numerica

From Mathematical Models to Advanced Situational Awareness ™

Network-Centric Multiple Frame Assignment (MFA) Tracking System

Challenge Being Addressed

The coordinated use of multiple distributed sensors by network communication can substantially improve track state estimates, associated feature and attribute estimates, and identification of targets (ID and CID), primarily due to geometric diversity, complementary sensor information, and different coverage areas. This multiple sensor fusion problem is a challenging one, especially in a target dense or cluttered environment. Added to this challenge is the goal of achieving a Common Operational Picture or Single Integrated Air Picture (SIAP) on each platform across the network. Multiple hypothesis tracking (MHT) offers the best solution to the multiple sensor fusion problem since it offers improved track accuracy, attribute / feature association, and covariance consistency, as well as reduced number of track switches, track breaks, and missed targets. What is more, local sensor corruption can be moderated in a composite tracker that uses multiple frame data association. MHT, on the other hand, has been developed for single sensors and for multiple sensors in a centralized architecture. The challenge then is to develop a distributed network-centric MHT that achieves the same quality solution as in a centralized architecture, but in a communications constrained environment.

Numerica's Innovative Approach

Numerica's solutions are based on patented techniques for data association (i.e., correlation) and coordinated measurement updates and track initiation across the network to achieve SAIP in a communications constrained environment. By dynamically adapting the tracker to single or multiple frame mode, one can balance performance, memory footprint, and computational loading. The design of the distributed architecture also achieves significant reductions in latency across the network. The resulting distributed MHT tracking system tracks multiple targets for both air and missile defense using multiple platforms and sensors in complex environments, including: closely spaced targets, maneuvering targets, and dense clutter. Numerica has developed a number of innovative techniques that ensures the complexity of the problem can be maintained within the processing resources available.

Numerica's Innovations include:

- Robust processing via a state-of-the-art Multiple Frame Assignment (MFA) approach combined with a unique network-centric approach.
- The capability to perform integrated multiple missile phase tracking and air defense.
- The ability to detect ambiguity in the data association problem and to communicate to downstream functions that are sensitive to association errors.
- Demonstrated tracking capabilities in sophisticated missile defense and air defense simulators with measured data.

The following features distinguish Numerica's MFA-based solution adapted for the radar-sensor network-centric tracker:

- The solution is based on Numerica's optimization based MFA approach to multiple hypothesis tracking (MHT).
- Distributed processing – The tracking system is capable of operating on N separate platforms (N arbitrary) that are interconnected through a communications network. Measurement reports are exchanged among the platforms, and track estimates are formed with both "local" and "remote" data, thereby allowing platforms to act on system tracks.
- Network-centric processing - Enables coordination among the tracking nodes. This is accomplished through coordination so that a Single Integrated Air Picture (SIAP) is maintained and all platforms produce a Common Operational Picture or SIAP.
- The current tracking implementation is capable of processing data from a variety of radar types (3D phased array radar, 2D and 3D mechanically scanned radar, each type with or without range-rate data). The tracker has also been adapted to space based IR tracking, boat tracking, and space surveillance.
- The solution employs sophisticated Interacting Multiple Model (IMM) filter techniques to simultaneously give good tracking performance to maneuvering and benign targets.
- The solution has an advanced C++ software implementation that operates in the Linux operating system environment. It is currently being transitioned into a real-time operating system.

Enabling Technologies Integrated into Solution

A few of the key technologies that Numerica has integrated with its network-centric tracking system for missile defense are the following:

- Patented N-dimensional assignment solver.
- Bias mitigation for multi-sensor processing.
- Network-centric communication architectures for Single Integrated Ballistic Missile or Air Picture maintenance.
- Integrated multiple missile phase (boost, mid-course, reentry) tracking filters and air defense tracking filters.

Photo courtesy of the US Air Force

Numerica's Multiple Frame Assignment tracking technology won the "Best of Breed" tracker contest at Hanscom for an upgrade to AWACS. This development was done jointly with Lockheed Martin of Owego, NY.

For additional information contact:

Dr. Benjamin Slocumb
Email: ben.slocumb@numerica.us
Phone: (970) 612-2312

www.numerica.us