



Programming for Robotics

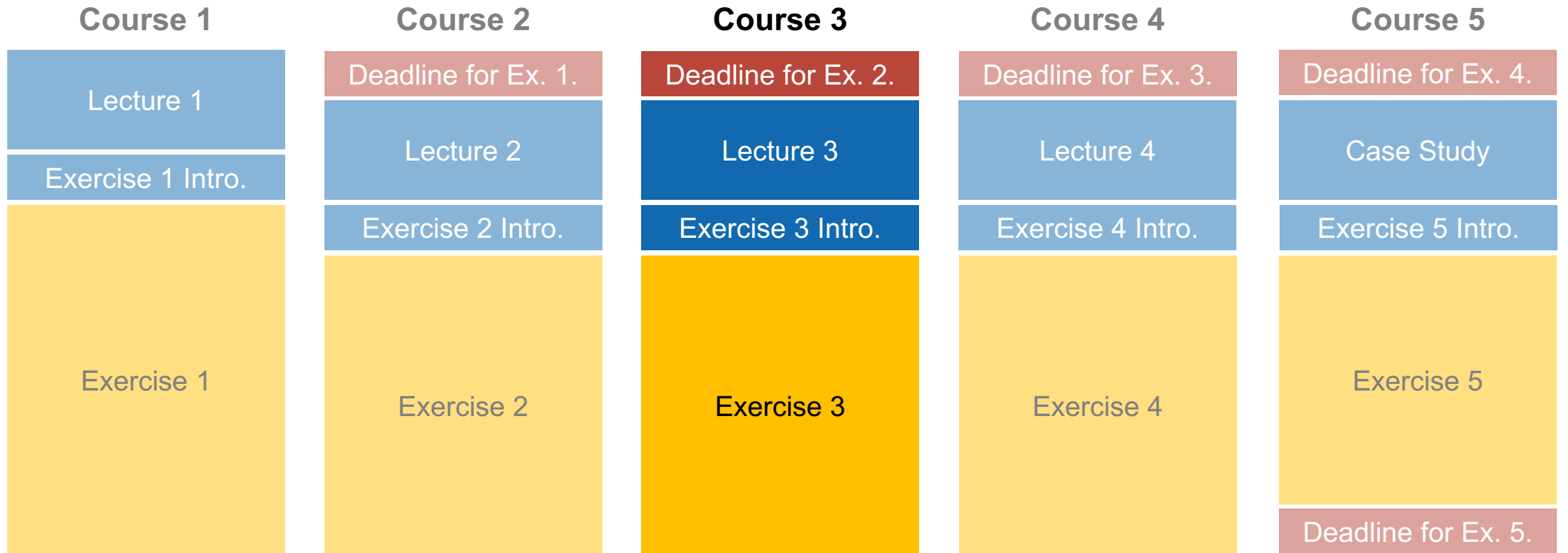
Introduction to ROS

Course 3

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Course Structure

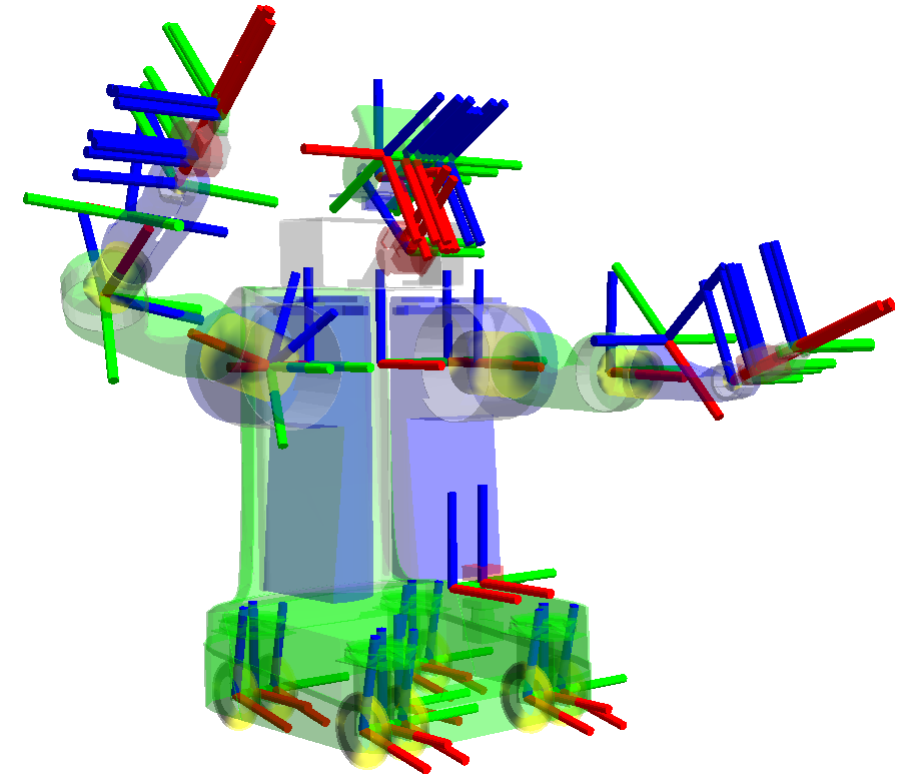
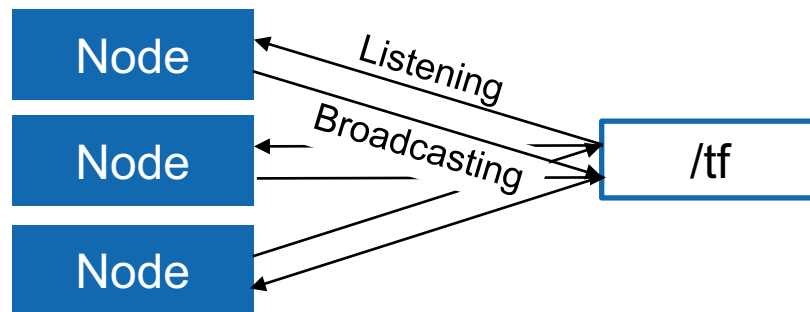


