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- Image Processing
- Image Capture
- Multimedia Processing and Applications
- Computer Vision

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2–6 February 2014
Hilton San Francisco, Union Square
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Course Index

continues

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Course Index

Image Capture

Computer Vision

Media Processing and Communication

Mobile Imaging

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  - Perception, Cognition, and Next Generation Imaging

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IS&T/SPIE reserves the right to cancel a course due to insufficient advance registration.

Course Daily Schedule

3D Imaging, Interaction, and Metrology

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
SC468 **Image Enhancement, Deblurring and Super-Resolution** *(Rabbani)* 8:30 am to 5:30 pm, $525 / $635, p. 10		SC1015 **Understanding and Interpreting Images** *(Rabbani)* 1:30 pm to 5:30 pm, $300 / $355, p. 10	SC927 **3D Imaging** *(Agam)* 8:30 am to 12:30 pm, $300 / $355, p. 9	
SC969 **Perception, Cognition, and Next Generation Imaging** *(Rogowitz)* 8:30 am to 12:30 pm, $300 / $355, p. 11				
SC060 **Stereoscopic Display Application Issues** *(Merritt, Woods)* 8:30 am to 5:30 pm, $525 / $635, p. 9				

Visualization, Perception, and Color

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
SC967 **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)* 8:30 am to 5:30 pm, $570 / $680, p. 13	SC807 **Digital Camera and Scanner Performance Evaluation: Standards and Measurement** *(Burns, Williams)* 12:00 am to 12:00 am, $300 / $355, p. 16	SC1015 **Understanding and Interpreting Images** *(Rabbani)* 1:30 pm to 5:30 pm, $300 / $355, p. 12	SC927 **3D Imaging** *(Agam)* 8:30 am to 12:30 pm, $300 / $355, p. 18	
SC468 **Image Enhancement, Deblurring and Super-Resolution** *(Rabbani)* 8:30 am to 5:30 pm, $525 / $635, p. 13	SC1049 **Objective and Subjective Image Quality Camera Benchmarking** *(Phillips)* 8:30 am to 5:30 pm, $525 / $635, p. 14		SC1131 **Computer Vision and Imaging in Transportation Applications** *(Bala, Loce)* 8:30 am to 12:30 pm, $300 / $355, p. 16	
SC1058 **Image Quality and Evaluation of Cameras In Mobile Devices** *(Wüller, Matherson)* 8:30 am to 5:30 pm, $525 / $635, p. 15	SC1097 **HDR Imaging in Cameras, Displays and Human Vision** *(Rizzi, McCann)* 1:30 to 5:30 pm, $300 / $355, p. 14			
SC969 **Perception, Cognition, and Next Generation Imaging** *(Rogowitz)* 8:30 am to 12:30 pm, $300 / $355, p. 11				
SC060 **Stereoscopic Display Application Issues** *(Merritt, Woods)* 8:30 am to 5:30 pm, $525 / $635, p. 17				
SC1130 **Image and Video Forensics: Recent Trends and Challenges** *(Battiato)* 1:30 pm to 5:30 pm, $300 / $355, p. 15				
SC812 **Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence** *(Pappas/Hemami)* 1:30 pm to 5:30 pm, $300 / $355, p. 12				

Image Processing

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
SC967 **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)* 8:30 am to 5:30 pm, $570 / $680, p. 22	SC807 **Digital Camera and Scanner Performance Evaluation: Standards and Measurement** *(Burns, Williams)* 12:00 am to 12:00 am, $300 / $355, p. 21	SC1015 **Understanding and Interpreting Images** *(Rabbani)* 1:30 pm to 5:30 pm, $300 / $355, p. 18	SC927 **3D Imaging** *(Agam)* 8:30 am to 12:30 pm, $300 / $355, p. 25	
SC468 **Image Enhancement, Deblurring and Super-Resolution** *(Rabbani)* 8:30 am to 5:30 pm, $525 / $635, p. 19	SC1097 **HDR Imaging in Cameras, Displays and Human Vision** *(Rizzi, McCann)* 1:30 to 5:30 pm, $300 / $355, p. 22		SC1131 **Computer Vision and Imaging in Transportation Applications** *(Bala, Loce)* 8:30 am to 12:30 pm, $300 / $355, p. 20	
SC1058 **Image Quality and Evaluation of Cameras In Mobile Devices** *(Wüller, Matherson)* 8:30 am to 5:30 pm, $525 / $635, p. 21				
SC969 **Perception, Cognition, and Next Generation Imaging** *(Rogowitz)* 8:30 am to 12:30 pm, $300 / $355, p. 25				
SC060 **Stereoscopic Display Application Issues** *(Merritt, Woods)* 8:30 am to 5:30 pm, $525 / $635, p. 24				
SC980 **Theory and Methods of Lightfield Photography** *(Georgiev, Lumsdaine, Georgieva)* 8:30 am to 5:30 pm, $525 / $635, p. 23				
SC1130 **Image and Video Forensics: Recent Trends and Challenges** *(Battiato)* 1:30 pm to 5:30 pm, $300 / $355, p. 20				
SC965 **Joint Design of Optics and Image Processing for Imaging Systems** *(Stork)* 1:30 pm to 5:30 pm, $300 / $355, p. 19				
SC812 **Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence** *(Pappas/Hemami)* 1:30 pm to 5:30 pm, $300 / $355, p. 23				

Image Capture

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
SC967 **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)* 8:30 am to 5:30 pm, $570 / $680, p. 28	SC807 **Digital Camera and Scanner Performance Evaluation: Standards and Measurement** *(Burns, Williams)* 12:00 am to 12:00 am, $300 / $355, p. 25	SC1015 **Understanding and Interpreting Images** *(Rabbani)* 1:30 pm to 5:30 pm, $300 / $355, p. 30		
SC468 **Image Enhancement, Deblurring and Super-Resolution** *(Rabbani)* 8:30 am to 5:30 pm, $525 / $635, p. 29	SC1049 **Objective and Subjective Image Quality Camera Benchmarking** *(Phillips)* 8:30 am to 5:30 pm, $525 / $635, p. 27			
SC1058 **Image Quality and Evaluation of Cameras In Mobile Devices** *(Wüller, Matherson)* 8:30 am to 5:30 pm, $525 / $635, p. 28	SC1097 **HDR Imaging in Cameras, Displays and Human Vision** *(Rizzi, McCann)* 1:30 to 5:30 pm, $300 / $355, p. 28			
SC969 **Perception, Cognition, and Next Generation Imaging** *(Rogowitz)* 8:30 am to 12:30 pm, $300 / $355, p. 30				
SC980 **Theory and Methods of Lightfield Photography** *(Georgiev, Lumsdaine, Georgieva)* 8:30 am to 5:30 pm, $525 / $635, p. 26				
SC1130 **Image and Video Forensics: Recent Trends and Challenges** *(Battiato)* 1:30 pm to 5:30 pm, $300 / $355, p. 29				
SC965 **Joint Design of Optics and Image Processing for Imaging Systems** *(Stork)* 1:30 pm to 5:30 pm, $300 / $355, p. 26				
SC812 **Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence** *(Pappas/Hemami)* 1:30 pm to 5:30 pm, $300 / $355, p. 31				

Course Daily Schedule

Computer Vision

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
SC468 **Image Enhancement, Deblurring and Super-Resolution** *(Rabbani)* 8:30 am to 5:30 pm, $525 / $635, p. 34	SC807 **Digital Camera and Scanner Performance Evaluation: Standards and Measurement** *(Burns, Williams)* 12:00 am to 12:00 am, $300 / $355, p. 34	SC1015 **Understanding and Interpreting Images** *(Rabbani)* 1:30 pm to 5:30 pm, $300 / $355, p. 32	SC1131 **Computer Vision and Imaging in Transportation Applications** *(Bala, Loce)* 8:30 am to 12:30 pm, $300 / $355, p. 32	
SC969 **Perception, Cognition, and Next Generation Imaging** *(Rogowitz)* 8:30 am to 12:30 pm, $300 / $355, p. 35	SC1049 **Objective and Subjective Image Quality Camera Benchmarking** *(Phillips)* 8:30 am to 5:30 pm, $525 / $635, p. 33			
SC1130 **Image and Video Forensics: Recent Trends and Challenges** *(Battiato)* 1:30 pm to 5:30 pm, $300 / $355, p. 33				
SC965 **Joint Design of Optics and Image Processing for Imaging Systems** *(Stork)* 1:30 pm to 5:30 pm, $300 / $355, p. 35				
SC812 **Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence** *(Pappas/Hemami)* 1:30 pm to 5:30 pm, $300 / $355, p. 36				

Media Processing and Communication

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
SC967 **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)* 8:30 am to 5:30 pm, $570 / $680, p. 38	SC1049 **Objective and Subjective Image Quality Camera Benchmarking** *(Phillips)* 8:30 am to 5:30 pm, $525 / $635, p. 39	SC1015 **Understanding and Interpreting Images** *(Rabbani)* 1:30 pm to 5:30 pm, $300 / $355, p. 38	SC1131 **Computer Vision and Imaging in Transportation Applications** *(Bala, Loce)* 8:30 am to 12:30 pm, $300 / $355, p. 40	
SC468 **Image Enhancement, Deblurring and Super-Resolution** *(Rabbani)* 8:30 am to 5:30 pm, $525 / $635, p. 39	SC1097 **HDR Imaging in Cameras, Displays and Human Vision** *(Rizzi, McCann)* 1:30 to 5:30 pm, $300 / $355, p. 38			
SC1058 **Image Quality and Evaluation of Cameras In Mobile Devices** *(Wüller, Matherson)* 8:30 am to 5:30 pm, $525 / $635, p. 37				
SC969 **Perception, Cognition, and Next Generation Imaging** *(Rogowitz)* 8:30 am to 12:30 pm, $300 / $355, p. 40				
SC1130 **Image and Video Forensics: Recent Trends and Challenges** *(Battiato)* 1:30 pm to 5:30 pm, $300 / $355, p. 36				
SC812 **Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence** *(Pappas/Hemami)* 1:30 pm to 5:30 pm, $300 / $355, p. 41				

Mobile Imaging

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
SC967 **High Dynamic Range Imaging: Sensors and Architectures** *(Darmont)* 8:30 am to 5:30 pm, $570 / $680, p. 42	SC1049 **Objective and Subjective Image Quality Camera Benchmarking** *(Phillips)* 8:30 am to 5:30 pm, $525 / $635, p. 44	SC1015 **Understanding and Interpreting Images** *(Rabbani)* 1:30 pm to 5:30 pm, $300 / $355, p. 44		
SC468 **Image Enhancement, Deblurring and Super-Resolution** *(Rabbani)* 8:30 am to 5:30 pm, $525 / $635, p. 43	SC1097 **HDR Imaging in Cameras, Displays and Human Vision** *(Rizzi, McCann)* 1:30 to 5:30 pm, $300 / $355, p. 43			
SC1058 **Image Quality and Evaluation of Cameras In Mobile Devices** *(Wüller, Matherson)* 8:30 am to 5:30 pm, $525 / $635, p. 42				
SC969 **Perception, Cognition, and Next Generation Imaging** *(Rogowitz)* 8:30 am to 12:30 pm, $300 / $355, p. 45				
SC812 **Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence** *(Pappas/Hemami)* 1:30 pm to 5:30 pm, $300 / $355, p. 45				

3D Imaging, Interaction, and Metrology

Stereoscopic Display Application Issues

SC060

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

When correctly implemented, stereoscopic 3D displays can provide significant benefits in many areas, including endoscopy and other medical imaging, teleoperated vehicles and telemanipulators, CAD, molecular modeling, 3D computer graphics, 3D visualization, photo interpretation, video-based training, and entertainment. This course conveys a concrete understanding of basic principles and pitfalls that should be considered when setting up stereoscopic systems and producing stereoscopic content. The course will demonstrate a range of stereoscopic hardware and 3D imaging & display principles, outline the key issues in an ortho-stereoscopic video display setup, and show 3D video from a wide variety of applied stereoscopic imaging systems.

LEARNING OUTCOMES

This course will enable you to:

- list critical human factors guidelines for stereoscopic display configuration and implementation
- calculate optimal camera focal length, separation, display size, and viewing distance to achieve a desired level of depth acuity
- examine comfort limits for focus/fixation mismatch and on-screen parallax values as a function of focal length, separation, convergence, display size, and viewing-distance factors
- set up a large-screen stereo display system using AV equipment readily available at most conference sites, for 3D stills and for full-motion 3D video
- rank the often-overlooked side-benefits of stereoscopic displays that should be included in a cost/benefit analysis for proposed 3D applications
- explain common pitfalls in designing tests to compare 2D vs. 3D displays
- calculate and demonstrate the distortions in perceived 3D space due to camera and display parameters
- design and set up an ortho-stereoscopic 3D imaging/display system
- understand the projective geometry involved in stereoscopic modeling
- determine the problems, and the solutions, for converting stereoscopic video across video standards such as NTSC and PAL
- work with stereoscopic 3D video and stills -using analog and digital methods of capture/filming, encoding, storage, format conversion, display, and publishing
- describe the trade-offs among currently available stereoscopic display system technologies and determine which will best match a particular application
- understand existing and developing stereoscopic standards

INTENDED AUDIENCE

This course is designed for engineers, scientists, and program managers who are using, or considering using, stereoscopic 3D displays in their applications. The solid background in stereoscopic system fundamentals, along with many examples of advanced 3D display applications, makes this course highly useful both for those who are new to stereoscopic 3D and also for those who want to advance their current understanding and utilization of stereoscopic systems.

INSTRUCTOR

John Merritt is a 3D display systems consultant at The Merritt Group, Williamsburg, MA, USA with more than 25 years experience in the design and human-factors evaluation of stereoscopic video displays for telepresence and telerobotics, off-road mobility, unmanned vehicles, night vision devices, photo interpretation, scientific visualization, and medical imaging.

Andrew Woods is a research engineer at Curtin University's Centre for Marine Science and Technology in Perth, Western Australia. He has over 20 years of experience working on the design, application, and evaluation of stereoscopic technologies for industrial and entertainment applications.

3D Imaging

SC927

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Wednesday 8:30 am to 12:30 pm

The purpose of this course is to introduce algorithms for 3D structure inference from 2D images. In many applications, inferring 3D structure from 2D images can provide crucial sensing information. The course will begin by reviewing geometric image formation and mathematical concepts that are used to describe it, and then move to discuss algorithms for 3D model reconstruction.

The problem of 3D model reconstruction is an inverse problem in which we need to infer 3D information based on incomplete (2D) observations. We will discuss reconstruction algorithms which utilize information from multiple views. Reconstruction requires the knowledge of some intrinsic and extrinsic camera parameters, and the establishment of correspondence between views. We will discuss algorithms for determining camera parameters (camera calibration) and for obtaining correspondence using epipolar constraints between views. The course will also introduce relevant 3D imaging software components available through the industry standard OpenCV library.

LEARNING OUTCOMES

This course will enable you to:

- describe fundamental concepts in 3D imaging
- develop algorithms for 3D model reconstruction from 2D images
- incorporate camera calibration into your reconstructions
- classify the limitations of reconstruction techniques
- use industry standard tools for developing 3D imaging applications

INTENDED AUDIENCE

Engineers, researchers, and software developers, who develop imaging applications and/or use camera sensors for inspection, control, and analysis. The course assumes basic working knowledge concerning matrices and vectors.

INSTRUCTOR

Gady Agam is an Associate Professor of Computer Science at the Illinois Institute of Technology. He is the director of the Visual Computing Lab at IIT which focuses on imaging, geometric modeling, and graphics applications. He received his PhD degree from Ben-Gurion University in 1999.

