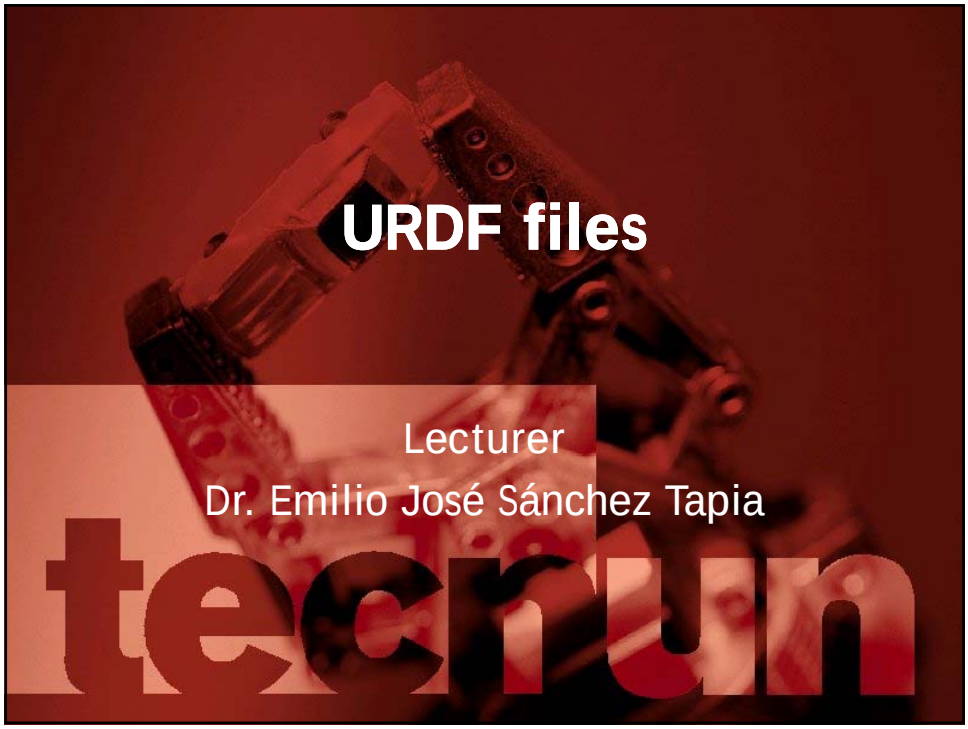
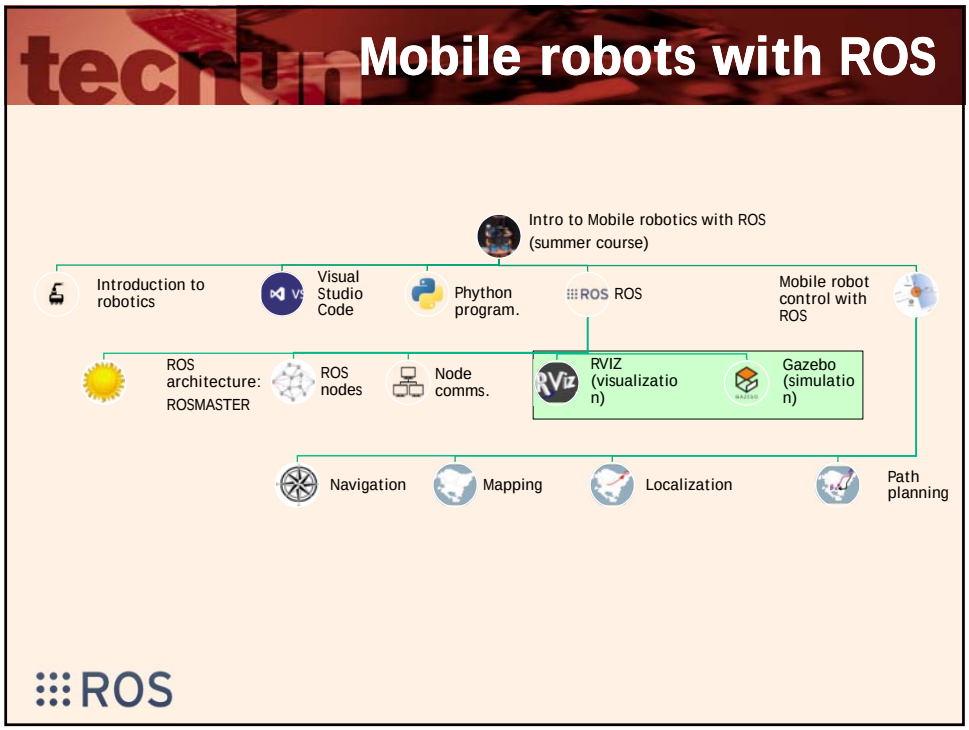
