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Introduction

This was the 21st in a series of SPIE conferences to focus on signal and data processing of small targets. Most SPIE conferences are concerned with processing large targets, namely, targets large enough for traditional automatic (or assisted) target recognition (ATR) with a single frame of data. A target large enough for ATR is typically larger than a total of 100 resolution elements, for example, larger than 10 by 10 pixels. In contrast, this conference series introduced a different thrust for SPIE: processing targets smaller than 100 pixels.

This year the conference was held in San Diego after being held in Orlando the prior year. In the future, these conferences are expected to continue to be located on the east coast in the spring on *even* years and in San Diego in the summer on *odd* years. The proceedings of the prior conferences in this series in 1989 through 2008 are SPIE Volumes 1096, 1305, 1481, 1698, 1954, 2235, 2561, 2759, 3163, 3373, 3809, 4048, 4473, 4728, 5204, 5428, 5913, 6236, 6699, and 6969. A compact disk of all the papers in this series from 1989 through 2000 is available from SPIE; it is Volume 20, which is a two-disk set.

The various types of processing tasks with sensor-derived data of targets can be broadly categorized into four generic classes, as follows:

- Sensor tracking of a single (bright) target
- Image and data processing of large targets
- Signal and data processing of medium sized targets
- Signal and data processing of small targets.

Note that the size indicated in this list is in terms of the number of resolution elements or pixels. The motivation for categorizing the processing of sensor data this way is because most of the appropriate algorithms for each of these problems differ substantially from that of the others. This conference concentrates on small targets that include:

- Point source objects
- Small extended objects
- Clusters of point source and small extended objects or a threat cloud, such as a bio/chem threat.

The size of a typical point source target in the field of view is from less than one to about 20 pixels (resolution elements) wide, depending on the sensor design. Although the processing of point targets has been studied extensively, there are still many interesting challenges in this field. In contrast, the state of the art for processing small extended objects and clusters is far less mature but interest is growing.

Small targets that are not point source objects include both small extended objects and unresolved closely spaced objects, sometimes called clumps. While these small targets provide little detailed information useful for ATR, they do exhibit some shape and size information that might be useful in tracking. In addition, an extended object may at times be partially or fully obscured or may obscure rather than add to the background. The apparent size and shape of a target can differ from sensor-to-sensor and over time; this may have to be taken into account. Similarly, cluster processing offers significant advantages and challenges.

Improved sensors, increasingly demanding system requirements, processor hardware limitations, severe operating environments, efficacious countermeasures, and challenging threat scenarios drive current algorithm development. Of special interest is the ability to track low observables or in a moderate to dense population of threshold exceedances caused by clutter, false signals, or targets that are close or crossing.

There is an increasing need for improvements in "algorithm efficiency," i.e., improved performance relative to the processor and communication resources required. A major trade in selecting algorithms for processing small targets is performance versus required processor and communications capacity. Also needed are accurate evaluations and predictions of required resources and functional performance under realistic conditions. Major improvements are needed in: multiple spectral signal processing, multiple target tracking, network centric sensor data fusion, multiple frame data association, multiple frame signal processing (such as track-before-detect), effective management of sensors, communications, and processor resources, target classification, processing of features and attributes, and the interaction between signal processing and tracking. Many of these issues are highlighted in Figure 1. In addition, needed is additional information and covariance consistency in the tracker output to the users and functions that depend on the tracker data to facilitate the improvement of their performance.

The term *fuse-before-detect* in Figure 1 refers to the combining (fusing) of raw data from multiple sensors before applying a threshold (detection) at the signal processing level. I coined this term in recognition of the increased interest in improving performance by fusing sensor data early in the processing chain. Note also in Figure 1 the possible use of track data at the signal processing level. There is a growing recognition of the importance of using all available information in every stage of the processing and hence the use of feedback.

