Environment mapping and robot localization in robotics with focus on use of sonar and laser sensors in Pioneer robot.

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Intermediate Project
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Abstract

Student project about the comparison of sonar and laser scanner in regards to Pioneer 3-DX and and mapping its surroundings. With use of ROS and associated softwares there was developed script which creates occupancy grid maps basing on data from laser scanner.

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1 Introduction

As my Intermediate Project I've chosen topic which covers aspects of mobile robotics. I decided to focus on mapping environment using sensors which are included in Pioneer 3-DX available in one of the laboratories of our Chair of Cybernetics and Robotics.

1.1 Assumptions

My goal was to make a way to map surroundings of mobile robot with use of laser scanner, sonar and encoders. I wanted to present then in easy to view form.

1.2 Constrains

What was constraining me was especially time and knowledge, where obtaining second one used the first one. Another thing was that robot is available only in laboratory, so contact with it was restricted.

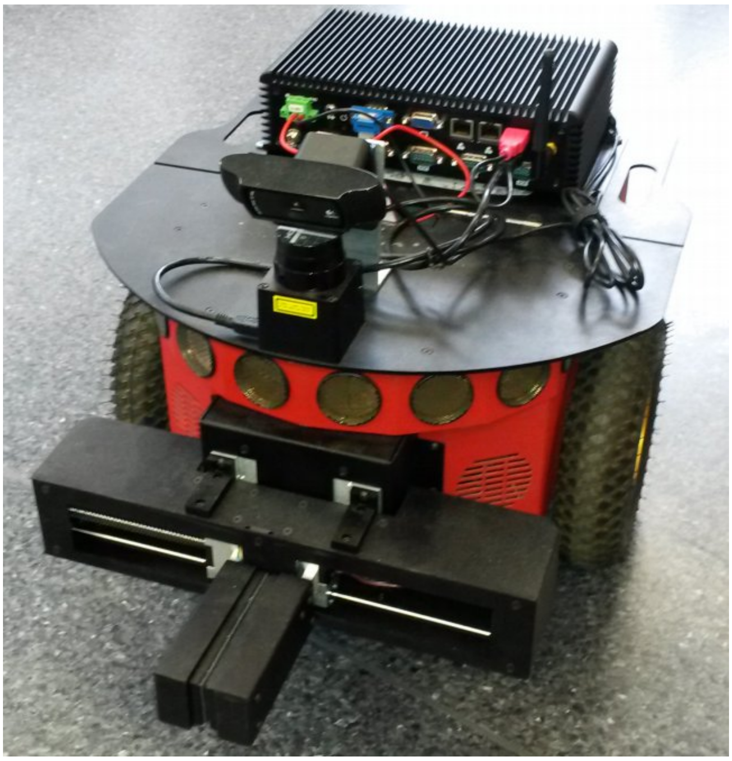

Figure 1: One of the Pioneer 3-DX used in Laboratory

2 Project development

During project I created python script which maps the surroundings in Occupancy grid map. It makes use of ROS (Robot Operating System) and its components which connects Pioneer robot with ROS, which makes possible to get data from sensors.

2.1 Preparation

Before were few things which were necessary to run robot and make it possible to connect to it in regards of software.

Those were:

- `ROS` environment [1]
- `ROSARIA` package [2]

Very useful was `RosAriaDriver`[3] made by Damian Barański, which simplifies connection to ROS topics related to robot.

2.2 Setting up

To operate properly running `roscore` [4] is required (as it is 'core' of `ROS` and needs to be running every time `ROS` is used).

When `roscore` was already running I was able to use `rqt_robot_steering` to control movement of robot. Using this it is possible to change values of driving and rotating velocities of robot with use of two sliders, which are then sent as messages to corresponding `ROS` topic.

To be able to progress without constant need to work with robot I used `rosbag` functionality which allowed me to record all topics and messages which were exchanged in `ROS` during movement, and which later are helping to simulate moving robot and its sensors in 'off-line' mode.

Later i 'replayed' it using `rosbag play` command.

[1] [http://www.ros.org/]
[2] [http://wiki.ros.org/ROSARIA]
[3] [http://panamint.ict.pwr.wroc.pl/~dbaransk/rosaria_drive/dox/html/index.html]
[4] [http://wiki.ros.org/roscore]