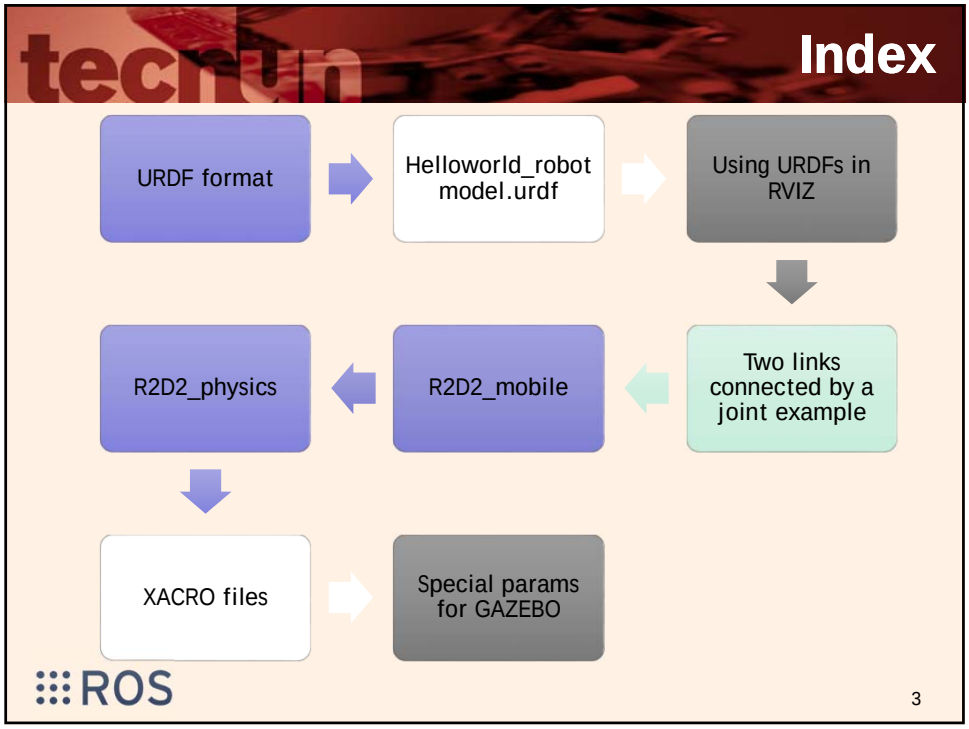

