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Transforms and Sensors in ROS

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The material of this slides is taken from the Robotics 2 lectures given by G.Grisetti, W.Burgard, C.Stachniss, K.Arras, D. Tipaldi and M.Bennewitz

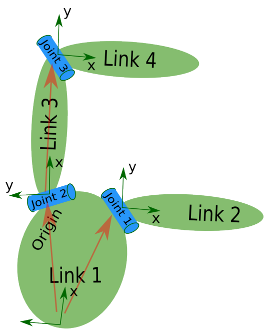
Outline

Specifying the Arrangement of Devices

- All these devices are mounted on a robot in an articulated way.
- Some devices are mounted on other devices that can move.
- In order to use all the sensors/ actuators together we need to describe this configuration.
  - For each "device" specify one or more frames of interest
  - Describe how these frames are located w.r.t each other

Defining the Structure

- You have to specify the kinematics of the robot, according to what you learned in the Robotics course.
- Each "Link" is a reference frame of a sensor
- Each "joint" defines the transformation that maps the child link in the parent link.
- ROS does not handle closed kinematic chains, thus only a "tree" structure is allowed
- The root of the tree is usually some convenient point on the mobile base (or on its footprint)



Transform Publishers

- **A transform can be published by any ros node**.
- The local configuration of a robot (e.g. the position of the sensors/actuators w.r.t a frame on the robot platform) is usually published by a convenience node: the **robot_state_publisher**.
- **The robot state publisher**:
  - takes a description of the robot (the kinematics), that specifies for each frame:
    - the parent frame
    - the type of joint
  - Listens the state of the joints
  - Computes the transforms for all the frames.
- If the robot has no movable devices (except the base) one can use the **static_transform_publisher**.
- The **static transform publisher** is a node that can be invoked like that

```
$> rosrun tf static_transform_publisher fromFrame toFrame x y z roll pitch yaw hz
```

e.g.

```
$> rosrun tf static_transform_publisher baseFrame cameraFrame 0 0 0.3 0 0 3.14 10
```

will start a node that publishes a transform between the baseFrame and the camera, telling that the camera is mounted at 30 cm above the mobile base and is looking backwards (yaw = M_PI).(*)

(*) check the online documentation for an updated command line

Visualizing The Data

- Once all sensors are started and the robot description is correctly done, we can visualize the data.
- To this end, we will use the RVIZ ros tool.
- I will give a practical example, you can look at the ros wiki, for rviz.

Interpolation

- A robot is a complex system consisting in a potentially large set of devices
- These devices typically run in an asynchronous fashion. Each of them outputs the data when available.
- In many tasks, we are interested in knowing the position of the robot when a specific information is gathered by the sensor
- At this time, however there might not be a valid transformation, thus we have to determine the sensor position by interpolation.

Interpolation (II)

- To interpolate the position of a joint at time *t* we need to know
  - The position at time $t_m < t$
  - The position at time $t_M > t$
  - The velocities and
  - The kinematic constraints
- All these informations are available in the tf messages
- ROS provides a ***tf*** client library to interpolate and publish transforms.

TF Main Facts

- To perform interpolation it installs a set of transform buffers, one for each frame.
- It allows to send/receive transform messages
- One can obtain the interpolated position between any pair of frames.
- The ***tf*** package contains several useful programs to debug the system
  - **view_frames**: generates a pdf file by listening all transforms

    ```
    $> rosrun tf view_frames
    ```
  - **static_transform_publisher**: is a node that streams a specific transform given as argument.

