

Introduction to the Special Issue on Recent Advances in Biometrics

THE SYSTEMS, Man, and Cybernetics Society sponsored the IEEE Second International Conference on Biometrics: Theory, Applications and Systems, or “BTAS 08,” held September 29–October 1, in Washington. BTAS 08 grew substantially over BTAS 07, both in number of submissions and in number of attendees, and this conference series has quickly established itself as the premier research conference focused on biometric technologies. See the conference Web page http://www.cse.nd.edu/BTAS_10 for information about the next BTAS conference, as well as for links to more information about BTAS 08.

As with BTAS 07, a biometrics-themed special issue of the IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART A (SMC-A) was organized following BTAS 08. However, unlike the SMC-A special section drawn from BTAS 07 [1], this special issue had an “open” call for papers, meaning that submissions were not limited to papers presented at BTAS 08. Following standard practice for IEEE journals, a paper submitted to the special issue was required to be a substantial extension over a paper appearing in the BTAS 08 or other conference proceedings. A total of 31 submissions were received for the special issue. All of the submissions were subjected to a rigorous review process. Several of the submissions underwent major revisions based on the first round of reviews, followed by a second round of review. The ten papers that appear in this special issue represent the result of this process. Four of the ten papers appearing in this special issue are revised and extended versions of papers presented in the closing session of the BTAS 08 conference, a session which, by BTAS tradition, is reserved for the submissions that receive the overall best reviews from the conference program committee.

The papers in this special issue cover a range of different biometric modalities, including face, ear, iris, signature, and multimodal. In the area of face recognition, there are papers dealing with 2-D, 3-D, and hand-drawn sketches. In addition, the papers in this special issue range from relatively application oriented to relatively theoretical. One common theme is that each paper addresses an important current topic in biometrics research and makes a novel contribution to the state of the art.

The first four papers are all in the general area of face recognition. The first of these is titled “Adaptive Appearance Model and Condensation Algorithm for Robust Face Tracking” and is authored by Yui Man Lui, Ross Beveridge, and Darrell Whitley, all from Colorado State University. The authors of this paper are interested in pushing the limits of tracking faces in practical video sequences. Their approach employs a condensation style of algorithm with adaptive sampling. They evaluate

their approach using video sequences that exhibit variation in face pose, facial expression, and illumination, as well as temporary occlusions. Moreover, they compare the results of their approach to those of an incremental visual-tracking approach such as that of Ross *et al.* [3] and a learned subspace approach such as that of Ho *et al.* [2]. This paper should be of interest to the broad community of researchers working in face image analysis from video.

The second paper in the face recognition area is “Assessing the Uniqueness and Permanence of Facial Actions for Use in Biometric Applications,” authored by Lanthao Benedikt, David Marshall, and Paul Rosin from Cardiff University and by Darren Cosker from the University of Bath. This is a revised version of one of the papers presented in the Best-Reviewed Papers Session at BTAS 08. The authors of this paper investigate the possibility of using facial actions as a biometric. That is, they look at video clips that capture short verbal or nonverbal facial actions and investigate how uniquely such actions can characterize a person and how stable or repeatable such actions are across elapsed time between enrollment and recognition. The use of facial actions for biometric purposes is an area that has seen relatively little previous work, making this a pioneering paper. The results in this work indicate that emotional expressions, such as happiness or disgust, are not as reliable for identity recognition as speech-related facial actions. This paper should also be of interest to the broad community of researchers working in face image analysis in video.

The third paper in the face recognition area is “Tracking Vertex Flow and Model Adaptation for 3-D Spatio-Temporal Face Analysis,” authored by Yi Sun and Xiaochen Chen from Binghamton University, Matthew Rosato from IBM Endicott, and Lijun Yin from Binghamton University. There has been a large body of work dealing with face recognition based on 3-D shapes [4]. However, only recently has much of this work begun to deal with problems of varying facial expression. While most work in this subarea deals with recognizing a person under varying facial expression, the authors tackle both the problem of 3-D spatiotemporal face recognition and the problem of classifying facial expression independent of recognizing the person. This is another example of pioneering biometrics work, tackling a modality that has seen very little work to date, i.e., dynamic 3-D face or “3-D video.”

