ECE 5463 Introduction to Robotics
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ROS
TUTORIAL 2

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Tutorial 2 Outline

- **ROS Graph**
- **ROS Services and Parameters**
  - Turtlesim – service application (spawn a new turtle)
- **Installing ROS Packages**
  - Using apt manager
  - Cloning from repository
- **Gazebo**
  - Introduction - Installation
  - Testing – Kinematic and Dynamic Simulation
  - Understanding Gazebo – ROS Filesystem
  - URDF – XACRO files

rqt_graph

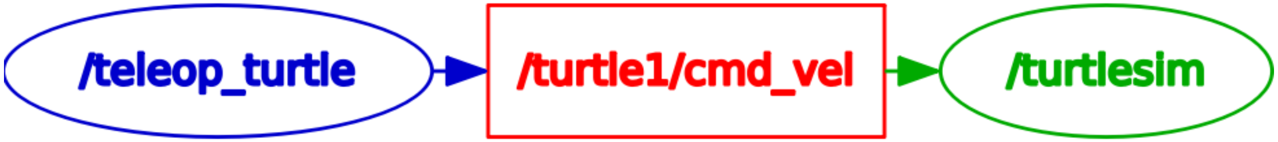
- rqt_graph is a useful tool that provides a GUI plugin for visualizing the ROS computation graph. Namely, it creates a dynamic graph of what's going on in the system (i.e. the ROS nodes that are currently running, as well as the ROS topics that connect them)
- Its components are made generic so that other packages where you want to achieve graph representation can depend upon it.
- Command:

```
rosrun rqt_graph rqt_graph
```

rqt_graph – example

Turtlesim simulation

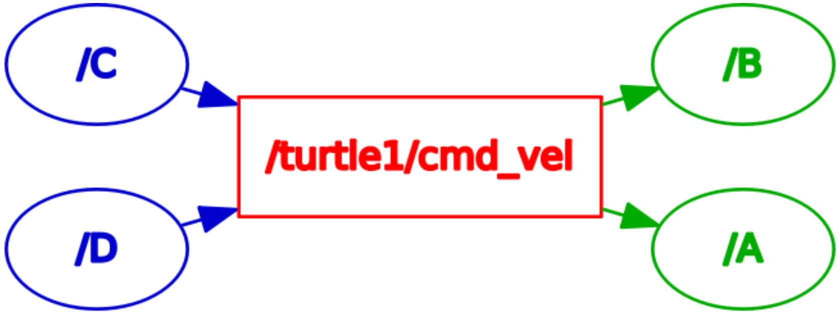
```
$ roscore
$ rosrun turtlesim turtlesim_node
$ rosrun rqt_graph rqt_graph
$ rosrun turtlesim turtle_teleop_key
```



rqt_graph – example

Turtlesim application

```
$ rosrun turtlesim turtlesim_node __name:=A
$ rosrun turtlesim turtlesim_node __name:=B
$ rosrun turtlesim turtle_teleop_key __name:=C
$ rosrun turtlesim turtle_teleop_key __name:=D
```



Services

- ROS supports the concept of "remote procedure call" (in contrast to local function call), in the form of ROS services. With ROS services, calling a function in another node is as easy as calling local functions.
- One time actions. Use services when your program can't continue until it receives the result from the service.

```
rosservice list      print information about active services
rosservice call      call the service with the provided args
rosservice type      print service type
```

```
$ rosservice list
$ rosservice type [service] | rossrv show
$ rosservice [service] [args]
```

Parameters

- rosparam allows you to store and manipulate data on the ROS Parameter Server. The Parameter Server can store integers, floats, boolean, dictionaries, and lists.

