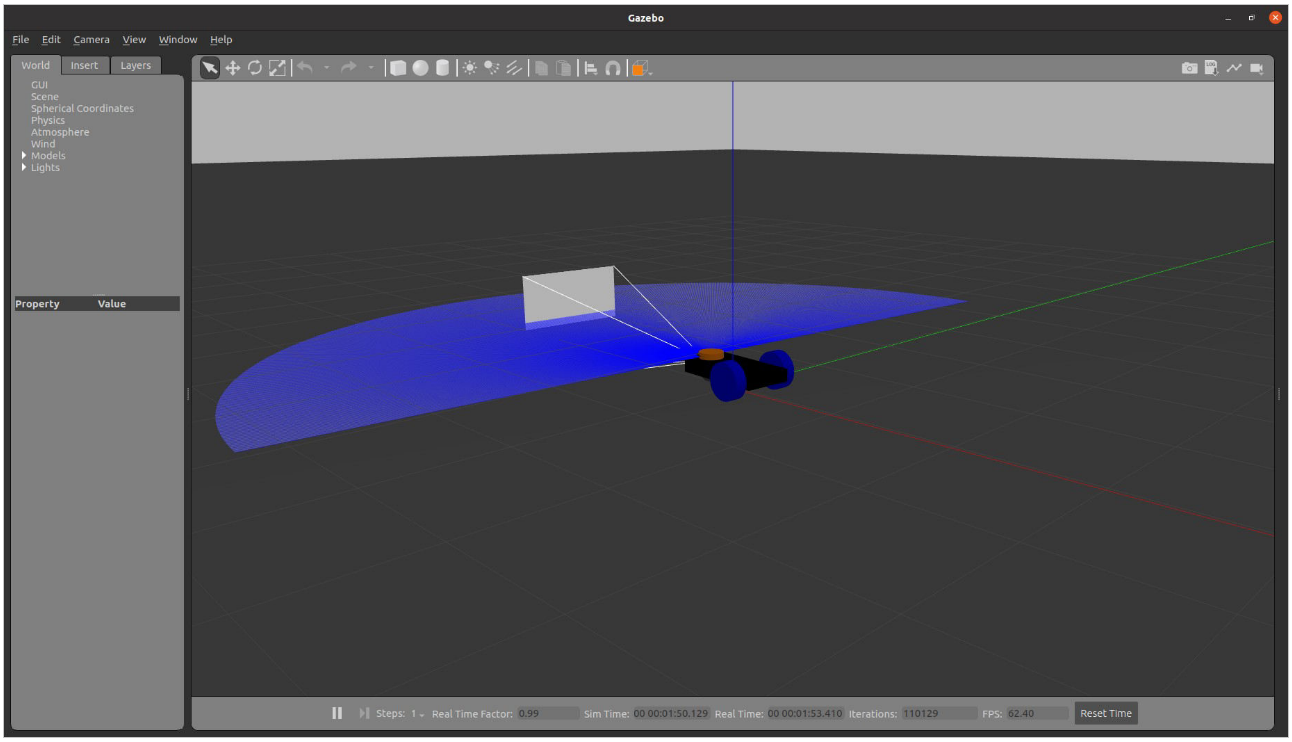

RViz*
File Panels Help
Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Goal Pose
Publish Point
Displays
Global Options
Fixed Frame base
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Fixed Frame OK
Grid
RobotModel
Status: Ok
Visual Enabled
Collision Enabled
Update Interval 0
Alpha 1
Description Sou… Topic
Description Topic /robot_description
TF Prefix
Links
TF
Status: Ok
Show Names
Show Axes
Show Arrows
Marker Scale 1
Update Interval 0
Frame Timeout 15
Frames
Tree
Description Topic
Topic where filepath to urdf is published.
Add
Duplicate
Remove
Rename
Reset
Views
Type: Orbit (rviz_defau
Zero
Current View Orbit (rviz)
Near Clip … 0.01
Invert Z Axis
Target Fra… <Fixed Frame>
Distance 10
Focal Shap… 0.05
Focal Shap…
Yaw 0.785398
Pitch 0.785398
Focal Point 0; 0; 0
Save
Remove
Rename
31 fps