Understanding and Interpreting Images

SC1015

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

A key problem in computer vision is image and video understanding, which can be defined as the task of recognizing objects in the scene and their corresponding relationships and semantics, in addition to identifying the scene category itself. Image understanding technology has numerous applications among which are smart capture devices, intelligent image processing, semantic image search and retrieval, image/video utilization (e.g., ratings on quality, usefulness, etc.), security and surveillance, intelligent asset selection and targeted advertising.

This tutorial provides an introduction to the theory and practice of image understanding algorithms by studying the various technologies that serve the three major components of a generalized IU system, namely, feature extraction and selection, machine learning tools used for classification, and datasets and ground truth used for training the classifiers. Following this general development, a few application examples are studied in more detail to gain insight into how these technologies are employed in a practical IU system. Applications include face detection, sky detection, image orientation detection, main subject detection, and content based image retrieval (CBIR). Furthermore, realtime demos including face detection and recognition, CBIR, and automatic zooming and cropping of images based on main-subject detection are provided.

LEARNING OUTCOMES

This course will enable you to:
- learn the various applications of IU and the scope of its consumer and commercial uses
- explain the various technologies used in image feature extraction such as global, block-based or region-based color histograms and moments, the “tiny” image, GIST, histogram of oriented gradients (HOG), scale-invariant feature transform (SIFT), speeded-up robust features (SURF), bag of words, etc.
- explain the various machine learning paradigms and the fundamental techniques used for classification such as Bayesian classifiers, linear support vector machines (SVM) and nonlinear kernels, boosting techniques (e.g., AdaBoost), k-nearest neighbors, .etc.
- explain the concepts used for classifier evaluation such as false positives and negatives, true positives and negatives, confusion matrix, precision and recall, and receiver operating characteristics (ROC)
- explain the basic methods employed in generating and labeling datasets and ground truth and examples of various datasets such as CMU PIE dataset, Label Me dataset, Caltech 256 dataset, TrecVid, FERET dataset, and Pascal Visual Object Recognition
- explain the fundamental ideas employed in the IU algorithms used for face detection, material detection, image orientation, and a few others
- learn the importance of using context in IU tasks

INTENDED AUDIENCE

Scientists, engineers, and managers who need to familiarize themselves with IU technology and understand its performance limitations in a diverse set of products and applications. No specific prior knowledge is required except familiarity with general mathematical concepts such as the dot product of two vectors and basic image processing concepts such as histograms, filtering, gradients, etc.

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book “Digital Image Compression Techniques” and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Image Enhancement, Deblurring and Super-Resolution

SC468

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course discusses some of the advanced algorithms in the field of digital image processing. In particular, it familiarizes the audience with the understanding, design, and implementation of advanced algorithms used in deblurring, contrast enhancement, sharpening, noise reduction, and super-resolution in still images and video. Some of the applications include medical imaging, entertainment imaging, consumer and professional digital still cameras/camcorders, forensic imaging, and surveillance. Many image examples complement the technical descriptions.

LEARNING OUTCOMES

This course will enable you to:
- explain the various nonadaptive and adaptive techniques used in image contrast enhancement. Examples include PhotoShop commands such as Brightness/Contrast, Auto Levels, Equalize and Shadow/Highlights, or Pizer’s technique and Moroney’s approach
- explain the fundamental techniques used in image Dynamic Range Compression (DRC).Illustrate using the fast bilateral filtering by Dorsey and Durand as an example.
- explain the various techniques used in image noise removal, such as bilateral filtering, sigma filtering and K-Nearest Neighbor
- explain the various techniques used in image sharpening such as nonlinear unsharp masking, etc.
- explain the basic techniques used in image deblurring (restoration) such as inverse filtering and Wiener filtering
- explain the fundamental ideas behind achieving image super-resolution from multiple lower resolution images of the same scene
- explain how motion information can be utilized in image sequences to improve the performance of various enhancement techniques such as noise removal, sharpening, and super-resolution

INTENDED AUDIENCE

Scientists, engineers, and managers who need to understand and/or apply the techniques employed in digital image processing in various products in a diverse set of applications such as medical imaging, professional and consumer imaging, forensic imaging, etc. Prior knowledge of digital filtering (convolution) is necessary for understanding the (Wiener filtering and inverse filtering) concepts used in deblurring (about 20% of the course content).

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book “Digital Image Compression Techniques” and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Perception, Cognition, and Next Generation Imaging

SC969

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 8:30 am to 12:30 pm

The world of electronic imaging is an explosion of hardware and software technologies, used in a variety of applications, in a wide range of domains. These technologies provide visual, auditory and tactile information to human observers, whose job it is to make decisions and solve problems. In this course, we will study fundamentals in human perception and cognition, and see how these principles can guide the design of systems that enhance human performance. We will study examples in display technology, image quality, visualization, image search, visual monitoring and haptics, and students will be encouraged to bring forward ongoing problems of interest to them.

LEARNING OUTCOMES

This course will enable you to:
- describe basic principles of spatial, temporal, and color processing by the human visual system, and know where to go for deeper insight
- explore basic cognitive processes, including visual attention and semantics
- develop skills in applying knowledge about human perception and cognition to engineering applications

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who are involved in the design, testing or evaluation of electronic imaging systems. Business managers responsible for innovation and new product development. Anyone interested in human perception and the evolution of electronic imaging applications.

INSTRUCTOR

Bernice Rogowitz founded and co-chairs the SPIE/IS&T Conference on Human Vision and Electronic Imaging (HVEI) which is a multi-disciplinary forum for research on perceptual and cognitive issues in imaging systems. Dr. Rogowitz received her PhD from Columbia University in visual psychophysics, worked as a researcher and research manager at the IBM T.J. Watson Research Center for over 20 years, and is currently a consultant in vision, visual analysis and sensory interfaces. She has published over 60 technical papers and has over 12 patents on perceptually-based approaches to visualization, display technology, semantic image search, color, social networking, surveillance, haptic interfaces. She is a Fellow of the SPIE and the IS&T.

Visualization, Perception, and Color

Perception, Cognition, and Next Generation Imaging

SC969

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 8:30 am to 12:30 pm

The world of electronic imaging is an explosion of hardware and software technologies, used in a variety of applications, in a wide range of domains. These technologies provide visual, auditory and tactile information to human observers, whose job it is to make decisions and solve problems. In this course, we will study fundamentals in human perception and cognition, and see how these principles can guide the design of systems that enhance human performance. We will study examples in display technology, image quality, visualization, image search, visual monitoring and haptics, and students will be encouraged to bring forward ongoing problems of interest to them.

LEARNING OUTCOMES

This course will enable you to:
- describe basic principles of spatial, temporal, and color processing by the human visual system, and know where to go for deeper insight
- explore basic cognitive processes, including visual attention and semantics
- develop skills in applying knowledge about human perception and cognition to engineering applications

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who are involved in the design, testing or evaluation of electronic imaging systems. Business managers responsible for innovation and new product development. Anyone interested in human perception and the evolution of electronic imaging applications.

INSTRUCTOR

Bernice Rogowitz founded and co-chairs the SPIE/IS&T Conference on Human Vision and Electronic Imaging (HVEI) which is a multi-disciplinary forum for research on perceptual and cognitive issues in imaging systems. Dr. Rogowitz received her PhD from Columbia University in visual psychophysics, worked as a researcher and research manager at the IBM T.J. Watson Research Center for over 20 years, and is currently a consultant in vision, visual analysis and sensory interfaces. She has published over 60 technical papers and has over 12 patents on perceptually-based approaches to visualization, display technology, semantic image search, color, social networking, surveillance, haptic interfaces. She is a Fellow of the SPIE and the IS&T.

Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence

SC812

Course Level: Intermediate
CEU 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

We will examine objective criteria for the evaluation of image quality that are based on models of visual perception. Our primary emphasis will be on image fidelity, i.e., how close an image is to a given original or reference image, but we will broaden the scope of image fidelity to include structural equivalence. We will also discuss no-reference and limited-reference metrics. We will examine a variety of applications with special emphasis on image and video compression. We will examine near-threshold perceptual metrics, which explicitly account for human visual system (HVS) sensitivity to noise by estimating thresholds above which the distortion is just-noticeable, and supra-threshold metrics, which attempt to quantify visible distortions encountered in high compression applications or when there are losses due to channel conditions. We will also consider metrics for structural equivalence, whereby the original and the distorted image have visible differences but both look natural and are of equally high visual quality. We will also take a close look at procedures for evaluating the performance of quality metrics, including database design, models for generating realistic distortions for various applications, and subjective procedures for metric development and testing. Throughout the course we will discuss both the state of the art and directions for future research.

Course topics include:
- Applications: Image and video compression, restoration, retrieval, graphics, etc.
- Human visual system review
- Near-threshold and supra-threshold perceptual quality metrics
- Structural similarity metrics
- Perceptual metrics for texture analysis and compression – structural texture similarity metrics
- No-reference and limited-reference metrics
- Models for generating realistic distortions for different applications
- Design of databases and subjective procedures for metric development and testing
- Metric performance comparisons, selection, and general use and abuse
- Embedded metric performance, e.g., for rate-distortion optimized compression or restoration
- Metrics for specific distortions, e.g., blocking and blurring, and for specific attributes, e.g., contrast, roughness, and glossiness
- Multimodal applications

LEARNING OUTCOMES

This course will enable you to:
- gain a basic understanding of the properties of the human visual system and how current applications (image and video compression, restoration, retrieval, etc.) that attempt to exploit these properties
- gain an operational understanding of existing perceptually-based and structural similarity metrics, the types of images/artifacts on which they work, and their failure modes
- review current distortion models for different applications, and how they can be used to modify or develop new metrics for specific contexts
- differentiate between sub-threshold and supra-threshold artifacts, the HVS responses to these two paradigms, and the differences in measuring that response
- establish criteria by which to select and interpret a particular metric for a particular application.
- evaluate the capabilities and limitations of full-reference, limited-reference, and no-reference metrics, and why each might be used in a particular application

INTENDED AUDIENCE

Image and video compression specialists who wish to gain an understanding of how performance can be quantified. Engineers and Scientists who wish to learn about objective image and video quality evaluation.

Managers who wish to gain a solid overview of image and video quality evaluation. Students who wish to pursue a career in digital image processing. Intellectual Property and Patent Attorneys who wish to gain a more fundamental understanding of quality metrics and the underlying technologies. Government laboratory personnel who work in imaging.

Prerequisites: a basic understanding of image compression algorithms, and a background in digital signal processing and basic statistics: frequency-based representations, filtering, distributions.

INSTRUCTORS

Thrasyvoulos N. Pappas received the S.B., S.M., and Ph.D. degrees in electrical engineering and computer science from MIT in 1979, 1982, and 1987, respectively. From 1987 until 1999, he was a Member of the Technical Staff at Bell Laboratories, Murray Hill, NJ. He is currently a professor in the Department of Electrical and Computer Engineering at Northwestern University, which he joined in 1999. His research interests are in image and video quality and compression, image and video analysis, content-based retrieval, perceptual models for multimedia processing, model-based halftoning, and tactile and multimodal interfaces. Dr. Pappas has served as co-chair of the 2005 SPIE/IS&T Electronic Imaging Symposium, and since 1997 he has been co-chair of the SPIE/IS&T Conference on Human Vision and Electronic Imaging. He has also served as editor-in-chief for the IEEE Transactions on Image Processing from 2010 to 2012. Dr. Pappas is a Fellow of IEEE and SPIE.

Sheila S. Hemami received the B.S.E.E. degree from the University of Michigan in 1990, and the M.S.E.E. and Ph.D. degrees from Stanford University in 1992 and 1994, respectively. She was with Hewlett-Packard Laboratories in Palo Alto, California in 1994 and was with the School of Electrical Engineering at Cornell University from 1995-2013. She is currently Professor and Chair of the Department of Electrical & Computer Engineering at Northeastern University in Boston, MA. Dr. Hemami's research interests broadly concern communication of visual information from the perspectives of both signal processing and psychophysics. She has held various technical leadership positions in the IEEE, served as editor-in-chief for the IEEE Transactions on Multimedia from 2008 to 2010, and was elected a Fellow of the IEEE in 2009 for her for contributions to robust and perceptual image and video communications.

Understanding and Interpreting Images

SC1015

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

A key problem in computer vision is image and video understanding, which can be defined as the task of recognizing objects in the scene and their corresponding relationships and semantics, in addition to identifying the scene category itself. Image understanding technology has numerous applications among which are smart capture devices, intelligent image processing, semantic image search and retrieval, image/video utilization (e.g., ratings on quality, usefulness, etc.), security and surveillance, intelligent asset selection and targeted advertising.

This tutorial provides an introduction to the theory and practice of image understanding algorithms by studying the various technologies that serve the three major components of a generalized IU system, namely, feature extraction and selection, machine learning tools used for classification, and datasets and ground truth used for training the classifiers. Following this general development, a few application examples are studied in more detail to gain insight into how these technologies are employed in a practical IU system. Applications include face detection, sky detection, image orientation detection, main subject detection, and content based image retrieval (CBIR). Furthermore, realtime demos including face detection and recognition, CBIR, and automatic zooming and cropping of images based on main-subject detection are provided.

LEARNING OUTCOMES

This course will enable you to:
- learn the various applications of IU and the scope of its consumer and commercial uses
- explain the various technologies used in image feature extraction such as global, block-based or region-based color histograms and moments, the "tiny" image, GIST, histogram of oriented gradients (HOG), scale-invariant feature transform (SIFT), speeded-up robust features (SURF), bag of words, etc.
- explain the various machine learning paradigms and the fundamental techniques used for classification such as Bayesian classifiers, linear support vector machines (SVM) and nonlinear kernels, boosting techniques (e.g., AdaBoost), k-nearest neighbors, .etc.
- explain the concepts used for classifier evaluation such as false positives and negatives, true positives and negatives, confusion matrix, precision and recall, and receiver operating characteristics (ROC)
- explain the basic methods employed in generating and labeling datasets and ground truth and examples of various datasets such as CMU PIE dataset, Label Me dataset, Caltech 256 dataset, TrecVid, FERET dataset, and Pascal Visual Object Recognition
- explain the fundamental ideas employed in the IU algorithms used for face detection, material detection, image orientation, and a few others
- learn the importance of using context in IU tasks

INTENDED AUDIENCE

Scientists, engineers, and managers who need to familiarize themselves with IU technology and understand its performance limitations in a diverse set of products and applications. No specific prior knowledge is required except familiarity with general mathematical concepts such as the dot product of two vectors and basic image processing concepts such as histograms, filtering, gradients, etc.

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/ CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Image Enhancement, Deblurring and Super-Resolution

SC468

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course discusses some of the advanced algorithms in the field of digital image processing. In particular, it familiarizes the audience with the understanding, design, and implementation of advanced algorithms used in deblurring, contrast enhancement, sharpening, noise reduction, and super-resolution in still images and video. Some of the applications include medical imaging, entertainment imaging, consumer and professional digital still cameras/camcorders, forensic imaging, and surveillance. Many image examples complement the technical descriptions.

LEARNING OUTCOMES

This course will enable you to:
- explain the various nonadaptive and adaptive techniques used in image contrast enhancement. Examples include PhotoShop commands such as Brightness/Contrast, Auto Levels, Equalize and Shadow/Highlights, or Pizer's technique and Moroney's approach
- explain the fundamental techniques used in image Dynamic Range Compression (DRC).Illustrate using the fast bilateral filtering by Dorsey and Durand as an example.
- explain the various techniques used in image noise removal, such as bilateral filtering, sigma filtering and K-Nearest Neighbor
- explain the various techniques used in image sharpening such as nonlinear unsharp masking, etc.
- explain the basic techniques used in image deblurring (restoration) such as inverse filtering and Wiener filtering
- explain the fundamental ideas behind achieving image super-resolution from multiple lower resolution images of the same scene
- explain how motion information can be utilized in image sequences to improve the performance of various enhancement techniques such as noise removal, sharpening, and super-resolution

INTENDED AUDIENCE

Scientists, engineers, and managers who need to understand and/or apply the techniques employed in digital image processing in various products in a diverse set of applications such as medical imaging, professional and consumer imaging, forensic imaging, etc. Prior knowledge of digital filtering (convolution) is necessary for understanding the (Wiener filtering and inverse filtering) concepts used in deblurring (about 20% of the course content).

