Gazebo with ROS

This tutorial is intended for roboticists that want to have realistic simulations of their robotic scenarios. Gazebo is a 3D simulator, while ROS serves as the interface for the robot. Both together result in a powerful combination of a robot simulator. With Gazebo you are able to create a 3D scenario on your computer with robots, obstacles and many other objects. Gazebo also uses a physical engine for illumination, gravity, inertia, etc.. You can evaluate and test your robot in difficult or dangerous scenarios without any harm to your robot. Additionally most of the time it is faster to run a simulator instead of starting the whole scenario on your real robot.

Originally Gazebo was designed to evaluate algorithms for robots. For many applications it is essential to test your robot application, like error handling, battery life, localization, navigation and grasping. As there was a need for a multi-robot simulator Gazebo was developed and improved.

-------> This Tutorial was tested with an Ubuntu 12.10 with ROS Hydro and Gazebo-1.9.

Sources

Sources for this tutorial can be found on GitHub at https://github.com/HumaRobotics/mybot_gazebo_tutorial

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Installation

For Gazebo there are also multiple options for installation. As I use an Ubuntu I selected the installation with precompiled binaries. Make sure you can launch "gzserver" and "gzclient" after the installation of Gazebo. Gazebo is split up in two parts. The server part computes all the physics and world, while the client is the graphical frontent for gazebo. So if you want to save performance on your computer you could also execute all tests without the graphical interface. Although it looks very nice, it consumes a lot of resources.

Your Gazebo should be installed in

```
/usr/bin/gzserver
/usb/bin/gzclient
```

or

```
/usr/local/bin/gzserver
/usr/local/bin/gzclient
```

if you installed Gazebo from sources.

After Gazebo and ROS have been installed it is time to install the bridge between them. With this bridge you can launch gazebo within ROS and dynamically add models to Gazebo. Depending on your Gazebo installation, there are different methods to continue.

If you have ROS Hydro you probably want to follow this guide to install the ROS Packages for Gazebo and look at the 'Install Pre-Built Debians' section.

If you do not have the ROS Version "Hydro" installed, you have to manually "git clone" the "gazebo_ros_pkgs". The git url can be found on http://www.ros.org/wiki/gazebo_ros_pkgs. If git is not installed:

```
sudo apt-get install git
```

If you have some missing depencencies, the following two packages may help

```
sudo apt-get install ros-hydro-pcl-conversions
sudo apt-get install ros-hydro-control-msgs
```

If the cmake_modules are missing, "git clone" them in the sources of your catkin directory.

```
git clone https://github.com/ros/cmake_modules
```

If everything worked you should be able to start Gazebo and ROS with (remember to source your environment):

```
roscore & rosrun gazebo_ros gazebo
```

You could also start them individually with gzserver and gzclient. If Gazebo is properly connected to ROS you should be able to the some published topics. Just type

```
rostopic list
```

in one of your favorite terminals to see, if there are some gazebo topics if the gzserver is running.

```
/gazebo/link_states
/gazebo/model_states
/gazebo/parameter_descriptions
/gazebo/parameter_updates
/gazebo/set_link_state
/gazebo/set_model_state
```

First Steps with Gazebo and ROS

You should have previously installed Gazebo and ROS. Now you are ready to discover the fascinating world of simulation. In this tutorial we are going to:

- setup a ROS workspace
- create projects for your simulated robot
- create a Gazebo world,
- create your own robot model,
- connect your robot model to ROS
- use a teleoperation node to control your robot
- add a camera to your robot
- use Rviz to vizualize all the robot information

Setup a new workspace

We'll assume that you start from scratch and need to create a new workspace for your project. Let's first source our ROS Hydro environment:

```
source /opt/ros/hydro/setup.bash
```

Now let's create the folder that will contain our workspace and the 'src' subfolder.

```
mkdir -p ~/catkin_ws/src
```

Go into the source and initialize the workspace:

```
cd ~/catkin_ws/src
```

```
catkin_init_workspace
```

Lets do a first build of your (empty) workspace just to generate the proper setup files

```
cd ..
```

```
catkin_make
```

From now on, each time we'll have to start ROS commands that imply using our packages, we'll have to source the workspace environment in each terminal:

```
source ~/catkin_ws/devel/setup.bash
```

Create projects for your simulated robot

Now that the workspace is ready, we're going to create projects for our robot. Make sure you've sourced your workspace environment and go into the 'src' subfolder:

```
cd ~/catkin_ws/src
```

There create a package with the name "turtlebot_gazebo" and the two dependencies "roscpp" and "gazebo_ros":

```
catkin_create_pkg turtlebot_gazebo roscpp gazebo_ros
```

We name it turtlebot and gazebo as the ros package is for turtlebot and gazebo. Catkin now created a new package file for you to be able to be found by roscd.

