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Multiple Hypotheses Tracking Based Distributed Fusion Using Decorrelated Pseudo Measurement Sequence

Mahendra Mallick, Lucy Y. Pao, and K. C. Chang

Abstract**—** A joint probabilistic data association based algorithm for multi-target tracking in clutter using the distributed tracking architecture has been proposed recently. The algorithm uses the decorrelated state estimates or equivalent pseudo measurements. This paper extends the previous approach to the multi-target tracking problem in clutter with probability of detection less than unity using the track-oriented multiple hypotheses tracking framework. We present multiple hypotheses distributed tracking algorithms for track initialization, gating, hypothesis generation, track update, computation of track likelihood, formation of global hypothesis, and pruning using the pseudo measurement formulation.

I. Introduction

The central tracking architecture [1], [2] has been proved [3] to be more accurate than the distributed tracking architecture [1], [2]. However, when the number of sensors and targets is large, the central tracking architecture is not a suitable approach to handle the large amount of data and high computational complexity. Limits on communication bandwidth also prohibit large amounts of data to be transmitted to a central tracker in such a scenario. The distributed tracking architecture as shown in Figure 1 has advantages over the centralized tracking architecture for real world and real time applications due to robustness against failure at certain local tracking nodes with a small loss in tracking accuracy when a large number of sensors are used. Data transmission and computational complexity issues are well handled in a distributed tracking architecture.

Joint probabilistic data association (JPDA) [5] based algorithms for multi-target tracking in clutter using a distributed tracking architecture have been presented recently [7]. Two basic requirements of the standard Kalman filter (KF) used in a tracker are that the measurement error should be uncorrelated with the state prediction error and the process noise should be uncorrelated with the previous state estimation error. The later condition is automatically satisfied if the measurement arrival times are time-ordered. The algorithms presented in [7] construct an equivalent or pseudo measurement y_k [4], [6] using the predicted state estimate $\hat{x}_{k|k-1}$, updated state estimate $\hat{x}_{k|k}$, predicted covariance $P_{k|k-1}$, and updated covariance $P_{k|k}$ such that the measurement error $\tilde{y}_k$ is uncorrelated with the predicted state estimation error $\tilde{x}_{k|k-1}$. This process is known as the *decorrelation process*. The advantage of this approach is that existing centralized tracking systems can adopt this framework easily for the distributed tracking problem. For each resolved track, a local tracker sends the corresponding pseudo measurement y_k and associated error covariance matrix Σ_k to the global tracker. The covariance matrix Σ_k is a function of $P_{k|k-1}$ and $P_{k|k}$. This allows a more efficient transmission of data from a local tracker to a global tracker.

We extend the approach used in [7] to the multi-target tracking problem in clutter with probability of detection less than unity using the track-oriented multiple hypotheses tracking (MHT) framework [2], [8]. We assume that a local tracker processes data from one or more sensors. Each sensor has a probability of detection P_D less than unity and collects measurements in a scan or dwell. Measurements in a scan include detections from actual targets and false alarms or clutter. We assume that the number of false alarms per unit measurement volume obeys a Poisson distribution and the false alarms are uniformly distributed in the measurement space. For simplicity the dynamic and measurement models are assumed to be linear with additive Gaussian process noise and measurement noise, respectively. Nonlinear models for target dynamics or/and measurement models can be easily incorporated into the algorithms. We also assume that the dimension of the target state in all trackers is the same. These assumptions are used in [7].

Mahendra Mallick is with Lockheed Martin Orincon Corporation, 4770 Eastgate Mall, San Diego, CA 92121-1970, USA (e-mail: mahendra.mallick@lmco.com).
Lucy Y. Pao is with the Dept. of Electrical and Computer Engineering, University of Colorado, Boulder, CO, 80309-0425 USA, (e-mail: pao@colorado.edu)
K. C. Chang is with the Dept. of SEOR, George Mason University, Fairfax, VA, 22030-4444 USA (e-mail: kchang@gmu.edu)

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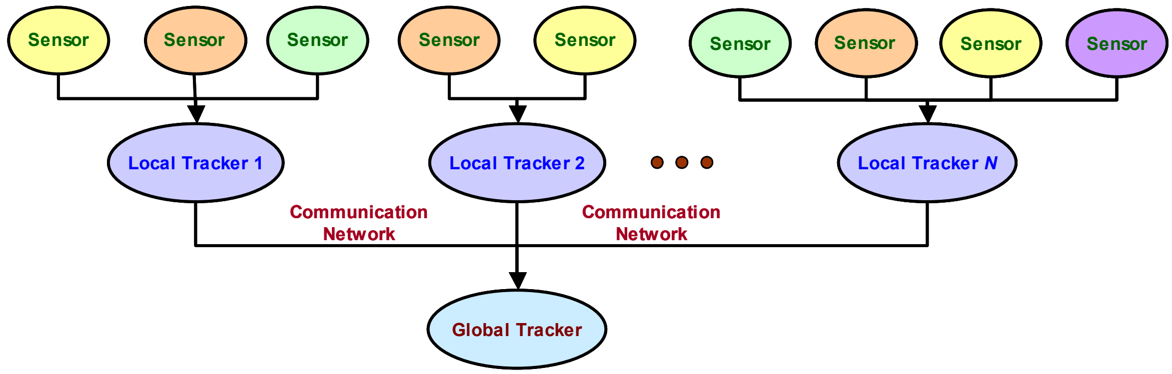

Figure 1. Distributed tracking architecture involving multiple sensors and multiple local trackers.

This paper presents distributed tracking algorithms for track initialization, gating, hypothesis generation, track update, computation of track likelihood, formation of global hypothesis, and pruning (track likelihood and NSCAN based) using the concept of pseudo measurement.

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