Overview Course 3

- TF Transformation System
- rqt User Interface
- Robot models (URDF)
- Simulation descriptions (SDF)

TF Transformation System

- Tool for keeping track of coordinate frames over time
- Maintains relationship between coordinate frames in a tree structure buffered in time
- Lets the user transform points, vectors, etc. between coordinate frames at desired time
- Implemented as publisher/subscriber model on the topics `/tf` and `/tf_static`



More info
<http://wiki.ros.org/tf2>

TF Transformation System

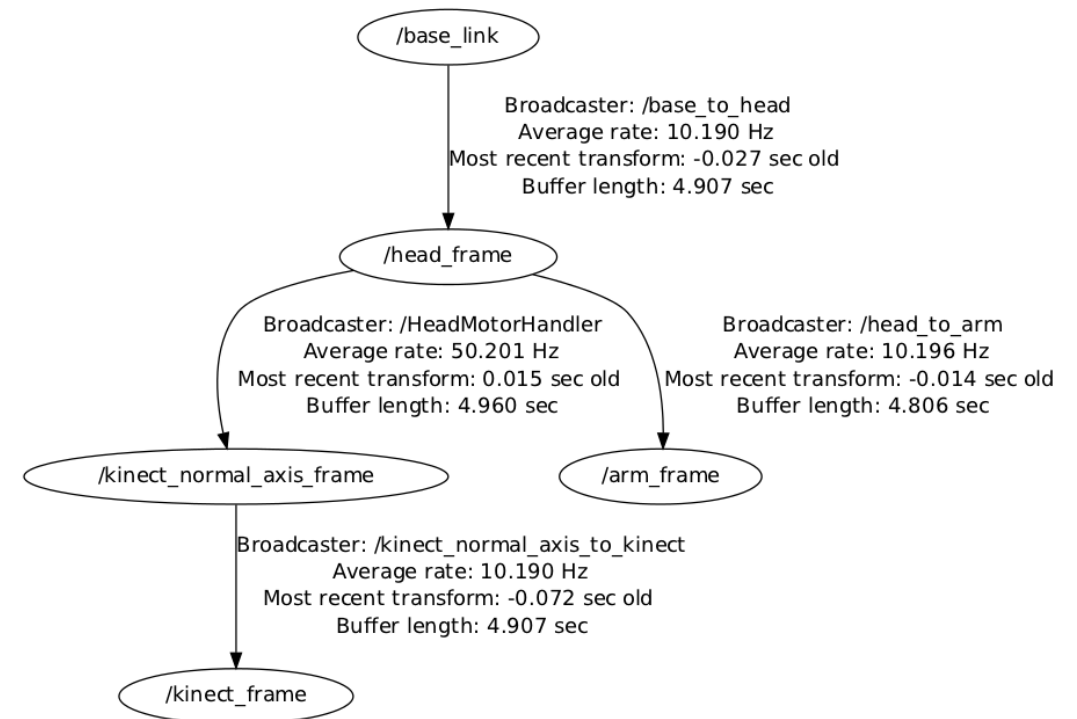
Transform Tree

- TF listeners use a buffer to listen to all broadcasted transforms
- Query for specific transforms from the transform tree

tf2_msgs/TFMessage.msg

```

geometry_msgs/TransformStamped[] transforms
std_msgs/Header header
uint32 seqtime stamp
string frame_id
string child_frame_id
geometry_msgs/Transform transform
geometry_msgs/Vector3 translation
geometry_msgs/Quaternion rotation
  
