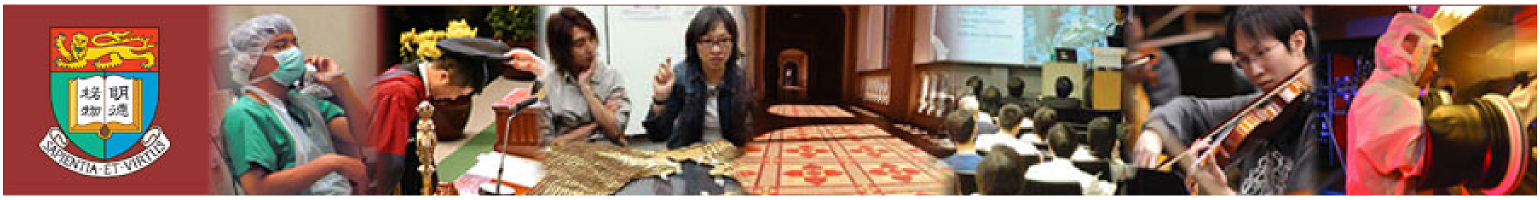

Title	Guest Editorial Computational and smart cameras
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Guest Editorial
Computational and Smart Cameras

RECENT advances in camera hardware, processing capabilities, storage capacities, and communication technologies suggest an evolution of traditional multi-camera systems into networks of highly capable computational and smart cameras. These networks can be seen as visual sensor nodes that combine sensing with onboard processing and storage, and that are able to communicate with other similar sensors in the vicinity. As a future development step, these visual sensor nodes will have the necessary control and coordination machinery to set up ad-hoc sensing networks, capable of capturing, analyzing, and storing large amounts of image and video data over extended spaces to support a variety of applications. Opportunities for application development abound in domains as diverse as smart environments, wearable sensing, security and surveillance, environmental monitoring and disaster response, traffic management and urban sensing, elderly care and wellness monitoring, geo-scale monitoring, etc. These networks must also exhibit a great deal of autonomy as the sheer scale of the networks and the tremendous amount of data present in them render human-in-the-loop operation for the most part infeasible.

Much work is still needed to realize this vision of ad-hoc networks of computational and smart cameras capable of providing perceptive coverage of wide areas with little or no human supervision. Problems arising in the domains of camera hardware, computer vision, and sensor networks must be solved concomitantly to realize this vision. Computational and smart camera hardware requires significant sensing and processing capabilities and long lifetimes. Additionally, the camera hardware must be able to communicate with other cameras and transmit the video over the network. Video transmission especially is expensive in terms of both bandwidth and energy consumption. Furthermore, camera nodes need to work together towards a common sensing goal. No single camera can observe the entire scene. Collaborative sensing, therefore, is important. The overall camera network must also be capable of autonomous behavior. It suggests that network level control and coordination strategies are needed. Lastly, new tools to study and experiment with these networks are required. The goal of this special issue is to bring together papers dealing with various aspects of this vision.

The paper titled "Automatic Fall Detection and Activity Classification by a Wearable Embedded Smart Camera" develops algorithms that enable a CITRIC-based wearable camera to detect if the subject wearing this camera has fallen, or is sitting or standing. It is easy to imagine that such wearable cameras can serve an enabling role in a technology solution aimed at independent living for the elderly. In terms of novel camera architectures, the paper titled "Hemispherical Multiple Camera System for High Resolution Omni-Directional Light Field Imaging" presents an imaging system capable of recording 30 frames per second video at resolutions of 9000×2400 pixels. The system also simultaneously captures the surrounding light field in its 360×100 degree field of view.

As stated above, the real power of computational and smart cameras lies in the fact that these cameras can be used to construct networks of cameras. When considering multiple cameras and camera networks, a natural question is how information captured from multiple cameras can be used for visual analysis. The paper titled "Feature Extraction and Representation for Distributed Multi-View Human Action Recognition" deals with the problem of activity analysis using multiple viewpoints. The paper titled "Dynamic Bayesian Network for Unconstrained Face Recognition in Surveillance Camera Networks" employs Bayesian networks to improve facial recognition rates in its target application by exploiting the fact that the person in question is being viewed by multiple cameras.

Video (data collection) synchronization is a challenge when dealing with multiple cameras. The paper titled "Action-Based Multi-Camera Synchronization" casts video synchronization as a frame association problem, as opposed to a continuous-time warping problem. High-level video analysis performed at each stream is used to solve the frame association problem, in turn solving the video synchronization problem. Then again, the question arises as to how to track objects, individuals, or events as they move out of the field of view of one camera and enter the field of view of another camera This problem is known as "consistent labeling" in computer vision circles and the paper titled "Geometry-Based Object Association and Consistent Labelling in Multi-Camera Surveillance" assumes a calibrated camera network and a known scene model to identify the same person across multiple cameras. Similarly, the paper titled "Multi-View ML Object Tracking with Online Learning on Riemannian Manifolds by Combining Geometric Constraints" studies the issue of tracking objects in multiple cameras; however, this paper learns appearance models of subjects and uses them to track them in the presence of short-duration occlusions.

