Robot Operating System (ROS)

Lab 6: URDF and Rviz

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Outline

ROS Visualization (Rviz)

ROS Visualization (Rviz)

Rviz

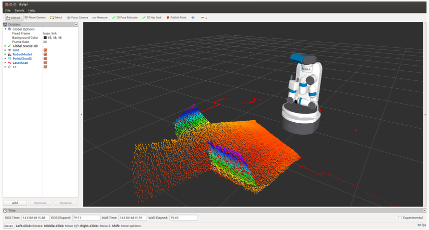
Rviz is a powerful 3D visualization tool for ROS. It allows the user to:

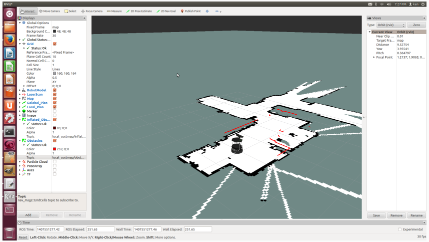
- view the simulated robot model.
- log sensor information.
- Replay the logged sensor information. (**rosbag**).

To launch Rviz:

```
$ roscore
```

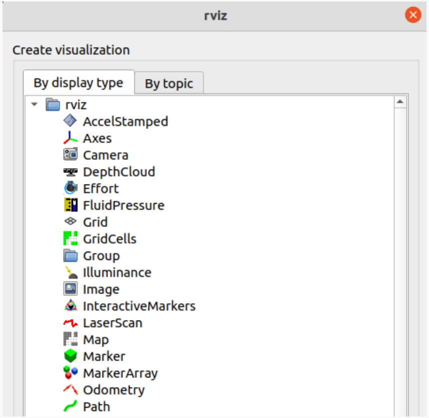
```
$ rviz
```





ROS Visualization (Rviz)

- On the left panel of the rviz main screen is the Displays panel, where the user can **add**, **remove**, or rename the visualization elements in the 3D environment.
- For further details on the display types, go to official ROS website.



Introduction to URDF

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URDF file

Unified Robotics Description Format, URDF, is an XML specification used in academia and industry to model multibody systems such as robotic manipulator arms or mobile robot.

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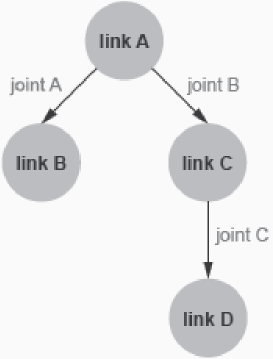
URDF Elements and Attributes

URDF files comprise various XML elements, such as <robot>, <link>, <joint>, nested in a tree.

```
<robot>
        <link>
        ...
        </link>
        <joint>
        ...
        </joint>
</robot>
```

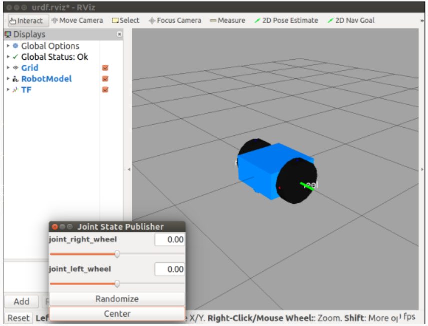


Building a differential drive robot URDF

Building a differential drive robot URDF

Objective

For our first robot model, we will build a URDF file for a two-wheeled differential drive robot. The model will be created incrementally, and we will view the results at each step in rviz. When our simple two-wheeled robot is complete, we will add Gazebo formatting and view the model in Gazebo.



Robot Model

Building a differential drive robot URDF

Step 1: Create a new ROS package.

- Create a new package in your own ROS workspace/src folder:

```
$ catkin_create_pgk diff_robot_gazebo
```

- Build the packages in the workspace:

```
$ cd ~/catkin_ws
$ catkin_make
```

- make a **urdf** folder inside the new created package:

```
$ mkdir urdf
```

Building a differential drive robot URDF

Step 2: Create a robot chassis.

- The robot URDF file is a set of **links** and **joints**.
- The link describes a rigid body and its physical properties:
  - dimensions.
  - position of its origin.
  - color.
- The joint describes the kinematic and dynamic properties:
  - links connected.
  - types of joint.
  - axis of rotation.
  - amount of friction and damping.

Building a differential drive robot URDF

Step 2: Create a robot chassis.

In the **urdf** folder, create a new file called diff_robot.urdf

```xml
<?xml version='1.0'?>
    <robot name="dd_robot">
    <!-- Base Link -->
        <link name="base_link">
            <visual>
                <origin xyz="0 0 0" rpy="0 0 0" />
                <geometry>
                    <box size="0.5 0.5 0.25"/>
                </geometry>
            </visual>
        </link>
    </robot>
```

Building a differential drive robot URDF

Step 2: Create a robot chassis.

```xml
<?xml version='1.0'?>
    <robot name="dd_robot">
    <!-- Base Link -->
        <link name="base_link">
            <visual>
                <origin xyz="0 0 0" rpy="0 0 0" />
                <geometry>
                    <box size="0.5 0.5 0.25"/>
                </geometry>
            </visual>
        </link>
    </robot>
```

Description:

- Robot name is dd_robot.
- The robot consists of one link called base_link.
- The link is a chassis box of width=0.5, depth=0.5 and height=0.25.
- The link is located at the origin without any orientation.