```



TF Transformation System Tools

Command line

Print information about the current transform tree

```
> rosrun tf tf_monitor
```

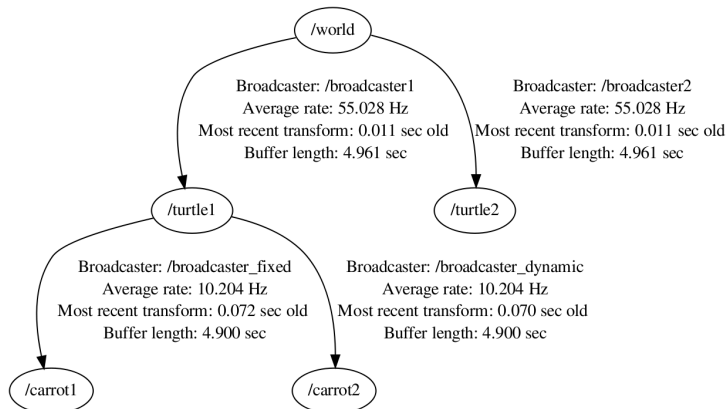
Print information about the transform between two frames

```
> rosrun tf tf_echo
  source_frame target_frame
```

View Frames

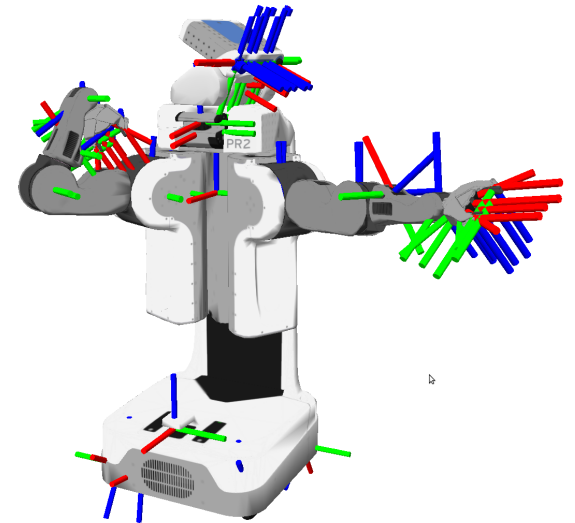
Creates a visual graph (PDF) of the transform tree

```
> rosrun tf view_frames
```

