The objective of the research under this ONR award is to develop distributed multisensor data fusion algorithms for tracking applications, as well as non-simulation and analytical methods of performance evaluation. Since the beginning of this project in June 1997, we have achieved results in several different areas: (1) We have developed a method of distributed fusion that is amenable to general distributed architectures; (2) We have developed two non-simulation techniques for comparing multisensor probabilistic data association filters that are significantly more computationally efficient than performing Monte Carlo simulation evaluations; (3) We have investigated and compared the computational complexity and tracking performance of sequential and parallel implementations of the multisensor probabilistic data association algorithm; and (4) We have developed several schemes for controlling sensor information and have evaluated the effects of delays. Our results will provide insight as to the relative performance of various multisensor fusion methods, and the results will also provide a basis for assessing the tradeoffs between performance and computational and communication requirements when planning new sensor network architectures or communication link protocols.
A brief summary of the progress made in research under this Young Investigator Award is given here. The following papers, funded fully or partially under this ONR award, were published or submitted and are attached.


Other related papers that were submitted or published include:


Research Activities

The objective of the research under this ONR award is to develop distributed multisensor data fusion algorithms for tracking applications, as well as non-simulation and analytical methods of performance evaluation. We are addressing the estimation and data association process, where different measurement types must be integrated into one common estimation process, and consistent probability metrics must be established for all sensor types. In developing various algorithms, we are focusing our work and results to be useful for Naval tracking and surveillance systems.

Since the beginning of this project in June 1997, we have achieved results in several different areas:

- Multisensor target tracking is often performed using a single processor to monitor several sensors (centralized fusion), but this method is demanding of both computational power and communication bandwidth. Distributed sensor fusion is a method of addressing these limitations. However, the distributed sensor fusion problem is more complex due to the correlation of separate track estimates. We previously developed a method known as measurement reconstruction and showed that it addresses this correlation problem in a specific class of distributed architectures [I]. We have extended the measurement reconstruction approach to a more generalized architecture using two new algorithms [A]. Computational and communication requirements have been compared with centralized sensor fusion, and Monte Carlo simulation studies have been used to compare the performance of these and other algorithms. We are currently investigating the robustness of our algorithms to modeling errors that can yield errors in the measurement reconstruction process.

- Because Monte Carlo simulation evaluations of multisensor multtarget tracking algorithms is time consuming and expensive, we have developed two non-simulation techniques for comparing multisensor probabilistic data association filters (MSPDAF) [B]. While requiring only a fraction of the time for Monte Carlo simulation evaluation, the non-simulation techniques have been shown to accurately predict the performance of the MSPDAF in terms of RMS position error and track lifetime which has been observed in simulations.
• We have investigated and compared the computational complexity and tracking performance of sequential and parallel implementations of the multisensor probabilistic data association algorithm [B]. Our studies indicate that the sequential implementation is better on the average than the parallel implementation, in terms of both RMS position error and track lifetime metrics. We have further developed analytical results that show that the sequential implementation is exponentially more computationally efficient as the clutter density and number of sensors increase. We are currently investigating how the order of processing sensors in a sequential implementation affects tracking performance.

• Using multiple sensors in surveillance systems allows the strengths of one sensor type to compensate for the weaknesses of another and further provides redundancy, therefore increasing system robustness. However, because multiple sensors in many surveillance systems provide more information than can be processed with the available computational resources, we have developed several schemes for controlling sensor information. In order to keep the mathematics more tractable in our initial work [C], we have assumed a centralized processing architecture, where the measurements from all sensors are sent to a global processor where the measurements are fused and used for estimating the states (position, velocity, etc.) of the objects in the surveillance region. We have developed three algorithms that maintain a target’s state estimate covariance near a desired level without over-taxing the computational resources of a tracking system. We have also modeled and evaluated the effects that (inevitable) delays can have on performance [D]. Current work is focused towards extending results to decentralized multisensor systems.

Our results will provide insight as to the relative performance of various multisensor fusion methods, and the results will also provide a basis for assessing the tradeoffs between performance and computational and communication requirements when planning new sensor network architectures or communication link protocols.