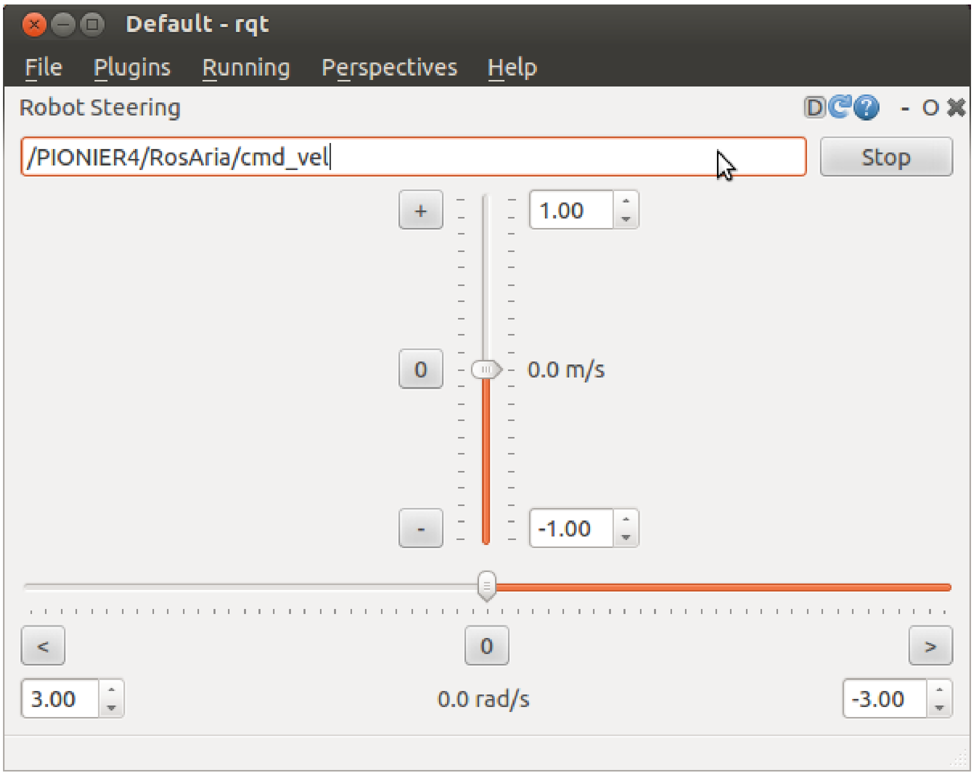

Figure 2: `rqt_robot_steering` window, connected to corresponding `ROS` topic with values set to zero

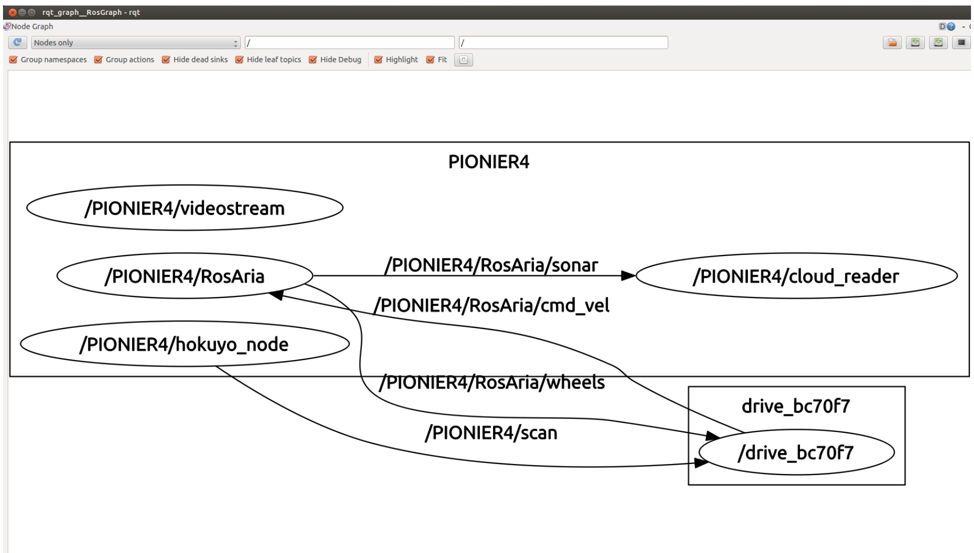

Figure 3: `rqt_graph` which shows connections between components

3 Sonar and laser scanner comparison

One of the things i wanted to check was how data obtained from Sonar and from laser scanner differs. Those are two different type of sensors so it would be helpful to decide on one and use it to mapping.

Main difference between then is angular resolution. It derives from two different ways of propagating signal.

Sonar uses ultrasounds which are acoustic waves, they tend to propagate in every direction and easily deflected multiple times which does not helps to state measurements.

This fact that sounds does not propagates as beam but as cone-like shape is the reason why in mobile robots there are limited amount of ultrasound sensors. In Pioneer 3-DX we have 8 of them located in front part of robot placed on arc of 180 degrees.

Laser scanner uses laser beam which reflects from rotating mirror. Laser beam does not spreads and keeps constant width. This property of light gives laser scanner critical advantage compared to sonar: angular resolution.