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/ CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

High Dynamic Range Imaging: Sensors and Architectures

SC967

Course Level: Intermediate
CEU: 0.65 $570 Members | $680 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course provides attendees with an intermediate knowledge of high dynamic range image sensors and techniques for industrial and non-industrial applications. The course describes various sensor and pixel architectures to achieve high dynamic range imaging as well as software approaches to make high dynamic range images out of lower dynamic range sensors or image sets. The course follows a mathematic approach to define the amount of information that can be extracted from the image for each of the methods described. Some methods for automatic control of exposure and dynamic range of image sensors and other issues like color and glare will be introduced.

LEARNING OUTCOMES

This course will enable you to:

- describe various approaches to achieve high dynamic range imaging
- predict the behavior of a given sensor or architecture on a scene
- specify the sensor or system requirements for a high dynamic range application
- classify a high dynamic range application into one of several standard types

INTENDED AUDIENCE

This material is intended for anyone who needs to learn more about quantitative side of high dynamic range imaging. Optical engineers, electronic engineers and scientists will find useful information for their next high dynamic range application.

INSTRUCTOR

Arnaud Darmont is owner and CEO of Aphesa, a company founded in 2008 and specialized in image sensor consulting, the EMVA1288 standard and camera benchmarking. He holds a degree in Electronic Engineering from the University of Liège (Belgium). Prior to founding Aphesa, he worked for over 7 years in the field of CMOS image sensors and high dynamic range imaging.

COURSE PRICE INCLUDES the text *High Dynamic Range Imaging: Sensors and Architectures* (SPIE Press, 2012) by Arnaud Darmont.

HDR Imaging in Cameras, Displays and Human Vision

SC1097

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 1:30 pm to 5:30 pm

High-dynamic range (HDR) imaging is a significant improvement over conventional imaging. After a description of the dynamic range problem in image acquisition, this course focuses on standard methods of creating and manipulating HDR images, replacing myths with measurements of scenes, camera images, and visual appearances. In particular, the course presents measurements about the limits of accurate camera acquisition and the usable range of light for displays of our vision system. Regarding our vision system, the course discusses the role of accurate vs. non-accurate luminance recording for the final appearance of a scene, presenting the quality and the characteristics of visual information actually available on the retina. It ends with a discussion of the principles of tone rendering and the role of spatial comparison.

LEARNING OUTCOMES

This course will enable you to:

- explore the history of HDR imaging
- describe dynamic range and quantization: the ‘salame’ metaphor
- compare single and multiple-exposure for scene capture
- measure optical limits in acquisition and visualization
- discover relationship between HDR range and scene dependency ; the effect of glare
- explore the limits of our vision system on HDR
- calculate retinal luminance
- put in relationship the HDR images and the visual appearance
- identify tone-rendering problems and spatial methods
- verify the changes in color spaces due to dynamic range expansion

INTENDED AUDIENCE

Color scientists, software and hardware engineers, photographers, cinematographers, production specialists, and students interested in using HDR images in real applications.

INSTRUCTOR

Alessandro Rizzi has been researching in the field of digital imaging and vision since 1990. His main research topic is the use of color information in digital images with particular attention to color vision mechanisms. He is Associate professor at the Dept. of Computer Science at University of Milano, teaching Fundamentals of Digital Imaging, Multimedia Video, and Human-Computer Interaction. He is one of the founders of the Italian Color Group and member of several program committees of conferences related to color and digital imaging.

John McCann received a degree in Biology from Harvard College in 1964. He worked in, and managed, the Vision Research Laboratory at Polaroid from 1961 to 1996. He has studied human color vision, digital image processing, large format instant photography, and the reproduction of fine art. His publications and patents have studied Retinex theory, color constancy, color from rod/cone interactions at low light levels, appearance with scattered light, and HDR imaging. He is a Fellow of the IS&T and the Optical Society of America (OSA). He is a past President of IS&T and the Artists Foundation, Boston. He is the IS&T/OSA 2002 Edwin H. Land Medalist, and IS&T 2005 Honorary Member.

Objective and Subjective Image Quality Camera Benchmarking

SC1049

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Monday 8:30 am to 5:30 pm

This course explains methodologies to assess image quality of photographic still image or motion picture capture device. The course will go through all the major image quality attributes, the flaws that degrade those attributes, their causes and consequences on subjective perception. One important goal of the course is to provide a clear understanding of all attributes, how they can be visually assessed in real life picture from many examples images, as well as the physical phenomenon that can degrade image quality.

The course thoroughly explains subjective evaluation methodologies, then objective measurement methodologies relying on existing standards from ISO, I3A/CPIQ and beyond, with many practical examples; how objective measurement metrics are related to subjective perception, methods to correlate objective metrics with subjective perception; and how one can build a benchmarking protocol with objective measurements from a capture use case perspective (such as consumer, landscape, sports,...) to an output use case perspective (such as handheld display, HDTV, photobook,...).

LEARNING OUTCOMES

This course will enable you to:

- identify defects that degrade image quality in natural images and what component of the camera should/could be improved for better image quality
- build up an image quality lab and master measurement protocols
- select best key components to build a camera (best sensor for a given price, best ISP on the market,...)
- judge the overall image quality of a camera
- evaluate the impact various output use cases have on overall image quality
- compare the image quality of a set of cameras
- define subjective test plans and protocols
- setup benchmarking protocols depending on use cases

INTENDED AUDIENCE

Image scientists, engineers, or managers who wish to learn more about image quality and how to evaluate camera performance for various output use cases. A good understanding of imaging and how a camera works is assumed. Anyone involved in photographic or motion picture imaging will benefit from this course.

INSTRUCTOR

Jonathan Phillips is a senior image quality scientist in the camera group at NVIDIA. His involvement in the imaging industry spans over 20 years, including two decades at Eastman Kodak Company. His focus has been on photographic quality, with an emphasis on psychophysical testing for both product development and fundamental perceptual studies. His broad experience has included image quality work with capture, display, and print technologies. He received the 2011 I3A Achievement Award for his work on camera phone image quality and headed up the 2012 revision of ISO 20462 - Psychophysical experimental methods for estimating image quality - Part 3: Quality ruler method. He completed his graduate work in color science in the Center for Imaging Science at Rochester Institute of Technology and his chemistry undergraduate at Wheaton College (IL).

Image Quality and Evaluation of Cameras In Mobile Devices

SC1058

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

Digital and mobile imaging camera system performance is determined by a combination of sensor characteristics, lens characteristics, and image-processing algorithms. As pixel size decreases, sensitivity decreases and noise increases, requiring a more sophisticated noise-reduction algorithm to obtain good image quality. Furthermore, small pixels require high-resolution optics with low chromatic aberration and very small blur circles. Ultimately, there is a tradeoff between noise, resolution, sharpness, and the quality of an image.

This short course provides an overview of "light in to byte out" issues associated with digital and mobile imaging cameras. The course covers, optics, sensors, image processing, and sources of noise in these cameras, algorithms to reduce it, and different methods of characterization. Although noise is typically measured as a standard deviation in a patch with uniform color, it does not always accurately represent human perception. Based on the "visual noise" algorithm described in ISO 15739, an improved approach for measuring noise as an image quality aspect will be demonstrated. The course shows a way to optimize image quality by balancing the tradeoff between noise and resolution. All methods discussed will use images as examples.

LEARNING OUTCOMES

This course will enable you to:

- describe pixel technology and color filtering
- describe illumination, photons, sensor and camera radiometry
- select a sensor for a given application
- describe and measure sensor performance metrics
- describe and understand the optics of digital and mobile imaging systems
- examine the difficulties in minimizing sensor sizes
- assess the need for per unit calibrations in digital still cameras and mobile imaging devices
- learn about noise, its sources, and methods of managing it
- make noise and resolution measurements based on international standards
  - o EMVA 1288
  - o ISO 14524 (OECF)/ISO 15739 (Noise)
  - o Visual Noise
  - o ISO 12233 (Resolution)
- assess influence of the image pipeline on noise
- utilize today's algorithms to reduce noise in images
- measure noise based on human perception
- optimize image quality by balancing noise reduction and resolution
- compare hardware tradeoffs, noise reduction algorithms, and settings for optimal image quality

INTENDED AUDIENCE

All people evaluating the image quality of digital cameras, mobile cameras, and scanners would benefit from participation. Technical staff of manufacturers, managers of digital imaging projects, as well as journalists and students studying image technology are among the intended audience.

INSTRUCTOR

Dietmar Wüller studied photographic sciences at the University of Cologne. He owns a test lab for digital photography and has been testing digital cameras and scanners for German magazines and manufacturers since 1997. He is the editor of the ISO scanner standards (ISO 21550 and ISO 16067) and the vice chairman of the photography section in the German DIN. He also chairs the digital photography working group in the European Color Initiative (ECI).

Kevin Matherson is a senior image scientist in the research and development lab of Hewlett-Packard's Imaging and Printing Group and has worked in the field of digital imaging since 1985. He joined Hewlett Packard in 1996 and has participated in the development of all HP digital and mobile imaging cameras produced since that time. His primary research interests focus on noise characterization, optical system analysis, and the optimization of camera image quality. Dr. Matherson currently leads the camera characterization laboratory in Fort Collins and holds Masters and PhD degrees in Optical Sciences from the University of Arizona.

Image and Video Forensics: Recent Trends and Challenges New

SC1130

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

The widespread adoption of digital content over traditional physical media such as film has given rise to a number of new information security challenges. Digital content can be altered, falsified, and redistributed with relative ease by adversaries. This has important consequences for governmental, commercial, and social institutions that rely on digital information. The pipeline which leads to ascertain whether an image has undergone to some kind of forgery leads through the following steps: determine whether the image is "original" and, in the case where the previous step has given negative results, try to understand the past history of the image.

Although the field of information forensics is still young, many forensic techniques have been developed to detect forgeries, identify the origin, and trace the processing history of digital multimedia content. This course provides an overview of information forensics research and related applications. Also we examine the device-specific fingerprints left by digital image and video cameras along with forensic techniques used to identify the source of digital multimedia files. Finally, an overview of the recent trends and evolution, considering the updated literature in the field, will be provided.

LEARNING OUTCOMES

This course will enable you to:

- describe forensics systems for commercial and scientific imaging applications
- explain how imaging data are processed and how proceed to detect forgeries
- list specifications and requirements to select a specific algorithm for your imaging application in the forensics context
- recognize performance differences among imaging pipeline technologies
- become familiar with current and future imaging technologies and applications

INTENDED AUDIENCE

This course is intended for those with a general computing background, and is interested in the topic of image and video processing. Students, researchers, and practicing engineers should all be able to benefit from the general overview of the field and the introduction of the most recent advance of the technology.

INSTRUCTOR

Sebastiano Battiato received his degree in computer science from University of Catania and his Ph.D. in computer science and applied mathematics from University of Naples in 1999. From 1999 to 2003 he was the leader of the "Imaging" team at STMicroelectronics in Catania. He joined the Department of Mathematics and Computer Science at the University of Catania as assistant professor in 2004 and became associate professor in the same department in 2011. His research interests include image enhancement and processing, image coding, camera imaging technology and multimedia forensics. He has edited 4 books and co-authored more than 150 papers in international journals, conference proceedings and book chapters. He is a co-inventor of about 15 international patents, reviewer for several international journals, and he has been regularly a member of numerous international conference committees.

Computer Vision and Imaging in Transportation Applications New

SC1131

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course introduces the attendee to applications in the transportation industry that employ imaging, computer vision, and video processing technologies. The class begins with a survey of key topics in transportation falling under three broad categories: safety, efficiency, and security. Topics include driver assistance, traffic surveillance and law enforcement, video-based tolling, monitoring vehicles of interest, and incident detection. The second part of the course provides a more in-depth treatment of state-of-art approaches to selected problems such as vehicle license plate recognition, vehicle occupancy estimation, speed enforcement, driver attention monitoring, and sensing of road and environmental conditions. Where necessary, background material on relevant computer vision concepts will be covered, such as image segmentation, object detection, classification, recognition, and tracking, and 3D camera geometry.

LEARNING OUTCOMES

This course will enable you to:

- explain the broad impact of imaging and computer vision towards enhancing safety, efficiency, and law enforcement in transportation applications
- acquire a solid understanding of the basic concepts in computer vision required for transportation imaging, including object detection, classification, recognition, tracking, and camera calibration from transportation-related images and videos
- be familiar with state-of-art approaches and current challenges in applications, such as vehicle license plate recognition, vehicle occupancy estimation, driver assistance, traffic law enforcement, and sensing of road conditions

INTENDED AUDIENCE

Scientists, engineers, technicians, and managers who wish to learn more about how to use imaging, video, and computer vision concepts to address important problems in the transportation domain. Attendees must be familiar with basic digital image and video processing and representations. Familiarity with basic concepts in computer vision is a plus – although we will quickly review the needed background.

INSTRUCTOR

Raja Bala received a Ph.D. in Electrical Engineering from Purdue University and is currently a Principal Scientist and Project Leader in the Xerox Research Center Webster. His research interests include mobile imaging, computer vision, video processing, and color imaging. Dr. Bala has taught many successful conference courses in color and digital imaging and has served as adjunct faculty member in the School of Electrical Engineering at the Rochester Institute of Technology. He holds over 100 U.S. patents, has authored over 90 publications in the field of digital imaging, and has served as Associate Editor of the Journal of Imaging Science and Technology. He is a Fellow of the Society for Imaging Science and Technology.

Robert Loce received an MS in Optical Engineering from the University of Rochester and a PhD in Imaging Science from Rochester Institute of Technology. He is currently a Research Fellow and Technical Manager in the Xerox Research Center Webster. His current research activities involve leading an organization and projects into new video processing and computer vision technologies that are relevant to transportation and healthcare. He has over 90 publications and 175 patents in the areas of digital image processing, image enhancement, imaging systems, and optics. He is a Fellow of SPIE and a Senior Member of IEEE. He is currently an associate editor for Journal of Electronic Imaging, and has been and associate editor for Real-Time Imaging, and IEEE Transactions on Image Processing.

Digital Camera and Scanner Performance Evaluation: Standards and Measurement

SC807

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 12:00 am to 12:00 am

This is an updated course on imaging performance measurement methods for digital image capture devices and systems. We introduce several ISO measurement protocols for camera resolution, tone-transfer, noise, etc. We focus on the underlying sources of variability in system performance, measurement error, and how to manage this variability in working environments. The propagation of measurement variability will be described for several emerging standard methods for; image texture, distortion, color shading, flare and chromatic aberration. Using actual measurements we demonstrate how standards can be adapted to evaluate capture devices ranging from cell phone cameras to scientific detectors. We will also discuss the required elements of software tools, and show how to use Matlab software to develop and perform system evaluation.

LEARNING OUTCOMES

This course will enable you to:
- appreciate the difference between imaging performance and image quality
- interpret and apply the different flavors of each ISO performance method
- identify sources of system variability, and understand resulting measurement error
- distill information-rich ISO metrics into single measures for quality assurance
- adapt standard methods for use in factory testing
- select software elements (with Matlab examples) for performance evaluation programs
- be aware of upcoming standard measurement protocols

INTENDED AUDIENCE

Although technical in content, this course is intended for a wide audience: image scientists, quality engineers, and others evaluating digital camera and scanner performance. No background in imaging performance (MTF, etc.) evaluation will be assumed, although the course will provide previous attendees with an update and further insight for implementation. Detailed knowledge of Matlab is not needed, but exposure to similar software environments will be helpful.