URDF files
Lecturer
Dr. Emilio José Sánchez Tapia
tecnun


tecnun
Mobile robots with ROS
Intro to Mobile robotics with ROS (summer course)
Introduction to robotics
Visual Studio Code
Phython program.
ROS
Mobile robot control with ROS
ROS architecture: ROSMASTER
ROS nodes
Node comms.
RVIZ (visualizatio n)
Gazebo (simulatio n)
Navigation
Mapping
Localization
Path planning
ROS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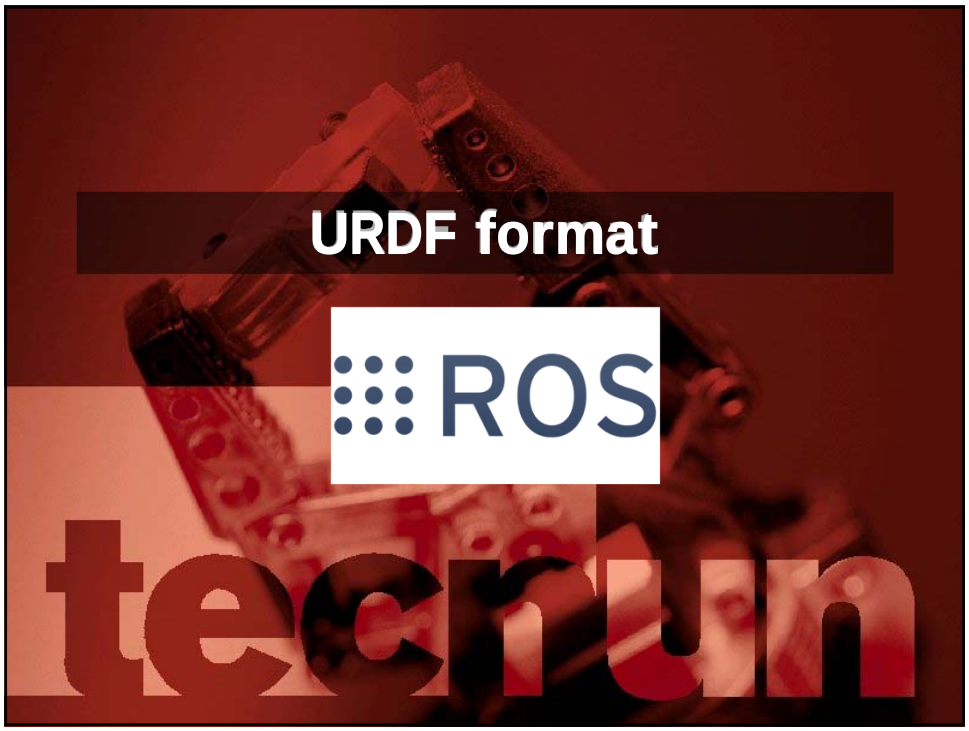
URDF format
ROS

Unified Robot Description Format (URDF)

- XML file that describes the robot model:
  - Kinematic and dynamic model
  - Robot visual representation
  - Collision model
- An URDF file can be generated from xacro files
- The robot description (URDF) is stored on the parameter server under `/robot_description`
- For Rviz (ROS visualizer) and GAZEBO (ROS simulator)
- To see a urdf file graphically, use *urdf_to_graphiz*
- http://wiki.ros.org/urdf/Tutorials

ROS

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URDF: file format description

- A set of link elements and a set of joint elements
- Joints connect the links
- robot_model.urdf

```
<robot name="robot">
   <link> ... </link>
   <link> ... </link>
   <link> ... </link>
   <joint> .... </joint>
   <joint> .... </joint>
   <joint> .... </joint>
</robot>
```

ROS

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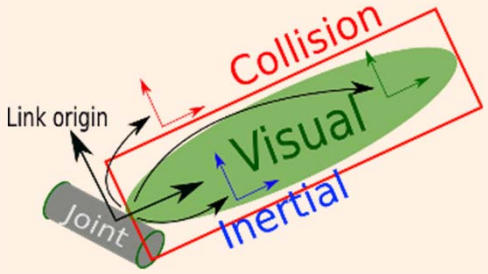
URDF: link description

Check http://wiki.ros.org/urdf/XML/link

- Inertial: origin (pose→[xyz and rpy] of the center of gravity, relative to the link, mass, inertia (Ixx, Ixy, Ixz, Izz, Izz)
- Visual: name,origin (pose→[xyz and rpy] with respect to the reference frame of the link), geometry (box, cylinder, sphere, mesh [*.dae (with colors) or *.stl (without colors)]), material> (name, color [rgba], texture[file])
- Collision: name, origin, geometry



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URDF: link description

```
<link name="link_name">
   <visual>
      <origin xyz="0 0 0" rpy="0 0 0"/>
      <geometry>
         <mesh filename="mesh.dae"/> <!-- with colors -->
      </geometry>
      <material name="Cyan">
       <color rgba="0 1.0 1.0 1.0"/>
      </material>
   </visual>
   <collision>
      <origin xyz="0 0 0" rpy="0 0 0"/>
      <geometry>
         <cylinder length="0.4" radius="0.25"/>
      </geometry>
   </collision>
   <inertial>
      <origin xyz="0 0 0" rpy="0 0 0"/>
      <mass value="10"/>
      <inertia ixx="10"  ixy="0"  ixz="0" iyy="10" iyz="0" izz="10" />
</inertial>
</link>
```

