Advances in Recognition Techniques, Part 2

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Over the last few years, tremendous advances have been made for both adaptive and nonadaptive recognition techniques, especially for image processing and pattern recognition applications. The researchers active in this area come from a very diverse background. They work not only on the process segment, but also on the systems and devices that may make many of these processes meaningful. The response to the call for this special section has been overwhelming. The 52 papers that were finally accepted had to be split into two different issues in January 1998 and March 1998. These papers summarize the works of 135 different researchers from Algeria, Australia, Canada, China, Finland, France, Hong Kong, India, Jordan, The Netherlands, Russia, Spain, the United Kingdom, and the United States.

The set of 25 papers appearing in this current issue of *Optical Engineering* deals mostly with adaptive processes. They cover the recognition domains of target detection and classification of hyperspectral imageries, holographical memory based recognition, modeling of recognition systems, neural network based recognition, cellular automata, feature extraction for recognition, and new recognition devices.

The first four papers address the issues of hyperspectral imageries. First, Chang, Sun, and Althouse use an approach to hyperspectral image classification by modeling a mixed pixel vector as a linear superposition of substances resident in a pixel with additive Gaussian noise. They include interference in the model so that it can be eliminated prior to detection and classification. This becomes particularly useful for hyperspectral images that tend to have high signal-to-noise ratio but low signal-to-interference ratio with interference difficult to identify. In the second paper, Fairhurst and Lettington study the human perception of images of various shapes which had been degraded by various combinations of Gaussian blurring, sampling, and fixed pattern noise. The responses collected during the trials have been used to develop an empirical model of a human observer correctly distinguishing between images. Then, Hardie, Vaidyanathan, and McManamon describe a statistical spectral band selection procedure and classifiers for an active multispectral laser radar sensor. They evaluate performance of four different classifier algorithms, which include a minimum distance classifier, a log-domain minimum distance classifier, a Bayes speckle-only classifier, and a Bayes speckle-Gaussian classifier. Last, Deschenes, Sheng, and Chevrette demonstrate 3-D object recognition from 2-D infrared images. They use wavelet transform for edge detection, edge tracking for removing noise, an invariant Fourier descriptor for describing the contour curves, and a feature space trajectory neural network for achieving invariance under out-of-plane rotation.

The next two papers deal with holographic memory based recognition techniques. In the first paper, Bandyopadhyay, Ghosh, and Datta propose a holographic binary associative memory model for binary character recognition. The preconditioning of pattern vectors is eliminated using a multistep correlation technique and the learning and recall is realized using a digital optical matrix-vector multiplication. Then, Liu, Jin, and Marzwell present the architecture and mathematical analysis of a new multichannel multistage holographic optical random-access memory (HORAM) architecture for use in ultra-high-capacity storage and high-speed random retrieval of information. A two-stage HORAM, using a Dammann grating and a multi-focus holographic lens, showed the capability of storing 2000 holographic matched filters.

The next group of three papers addresses modeling of recognition systems. First, Driggers et al. model the target acquisition system by a sensor's minimum resolvable temperature, the Johnson criteria, atmospherics, and object specifics. When quantifying the performance of intelligence-surveillance-reconnaissance, they assess ob-

ject recognition using the National Imagery Interpretability Scale. The second paper by Du, Ahalt, and Stribling describes a model-based image analysis system that automatically estimates the 3-D orientation vector of satellites and their subcomponents by analyzing images obtained from a ground-based optical surveillance system. Their results include their efforts at isolating and estimating orientation vectors from degraded imagery on a significant database of satellites. Finally, in the third paper, Ghali, Daemi, and Al-Khateeb describe how the image overall information content may be defined, identified, assessed, and analyzed. They show information measure to be related to the recognition information that in turn provides a reliable way of evaluating the optimal scan-resolution required for unambiguous recognition of an image.

Neural network based recognition technique is the topic for the next group of two papers. First, Krupinski, Nodine, and Kundel consider the situation when observers have their eyes often fixate and re-fixate the true target, dwelling on it for prolonged times, often without recognizing that they have discovered the object of search. By having the dwelling location superimposed on the image and dynamically feeding back to the observer for re-evaluation, the authors show an increase of 20% in observer performance. To improve recognition accuracy under noisy or occluded conditions, as well as to eliminate false alarms, Takacs and Sadovnik next use a 3-D recognition and tracking system that employs a temporal evidence integration technique. It allows for tracking and lock-on even when both targets and camera move.

