From the Editor-in-Chief:

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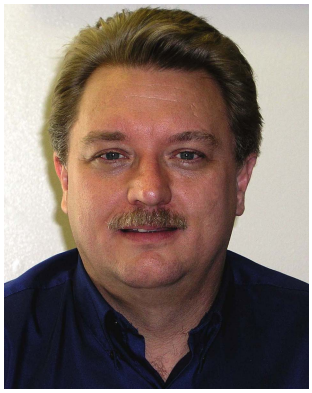

Where Are the Performance Guarantees for Information Fusion Algorithms?

In my editorial for the December 2011 issue of JAIF, I connected the low rate of transitions of information fusion techniques to real-world systems to the lack design methods for information fusion algorithms. Since engineers, not researchers, design and build systems, tools and design processes for design engineers are critical to the implementation of information fusion methods in real-world systems. Also, in that editorial, the development of effective design methods for information fusion algorithms was called out as the next frontier for the information fusion community. The focus of this editorial is on the need for performance guarantees for information fusion algorithms.

When one shops for an automobile, a long list of specifications and performance data are made available to the consumer. One of the most popular specifications for automobiles is the gas mileage and it is usually given in terms of miles per gallon for driving in the city and highway. While the miles per gallon varies with fuel quality, driving habits, etc., most consumers factor gas mileage specification into their purchasing decision. Another popular specification is the time required for the automobile to change speed from 0 to 60 miles per hour. Most all items in the market place have performance data and specifications provided for consumers to make purchasing decisions. On the other hand, no performance guarantee of any type is made available with information fusion algorithms. It is amazing that any of these algorithms get implemented in real systems. It is typically the reputations of the engineers and their professional opinions that lead to the implementation of new algorithms in a real system.

If you are still contemplating the reasons for the low rate of transitions of new algorithms to real systems, consider the last time that you purchased something of monetary significance with little or no insight into its value to you. Furthermore, consider the challenges of systems engineering when you have no performance characteristics for this important piece of your system called information fusion. How does one conduct a cost benefits analysis without any insight into the benefits?

Without a cost benefits analysis that supports the implementation of a new algorithm, the conventional algorithm will do just fine. Hence, new advances in information fusion will remain dormant.

Consider the well-studied and rather straightforward problem of tracking maneuvering targets. Prior to [1,2], the wealth of literature on this problem did not address achievement of a specified level of filter performance. In [1,2], the performance specifications were discussed with respect to setting an upper limit on the maximum mean squared error (MMSE) relative to the measurement error and minimizing the MMSE. The very basic tracking problem of linear measurements of a single maneuvering target in a scalar coordinate is addressed in [1,2]. Most tracking problems are significantly more complex. The methods were applied to radar tracking in [3] with some success. However, [1-3] addresses only a few of the issues associated with tracking performance. For tracking maneuvering targets with a radar or other nonlinear sensor, restrictions on the characteristics of the maneuver, the sensor-target geometry, and sensing requirements are needed be define the bounds for which the performance measures can be achieved. The tracking algorithm that can provide those performance measures with the fewest restrictions could be considered the best algorithm. However, for the most part, the performance specifications for tracking maneuvering targets is still an open problem.

The Tracker Operating Characteristic (TOC) and the average track life [4] are two metrics that have been proposed for characterizing the performance of tracking targets in the presence of false alarms. The TOC gives the average tracking accuracy of the Probabilistic Data Association Filter (PDAF) as a function of the probability of detection and false alarm density. Thus, given a false alarm density and probability of detection, the TOC gives the average tracking accuracy for the PDAF. Given a false alarm density and probability of detection, the average track life corresponds to the average number of measurements that will be included in a track before it is declared lost. A shortcoming of the TOC and average track life in [4] is the need to select the process noise standard deviation that was known to be an open issue during its publication.

Development of methods for specifying the performance of information fusion algorithms and algorithms that can guarantee that performance are important research problems for the information fusion community. The tracking of maneuvering targets and tracking of a single target in the presence of false alarms are the simplest of problems. MTT with finite sensor resolutions is extremely complex in comparison and this is the tracking problem of most real-world sensors. The development of design methods and performance characterization measures for MTT algorithms and other information fusion algorithms are difficult challenges that could be beyond the reach of our abilities, but the lack of these are clearly standing in the path toward the implementation of advanced algorithms in real-world systems.

William Dale Blair
Editor in Chief

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