ROS

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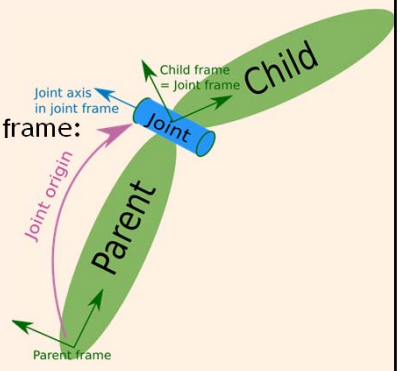
URDF: joint description

Check http://wiki.ros.org/urdf/XML/joint

- Type: revolute, continuous, prismatic, fixed, floating, and planar
- Parent and Child: to define to which links it is connected
- Origin: the xyz coord and rpy are referenced to the Parent axis, not the child axis.
- Limit: lower, upper, effort, velocity
- Dynamics: damping, friction
- Axis: the joint axis, specified in the joint frame:
  - Revolute: the axis of rotation
  - Prismatic: the axis of translation
  - Planar: the surface normal
  - Fixed and floating: do not use this option
- Safety_controller:
  - limits the joint boundaries
  - saturates the control action



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URDF: joint description

```
<joint name="joint_name" type="revolute">
   <axis xyz="0 0 1"/>
   <limit effort="1000.0" upper="0.548" … />
   <origin rpy="0 0 0" xyz="0.2 0.01 0"/>
   <parent link="parent_link_name"/>
   <child link="child_link_name"/>
   <dynamics damping="0.0" friction="0.0"/>
   <limit effort="30" velocity="1.0" lower="-2.2" upper="0.7"
/>
   <safety_controller k_velocity="10" k_position="15"
soft_lower_limit="-2.0" soft_upper_limit="0.5" />
</joint>
```

ROS

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URDF: helloworld_robotmodel.urdf

- Create helloworld_robotmodel.urdf
- Save it in the urdf folder of the helloworld_pkg package
- The file:

```
<?xml version="1.0"?>
<robot name="myfirstRobot">
  <link name="base_link">
    <visual>
      <geometry>
        <cylinder length="0.6" radius="0.2"/>
      </geometry>
    </visual>
  </link>
</robot>
```

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URDF: helloworld_robotmodel.launch

- Create helloworld_robotmodel.launch
- Save it with other launch files
- The file:

```
<launch>
  <param name="robot_description" textfile="$(find
helloworld_pkg)/urdf/helloworld_robotmodel.urdf" />
  <arg name="gui" default="False" />
  <param name="use_gui" value="$(arg gui)"/>
  <node pkg="tf" type="static_transform_publisher" name= "world_frame"
args="0 0 0 0 0 0 map base_link 100"/>
  <node name="rviz" pkg="rviz" type="rviz" />
</launch>
```

- Execute the launch file:

```
> roslaunch helloworld_pkg helloworld_robotmodel.launch gui:=true
```