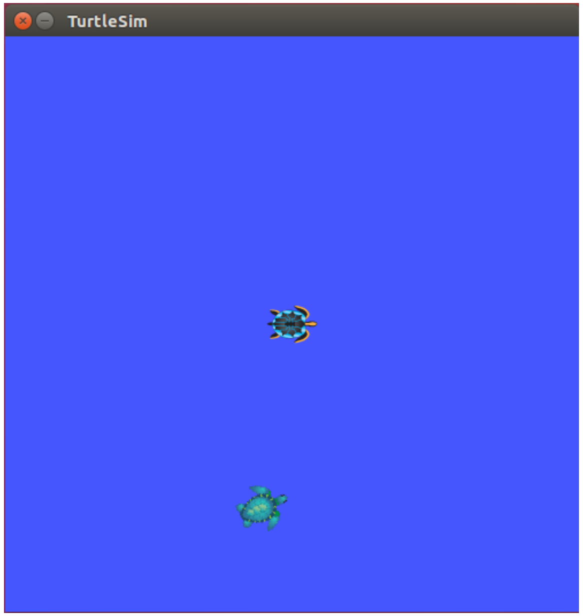
```
rosparam list           list parameter names
rosparam set            set parameter
rosparam get            get parameter
rosparam delete         delete parameter
```

```
$ rosparam list
$ rosparam set [param_name]
$ rosparam get [param_name]
```

Application on Turtlesim

Spawn a new turtle:

```
$ rosservice list
$ rosservice type /spawn | rossrv show
$ rosservice call /spawn 2 7 0.2 "turtle_tutorial"
```



Recall: What is a package?

- All the files that a specific ROS program contains; all its cpp files, python files, configuration files, compilation files, launch files, and parameters files.

- Generally all those files in the package are organized with the following structure:
  - **launch** folder: Contains launch files
  - **src** folder: Source files (cpp, python)
  - **CMakeLists.txt**: List of cmake rules for compilation
  - **package.xml**: Package information and dependencies

Not always

Installing ROS package

Using Ubuntu´s package manager

- The **apt-get** command is a powerful command-line tool, which works with Ubuntu's Advanced Packaging Tool (APT) performing such functions as downloading and installation of new software packages, updating, etc.
- This method is used for installing released ROS packages (packages verified by ROS developers) and install the package’s necessary dependencies.
- Command:

```
sudo apt-get install ros-<ros_distro>-<package-name>
```

•Example

```
sudo apt-get install ros-kinetic-urdf
```

Installing ROS package

Installing from source code

- If the package is not released, you will need to install it from source code. Find out where the code is hosted (mostly github), **and install the package in the src folder from your workspace directory** `(~/catkin_ws/src)`

https://github.com/ros/urdf, https://github.com/ROBOTIS-GIT/turtlebot3

- Command:

```
git clone <address> / git clone -b <branch> <address>
```

- Example:

```
$ cd ~/catkin_ws/src
$ git clone -b kinetic-devel https://github.com/ros/urdf.git
$ git clone https://github.com/ROBOTIS-GIT/turtlebot3
$ cd ~/catkin_ws
$ catkin_make
```

Installing ROS package

Installing from source code

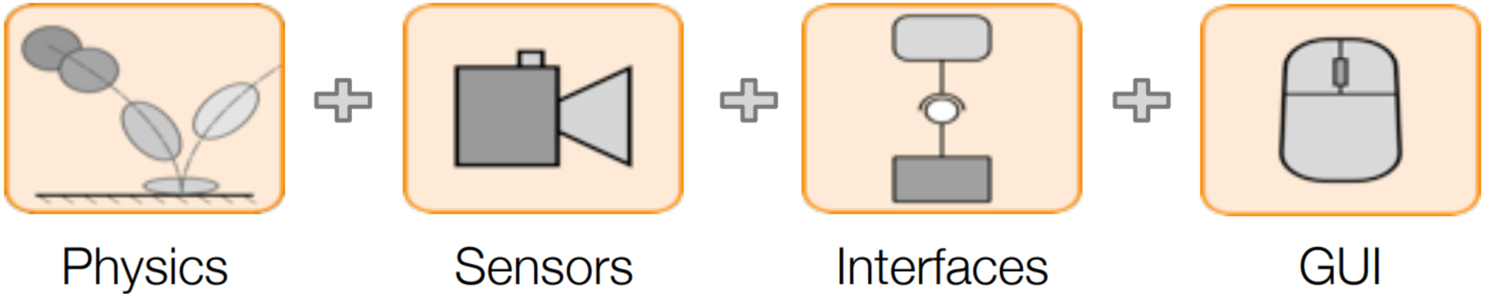
- Problem: You have to take care of the dependencies by yourself.
- Whenever you see "Could not find a configuration file for package <package_name>" it means this package is missing and is needed for compiling your code.
- Possible solution: Use **rosdep** command, which will automatically try to find all the dependencies of your package and install them.

