

Map building and navigation

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Before we begin

- Be sure to install the following packages for the class:

```
$ sudo apt-get update
$ sudo apt-get install ros-$ROS_DISTRO-stdr-simulator
$ sudo apt-get install \
  ros-$ROS_DISTRO-teleop-twist-keyboard
$ sudo apt-get install ros-$ROS_DISTRO-amcl
$ sudo apt-get install ros-$ROS_DISTRO-move-base
$ sudo apt-get install ros-$ROS_DISTRO-gmapping
```

So you want an autonomous robot?

- A robot is in a completely unknown environment for the first time. What to do next?
- One of the most fundamental problems in mobile robotics is map building of an unknown environment
- Ends up being a prerequisite for autonomous mobile robots (without making structural changes in the environment)
- This problem is known as Simultaneous localization and mapping (SLAM)

So you want an autonomous robot?

- SLAM is difficult, and what if you are not a SLAM expert?
- Say thank you to researchers who open-sourced their solution
- At the moment two most commonly used SLAM implementations in 2D are GMapping/OpenSLAM and Hector SLAM
- In this class we will setup a robot in the STDR simulator with a laser as a sensor and build a map of our environment with the GMapping algorithm (homework), perform localization with the AMCL algorithm and use the `move_base` package to navigate the robot in the environment

- Launch the simulator with the default map and a robot inside

```
$ roslaunch stdr_launchers \
  server_with_map_and_gui_plus_robot.launch
```

- Familiarize yourself with the environment and the robot sensors
- Launch rviz

```
$ roslaunch stdr_launchers rviz.launch
```

- Analyze the topics published by the simulator (rostopic list, info, ...)

Controlling the robot

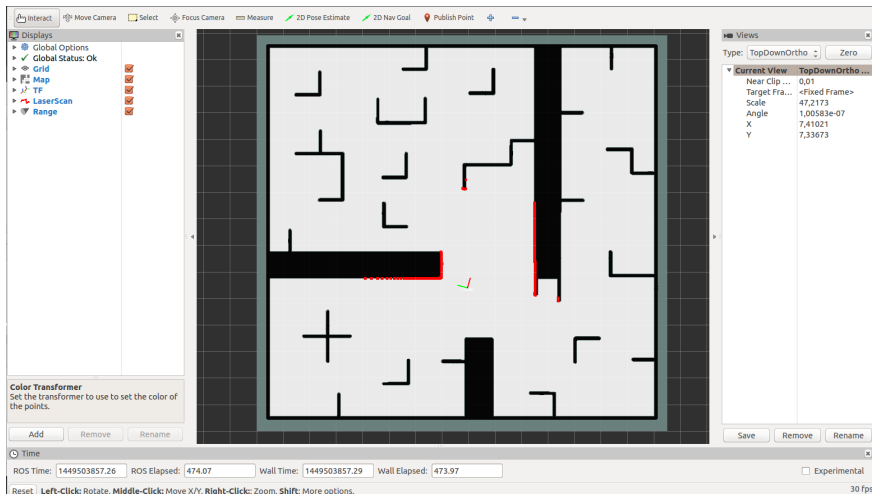
- One of the listed topics is /robot0/cmd_vel

```
$ rostopic info /robot0/cmd_vel
Type: geometry_msgs/Twist
...
```

- We will send messages to this topic in order to control the robot
- Analyze the message type. What kind of information does the message contain? (hint: `rosmmsg show`)
- The package `teleop_twist_keyboard` offers the option of controlling the robot via the keyboard

```
$ rosrn teleop_twist_keyboard teleop_twist_keyboard.py \
cmd_vel:=robot0/cmd_vel
```

RViz showing map, robot and laser scan



- We assume that we have the map the environment. Where is this map published?
- Having the map, we can start making the robot do useful tasks in the environment
- But first we need an algorithm which will tell us where the robot is located based on the map and received measurements
- For this purpose we will use adaptive Monte Carlo localization (AMCL) algorithm

