Automatic Target Recognition

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Automatic target recognition (ATR) is not a new field. Research in this area has been ongoing for more than two decades now. This field, which originally started with the goal of automatic target cuing to aid helicopter pilots in air-to-ground combat scenarios, has led to the creation of several generations of automatic targeting systems that have been effective and useful mostly in localized domains. The realization of the ultimate goals of ATR—the detection, tracking, and recognition of targets of interest in all and every scene, scenario, and weather condition—however, has shown to be somewhat difficult. One of the main sources of this difficulty has been our lack of attention to the direct problem of signal and image understanding—what transformation a signal goes through before it is presented to the user (man or machine). It is only after this understanding that the reverse problem of recognizing the targets based on their received signals (target recognition) can be addressed. The signal understanding issue has led to the need for phenomenological studies of the targets, backgrounds, transmission paths, and sensors, and has helped the development of a new area of research, model-based ATR. The presence of uncertainty in the received signals, due to many elements such as phenomenological parameters, natural and intentional occlusion, etc., has provided the impetus for the burst of activities that are more effective in dealing with uncertainty, such as neural networks and multisensor/multisource information fusion. These activities have benefited and changed the ATR field tremendously in recent years.

The future of ATR seems very bright. This is partly due to the growing number of researchers devoting their time to this topic, and partly due to the maturity of this technology—its growth from a black art into a scientific discipline.

This special section presents a collection of refereed articles on the recent activities in ATR. The first two articles are two exciting works on the use of artificial neural networks for target recognition. The first article by Daniell et al. presents the IR-based SAHTIRN™ target recognition system being developed at Hughes Aircraft Company. The second paper by Thoet et al. discusses the MODALS system being developed by Booz • Allen and Hamilton, Inc., under the visible sensor ANVIL program.

The exciting model-based ATR approach using the forward-looking laser radar is discussed by Verly, Delanoy, and Dudgeon of the MIT Lincoln Laboratory.

The next three papers present the very interesting work being done in target recognition using acoustic sensors. The first one by Gaunaurd presents the exploitation of transient resonance for target recognition that has been ongoing in the U.S. Navy's White Oak Detachment for a number of years. The second paper, by Werby, from the Naval Oceanographic and Atmospheric Research Laboratory, and Gaunaurd, deals with the problem of phenomenological understanding of the acoustic scattering by underwater targets, and shows how to exploit this understanding for the extraction of robust features for target recognition. The third paper, by Aymé-Bellegarda, Habashy, and Bellegarda of Schlumberger-Doll Research and IBM, presents a new method in the use of ultrasound sensors for recognizing objects buried in multilayered media.

My paper presents a new approach for target recognition that has the advantages of both feature-based and silhouette-based techniques. This technique is demonstrated on ladar imagery.

The tough problem of multisensor target recognition is discussed in the paper by Sims of the U.S. Army Missile Command and Dasarathy of Dynetics, Inc. They present the results of their ongoing work on the use of a suite of passive sensors for target recognition consisting of electro-optic and acoustic sensors, a rf interferometer, and meteorological sensors.

One of the major problems in ATR is target segmentation. The paper by Farag of the University of Louisville and Delp of Purdue University presents an interesting approach to image segmentation using composite random field models.

Performance evaluation and optimization is an essential part of ATR development.[1] Multisensor data characterization by means of image and signal metrics and proper definition of performance measures are the building blocks of any scientific evaluation approach.[2] The last three papers of this special section address this important problem. The paper by Snorrason of California and Garber of Wright State University presents new insight into the use of nonparametric discriminant functions in radar target recognition with their comparative analysis of several techniques for feature selection and extraction. The paper by Clark of Wright Laboratories/AARA and Perlovsky et al. of Nichols Research Corporation presents the use of a set of new information-theoretic metrics for the FLIR-based ATR sensor evaluation. Finally, the very important issue of dealing with clutter in target detection is discussed in the paper by Shirvaikar and Trivedi of the University of Tennessee. They present a set of new texture-based clutter metrics for automatic target detection.

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[1] *Optical Engineering* special section on "Performance Evalution of Signal and Image Processing Systems," *Opt. Eng.* **30**(2), 141–194 (1991).

[2] F. A. Sadjadi, "Experimental design methodology: the scientific tool for performance evaluation," *Proc. SPIE* **1310,** 100–107 (1990).

Firooz A. Sadjadi received the BSEE degree from Purdue University in 1972 and the MSEE degree and the Engineer degree in electrical engineering from the University of Southern California (USC) in 1974 and 1976, respectively. He performed postgraduate studies toward the PhD at USC and the University of Tennessee, Knoxville. He worked at the USC Image Processing Institute and the Image and Pattern Analysis Laboratory of the University of Tennessee, and was a consultant to the Oak Ridge National Laboratory. Since 1983 he has been with the Honeywell Systems and Research Center where he is currently a principal research scientist. He specializes in modeling, algorithm design, sensor fusion, and performance evaluation for the development and enhancement of adaptive millimeter wave radar, ladar, IR, and sonar signal processing systems with emphasis on automatic target recognizers and autonomous vehicles. He has been the principal investigator and program manager of several automatic target recognition (ATR) programs for the Defense Advanced Research Projects Agency and other agencies. He is the author of more than 80 technical publications and holds two patents in the area of automatic object recognition. He is the principal author of a forthcoming book on ATR systems to be published by SPIE. He lectures frequently in the areas of ATR, multisensor fusion, and image understanding at George Washington University, University of California at Los Angeles, University of Maryland, King's College London, U.S. government centers, and at international conferences. He is on the review boards of numerous technical journals and national research and development agencies. He has chaired many conferences and was the guest editor of the *Optical Engineering* special section " Performance Evaluation of Signal and Image Processing Systems" in February 1991. Sadjadi is a senior member of IEEE and a member of Sigma Xi and SPIE. He has received a number of technical awards, among them the Honeywell Technical Achievement Award.