Requirements in terms of storage, bandwidth, and energy determine the overall "performance" of a camera network. The paper titled "Implementation of Wireless Vision Sensor Node with a Lightweight Bi-Level Video Coding" develops an energy efficient programmable vision sensor node (VSN). Here, data intensive vision tasks are performed at the VSN, whereas control centric tasks are performed at the server. This partitioning reduces energy requirements while at the same time keeping the design complexity low. The paper titled "P-FAD: Real-Time Face Detection Scheme on Embedded Smart Cameras" presents a real-time face detection system geared towards embedded devices such as mobile phones. The face detection system presented here balances detection speed against accuracy, given the processing resources available.

Within this theme of power-aware sensing, the paper titled "Multimodal Video Analysis on Self-Powered Resource-Limited Wireless Smart Camera" develops a solar-powered video

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sensor node capable of on-board video processing. The visual sensor node is self-reliant in that it does not require an external power source for its operation. The video processing capabilities of this sensor node are demonstrated by implementing abandoned object detection routines. The paper titled "Characterizing a Heterogeneous System for Person Detection in Video using Histogram of Oriented Gradients: Power Versus Speed Versus Accuracy" presents a hardware implementation of the popular histogram of oriented gradients (HOG) detector for person identification. The work presented herein sheds light on the power/speed/accuracy tradeoffs when using FPGA, GPU, and CPU units for different stages of the HOG algorithm. HOG detector is a sophisticated computer vision algorithm and it is expected that the findings presented in this paper can be extrapolated to other vision algorithms.

The paper titled "On the Hardware/Software Design and Implementation of a High Definition Multiview Video Surveillance System" presents a prototype of a multi-view high-definition surveillance system. Here each camera includes field programmable gate array (FPGA) hardware responsible for single-view image analysis, such as background subtraction, tracking, etc. Video processed at each camera is sent to a back-end server equipped with storage and graphical processing units (GPUs) for higher level multi-view video analysis. When discussing real-time video analysis in camera networks, the paper titled "Real-Time People Tracking in a Camera Network" uses a GPU-based parallel implementation of particle filters for tracking individuals in multiple cameras at real-time rates. The paper titled "An Accurate Algorithm for the Identification of Fingertips Using an RGB-D Camera" develops a real-time system for fingertip tracking using the Microsoft Kinect sensor.

For tools and frameworks for studying and prototyping large scale networks of computational and smart cameras, the paper titled "Software Laboratory for Camera Networks Research" presents a distributed virtual vision system that can be used to simulate camera networks consisting of 100+ cameras in 3-D environments populated with self-animated virtual humans. Such software tools will become increasingly relevant as we begin to study and model larger networks of computational and smart cameras.

We conclude by expressing our sincere thanks to the IEEE JETCAS Editor-in-Chief, Prof. Massoud Pedram, Deputy-Editor-in-Chief, Prof. Manuel Delgado-Restituto, and the entire team at the IEEE JETCAS. Of course this issue would not have been possible without the hard work of the authors who submitted their papers to this issue. Our sincere thanks also go to the reviewers, who did a superb job reviewing the submitted papers under very tight deadlines.

We hope that you will find this issue illuminating. Happy reading!

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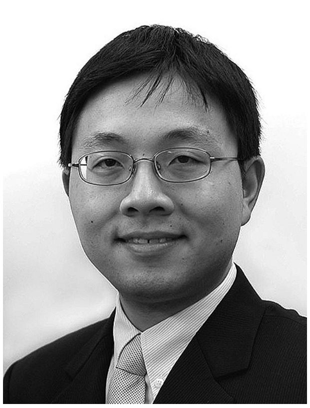

Edmund Y. Lam (M'00–SM'05) received the B.S. (with distinction), M.S., and Ph.D. degrees in electrical engineering from Stanford University, Stanford, CA, USA.

At Stanford University, he conducted research for the Programmable Digital Camera project in the Information Systems Laboratory. He also consulted for industry in the areas of digital camera systems design and algorithms development. He is now an Associate Professor in Electrical and Electronic Engineering and the founding Director of the Imaging Systems Laboratory at The University of Hong Kong, with broad research interests around the theme of computational optics and imaging. During the 2010–2011 academic year, he taught at the Department of Electrical Engineering and Computer Science at Massachusetts Institute of Technology as a Visiting Associate Professor. He is a Topical Editor of the *Journal of the Optical Society of America A*, and has guest edited special issues in the *Multidimensional Systems and Signal Processing* journal, and *Journal of Electronic Imaging*.

Dr. Lam also currently serves as an Associate Editor of the IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS, and a Guest Editor in the IEEE JOURNAL ON EMERGING AND SELECTED TOPICS IN CIRCUITS AND SYSTEMS. In addition, he is active in conference organizations, serving as General Chair of the ACM/IEEE International Conference on Distributed Smart Cameras in 2012, Program Chair of OSA Signal Recovery and Synthesis meeting in 2011, and Chair of SPIE conference on Image Processing: Machine Vision Applications in 2012–2013. He is a Fellow of the Optical Society (OSA) and Society of Photo-optical Instrumentation Engineers (SPIE). He was presented an Outstanding Young Researcher Award, a Best Teacher Award, and an Outstanding Teaching Award (team award) from The University of Hong Kong.

