ENGR 4421: Robotics II

Gazebo

02/15/2022

Outline

- Introduction
- Simulate a Differential Drive Robot in Gazebo

Gazebo Introduction

- Gazebo (http://gazebosim.org/) is a 3D dynamic simulator.
- Supports multiple physics engines: ODE, Bullet, Simbody, Dart .
- Realistic rendering of environment.
- Custom plugins for models, sensors, environment control.
- ROS integration.

Gazebo Tutorial

https://navigation.ros.org/setup_guides/odom/setup_odom.html

Install Gazebo

```
sudo apt install ros-galactic-gazebo-ros-pkgs
```

Prepare Package

- Create ROS package

```
cd ~/<ros workspace>/src  # go to `src/` in your ros workspace
ros2 pkg create --build-type ament_python <gazebo package dir>  # create a package
cd <gazebo package dir>  # go to your package
mkdir launch worlds  # create useful directories
```

- Download world description file (or, you can create one)

```
cd ~/<ros workspace>/src/<gazebo package dir>/worlds
wget https://raw.githubusercontent.com/linzhangUCA/gazebo_demo/master/worlds/demo_world.sdf
```

- Download launch file

```
cd ~/<ros workspace>/src/<gazebo package dir>/launch
wget https://raw.githubusercontent.com/linzhangUCA/gazebo_demo/master/launch/simulate_bot.launch.py
# make sure line 14 ~ 18 match the contents in your packages.
```

Set Link Inertia

- Inertial is the key to provide satisfying dynamics simulation.
- Refer to the URDF tutorial.

$$F = ma$$

$$\tau = I\alpha$$

Setup Package

- Update package dependencies in `<gazebo package dir>/package.xml`

```
<package format="3">
  ...
  <license>TODO: License declaration</license>

  <exec_depend>joint_state_publisher</exec_depend>
  <exec_depend>robot_state_publisher</exec_depend>
  <exec_depend>rviz2</exec_depend>

  <test_depend>ament_copyright</test_depend>
  ...
```

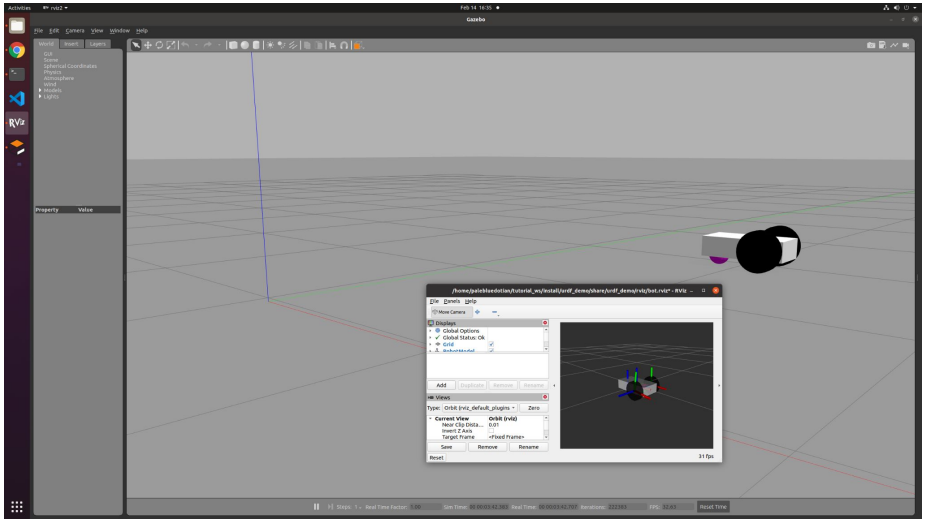
- Add data files in `<gazebo package dir>/setup.py`

```
import os
from glob import glob
from setuptools import setup
    ...
    data_files=[
        ...
        (os.path.join('share', package_name, 'launch'), glob(os.path.join('launch', '*.launch.py'))),
        (os.path.join('share', package_name, 'worlds'), glob(os.path.join('worlds', '*.sdf'))),
    ],
    ...
```

Simulation in Gazebo

- Build package and launch.

```
cd ~/<ros workspace>  # e.g. cd ~/tutorial_ws
rosdep install -i --from-path src --rosdistro galactic -y
colcon build
source install/setup.bash
ros2 launch <gazebo package dir> simulate_bot.launch.py
```



Add Gazebo Properties

- A variety of textures: http://gazebosim.org/tutorials?tut=color_model
- List of materials: http://wiki.ros.org/simulator_gazebo/Tutorials/ListOfMaterials
- Physical properties: http://gazebosim.org/tutorials/?tut=ros_urdf
- More physics: https://gazebosim.org/tutorials?tut=physics_params&cat=physics

```
<link name="caster">
    ...
</link>
<gazebo reference="caster">
    <mu1>0.0</mu1>
    <mu2>0.0</mu2>
    <material>Gazebo/Purple</material>
</gazebo>
```

Use Gazebo ROS Plugins

```
<!-- differential_drive_controller plugin -->
<gazebo>
    <plugin name="differential_drive_controller" filename="libgazebo_ros_diff_drive.so">
        <ros>
            <namespace>/bot</namespace>
        </ros>
        <robot_base_frame>base_link</robot_base_frame>
        <update_rate>100</update_rate>
        <left_joint>left_wheel_joint</left_joint>
        <right_joint>right_wheel_joint</right_joint>
        <wheel_separation>0.26</wheel_separation>
        <wheel_diameter>0.2</wheel_diameter>
        <publish_odom>true</publish_odom>
        <publish_odom_tf>false</publish_odom_tf>
        <publish_wheel_tf>true</publish_wheel_tf>
        <odometry_frame>odom</odometry_frame>
        <max_wheel_torque>10</max_wheel_torque>
        <max_acceleration>1.0</max_acceleration>
    </plugin>
</gazebo>
```

Do this in URDF

Popular Simulation Software

- Webots
- Pybullet
- MuJoCo
- Nvidia Isaac Sim
- CoppelliaSim (V-Rep)
- ...