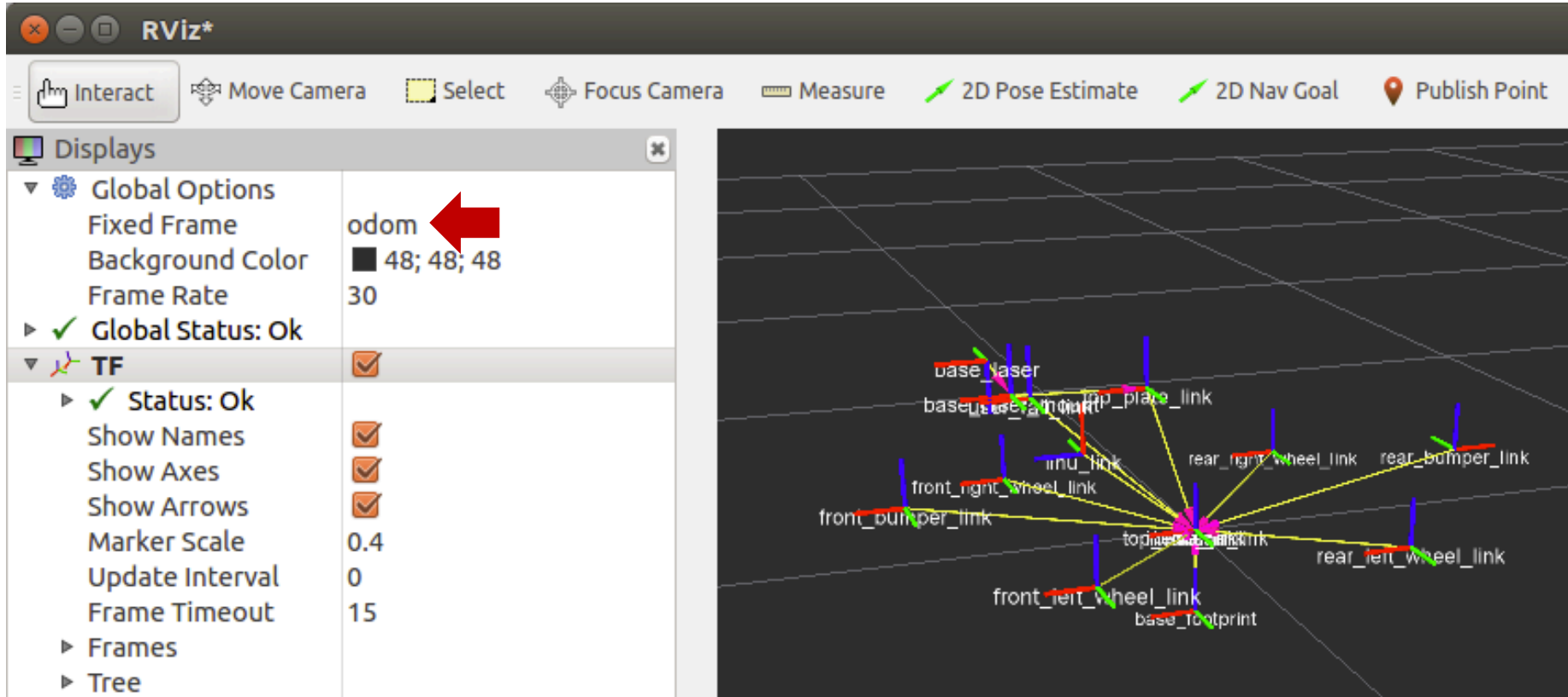


RViz

3D visualization of the transforms



TF Transformation System RViz Plugin



TF Transformation System

Transform Listener C++ API

- Create a TF listener to fill up a buffer

```
tf2_ros::Buffer tfBuffer;
tf2_ros::TransformListener tfListener(tfBuffer);
```

- Make sure, that the listener does not run out of scope!
- To lookup transformations, use

```
geometry_msgs::TransformStamped transformStamped =
tfBuffer.lookupTransform(target_frame_id,
                        source_frame_id, time);
```

- For time, use `ros::Time(0)` to get the latest available transform

```
#include <ros/ros.h>
#include <tf2_ros/transform_listener.h>
#include <geometry_msgs/TransformStamped.h>

int main(int argc, char** argv) {
  ros::init(argc, argv, "tf2_listener");
  ros::NodeHandle nodeHandle;
  tf2_ros::Buffer tfBuffer;
  tf2_ros::TransformListener tfListener(tfBuffer);

  ros::Rate rate(10.0);
  while (nodeHandle.ok()) {
    geometry_msgs::TransformStamped transformStamped;
    try {
      transformStamped = tfBuffer.lookupTransform("base",
                                                "odom", ros::Time(0));
    } catch (tf2::TransformException &exception) {
      ROS_WARN("%s", exception.what());
      ros::Duration(1.0).sleep();
      continue;
    }
    rate.sleep();
  }
  return 0;
};
```

More info

<http://wiki.ros.org/tf2/Tutorials/Writing%20a%20tf2%20listener%20%28C%2B%2B%29>

rqt User Interface

- User interface base on Qt
- Custom interfaces can be setup
- Lots of existing plugins exist
- Simple to write own plugins

Run RQT with

```
> rosrun rqt_gui rqt_gui
```

or

```
> rqt
```

The screenshot displays the ROS GUI (rqt) interface. The top window shows a publisher configuration for the `/cmd_vel3` topic, with a rate of 5 Hz and an expression of $\sin(t/20)*10$. The console window shows a list of messages from the `/moveit_setup_assistant` node, including 'Loading Setup Assistant Complete', 'Listening to 'moveit_planning_scene'', 'Starting scene monitor', 'Configuring kinematics solvers', 'Robot semantic model successfully loaded.', and 'Setting Param Server with Robot Seman...'. The plot window shows a graph of the `/cmd_vel3/data` topic, displaying a red sine wave oscillating between approximately -17.4 and 23.2.