Laser scanner incorporated in Pioneer 3-DX robots used in laboratory measures distance at 512 different angles spanned at 180 degrees arc (same range as sonar). This advantage gives it much higher precision and faster map making process.

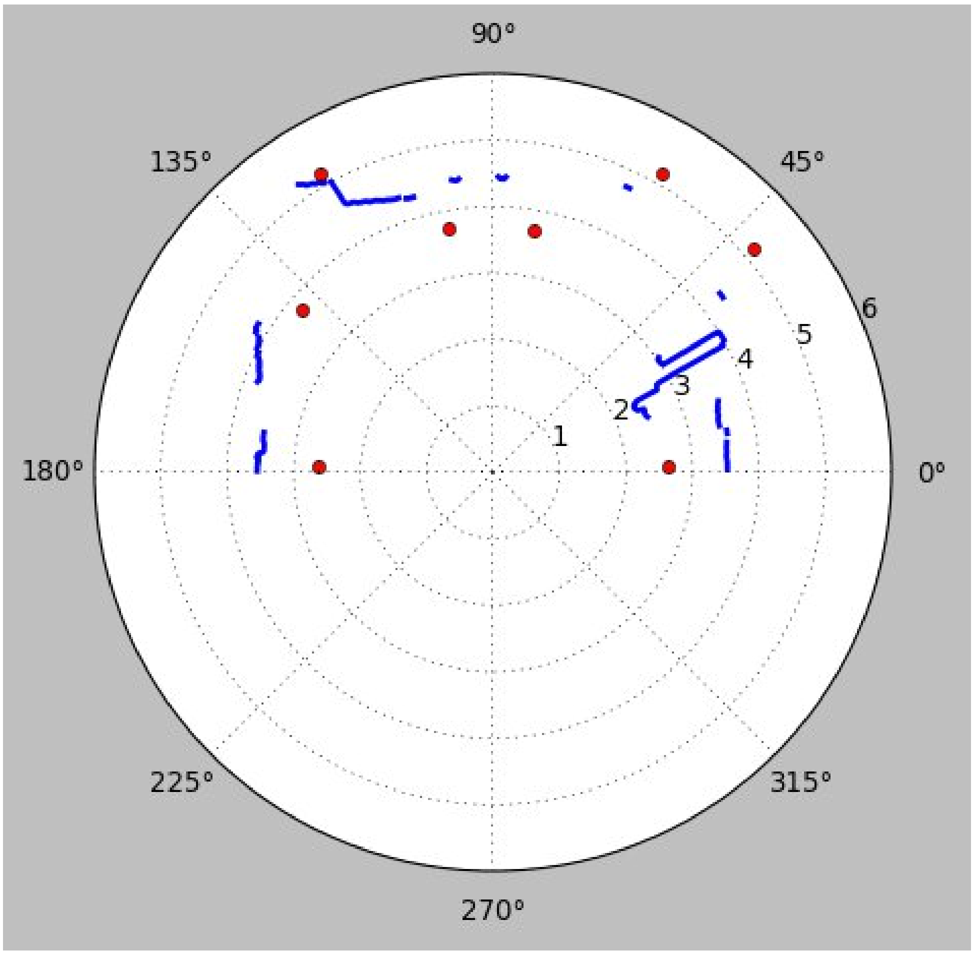

Figure 4: comparison of data acquired by both sensors
red dots are measurements from sonar
blue points are measurements from laser scanner

4 Mapping using laser scanner

4.1 Method

I decided to use laser scanner as source of data and occupancy grid map as representation on surroundings.

Occupancy grid mapping is probabilistic robotics algorithm which based on data with noise is able to decide if there is obstacle present or not.

Occupancy grid is a map of environment, divided in even cells, in which every cell is represented by probability of obstacle being present in it.

For every cell there is calculated probability of containing obstacle, which is modified with each measurement which refers to this cell (f.e. laser beam goes through it or obstacle was detected).

4.2 Results commentary

probability of obstacle existing in cell is depicted as gray-scale, where white color indicates obstacle-free cell, and black indicates detected obstacle.

As it is visible in figure 5, grid map changed its clarity in every each iteration - color of area which was obstacle-free was becoming lighter, cells which included obstacles became black.

Between second and third screenshot there is visible example of change in area which was covered - there was executed first movement of robot forward 'south'. It is also visible in following transitions, where robot changed its direction and made it possible to scan what originally was behind it and not visible.

In last screenshot we can distinct few features in surroundings:

- In top-right corner there is clearly visible indentation in classroom - which is room in which network routers and switches are installed.
- At bottom wall there are visible two sections which are pushed up - those are two heaters standing in those places.
- on the left part of screenshot there is aggregation of dots which is hard to explain without knowledge that it was the place where I was sitting in time of measurements.