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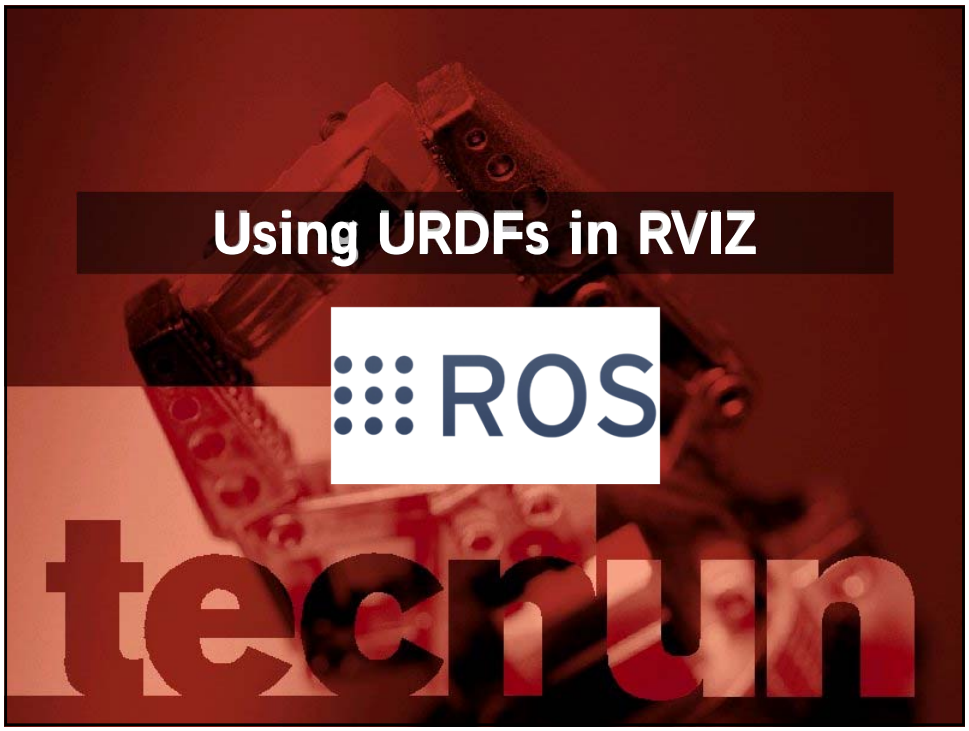
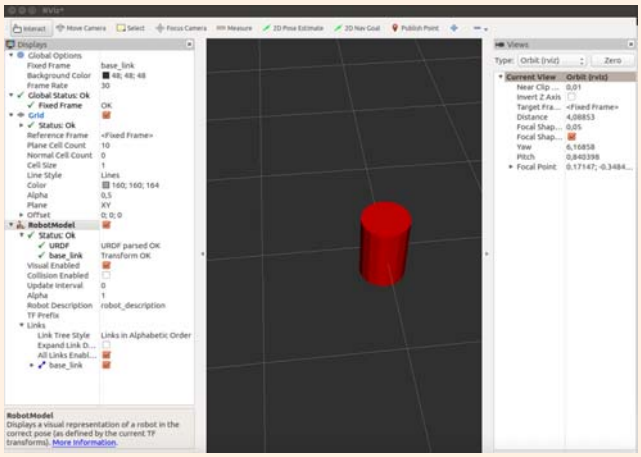


URDF: rviz configuration to see the robot model

- Select the base_link as a fixed frame
- Load the plugin robot model



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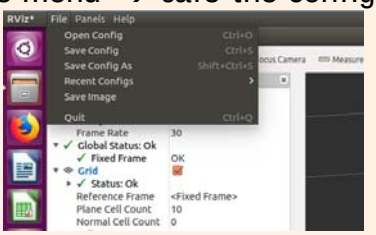
URDF: Save the configuration

- In the file menu → safe the config



- Modify the launch file changing the rviz node
  - Old line

```
<node name="rviz" pkg="rviz" type="rviz" />
```

  - Replace with

```
<node name="rviz" pkg="rviz" type="rviz" args="-d $(find
helloworld_pkg)/rviz/helloworld.rviz"/>
```

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URDF: launch file template for RVIZ

```
<launch>
<!-- USE: roslaunch my_package urdf_visualize.launch model' -->
  <arg name="model" default=""/>
  <param name="robot_description" command="$(find myrobot_package)
                                           /urdf/myrobot.urdf" />
   <!- if we want a second (clone robot) -->
   <param name="robot2_description" command="$(find myrobot_package)
                                           /urdf/myrobot.urdf" />
   <!- if you do not have previously defined, include a TF -->
   <node pkg="tf" type="static_transform_publisher" name=
                "world_frame" args="0 0 0 0 0 0 map base_link 100"/>
   <!- add all nodes you need -->
   <node name="node name" pkg="package name" type="file">
    <param name="param name" value="param value"/> </node>
    <!-- Show in Rviz   -->
    <node name="rviz" pkg="rviz" type="rviz" args="-d
                $(find my_package)/rviz_config/urdf.rviz"/>-->
</launch>
```

