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Probabilistic Consensus on Feature Distribution for Multi-Robot Systems

Multi-robot systems (MRS) composed of multiple mobile robots have been used for various collective exploration and perception tasks, such as mapping unknown environments, disaster response, and surveillance and monitoring. The performance of MRS in such applications is constrained by the capabilities of the payloads that the robots can carry on-board, including the power source, sensor suite, computational resources, and communication devices for transmitting information to other robots and/or a central node. These constraints are particularly restrictive in the case of small aerial robots such as multi-rotors that perform vision-guided tasks. Centralized MRS strategies for exploration and mapping, such as the next-best-view planning method, rely on constant communication between all the robots and a central node. Scaling up such strategies with the number of robots requires expanding the communication infrastructure and preventing communication failures of the central node.

Decentralized MRS exploration and mapping strategies that employ only local communication alleviate these drawbacks and are designed to work robustly under inter-robot communication bandwidth constraints and disruptions to communication links by environmental effects. Many decentralized MRS estimation strategies are designed to achieve consensus among the robots on a particular variable or property of interest through local inter-robot communication. For example, distributed consensus-based approaches have been designed for spacecraft attitude estimation and space debris tracking. Consensus strategies have been developed for MRS communication networks that are static or dynamic, and that can be represented as directed or undirected graphs, as well as random networks and networks with communication delays. However, few works address consensus problems for MRS that follow random mobility models, often used in MRS exploration strategies. With random exploration strategies having certain advantages for MRS, such as not requiring centralized motion planning, localization, or communication, there is a need for a MRS strategy for tracking multiple static features without any requirements on the connectivity of the robots' communication network.

Researchers at Arizona State University have developed a multi-robot exploration and mapping strategy in which the robots use a consensus protocol, without communication connectivity requirements, to arrive at a common reconstruction of a feature distribution on a 2D grid. This strategy can reconstruct a discrete distribution of features, modeled as an occupancy grid map, that represents information contained in a bounded planar 2D environment, such as visual cues used for navigation or semantic labels associated with object detection.

Related publication: Probabilistic Consensus on Feature Distribution for Multi-robot

Systems with Markovian Exploration Dynamics

Related video: Probabilistic Consensus on Feature Distribution for MRS with Markovian Exploration Dynamics

Potential Applications:

- Multi-Robot System (MRS)

Benefits and Advantages:

- Robots update their estimate of feature distribution using their own measurements during random-walk exploration and estimates from nearby robots
- Strategy is distributed and asynchronous, and it preserves the required communication bandwidth by relying only on local inter-robot communication
- Strategy has been validated in both numerical simulations and software-in-the-loop (SITL) simulations with quadrotors