Robust pattern recognition within the Bayesian framework for scene segmentation/boundary detection is often times hampered by the presence of textures within natural images. In order to improve segmentation/boundary detection on natural images, Kubota and Huntsberger introduce two algorithms for combining both color and texture features to assist boundary detection processes. The next paper is a survey of neural network-based tracking by Amoozegar. He classifies and addresses various neural network-based tracking algorithms that have been introduced since 1986 till now and discusses their common views as well as their differences in results and in architectures.

de Ridder, Schutte, and Schwering investigate the possibility of using certain kinds of neural networks, shared weights neural networks, to recognize vehicles in infrared images. Although they train the networks on individual samples, they use the trained networks as nonlinear filters on entire images. Next, Wang, Der, and Nasrabadi use two existing classifiers, one based on learning vector quantization and the other on modular neural networks, as the building blocks for composite classifiers. By testing on real FLIR images, they demonstrate that the composite classifier based on cascade architecture greatly reduces computational complexity with a statistically insignificant decrease in performance in comparison to standard classifier fusion algorithms. Mirhosseini, Yan, and Lam introduce an adaptive algorithm for human face recognition and lip-reading assisted speech recognition systems in particular, and multi-modal human-computer interaction systems in general. The new model adaptation technique they present satisfactorily generalizes the mouth boundary model extraction in an automated fashion. Diab, Karim, and Iftekharuddin propose an enabling algorithm for automatic target detection wherein the targets are almost similar but differ in fine details. In this work, multiple translated and scaled target images are processed in Mellin transform domain and subsequently detected using a learning vector quantization neural network. Then, McAulay and Wang describe an optical diffraction method using neural networks for inspecting periodic structures such as combs or semiconductor leads. The authors demonstrate a neural network that learns to distinguish end effect signals from prong damage signals. Finally, Mello-Thoms and Dunn study the approximation capabilities of two different four-layered neural networks. The authors present an alternative to the backpropagation approach, namely, a one-pass algorithm. An arbitrarily small approximation error can be obtained for this network by adjusting the appropriate parameters.

Spillman and Huston use cellular automata to analyze multispectral images of large civil structures to identify structural damage. The size of the cellular automata population was successfully correlated with structural lifetime, time required for detailed inspection, and other engineering parameters.

The next two papers deal with feature extraction for recognition applications. First, Talukder and Casasent present a maximum representation and discrimination feature (MRDF) method for linear and nonlinear feature extraction for simultaneous representation and classification. They develop a novel nonlinear eigen feature extraction technique to represent data with closed-form solutions and use it to derive a nonlinear MRDF algorithm. Then, Casasent, Neiberg, and Sipe use the feature space trajectory neural net for classification and pose estimation of the contents of regions of interest. They discuss its use in rejecting clutter inputs, selecting the number and identity of the aspect views most necessary to represent an object and to distinguish between two objects, temporal image processing, automatic target recognition, and active vision.

The last three papers of this special section deal with instrumentation for recognition. First, Gorecki and Trolard demonstrate an optical implementation of real-time preprocessing using liquid crystal television (LCTV) working as a spatial matched filter. They considered two filters for smoothing and edge-enhancement using the hybrid modulation of the LCTV. Second, Hicks and Reeve describe a simple acousto-optic system capable of demodulating frequency and phase-modulated signals. They show the viability of the system in various surveillance receiver applications. Finally, Kane, Kincaid, and Hemmer use optical feedback as a method of improving spatial light modulator (SLM) device performance. Placing the SLM in a positive feedback system causes the system to act like a memory. Placing the SLM in a negative feedback system makes the SLM response more analog, which in turn leads to improved uniformity.

In conclusion, this special section, along with part 1 which appeared in January 1998, is well balanced and reports on the many ongoing efforts in recognition techniques at different government, university, and industrial laboratories. We would like to thank the many contribu-

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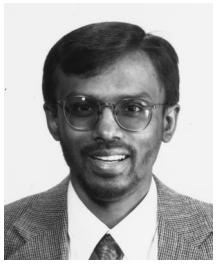

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