The fourth paper in the face recognition area is “Hand-Drawn Face Sketch Recognition by Humans and a PCA-based Algorithm for Forensic Applications,” by Yong Zhang, Christine McCullough, and John Sullins from Youngstown State University and Christine Ross from the Ohio Bureau of Criminal Identification. This is a revised and extended version of another of the papers presented in the Best-Reviewed Papers Session at BTAS 08. Using a data set of 250 sketches of 50 people,

involving five different sketch artists, they compare the recognition performance of humans with the performance of a PCA-based, or “eigen-face,” algorithm. This is again a highly novel and pioneering work, one of a very few that have looked at face recognition using hand-drawn face sketches rather than photographic images. This topic obviously has strong relevance to law enforcement applications and represents an area that is likely to grow in level of interest and activity.

The next paper deals with recognizing persons based on the appearance of the ear, rather than of the face. This paper is “Toward Unconstrained Ear Recognition from 2-D Images,” authored by John Bustard and Mark Nixon from the University of Southampton in the U.K. Recognizing persons based on the appearance of the ear is a topic that has been studied by a relatively small but growing number of researchers. This paper represents the latest results by one of the groups with substantial previous experience in this area. Their approach in this work uses a Scale-Invariant Feature Transform on standard intensity images of the ear. Their results suggest that the accuracy of their automated approach is similar to that of a manually landmarked Principal Components Analysis (PCA), or “eigen-ear,” approach and that their approach is relatively robust to a variety of complicating factors.

The next paper is “Extended Depth of Field Iris Recognition using Unrestored Wavefront-Coded Imagery,” authored by Vishnu Boddeti and Vijayakumar Bhagavatula from Carnegie Mellon University. This is a revised and extended version of another of the papers presented in the Best-Reviewed Papers Session at BTAS 08. The authors of this paper tackle one of the important problems in iris biometrics, which is the relatively constrained distance between the subject and the sensor required in order to obtain a usable image. The authors investigate the use of wavefront-coded imaging in order to effectively extend the depth of field. The use of wavefront-coded imaging to extend the depth of field for iris biometrics is a topic that has received relatively little work to date (e.g., see [5]). However, it is a promising approach to an important current issue within iris biometrics, and hence, it is a topic likely to increase in interest in the near future.

The seventh paper is “Estimating and Fusing Quality Factors for Iris Biometric Images,” authored by Nathan Kalka, Jinyu Zuo, Natalia Schmid, and Bojan Cukic from West Virginia University. Everyone accepts that image quality can have serious effects on the accuracy of biometric recognition. However, the problem of automatically computing one or a small number of image quality metrics and using them to improve recognition accuracy is a difficult one and a topic of great current interest. The authors of this paper study this problem in the context of iris biometrics. They introduce approaches to estimate iris image quality in terms of defocus blur, motion blur, off-angle, occlusion, lighting, specular reflection, and pixels-on-the-iris. They show that screening out images with poor-quality metric scores can improve average recognition performance.

The eighth paper in this special issue is “Cancelable Templates for Sequence-Based Biometrics with Application to On-line Signature Recognition,” authored by Emanuele Maiorana, Patrizio Campisi, and Alessandro Neri from the Università degli Studi Roma TRE and Julian Fierrez and Javier Ortega-García from the Universidad Politécnica de Madrid. This

is a revised and extended version of another of the papers presented in the Best-Reviewed Papers Session at BTAS 08. The authors use signature recognition as a context for studying the application of cancelable biometric templates. Cancelable templates are an important topic of growing interest to the biometrics research community. They provide a potential solution to the privacy concerns that arise due to the possibility that a biometric template might be stolen by a hacker. With an appropriate cancelable biometrics scheme, the stolen template would simply be canceled and the rightful person re-enrolled in the system. Researchers, from any area of biometrics, who are not already familiar with cancelable biometric concepts should find this to be an interesting and worthwhile paper.

