tf: On the PR2

ROS + PR2 Training Workshop

What is tf?

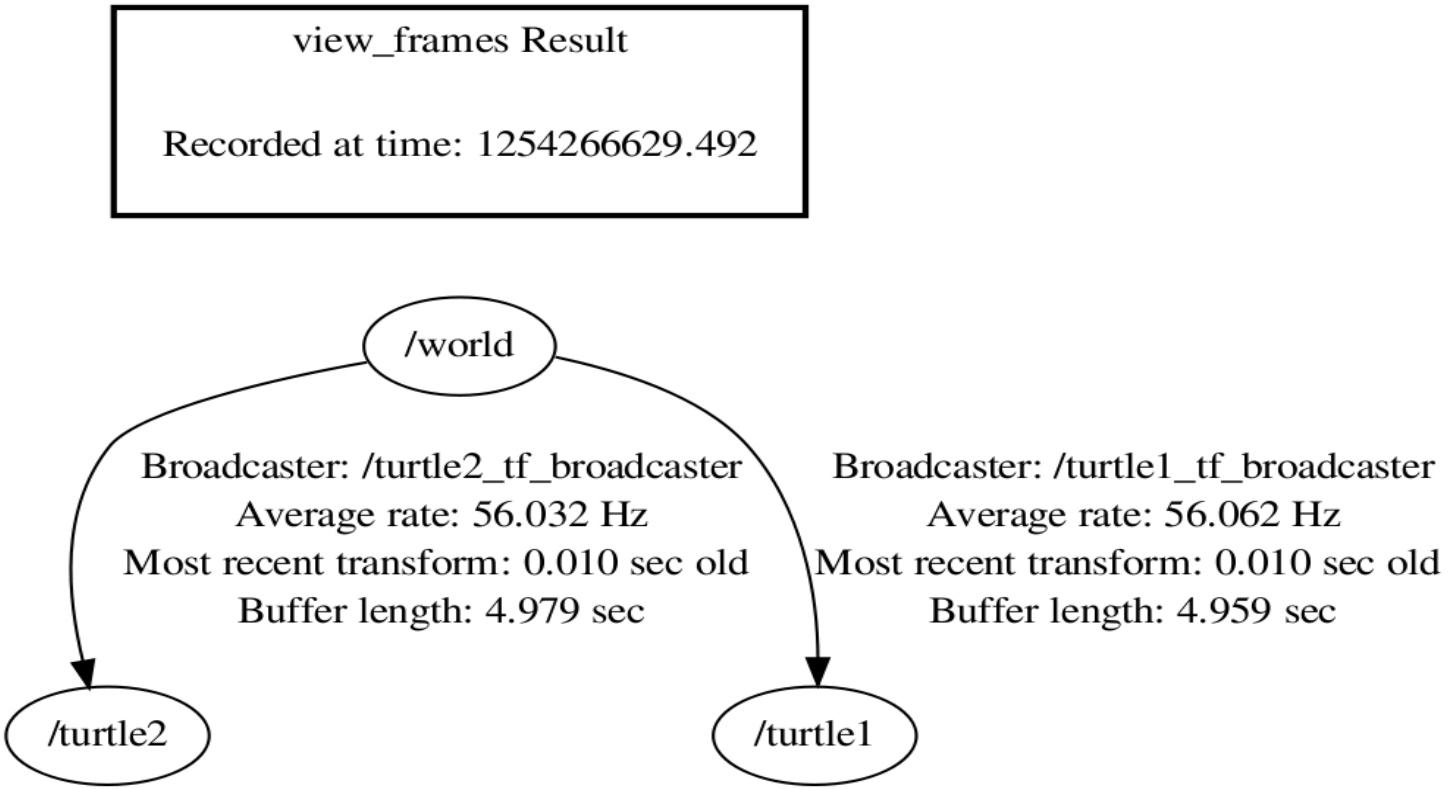
A coordinate frame tracking system

- A standardized protocol for publishing transform data to a distributed system
- Helper classes and methods for:
  - Publishing coordinate frame data – TransformPublisher
  - Collecting transform data and using it to manipulate data – Transformer, TransformListener, tf::MessageFilter, ...

tf is Distributed!

- There are two types of tf nodes:
  - Publishers
  - Listeners
- Listeners – listen to /tf and cache all data heard up to cache limit
- Publishers – publish transforms between coordinate frames on /tf
- There is no central source of tf information, or history before a node was started.