Hamid Aghajan received the B.S. degree from Sharif University of Technology, Tehran, Iran, in 1989, and the M.S. and Ph.D. degrees from Stanford University, Stanford, CA, USA, in 1991 and 1995, respectively, all in electrical engineering.

He is Director of Stanford's Ambient Intelligence Research (AIR) Lab, and Wireless Sensor Networks (WSN) Lab, where he has supervised research on multi-camera and sensor networks for smart environments since 2003. Focus of research in his group is on methods and applications of ambient intelligence with an emphasis on activity recognition with networks of cameras, smart phones, and other sensors. Specific research topics include behavior modeling using long-term sensory data, occupancy modeling of smart buildings for resource efficiency, detection of anomaly or shift in behavior in elderly care, improving office worker's well-being through personalized ergonomic recommendations, analysis of meetings, and avatar-based social interactions. He is Co-Editor-in-Chief of *Journal of Ambient Intelligence and Smart Environments*, and has served as Guest Editor for *International Journal of Computer Vision* and *Computer Vision and Image Understanding*.

Dr. Aghajan has served as Guest Editor for the IEEE TRANSACTIONS ON MULTIMEDIA and IEEE JOURNAL OF SELECTED TOPICS IN SIGNAL PROCESSING. He was a General Chair of ACM/IEEE ICDSC 2008, AMI 2011, Program Chair of ICDSC 2007, and is a General Chair of ICMI 2012. He has organized workshops, special sessions, or tutorials at ECCV, ACM MM, CVPR, ICCV, ICMI, FG, ECAI, EI, and ICASSP.

Andrea Prati (SM'09) received the Laurea (*cum laude*) in computer engineering in 1998, and the Ph.D. degree in information engineering, in 2001.

He is currently an Associate Professor at the Department of Design and Planning in Complex Environments of the University IUAV of Venice. He collaborated in several research projects, at regional, national, and international level (such as the project BE SAFE (2006–2010) under the NATO funding scheme Science for Peace). Moreover, he collaborates with several local companies in specific research projects, related mainly to industrial applications of computer vision. His research interests belong to different themes, from embedded devices for sensor networks in computer vision applications, to robotic vision, to multimedia, to performance analysis for multimedia computers. However, his main research activity is on video-surveillance topics: object tracking in distributed, multi-camera environments; analysis and removal of the shadows; behavior analysis through trajectory classification. He recently started to research on mobile vision, i.e., the application of sophisticated computer vision techniques on mobile phones. He is author of more than 130 papers in international journals and conference proceedings, he has been invited speaker, and reviewer for many international journals. He is also a member of the Editorial Board of *Journal of Optical Engineering* (SPIE) and *Journal on Ambient Intelligence and Smart Environments* (IOS Press).

Dr. Prati has been the Program Chair of ICIAP 2007. He has been the PC of ACM/IEEE International Conference on Distributed Smart Cameras (ICDSC) in 2011 and 2012, and will be for 2013 edition in Palm Springs, CA, USA. He is also organizing as General Chair the 2014 ICDSC edition in Venice. He is a member of ACM and GIRPR.

Faisal Z. Qureshi (M'06) received the M.Sc. degree in electronics (with distinction) from the Quaid-e-Azam University, Islamabad, Pakistan, in 1995, and the M.Sc. and Ph.D. degrees in computer science from the University of Toronto, Toronto, ON, Canada, in 2000 and 2007, respectively

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Dr. Qureshi is also active in conference organizations, serving as the General co-Chair of the Workshop on Camera Networks and Wide-Area Scene Analysis (co-located with CVPR) in 2011–2013, Technical Program Committee Chair for the 2013 ACM/IEEE International Conference on Distributed Smart Cameras, and Publicity Chair for the 2013 IEEE International Conference on Advanced Video and Signal-Based Surveillance. Additionally, he has served on the program committees of the major conferences in his fields of expertise. He is a member of the ACM.

Dr. Vincent Tam is a Senior Teaching Consultant and Honorary Assistant Professor in Department of Electrical and Electronic Engineering, The University of Hong Kong. He has been actively involved as the principal or co-investigator of various research projects related to human–computer interaction, uses of smart/video sensors and wireless sensor networks in real-life applications. He is also serving on the on the Editorial Board of the *Journal of Ambient Intelligence and Smart Environments*. He has over 80 refereed publications including five book chapters and 16 journal papers. His research interests include image/video sensors, wireless sensor networks, mobile applications, and e-learning systems.

Prof. Tam served as both the Publicity and Workshop Chairs of the 6th ACM/IEEE International Conference on Distributed and Smart Cameras (ICDSC 2012). He is serving on the Advisory Board of the International Association for Smart Learning Environments.