

Introduction to the Issue on Perception Inspired Video Processing

VIDEO services are demanding a significant and rapidly increasing fraction of Internet traffic. The ability of traditional approaches to video processing to cope with this data glut are being stretched to the limit, hence new approaches to video processing are necessary to keep up with current and predicted exponential increases in the creation and consumption of video. The knowledge accrued by more than a century of largely unexplored findings from Vision Science research, along with recent breakthroughs in brain imaging, neural computational modeling, and models of users' Quality of Experience (QoE), provides a verdant ground for developing efficient, perceptually optimized video processing paradigms. The papers in this special issue report recent advances and new directions in applying human perception for optimizing video processing. Due to the broad nature of applications of video processing, the papers in this issue cover a wide range of topics including quality of video, neural correlates, 3D video, classification, segmentation, and compression.

A. Neural Responses to Video

Understanding neural responses to visual data will enable a better understanding of how the human visual system processes videos. This understanding is essential for developing next-generation video processing systems that deliver the highest visual quality. This issue includes two papers that study neural responses to video. The paper by Rosenthal *et al.* entitled "Evoked Neural Responses to Events in Video" reports on neural responses to events in video, while neural responses to varying video quality is reported by Arndt *et al.* in "Using Electroencephalography to Measure Perceived Video Quality." With electroencephalographic (EEG) instruments becoming more accessible, we can expect very active research in this direction within the next few years.

B. Video Quality

Quality assessment is an important area of video processing, and research in this areas focuses on developing models and tools for quantifying video quality. Quality assessment is especially challenging in cases of image retargeting where the target images are transformed using content-aware methods to fit the device display. The paper "Objective Quality Assessment for Image Retargeting Based on Perceptual Geometric Distortion and Information Loss" by Hsu *et al.* introduces an objective metric based on perceptual principles. Maintaining mobile video quality is also a challenging problem. Observing that the quality of video experienced by users on mobile devices depends on the device, content, and the environment, Xue and

Chen introduce methods for maximizing mobile video quality in their paper entitled "Mobile Video Perception: New Insights and Adaptation Strategies."

C. 3D Video

There is continued interest in 3D video services, and technology in this area continues to improve. Two papers in this issue address 3D video by focusing on the important topics of compression and 3D quality of experience. Asymmetric coding is used in 3D video compression systems to reduce the bandwidth requirements by encoding one of the views at a lower quality than the other. In the paper "Visual Attention Model Aided Non-Uniform Asymmetric Coding of Stereoscopic Video," Ekmekcioglu *et al.* propose content aware methods to improve asymmetric coding using attentional cues. One of the common complaints when watching 3D videos is visual discomfort. In the paper "3D Visual Discomfort Prediction: Vergence, Foveation, and the Physiological Optics of Accommodation," Park *et al.* analyze the physiological aspects of stereo perception and present a method for visual discomfort prediction based on perceptual features.

D. Applications of Human Visual Perception

This issue includes several papers that focus on applying models/principles of human visual perception to video processing problems. The slowness principle in visual perception describes how the brain extracts slow changing representational features from fast changing input stimuli captured by the retina. Theriault *et al.* apply this principle in a video classification problem presented in their paper "Perceptual Principles for Video Classification with Slow Feature Analysis." In "A Retina-Based Perceptually Lossless Limit and a Gaussian Foveation Scheme with Loss Control," Targino da Costa *et al.* use models of retinal image projection and receptor distribution to develop a model for perceptually lossless image compression.

Another challenging problem in video processing is object segmentation. In "Coherency Based Spatio-Temporal Saliency Detection for Video Object Segmentation," Mahapatra *et al.* present methods for salient object detection and segmentation. Heinrich *et al.* present a motion estimation method for frame rate conversion in "Perception-Oriented Methodology for Robust Motion Estimation Design."

