

Target Recognition Techniques

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Over the past two decades tremendous advances have been made in the general area of target recognition techniques. The scope of target recognition is rather broad. As a result, the contributors to this special section come not only from the optical information processing community but also from many other disciplines. The 23 papers that were finally accepted for this special section encompass the latest trends and advancements of many different areas of target recognition techniques. These techniques include filter based recognition, distortion-invariant recognition, joint transform correlator (JTC) based recognition, wavelet based recognition, synthetic aperture radar based recognition, neural network based recognition, three-dimensional processing based recognition, and multispectral target recognition. These papers summarize the works of 64 researchers from Canada, China, Singapore, South Africa, Taiwan, and the United States.

The first three papers address the issues pertaining to matched filtering. At first, Khoury, Gianino, and Woods present several filter algorithms for modifying the transmissivity of many matched filters multiplexed onto one hologram. They show that some of these algorithms operate over a wide range of obscurations, while others have restricted operating range. These algorithms have applications in associative memory and correlation based target recognition. In the second paper, Alkanhal, Vijaya Kumar, and Mahalanobis have shown that the maximum average correlation height (MACH) correlation filter over-emphasizes the importance of the average training image leading to poor discrimination of the desired target from clutter. To overcome this problem, they proposed a filter design by introducing and optimizing two new metrics called the all image correlation height (AICH) and modified image similarity measure (MISM). This filter has been found to exhibit better clutter rejection when com-

pared to the MACH filter. Then, Khoury, Gianino, and Woods describe a new fixed-phase hetero-associative correlation filter by enhancing the crosscorrelation between selected objects. This particular algorithm optimizes the correlation peak intensity relative to the total average energy of the spectrum that should be rejected.

The next group of three papers deals with distortion-invariant target recognition techniques. In the first paper, Yao and Chin propose an amplitude-modulated radial harmonic filter for improved shift and scale-invariant pattern recognition. The improvement of discrimination is achieved via Fourier domain amplitude modulation. The second paper, by Riasati et al., describes a ring synthetic discriminant function (SDF) filter for rotation invariant target recognition. They show that the proposed ring SDF can significantly outperform the performance of the matched filter and SDF filter. Then, Kozaitis and Thangwaritorn show that advanced distortion-invariant filters such as optimal trade-off SDF and distance classifier correlation filters can be effectively utilized as circular filters to achieve rotation-invariant target recognition. These filters are real-valued; therefore, it is easier to implement them using a variety of off-the-shelf spatial light modulators (SLMs).

Joint transform correlation is the topic for the next group of three papers. First, Alam introduces a phase-encoded fringe-adjusted JTC technique for multiple target detection. This JTC technique guarantees multiple target detection in one step, yields one peak per target, and ensures better utilization of the space-bandwidth product. Thereafter, Khoury, Gianino, and Woods discuss the engineering aspects of two-beam coupling photorefractive JTCs. Their study show that the optimal trade-off between correlation peak intensity, efficiency and noise performance is realized when the holographic material is thin

and operates with relatively small negative gain. Then, Zhang and Karim propose two JTC configurations for achieving normalized correlation in real time in the space domain. This technique is also robust in terms of system alignment.

Robust target recognition using wavelet transform based processing is the topic of the next set of five papers. In the first paper, Song, Lei, and Jutamulia demonstrate two modified versions of Haar wavelet transform for achieving better performance in the presence of random noise. The modified transforms can be effectively used for the inspection of surface mount devices in electronic industry. Then, Chen and Karim describe a forest representation of two-dimensional wavelet transform for multi-resolution analysis. In this technique, the coefficients are grouped into four forests (an approximate forest, a horizontal forest, a vertical forest, and a diagonal forest) to preserve the locality of coefficient across multiple scales. Thereafter, Alam and Chain propose an enhanced multiple target detection technique by using wavelet transform-based joint transform correlation. They utilize a bank of wavelet filters generated from the Mexican hat wavelet function that are sequentially superimposed on the joint power spectrum before applying the inverse Fourier transform to yield the correlation output. This technique also utilizes correlation plane image subtraction to eliminate the false alarms, reduce the effects of noise, and other artifacts. In the next paper, Iftekharruddin describes an orthogonal wavelet based approach to reduce speckle in synthetic aperture radar and gray scale images for automatic target recognition. In the last paper of this category, Riasati et al. propose a technique for data reduction via the wavelet transform for synthesizing projection slice SDF. Their technique reduces significant portion of the training data used in the synthesis process thus ensuring reduction of data overlap in the synthesized filter.

