Master 2 Recherche "Systèmes Dynamiques et Signaux" Subject

2021-2022

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Title : Graph based SLAM with a set membership approach
Keywords : SLAM, Mobile Robotics, Interval Analysis
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Context :

Localization is one of the most fundamental requirement for an autonomous mobile robot. Localization is the basis of all the missions the robot could have (path planning, detection, exploration...). Considering indoor robotics (inside buildings), all satellite-based localization solutions are useless. To be able to locate themselves, robots need a map (a known representation of their environment). However, in many cases it is not possible to have this map a priori. We therefore find ourselves in a situation where the robot must make its own map to localize itself, but needs to localize itself to make the map. This problem is classically called SLAM, for Simultaneous Localization and Mapping (Figure 1).
One approach to solve this kind of problem is to consider it as a puzzle: the first data acquired by the robot represents the first piece of the puzzle to which all the other pieces (the new measurements acquired over time) will be added in a consistent way.
There is a multitude of SLAM approaches [1, 2, 3], considering different tools to generate the map (occupancy grid, graph...).

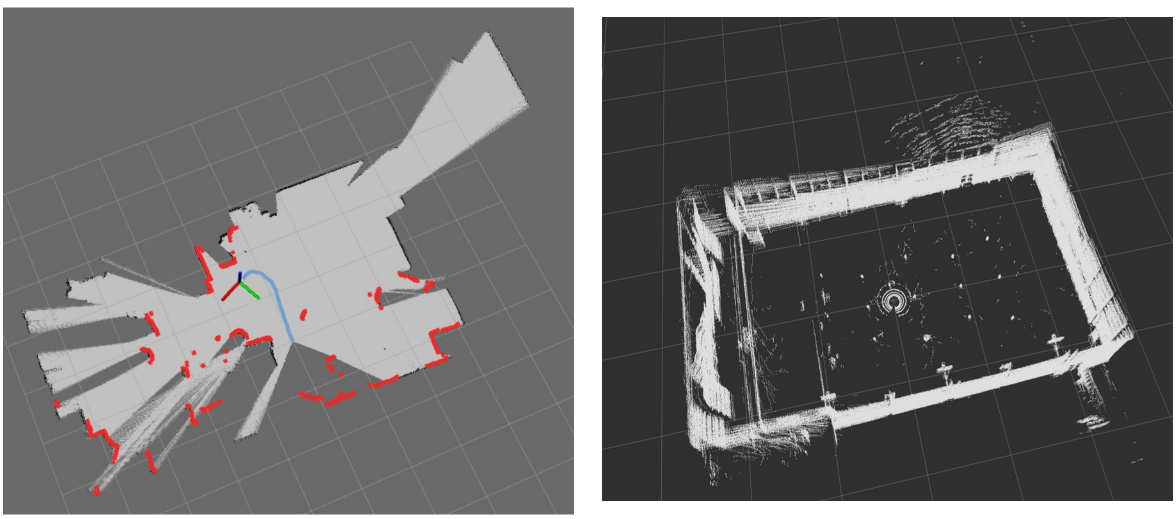
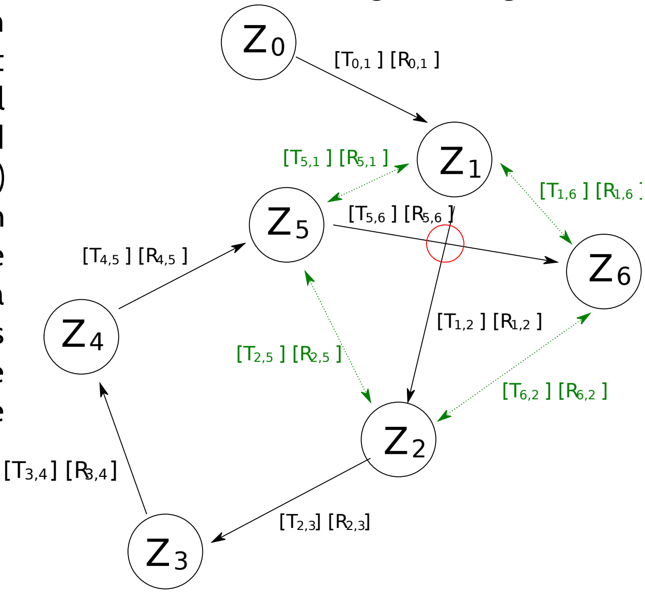


Figure 1: SLAM examples

Subject

Interval analysis is a set membership approach that allows guaranteed computation. Assuming a bounded error context, it allows to compute uncertainties with a guaranteed result: for instance if a range sensor has a +/- 2cm precision and provides a 751cm measurement, I can conclude that the actual measured distance is in the interval [749, 753]cm. This interval arithmetic can be used in mobile robotics [5, 6].

The objective of this project is to develop a new graph based SLAM approach using LiDAR[1] data and interval analysis for loop detection.
Let Z_t be the measurements done at time t (a point cloud provided by the LiDAR sensors). As the time goes by, the sensor provides several measurements Z_0, Z_1,... Z_t. Using a ICP[2] algorithm it is possible to evaluate the transformation (translation T and rotation R) between to point clouds (measurement sets). Using interval analysis the idea is to have a guaranteed evaluation of the transformation ([$R_{t-1,t}$], [$T_{t-1,t}$]) between the measurements Z_{t-1} and Z_t. Then using loop detection (identify the places where the robot went at two different times). The idea is that when a loop is detected, more constraints can be add to the graph in order to improve the overall measurements localization, and thus the robot localization.



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1 Light Detection And Ranging
2 Iterative Closest Point