Now we move in this directory and create all directories we require for this tutorial.

```
cd turtlebot_gazebo
mkdir launch src worlds
```

Check if your sources of gazebo and catkin are setup correctly. The easiest way to not enter the following lines in all terminals, is to enter them into your .bashrc file in your home directory. Type:

```
echo source /usr/share/gazebo/setup.sh >> ~/.bashrc
echo source ~/catkin_ws/devel/setup.bash >> ~/.bashrc
```

Creating your own World

At first we want to create a world for our gazebo server. Therefore we switch to our worlds directory of our turtlebot project and create a new world file.

```
cd worlds
gedit turtleworld.world
```

A basic world file contains the xml standard, the model version and the world name. It looks like

```
<?xml version="1.0"?>
<sdf version="1.4">
  <world name="turtleworld">
  </world>
</sdf>
```

Here you could directly add models and object with their position. Also the laws of physics may defined in a world. This is an important step to understand, because in this file you could also attach a specific plugin to an object. The plugin itself contains ros and gazebo specific code for more complex behaviors.

At first we just want to add some basic objects, like a ground and a basic illumination source inside the world tags.

```
<include>
  <uri>model://sun</uri>
</include>
<include>
  <uri>model://ground_plane</uri>
</include>
```

Check your "~/.gazebo/models" directory, as this is a default path for saved models. If this path does not exist try to find

`/usr/share/gazebo/setup.sh`where gazebo looks for models. Otherwise add it to your model path.

As the ground plane and the sun are basic models that are also on the gazebo server and downloaded on startup, if they cannot be found locally. If you want to know which object are available on the gazebo server, take a look at Gazebo model database. To start the gazebo server there are several methods. As it is a good practice to use a launch file, we will create one now. This could later also be used for multiple nodes.

Change to the launch directory of your project:

```
roscd turtlebot_gazebo/launch
```

Create a new file:

```
gedit turtlebot_interface.launch
```

and insert:

```
<launch>
  <node name="gzserver" type="gzserver" pkg="gazebo_ros" args="$(find turtlebot_gazebo)/worlds/turtleworld.world"/>
  <node name="gzclient" type="gzclient" pkg="gazebo_ros"/>
</launch>
```

Now you can easily start your project with:

```
roslaunch turtlebot_gazebo turtlebot_interface.launch
```

Now you should see the gazebo server and the gui starting with a world that contains a ground plane and a sun (which is not obviously visible without objects). If not, it can be that there are some connections problems with the server. If that happens, start gazebo without the launch file, go to the models, you should find the one you want in the server. Click on them, they will be put in the cache. Now, if you close gazebo and start it again with the launch file, it should work.

If you would press "Save world as" in "File" in your gazebo client and save the world in a text file, you could investigate the full world description.