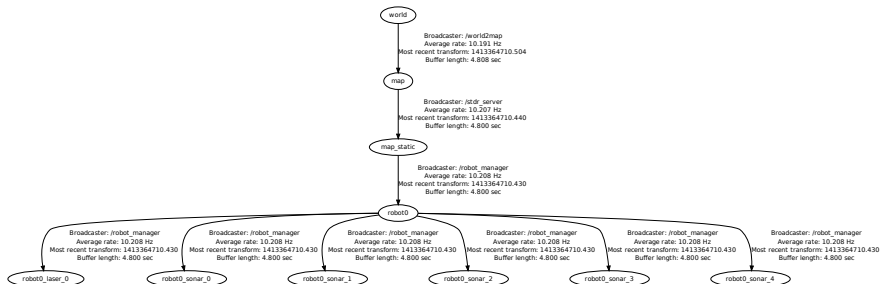
- Let's look at the AMCL documentation
- It requires a laser scan, initial pose, the map, some transformations, and has many parameters to set up (most we can leave default, but some require attention)
- Laser scan is already being published by the simulator
- Map is just like any other topic AMCL will subscribe to, usually it is ran as follows but the simulator is already publishing the map

```
$ rosrun map_server map_server map.yaml
```
- What about the transforms?

- We will not go at this point in the details of the tf package
- Take a look in RViz at defined coordinate systems (TF checkbox should be switched on)
- Now lets look at the available transforms:

```
$ rosrun tf view_frames
```
- Are all the required transforms available?

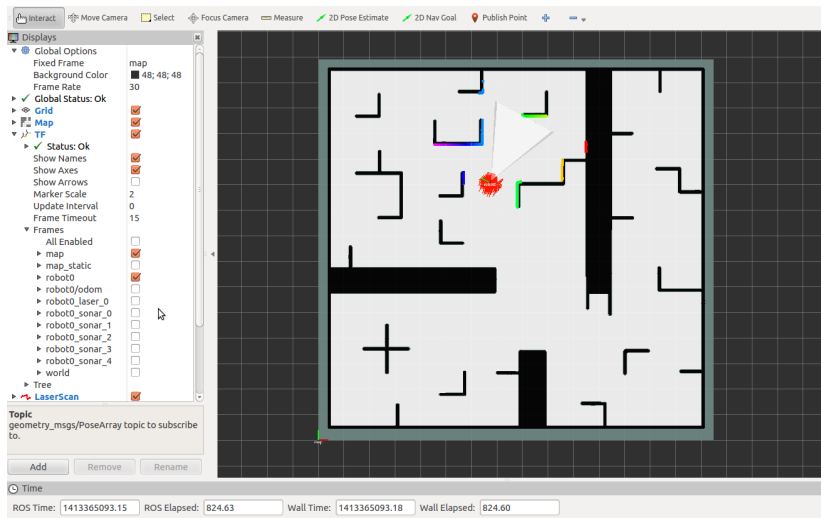
TF tree



- We are ready to run the AMCL for which we will need to set the frames

```
$ rosrun amcl amcl _use_map_topic:=true \  
scan:=/robot0/laser_0 _odom_frame_id:=/world \  
_base_frame_id:=/robot0 _global_frame_id:=/world
```

- We are taking a shortcut here by saying that our odometry frame is the map frame (this causes error but for the moment it is safe to ignore it)
- In the RViz add PoseArray to visualize particlecloud topic and click 2D Pose Estimate and then click on the map to set up the initial position
- Drive the robot around a bit and see how the algorithm converges to the location



