Creating a Simple 4-Wheel Robot URDF

1 God Made You, So You Make Robots

God made you with two legs, two arms, a head, and a body. All these parts are connected together. Your legs are attached to your hip, your arms to your shoulders, and your head to your neck.

Now you want to make a robot! But instead of legs, you'll give it 4 wheels. Instead of arms, maybe some sensors. Just like how God described how to build you (with DNA), you need to describe how to build your robot.

That's what URDF does - it's like DNA for robots!

2 What is URDF?

URDF stands for "Unified Robot Description Format". Think of it like writing instructions to build a robot, just like IKEA furniture instructions but for robots.

You need to tell the computer:

- What parts the robot has (wheels, body, sensors)
- How big each part is
- How the parts connect to each other
- What each part looks like
- How each part can move

3 Visual Model vs Collision Model

Just like you have clothes and a body underneath:

Visual Model = Your clothes (what others see)

- Pretty colors and textures
- Detailed shape and design
- Makes the robot look good

Collision Model = Your body (what actually bumps into things)

- Simple shapes (boxes, cylinders, spheres)
- No fancy details
- Just tells the computer ”don’t let things pass through here”

Why separate? Because checking if two complex 3D models bump into each other is like trying to solve a math puzzle every millisecond. But checking if two simple boxes bump into each other is easy!

4 Building Our 4-Wheel Robot

4.1 The Robot Body (Base Link)

```
<link name="base_link">
    <visual>
        <geometry>
            <box size="0.6 0.4 0.2"/>
        </geometry>
        <material name="blue">
            <color rgba="0 0 1 1"/>
        </material>
    </visual>
    <collision>
        <geometry>
            <box size="0.6 0.4 0.2"/>
        </geometry>
    </collision>
    <inertial>
        <mass value="10"/>
        <inertia ixx="0.4" ixy="0" ixz="0" iyy="0.4" iyz="0" izz="0.2"/>
    </inertial>
</link>
```

This creates the robot’s body:

- `<visual>` = What you see (a blue box, 60cm long, 40cm wide, 20cm tall)
- `<collision>` = What bumps into things (same box, but computer doesn’t care about color)
- `<inertial>` = How heavy it is (10kg) and how it spins (like a spinning top)

Think of it like your torso - it’s the main part everything else attaches to.

4.2 The Wheels

```
<link name="front_left_wheel">
    <visual>
        <geometry>
            <cylinder radius="0.1" length="0.05"/>
        </geometry>
        <material name="black">
            <color rgba="0 0 0 1"/>
        </material>
    </visual>
    <collision>
        <geometry>
            <cylinder radius="0.1" length="0.05"/>
        </geometry>
    </collision>
    <inertial>
        <mass value="1"/>
        <inertia ixx="0.01" ixy="0" ixz="0" iyy="0.01" iyz="0" izz="0.01"/>
    </inertial>
</link>
```

Each wheel is:

- A black cylinder (10cm radius, 5cm thick)
- 1kg heavy
- Can spin around

Think of wheels like your feet - they touch the ground and help you move.

4.3 Connecting Body to Wheels (Joints)

```
<joint name="base_to_front_left_wheel" type="continuous">
    <parent link="base_link"/>
    <child link="front_left_wheel"/>
    <origin xyz="0.25 0.25 -0.15" rpy="1.57 0 0"/>
    <axis xyz="0 0 1"/>
</joint>
```

This connects the body to the front left wheel:

- `parent="base_link"` = The wheel is attached to the body
- `child="front_left_wheel"` = This is what's being attached
- `origin xyz="0.25 0.25 -0.15"` = Where the wheel is (25cm forward, 25cm left, 15cm down)

- `type="continuous"` = The wheel can spin forever (like your wrist can rotate)
- `axis xyz="0 0 1"` = Which direction it spins around

Think of joints like your shoulders and hips - they connect body parts and let them move.

4.4 Complete Robot Structure

Our robot family tree looks like:

```
base_link (body)
 front_left_wheel
 front_right_wheel
 back_left_wheel
 back_right_wheel
```

Just like your body:

```
torso (your body)
 left_arm
 right_arm
 left_leg
 right_leg
```

4.5 Materials and Colors

```
<material name="blue">
    <color rgba="0 0 1 1"/>
</material>
<material name="black">
    <color rgba="0 0 0 1"/>
</material>
```

RGBA colors work like paint mixing:

- R = Red (0 = no red, 1 = full red)
- G = Green (0 = no green, 1 = full green)
- B = Blue (0 = no blue, 1 = full blue)
- A = Alpha (0 = invisible, 1 = solid)

So `rgba="0 0 1 1"` = no red, no green, full blue, fully solid = BLUE!

5 Inertia - Why Robots Don’t Fall Over

```
<inertial>
    <mass value="10"/>
    <inertia ixx="0.4" ixy="0" ixz="0" iyy="0.4" iyz="0" izz="0.2"/>
</inertial>
```

Inertia is like how hard it is to push you over:

- `mass` = How heavy you are (harder to push heavy things)
- `ixx, iyy, izz` = How hard to spin you around different axes
- Think of a figure skater: arms out = hard to spin, arms in = easy to spin

If you don’t give your robot proper inertia, it might:

- Fall through the ground
- Spin like crazy
- Act like it’s made of paper

6 Joint Types - How Things Move

```
<joint name="wheel_joint" type="continuous">
    <axis xyz="0 0 1"/>
</joint>
```

Different joint types, like different body parts:

- `continuous` = Can spin forever (like your wrist)
- `revolute` = Can spin but has limits (like your elbow - you can’t bend it backwards!)
- `prismatic` = Slides in and out (like a telescope)
- `fixed` = Doesn’t move at all (like your skull to your brain)

Our wheels use `continuous` because wheels should spin freely in both directions.

7 Why Do We Need This?

Imagine you’re building a toy robot and your little cousin asks: ”How do I know where the wheels are?”

Without URDF, you’d have to remember:

- The front left wheel is 25cm forward and 25cm left

- The front right wheel is 25cm forward and 25cm right
- Wait, which way is forward again?
- Is the wheel touching the ground or floating?

With URDF, the computer remembers everything! Plus:

- Simulation software can make your robot move realistically
- You can see if your robot design works before building it
- Other people can understand your robot design
- You can easily change wheel size or add new parts

It's like having a perfect instruction manual that never gets lost!

8 Summary

URDF is like DNA for robots:

1. `<link>` defines robot parts (like your arms, legs, head)
2. `<joint>` connects parts together (like your shoulders, hips, neck)
3. `<visual>` makes it look pretty (like your clothes)
4. `<collision>` prevents things from passing through (like your actual body)
5. `<inertial>` makes physics work correctly (like your weight and balance)

Just like God designed you with everything connected properly, you design your robot with URDF so everything works together perfectly!