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Complexity-reduced FootSLAM for Indoor Pedestrian Navigation

Achieving *t log t* Complexity for Real-Time and Mass Market Usage

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ABSTRACT

FootSLAM or simultaneous localization and mapping (SLAM) for pedestrians is a technique that addresses the indoor positioning and mapping problem based on human odometry (aka pedestrian dead reckoning), e.g. with a foot-mounted inertial sensor. FootSLAM follows the FastSLAM factorization, using a Rao-Blackwellized particle filter to jointly estimate the building layout and the pedestrian's pose – his position and orientation. To that end, FootSLAM divides the 2D space into a grid of uniform and adjacent hexagons and counts the number of times each particle crosses the edges of the hexagons it visits. The complexity per time step of a naïve implementation of this algorithm grows with the product of the number of particles and the area they visit.

In this paper we present a new geographic tree-based data structure, called H-tree, to reduce the quadratic in time growth of naïve FootSLAM to *t* times *log t* growth. The H-tree builds on a perfectly-balanced global, pre-computed tree in which each leaf refers unambiguously to a hexagon in the grid. The paths to each hexagon are pre-stored and each particle builds its own (sparse) dynamic tree using those paths to copy the corresponding branches from the global tree.

In addition, a compact representation (alphabet) for the set of transition counters across the edges of the hexagons is used. For efficient map updates, the next six possible transitions are pre-computed for each alphabet symbol. This alphabet is particularly effective during the exploration phases of FootSLAM that requires much particle diversity.

In this contribution we present the computational savings of the H-tree both theoretically and with real-world data. In practice, we believe that FootSLAM can be applied in quasi real-time applications that require rapid mapping of unknown areas. Additionally, the mass market offline mapping process can be undertaken much more efficiently.

KEYWORDS: indoor navigation, real-time pedestrian localization and mapping, FootSLAM, FastSLAM.

NOTE: We plan to submit a real-time demonstration to IPIN.