IMPORTANT NOTE

- Sometimes the `<package-name> or <address>` arguments correspond to a directory which contains more than one package.

Gazebo simulator

- Goal: Best possible substitute for physical robot
- Architecture



- Advantages
  - Design and testing of robot's components and control
  - Software testing and verification (controllers)
  - Save time and money
- Installation : Built-in along with the ROS desktop-full.

Testing Gazebo

- Gazebo runs two executables: Gazebo server (simulation process) and Gazebo client (Gazebo GUI)

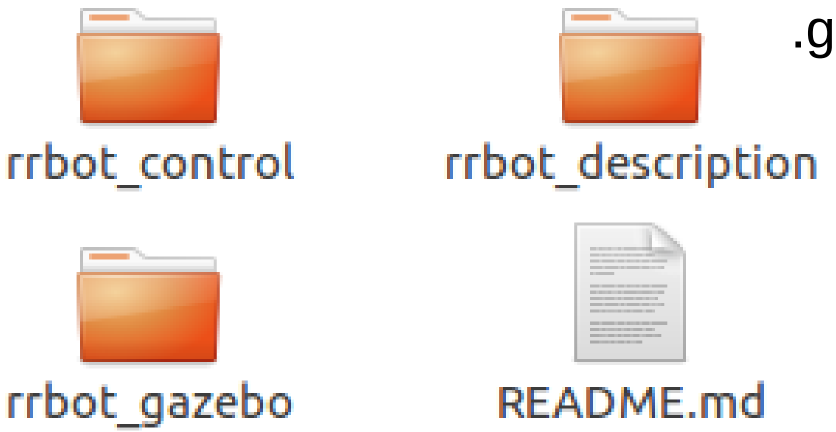
```
gazebo
```

- Add a square block and a sphere using the upper tool bar
- Right click on the sphere
- Select Apply Force/Torque
- Choose a value for the torque and force and select apply.
- Observe kinematics and dynamics simulation