Transform Tree



- Each link in the tree is cached
- 10 seconds is default cache time
- It will work with multiple disconnected trees
- Only for transforms within the same tree

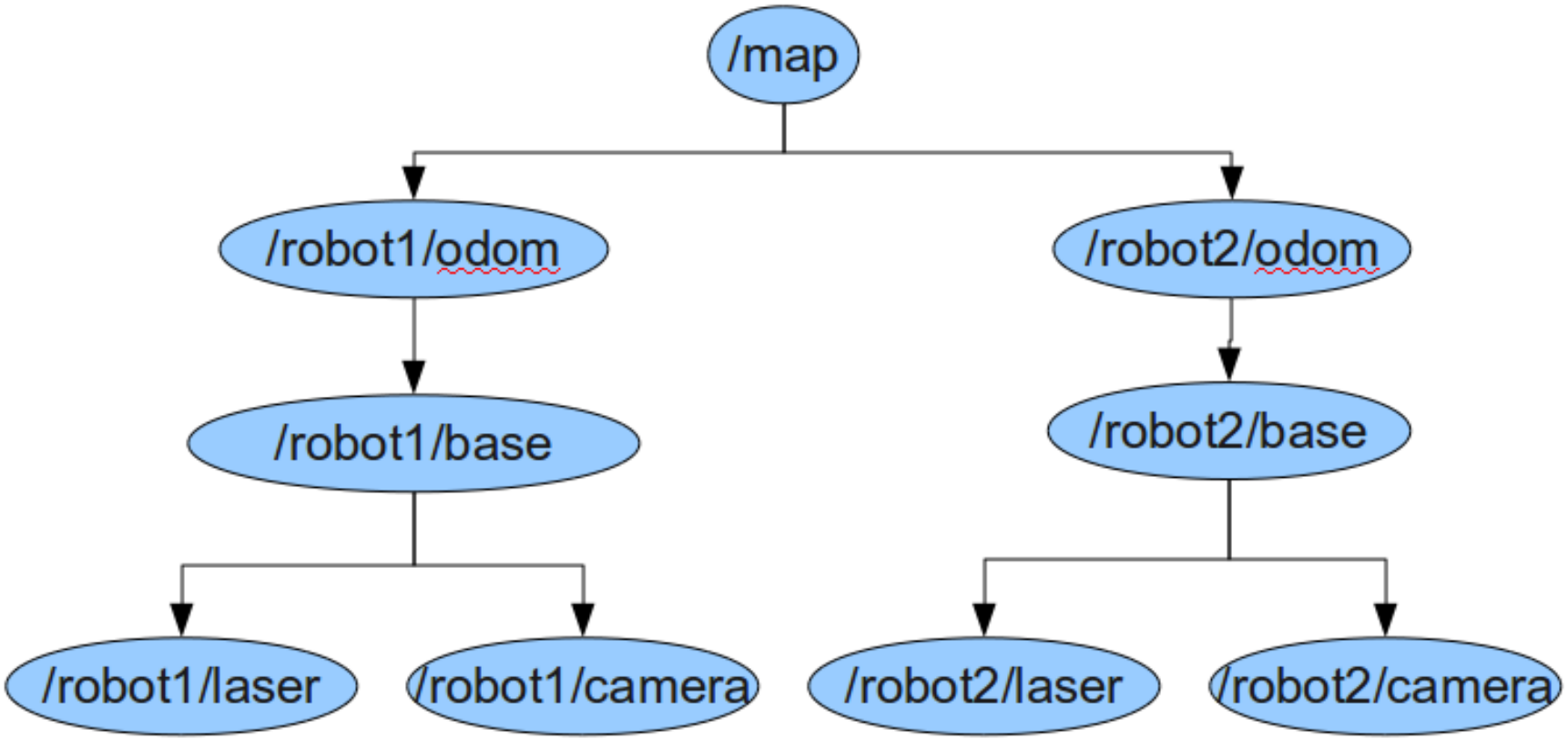
Values of tf

- No data loss when transforming multiple times
- No computational cost of intermediate data transformations between coordinate frames
- The user does not need to worry about which frame their data started
- Information about past locations is also stored and accessible, but not before recording locally was started

Core Methods of Transformer

- LookupTransform
  - Get the transform between two coordinate frames
- CanTransform
  - Test if a transform is possible between to coordinate frames

How does this work?



Helper Methods

1. For both tf data types and message datatypes.
   - TransformPoint
   - TransformVector
   - TransformPose
   - TransformQuaternion
2. Other common message datatypes
   - transformPointcloud

Syncronization Methods

- WaitForTransform
  - Block until timeout or transform is available.
- tf::MessageFilter
  - Subscribe to a topic an provide the callbacks only when there is enough tf messages to tansform the data.