Using TF

- TF has an own Listener that sets up the buffers

  ```
  TransformListener(
        ros::Duration max_cache_time=ros::Duration(DEFAULT_CACHE_TIME),
        bool spin_thread=true)
  ```

- To see if you can compute the position of a frame w.r.t. another one you should first check that the buffers are consistend with the query

  ```
  bool tf::TransformListener::canTransform (
        const std::string &target_frame,
        const std::string &source_frame,
        const ros::Time &time,
        std::string *error_msg=NULL) const
  ```

- To compute a transform between to frames use the following function

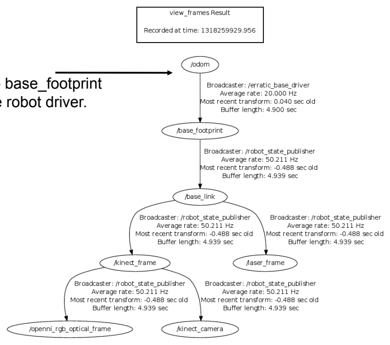
  ```
  void tf::TransformListener::lookupTransform (
        const std::string &target_frame,
        const ros::Time &target_time,
        const std::string &source_frame,
        const ros::Time &source_time,
        const std::string &fixed_frame,
        StampedTransform &transform) const
  ```

Recording a Dataset

- With **rosbag** you can record in a bag all the messages about a specific topic
- We will now record a bag of a moving robot
- This bag will be made available to you

Transform Tree in the Bag

New base frame.
Transform from odom to base_footprint
Is published by the base robot driver.


view_frames Result
Recorded at time: 1318259929.956
/odom
Broadcaster: /erratic_base_driver
Average rate: 20.000 Hz
Most recent transform: 0.040 sec old
Buffer length: 4.900 sec
/base_footprint
Broadcaster: /robot_state_publisher
Average rate: 50.211 Hz
Most recent transform: -0.488 sec old
Buffer length: 4.939 sec
/base_link
Broadcaster: /robot_state_publisher
Average rate: 50.211 Hz
Most recent transform: -0.488 sec old
Buffer length: 4.939 sec
Broadcaster: /robot_state_publisher
Average rate: 50.211 Hz
Most recent transform: -0.488 sec old
Buffer length: 4.939 sec
/kinect_frame
/laser_frame
Broadcaster: /robot_state_publisher
Average rate: 50.211 Hz
Most recent transform: -0.488 sec old
Buffer length: 4.939 sec
Broadcaster: /robot_state_publisher
Average rate: 50.211 Hz
Most recent transform: -0.488 sec old
Buffer length: 4.939 sec
/openni_rgb_optical_frame
/kinect_camera

Launch Files

- A system running on ROS may consist in a large number of nodes, each with its parameters
- To start these nodes, one might use the .launch files (See roslaunch).
- Launch files are xml scripts used to start and configure a large number of nodes

- They need to reside in the / launch directory of a package

- They can be started with
- **`roslaunch <package_name> <launch_file>`**

```
<launch>

     <node name="map_server" pkg="map_server" type="map_server"
     args="$(find dis_navigation)/maps/dis-B1-2011-09-27.yaml"/>

       <group ns="erratic1">
               <param name="tf_prefix" value="erratic1" />

              <include file="$(find dis_robots)/launch/
     erratic_hokuyo.launch" />
              <param name="hokuyo/frame_id" type="str" value="/
     erratic1/laser_frame"/>

               <include file="$(find dis_navigation)/config/
     localization/glocalizer_node.xml" />
               <include file="$(find dis_navigation)/config/
     navigation/move_base.xml" />
               <node pkg="tf" type="static_transform_publisher"
     name="link_broadcaster_0" args="0 0 0 0 0 0 /map /erratic1/
     map 100" />
       </group>


      <group ns="erratic1">
               <param name="glocalizer/initial_pose_x"
     value="0" />
               <param name="glocalizer/initial_pose_y"
     value="1.8" />
               <param name="glocalizer/initial_pose_a"
     value="0" />
       </group>


</launch>
```

Homework (2)

- Write a ros node that writes in a text format the 3D location of the sensor when a depth image arrives, and the timestamp
- FORMAT:
    - One line per message
    - **`DEPTHIMAGE <timestamp.sec>.<timestamp.usec> <camera pose w.r.t. odom frame (x,y,z,qx,qy,qz,qw)>`**