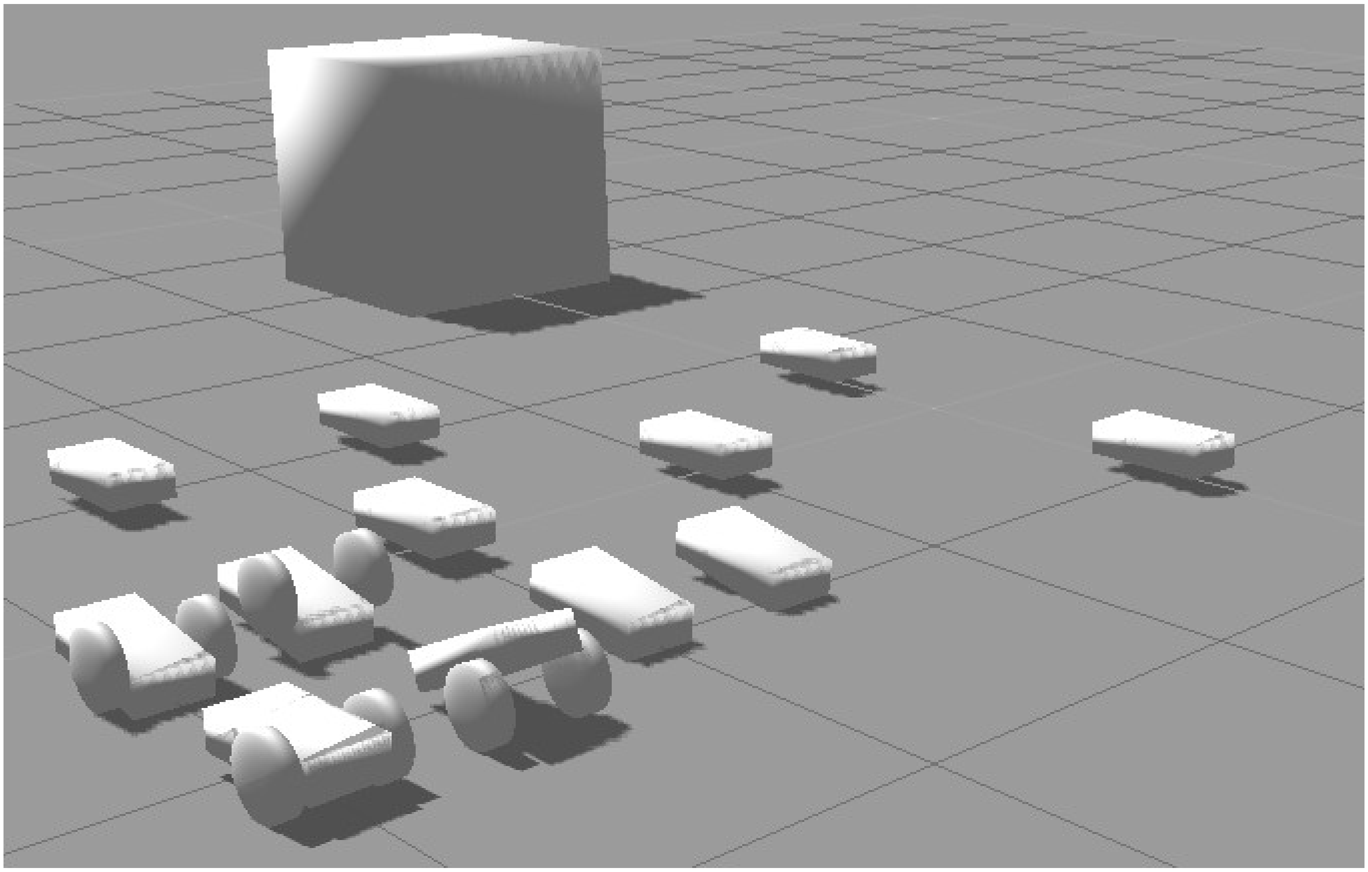
If you want to watch a more complex and beautiful world environment then add the following inside your world tag:

```
<include>
  <uri>model://willowgarage</uri>
</include>
```

This one shows you the office of willow garage.

Creating your own Model

The more accurate you want to model your robot the more time you need to spend on the design. In the next image you see a developing process of a robot model, from a simple cube to a differential drive robot. You can also check the ROS tutorial about the rrbot.



For a working robot model you require at least one or two files.

We could put our model in the model sub-directory of the gazebo directory. This is the standard way when you work only with gazebo.

However, we will use an urdf file associated with xacro. The Universal Robotic Description Format (URDF) is an XML file format used in ROS as the native format to describe all elements of a robot. Xacro (XML Macros) Xacro is an XML macro language. It is very useful to make shorter and clearer urdf files. Working with both ROS and Gazebo, a common way to organize files is to make a ROS-Project called by the name of your robot and add some catkin packages in it: {the name of your model}_descritpion and {the name of your model}_gazebo. The first one will contain the model and the second will be used to start a gazebo world with your model in it. But that's a story for later.