Transformer::waitForTransform

- Dangers
  - No data coming in if in single thread
  - Blocks all progress, can make all processing late
  - Protection in Transformer class usingSeperateThread method
  - Using this method can delay the whole system unnecessarily
  - But it's very convenient for scripting/sequencing

tf::MessageFilter

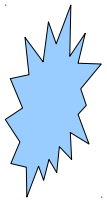
Purpose

- Provide a non blocking way to queue data pending transform data availability

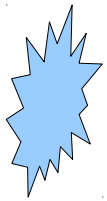
Usage

- Register a target frame and an incoming topic
- Receive a callback when transforms are available

Advanced API

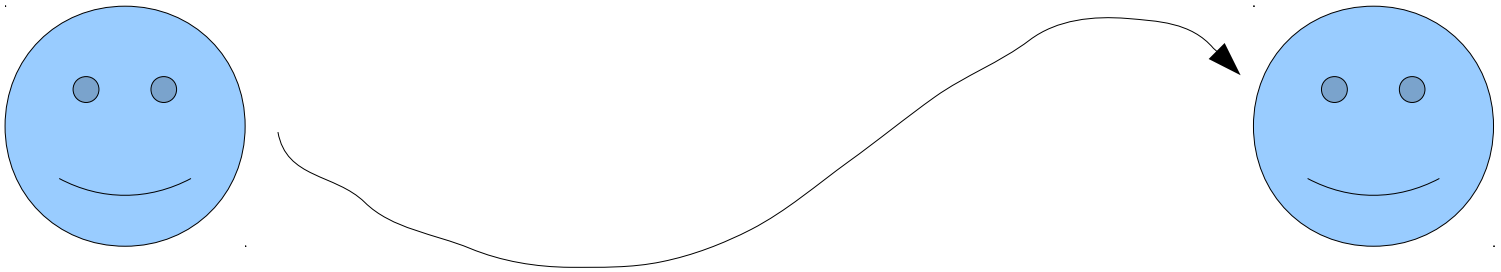


Object 1 observed in the camera at Time = 0.25 while driving past



Object 2 observed in the camera at Time = 0.5 while driving past

The robot is planning it's path at Time = 1 where are all objects?

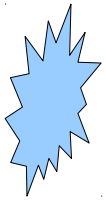


Time = 0

Time = 1

Tme

Advanced API



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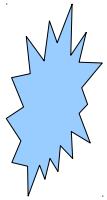

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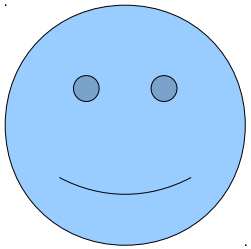
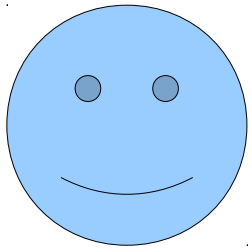
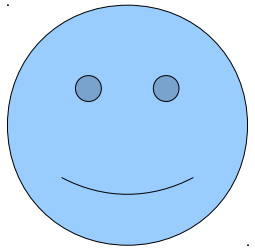






Time = 0

Time = 1

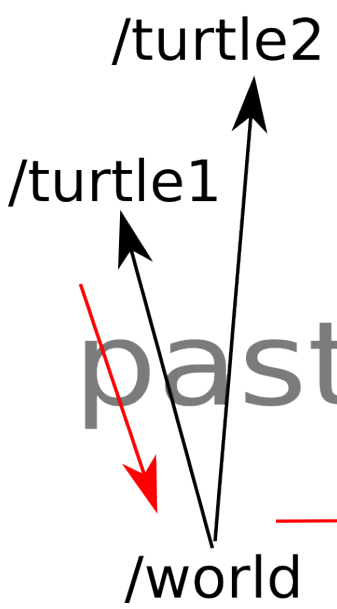
Tme

Advanced API

1. Construct transform from first frame to fixed frame at data timestamp
2. Jump to query time in the fixed frame
3. Compute the transform from fixed frame to query frame at query time
4. Return the product of these transforms