INSTRUCTOR

Peter Burns is a consultant working in imaging system evaluation, modeling, and image processing. Previously he worked for Carestream Health, Xerox and Eastman Kodak. A frequent speaker at technical conferences, he has contributed to several imaging standards. He has taught several imaging courses: at Kodak, SPIE, and IS&T technical conferences, and at the Center for Imaging Science, RIT.

Donald Williams is the founder of Image Science Associates, and formerly with Kodak Research Laboratories. His work focuses on quantitative signal and noise performance metrics for digital capture imaging devices, and imaging fidelity issues. He co-leads the TC42 standardization efforts on digital print and film scanner resolution (ISO 16067-1, ISO 16067-2) scanner dynamic range (ISO 21550) and is the editor for the second edition to digital camera resolution (ISO 12233).

Stereoscopic Display Application Issues

SC060

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

When correctly implemented, stereoscopic 3D displays can provide significant benefits in many areas, including endoscopy and other medical imaging, teleoperated vehicles and telemanipulators, CAD, molecular modeling, 3D computer graphics, 3D visualization, photo interpretation, video-based training, and entertainment. This course conveys a concrete understanding of basic principles and pitfalls that should be considered when setting up stereoscopic systems and producing stereoscopic content. The course will demonstrate a range of stereoscopic hardware and 3D imaging & display principles, outline the key issues in an ortho-stereoscopic video display setup, and show 3D video from a wide variety of applied stereoscopic imaging systems.

LEARNING OUTCOMES

This course will enable you to:
- list critical human factors guidelines for stereoscopic display configuration and implementation
- calculate optimal camera focal length, separation, display size, and viewing distance to achieve a desired level of depth acuity
- examine comfort limits for focus/fixation mismatch and on-screen parallax values as a function of focal length, separation, convergence, display size, and viewing-distance factors
- set up a large-screen stereo display system using AV equipment readily available at most conference sites, for 3D stills and for full-motion 3D video
- rank the often-overlooked side-benefits of stereoscopic displays that should be included in a cost/benefit analysis for proposed 3D applications
- explain common pitfalls in designing tests to compare 2D vs. 3D displays
- calculate and demonstrate the distortions in perceived 3D space due to camera and display parameters
- design and set up an ortho-stereoscopic 3D imaging/display system
- understand the projective geometry involved in stereoscopic modeling
- determine the problems, and the solutions, for converting stereoscopic video across video standards such as NTSC and PAL
- work with stereoscopic 3D video and stills -using analog and digital methods of capture/filming, encoding, storage, format conversion, display, and publishing
- describe the trade-offs among currently available stereoscopic display system technologies and determine which will best match a particular application
- understand existing and developing stereoscopic standards

INTENDED AUDIENCE

This course is designed for engineers, scientists, and program managers who are using, or considering using, stereoscopic 3D displays in their applications. The solid background in stereoscopic system fundamentals, along with many examples of advanced 3D display applications, makes this course highly useful both for those who are new to stereoscopic 3D and also for those who want to advance their current understanding and utilization of stereoscopic systems.

INSTRUCTOR

John Merritt is a 3D display systems consultant at The Merritt Group, Williamsburg, MA, USA with more than 25 years experience in the design and human-factors evaluation of stereoscopic video displays for telepresence and telerobotics, off-road mobility, unmanned vehicles, night vision devices, photo interpretation, scientific visualization, and medical imaging.

Andrew Woods is a research engineer at Curtin University's Centre for Marine Science and Technology in Perth, Western Australia. He has over 20 years of experience working on the design, application, and evaluation of stereoscopic technologies for industrial and entertainment applications.

3D Imaging

SC927

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Wednesday 8:30 am to 12:30 pm

The purpose of this course is to introduce algorithms for 3D structure inference from 2D images. In many applications, inferring 3D structure from 2D images can provide crucial sensing information. The course will begin by reviewing geometric image formation and mathematical concepts that are used to describe it, and then move to discuss algorithms for 3D model reconstruction.

The problem of 3D model reconstruction is an inverse problem in which we need to infer 3D information based on incomplete (2D) observations. We will discuss reconstruction algorithms which utilize information from multiple views. Reconstruction requires the knowledge of some intrinsic and extrinsic camera parameters, and the establishment of correspondence between views. We will discuss algorithms for determining camera parameters (camera calibration) and for obtaining correspondence using epipolar constraints between views. The course will also introduce relevant 3D imaging software components available through the industry standard OpenCV library.

LEARNING OUTCOMES

This course will enable you to:
- describe fundamental concepts in 3D imaging
- develop algorithms for 3D model reconstruction from 2D images
- incorporate camera calibration into your reconstructions
- classify the limitations of reconstruction techniques
- use industry standard tools for developing 3D imaging applications

INTENDED AUDIENCE

Engineers, researchers, and software developers, who develop imaging applications and/or use camera sensors for inspection, control, and analysis. The course assumes basic working knowledge concerning matrices and vectors.

INSTRUCTOR

Gady Agam is an Associate Professor of Computer Science at the Illinois Institute of Technology. He is the director of the Visual Computing Lab at IIT which focuses on imaging, geometric modeling, and graphics applications. He received his PhD degree from Ben-Gurion University in 1999.

Image Processing

Understanding and Interpreting Images

SC1015

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

A key problem in computer vision is image and video understanding, which can be defined as the task of recognizing objects in the scene and their corresponding relationships and semantics, in addition to identifying the scene category itself. Image understanding technology has numerous applications among which are smart capture devices, intelligent image processing, semantic image search and retrieval, image/video utilization (e.g., ratings on quality, usefulness, etc.), security and surveillance, intelligent asset selection and targeted advertising.

This tutorial provides an introduction to the theory and practice of image understanding algorithms by studying the various technologies that serve the three major components of a generalized IU system, namely, feature extraction and selection, machine learning tools used for classification, and datasets and ground truth used for training the classifiers. Following this general development, a few application examples are studied in more detail to gain insight into how these technologies are employed in a practical IU system. Applications include face detection, sky detection, image orientation detection, main subject detection, and content based image retrieval (CBIR). Furthermore, realtime demos including face detection and recognition, CBIR, and automatic zooming and cropping of images based on main-subject detection are provided.

LEARNING OUTCOMES

This course will enable you to:
- learn the various applications of IU and the scope of its consumer and commercial uses
- explain the various technologies used in image feature extraction such as global, block-based or region-based color histograms and moments, the “tiny” image, GIST, histogram of oriented gradients (HOG), scale-invariant feature transform (SIFT), speeded-up robust features (SURF), bag of words, etc.
- explain the various machine learning paradigms and the fundamental techniques used for classification such as Bayesian classifiers, linear support vector machines (SVM) and nonlinear kernels, boosting techniques (e.g., AdaBoost), k-nearest neighbors, .etc.
- explain the concepts used for classifier evaluation such as false positives and negatives, true positives and negatives, confusion matrix, precision and recall, and receiver operating characteristics (ROC)
- explain the basic methods employed in generating and labeling datasets and ground truth and examples of various datasets such as CMU PIE dataset, Label Me dataset, Caltech 256 dataset, TrecVid, FERET dataset, and Pascal Visual Object Recognition
- explain the fundamental ideas employed in the IU algorithms used for face detection, material detection, image orientation, and a few others
- learn the importance of using context in IU tasks

INTENDED AUDIENCE

Scientists, engineers, and managers who need to familiarize themselves with IU technology and understand its performance limitations in a diverse set of products and applications. No specific prior knowledge is required except familiarity with general mathematical concepts such as the dot product of two vectors and basic image processing concepts such as histograms, filtering, gradients, etc.

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book “Digital Image Compression Techniques” and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Image Enhancement, Deblurring and Super-Resolution

SC468

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course discusses some of the advanced algorithms in the field of digital image processing. In particular, it familiarizes the audience with the understanding, design, and implementation of advanced algorithms used in deblurring, contrast enhancement, sharpening, noise reduction, and super-resolution in still images and video. Some of the applications include medical imaging, entertainment imaging, consumer and professional digital still cameras/camcorders, forensic imaging, and surveillance. Many image examples complement the technical descriptions.

LEARNING OUTCOMES

This course will enable you to:

- explain the various nonadaptive and adaptive techniques used in image contrast enhancement. Examples include PhotoShop commands such as Brightness/Contrast, Auto Levels, Equalize and Shadow/Highlights, or Pizer's technique and Moroney's approach
- explain the fundamental techniques used in image Dynamic Range Compression (DRC).Illustrate using the fast bilateral filtering by Dorsey and Durand as an example.
- explain the various techniques used in image noise removal, such as bilateral filtering, sigma filtering and K-Nearest Neighbor
- explain the various techniques used in image sharpening such as nonlinear unsharp masking, etc.
- explain the basic techniques used in image deblurring (restoration) such as inverse filtering and Wiener filtering
- explain the fundamental ideas behind achieving image super-resolution from multiple lower resolution images of the same scene
- explain how motion information can be utilized in image sequences to improve the performance of various enhancement techniques such as noise removal, sharpening, and super-resolution

INTENDED AUDIENCE

Scientists, engineers, and managers who need to understand and/or apply the techniques employed in digital image processing in various products in a diverse set of applications such as medical imaging, professional and consumer imaging, forensic imaging, etc. Prior knowledge of digital filtering (convolution) is necessary for understanding the (Wiener filtering and inverse filtering) concepts used in deblurring (about 20% of the course content).

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Joint Design of Optics and Image Processing for Imaging Systems

SC965

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

For centuries, optical imaging system design centered on exploiting the laws of the physics of light and materials (glass, plastic, reflective metal, ...) to form high-quality (sharp, high-contrast, undistorted, ...) images that "looked good." In the past several decades, the optical images produced by such systems have been ever more commonly sensed by digital detectors and the image imperfections corrected in software. The new era of electro-optical imaging offers a more fundamental revision to this paradigm, however: now the optics and image processing can be designed jointly to optimize an end-to-end digital merit function without regard to the traditional quality of the intermediate optical image. Many principles and guidelines from the optics-only era are counterproductive in the new era of electro-optical imaging and must be replaced by principles grounded on both the physics of photons and the information of bits.

This short course will describe the theoretical and algorithmic foundations of new methods of jointly designing the optics and image processing of electro-optical imaging systems. The course will focus on the new concepts and approaches rather than commercial tools.

LEARNING OUTCOMES

This course will enable you to:

- describe the basics of information theory
- characterize electro-optical systems using linear systems theory
- compute a predicted mean-squared error merit function
- characterize the spatial statistics of sources
- implement a Wiener filter
- implement spatial convolution and digital filtering
- make the distinction between traditional optics-only merit functions and end-to-end digital merit functions
- perform point-spread function engineering
- become aware of the image processing implications of various optical aberrations
- describe wavefront coding and cubic phase plates
- utilize the power of spherical coding
- compare super-resolution algorithms and multi-aperture image synthesizing systems
- simulate the manufacturability of jointly designed imaging systems
- evaluate new methods of electro-optical compensation

INTENDED AUDIENCE

Optical designers familiar with system characterization (f#, depth of field, numerical aperture, point spread functions, modulation transfer functions, ...) and image processing experts familiar with basic operations (convolution, digital sharpening, information theory, ...).

INSTRUCTOR

David Stork is Distinguished Research Scientist and Research Director at Rambus Labs, and a Fellow of the International Association for Pattern Recognition. He holds 40 US patents and has written nearly 200 technical publications including eight books or proceedings volumes such as Seeing the Light, Pattern Classification (2nd ed.) and HAL's Legacy. He has given over 230 technical presentations on computer image analysis of art in 19 countries.

Image and Video Forensics: Recent Trends and Challenges New

SC1130

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

The widespread adoption of digital content over traditional physical media such as film has given rise to a number of new information security challenges. Digital content can be altered, falsified, and redistributed with relative ease by adversaries. This has important consequences for governmental, commercial, and social institutions that rely on digital information. The pipeline which leads to ascertain whether an image has undergone to some kind of forgery leads through the following steps: determine whether the image is "original" and, in the case where the previous step has given negative results, try to understand the past history of the image.

Although the field of information forensics is still young, many forensic techniques have been developed to detect forgeries, identify the origin, and trace the processing history of digital multimedia content. This course provides an overview of information forensics research and related applications. Also we examine the device-specific fingerprints left by digital image and video cameras along with forensic techniques used to identify the source of digital multimedia files. Finally, an overview of the recent trends and evolution, considering the updated literature in the field, will be provided.

LEARNING OUTCOMES

This course will enable you to:
- describe forensics systems for commercial and scientific imaging applications
- explain how imaging data are processed and how proceed to detect forgeries
- list specifications and requirements to select a specific algorithm for your imaging application in the forensics context
- recognize performance differences among imaging pipeline technologies
- become familiar with current and future imaging technologies and applications

INTENDED AUDIENCE

This course is intended for those with a general computing background, and is interested in the topic of image and video processing. Students, researchers, and practicing engineers should all be able to benefit from the general overview of the field and the introduction of the most recent advance of the technology.

INSTRUCTOR

Sebastiano Battiato received his degree in computer science from University of Catania and his Ph.D. in computer science and applied mathematics from University of Naples in 1999. From 1999 to 2003 he was the leader of the "Imaging" team at STMicroelectronics in Catania. He joined the Department of Mathematics and Computer Science at the University of Catania as assistant professor in 2004 and became associate professor in the same department in 2011. His research interests include image enhancement and processing, image coding, camera imaging technology and multimedia forensics. He has edited 4 books and co-authored more than 150 papers in international journals, conference proceedings and book chapters. He is a co-inventor of about 15 international patents, reviewer for several international journals, and he has been regularly a member of numerous international conference committees.

Computer Vision and Imaging in Transportation Applications New

SC1131

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course introduces the attendee to applications in the transportation industry that employ imaging, computer vision, and video processing technologies. The class begins with a survey of key topics in transportation falling under three broad categories: safety, efficiency, and security. Topics include driver assistance, traffic surveillance and law enforcement, video-based tolling, monitoring vehicles of interest, and incident detection. The second part of the course provides a more in-depth treatment of state-of-art approaches to selected problems such as vehicle license plate recognition, vehicle occupancy estimation, speed enforcement, driver attention monitoring, and sensing of road and environmental conditions. Where necessary, background material on relevant computer vision concepts will be covered, such as image segmentation, object detection, classification, recognition, and tracking, and 3D camera geometry.

LEARNING OUTCOMES

This course will enable you to:
- explain the broad impact of imaging and computer vision towards enhancing safety, efficiency, and law enforcement in transportation applications
- acquire a solid understanding of the basic concepts in computer vision required for transportation imaging, including object detection, classification, recognition, tracking, and camera calibration from transportation-related images and videos
- be familiar with state-of-art approaches and current challenges in applications, such as vehicle license plate recognition, vehicle occupancy estimation, driver assistance, traffic law enforcement, and sensing of road conditions

INTENDED AUDIENCE

Scientists, engineers, technicians, and managers who wish to learn more about how to use imaging, video, and computer vision concepts to address important problems in the transportation domain. Attendees must be familiar with basic digital image and video processing and representations. Familiarity with basic concepts in computer vision is a plus – although we will quickly review the needed background.

INSTRUCTOR

Raja Bala received a Ph.D. in Electrical Engineering from Purdue University and is currently a Principal Scientist and Project Leader in the Xerox Research Center Webster. His research interests include mobile imaging, computer vision, video processing, and color imaging. Dr. Bala has taught many successful conference courses in color and digital imaging and has served as adjunct faculty member in the School of Electrical Engineering at the Rochester Institute of Technology. He holds over 100 U.S. patents, has authored over 90 publications in the field of digital imaging, and has served as Associate Editor of the Journal of Imaging Science and Technology. He is a Fellow of the Society for Imaging Science and Technology.