Neural network based target recognition using synthetic aperture radar imagery is the subject of the next group of three papers. In the first paper, Carlotto proposes nonlinear background estimation and change detection in synthetic aperture radar images for wide area search applications. He describes a nonlinear mean squared estimation technique to compute image backgrounds from multiple reference images. His technique yields significantly better background estimate and reduces the registration error between images when compared to the linear estimator. Then, Zhao et al. describe a new architecture for synthetic aperture radar based automatic target recognition assuming that the pose of the target is estimated within a high degree of precision. In their technique, the training of the classifier can be done indiscriminately which also improves performance and decreases the complexity of the classifier. In the next paper, Nieuwoudt and Botha evaluate the relative performance of correlation- and feature-based neural classifiers over a wide range of target orientations using synthetic radar range profiles. They show that feature-based classifiers outperform correlation-based classifiers and the output is highly dependent on target orientation.

The next group of two papers exploits three-dimensional processing for target recognition applications. First, Duarte and Yin utilize three-dimensional profiles to design composite filters for illumination-invariant

highspeed face recognition. Their composite filter is synthesized by simulated annealing from artificial images generated under different illuminations conditions. Then, Ping et al. show that the Fourier-Mellin moments can provide an invariant and orthogonal description for binary and contour images. They utilized cubic spline interpolation of the feature space trajectories to improve the linear interpolation for three-dimensional target recognition from two-dimensional perspective views.

Qi, Snyder, and Marchette propose an efficient image segmentation approach to segment man-made targets from unmanned aerial vehicle imagery using curvature information derived from image histogram smoothed by Bezier splines. By enhancing the histogram instead of the original image, automatic target recognition operations can be achieved in a more efficient way.

The next group of two papers deals with target detection using multispectral imagery. In the first paper, Chang et al. present a generalized constrained energy minimization approach to detect subpixel targets in multispectral imagery. Their technique combines a constrained energy minimization method for subpixel target detection, and a dimensionality expansion technique for nonlinearly creating additional bands from original multispectral images to effectively eliminate the interference due to the lack of sufficient dimensionality. Then, Lanterman uses a Bayesian model order estimation technique to realize infrared target recognition. This particular technique prevents target models with numerous eigentanks in their representation from having an advantage over simple target models.

The last paper of this special section, by Yang et al., deals with the detection of venous beading in retinal images. Such venous beading detection plays an important role toward diagnosing diabetic retinopathy and other ocular diseases. The authors present a computer aided diagnostic system to automatically detect venous beading blood vessels.

This special section is well balanced and reports on the many ongoing efforts in target recognition techniques at different academic, industrial, and government research labs.

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Mohammad S. Alam received his BS and MS degrees in electrical engineering from Bangladesh University of Engineering and Technology in 1983 and 1985, his MS degree in computer engineering from the Wayne State University in 1989, and his PhD degree in electrical engineering from the University of Dayton in 1992. From 1992 to 1999, he served as a faculty of electrical engineering at Purdue University, Fort Wayne, Indiana, and as a graduate faculty member of both Purdue University and Indiana University. Currently, he is a faculty member of the Department of Electrical and Computer Engineering at The University of Alabama. His research interests include optoelectronic computer architectures and algorithms, digital/optical signal and image processing, communication systems, pattern recognition, fiber optics, infrared systems, microprocessor applications and digital system design. He is the principal author of more than 140 published pa-

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