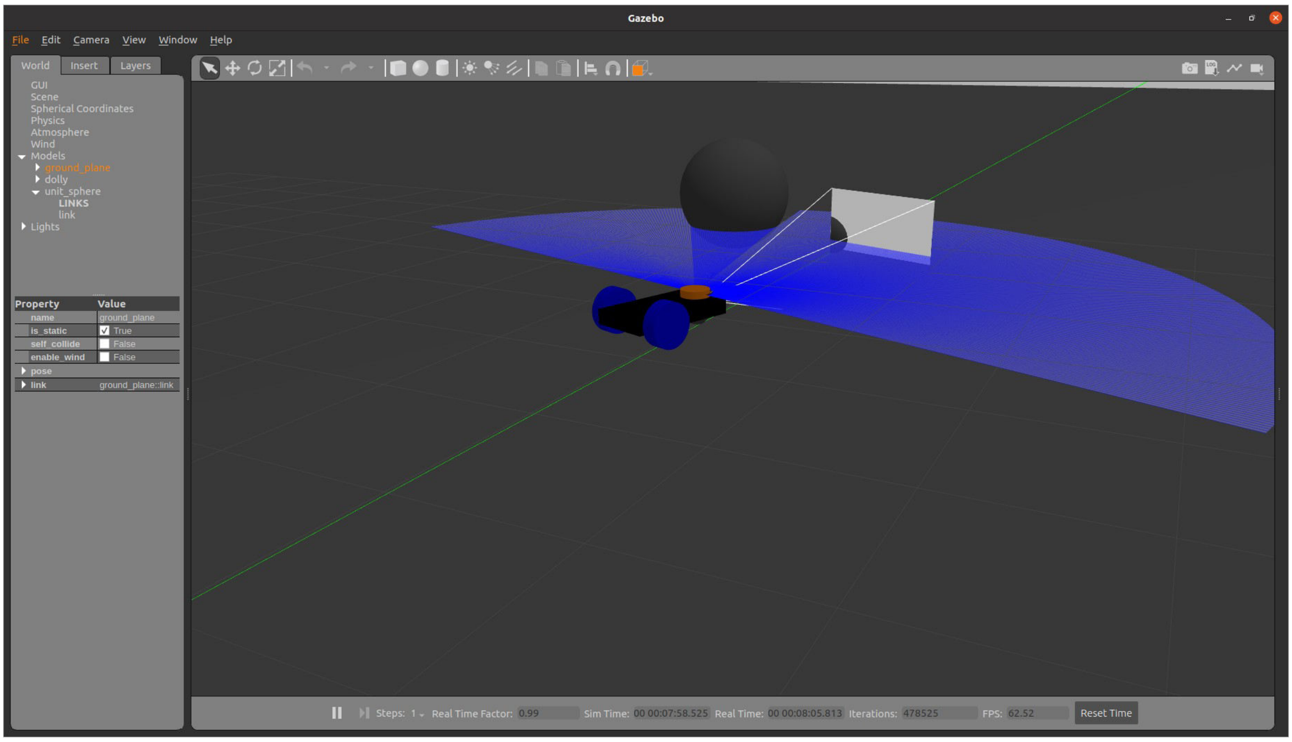

rviz2
Create visualization
By display type
By topic
Group
rviz_default_plugins
Axes
Camera
FluidPressure
Grid
GridCells
Illuminance
Image
InteractiveMarkers
LaserScan
Map
Marker
MarkerArray
Odometry
Path
PointCloud
Description:
Displays an image from a camera, with the visualized world rendered behind it. More Information.
Display Name
Camera
Cancel
OK


rviz2
Create visualization
By display type
By topic
Map
Marker
MarkerArray
Odometry
Path
PointCloud
PointCloud2
PointStamped
Polygon
Pose
PoseArray
PoseWithCovariance
Range
RelativeHumidity
RobotModel
TF
Temperature
Description:
Displays the TF transform hierarchy. More Information.
Display Name
TF
Cancel
OK


RViz*
File Panels Help
Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Goal Pose
Publish Point
Displays
Global Status: Ok
Fixed Frame OK
Grid
RobotModel
Status: Ok
Visual Enabled
Collision Enabled
Update Interval 0
Alpha 1
Description Sou... Topic
Description Topic /robot_description
TF Prefix
Links
TF
Status: Warn
Show Names
Show Axes
Show Arrows
Marker Scale 1
Update Interval 0
Frame Timeout 15
Frames
Tree
Camera
Status: Ok
Visibility
Topic camera1/image_raw
Image Rendering background and overlay
Overlay Alpha 0.5
Zoom Factor 1
Topic
topic to subscribe to.
Add
Duplicate
Remove
Rename
Camera
Views
Type: Orbit (rviz_defau
Zero
Current View Orbit (rviz)
Near Clip ... 0.01
Invert Z Axis
Target Fra... <Fixed Frame>
Distance 2.15671
Focal Shap... 0.05
Focal Shap...
Yaw 4.49358
Pitch 0.299798
Focal Point 0.021114; 0.165...
Save
Remove
Rename
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
31 fps