For now got to the source directory of your catkin work directory. Assuming your working directory is in your home directory and that its name is « catkin_ws », the command should be :

```
cd ~/catkin_ws/src
```

There create a directory for your robot. You can name it as you want, mine is named mybot :

```
mkdir mybot
cd mybot
```

Create a catkin package that will contain the description of your model :

```
catkin_create_pkg mybot_description
```

as we will need to come back here, it is useful to catkin_make in your catkin work directory in order to be able to use the “roscd mybot_description” command to move directly to that directory. In it, create a urdf directory :

```
 mkdir urdf
cd urdf
```

You could describe your model in a single file. A good side of xacro is that you can include other files. This make the model description clearer, especially when the model is complex.

Xacro Concepts

- **xacro:include**: Import the content from other file. We can divide the content in different xacros and re-unite it again using xacro:include.
- **property**: Useful to define constant values. Use it later using `${property_name}`
- **xacro:macro**: Macro with variable values. Later, we can use this macro from another xacro file, and we specify the required value for the variables. To use a macro, you have to include the file where the macro is, and call it using the macro's name and filling the required values.

We will call the main file “mybot.xacro” after the name of our model :

```
gedit mybot.xacro
```

Create a basic

```
<?xml version="1.0"?>
<robot name="mybot" xmlns:xacro="http://www.ros.org/wiki/xacro">
        <!-- Put here the robot description -->
</robot>
```

The structure is basic for a urdf file. The complete description (links, joints, transmission...) have to be within the robot tag. The “`xmlns:xacro="http://www.ros.org/wiki/xacro"`” specifies that this file will use xacro. If you want to use xacro you have to put this.

With xacro, you can define parameters. Once again, this make the file clearer. They are usually put at the beginning of the file (within the robot tag, of course).

We will use many parameters :

```
  <xacro:property name="PI" value="3.1415926535897931"/>

 <xacro:property name="chassisHeight" value="0.1"/>
  <xacro:property name="chassisLength" value="0.4"/>
  <xacro:property name="chassisWidth" value="0.2"/>
  <xacro:property name="chassisMass" value="50"/>

  <xacro:property name="casterRadius" value="0.05"/>
  <xacro:property name="casterMass" value="5"/>

  <xacro:property name="wheelWidth" value="0.05"/>
  <xacro:property name="wheelRadius" value="0.1"/>
  <xacro:property name="wheelPos" value="0.2"/>
  <xacro:property name="wheelMass" value="5"/>

  <xacro:property name="cameraSize" value="0.05"/>
```

```
  <xacro:property name="cameraMass" value="0.1"/>
```

These parameters or properties can be used in all the file with ${property name}.

We will also include three files :

```
 <xacro:include filename="$(find mybot_description)/urdf/mybot.gazebo" />
 <xacro:include filename="$(find mybot_description)/urdf/materials.xacro" />
 <xacro:include filename="$(find mybot_description)/urdf/macros.xacro" />
```

You must have make your ROS package in order for this lines to work. In the ".gazebo" file, we will put every gazebo tags. More information about this tag can be found here. "materials.xacro" is a simple Rviz colors file for storing rgba values. And finally, we will put macros in the last file to make the main file clearer. Every file has to contain the robot tag and everything we put in them should be in this tag.

Now we want to add a rectangular base for our robot. Insert this withing the robot tag.

```
<link name='chassis'>
  <collision>
    <origin xyz="0 0 ${wheelRadius}" rpy="0 0 0"/>
    <geometry>
      <box size="${chassisLength} ${chassisWidth} ${chassisHeight}"/>
    </geometry>
  </collision>
  <visual>
    <origin xyz="0 0 ${wheelRadius}" rpy="0 0 0"/>
    <geometry>
      <box size="${chassisLength} ${chassisWidth} ${chassisHeight}"/>
    </geometry>
    <material name="orange"/>
  </visual>
  <inertial>
    <origin xyz="0 0 ${wheelRadius}" rpy="0 0 0"/>
    <mass value="${chassisMass}"/>
    <box_inertia m="${chassisMass}" x="${chassisLength}" y="${chassisWidth}" z="$
     {chassisHeight}"/>
  </inertial>
</link>
```

We added box with `chassisLength` x `chassisWidth` x `chassisHeight` meters. As you can see, we have three tags for this one box, where one is used to the collision detection engine, one to the visual rendering engine and the last to the physic engine. Most of the time they are the same, except when you have complicated and beautiful visual meshes. As they don't need to be that complicated for collision detection you could use a simple model for the collision. The material element in the visual tag refer to a color that must be defined in the materials.xacro and refred to in the mybot.gazebo file, at least, in the structure we adopted.