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Two links connected by a joint example

ROS

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URDF: example of two links connected by a joint

```
<?xml version="1.0"?>
<robot name="multipleshapes">
  <link name="base_link">
    <visual>
      <geometry>
        <cylinder length="0.6" radius="0.2"/>
      </geometry>
    </visual>
  </link>

  <link name="right_leg">
    <visual>
      <geometry>
        <box size="0.6 0.1 0.2"/>
      </geometry>
    </visual>
  </link>

  <joint name="base_to_right_leg" type="fixed">
    <parent link="base_link"/>
    <child link="right_leg"/>
  </joint>
</robot>
```

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URDF: example of two links connected by a joint

- Modify the launch file changing the TF node
  - Old line

```
<node pkg="tf" type="static_transform_publisher" name= "world_frame"
args="0 0 0 0 0 0 map base_link 100"/>
```

  - Replace with

```
<node name="joint_state_publisher" pkg="joint_state_publisher"
type="joint_state_publisher" />
<node name="robot_state_publisher" pkg="robot_state_publisher"
type="state_publisher" />
```

ROS

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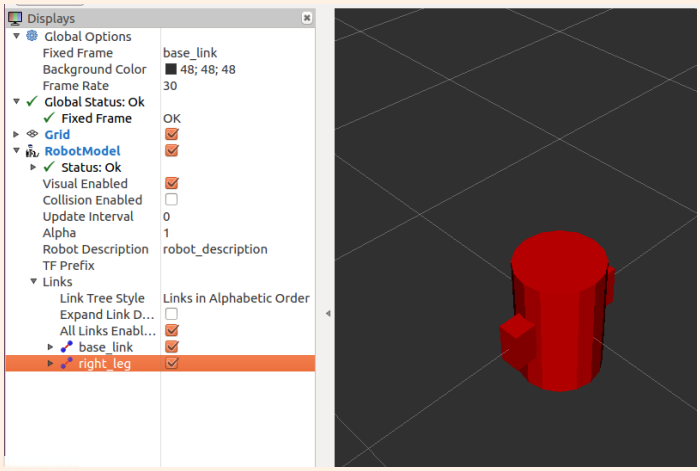
URDF: example of two links connected by a joint

- Now, the launch file will activate a node that will create all TF we need for all links/joint we have in our model



ROS

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URDF: simple 2 joints- adding origings

```
<?xml version="1.0"?>
<robot name="multipleshapes">
  <link name="base_link">
    <visual>
      <geometry>
        <cylinder length="0.6" radius="0.2"/>
      </geometry>
    </visual>
  </link>

  <link name="right_leg">
    <visual>
      <geometry>
        <box size="0.6 0.1 0.2"/>
      </geometry>
        <origin rpy="0 1.57075 0" xyz="0 0 -0.3"/>
      </visual>
  </link>

  <joint name="base_to_right_leg" type="fixed">
    <parent link="base_link"/>
    <child link="right_leg"/>
      <origin xyz="0 -0.22 0.25"/>
  </joint>

</robot>
```

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URDF: simple 2 joints- adding material

```
<?xml version="1.0"?>
<robot name="multipleshapes">
    <material name="blue">
      <color rgba="0 0 0.8 1"/>
    </material>
    <material name="white">
      <color rgba="1 1 1 1"/>
    </material>

   <link name="base_link">
    <visual>
      <geometry>
        <cylinder length="0.6" radius="0.2"/>
      </geometry>
      <material name="blue"/>
    </visual>
  </link>

…

</robot>
```

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URDF: R2D2_mobile

- Create the following launch file (r2d2_mobile.launch)

```
<launch>
  <param name="robot_description" textfile="$(find
helloworld_pkg)/urdf/r2d2_mobile.urdf" />

  <arg name="gui" default="False" />
  <param name="use_gui" value="$(arg gui)"/>

  <node name="joint_state_publisher" pkg="joint_state_publisher"
type="joint_state_publisher" />
  <node name="robot_state_publisher" pkg="robot_state_publisher"
type="state_publisher" />

  <node name="rviz" pkg="rviz" type="rviz" args="-d $(find
helloworld_pkg)/rviz/helloworld.rviz"/>
</launch>
```

