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Developing an Experimental Baseline for Navigation Research with the Khepera III Mobile Robot Platform

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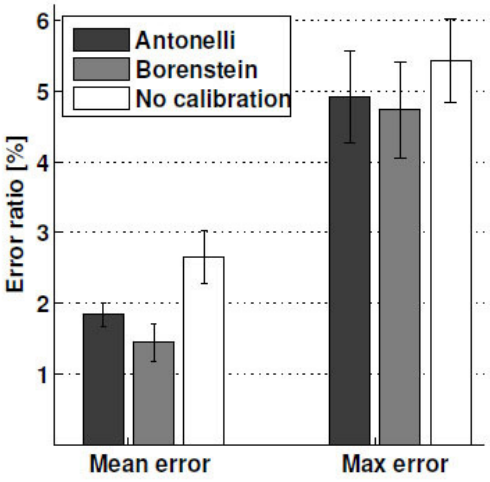
The growing demand for indoor location-based applications is creating a need for systematic, efficient, and precise experimental methods able to assess the localization and perhaps also navigation performance of a given device. The Khepera III is a popular platform for research, with hundreds of them in academic use today, and has an important potential for single and multi-robot localization and navigation research. In order to create a baseline for more complex navigation techniques, we looked at the Khepera's localization capabilities based only on its on-board sensors.

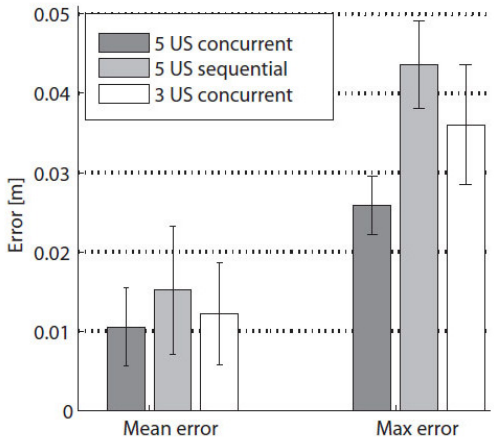


Normalized (over distance) error ratio obtained for the odometry calibration methods, as well as for non-calibrated robots. The errorbar shows a 95% confidence interval.

An integral part of most localization techniques is the use of odometry. Odometry provides good short-term accuracy, is inexpensive, and allows very high sampling rates. Nevertheless, the fact that odometry is based on the integration of incremental motion information over time leads unavoidably to the accumulation of errors.

Systematic errors given by uncertainties in the kinematic model can be significantly reduced by calibration methods like the one proposed in 1996 by Borenstein, based on a geometric derivation, or the least-squares formulation of the problem proposed by Antonelli in 2005. Both approaches were applied and their performance compared.

The next step was to add exteroceptive sensing and fuse it together with the odometry through an extended Kalman filter (EKF). The ultrasound sensors on the Khepera were modeled using a geometric approach for scan predictions and extensive experiments to characterize the beam shape.



Performance of the EKF localization algorithm with different sensor configurations

The algorithm was tested in a 3x3m^2 arena and the obtained results show that in this basic scenario, the Khepera III is able to localize itself with an error that is below 1.5cm in average (which is in the order of the ground truth measurement error). Three firing schemes for the ultrasound sensors were used, with the version in which all the sensors were fired at the same time proving to be the best. In other words, in this scenario, the importance of having a high measurement rate was more important than any crosstalk effect that might have appeared.