The next paper is “Quality-Based Score Normalization with Device Qualitative Information for Multimodal Biometric Fusion,” authored by Norman Poh and Josef Kittler from the University of Surrey and Thirimahos Bourlai from West Virginia University. The authors tackle an important and fundamental problem motivated by the practicalities of large-scale biometric applications. As biometrics are applied on larger scales and over longer time periods, it becomes inevitable that biometric templates arising from different sensors must be compared. Such “cross-sensor matching” may, in some cases, result in degraded performance. The authors propose a method to address this degradation by using device-specific quality-dependent score normalization. Experimental results obtained using the Biosecure DS2 data set [6] show that such an approach has the potential to improve performance through decreasing both false-accept and false-reject rates.

The last paper in this special issue is “Binary Biometrics: An Analytic Framework to Estimate the Performance Curves under Gaussian Assumption,” by Emile Kelkboom, Gary Garcia, Jeroen Breebaart, and Willem Jonker from Philips Research, Raymond Veldhuis from the University of Twente, and Tom Kevenaar from priv-ID. This paper seeks to develop an analytical model for estimating the performance curve of a biometric system that incorporates template protection and uses multiple biometric samples to enroll or recognize a person. This work is relevant to biometric systems that represent a biometric sample by a binary vector and compute the difference between two samples using the Hamming distance, as is the case with the standard approach to iris biometrics. This is important work in the conceptual modeling of the performance of biometric systems.

I hope that you will enjoy reading the papers in this special issue and that you will find them to be a good and useful representation of recent advances in the state of the art in biometrics. I want to congratulate the authors on the acceptance of their papers. I also want to offer my thanks to the referees and to the authors for promptly completing reviewing tasks and revisions of papers, respectively. Lastly, thanks also to the SMC-A Editor, Witold Pedrycz, and the editorial manager, Tina Scheman-Moje, for their help in nurturing this special issue through to publication.

KEVIN W. BOWYER, *Guest Editor*
Department of Computer Science and Engineering
University of Notre Dame
Notre Dame, IN 46556, USA

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Kevin W. Bowyer (S'77–M'80–SM'92–F'98) received the Ph.D. degree in computer science from Duke University, Durham, NC.

Following a year with the Institute for Informatics, Eidgenössische Technische Hochschule Zürich, Zurich, he joined the Department of Computer Science and Engineering, University of South Florida (USF), Tampa. He currently serves as the Schubmehl-Prein Professor and the Chair of the Department of Computer Science and Engineering, University of Notre Dame, Notre Dame, IN. His recent research activities focus on problems in biometrics and data mining. His particular contributions in biometrics include experimental investigation of basic phenomena in iris biometrics, algorithms for improved accuracy in iris biometrics, face recognition using 3-D shapes, 2-D and 3-D ear biometrics, advances in multimodal biometrics, and support of the government's Face Recognition Grand Challenge, Iris Challenge Evaluation, Face Recognition Vendor Test 2006, and Multiple Biometric Grand Challenge programs. His data mining research has been supported by Sandia National Laboratories. This work focuses on classifier ensemble

techniques for problems that exhibit "extreme" characteristics, such as a high imbalance between classes, unusually large size of training data, and noise in the class labels of the training data. He authored the textbook *Ethics and Computing* and led a series of National Science Foundation (NSF)-sponsored workshops on curriculum development in this area.

Prof. Bowyer is the recipient of three teaching awards while teaching at USF, a Distinguished Faculty Award for his mentoring work with underrepresented students in the McNair Scholars Program, and a sequence of five NSF site grants for Research Experiences for Undergraduates. His paper "Face Recognition Technology: Security Versus Privacy," published in the *IEEE TECHNOLOGY AND SOCIETY MAGAZINE*, was recognized with an "Award of Excellence" from the Society for Technical Communication in 2005. He has served as Editor-in-Chief of the *IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE*, recognized as a premier journal in its areas of coverage, and was elected an IEEE Fellow for his research in object recognition. He is the founding General Chair of the IEEE International Conference on Biometrics Theory, Applications and Systems, having served as General Chair in 2007, 2008, and 2009. He is a Golden Core Member of the IEEE Computer Society.