Avanced API Walk Through

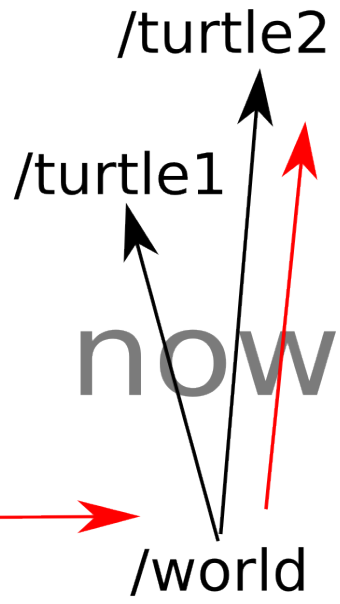
1) Object Observed



2) Object Transformed into Fixed Frame at Observation Time

3) Object Assumed Static in Fixed Frame

5) Object available for manipulation in Target Frame at Target Time



4) Object Transformed into Target Frame At Target Time

Advanced API examples

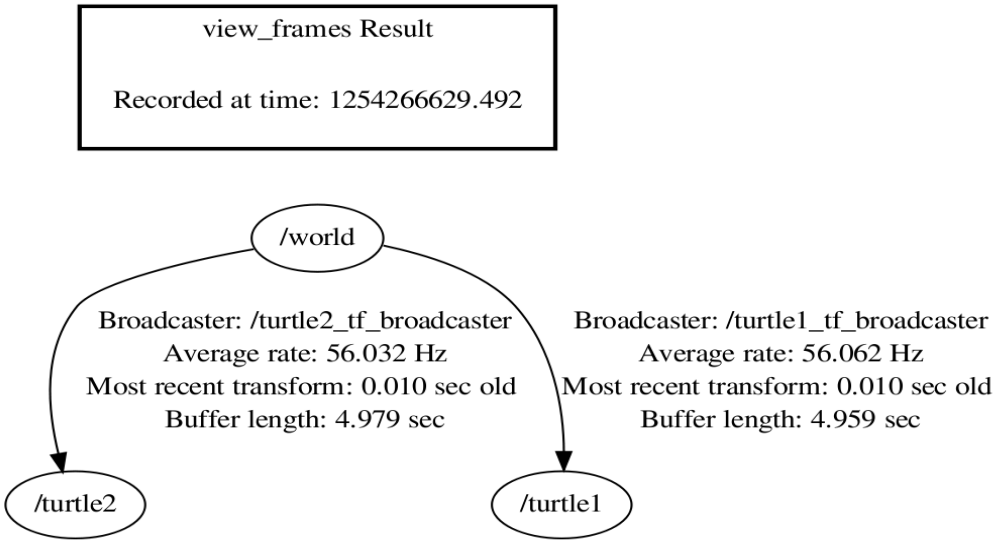
1. Compute the position of an observed ball in the target frame at the target time assuming it was stationary in the fixed frame
   - lookupTransform(ball_frame, ball_time, target_frame, target_time, fixed_frame, result_transform)
2. Compute how far the robot moved between t =1 and t = 2 in the map frame
   - lookupTransform(robot_frame, t = 1,robot_frame, t =2, map_frame, result_transform)

Debugging Tools

1. Command Line Tools
   - tf_echo – Print a specific transform to the screen
   - tf_monitor – Display statistics about transforms
   - roswtf (tf_plugin) Debug common tf configuration errors