Understanding ROS-Gazebo Filesystem

Controllers
.yaml files

Robot modelling
.urdf, .xacro,
.gazebo files

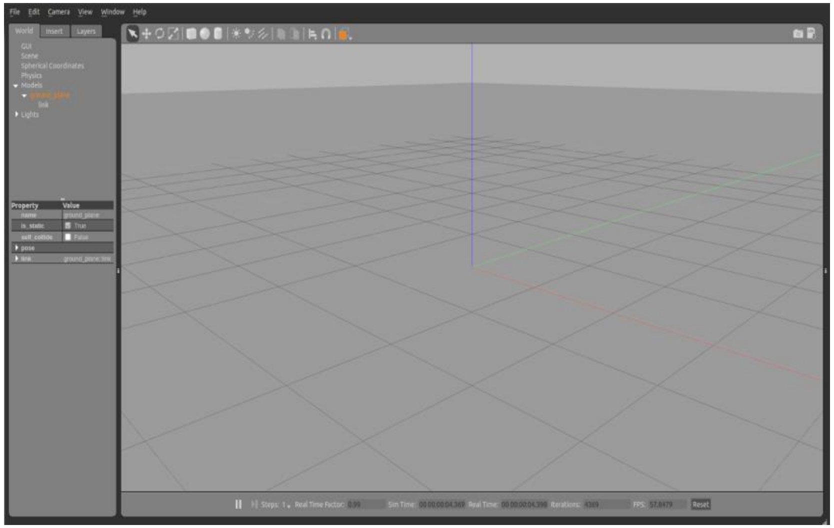


Simulation
Environment
.world files

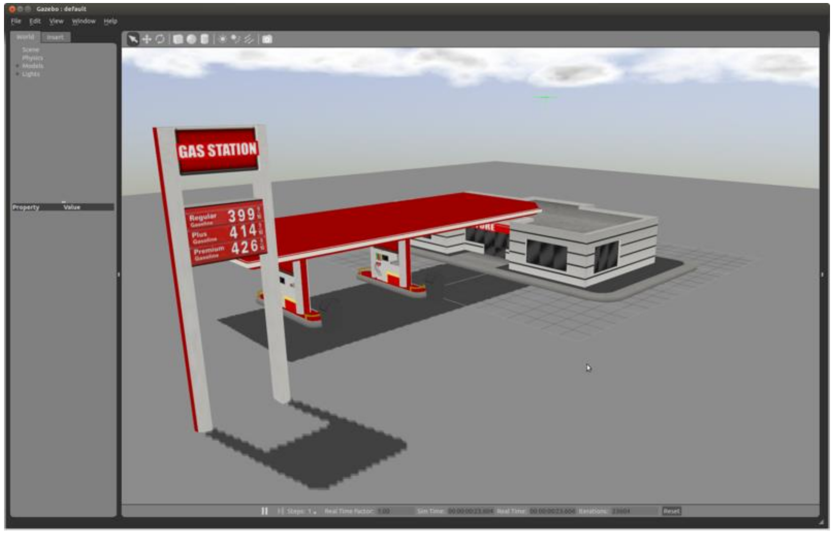
Notice that each one of this folders is a different package and usually they are located inside the robot’s name folder. Packages’ names are recommended but not mandatory.

World

```
<?xml version="1.0" ?>
<sdf version="1.4">
  <world name="default">
    <include>
      <uri>model://ground_plane</uri>
    </include>
    <!-- Global light source -->
    <include>
      <uri>model://sun</uri>
    </include>
  </world>
</sdf>
```



```
<?xml version="1.0" ?>
<sdf version="1.4">
  <world name="default">
    <include>
      <uri>model://ground_plane</uri>
    </include>
    <!-- Global light source -->
    <include>
      <uri>model://sun</uri>
    </include>
    <!-- Include model of gas station-->
    <include>
      <uri>model://gas_station</uri>
      <name>gas_station</name>
      <pose>-2.0 7.0 0 0 0 0</pose>
    </include>
  </world>
</sdf>
```



URDF - XACRO files (XML)

The Universal Robotic Description Format (URDF) is an XML file format used in ROS to describe all elements of a robot.

To use a URDF file in Gazebo, some additional simulation-specific tags must be added to work properly with Gazebo.