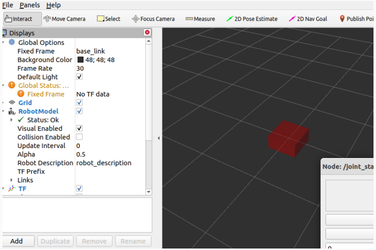
Building a differential drive robot URDF

Step 3: Display the created URDF file into Rviz.

```
$ roslaunch urdf_tutorial display.launch model:=`rospack find diff_robot_gazebo`/urdf/diff_robot.urdf gui:=true
```

roslaunch: launch many nodes at the same time.

rospack: return the path of a ROS package.



Building a differential drive robot URDF

Step 4: Adding wheels.

- Joints used to describe the relationship between the links.
- In URDF joint types: **Fixed, Revolute, Prismatic, Float, Planar, Continuous**.

```
<!-- Right Wheel -->
<link name="right_wheel">
    <visual>
        <origin xyz="0 0 0" rpy="1.570795 0 0" />
        <geometry>
            <cylinder length="0.1" radius="0.2" />
        </geometry>
    </visual>
</link>
<joint name="joint_right_wheel" type="continuous">
    <parent link="base_link"/>
    <child link="right_wheel"/>
    <origin xyz="0 -0.30 0" rpy="0 0 0" />
    <axis xyz="0 1 0" />
</joint>
```

- A continuous joint for the wheel is added to allow for continuous rotation.
- The wheel is a cylinder rotated $\pi/2$ radians around x.
- The joint has the base_link as a parent and the right_wheel as a child and 0.3 m away from it's parent on x-axis.

Building a differential drive robot URDF

Step 4: Adding wheels.

- Joints used to describe the relationship between the links.
- In URDF joint types: **Fixed, Revolute, Prismatic, Float, Planar, Continuous**.

```xml
<!-- Left Wheel -->
<link name="left_wheel">
    <visual>
        <origin xyz="0 0 0" rpy="1.570795 0 0" />
        <geometry>
            <cylinder length="0.1" radius="0.2" />
        </geometry>
    </visual>
</link>
<joint name="joint_left_wheel" type="continuous">
    <parent link="base_link"/>
    <child link="left_wheel"/>
    <origin xyz="0 0.30 0" rpy="0 0 0" />
    <axis xyz="0 1 0" />
</joint>
```

- A continuous joint for the wheel is added to allow for continuous rotation.
- The wheel is a cylinder rotated $\pi/2$ radians around x.
- The joint has the base_link as a parent and the left_wheel as a child and 0.3 m away from it's parent on x-axis.

BUILDING A DIFFERENTIAL DRIVE ROBOT URDF

Step 5: Adding a castor.

- The castor will only be a visual element added to the chassis and not a joint.
- The caster will slide along the ground plane as the robot's wheels move.

```xml
    <!-- Base Link -->
        <link name="base_link">
            <visual>
                <origin xyz="0 0 0" rpy="0 0 0" />
                <geometry>
                    <box size="0.5 0.5 0.25"/>
                </geometry>
            </visual>
            <!-- Caster -->
            <visual name="caster">
                <origin xyz="0.2 0 -0.125" rpy="0 0 0" />
                <geometry>
                    <sphere radius="0.05" />
                </geometry>
            </visual>
        </link>

        <!-- Right Wheel -->
```

Modified base_link

Building a differential drive robot URDF

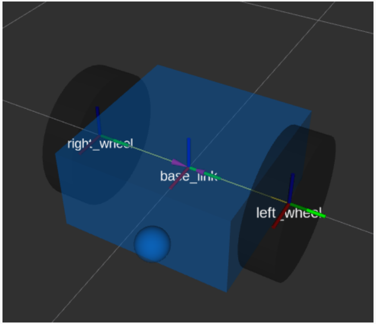
Step 6: Adding color.

Color is added with the **material** tag:

```
    <!-- Base Link -->
        <link name="base_link">
            <visual>

                <origin xyz="0 0 0" rpy="0 0 0" />
                <material name="blue">
                    <color rgba="0 0.5 1 1"/>
                </material>
                <geometry>
                    <box size="0.5 0.5 0.25"/>
                </geometry>
            </visual>
            <!-- Caster -->
```

Modified base_link



r: red, **g:** green, **b:** blue

a: alpha: transparency [0-1]

BUILDING A DIFFERENTIAL DRIVE ROBOT URDF

Step 7: Adding collision.