Add this in "mybot.gazebo", within the robot tag :

```
<gazebo reference="chassis">
  <material>Gazebo/Orange</material>
</gazebo>
```

And this in the "materials.xacro" :

```
<material name="black">
```

```
  <color rgba="0.0 0.0 0.0 1.0"/>
</material>

<material name="blue">
  <color rgba="0.0 0.0 0.8 1.0"/>
</material>

<material name="green">
  <color rgba="0.0 0.8 0.0 1.0"/>
</material>

<material name="grey">
  <color rgba="0.2 0.2 0.2 1.0"/>
</material>

<material name="orange">
  <color rgba="${255/255} ${108/255} ${10/255} 1.0"/>
</material>

<material name="brown">
  <color rgba="${222/255} ${207/255} ${195/255} 1.0"/>
</material>

<material name="red">
  <color rgba="0.8 0.0 0.0 1.0"/>
</material>

<material name="white">
  <color rgba="1.0 1.0 1.0 1.0"/>
</material>
```

As you can see, we add more that the color we wanted, this is for convenience. Now, we can leave this file alone and use any color we want.

Another particular thing in the chassis link is the use of “box_inertia” in the inertial tag. This is a macro made with xacro. As you can see, when you use a macro, you can simply use the tag and specifies the parameters. Xacro will understand.

Add this in the macros.xacro file, within the robot tag :

```
<macro name="cylinder_inertia" params="m r h">
  <inertia  ixx="${m*(3*r*r+h*h)/12}" ixy = "0" ixz = "0"
    iyy="${m*(3*r*r+h*h)/12}" iyz = "0"
    izz="${m*r*r/2}"
  />
</macro>

<macro name="box_inertia" params="m x y z">
  <inertia  ixx="${m*(y*y+z*z)/12}" ixy = "0" ixz = "0"
    iyy="${m*(x*x+z*z)/12}" iyz = "0"
    izz="${m*(x*x+z*z)/12}"
  />
</macro>

<macro name="sphere_inertia" params="m r">
  <inertia  ixx="${2*m*r*r/5}" ixy = "0" ixz = "0"
    iyy="${2*m*r*r/5}" iyz = "0"
    izz="${2*m*r*r/5}"
  />
```

```
</macro>
```

Once again, we add more than we needed. We will use the others later. The inertia tag is a convention of the inertial tag in a link.

We have two small things to do before testing our model with gazebo.

The physic engine does not accept a base_link with inertia. It is then useful to add a simple link without inertia and make a joint between it and the chassis. Add this before the chassis link in the main file :

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

<joint name="base_joint" type="fixed">
  <parent link="footprint"/>
  <child link="chassis"/>
</joint>
```

In order to start gazebo with our model, we will use a launch file. In the mybot directory in your catkin workspace, create a new catkin package named “mybot_gazebo” with a dependency to gazebo. Make this package (catkin_make) and add a launch directory in it. In this directory, create a launch file, by convention, let's name it “mybot_gazebo.launch”. In this file, add this :

```
<launch>
  <!-- roslaunch arguments -->
  <arg name="paused" default="false"/>
  <arg name="debug" default="false"/>
  <arg name="gui" default="true"/>

  <include file="$(find gazebo_ros)/launch/empty_world.launch">
    <arg name="world_name" value="worlds/empty.world" />
    <arg name="paused" value="$(arg paused)" />
    <arg name="debug" value="$(arg debug)" />
    <arg name="gui" value="$(arg gui)" />
    <arg name="use_sim_time" value="true" />
    <arg name="headless" value="false" />
  </include>

<!-- urdf xml robot description loaded on the Parameter Server, converting the
xacro into a proper urdf file-->
  <param name="robot_description" command="$(find xacro)/xacro.py '$(find
mybot_description)/urdf/mybot.xacro'" />