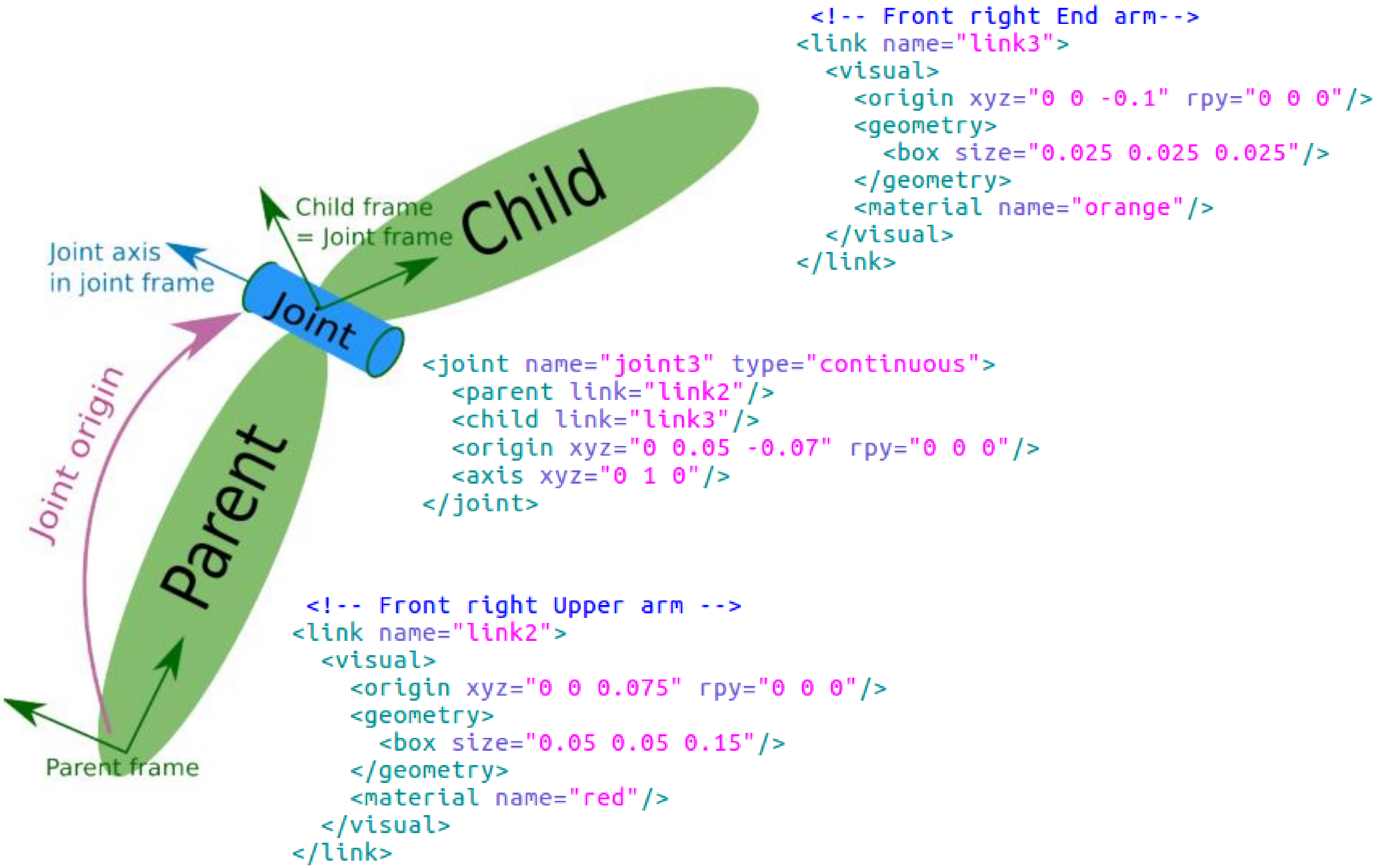
URDF

- Specify the kinematic and dynamic properties
- Tags: link, joint, transmission
- Order in the file does not matter

XACRO

- XML Macro Language used for URDF simplification
- Reduce redundancy and increase modularity
- Use parametrization (Use parameters for lengths and links and math for origin and inertia calculation)

Link and joint representation



```
 <!-- Front right End arm-->
<link name="link3">
  <visual>
    <origin xyz="0 0 -0.1" rpy="0 0 0"/>
    <geometry>
      <box size="0.025 0.025 0.025"/>
    </geometry>
    <material name="orange"/>
  </visual>
</link>
```

```
<joint name="joint3" type="continuous">
  <parent link="link2"/>
  <child link="link3"/>
  <origin xyz="0 0.05 -0.07" rpy="0 0 0"/>
  <axis xyz="0 1 0"/>
</joint>
```

```
 <!-- Front right Upper arm -->
<link name="link2">
  <visual>
    <origin xyz="0 0 0.075" rpy="0 0 0"/>
    <geometry>
      <box size="0.05 0.05 0.15"/>
    </geometry>
    <material name="red"/>
  </visual>
</link>
```

Thanks for your attention