- A <collision> is added to each <link> to identify the boundaries of the object.
- If an object has complex visual shape, a simplified collision property should be defined.

```xml
    <!-- Base Link -->
        <link name="base_link">
            <visual>
                <origin xyz="0 0 0" rpy="0 0 0" />
                <material name="blue">
                    <color rgba="0 0.5 1 1"/>
                </material>
                <geometry>
                    <box size="0.5 0.5 0.25"/>
                </geometry>
            </visual>
            <!-- Base collision -->
            <collision>
                <origin xyz="0 0 0" rpy="0 0 0" />
                <geometry>
                    <box size="0.5 0.5 0.25"/>
                </geometry>
            </collision>

            <!-- Caster -->
```

Building a differential drive robot URDF

Step 7: Adding collision. (Castor)

```
            <!-- Caster -->
            <visual name="caster">
                <origin xyz="0.2 0 -0.125" rpy="0 0 0" />
                <geometry>
                    <sphere radius="0.05" />
                </geometry>
            </visual>
            <!-- Caster collision -->
            <collision>
                <origin xyz="0.2 0 -0.125" rpy="0 0 0" />
                <geometry>
                    <sphere radius="0.05" />
                </geometry>
            </collision>

        </link>

```

Building a differential drive robot URDF

Step 7: Adding collision. (Left wheel)

```
<!-- Left Wheel -->
<link name="left_wheel">
    <visual>
        <origin xyz="0 0 0" rpy="1.570795 0 0" />
        <material name="black"/>

        <geometry>
            <cylinder length="0.1" radius="0.2" />
        </geometry>
    </visual>
</link>
```

Building a differential drive robot URDF

Step 7: Adding collision. (Right wheel)

```
        <!-- Right Wheel -->
        <link name="right_wheel">
            <visual>
                <origin xyz="0 0 0" rpy="1.570795 0 0" />
                <material name="black">
                    <color rgba="0.05 0.05 0.05 1"/>
                </material>
                <geometry>
                    <cylinder length="0.1" radius="0.2" />
                </geometry>
            </visual>
            <!-- Right Wheel collision -->
            <collision>
                <origin xyz="0 0 0" rpy="1.570795 0 0" />
                <geometry>
                    <cylinder length="0.1" radius="0.2" />
                </geometry>
            </collision>
```

Building a differential drive robot URDF

Step 8: Adding Physical properties (mass and inertia).

The <inertial> tag could be used to add:

- **Mass:** This is the weight defined in kilograms.
- **inertia** : This frame is a 3×3 rotational inertia matrix.

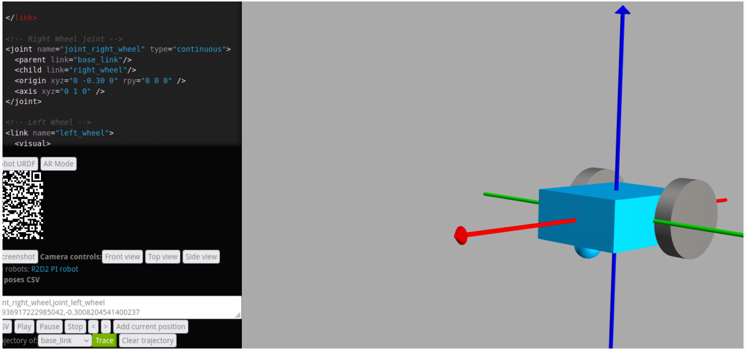
ixx	ixy	ixz
ixy	iyy	iyz
ixz	iyz	izz

```xml
<!-- Base Link -->
<link name="base_link">
  <visual>
    <origin xyz="0 0 0" rpy="0 0 0" />
    <geometry>
        <box size="0.5 0.5 0.25"/>
    </geometry>
    <material name="blue">
      <color rgba="0 0.5 1 1"/>
    </material>
  </visual>
  <!-- Base collision, mass and inertia -->
  <collision>
    <origin xyz="0 0 0" rpy="0 0 0" />
    <geometry>
        <box size="0.5 0.5 0.25"/>
    </geometry>
  </collision>
  <inertial>
    <mass value="5"/>
    <inertia ixx="0.13" ixy="0.0" ixz="0.0" iyy="0.21" iyz="0.0" izz="0.13"/>
  </inertial>
```

Building a differential drive robot URDF

Step 9: Visualization of the URDF file

- You can visulaize the URDF file using the **mymodelrobot** website.
- To import the URDF file into CoppeliaSim:
  1. Press **Modules**.
  2. Choose **Importers**.
  3. Press **URDF importer**.



Check the website here!

Building a differential drive robot URDF

Finally: Try this code in CoopeliaSim script

```
function sysCall_init()
    -- do some initialization here
        -- do some initialization here
    robot = sim.getObjectHandle('/my_robot')
    leftMotor = sim.getObjectHandle('/my_robot/joint_left_wheel')
    rightMotor = sim.getObjectHandle('/my_robot/joint_right_wheel')
end

function sysCall_actuation()
    -- put your actuation code here

    sim.setJointTargetVelocity(leftMotor,1)
    sim.setJointTargetVelocity(rightMotor,1)
end

function sysCall_sensing()
    -- put your sensing code here
end
```

End of Lecture

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