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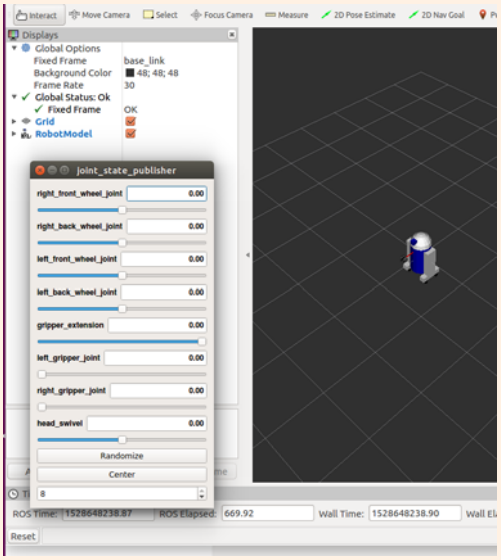
URDF: R2D2_mobile

- Copy the file R2D2_mobile.urdf in the urdf file of the helloworld_pkg
- Run the launch file

```
> roslaunch helloworld_pkg
r2d2_mobile.launch gui:=true
```



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URDF: R2D2_physics

- View open R2D2_mobile.urdf with gedit or notepad or notepad++ and identify all html tags corresponding to the link and joint definition
- Now→ physics and collition data
  - Check the file : R2D2_physics.urdf
  - Try it with `rviz`
- Use the urdf_to_graphiz tool

```
$ urdf_to_graphiz r2d2_physics.urdf
Created file physics.gv
Created file physics.pdf
```

- Open and see the generated pdf

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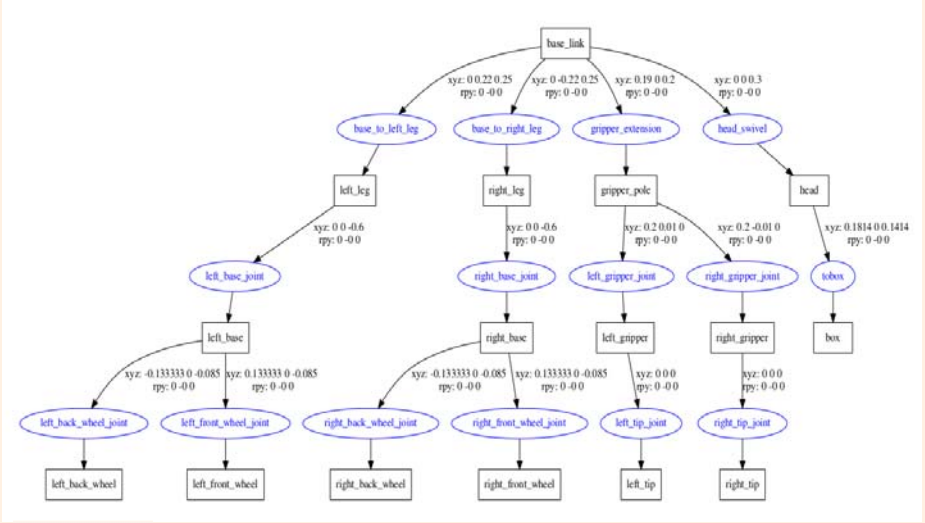
URDF: R2D2_physics graph



ROS

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Xacro files

ROS

xacro files

- The building of a URDF file involved lots of math calculations
- Instead of using URDF format→ use XACRO files
- In XACRO files, we can use:
  - Constants
  - Simple Math
  - Macros
- XACRO→ a macro language to create URDF files
- Working procedure:
  - Create a XACRO file
  - Convert the XACRO file to URDF

```
rosrun xacro xacro model.xacro > model.urdf
```

  - Use the automatically generated URDF

ROS

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XACRO files: launch file

- We can write the XACRO files and automatically translate them to URDF files → launch files
- Automatically generation of URDF files in a launch file → include the following line

```
<param name="robot_description" command="$(find
xacro)/xacro      '$(find
my_package)/urdf/my_robot_description.xacro'" />
```

