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Derivation of the multi-model generalized labeled multi-Bernoulli filter: a solution to multi-target hybrid systems

Key words: Multi-maneuvering-target tracking; Multi-model; Generalized labeled multi-Bernoulli filter; Multi-target hybrid systems

Corresponding author: Weihua WU
E-mail: weihuawu1987@163.com
ORCID: https://orcid.org/0000-0002-8737-3525

Motivation

1. Multi-target hybrid systems have attracted considerable interest in the field of state estimation and control, because it can model complicated behaviors of various estimation and control systems.

2. Applications of the augmented state method to probability hypothesis density (PHD), cardinalized PHD (CPHD), and multi-Bernoulli (MB) filters are straightforward since the structures of these filters are relatively simple. However, the generalized labeled MB (GLMB) filter is more complex and involves a labeled multi-target state space.

3. It is unknown whether directly incorporating an augmented discrete state will change the closure property of the GLMB filter. This question has not been answered although the multi-model GLMB (MM-GLMB) filter was proposed.

Main idea

1. The continuous kinematic state is augmented with an additional discrete mode state, and the mode state evolves as a Markov process with constant mode transition probabilities independent of the continuous state.

2. By defining a new H-GLMB (a GLMB for hybrid systems) density, we will prove that the H-GLMB density is closed under the Chapman-Kolmogorov prediction and Bayes update for multi-target hybrid systems.

Method

1. An exact derivation of the MM-GLMB filter is provided, which consists of the Chapman-Kolmogorov prediction and Bayes update.

2. Using the extended inner product, vector integral, and set integral incorporating the mode variables, and by substituting the new H-GLMB density into the multi-target Bayesian filter, we prove that the H-GLMB density is closed for multi-target hybrid systems.

Conclusions

1. A solution of multi-target hybrid systems with a focus on the multi-maneuvering-target tracking system, i.e., the MM-GLMB filter, has been derived strictly.

2. The H-GLMB density is closed under the Chapman-Kolmogorov prediction and Bayes update for multi-target hybrid systems.

Weihua WU, corresponding author of this paper, is an associate professor at the Air Force Early Warning Academy (AFEWA). He received his PhD degree from AFEWA, China, in 2015. He is a candidate of the Young Talent Support Project of Chinese Association for Science and Technology, and the recipient of the excellent doctoral dissertation of the whole army. He presided over the completion of a number of scientific research projects such as the National Natural Science Foundation. He was funded and has published three books in National Defense Industry Press: *Target Tracking with Random Finite Sets*, *Target Tracking Technology for Moving Sensors,* and *Multi-sensor Data Fusion*. His research interests include target tracking and information fusion, with a focus on random finite sets.