  <!-- push robot_description to factory and spawn robot in gazebo -->
  <node name="mybot_spawn" pkg="gazebo_ros" type="spawn_model" output="screen"
    args="-urdf -param robot_description -model mybot" />
</launch>
```

If you launch your project with this launch file, the gazebo client opens and the the chassis should be there. It should also fall because of the physic engine.

As a next step we add a caster wheel to the robot. This is the simplest wheel as we have no axis and no friction. We can simply approximate the caster wheel with a ball. Add this after the chassis link in the main urdf file :

```
<joint name="fixed" type="fixed">
  <parent link="chassis"/>
  <child link="caster_wheel"/>
```

```
</joint>

<link name="caster_wheel">
  <collision>
    <origin xyz="${casterRadius-chassisLength/2} 0 ${casterRadius-
chassisHeight+wheelRadius}" rpy="0 0 0"/>
    <geometry>
      <sphere radius="${casterRadius}"/>
    </geometry>
  </collision>

  <visual>
    <origin xyz="${casterRadius-chassisLength/2} 0 ${casterRadius-
chassisHeight+wheelRadius}" rpy="0 0 0"/>
    <geometry>
      <sphere radius="${casterRadius}"/>
    </geometry>
    <material name="red"/>
  </visual>

  <inertial>
    <origin xyz="${casterRadius-chassisLength/2} 0 ${casterRadius-
chassisHeight+wheelRadius}" rpy="0 0 0"/>
    <mass value="${casterMass}"/>
    <sphere_inertia m="${casterMass}" r="${casterRadius}"/>
  </inertial>
</link>
```

We attach this caster wheel to the chassis with a fixed joint. The two links will then always move together. We use the sphere_inertia macro we added earlier in the macros.xacro file. Also add a gazebo tag in the gazebo file for this link :

```
<gazebo reference="caster_wheel">
  <mu1>0.0</mu1>
  <mu2>0.0</mu2>
  <material>Gazebo/Red</material>
</gazebo>
```

As usual, we specify the color used in material. We also added mu1 and mu2, with value 0 to remove the friction.

At least we want to add some wheels to the robot. We could add the two links in the main file. Let's make a macro to make it simple. In the macro file, add this :

```
<macro name="wheel" params="lr tY">

<link name="${lr}_wheel">
  <collision>
    <origin xyz="0 0 0" rpy="0 ${PI/2} ${PI/2}" />
    <geometry>
      <cylinder length="${wheelWidth}" radius="${wheelRadius}"/>
    </geometry>
  </collision>

  <visual>
    <origin xyz="0 0 0" rpy="0 ${PI/2} ${PI/2}" />
```

```
    <geometry>
      <cylinder length="${wheelWidth}" radius="${wheelRadius}"/>
    </geometry>
    <material name="black"/>
  </visual>

  <inertial>
    <origin xyz="0 0 0" rpy="0 ${PI/2} ${PI/2}" />
    <mass value="${wheelMass}"/>
    <cylinder_inertia m="${wheelMass}" r="${wheelRadius}" h="${wheelWidth}"/>
  </inertial>
</link>

<gazebo reference="${lr}_wheel">
  <mu1 value="1.0"/>
  <mu2 value="1.0"/>
  <kp  value="10000000.0" />
  <kd  value="1.0" />
  <fdir1 value="1 0 0"/>
  <material>Gazebo/Black</material>
</gazebo>


<joint name="${lr}_wheel_hinge" type="continuous">
  <parent link="chassis"/>
  <child link="${lr}_wheel"/>
  <origin xyz="${-wheelPos+chassisLength/2} ${tY*wheelWidth/2+tY*chassisWidth/2}
${wheelRadius}" rpy="0 0 0" />
  <axis xyz="0 1 0" rpy="0 0 0" />
  <limit effort="100" velocity="100"/>
  <joint_properties damping="0.0" friction="0.0"/>
</joint>


<transmission name="${lr}_trans">
  <type>transmission_interface/SimpleTransmission</type>
  <joint name="${lr}_wheel_hinge"/>
  <actuator name="${lr}Motor">
    <hardwareInterface>EffortJointInterface</hardwareInterface>
    <mechanicalReduction>10</mechanicalReduction>
  </actuator>
</transmission>