More info

<http://wiki.ros.org/rqt/Plugins>

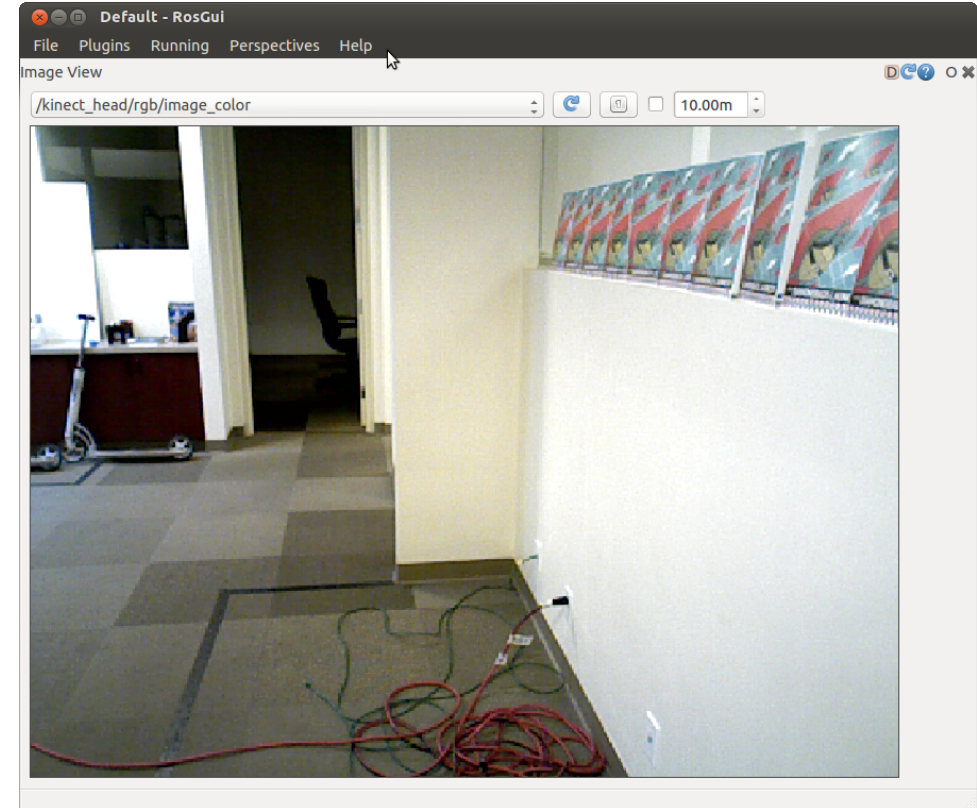
rqt User Interface

rqt_image_view

- Visualizing images

Run *rqt_graph* with

```
> rosrun rqt_image_view rqt_image_view
```



More info

http://wiki.ros.org/rqt_image_view

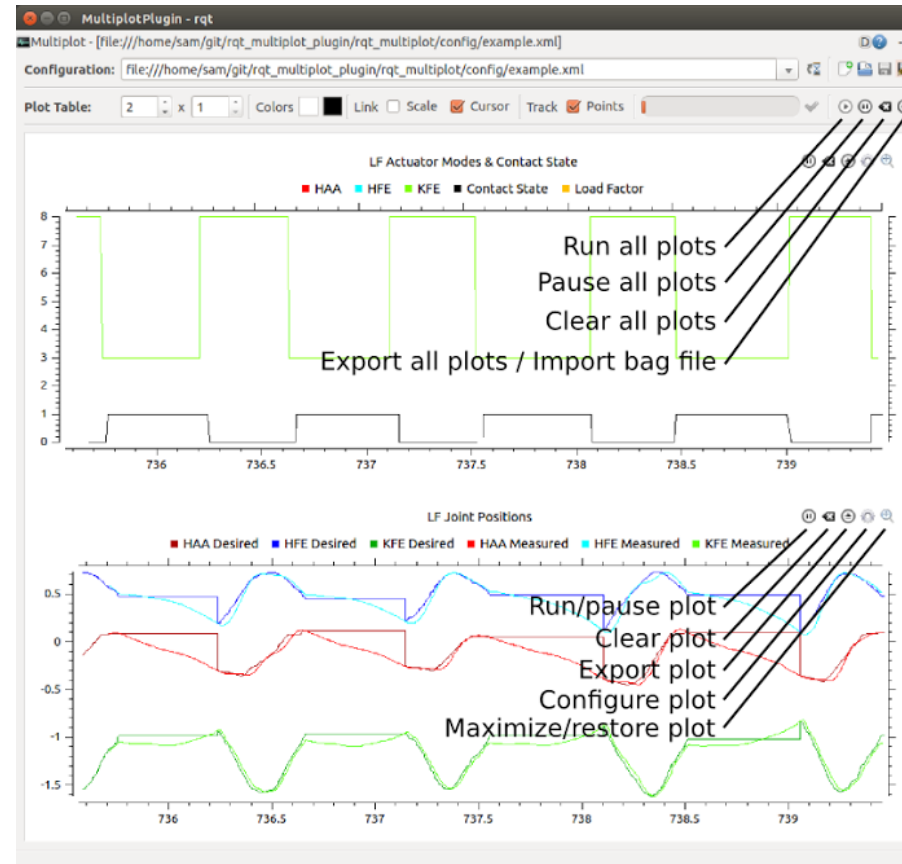
rqt User Interface

rqt_multiplot

- Visualizing numeric values in 2D plots

Run *rqt_multiplot* with

```
> rosrun rqt_multiplot rqt_multiplot
```



More info

http://wiki.ros.org/rqt_multiplot