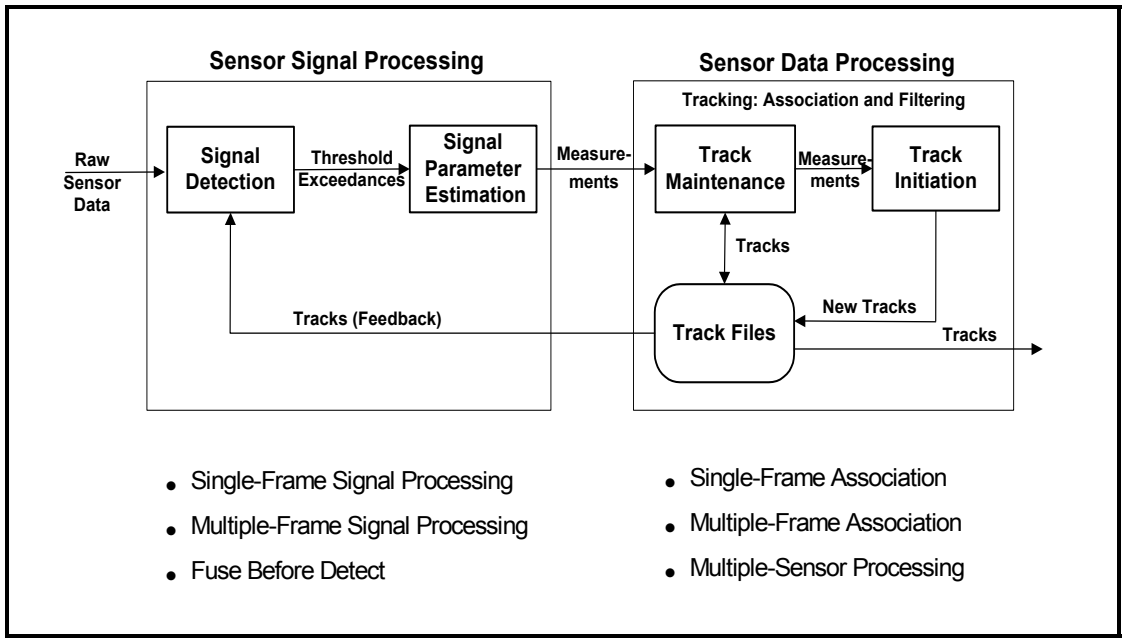

Figure 1. Sensor Signal and Data Processing

This conference has provided a forum to address these issues through discussion of algorithms and simulations for both digital signal processing and target tracking under challenging conditions, i.e., association (correlation) and filtering, including related data processing, such as sensor fusion, resource management, and target classification/typing. Of the five half-day sessions, one addressed signal-level and extended object processing, one concentrated on probability hypothesis density processing, and three addressed target tracking, sensor data fusion, and related network wide processing. The distinction between the two stages of single sensor-level processing is shown in Figure 1.

These proceedings contain a wealth of information that addresses the issues critical to practical processing under the challenging conditions outlined above. For example, important advances were presented in: chem/biodefense, novel clutter processing methods, track filter methods to accommodate non-linearities, probability hypothesis density processing, advanced distributed sensor data fusion, improved methods for tracking maneuvering targets, video tracking, processing registration biases, tracking ground targets, feature/attribute processing, and track covariance consistency processing. These techniques and others presented are strong candidates to permit high performance target tracking and classification and related processing of low observables or in an environment of moderately dense detections and with abruptly maneuvering targets. These and other innovative yet practical techniques were presented that contribute to improving algorithm efficiency for processing small targets.

Many of the experts and organizations that are making the major important advances in practical sensor signal and data processing have contributed to these proceedings. We thank the authors, session chairs, attendees, and SPIE staff for making the three-day conference such a success. They have taken part in enthusiastic discussions that generated better understanding for the application of the techniques presented and have stimulated thoughts for further improvements. Informal discussions during the coffee breaks and during lunch were especially productive, as usual. With these proceedings, the authors have extended the state of the art of analysis, algorithms, and simulations for the use of data from one or more sensors used in signal and data processing of small targets and related processing.

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