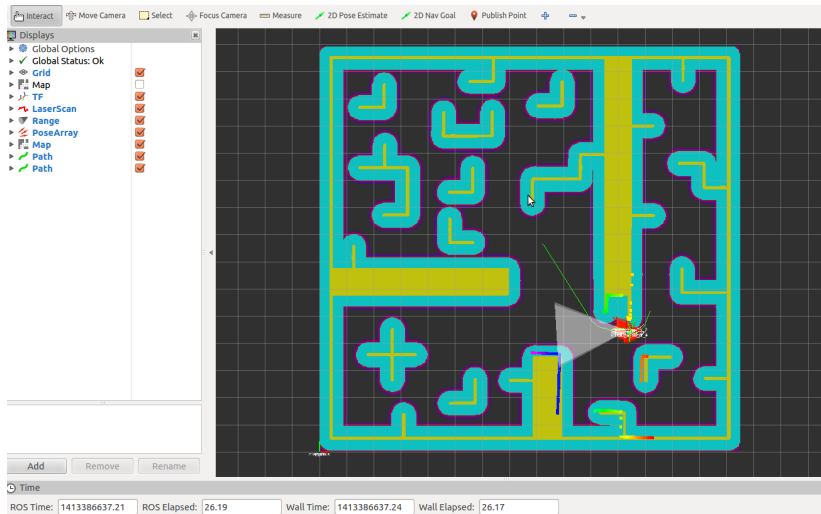
- Now that you have the map and a way to localize your robot in the map we can start with robot navigation
- In essence, the purpose of navigation is to move the robot from point A to point B
- But this stems a plethora of problems: finding the optimal global path, acting locally, avoiding static and dynamic obstacles, recalculating paths due to changes in the environment, controlling the robot etc.
- We will use the Move Base package

- Unpack the prepared configuration files and the launch; update the hardcoded lines in the launch file to point at the unpacked folder
- Be sure that STDR simulator, AMCL, and RViz are running
- Open the prepared RViz visualization file
- Make sure that the robot is properly localized
- Launch the prepared launch file

```
$ roslaunch move_base_stdrr_sim.launch
```

- In RViz click on the 2D Nav Goal, set it, and see the robot move!

Move Base



Homework

For homework you will need to build the map of the environment using the GMapping package.

Assignments

- 1 Study the GMapping documentation. What topics does GMapping subscribe to?
- 2 You will have to remap the scan topic, and odometry and base link frames (Hint: look for the exact topic names in the GMapping documentation or GitHub source code or both)
- 3 STDR simulator publishes map on the `map` topic. Make sure that GMapping does not do the same or otherwise the GMapping node will kill the STDR node!
- 4 Manually drive the robot until you have a complete map. Create an image consisting of four snapshots of the map in RViz taken at different times. Submit the snapshot images as your homework.

Homework

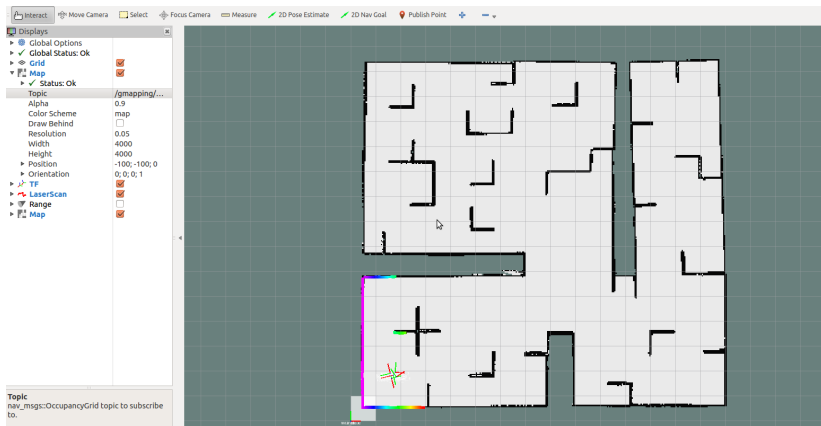


Figure: An example of a map produced by the GMapping package

- <http://www.ros.org/wiki/gmapping>
- <http://openslam.org/>
- http://www.ros.org/wiki/hector_slam
- <http://www.ros.org/wiki/amcl>
- http://www.ros.org/wiki/move_base