Optimizing High Efficiency Video Coding (HEVC) is an important problem that has received great interest in the research community. Services such as video telephony present interesting challenges and opportunities to apply new coding optimizations. Xu *et al.* exploit face perception for HEVC optimization in their paper "Region-of-Interest Based Conversational HEVC Coding with Hierarchical Perception Model

of Face.” In “Gamut Mapping in Cinematography through Perceptually-based Contrast Modification,” Zamir *et al.* exploit contrast sensitivity for faithful color reproduction in cinematography.

We hope this special issue is able to highlight some of the many ways that models of human visual perception can be applied to video processing applications. This is just the beginning of the next phase of video processing research that we foresee will have to consider perception, cognition, and emotion to solve current as well as new problems. The guest editors would like to sincerely thank the many reviewers that provided valuable input in shaping this special issue.

HARI KALVA, *Lead Guest Editor*
Florida Atlantic University
Boca Raton, FL 33431 USA

AL BOVIK, *Guest Editor*
The University of Texas at Austin
Austin, TX 78712 USA

HOMER CHEN, *Guest Editor*
National Taiwan University
Taipei 10617, Taiwan

KAREN EGAZARIAN, *Guest Editor*
Tampere University of Technology
33720 Tampere, Finland

ZHOU WANG, *Guest Editor*
University of Waterloo
Waterloo, ON N2L 3G1, Canada



Hari Kalva (S'92–M'00–SM'05) is an Associate Professor and the Director of the Multimedia Lab in the Department of Computer & Electrical Engineering and Computer Science at Florida Atlantic University (FAU).

He has over 20 years of experience in multimedia research, development, and standardization. His current research activities include video compression and video communication with emphasis on perceptual video processing, HEVC optimization, and Social TV. His work has received recognition in the form of publications, granted patents, technology transfer, and professional awards.

Dr. Kalva received a Ph.D. in Electrical Engineering from Columbia University in 2000. He received an M.S. in Computer Engineering from Florida Atlantic University in 1994, and a B. Tech. in Electronics and Communications Engineering from N.B.K.R. Institute of Science and Technology, S.V. University, Tirupati, India in 1991.



Al Bovik is the Curry/Cullen Trust Endowed Chair Professor at The University of Texas at Austin, where he is Director of the Laboratory for Image and Video Engineering (LIVE). He is a faculty member in the Department of Electrical and Computer Engineering and the Center for Perceptual Systems in the Institute for Neuroscience. His research interests include image and video processing, computational vision, and visual perception. He has published more than 700 technical articles in these areas and holds four U.S. patents. His several books include the companion volumes *The Essential Guides to Image and Video Processing* (Academic Press, 2009).

Dr. Bovik has received a number of major awards from the IEEE Signal Processing Society, including: the Society Award (2013); the Technical Achievement Award (2005); the Best Paper Award (2009); the Signal Processing Magazine Best Paper Award (2013); the Education Award (2007); the Distinguished Lecturer Award (2000); the Meritorious Service Award (1998) and (co-author) the Young Author Best Paper Award (2013). He also was named recipient of the Honorary Member Award of the Society for Imaging Science and Technology for 2013, received the SPIE

Technology Achievement Award for 2012, and was the IS&T/SPIE Imaging Scientist of the Year for 2011. He is also a recipient of the Hocott Award for Distinguished Engineering Research from the Cockrell School of Engineering at The University of Texas at Austin (2008), the Distinguished Alumni Award from the University of Illinois at Champaign-Urbana (2008), the IEEE Third Millennium Medal (2000) and two journal paper awards from the Pattern Recognition Society (1988 and 1993). He is a Fellow of the IEEE, a Fellow of the Optical Society of America (OSA), a Fellow of the Society of Photo-Optical and Instrumentation Engineers (SPIE), and a Fellow of the American Institute of Medical and Biomedical Engineering (AIMBE). He has been involved in numerous professional society activities, including: Board of Governors, IEEE Signal Processing Society, 1996–1998; co-founder and Editor-in-Chief, IEEE TRANSACTIONS ON IMAGE PROCESSING, 1996–2002; Editorial Board, THE PROCEEDINGS OF THE IEEE, 1998–2004; Series Editor for Image, Video, and Multimedia Processing, Morgan and Claypool Publishing Company, 2003–present; and Founding General Chairman, First IEEE International Conference on Image Processing, held in Austin, Texas, in November, 1994.

