Cooperative localization of mobile robots with biased measurements by using Constraint Propagation

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Abstract

When mobile robots need to cooperate, mutual localization is a key issue. The objective is to provide the robots with cooperative localization capabilities, such that each robot determines the partner position with respect to its own local coordinate frame with some confidence estimates. Exteroceptive sensors can measure distance to known beacons in order to provide an absolute information of the position of the robots. Often there are biases that affect these measurements because of particular environment conditions or because of inaccurate knowledge of the beacons positions. Cooperative localization is a way to remove the effect of those biases. In this work, each robot is also equipped with proprioceptive sensors, but there is no sensor that measures the inter-distance between the robots. The method that we consider is fully distributed among the robots which cooperate together and the robots share positions and biases estimates. In order to handle the data incest problem, we use Constraint Propagation (CP) techniques on intervals. Therefore, the proposed Distributed Cooperative Localization (DCL) method gives sets that always contain the true position of robots without any over-convergence, unlike conventional probabilistic methods such as EKF, which need to handle private copies of the knowledge of the group to address this over-convergence issue.

In this work, only two robots are taken in consideration, but the localization method can be easily extended and it can be applied to an heterogeneous system made with robots of different kinds such as ground and aerial robots.

In order to evaluate the performance of the method, several comparisons have been conducted in simulation. We consider an environment where beacons with known location are distant from the evolution area of robots like a typical geometrical configuration of GPS satellites. We assume that each robot follows a circular trajectory with different radius. The robots communicate to share positions, biases estimates and measurements information, but it can happen that they lose communication in some areas. Three scenarios have been therefore simulated. In the first, each robot localizes itself in a standalone mode, in the second one cooperative localization with a fully-available communication is addressed and, in the last one, cooperative localization is done with intermittent communication.

Simulation results show that the cooperative method improves the localization performance highly compared to standalone methods. Measurement biases are eliminated deeply. It is also able to give the mutual position of every cooperative robot even when communication is lost.

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