



# Large Robotic Swarm Control via Random Finite Set Theory

## Decentralized Robotic Swarm Control Policy

This technique for controlling swarms of robotic units uses technical control algorithms based on Random Finite Set (RFS) theory. Using this method, each robotic device has a computing platform (i.e., an embedded processor) configured to apply the techniques to estimate local formation configuration and design a decentralized control policy, thus achieving a local, individualized configuration of each robotic device of the swarm. Using RFS theory for localizing and controlling swarming units and solving the control problem employs behavioral distribution and model predictive control to generalize the swarm state. The RFS-based approach localizes swarms through a Gaussian mixture Probability Hypothesis Density (PHD) filter, and then information divergence defines the distance between swarm RFS and a desired distribution. A stochastic optimal control problem is formulated using the information divergence, and it is solved through behavioral distribution and model predictive control.

## Low Cost Approach for Swarm Satellites, UAVs and Rovers

Controlling large swarms of robotic units has many challenges, such as computational complexity due to the number of units, uncertainty in the functionality of each unit in the swarm, and limited knowledge of information of each unit. This random finite set-based approach addresses these challenges, and through optimal control, the swarm can optimally track a target density to a cost function. Decentralized approaches to controlling swarms through optimal transport and sequential convex programming create efficient trajectories for swarms including uncertainty, but they require computational power. This new approach considers the swarm units as a distribution through random finite sets and provides optimal trajectories—including uncertainty—without requiring computational power. This approach works best for low cost swarms swarm satellites, UAVs and rovers.

### BENEFITS AND FEATURES:

- Controls swarms of robotic units
- Based on Random Finite Set (RFS) theory
- Estimates local formation configuration
- Designs a decentralized control policy
- Achieves a local, individualized configuration of each robotic device of a swarm
- Employs behavioral distribution and model predictive control
- Applies a Gaussian mixture Probability Hypothesis Density filter
- Information divergence defines the distance between swarm RFS and a desired distribution
- Modified  $L^2_2$  distance formulates a stochastic optimal control problem

### APPLICATIONS:

- Low cost swarm satellites, UAVS and rovers

**Phase of Development** - Proof of concept

### Researchers

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