Dr. Bovik is a registered Professional Engineer in the State of Texas and is a frequent consultant to legal, industrial and academic institutions.



Homer Chen (M'86–SM'01–F'03) received the Ph.D. degree in Electrical and Computer Engineering from University of Illinois at Urbana-Champaign.

Dr. Chen's professional career has spanned across academia and industry. Since August 2003, he has been with the College of Electrical Engineering and Computer Science, National Taiwan University, where he is Irving T. Ho Chair Professor. Prior to that, he held various R&D management and engineering positions with U.S. companies over a period of 17 years, including AT&T Bell Labs, Rockwell Science Center, iVast, and Digital Island (acquired by Cable & Wireless). He was a U.S. delegate for ISO and ITU standards committees and contributed to the development of many new interactive multimedia technologies that are now part of the MPEG-4 and JPEG-2000 standards. His professional interests lie in the broad area of multimedia signal processing and communications.

Dr. Chen was an Associate Editor of IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY from 2004 to 2010, IEEE TRANSACTIONS ON IMAGE PROCESSING from 1992 to 1994, and Pattern Recognition from 1989 to 1999. He served as a Guest Editor for IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY in 1999 and for IEEE TRANSACTIONS ON MULTIMEDIA in 2011.



Karen Egiazarian (Eguiazarian) (SM'96) received the Ph.D. degree in Mathematics and Physics from Moscow Lomonosov State University, Russia, in 1986, and Doctor of Technology degree from Tampere University of Technology, Finland, in 1994.

He is currently a visiting Professor in Nvidia Research, Santa Clara. He is a Professor in the Department of Signal Processing, Tampere University of Technology, Finland, leading there a 'Computational imaging' group. He is a Docent in the Department of Information Technology, University of Jyväskylä, Finland. His main research interests are in the fields of digital image/video restoration, compression, efficient transforms and multirate signal processing, on which he has published over 600 papers. His most known contributions are in image denoising (BM3D) and perceptual quality assessment (PSNR-HVS-M).

Dr. Egiazarian was a Chair of IEEE CAS/SP Finland Chapter (2001–2003), and is a member of the DSP Technical Committee of the IEEE Circuits and Systems Society (since 2002).



Zhou Wang (S'99–M'02–SM'12–F'14) received the Ph.D. degree in Electrical and Computer Engineering from The University of Texas at Austin in 2001.

Dr. Wang is currently an Associate Professor in the Department of Electrical and Computer Engineering, University of Waterloo, Canada. His research interests include image processing, coding, and quality assessment; computational vision and pattern analysis; multimedia communications; and biomedical signal processing. He has more than 100 papers in these fields and is widely cited for his contributions to perceptual image quality assessment, processing and coding.

Dr. Wang is a member of IEEE Multimedia Signal Processing Technical Committee (2013–2015). He had served or has been serving as an Associate Editor of IEEE TRANSACTIONS ON IMAGE PROCESSING (2009–2013), Pattern Recognition (2006–present) and IEEE Signal Processing Letters (2006–2010), and a Guest Editor of IEEE JOURNAL OF SELECTED TOPICS IN SIGNAL PROCESSING (2013–present and 2007–2009), EURASIP Journal of Image and Video Processing (2009–2010), and Signal, Image and Video Processing (2011–2013). He is a recipient

of 2014 NSERC E.W.R. Steacie Memorial Fellowship Award, 2013 IEEE Signal Processing Best Magazine Paper Award, 2009 IEEE Signal Processing Society Best Paper Award, 2009 Ontario Ministry of Research and Innovation Early Researcher Award, and ICIP 2008 IBM Best Student Paper Award (as senior author).