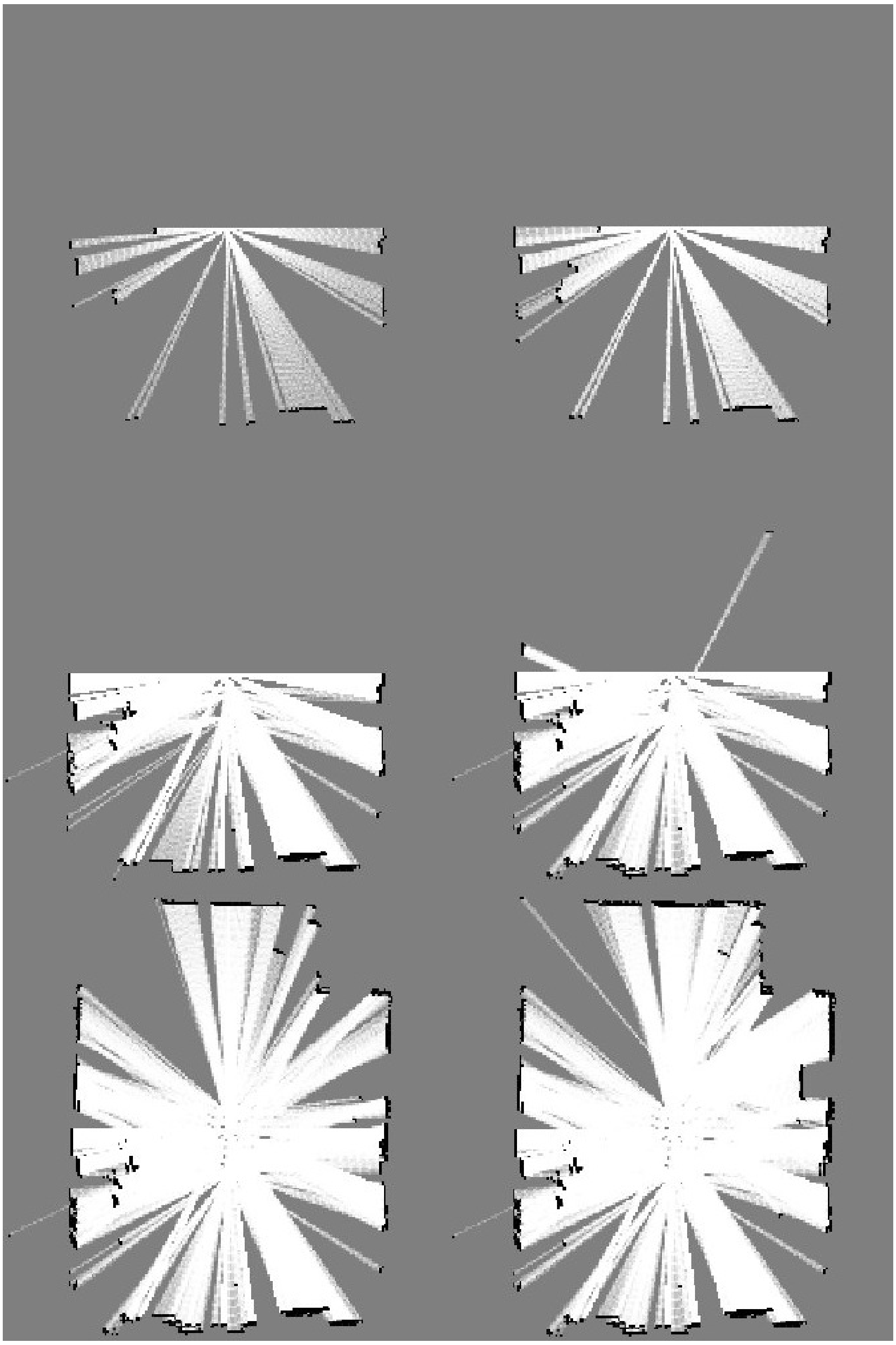

Figure 5: Occupancy grid map in 6 different moments (for visibility of changes) from top left to bottom right
- darker shade indicates higher probability of obstacle

5 Conclusions

After finishing this project there is moment to make few conclusions.

First conclusion which arises regards software and is about `ROS`. In this semester for the first time i had contact with this environment. It was not only during works on this project, but also during another courses, among them in one `ROS` was the main object of interest. In this place i would like to say, that I grown up to like it. After first shock while using it became fine tool, flexible and light-weight.

Second conclusion connects with first one and it's about robots and it's software. During developing this project i encountered many solutions which were well developed and documented, which made them easy to use. It only encourages me to make a resolve to not only getting something done in the future, but also done well.

Third conclusion is about encountered sensors and their functionality and significance in regards to some divisions of mobile robotics such as autonomous cars. After 'experiencing' how it works it gave me a deeper understanding how technologies like that develops.