- Compare to the old style if we use URDF directly

```
<param name="robot_description" textfile="$(find
my_package)/urdf/my_robot_description.urdf" />
```

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XACRO files: constants

XACRO file → URDF file

```
<xacro:property name="width" value="0.2" />
<xacro:property name="bodylen" value="0.6" />
<link name="base_link">
  <visual>
    <geometry>
      <cylinder radius="${width}"
length="${bodylen}"/>
    </geometry>
    <material name="blue"/>
  </visual>
  <collision>
    <geometry>
      <cylinder radius="${width}"
length="${bodylen}"/>
    </geometry>
  </collision>
</link>
```

```
<link name="base_link">
  <visual>
    <geometry>
      <cylinder length="0.6" radius="0.2"/>
    </geometry>
    <material name="blue"/>
  </visual>
  <collision>
    <geometry>
      <cylinder length="0.6" radius="0.2"/>
    </geometry>
  </collision>
</link>
```

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XACRO files: MATH

XACRO file → URDF file

```
<link name="${5/6}"/>
```

```
<link name="0.833333333333"/>
```

- We can do simple maths using constants

```
<cylinder radius="${wheeldiam/2}" length="0.1"/>
<origin xyz="${reflect*(width+.02)} 0 0.25" />
```

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XACRO files: PARAMETRIZED MACRO

XACRO file

```
<xacro:macro name="default_inertial"
params="mass">
    <inertial>
        <mass value="${mass}" />
        <inertia ixx="1.0" ixy="0.0" ixz="0.0"
            iyy="1.0" iyz="0.0"
            izz="1.0" />
    </inertial>
  </xacro:macro>
<xacro:default_inertial mass="10"/>
```

```
<origin rpy="4 5 6" xyz="1 2 3"/>
```

- BE CAREFUL: If the xacro with a specified name is not found, it will not be expanded and will NOT generate an error!
- In this example the paremeter is a simple number

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XACRO files: PARAMETRIZED MACRO

XACRO file

- But the paremeter can be block of code!

```
<xacro:macro name="blue_shape"
params="name *shape">
  <link name="${name}">
    <visual>
      <geometry>
        <xacro:insert_block name="shape" />
      </geometry>
      <material name="blue"/>
    </visual>
    <collision>
      <geometry>
        <xacro:insert_block name="shape" />
      </geometry>
    </collision>
  </link>
</xacro:macro>
<xacro:blue_shape name="base_link">
  <cylinder radius=".42" length=".01" />
</xacro:blue_shape>
```

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XACRO files: r2d2_macroed.urdf.xacro

- Check the file 04.r2d2_macroed.urdf.xacro
- Create a launch file to see it in rviz
- Execute the lauch file

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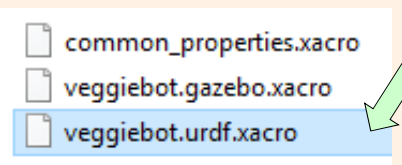
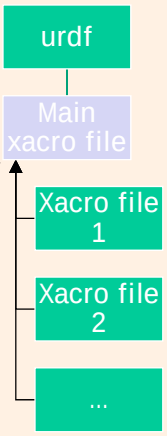
XACRO files: Veggiebot

- Xacro files are distributed in three files that combined → urdf
  - Common properties
    - Material properties
  - Gazebo
    - GAZEBO specific properties (contact models, gazebo plugins)
  - URDF
    - Main file includes the other two
    - With visual, collision and inertial fiel





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XACRO/URDF files: special tags for GAZEBO

- In a URDF/XACRO files we can use tags only understood by GAZEBO.
- These tags controls the properties of the physis engine and GAZEBO plubings.
- This must to be studied during the GAZEBO lecture.

ROS

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URDF:link contact coefficients

- To define how the links behave when they are in contact with one another.
- Typical scenario: wheels contacting the floor
- Three types
  - mu - The friction coefficient
  - kp - Stiffness coefficient
  - kd - Dampening coefficient

ROS

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