Design and Evaluation of a SLAM Algorithm for a Small-Scale Multi-Robot System

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This semester project aims to implement a physic based simulation using Webots for targeted on-board Multi-Robot SLAM (MR-SLAM) using the small scale mobile robots Khepera IV (K4).

The K4's sonars are used as exteroceptive sensors for mapping the environment. Two SLAM simulation frameworks, one based on LIght Detection And Ranging (LIDAR) and another one on five sonars, have been setting up.

The Rao-Blackwellised Particle Filter SLAM (RBPF-SLAM) algorithm with grid-map representation is used in both cases. The open source library named Mobile Robotics Programming Toolkit (MRPT) has been chosen to implement the SLAM controllers in Webots.

Additionally, several modifications have been done concerning the simulated sonar model on Webots, leading to more realistic simulations. The two different distributions, uniform circle and 2D gaussian, have been tested for generating additional points. The goals were to better represent the beam-like shape and to overcome the sparseness of such sensors.

A two stages navigation architecture composed of an obstacle avoidance, with highest priority, and of a way points navigation have been implemented.

The odometry is successfully improved thanks to both maximum speed and acceleration limitation blocs running at the end of the navigation part.

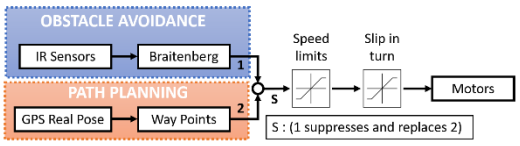

Figure 1: Navigation scheme, Behavior based with Subsumption.

The resulting maps and pose estimations of three simulations, one LIDAR based SLAM and two sonar based SLAM, are discussed.

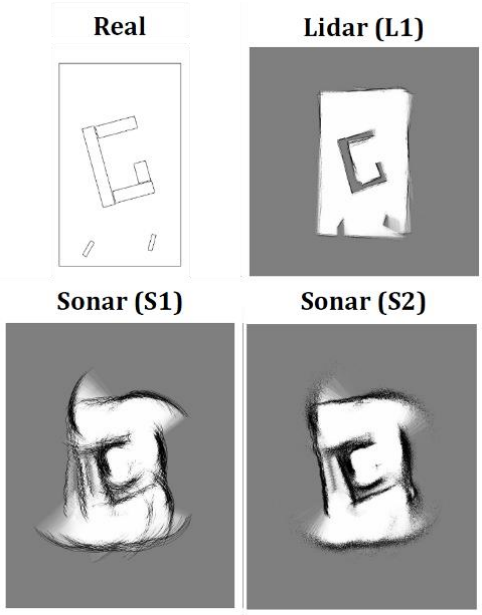

Figure 2: Resulting maps. ***[Upper Left]:*** *Real Map.* ***[Upper Right]:*** *Resulting map of the LIDAR SLAM (L1).* ***[Lower Left]:*** *Resulting map of the sonar based SLAM (S1) using Circle-like distribution.* ***[Lower Right]:*** *Resulting map of the sonar based SLAM (S2) using 2D-Gaussian distribution.*

Three critical points are identified for sonar based SLAM: odometry accuracy, the sensor sampling scheme and the quality of the sonar measurement.

The key message is to plan how moving to not decrease the quality of both odometry and sonar measurements, while designing the navigation blocs.

Finally, an idea for possible future work about centralized multi-robot systems is presented.