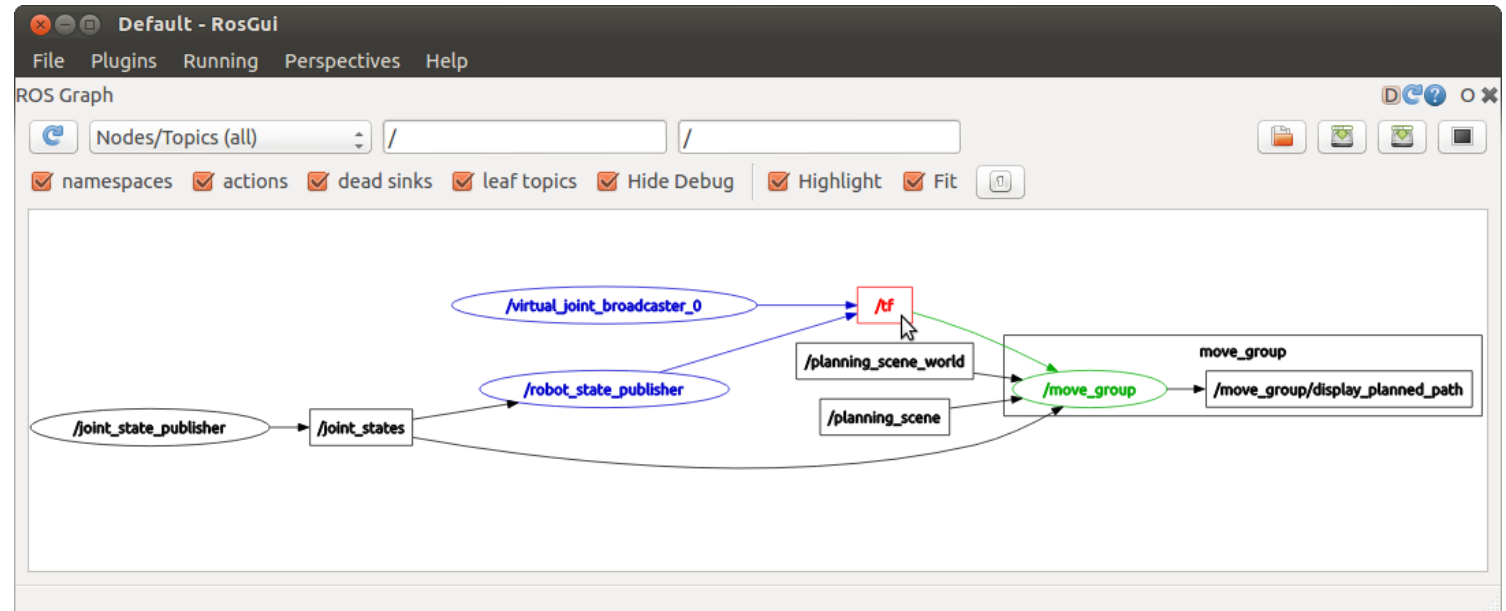
rqt User Interface

rqt_graph

- Visualizing the ROS computation graph

Run *rqt_graph* with

```
> rosrun rqt_graph rqt_graph
```



More info

http://wiki.ros.org/rqt_graph

rqt User Interface

rqt_console

- Displaying and filtering ROS messages

Run *rqt_console* with

```
> rosrun rqt_console rqt_console
```

The screenshot shows the rqt_console window with a table of messages. The table has columns for Message, Severity, Node, and Time. The messages are as follows:

#	Message	Severity	Node	Time
#12	The input topic '/narrow_stereo/left/image_raw' is not yet advertised	Warn	/narrow_stereo_textured/...	21:39:04.833 (2013-05-06)
#10	The input topic '/narrow_stereo/right/image_raw' is not yet advertised	Warn	/narrow_stereo/narrow_st...	21:39:02.337 (2013-05-06)
#11	The input topic '/narrow_stereo/right/camera_info' is not yet advertised	Warn	/narrow_stereo/narrow_st...	21:39:02.337 (2013-05-06)
#8	The input topic '/narrow_stereo/left/image_raw' is not yet advertised	Warn	/narrow_stereo/narrow_st...	21:39:02.336 (2013-05-06)
#9	The input topic '/narrow_stereo/left/camera_info' is not yet advertised	Warn	/narrow_stereo/narrow_st...	21:39:02.336 (2013-05-06)
#7	Holding arms	Info	/arm_holder	21:39:01.402 (2013-05-06)
#18	The input topic '/wide_stereo/right/camera_info' is not yet advertised	Warn	/wide_stereo/wide_stereo...	21:39:01.086 (2013-05-06)
#16	The input topic '/wide_stereo/left/camera_info' is not yet advertised	Warn	/wide_stereo/wide_stereo...	21:39:01.085 (2013-05-06)
#17	The input topic '/wide_stereo/right/image_raw' is not yet advertised	Warn	/wide_stereo/wide_stereo...	21:39:01.085 (2013-05-06)
#6	The input topic '/wide_stereo/left/image_raw' is not yet advertised	Warn	/wide_stereo/wide_stereo...	21:39:01.085 (2013-05-06)
#5	Moving torso up	Info	/arm_holder	21:38:56.400 (2013-05-06)

Below the table, there are sections for 'Exclude Rules' and 'Highlight Rules', each with a text input field and a '+' button.

More info

http://wiki.ros.org/rqt_console

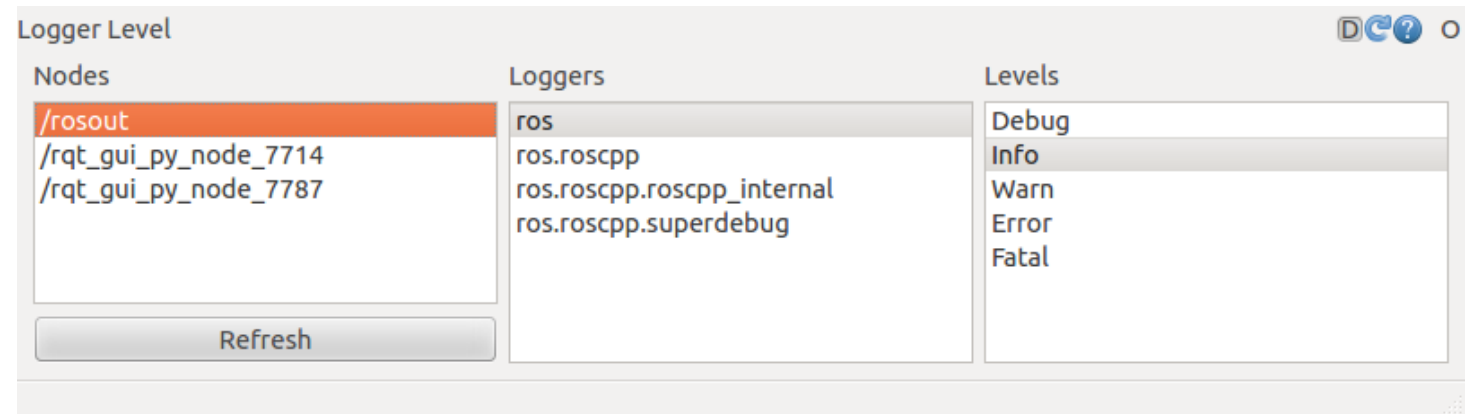
rqt User Interface

rqt_logger_level

- Configuring the logger level of ROS nodes

Run *rqt_logger_level* with

```
> rosrun rqt_logger_level  
rqt_logger_level
```

