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# DISTRIBUTED DATA FUSION TECHNIQUES FOR CLASSIFICATION OF RESIDENT SPACE OBJECTS


**Abstract**

Space Situational Awareness (SSA) involves detecting, tracking, identifying, and characterizing resident space objects (RSOs). Knowing properties such as size, shape, configuration, rotational dynamics, and surface properties such as specular and diffuse albedo of a RSO are useful in accurate prediction of its motion. Previous work has shown that astrometric and photometric data from non-resolved observations can be used to estimate these characteristics.

This paper proposes utilizing distributed data fusion (DDF) techniques with use of a dual layer hierarchical mixture of experts (HME) to estimate an RSO's size and reflectivity in parallel using noisy simulated measurements. The HME 'experts' shall consist of unscented Kalman filters (UKFs) which are tested by the HME gating networks for probability of fitting the observation data. The filters differ in the size and reflectivity model characteristics of the RSO. These filters estimate state information of the RSO. The measurements consist of astrometric and photometric data from non-resolved observations of the target gathered via a telescope with a charged coupled device (CCD) camera. Each filter receives the same measurement sequence. The apparent magnitude measurement model utilizes a parametric directional statistics bidirectional reflectance distribution function (BRDF). The measurements, process models, and additional model characteristics allow the algorithm to predict the state and select the most probable fit to the size and reflectance characteristics based on the statistics of the UKFs.

Each site shall manage its own dual-layer HME filter. The measurement noise shall be independent since each site contains its own sensor. However, since they shall be tracking the same RSO, the process noise is dependent and therefore there is correlation in the uncertainties. The statistics of each UKF bank within the HME shall propagate through the DDF network with each node fusing the data of its neighbor with that of its own, updating the state estimates and covariance matrix of each UKF bank. The statistics of each fuzzed bank shall go through the HME network to predict the most probable size and reflectivity of the RSO. It will be shown that fuzzing data from multiple sites is more accurate than using a single site only.

The ability to detect and classify RSOs via ground based optical observations is of concern to the astrodynamics community as the space of Earth orbit and especially geosynchronous orbit fills up. This paper will show how the use of DDF with UKF banks together with HME can assist with this goal.