Master 2 Recherche "Systèmes Dynamiques et Signaux" Subject

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Title : A set membership approach for ground truth evaluation: application to mobile robot localization and SLAM evaluation
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Laboratory : LARIS, University of Angers
Team : Systèmes Dynamiques et Optimisation (SDO)

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], and being able to evaluate their precision can be interesting. Usually to evaluate a SLAM result, it is compared to a ground truth.

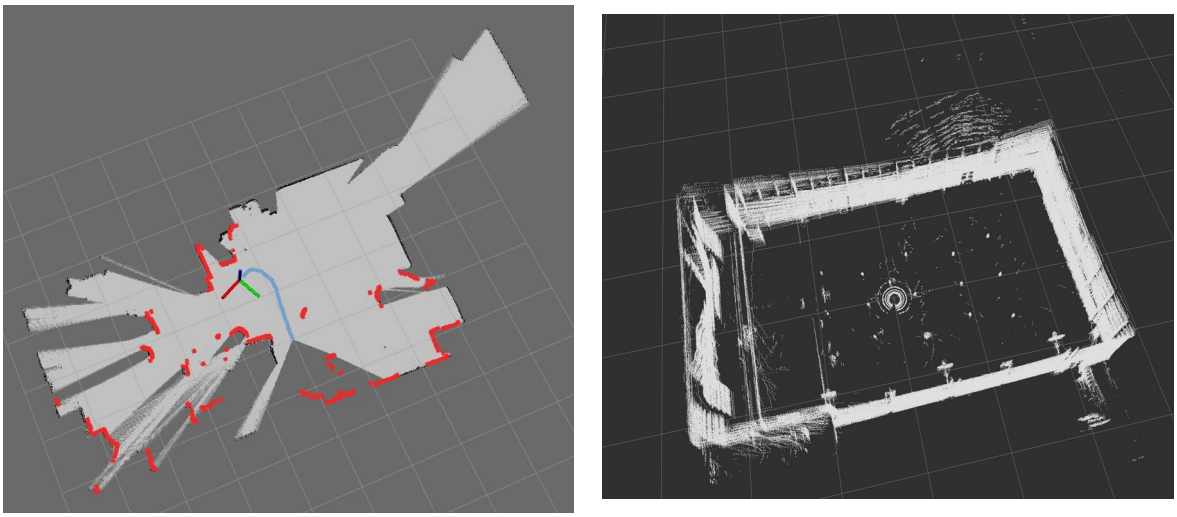


Figure 1: SLAM examples

Subject

The drawback of using a ground truth to evaluate a SLAM result is that it requires a ground truth... This Lapalissade hides the fact that it can lead to tedious work to have the so called ground truth and that it can raise several questions as "how precise is it?".

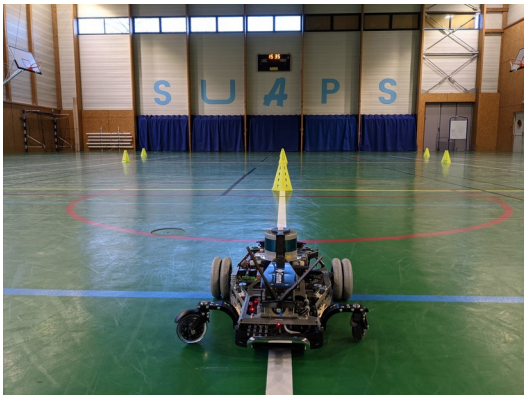
Interval analysis is a set membership approach that allows guaranteed computation. Assuming a bounded error context, it allows to compute uncertainties with a guaranteed result: for instance if a range sensor has a +/- 2cm precision and provides a 751cm measurement, I can conclude that the actual measured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

The objective of the project presented here is to propose an approach to

- Provide a guaranteed ground truth based on interval analysis
- Evaluate a SLAM result based on the guaranteed ground truth

This project also aims to implement this approach with actual mobile robot data, based on ROS[1] middle-ware.

ROS.org



Bibliography

[1] WANG, Peng, CHEN, Zonghai, ZHANG, Qibin, *et al.* A loop closure improvement method of Gmapping for low cost and resolution laser scanner. *IFAC-PapersOnLine*, 2016, vol. 49, no 12, p. 168-173.

[2] KOHLBRECHER, Stefan, MEYER, Johannes, GRABER, Thorsten, *et al.* Hector open source modules for autonomous mapping and navigation with rescue robots. In : *Robot Soccer World Cup*. Springer, Berlin, Heidelberg, 2013. p. 624-631.

[3] NÜCHTER, Andreas, BLEIER, M., SCHAUER, Johannes, *et al.* Improving Google's Cartographer 3D mapping by continuous-time slam. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2017, vol. 42, p. 543.

[4] FILIPENKO, Maksim et AFANASYEV, Ilya. Comparison of various slam systems for mobile robot in an indoor environment. In : *2018 International Conference on Intelligent Systems (IS)*. IEEE, 2018. p. 400-407.

[5] Kieffer, Michel, et al. "Robust autonomous robot localization using interval analysis." *Reliable computing* 6.3 (2000): 337-362.

[6] Guyonneau, Rémy, et al. "Guaranteed interval analysis localization for mobile robots." *Advanced Robotics* 28.16 (2014): 1067-1077.

1 Robot Operating System