Correlation Pattern Recognition

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Model-based techniques, neural networks, and correlation pattern recognition (CPR) are three of the most popular approaches to machine vision and pattern recognition. While the former two techniques are being widely pursued by the signal and image processing community, CPR has been mostly investigated by the optical pattern recognition community. As a result, the understanding of CPR and its applications has steadily grown over the last decade.

CPR offers several unique advantages in machine vision applications. Correlation is a ''sensor independent'' approach that generally does not require data specific operations (such as segmentation, feature extraction, on-line model synthesis, or other processes). Consequently, correlation processors and algorithms can be shared by different types of sensors including infrared (IR), synthetic aperture radar (SAR), CCDs, and laser radar (LADAR) to name a few. Thus, CPR is a unifying approach to pattern recognition in a multi-sensor environment that does not require separate software suites to accommodate the different sensor phenomenology. Since the throughput of a correlator generally depends on the dimensions of the image, the algorithm complexity depends on the scene size and not on the number of objects to be detected. Not only does this provide a precise estimate for throughput, but it also avoids the computational bottlenecks faced by some approaches due to scene complexity, clutter, and the number of objects present. Among the many applications of CPR are medical image processing, security systems, fingerprint and face recognition, optical character recognition, surveillance, automatic target recognition, and object tracking.

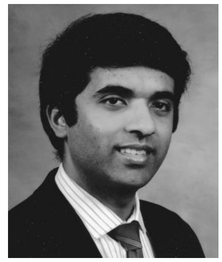
The underlying philosophy of CPR is that the signatures of objects to be recognized may be treated as signals to be detected. The present theory is a unique blend of concepts from the fields of signals and systems, Fourier optics, and statistical pattern recognition. Generally speaking, the algorithms are analytical closed-form solutions that optimize relevant performance criteria. From an implementation standpoint, both digital and optical processors have matured considerably so that practical realization of CPR is no longer a significant issue. While digital processors offer greater accuracy, optical processors promise far higher throughput rates. The challenge for optical correlators is to improve their fidelity in favor of greater dynamic ranges, and to design optimum algorithms given the limitations of the present devices.

This special section on CPR is divided into three sections. The first five papers address fundamental theoretical issues pertaining to the design of correlation filters. Fazlollahi and Javidi discuss optimum techniques for recognizing targets in nonoverlapping noise. Mahalanobis and Kumar describe the properties of the maximum average correlation height (MACH) filter as an optimum detector. Laude and Formont talk about a Bayesian technique for recognizing targets in images. Guérault et al. propose an optimum technique for identifying the location of a target in a correlated background scene. Sims addresses information loss and distortions introduced by different types of data compression techniques and their implication on automatic target recognition systems including those based on CPR techniques.

The next seven papers in the second section cover some novel developments in CPR. Shamir describes techniques for adaptive pattern recognition using hybrid correlators. Javidi, Wang, and Zhang describe a nonlinear filter for distortion-invariant pattern recognition. Fisher and Principe review the recent developments in the area of nonlinear minimum average correlation energy (MACE) filters. Hassebrook et al. introduce a high signal-to-noise ratio technique for estimating orientation of a pattern using correlation. Casasent and Ashizawa report the results of using correlation filters for recognizing targets in SAR imagery, and Casasent and Shenoy introduce the concept of feature space trajectory. A novel approach for robot vision and vehicle navigation using holographic memory is described by Pu, Denkewalter, and Psaltis.

The final four papers deal with optical hardware for correlation. Karins et al. review Litton Data System's miniature ruggedized optical correlator (MROC™) unit as a good example of a mature optical correlator. Young and Chatwin discuss the results of their work to assess a photorefractive bandpass joint transform correlator (JTC). Purwosumarto and Yu compare the robustness of the JTC with the conventional VanderLugt correlator, and Grycewicz introduces a lensless technique for implementing the JTC.

The scope of the research in the field of CPR has been steadily growing thanks to the efforts of the skillful teams at many laboratories, universities, and industries in many countries. The collection of papers in this special section is by no means a complete survey of the field, but is a good representation of the state of the art in CPR. I would like to thank the contributing authors and the reviewers who made this issue possible, and the staff and editors at *Optical Engineering* for giving me the opportunity to compile this selection of papers on CPR.



Abhijit Mahalanobis is a senior scientist/engineer in the Electro-Optics Department at Hughes Missile Systems Company (HMSC). His main interests are in multi-sensor automatic target recognition, pattern recognition, and image processing. He has more than 70 publications in these areas. He is currently the technical manager for ATR programs at HMSC. Abhijit completed his BS degree with honors at the University of California, Santa Barbara, in 1984. He then received the MS and PhD degrees from Carnegie Mellon University in 1985 and 1987, respectively. Prior to joining Hughes, Abhijit was a member of the professional staff at Martin Marietta, Orlando, and on the faculty at the University of Arizona. Abhijit is an associate editor for the journal of the Pattern Recognition Society. He is a frequent reviewer of papers for *Applied Optics*, and serves on the organizing committee for the SPIE conference in Orlando. Abhijit is a member of Eta Kappa Nu and Tau Beta Pi and a fellow of SPIE.