</macro>
```

The parameters allows us to specify which wheel we are talking about. “lr” could have two values (left or right) and “tY”, for translation along the Y-axis, also (respectively 1 and -1). There is nothing new concerning the link part. The gazebo tag is inserted here so that we don't need to worry about it every time we add a wheel. This macro is thus self-sufficient. The joint type is continuous. This allows a rotation around one axis. This axis is y <xyz>0 1 0</xyz> and connect each wheel to the chassis of your robot.

What's new is the transmission element. To use ros_control with your robot, you need to add some additional elements to your URDF. The `<transmission>` element is used to link actuators to joints, see the <transmission> spec for exact XML format. In addition to the transmission tags, a Gazebo plugin needs to be added to your URDF that actually parses the transmission tags and loads the appropriate hardware interfaces and controller manager. Add it to the gazebo file :

```
<gazebo>
```

```
  <plugin name="gazebo_ros_control" filename="libgazebo_ros_control.so">
    <robotNamespace>/mybot</robotNamespace>
  </plugin>
</gazebo>
```

Look at this tutorial for more information.

Now you can add the wheels to the main file :

```
<wheel lr="left" tY="1"/>
<wheel lr="right" tY="-1"/>
```

As you see, the macro make it very simple.

Yeahhh, the robot model is finished now. Start gazebo using the launch file that we previously created and the whole model should appear.

Plugins

Plugins are extensions for your Gazebo simulation and add additional functionality, which is not possible in the GUI. For the There are different types of plugins:

- World: Dynamic changes to the world, e.g. Physics, like illumination or gravity, inserting models
- Model: Manipulation of models (robots), e.g. move the robots
- Sensor: Feedback from virtual sensor, like camera, laser scanner
- System: Plugins that are loaded by the GUI, like saving images

Let's use a sensor plugin and a control plugin. We will be able to move the robot around and get the feedback from it's virtual camera.

Sensor Plugin: Camera

This plugin should give us a camera view of the robot. If you already created some environment, you can now what it is, with the eyes of your robot. As the turtlebot has a kinect, we are using its RGB camera.

For this plugin we are using an already existing library, called "libgazebo_ros_camera.so", which is located in "~/catkin_ws/devel/lib" or "~/catkin_ws/install/lib". You have to add a camera to your robot model. For that, two things are necessary, a link and the actual plugin.

Add the link to your main model file :

```
<link name="camera">
  <collision>
    <origin xyz="0 0 0" rpy="0 0 0"/>
    <geometry>
      <box size="${cameraSize} ${cameraSize} ${cameraSize}"/>
    </geometry>
  </collision>

  <visual>
    <origin xyz="0 0 0" rpy="0 0 0"/>
    <geometry>
      <box size="${cameraSize} ${cameraSize} ${cameraSize}"/>
    </geometry>
    <material name="blue"/>
  </visual>
```

```
  <inertial>
    <mass value="${cameraMass}" />
    <origin xyz="0 0 0" rpy="0 0 0"/>
    <box_inertia m="${cameraMass}" x="${cameraSize}" y="${cameraSize}" z="$
{cameraSize}" />
  </inertial>
</link>
```

And the plugin to the gazebo file:

```
<gazebo reference="camera">
  <material>Gazebo/Blue</material>
  <sensor type="camera" name="camera1">
    <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>0.0</updateRate>
      <cameraName>mybot/camera1</cameraName>
      <imageTopicName>image_raw</imageTopicName>
      <cameraInfoTopicName>camera_info</cameraInfoTopicName>
      <frameName>camera_link</frameName>
      <hackBaseline>0.07</hackBaseline>
      <distortionK1>0.0</distortionK1>
      <distortionK2>0.0</distortionK2>
      <distortionK3>0.0</distortionK3>
      <distortionT1>0.0</distortionT1>
      <distortionT2>0.0</distortionT2>
    </plugin>
  </sensor>
 </gazebo>
```

To visualize the robots camera, which is sending ROS images, as a real camera would do it, you can now simply subscribe to the published image by one line in the command line:

```
rosrun image_view image_view image:=/mybot/camera1/image_raw
```

Control the robot

With this plugin, we will be able to move the robot around. The ros_control plugin is already here for that but all it is doing is create the ROS-topics for the actuators (linked to the joints by the transmission tags) to be commanded, either in position, in velocity or in effort.

Create a new catkin package called “mybot_control” in the “mybot” directory within your catkin workspace. It will include the configuration file need to control the model and also the launch file useful to launch the controller. A little catkin_make is welcome here. In this package, create a launch folder and a config folder.

The PID gains and controller settings must be saved in a yaml file that gets loaded to the param server via the roslaunch file. In the config folder , create a yaml file called whatever, I called mine “mybot_control.yaml”. Add this in it :

```
mybot:
  # Publish all joint states -----------------------------------
  joint_state_controller:
    type: joint_state_controller/JointStateController
    publish_rate: 50


  # Effort Controllers ---------------------------------------
  leftWheel_effort_controller:
    type: effort_controllers/JointEffortController
    joint: left_wheel_hinge
    pid: {p: 100.0, i: 0.1, d: 10.0}
  rightWheel_effort_controller:
    type: effort_controllers/JointEffortController
    joint: right_wheel_hinge
    pid: {p: 100.0, i: 0.1, d: 10.0}
```

Create a launch file in the launch folder :

```
<launch>

  <!-- Load joint controller configurations from YAML file to parameter server
-->
  <rosparam file="$(find mybot_control)/config/mybot_control.yaml"
command="load"/>

  <!-- load the controllers -->
  <node name="controller_spawner"
    pkg="controller_manager"
    type="spawner" respawn="false"
    output="screen" ns="/mybot"
    args="joint_state_controller
      rightWheel_effort_controller
      leftWheel_effort_controller"
  />


  <!-- convert joint states to TF transforms for rviz, etc -->
  <node name="robot_state_publisher" pkg="robot_state_publisher"
type="robot_state_publisher" respawn="false" output="screen">
    <param name="robot_description" command="$(find xacro)/xacro.py '$(find
mybot_description)/urdf/mybot.xacro'" />
    <remap from="/joint_states" to="/mybot/joint_states" />
  </node>

</launch>
```

We could launch our model on gazebo and then the controller, let's add a line to the “mybot_world.launch” in the mybot_gazebo package to launch the controller and gazebo at the same time :

```
<!-- ros_control mybot launch file -->
<include file="$(find mybot_control)/launch/mybot_control.launch" />
```

Now launch gazebo using this launch file. Your model should be there. And that's it. The controller is waiting for instructions.

You can manually send command :

```
rostopic pub -1 /mybot/leftWheel_effort_controller/command std_msgs/Float64 "data:
1.5"
rostopic pub -1 /mybot/rightWheel_effort_controller/command std_msgs/Float64
"data: 1.0"
```

The robot should start moving. As you can see, this can be difficult to control the robot this way. Let's had some plugin to make it easier. Add this in the gazebo file of your model :

```
<gazebo>
  <plugin name="differential_drive_controller"
filename="libgazebo_ros_diff_drive.so">
    <alwaysOn>true</alwaysOn>
    <updateRate>100</updateRate>
    <leftJoint>left_wheel_hinge</leftJoint>
    <rightJoint>right_wheel_hinge</rightJoint>
    <wheelSeparation>${chassisWidth+wheelWidth}</wheelSeparation>
    <wheelDiameter>${2*wheelRadius}</wheelDiameter>
    <torque>20</torque>
    <commandTopic>mybot/cmd_vel</commandTopic>
    <odometryTopic>mybot/odom_diffdrive</odometryTopic>
    <odometryFrame>odom</odometryFrame>
    <robotBaseFrame>footprint</robotBaseFrame>
  </plugin>
</gazebo>
```

This plugin to the topic specified within the « commandTopic » tag and convert it to the proper commands on the wheels.

Now, you can start gazebo with the usual launch file.

You can control your robot with the keybord through the keybord controller of the turtlesim. We just have to change on which topic it is publishing :

```
rosrun turtlesim turtle_teleop_key /turtle1/cmd_vel:=/mybot/cmd_vel
```

Enjoy the ride !