RViz*
File Panels Help
Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Goal Pose
Publish Point
Displays
Global Options
Fixed Frame base
Background Color 48; 48; 48
Frame Rate 30
Global Status: Ok
Fixed Frame OK
Grid
RobotModel
Status: Ok
Visual Enabled
Collision Enabled
Update Interval 0
Alpha 1
Description Sou... Topic
Description Topic /robot_description
TF Prefix
Links
TF
Status: Ok
Show Names
Show Axes
Show Arrows
Marker Scale 1
Update Interval 0
Frame Timeout 15
Frames
Tree
Description Topic
Topic where filepath to urdf is published.
Add
Duplicate
Remove
Rename
Reset
Views
Type: Orbit (rviz_defau
Zero
Current View Orbit (rviz)
Near Clip ... 0.01
Invert Z Axis
Target Fra... <Fixed Frame>
Distance 10
Focal Shap... 0.05
Focal Shap...
Yaw 0.785398
Pitch 0.785398
Focal Point 0; 0; 0
Save
Remove
Rename
31 fps


Gazebo
File Edit Camera View Window Help
World Insert Layers
GUI
Scene
Spherical Coordinates
Physics
Atmosphere
Wind
Models
Lights
Property Value
Steps: 1
Real Time Factor: 0.99
Sim Time: 00 00:01:50.129
Real Time: 00 00:01:53.410
Iterations: 110129
FPS: 62.40
Reset Time




```
sudo apt-get install python3-pip
pip3 install transforms3d
```

Edit move_robot.py

```
#!/usr/bin/env python3
import rclpy
from rclpy.node import Node
from geometry_msgs.msg import Twist
from nav_msgs.msg import Odometry
import transforms3d
import math


class GotoGoalNode(Node):
    def __init__(self):
        super().__init__("move_robot")
        self.target_x = 2
        self.target_y = 2
        self.publisher = self.create_publisher(Twist, "cmd_vel", 10)
        self.subscriber = self.create_subscription(Odometry, "odom", self.control_loop, 10)

    def control_loop(self, msg):

        dist_x = self.target_x - msg.pose.pose.position.x
        dist_y = self.target_y - msg.pose.pose.position.y
        print('current position: {}
{}'.format(msg.pose.pose.position.x,msg.pose.pose.position.y))
```

```
        distance = math.sqrt(dist_x * dist_x + dist_y * dist_y)
        print('distance : {}'.format(round(distance, 3)))


        goal_theta = math.atan2(dist_y, dist_x)
        quat = msg.pose.pose.orientation
        roll, pitch, yaw = transforms3d.euler.quat2euler([quat.w,quat.x,quat.y,quat.z])
        diff = math.pi - round(yaw, 2) + round(goal_theta, 2)
        print('yaw: {}'.format(round(yaw, 2)))
        print('target angle: {}'.format(round(goal_theta, 2)))

        if diff > math.pi:
            diff -= 2*math.pi
        elif diff < -math.pi:
            diff += 2*math.pi
        print('orientation : {}'.format(round(diff, 2)))

        vel = Twist()

        if abs(diff) > 0.2:
            vel.linear.x = 0.0
            vel.angular.z = 0.4*round(diff, 2)

        else:
            if abs(distance) > 0.2:
                vel.linear.x = 0.3*round(distance, 3)
                vel.angular.z = 0.0

            else:
                vel.linear.x = 0.0
                vel.angular.z = 0.0

        print('speed : {}'.format(vel))
        self.publisher.publish(vel)


def main(args=None):
    rclpy.init(args=args)
    node = GotoGoalNode()
    rclpy.spin(node)
    rclpy.shutdown()


if __name__ == "__main__":
        main()
```

Execute in Terminal #1

```
colcon build --packages-select lab4
ros2 launch lab4 rviz.launch.py
```

Execute in Terminal #2

killall gzserver
ros2 launch lab4 gazebo.launch.py

Execute in Terminal #3

ros2 run lab4 controller

Edit setup.py

```
 entry_points={
        'console_scripts': [
            'controller = lab4.move_robot:main'
        ],
```

Exercise 1: Write a python code to move the robot to along the wall using the laser scan data.
Exercise 2: Modify the URDF code to change to 4 wheeled robot and run the program.