Robert Loce received an MS in Optical Engineering from the University of Rochester and a PhD in Imaging Science from Rochester Institute of Technology. He is currently a Research Fellow and Technical Manager in the Xerox Research Center Webster. His current research activities involve leading an organization and projects into new video processing and computer vision technologies that are relevant to transportation and healthcare. He has over 90 publications and 175 patents in the areas of digital image processing, image enhancement, imaging systems, and optics. He is a Fellow of SPIE and a Senior Member of IEEE. He is currently an associate editor for Journal of Electronic Imaging, and has been and associate editor for Real-Time Imaging, and IEEE Transactions on Image Processing.

Digital Camera and Scanner Performance Evaluation: Standards and Measurement

SC807

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 12:00 am to 12:00 am

This is an updated course on imaging performance measurement methods for digital image capture devices and systems. We introduce several ISO measurement protocols for camera resolution, tone-transfer, noise, etc. We focus on the underlying sources of variability in system performance, measurement error, and how to manage this variability in working environments. The propagation of measurement variability will be described for several emerging standard methods for; image texture, distortion, color shading, flare and chromatic aberration. Using actual measurements we demonstrate how standards can be adapted to evaluate capture devices ranging from cell phone cameras to scientific detectors. We will also discuss the required elements of software tools, and show how to use Matlab software to develop and perform system evaluation.

LEARNING OUTCOMES

This course will enable you to:
- appreciate the difference between imaging performance and image quality
- interpret and apply the different flavors of each ISO performance method
- identify sources of system variability, and understand resulting measurement error
- distill information-rich ISO metrics into single measures for quality assurance
- adapt standard methods for use in factory testing
- select software elements (with Matlab examples) for performance evaluation programs
- be aware of upcoming standard measurement protocols

INTENDED AUDIENCE

Although technical in content, this course is intended for a wide audience: image scientists, quality engineers, and others evaluating digital camera and scanner performance. No background in imaging performance (MTF, etc.) evaluation will be assumed, although the course will provide previous attendees with an update and further insight for implementation. Detailed knowledge of Matlab is not needed, but exposure to similar software environments will be helpful.

INSTRUCTOR

Peter Burns is a consultant working in imaging system evaluation, modeling, and image processing. Previously he worked for Carestream Health, Xerox and Eastman Kodak. A frequent speaker at technical conferences, he has contributed to several imaging standards. He has taught several imaging courses: at Kodak, SPIE, and IS&T technical conferences, and at the Center for Imaging Science, RIT.

Donald Williams is the founder of Image Science Associates, and formerly with Kodak Research Laboratories. His work focuses on quantitative signal and noise performance metrics for digital capture imaging devices, and imaging fidelity issues. He co-leads the TC42 standardization efforts on digital print and film scanner resolution (ISO 16067-1, ISO 16067-2) scanner dynamic range (ISO 21550) and is the editor for the second edition to digital camera resolution (ISO 12233).

Image Quality and Evaluation of Cameras In Mobile Devices

SC1058

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

Digital and mobile imaging camera system performance is determined by a combination of sensor characteristics, lens characteristics, and image-processing algorithms. As pixel size decreases, sensitivity decreases and noise increases, requiring a more sophisticated noise-reduction algorithm to obtain good image quality. Furthermore, small pixels require high-resolution optics with low chromatic aberration and very small blur circles. Ultimately, there is a tradeoff between noise, resolution, sharpness, and the quality of an image.

This short course provides an overview of “light in to byte out” issues associated with digital and mobile imaging cameras. The course covers, optics, sensors, image processing, and sources of noise in these cameras, algorithms to reduce it, and different methods of characterization. Although noise is typically measured as a standard deviation in a patch with uniform color, it does not always accurately represent human perception. Based on the “visual noise” algorithm described in ISO 15739, an improved approach for measuring noise as an image quality aspect will be demonstrated. The course shows a way to optimize image quality by balancing the tradeoff between noise and resolution. All methods discussed will use images as examples.

LEARNING OUTCOMES

This course will enable you to:
- describe pixel technology and color filtering
- describe illumination, photons, sensor and camera radiometry
- select a sensor for a given application
- describe and measure sensor performance metrics
- describe and understand the optics of digital and mobile imaging systems
- examine the difficulties in minimizing sensor sizes
- assess the need for per unit calibrations in digital still cameras and mobile imaging devices
- learn about noise, its sources, and methods of managing it
- make noise and resolution measurements based on international standards

o EMVA 1288
o ISO 14524 (OECF)/ISO 15739 (Noise)
o Visual Noise
o ISO 12233 (Resolution)

- assess influence of the image pipeline on noise
- utilize today’s algorithms to reduce noise in images
- measure noise based on human perception
- optimize image quality by balancing noise reduction and resolution
- compare hardware tradeoffs, noise reduction algorithms, and settings for optimal image quality

INTENDED AUDIENCE

All people evaluating the image quality of digital cameras, mobile cameras, and scanners would benefit from participation. Technical staff of manufacturers, managers of digital imaging projects, as well as journalists and students studying image technology are among the intended audience.

INSTRUCTOR

Dietmar Wüller studied photographic sciences at the University of Cologne. He owns a test lab for digital photography and has been testing digital cameras and scanners for German magazines and manufacturers since 1997. He is the editor of the ISO scanner standards (ISO 21550 and ISO 16067) and the vice chairman of the photography section in the German DIN. He also chairs the digital photography working group in the European Color Initiative (ECI).

Kevin Matherson is a senior image scientist in the research and development lab of Hewlett-Packard's Imaging and Printing Group and has worked in the field of digital imaging since 1985. He joined Hewlett Packard in 1996 and has participated in the development of all HP digital and mobile imaging cameras produced since that time. His primary research interests focus on noise characterization, optical system analysis, and the optimization of camera image quality. Dr. Matherson currently leads the camera characterization laboratory in Fort Collins and holds Masters and PhD degrees in Optical Sciences from the University of Arizona.

High Dynamic Range Imaging: Sensors and Architectures

SC967

Course Level: Intermediate
CEU: 0.65 $570 Members | $680 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course provides attendees with an intermediate knowledge of high dynamic range image sensors and techniques for industrial and non-industrial applications. The course describes various sensor and pixel architectures to achieve high dynamic range imaging as well as software approaches to make high dynamic range images out of lower dynamic range sensors or image sets. The course follows a mathematic approach to define the amount of information that can be extracted from the image for each of the methods described. Some methods for automatic control of exposure and dynamic range of image sensors and other issues like color and glare will be introduced.

LEARNING OUTCOMES

This course will enable you to:
- describe various approaches to achieve high dynamic range imaging
- predict the behavior of a given sensor or architecture on a scene
- specify the sensor or system requirements for a high dynamic range application
- classify a high dynamic range application into one of several standard types

INTENDED AUDIENCE

This material is intended for anyone who needs to learn more about quantitative side of high dynamic range imaging. Optical engineers, electronic engineers and scientists will find useful information for their next high dynamic range application.

INSTRUCTOR

Arnaud Darmont is owner and CEO of Aphesa, a company founded in 2008 and specialized in image sensor consulting, the EMVA1288 standard and camera benchmarking. He holds a degree in Electronic Engineering from the University of Liège (Belgium). Prior to founding Aphesa, he worked for over 7 years in the field of CMOS image sensors and high dynamic range imaging.

COURSE PRICE INCLUDES the text *High Dynamic Range Imaging: Sensors and Architectures* (SPIE Press, 2012) by Arnaud Darmont.

HDR Imaging in Cameras, Displays and Human Vision

SC1097

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 1:30 pm to 5:30 pm

High-dynamic range (HDR) imaging is a significant improvement over conventional imaging. After a description of the dynamic range problem in image acquisition, this course focuses on standard methods of creating and manipulating HDR images, replacing myths with measurements of scenes, camera images, and visual appearances. In particular, the course presents measurements about the limits of accurate camera acquisition and the usable range of light for displays of our vision system. Regarding our vision system, the course discusses the role of accurate vs. non-accurate luminance recording for the final appearance of a scene, presenting the quality and the characteristics of visual information actually available on the retina. It ends with a discussion of the principles of tone rendering and the role of spatial comparison.

LEARNING OUTCOMES

This course will enable you to:
- explore the history of HDR imaging
- describe dynamic range and quantization: the 'salame' metaphor
- compare single and multiple-exposure for scene capture
- measure optical limits in acquisition and visualization
- discover relationship between HDR range and scene dependency ; the effect of glare
- explore the limits of our vision system on HDR
- calculate retinal luminance
- put in relationship the HDR images and the visual appearance
- identify tone-rendering problems and spatial methods
- verify the changes in color spaces due to dynamic range expansion

INTENDED AUDIENCE

Color scientists, software and hardware engineers, photographers, cinematographers, production specialists, and students interested in using HDR images in real applications.

INSTRUCTOR

Alessandro Rizzi has been researching in the field of digital imaging and vision since 1990. His main research topic is the use of color information in digital images with particular attention to color vision mechanisms. He is Associate professor at the Dept. of Computer Science at University of Milano, teaching Fundamentals of Digital Imaging, Multimedia Video, and Human-Computer Interaction. He is one of the founders of the Italian Color Group and member of several program committees of conferences related to color and digital imaging.

John McCann received a degree in Biology from Harvard College in 1964. He worked in, and managed, the Vision Research Laboratory at Polaroid from 1961 to 1996. He has studied human color vision, digital image processing, large format instant photography, and the reproduction of fine art. His publications and patents have studied Retinex theory, color constancy, color from rod/cone interactions at low light levels, appearance with scattered light, and HDR imaging. He is a Fellow of the IS&T and the Optical Society of America (OSA). He is a past President of IS&T and the Artists Foundation, Boston. He is the IS&T/OSA 2002 Edwin H. Land Medalist, and IS&T 2005 Honorary Member.

Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence

SC812

Course Level: Intermediate
CEU 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

We will examine objective criteria for the evaluation of image quality that are based on models of visual perception. Our primary emphasis will be on image fidelity, i.e., how close an image is to a given original or reference image, but we will broaden the scope of image fidelity to include structural equivalence. We will also discuss no-reference and limited-reference metrics. We will examine a variety of applications with special emphasis on image and video compression. We will examine near-threshold perceptual metrics, which explicitly account for human visual system (HVS) sensitivity to noise by estimating thresholds above which the distortion is just-noticeable, and supra-threshold metrics, which attempt to quantify visible distortions encountered in high compression applications or when there are losses due to channel conditions. We will also consider metrics for structural equivalence, whereby the original and the distorted image have visible differences but both look natural and are of equally high visual quality. We will also take a close look at procedures for evaluating the performance of quality metrics, including database design, models for generating realistic distortions for various applications, and subjective procedures for metric development and testing. Throughout the course we will discuss both the state of the art and directions for future research.

Course topics include:
- Applications: Image and video compression, restoration, retrieval, graphics, etc.
- Human visual system review
- Near-threshold and supra-threshold perceptual quality metrics
- Structural similarity metrics
- Perceptual metrics for texture analysis and compression – structural texture similarity metrics
- No-reference and limited-reference metrics
- Models for generating realistic distortions for different applications
- Design of databases and subjective procedures for metric development and testing
- Metric performance comparisons, selection, and general use and abuse
- Embedded metric performance, e.g., for rate-distortion optimized compression or restoration
- Metrics for specific distortions, e.g., blocking and blurring, and for specific attributes, e.g., contrast, roughness, and glossiness
- Multimodal applications

LEARNING OUTCOMES

This course will enable you to:
- gain a basic understanding of the properties of the human visual system and how current applications (image and video compression, restoration, retrieval, etc.) that attempt to exploit these properties
- gain an operational understanding of existing perceptually-based and structural similarity metrics, the types of images/artifacts on which they work, and their failure modes
- review current distortion models for different applications, and how they can be used to modify or develop new metrics for specific contexts
- differentiate between sub-threshold and supra-threshold artifacts, the HVS responses to these two paradigms, and the differences in measuring that response
- establish criteria by which to select and interpret a particular metric for a particular application.
- evaluate the capabilities and limitations of full-reference, limited-reference, and no-reference metrics, and why each might be used in a particular application

INTENDED AUDIENCE

Image and video compression specialists who wish to gain an understanding of how performance can be quantified. Engineers and Scientists who wish to learn about objective image and video quality evaluation.

Managers who wish to gain a solid overview of image and video quality evaluation. Students who wish to pursue a career in digital image processing. Intellectual Property and Patent Attorneys who wish to gain a more fundamental understanding of quality metrics and the underlying technologies. Government laboratory personnel who work in imaging.

Prerequisites: a basic understanding of image compression algorithms, and a background in digital signal processing and basic statistics: frequency-based representations, filtering, distributions.

INSTRUCTORS

Thrasyvoulos N. Pappas received the S.B., S.M., and Ph.D. degrees in electrical engineering and computer science from MIT in 1979, 1982, and 1987, respectively. From 1987 until 1999, he was a Member of the Technical Staff at Bell Laboratories, Murray Hill, NJ. He is currently a professor in the Department of Electrical and Computer Engineering at Northwestern University, which he joined in 1999. His research interests are in image and video quality and compression, image and video analysis, content-based retrieval, perceptual models for multimedia processing, model-based halftoning, and tactile and multimodal interfaces. Dr. Pappas has served as co-chair of the 2005 SPIE/IS&T Electronic Imaging Symposium, and since 1997 he has been co-chair of the SPIE/IS&T Conference on Human Vision and Electronic Imaging. He has also served as editor-in-chief for the IEEE Transactions on Image Processing from 2010 to 2012. Dr. Pappas is a Fellow of IEEE and SPIE.

Sheila S. Hemami received the B.S.E.E. degree from the University of Michigan in 1990, and the M.S.E.E. and Ph.D. degrees from Stanford University in 1992 and 1994, respectively. She was with Hewlett-Packard Laboratories in Palo Alto, California in 1994 and was with the School of Electrical Engineering at Cornell University from 1995-2013. She is currently Professor and Chair of the Department of Electrical & Computer Engineering at Northeastern University in Boston, MA. Dr. Hemami's research interests broadly concern communication of visual information from the perspectives of both signal processing and psychophysics. She has held various technical leadership positions in the IEEE, served as editor-in-chief for the IEEE Transactions on Multimedia from 2008 to 2010, and was elected a Fellow of the IEEE in 2009 for her for contributions to robust and perceptual image and video communications.

Theory and Methods of Lightfield Photography

SC980

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

Lightfield photography is based on capturing discrete representations of all light rays in a volume of 3D space. Since light rays are characterized with 2D position and 2D direction (relative to a plane of intersection), lightfield photography captures 4D data. In comparison, conventional photography captures 2D images. Multiplexing this 4D radiance data onto conventional 2D sensors demands sophisticated optics and imaging technology. Rending an image from the 4D lightfield is accomplished computationally based on creating 2D integral projections of the 4D radiance. Optical transformations can also be applied computationally, enabling effects such as computational focusing anywhere in space.

This course presents a comprehensive development of lightfield photography, beginning with theoretical ray optics fundamentals and progressing through real-time GPU-based computational techniques. Although the material is mathematically rigorous, our goal is simplicity. Emphasizing fundamental underlying ideas leads to the development of surprisingly elegant analytical techniques. These techniques are in turn used to develop and characterize computational techniques, model lightfield cameras, and analyze resolution.

