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DUAL LAYER HIERARCHICAL MIXTURE OF EXPERTS FOR SIMULTANEOUS ESTIMATION OF SIZE AND REFLECTIVITY OF 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 the 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 authors then compare the results to a single-layer mixture of experts (ME) and will show the viability and benefits of the dual-layer HME.

This paper uses banks of unscented Kalman filters (UKFs) as 'experts' which will be tested by the HME gating networks. 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 consists of the Ashikhmin Shirley 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.

This paper will show a method of selecting nodes within each ME macromode and then selecting the ME macromode with the highest probability of being the correct estimate.

The results show that the HME can select the correct size and reflectivity of the RSO and will properly address any limitations. This paper will demonstrate the potential usefulness of a dual layer HME and how it offers some computational advantages over a permutation of the states in a single layer ME.

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. Knowing properties such as size, position, velocity, rotational dynamics, and surface properties such as specular and diffuse albedo of a RSO are useful in accurate prediction of its motion. This paper demonstrates a new dual-layer HME method towards achieving this goal.