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DISTRIBUTED FUSION SENSOR NETWORKS FOR SPACE SITUATIONAL AWARENESS

Abstract

The estimation and cataloging of debris objects in Earth orbit poses a number of challenges, driven by the nonlinear dynamical effects and exacerbated by incomplete force modeling and sparse data conditions. Improvements in state estimation, object characterization, and uncertainty quantification require networks of coordinated sensors providing broad coverage and complementary data types to effectively interrogate these problems. Given the large number of objects and limited number of sensors, it is essential to manage the network efficiently in order to maximize the information gained on the multitarget system.

In the ideal case, sensor networks would be highly centralized, working from a common object catalog updated in real time as new data are collected and processed. Centralized sensor management ensures all tasking decisions are based on the best available information at each time and therefore provides the best opportunity to approximate a globally optimal solution. In practice, however, processing and communication delays inhibit the implementation of a fully centralized architecture, and centralized fusion of measurements and tracks is complicated by the asynchronous operation of individual sensors.

Recent work exploring the use of distributed fusion sensor networks for Random Finite Set (RFS) multitarget distributions offers a principled approach to sensor network management. The RFS framework provides a mathematically rigorous and computationally efficient representation of multisensor-multitarget problems, including the ability to perform distributed data fusion using Exponential Mixture Densities (EMDs). The approach improves the flexibility of the network management scheme while maintaining an efficient use of sensor resources to gather data on orbital debris. This paper provides details on the implementation of a distributed fusion sensor network utilizing information theoretic tasking decisions for individual sensors. Results for a simulated network of optical and laser ranging sensors are provided and compared against a fully centralized architecture.

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