The course also demonstrates practical approaches and engineering solutions. The course includes a hands-on demonstration of several working plenoptic cameras that implement different methods for radiance capture, including the micro-lens approach of Lippmann, the mask-enhanced “heterodyning” camera, the lens-prism camera, multispectral and polarization capture, and the plenoptic 2.0 camera. One section of the course is devoted specifically to the commercially available Lytro camera. Various computational techniques for processing captured data are demonstrated, including basic rendering, Ng’s Fourier slice algorithm, the heterodyned light-field approach for computational refocusing, glare reduction, super-resolution, artifact reduction, and others.

LEARNING OUTCOMES

This course will enable you to:
- formulate arbitrary lens systems in terms of matrix optics, i.e., to use matrix operations to express ray propagation
- formulate typical lightfield photography problems in terms of the radiance in 4D ray space using ray propagation computations, enabling you to design and construct different plenoptic cameras both theoretically and as an engineering task
- classify plenoptic cameras into version 1.0 and 2.0 and analyze the reasons for the higher resolution of 2.0 cameras
- construct your own Plenoptic, 3D, HDR, multispectral or Superresolution cameras
- write GPU-based applications to perform lightfield rendering of the captured image in real time
- develop approaches to artifact reduction

INTENDED AUDIENCE

This course is intended for anyone interested in learning about lightfield photography. Prerequisites are basic familiarity with ray optics, image processing, linear algebra, and programming. Deeper involvement in one or several of those areas is a plus, but not required to understand the course.

INSTRUCTOR

Todor Georgiev is a principal engineer at Qualcomm. With background in theoretical physics, he concentrates on applications of mathematical methods taken from physics to image processing. Todor was previously with Adobe Systems, where he authored the Photoshop Healing Brush (a tool on which Poisson image editing was based). He works on theoretical and practical ideas in optics and computational photography, including plenoptic cameras and radiance capture. He has a number of papers and patents in these and related areas.

Andrew Lumsdaine received his PhD degree in electrical engineering and computer science from the Massachusetts Institute of Technology in 1992. He is presently a professor of computer science at Indiana University, where he is also the director of the Center for Research in Extreme Scale Technologies. His research interests include computational science and engineering, parallel and distributed computing, programming languages, numerical analysis, and computational photography. He is a member of the IEEE, the IEEE Computer Society, the ACM, and SIAM.

Elka Georgieva has a background in Mathematics and Astrophysics. She has 11 years working experience in the Space Systems division of Lockheed Martin on various NASA projects, including Sitzer Infrared Observatory and Mars Reconissence Orbiter as well as Stanford University’s GravityProB, as a softwre engineer and a systems engineer. Elka currently concentrates on plenoptic cameras and image processing for computational photography.

Stereoscopic Display Application Issues

SC060

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

When correctly implemented, stereoscopic 3D displays can provide significant benefits in many areas, including endoscopy and other medical imaging, teleoperated vehicles and telemanipulators, CAD, molecular modeling, 3D computer graphics, 3D visualization, photo interpretation, video-based training, and entertainment. This course conveys a concrete understanding of basic principles and pitfalls that should be considered when setting up stereoscopic systems and producing stereoscopic content. The course will demonstrate a range of stereoscopic hardware and 3D imaging & display principles, outline the key issues in an ortho-stereoscopic video display setup, and show 3D video from a wide variety of applied stereoscopic imaging systems.

LEARNING OUTCOMES

This course will enable you to:
- list critical human factors guidelines for stereoscopic display configuration and implementation
- calculate optimal camera focal length, separation, display size, and viewing distance to achieve a desired level of depth acuity
- examine comfort limits for focus/fixation mismatch and on-screen parallax values as a function of focal length, separation, convergence, display size, and viewing-distance factors
- set up a large-screen stereo display system using AV equipment readily available at most conference sites, for 3D stills and for full-motion 3D video
- rank the often-overlooked side-benefits of stereoscopic displays that should be included in a cost/benefit analysis for proposed 3D applications
- explain common pitfalls in designing tests to compare 2D vs. 3D displays
- calculate and demonstrate the distortions in perceived 3D space due to camera and display parameters
- design and set up an ortho-stereoscopic 3D imaging/display system
- understand the projective geometry involved in stereoscopic modeling
- determine the problems, and the solutions, for converting stereoscopic video across video standards such as NTSC and PAL
- work with stereoscopic 3D video and stills -using analog and digital methods of capture/filming, encoding, storage, format conversion, display, and publishing
- describe the trade-offs among currently available stereoscopic display system technologies and determine which will best match a particular application
- understand existing and developing stereoscopic standards

INTENDED AUDIENCE

This course is designed for engineers, scientists, and program managers who are using, or considering using, stereoscopic 3D displays in their applications. The solid background in stereoscopic system fundamentals, along with many examples of advanced 3D display applications, makes this course highly useful both for those who are new to stereoscopic 3D and also for those who want to advance their current understanding and utilization of stereoscopic systems.

INSTRUCTOR

John Merritt is a 3D display systems consultant at The Merritt Group, Williamsburg, MA, USA with more than 25 years experience in the design and human-factors evaluation of stereoscopic video displays for telepresence and telerobotics, off-road mobility, unmanned vehicles, night vision devices, photo interpretation, scientific visualization, and medical imaging.

Andrew Woods is a research engineer at Curtin University’s Centre for Marine Science and Technology in Perth, Western Australia. He has over 20 years of experience working on the design, application, and evaluation of stereoscopic technologies for industrial and entertainment applications.

3D Imaging

SC927

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Wednesday 8:30 am to 12:30 pm

The purpose of this course is to introduce algorithms for 3D structure inference from 2D images. In many applications, inferring 3D structure from 2D images can provide crucial sensing information. The course will begin by reviewing geometric image formation and mathematical concepts that are used to describe it, and then move to discuss algorithms for 3D model reconstruction.

The problem of 3D model reconstruction is an inverse problem in which we need to infer 3D information based on incomplete (2D) observations. We will discuss reconstruction algorithms which utilize information from multiple views. Reconstruction requires the knowledge of some intrinsic and extrinsic camera parameters, and the establishment of correspondence between views. We will discuss algorithms for determining camera parameters (camera calibration) and for obtaining correspondence using epipolar constraints between views. The course will also introduce relevant 3D imaging software components available through the industry standard OpenCV library.

LEARNING OUTCOMES

This course will enable you to:

- describe fundamental concepts in 3D imaging
- develop algorithms for 3D model reconstruction from 2D images
- incorporate camera calibration into your reconstructions
- classify the limitations of reconstruction techniques
- use industry standard tools for developing 3D imaging applications

INTENDED AUDIENCE

Engineers, researchers, and software developers, who develop imaging applications and/or use camera sensors for inspection, control, and analysis. The course assumes basic working knowledge concerning matrices and vectors.

INSTRUCTOR

Gady Agam is an Associate Professor of Computer Science at the Illinois Institute of Technology. He is the director of the Visual Computing Lab at IIT which focuses on imaging, geometric modeling, and graphics applications. He received his PhD degree from Ben-Gurion University in 1999.

Perception, Cognition, and Next Generation Imaging

SC969

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 8:30 am to 12:30 pm

The world of electronic imaging is an explosion of hardware and software technologies, used in a variety of applications, in a wide range of domains. These technologies provide visual, auditory and tactile information to human observers, whose job it is to make decisions and solve problems. In this course, we will study fundamentals in human perception and cognition, and see how these principles can guide the design of systems that enhance human performance. We will study examples in display technology, image quality, visualization, image search, visual monitoring and haptics, and students will be encouraged to bring forward ongoing problems of interest to them.

LEARNING OUTCOMES

This course will enable you to:

- describe basic principles of spatial, temporal, and color processing by the human visual system, and know where to go for deeper insight
- explore basic cognitive processes, including visual attention and semantics
- develop skills in applying knowledge about human perception and cognition to engineering applications

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who are involved in the design, testing or evaluation of electronic imaging systems. Business managers responsible for innovation and new product development. Anyone interested in human perception and the evolution of electronic imaging applications.

INSTRUCTOR

Bernice Rogowitz founded and co-chairs the SPIE/IS&T Conference on Human Vision and Electronic Imaging (HVEI) which is a multi-disciplinary forum for research on perceptual and cognitive issues in imaging systems. Dr. Rogowitz received her PhD from Columbia University in visual psychophysics, worked as a researcher and research manager at the IBM T.J. Watson Research Center for over 20 years, and is currently a consultant in vision, visual analysis and sensory interfaces. She has published over 60 technical papers and has over 12 patents on perceptually-based approaches to visualization, display technology, semantic image search, color, social networking, surveillance, haptic interfaces. She is a Fellow of the SPIE and the IS&T.

Image Capture

Digital Camera and Scanner Performance Evaluation: Standards and Measurement

SC807

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 12:00 am to 12:00 am

This is an updated course on imaging performance measurement methods for digital image capture devices and systems. We introduce several ISO measurement protocols for camera resolution, tone-transfer, noise, etc. We focus on the underlying sources of variability in system performance, measurement error, and how to manage this variability in working environments. The propagation of measurement variability will be described for several emerging standard methods for; image texture, distortion, color shading, flare and chromatic aberration. Using actual measurements we demonstrate how standards can be adapted to evaluate capture devices ranging from cell phone cameras to scientific detectors. We will also discuss the required elements of software tools, and show how to use Matlab software to develop and perform system evaluation.

LEARNING OUTCOMES

This course will enable you to:
- appreciate the difference between imaging performance and image quality
- interpret and apply the different flavors of each ISO performance method
- identify sources of system variability, and understand resulting measurement error
- distill information-rich ISO metrics into single measures for quality assurance
- adapt standard methods for use in factory testing
- select software elements (with Matlab examples) for performance evaluation programs
- be aware of upcoming standard measurement protocols

INTENDED AUDIENCE

Although technical in content, this course is intended for a wide audience: image scientists, quality engineers, and others evaluating digital camera and scanner performance. No background in imaging performance (MTF, etc.) evaluation will be assumed, although the course will provide previous attendees with an update and further insight for implementation. Detailed knowledge of Matlab is not needed, but exposure to similar software environments will be helpful.

INSTRUCTOR

Peter Burns is a consultant working in imaging system evaluation, modeling, and image processing. Previously he worked for Carestream Health, Xerox and Eastman Kodak. A frequent speaker at technical conferences, he has contributed to several imaging standards. He has taught several imaging courses: at Kodak, SPIE, and IS&T technical conferences, and at the Center for Imaging Science, RIT.

Donald Williams is the founder of Image Science Associates, and formerly with Kodak Research Laboratories. His work focuses on quantitative signal and noise performance metrics for digital capture imaging devices, and imaging fidelity issues. He co-leads the TC42 standardization efforts on digital print and film scanner resolution (ISO 16067-1, ISO 16067-2) scanner dynamic range (ISO 21550) and is the editor for the second edition to digital camera resolution (ISO 12233).

Joint Design of Optics and Image Processing for Imaging Systems

SC965

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

For centuries, optical imaging system design centered on exploiting the laws of the physics of light and materials (glass, plastic, reflective metal, ...) to form high-quality (sharp, high-contrast, undistorted, ...) images that “looked good.” In the past several decades, the optical images produced by such systems have been ever more commonly sensed by digital detectors and the image imperfections corrected in software. The new era of electro-optical imaging offers a more fundamental revision to this paradigm, however: now the optics and image processing can be designed jointly to optimize an end-to-end digital merit function without regard to the traditional quality of the intermediate optical image. Many principles and guidelines from the optics-only era are counterproductive in the new era of electro-optical imaging and must be replaced by principles grounded on both the physics of photons and the information of bits.

This short course will describe the theoretical and algorithmic foundations of new methods of jointly designing the optics and image processing of electro-optical imaging systems. The course will focus on the new concepts and approaches rather than commercial tools.

LEARNING OUTCOMES

This course will enable you to:
- describe the basics of information theory
- characterize electro-optical systems using linear systems theory
- compute a predicted mean-squared error merit function
- characterize the spatial statistics of sources
- implement a Wiener filter
- implement spatial convolution and digital filtering
- make the distinction between traditional optics-only merit functions and end-to-end digital merit functions
- perform point-spread function engineering
- become aware of the image processing implications of various optical aberrations
- describe wavefront coding and cubic phase plates
- utilize the power of spherical coding
- compare super-resolution algorithms and multi-aperture image synthesizing systems
- simulate the manufacturability of jointly designed imaging systems
- evaluate new methods of electro-optical compensation

INTENDED AUDIENCE

Optical designers familiar with system characterization (f#, depth of field, numerical aperture, point spread functions, modulation transfer functions, ...) and image processing experts familiar with basic operations (convolution, digital sharpening, information theory, ...).

INSTRUCTOR

David Stork is Distinguished Research Scientist and Research Director at Rambus Labs, and a Fellow of the International Association for Pattern Recognition. He holds 40 US patents and has written nearly 200 technical publications including eight books or proceedings volumes such as Seeing the Light, Pattern Classification (2nd ed.) and HAL’s Legacy. He has given over 230 technical presentations on computer image analysis of art in 19 countries.

Theory and Methods of Lightfield Photography

SC980

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

Lightfield photography is based on capturing discrete representations of all light rays in a volume of 3D space. Since light rays are characterized with 2D position and 2D direction (relative to a plane of intersection), lightfield photography captures 4D data. In comparison, conventional photography captures 2D images. Multiplexing this 4D radiance data onto conventional 2D sensors demands sophisticated optics and imaging technology. Rending an image from the 4D lightfield is accomplished computationally based on creating 2D integral projections of the 4D radiance. Optical transformations can also be applied computationally, enabling effects such as computational focusing anywhere in space.

This course presents a comprehensive development of lightfield photography, beginning with theoretical ray optics fundamentals and progressing through real-time GPU-based computational techniques. Although the material is mathematically rigorous, our goal is simplicity. Emphasizing fundamental underlying ideas leads to the development of surprisingly elegant analytical techniques. These techniques are in turn used to develop and characterize computational techniques, model lightfield cameras, and analyze resolution.

The course also demonstrates practical approaches and engineering solutions. The course includes a hands-on demonstration of several working plenoptic cameras that implement different methods for radiance capture, including the micro-lens approach of Lippmann, the mask-enhanced "heterodyning" camera, the lens-prism camera, multispectral and polarization capture, and the plenoptic 2.0 camera. One section of the course is devoted specifically to the commercially available Lytro camera. Various computational techniques for processing captured data are demonstrated, including basic rendering, Ng's Fourier slice algorithm, the heterodyned light-field approach for computational refocusing, glare reduction, super-resolution, artifact reduction, and others.

LEARNING OUTCOMES

This course will enable you to:
- formulate arbitrary lens systems in terms of matrix optics, i.e., to use matrix operations to express ray propagation
- formulate typical lightfield photography problems in terms of the radiance in 4D ray space using ray propagation computations, enabling you to design and construct different plenoptic cameras both theoretically and as an engineering task
- classify plenoptic cameras into version 1.0 and 2.0 and analyze the reasons for the higher resolution of 2.0 cameras
- construct your own Plenoptic, 3D, HDR, multispectral or Superresolution cameras
- write GPU-based applications to perform lightfield rendering of the captured image in real time
- develop approaches to artifact reduction

INTENDED AUDIENCE

This course is intended for anyone interested in learning about lightfield photography. Prerequisites are basic familiarity with ray optics, image processing, linear algebra, and programming. Deeper involvement in one or several of those areas is a plus, but not required to understand the course.

INSTRUCTOR

Todor Georgiev is a principal engineer at Qualcomm. With background in theoretical physics, he concentrates on applications of mathematical methods taken from physics to image processing. Todor was previously with Adobe Systems, where he authored the Photoshop Healing Brush (a tool on which Poisson image editing was based). He works on theoretical and practical ideas in optics and computational photography, including plenoptic cameras and radiance capture. He has a number of papers and patents in these and related areas.