Debugging Tools

1. Visualizations
   - Rviz tf visualization
     - TODO add figure
   - view_frames



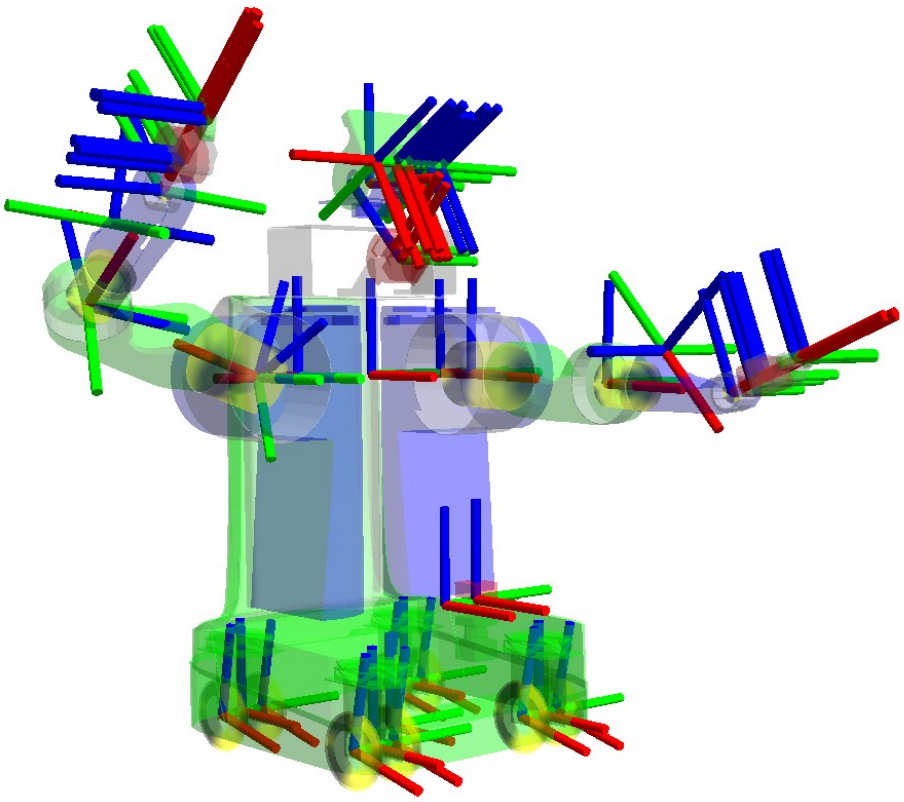
tf Python

There are Python bindings for most of the C++ API

See Docs at:
http://www.ros.org/doc/api/tf/html/python

The Python bindings do not have full coverage on c++ methods, in particular the tf::MessageFilter does not have an analog.

Coordinate Frames in the PR2



- Every Link has a frame_id the same name as in the URDF
- Each sensor has a frame_id in which it takes measurements
- Data is broadcast in the frame in which it was observed.

PR2 Navigation frame_ids

map - The coordinate frame fixed to the map

odom_combined - The self consistent coordinate frame using the odometry measurements only(This will not change on localization updates)

base_footprint - The base of the robot at zero height above the ground

base_link - The base link of the robot

PR2 Sensor Frames

/r(l)_forearm_cam
/wide(narrow)_stereo_r(l)_stereo_camera_frame
/wide(narrow)_stereo_link
/wide(narrow)_stereo_optical_frame
/imu_link
/sensor_mount_link
/high_def_frame
/high_def_optical_frame
/laser_tilt_link
/base_laser_link

PR2 Manipulation Frames

/r(l)_elbow_flex_link
/r(l)_forearm_cam_frame
/r(l)_forearm_cam_optical_frame
/r(l)_forearm_link
/r(l)_forearm_roll_link
/r(l)_gripper_l_finger_link
/r(l)_gripper_l_finger_tip_link
/r(l)_gripper_motor_accelerometer_link
/r(l)_gripper_palm_link
/r(l)_gripper_r_finger_link
/r(l)_gripper_r_finger_tip_link
/r(l)_gripper_tool_frame
/r(l)_shoulder_lift_link
/r(l)_shoulder_pan_link
/r(l)_upper_arm_link
/r(l)_upper_arm_roll_link
/r(l)_wrist_flex_link
/r(l)_wrist_roll_link
/torso_lift_link

/base_footprint
/base_laser_link
/base_link
/bl_caster_l_wheel_link
/bl_caster_r_wheel_link
/bl_caster_rotation_link
/br_caster_l_wheel_link
/br_caster_r_wheel_link
/br_caster_rotation_link
/double_stereo_link
/fl_caster_l_wheel_link
/fl_caster_r_wheel_link
/fl_caster_rotation_link
/fr_caster_l_wheel_link
/fr_caster_r_wheel_link
/fr_caster_rotation_link
/head_pan_link
/head_plate_frame
/head_tilt_link

The End

Full documentation at
http://www.ros.org/wiki/tf

Questions?

Tf Challenge

Write a node to draw a visulization_msgs/Marker in rviz on the ground below a detected checkerboard

1. All the other nodes and launch files will be setup.
2. Use the online documentation
3. Setup instructions are on the next page

tf Challenge Setup

1. Install boxturtle unreleased:

   wget --no-check-certificate http://ros.org/rosinstall -O ~/rosinstall

   chmod 755 ~/rosinstall

   . /opt/ros/boxturtle/setup.sh

   ~/rosinstall -o ~/boxturtle_wg_devel http://ros.org/rosinstalls/wg_boxturtle_devel.rosinstall

2. Setup each terminal opened on the robot with:

   . ~/boxturtle_wg_devel/setup.sh

3. Compile and Run with robot started

   - rosmake tf_workshop_demo
   - roslaunch tf_workshop_demo system.launch

tf Challenge Hints

1. There is a topic /board_pose provided
2. You will want to subscribe to it with a tf::MessageFilter
3. You will then want to transform it into a frame on the ground.
4. You will want to zero out the height.
5. Then create a marker with the resultant pose and broadcast it.
6. Using a C++ class to do this is recommended
7. These slides with the instructions can be found on the workshop wiki page