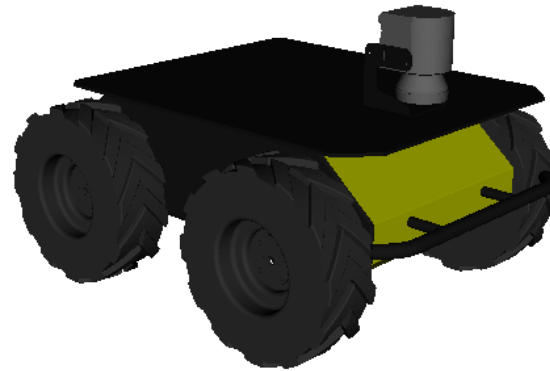


More info
http://wiki.ros.org/rqt_logger_level

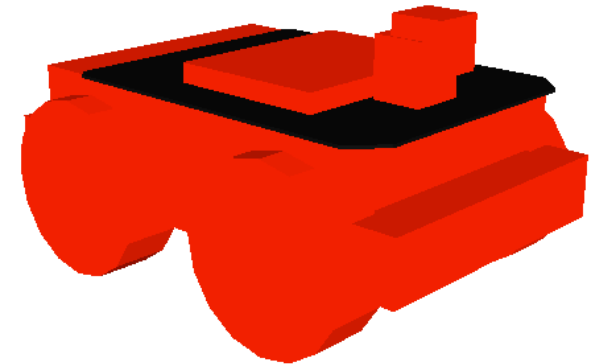
Robot Models

Unified Robot Description Format (URDF)

- Defines an XML format for representing a robot model
 - Kinematic and dynamic description
 - Visual representation
 - Collision model
- URDF generation can be scripted with *XACRO*



Mesh for visuals



Primitives for collision

More info

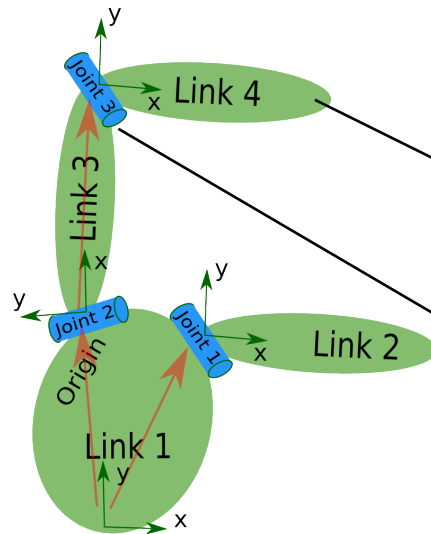
<http://wiki.ros.org/urdf>

<http://wiki.ros.org/xacro>

Robot Models

Unified Robot Description Format (URDF)

- Description consists of a set of *link* elements and a set of *joint* elements
- Joints connect the links together



robot.urdf

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

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

```
<link name="Link_name">
  <visual>
    <geometry>
      <mesh filename="mesh.dae"/>
    </geometry>
  </visual>
  <collision>
    <geometry>
      <cylinder length="0.6" radius="0.2"/>
    </geometry>
  </collision>
  <inertial>
    <mass value="10"/>
    <inertia ixx="0.4" ixy="0.0" .../>
  </inertial>
</link>
```


```
<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"/>
</joint>
```

More info

<http://wiki.ros.org/urdf/XML/model>

Robot Models

Usage in ROS

- The robot description (URDF) is stored on the parameter server (typically) under `/robot_description`
- You can visualize the robot model in Rviz with the  *RobotModel* plugin

husky_empty_world.launch

```
...  
<include file="$(find husky_gazebo)/launch/spawn_husky.launch">  
  <arg name="laser_enabled" value="$(arg laser_enabled)"/>  
  <arg name="ur5_enabled" value="$(arg ur5_enabled)"/>  
  <arg name="kinect_enabled" value="$(arg kinect_enabled)"/>  
</include>  
...
```

spawn_husky.launch

```
...  
<param name="robot_description" command="$(find xacro)/xacro.py  
'$(arg husky_gazebo_description)'  
  laser_enabled:=$(arg laser_enabled)  
  ur5_enabled:=$(arg ur5_enabled)  
  kinect_enabled:=$(arg kinect_enabled)" />  
...
```

Simulation Descriptions

Simulation Description Format (SDF)

- Defines an XML format to describe
 - Environments (lighting, gravity etc.)
 - Objects (static and dynamic)
 - Sensors
 - Robots
- SDF is the standard format for Gazebo
- Gazebo converts a URDF to SDF automatically



More info

<http://sdformat.org>

Further References

- **ROS Wiki**
 - <http://wiki.ros.org/>
- **Installation**
 - <http://wiki.ros.org/ROS/Installation>
- **Tutorials**
 - <http://wiki.ros.org/ROS/Tutorials>
- **Available packages**
 - <http://www.ros.org/browse/>
- **ROS Cheat Sheet**
 - https://github.com/ros/cheatsheet/releases/download/0.0.1/ROSCheatsheet_catkin.pdf
- **ROS Best Practices**
 - https://github.com/ethz-asl/ros_best_practices/wiki
- **ROS Package Template**
 - https://github.com/ethz-asl/ros_best_practices/tree/master/ros_package_template

Contact Information

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Course website:

<http://www.rsl.ethz.ch/education-students/lectures/ros.html>