Andrew Lumsdaine received his PhD degree in electrical engineering and computer science from the Massachusetts Institute of Technology in 1992. He is presently a professor of computer science at Indiana University, where he is also the director of the Center for Research in Extreme Scale Technologies. His research interests include computational science and engineering, parallel and distributed computing, programming languages, numerical analysis, and computational photography. He is a member of the IEEE, the IEEE Computer Society, the ACM, and SIAM.

Elka Georgieva has a background in Mathematics and Astrophysics. She has 11 years working experience in the Space Systems division of Lockheed Martin on various NASA projects, including Sitzer Infrared Observatory and Mars Reconissence Orbiter as well as Stanford University's GravityProB, as a softwre engineer and a systems engineer. Elka currently concentrates on plenoptic cameras and image processing for computational photography.

Objective and Subjective Image Quality Camera Benchmarking

SC1049

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Monday 8:30 am to 5:30 pm

This course explains methodologies to assess image quality of photographic still image or motion picture capture device. The course will go through all the major image quality attributes, the flaws that degrade those attributes, their causes and consequences on subjective perception. One important goal of the course is to provide a clear understanding of all attributes, how they can be visually assessed in real life picture from many examples images, as well as the physical phenomenon that can degrade image quality.

The course thoroughly explains subjective evaluation methodologies, then objective measurement methodologies relying on existing standards from ISO, I3A/CPIQ and beyond, with many practical examples; how objective measurement metrics are related to subjective perception, methods to correlate objective metrics with subjective perception; and how one can build a benchmarking protocol with objective measurements from a capture use case perspective (such as consumer, landscape, sports,...) to an output use case perspective (such as handheld display, HDTV, photobook,...).

LEARNING OUTCOMES

This course will enable you to:
- identify defects that degrade image quality in natural images and what component of the camera should/could be improved for better image quality
- build up an image quality lab and master measurement protocols
- select best key components to build a camera (best sensor for a given price, best ISP on the market,...)
- judge the overall image quality of a camera
- evaluate the impact various output use cases have on overall image quality
- compare the image quality of a set of cameras
- define subjective test plans and protocols
- setup benchmarking protocols depending on use cases

INTENDED AUDIENCE

Image scientists, engineers, or managers who wish to learn more about image quality and how to evaluate camera performance for various output use cases. A good understanding of imaging and how a camera works is assumed. Anyone involved in photographic or motion picture imaging will benefit from this course.

INSTRUCTOR

Jonathan Phillips is a senior image quality scientist in the camera group at NVIDIA. His involvement in the imaging industry spans over 20 years, including two decades at Eastman Kodak Company. His focus has been on photographic quality, with an emphasis on psychophysical testing for both product development and fundamental perceptual studies. His broad experience has included image quality work with capture, display, and print technologies. He received the 2011 I3A Achievement Award for his work on camera phone image quality and headed up the 2012 revision of ISO 20462 - Psychophysical experimental methods for estimating image quality - Part 3: Quality ruler method. He completed his graduate work in color science in the Center for Imaging Science at Rochester Institute of Technology and his chemistry undergraduate at Wheaton College (IL).

Image Quality and Evaluation of Cameras In Mobile Devices

SC1058

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

Digital and mobile imaging camera system performance is determined by a combination of sensor characteristics, lens characteristics, and image-processing algorithms. As pixel size decreases, sensitivity decreases and noise increases, requiring a more sophisticated noise-reduction algorithm to obtain good image quality. Furthermore, small pixels require high-resolution optics with low chromatic aberration and very small blur circles. Ultimately, there is a tradeoff between noise, resolution, sharpness, and the quality of an image.

This short course provides an overview of "light in to byte out" issues associated with digital and mobile imaging cameras. The course covers, optics, sensors, image processing, and sources of noise in these cameras, algorithms to reduce it, and different methods of characterization. Although noise is typically measured as a standard deviation in a patch with uniform color, it does not always accurately represent human perception. Based on the "visual noise" algorithm described in ISO 15739, an improved approach for measuring noise as an image quality aspect will be demonstrated. The course shows a way to optimize image quality by balancing the tradeoff between noise and resolution. All methods discussed will use images as examples.

LEARNING OUTCOMES

This course will enable you to:
- describe pixel technology and color filtering
- describe illumination, photons, sensor and camera radiometry
- select a sensor for a given application
- describe and measure sensor performance metrics
- describe and understand the optics of digital and mobile imaging systems
- examine the difficulties in minimizing sensor sizes
- assess the need for per unit calibrations in digital still cameras and mobile imaging devices
- learn about noise, its sources, and methods of managing it
- make noise and resolution measurements based on international standards

o EMVA 1288
o ISO 14524 (OECF)/ISO 15739 (Noise)
o Visual Noise
o ISO 12233 (Resolution)

- assess influence of the image pipeline on noise
- utilize today's algorithms to reduce noise in images
- measure noise based on human perception
- optimize image quality by balancing noise reduction and resolution
- compare hardware tradeoffs, noise reduction algorithms, and settings for optimal image quality

INTENDED AUDIENCE

All people evaluating the image quality of digital cameras, mobile cameras, and scanners would benefit from participation. Technical staff of manufacturers, managers of digital imaging projects, as well as journalists and students studying image technology are among the intended audience.

INSTRUCTOR

Dietmar Wüller studied photographic sciences at the University of Cologne. He owns a test lab for digital photography and has been testing digital cameras and scanners for German magazines and manufacturers since 1997. He is the editor of the ISO scanner standards (ISO 21550 and ISO 16067) and the vice chairman of the photography section in the German DIN. He also chairs the digital photography working group in the European Color Initiative (ECI).

Kevin Matherson is a senior image scientist in the research and development lab of Hewlett-Packard's Imaging and Printing Group and has worked in the field of digital imaging since 1985. He joined Hewlett Packard in 1996 and has participated in the development of all HP digital and mobile imaging cameras produced since that time. His primary research interests focus on noise characterization, optical system analysis, and the optimization of camera image quality. Dr. Matherson currently leads the camera characterization laboratory in Fort Collins and holds Masters and PhD degrees in Optical Sciences from the University of Arizona.

High Dynamic Range Imaging: Sensors and Architectures

SC967

Course Level: Intermediate
CEU: 0.65 $570 Members | $680 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course provides attendees with an intermediate knowledge of high dynamic range image sensors and techniques for industrial and non-industrial applications. The course describes various sensor and pixel architectures to achieve high dynamic range imaging as well as software approaches to make high dynamic range images out of lower dynamic range sensors or image sets. The course follows a mathematic approach to define the amount of information that can be extracted from the image for each of the methods described. Some methods for automatic control of exposure and dynamic range of image sensors and other issues like color and glare will be introduced.

LEARNING OUTCOMES

This course will enable you to:
- describe various approaches to achieve high dynamic range imaging
- predict the behavior of a given sensor or architecture on a scene
- specify the sensor or system requirements for a high dynamic range application
- classify a high dynamic range application into one of several standard types

INTENDED AUDIENCE

This material is intended for anyone who needs to learn more about quantitative side of high dynamic range imaging. Optical engineers, electronic engineers and scientists will find useful information for their next high dynamic range application.

INSTRUCTOR

Arnaud Darmont is owner and CEO of Aphesa, a company founded in 2008 and specialized in image sensor consulting, the EMVA1288 standard and camera benchmarking. He holds a degree in Electronic Engineering from the University of Liège (Belgium). Prior to founding Aphesa, he worked for over 7 years in the field of CMOS image sensors and high dynamic range imaging.

COURSE PRICE INCLUDES the text *High Dynamic Range Imaging: Sensors and Architectures* (SPIE Press, 2012) by Arnaud Darmont.

HDR Imaging in Cameras, Displays and Human Vision

SC1097

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 1:30 pm to 5:30 pm

High-dynamic range (HDR) imaging is a significant improvement over conventional imaging. After a description of the dynamic range problem in image acquisition, this course focuses on standard methods of creating and manipulating HDR images, replacing myths with measurements of scenes, camera images, and visual appearances. In particular, the course presents measurements about the limits of accurate camera acquisition and the usable range of light for displays of our vision system. Regarding our vision system, the course discusses the role of accurate vs. non-accurate luminance recording for the final appearance of a scene, presenting the quality and the characteristics of visual information actually available on the retina. It ends with a discussion of the principles of tone rendering and the role of spatial comparison.

LEARNING OUTCOMES

This course will enable you to:
- explore the history of HDR imaging
- describe dynamic range and quantization: the 'salame' metaphor
- compare single and multiple-exposure for scene capture
- measure optical limits in acquisition and visualization
- discover relationship between HDR range and scene dependency ; the effect of glare
- explore the limits of our vision system on HDR
- calculate retinal luminance
- put in relationship the HDR images and the visual appearance
- identify tone-rendering problems and spatial methods
- verify the changes in color spaces due to dynamic range expansion

INTENDED AUDIENCE

Color scientists, software and hardware engineers, photographers, cinematographers, production specialists, and students interested in using HDR images in real applications.

INSTRUCTOR

Alessandro Rizzi has been researching in the field of digital imaging and vision since 1990. His main research topic is the use of color information in digital images with particular attention to color vision mechanisms. He is Associate professor at the Dept. of Computer Science at University of Milano, teaching Fundamentals of Digital Imaging, Multimedia Video, and Human-Computer Interaction. He is one of the founders of the Italian Color Group and member of several program committees of conferences related to color and digital imaging.

John McCann received a degree in Biology from Harvard College in 1964. He worked in, and managed, the Vision Research Laboratory at Polaroid from 1961 to 1996. He has studied human color vision, digital image processing, large format instant photography, and the reproduction of fine art. His publications and patents have studied Retinex theory, color constancy, color from rod/cone interactions at low light levels, appearance with scattered light, and HDR imaging. He is a Fellow of the IS&T and the Optical Society of America (OSA). He is a past President of IS&T and the Artists Foundation, Boston. He is the IS&T/OSA 2002 Edwin H. Land Medalist, and IS&T 2005 Honorary Member.

Image and Video Forensics: Recent Trends and Challenges New

SC1130

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

The widespread adoption of digital content over traditional physical media such as film has given rise to a number of new information security challenges. Digital content can be altered, falsified, and redistributed with relative ease by adversaries. This has important consequences for governmental, commercial, and social institutions that rely on digital information. The pipeline which leads to ascertain whether an image has undergone to some kind of forgery leads through the following steps: determine whether the image is "original" and, in the case where the previous step has given negative results, try to understand the past history of the image.

Although the field of information forensics is still young, many forensic techniques have been developed to detect forgeries, identify the origin, and trace the processing history of digital multimedia content. This course provides an overview of information forensics research and related applications. Also we examine the device-specific fingerprints left by digital image and video cameras along with forensic techniques used to identify the source of digital multimedia files. Finally, an overview of the recent trends and evolution, considering the updated literature in the field, will be provided.

LEARNING OUTCOMES

This course will enable you to:
- describe forensics systems for commercial and scientific imaging applications
- explain how imaging data are processed and how proceed to detect forgeries
- list specifications and requirements to select a specific algorithm for your imaging application in the forensics context
- recognize performance differences among imaging pipeline technologies
- become familiar with current and future imaging technologies and applications

INTENDED AUDIENCE

This course is intended for those with a general computing background, and is interested in the topic of image and video processing. Students, researchers, and practicing engineers should all be able to benefit from the general overview of the field and the introduction of the most recent advance of the technology.

INSTRUCTOR

Sebastiano Battiato received his degree in computer science from University of Catania and his Ph.D. in computer science and applied mathematics from University of Naples in 1999. From 1999 to 2003 he was the leader of the "Imaging" team at STMicroelectronics in Catania. He joined the Department of Mathematics and Computer Science at the University of Catania as assistant professor in 2004 and became associate professor in the same department in 2011. His research interests include image enhancement and processing, image coding, camera imaging technology and multimedia forensics. He has edited 4 books and co-authored more than 150 papers in international journals, conference proceedings and book chapters. He is a co-inventor of about 15 international patents, reviewer for several international journals, and he has been regularly a member of numerous international conference committees.

Image Enhancement, Deblurring and Super-Resolution

SC468

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course discusses some of the advanced algorithms in the field of digital image processing. In particular, it familiarizes the audience with the understanding, design, and implementation of advanced algorithms used in deblurring, contrast enhancement, sharpening, noise reduction, and super-resolution in still images and video. Some of the applications include medical imaging, entertainment imaging, consumer and professional digital still cameras/camcorders, forensic imaging, and surveillance. Many image examples complement the technical descriptions.

LEARNING OUTCOMES

This course will enable you to:
- explain the various nonadaptive and adaptive techniques used in image contrast enhancement. Examples include PhotoShop commands such as Brightness/Contrast, Auto Levels, Equalize and Shadow/Highlights, or Pizer's technique and Moroney's approach
- explain the fundamental techniques used in image Dynamic Range Compression (DRC).Illustrate using the fast bilateral filtering by Dorsey and Durand as an example.
- explain the various techniques used in image noise removal, such as bilateral filtering, sigma filtering and K-Nearest Neighbor
- explain the various techniques used in image sharpening such as nonlinear unsharp masking, etc.
- explain the basic techniques used in image deblurring (restoration) such as inverse filtering and Wiener filtering
- explain the fundamental ideas behind achieving image super-resolution from multiple lower resolution images of the same scene
- explain how motion information can be utilized in image sequences to improve the performance of various enhancement techniques such as noise removal, sharpening, and super-resolution

INTENDED AUDIENCE

Scientists, engineers, and managers who need to understand and/or apply the techniques employed in digital image processing in various products in a diverse set of applications such as medical imaging, professional and consumer imaging, forensic imaging, etc. Prior knowledge of digital filtering (convolution) is necessary for understanding the (Wiener filtering and inverse filtering) concepts used in deblurring (about 20% of the course content).

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Understanding and Interpreting Images

SC1015

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

A key problem in computer vision is image and video understanding, which can be defined as the task of recognizing objects in the scene and their corresponding relationships and semantics, in addition to identifying the scene category itself. Image understanding technology has numerous applications among which are smart capture devices, intelligent image processing, semantic image search and retrieval, image/video utilization (e.g., ratings on quality, usefulness, etc.), security and surveillance, intelligent asset selection and targeted advertising.

This tutorial provides an introduction to the theory and practice of image understanding algorithms by studying the various technologies that serve the three major components of a generalized IU system, namely, feature extraction and selection, machine learning tools used for classification, and datasets and ground truth used for training the classifiers. Following this general development, a few application examples are studied in more detail to gain insight into how these technologies are employed in a practical IU system. Applications include face detection, sky detection, image orientation detection, main subject detection, and content based image retrieval (CBIR). Furthermore, realtime demos including face detection and recognition, CBIR, and automatic zooming and cropping of images based on main-subject detection are provided.

LEARNING OUTCOMES

This course will enable you to:
- learn the various applications of IU and the scope of its consumer and commercial uses
- explain the various technologies used in image feature extraction such as global, block-based or region-based color histograms and moments, the "tiny" image, GIST, histogram of oriented gradients (HOG), scale-invariant feature transform (SIFT), speeded-up robust features (SURF), bag of words, etc.
- explain the various machine learning paradigms and the fundamental techniques used for classification such as Bayesian classifiers, linear support vector machines (SVM) and nonlinear kernels, boosting techniques (e.g., AdaBoost), k-nearest neighbors, .etc.
- explain the concepts used for classifier evaluation such as false positives and negatives, true positives and negatives, confusion matrix, precision and recall, and receiver operating characteristics (ROC)
- explain the basic methods employed in generating and labeling datasets and ground truth and examples of various datasets such as CMU PIE dataset, Label Me dataset, Caltech 256 dataset, TrecVid, FERET dataset, and Pascal Visual Object Recognition
- explain the fundamental ideas employed in the IU algorithms used for face detection, material detection, image orientation, and a few others
- learn the importance of using context in IU tasks

INTENDED AUDIENCE

Scientists, engineers, and managers who need to familiarize themselves with IU technology and understand its performance limitations in a diverse set of products and applications. No specific prior knowledge is required except familiarity with general mathematical concepts such as the dot product of two vectors and basic image processing concepts such as histograms, filtering, gradients, etc.

