CUPID algorithm for indoor multipath-aided cooperative localization using a single anchor

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ABSTRACT

The main drawback today for range-based indoor localization is the requirement of a sufficient amount of fixed reference nodes within radio range of the user. However, these reference nodes, called anchors, are expensive and require professional maintenance. Using ultra-wideband in an indoor environment, the number of anchors can be reduced to one when reflections are taken into account. With the help of a floorplan it is possible to obtain a set of virtual anchors that can be associated with the reflections. However, due to the non-identifiability of the measured reflections, simple multilateration techniques are not applicable. In a probabilistic approach where reflections have a certain probability of coming from a certain virtual anchor, estimating the absolute position of a user becomes possible. When multiple cooperating users are considered, this leads to a highly non-linear and non-convex problem that cannot be solved using optimization techniques without accurate initial estimates.
In this paper the two-step CUPID (Cooperative UWB Positioning InDoor) algorithm is presented. A first step consists in estimating relative coordinates of the cooperating users and the anchor using weighted Multi Dimensional Scaling. After identifying the anchor position, these relative coordinates can be mapped to absolute coordinates with an orthogonal transformation, i.e., a rotation and/or reflection. In the second step, this orthogonal transformation is obtained with a maximum likelihood (ML) estimator that exploits the multipath information for all different users. Further refinement of the estimates can be obtained by using a joint ML estimation with the CUPID estimations used for initialization. Using extensive simulations, it is shown that the presented, low-complex algorithm can provide positioning accuracy similar to multi-anchor localization algorithms, even in scenarios with many unwanted scatterers and non-line-of-sight. Extending the algorithm for tracking is straightforward and can be considered as well.

KEYWORDS: localization, cooperation, indoor, ultra-wideband, multipath-aided.