The Next Generation Multi-Robot Exploration: Biased Viewpoint Sampling via Dynamic Voronoi Space Partitioning and Receding Horizon Scheme

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Multi-robot exploration problem is generally constituted of three NP-hard problems, which are a determination of next-best-views (NBVs), a path planning, and a multi-robot coordination. This paper presents an effective 3D multi-robot exploration algorithm in order to solve the inefficiency that takes place when the aforementioned three components are performed individually. The proposed algorithm is composed of two parts: an allocation of exploration regions and a determination of the best path. For the allocation of the region to explore, each robot generates a sampling-based tree, e.g. RRT, which composes a Voronoi-biased forest (VBF). A VBF, a new data structure introduced within this work, dynamically assigns a region for each robot to explore in a probabilistic manner. The amount of the space a VBF covers is quantitatively analyzed depending on its parameters. From the generated VBF, each robot determines the best path from branches of its tree based on the amount of information gained along and the paths of peer robots. Only the first edge of the best branch of each tree is executed in a receding horizon scheme. The overall exploration algorithm is evaluated in a computer simulated environment. The results demonstrate that our coordination algorithm allows robots to explore the environment both more reliably and quickly than widely used previous algorithms.