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Perception, Cognition, and Next Generation Imaging

SC969

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 8:30 am to 12:30 pm

The world of electronic imaging is an explosion of hardware and software technologies, used in a variety of applications, in a wide range of domains. These technologies provide visual, auditory and tactile information to human observers, whose job it is to make decisions and solve problems. In this course, we will study fundamentals in human perception and cognition, and see how these principles can guide the design of systems that enhance human performance. We will study examples in display technology, image quality, visualization, image search, visual monitoring and haptics, and students will be encouraged to bring forward ongoing problems of interest to them.

LEARNING OUTCOMES

This course will enable you to:
- describe basic principles of spatial, temporal, and color processing by the human visual system, and know where to go for deeper insight
- explore basic cognitive processes, including visual attention and semantics
- develop skills in applying knowledge about human perception and cognition to engineering applications

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who are involved in the design, testing or evaluation of electronic imaging systems. Business managers responsible for innovation and new product development. Anyone interested in human perception and the evolution of electronic imaging applications.

INSTRUCTOR

Bernice Rogowitz founded and co-chairs the SPIE/IS&T Conference on Human Vision and Electronic Imaging (HVEI) which is a multi-disciplinary forum for research on perceptual and cognitive issues in imaging systems. Dr. Rogowitz received her PhD from Columbia University in visual psychophysics, worked as a researcher and research manager at the IBM T.J. Watson Research Center for over 20 years, and is currently a consultant in vision, visual analysis and sensory interfaces. She has published over 60 technical papers and has over 12 patents on perceptually-based approaches to visualization, display technology, semantic image search, color, social networking, surveillance, haptic interfaces. She is a Fellow of the SPIE and the IS&T.

Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence

SC812

Course Level: Intermediate
CEU 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

We will examine objective criteria for the evaluation of image quality that are based on models of visual perception. Our primary emphasis will be on image fidelity, i.e., how close an image is to a given original or reference image, but we will broaden the scope of image fidelity to include structural equivalence. We will also discuss no-reference and limited-reference metrics. We will examine a variety of applications with special emphasis on image and video compression. We will examine near-threshold perceptual metrics, which explicitly account for human visual system (HVS) sensitivity to noise by estimating thresholds above which the distortion is just-noticeable, and supra-threshold metrics, which attempt to quantify visible distortions encountered in high compression applications or when there are losses due to channel conditions. We will also consider metrics for structural equivalence, whereby the original and the distorted image have visible differences but both look natural and are of equally high visual quality. We will also take a close look at procedures for evaluating the performance of quality metrics, including database design, models for generating realistic distortions for various applications, and subjective procedures for metric development and testing. Throughout the course we will discuss both the state of the art and directions for future research.

Course topics include:
- Applications: Image and video compression, restoration, retrieval, graphics, etc.
- Human visual system review
- Near-threshold and supra-threshold perceptual quality metrics
- Structural similarity metrics
- Perceptual metrics for texture analysis and compression – structural texture similarity metrics
- No-reference and limited-reference metrics
- Models for generating realistic distortions for different applications
- Design of databases and subjective procedures for metric development and testing
- Metric performance comparisons, selection, and general use and abuse
- Embedded metric performance, e.g., for rate-distortion optimized compression or restoration
- Metrics for specific distortions, e.g., blocking and blurring, and for specific attributes, e.g., contrast, roughness, and glossiness
- Multimodal applications

LEARNING OUTCOMES

This course will enable you to:
- gain a basic understanding of the properties of the human visual system and how current applications (image and video compression, restoration, retrieval, etc.) that attempt to exploit these properties
- gain an operational understanding of existing perceptually-based and structural similarity metrics, the types of images/artifacts on which they work, and their failure modes
- review current distortion models for different applications, and how they can be used to modify or develop new metrics for specific contexts
- differentiate between sub-threshold and supra-threshold artifacts, the HVS responses to these two paradigms, and the differences in measuring that response
- establish criteria by which to select and interpret a particular metric for a particular application.
- evaluate the capabilities and limitations of full-reference, limited-reference, and no-reference metrics, and why each might be used in a particular application

INTENDED AUDIENCE

Image and video compression specialists who wish to gain an understanding of how performance can be quantified. Engineers and Scientists who wish to learn about objective image and video quality evaluation.

Managers who wish to gain a solid overview of image and video quality evaluation. Students who wish to pursue a career in digital image processing. Intellectual Property and Patent Attorneys who wish to gain a more fundamental understanding of quality metrics and the underlying technologies. Government laboratory personnel who work in imaging.

Prerequisites: a basic understanding of image compression algorithms, and a background in digital signal processing and basic statistics: frequency-based representations, filtering, distributions.

INSTRUCTORS

Thrasyvoulos N. Pappas received the S.B., S.M., and Ph.D. degrees in electrical engineering and computer science from MIT in 1979, 1982, and 1987, respectively. From 1987 until 1999, he was a Member of the Technical Staff at Bell Laboratories, Murray Hill, NJ. He is currently a professor in the Department of Electrical and Computer Engineering at Northwestern University, which he joined in 1999. His research interests are in image and video quality and compression, image and video analysis, content-based retrieval, perceptual models for multimedia processing, model-based halftoning, and tactile and multimodal interfaces. Dr. Pappas has served as co-chair of the 2005 SPIE/IS&T Electronic Imaging Symposium, and since 1997 he has been co-chair of the SPIE/IS&T Conference on Human Vision and Electronic Imaging. He has also served as editor-in-chief for the IEEE Transactions on Image Processing from 2010 to 2012. Dr. Pappas is a Fellow of IEEE and SPIE.

Sheila S. Hemami received the B.S.E.E. degree from the University of Michigan in 1990, and the M.S.E.E. and Ph.D. degrees from Stanford University in 1992 and 1994, respectively. She was with Hewlett-Packard Laboratories in Palo Alto, California in 1994 and was with the School of Electrical Engineering at Cornell University from 1995-2013. She is currently Professor and Chair of the Department of Electrical & Computer Engineering at Northeastern University in Boston, MA. Dr. Hemami's research interests broadly concern communication of visual information from the perspectives of both signal processing and psychophysics. She has held various technical leadership positions in the IEEE, served as editor-in-chief for the IEEE Transactions on Multimedia from 2008 to 2010, and was elected a Fellow of the IEEE in 2009 for her for contributions to robust and perceptual image and video communications.

Computer Vision

Computer Vision and Imaging in Transportation Applications New

SC1131

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course introduces the attendee to applications in the transportation industry that employ imaging, computer vision, and video processing technologies. The class begins with a survey of key topics in transportation falling under three broad categories: safety, efficiency, and security. Topics include driver assistance, traffic surveillance and law enforcement, video-based tolling, monitoring vehicles of interest, and incident detection. The second part of the course provides a more in-depth treatment of state-of-art approaches to selected problems such as vehicle license plate recognition, vehicle occupancy estimation, speed enforcement, driver attention monitoring, and sensing of road and environmental conditions. Where necessary, background material on relevant computer vision concepts will be covered, such as image segmentation, object detection, classification, recognition, and tracking, and 3D camera geometry.

LEARNING OUTCOMES

This course will enable you to:

- explain the broad impact of imaging and computer vision towards enhancing safety, efficiency, and law enforcement in transportation applications
- acquire a solid understanding of the basic concepts in computer vision required for transportation imaging, including object detection, classification, recognition, tracking, and camera calibration from transportation-related images and videos
- be familiar with state-of-art approaches and current challenges in applications, such as vehicle license plate recognition, vehicle occupancy estimation, driver assistance, traffic law enforcement, and sensing of road conditions

INTENDED AUDIENCE

Scientists, engineers, technicians, and managers who wish to learn more about how to use imaging, video, and computer vision concepts to address important problems in the transportation domain. Attendees must be familiar with basic digital image and video processing and representations. Familiarity with basic concepts in computer vision is a plus – although we will quickly review the needed background.

INSTRUCTOR

Raja Bala received a Ph.D. in Electrical Engineering from Purdue University and is currently a Principal Scientist and Project Leader in the Xerox Research Center Webster. His research interests include mobile imaging, computer vision, video processing, and color imaging. Dr. Bala has taught many successful conference courses in color and digital imaging and has served as adjunct faculty member in the School of Electrical Engineering at the Rochester Institute of Technology. He holds over 100 U.S. patents, has authored over 90 publications in the field of digital imaging, and has served as Associate Editor of the Journal of Imaging Science and Technology. He is a Fellow of the Society for Imaging Science and Technology.

Robert Loce received an MS in Optical Engineering from the University of Rochester and a PhD in Imaging Science from Rochester Institute of Technology. He is currently a Research Fellow and Technical Manager in the Xerox Research Center Webster. His current research activities involve leading an organization and projects into new video processing and computer vision technologies that are relevant to transportation and healthcare. He has over 90 publications and 175 patents in the areas of digital image processing, image enhancement, imaging systems, and optics. He is a Fellow of SPIE and a Senior Member of IEEE. He is currently an associate editor for Journal of Electronic Imaging, and has been and associate editor for Real-Time Imaging, and IEEE Transactions on Image Processing.

Understanding and Interpreting Images

SC1015

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

A key problem in computer vision is image and video understanding, which can be defined as the task of recognizing objects in the scene and their corresponding relationships and semantics, in addition to identifying the scene category itself. Image understanding technology has numerous applications among which are smart capture devices, intelligent image processing, semantic image search and retrieval, image/video utilization (e.g., ratings on quality, usefulness, etc.), security and surveillance, intelligent asset selection and targeted advertising.

This tutorial provides an introduction to the theory and practice of image understanding algorithms by studying the various technologies that serve the three major components of a generalized IU system, namely, feature extraction and selection, machine learning tools used for classification, and datasets and ground truth used for training the classifiers. Following this general development, a few application examples are studied in more detail to gain insight into how these technologies are employed in a practical IU system. Applications include face detection, sky detection, image orientation detection, main subject detection, and content based image retrieval (CBIR). Furthermore, realtime demos including face detection and recognition, CBIR, and automatic zooming and cropping of images based on main-subject detection are provided.

LEARNING OUTCOMES

This course will enable you to:

- learn the various applications of IU and the scope of its consumer and commercial uses
- explain the various technologies used in image feature extraction such as global, block-based or region-based color histograms and moments, the “tiny” image, GIST, histogram of oriented gradients (HOG), scale-invariant feature transform (SIFT), speeded-up robust features (SURF), bag of words, etc.
- explain the various machine learning paradigms and the fundamental techniques used for classification such as Bayesian classifiers, linear support vector machines (SVM) and nonlinear kernels, boosting techniques (e.g., AdaBoost), k-nearest neighbors, .etc.
- explain the concepts used for classifier evaluation such as false positives and negatives, true positives and negatives, confusion matrix, precision and recall, and receiver operating characteristics (ROC)

- explain the basic methods employed in generating and labeling datasets and ground truth and examples of various datasets such as CMU PIE dataset, Label Me dataset, Caltech 256 dataset, TrecVid, FERET dataset, and Pascal Visual Object Recognition
- explain the fundamental ideas employed in the IU algorithms used for face detection, material detection, image orientation, and a few others
- learn the importance of using context in IU tasks

INTENDED AUDIENCE

Scientists, engineers, and managers who need to familiarize themselves with IU technology and understand its performance limitations in a diverse set of products and applications. No specific prior knowledge is required except familiarity with general mathematical concepts such as the dot product of two vectors and basic image processing concepts such as histograms, filtering, gradients, etc.

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/ CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Objective and Subjective Image Quality Camera Benchmarking

SC1049

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Monday 8:30 am to 5:30 pm

This course explains methodologies to assess image quality of photographic still image or motion picture capture device. The course will go through all the major image quality attributes, the flaws that degrade those attributes, their causes and consequences on subjective perception. One important goal of the course is to provide a clear understanding of all attributes, how they can be visually assessed in real life picture from many examples images, as well as the physical phenomenon that can degrade image quality.

The course thoroughly explains subjective evaluation methodologies, then objective measurement methodologies relying on existing standards from ISO, I3A/CPIQ and beyond, with many practical examples; how objective measurement metrics are related to subjective perception, methods to correlate objective metrics with subjective perception; and how one can build a benchmarking protocol with objective measurements from a capture use case perspective (such as consumer, landscape, sports,...) to an output use case perspective (such as handheld display, HDTV, photobook,...).

LEARNING OUTCOMES

This course will enable you to:

- identify defects that degrade image quality in natural images and what component of the camera should/could be improved for better image quality
- build up an image quality lab and master measurement protocols
- select best key components to build a camera (best sensor for a given price, best ISP on the market,...)
- judge the overall image quality of a camera
- evaluate the impact various output use cases have on overall image quality
- compare the image quality of a set of cameras
- define subjective test plans and protocols
- setup benchmarking protocols depending on use cases

INTENDED AUDIENCE

Image scientists, engineers, or managers who wish to learn more about image quality and how to evaluate camera performance for various output use cases. A good understanding of imaging and how a camera works is assumed. Anyone involved in photographic or motion picture imaging will benefit from this course.

INSTRUCTOR

Jonathan Phillips is a senior image quality scientist in the camera group at NVIDIA. His involvement in the imaging industry spans over 20 years, including two decades at Eastman Kodak Company. His focus has been on photographic quality, with an emphasis on psychophysical testing for both product development and fundamental perceptual studies. His broad experience has included image quality work with capture, display, and print technologies. He received the 2011 I3A Achievement Award for his work on camera phone image quality and headed up the 2012 revision of ISO 20462 - Psychophysical experimental methods for estimating image quality - Part 3: Quality ruler method. He completed his graduate work in color science in the Center for Imaging Science at Rochester Institute of Technology and his chemistry undergraduate at Wheaton College (IL).

Image and Video Forensics: Recent Trends and Challenges New

SC1130

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

The widespread adoption of digital content over traditional physical media such as film has given rise to a number of new information security challenges. Digital content can be altered, falsified, and redistributed with relative ease by adversaries. This has important consequences for governmental, commercial, and social institutions that rely on digital information. The pipeline which leads to ascertain whether an image has undergone to some kind of forgery leads through the following steps: determine whether the image is "original" and, in the case where the previous step has given negative results, try to understand the past history of the image.

Although the field of information forensics is still young, many forensic techniques have been developed to detect forgeries, identify the origin, and trace the processing history of digital multimedia content. This course provides an overview of information forensics research and related applications. Also we examine the device-specific fingerprints left by digital image and video cameras along with forensic techniques used to identify the source of digital multimedia files. Finally, an overview of the recent trends and evolution, considering the updated literature in the field, will be provided.

LEARNING OUTCOMES

This course will enable you to:

- describe forensics systems for commercial and scientific imaging applications
- explain how imaging data are processed and how proceed to detect forgeries
- list specifications and requirements to select a specific algorithm for your imaging application in the forensics context
- recognize performance differences among imaging pipeline technologies
- become familiar with current and future imaging technologies and applications

INTENDED AUDIENCE

This course is intended for those with a general computing background, and is interested in the topic of image and video processing. Students, researchers, and practicing engineers should all be able to benefit from the general overview of the field and the introduction of the most recent advance of the technology.

INSTRUCTOR

Sebastiano Battiato received his degree in computer science from University of Catania and his Ph.D. in computer science and applied mathematics from University of Naples in 1999. From 1999 to 2003 he was the leader of the "Imaging" team at STMicroelectronics in Catania. He joined the Department of Mathematics and Computer Science at the University of Catania as assistant professor in 2004 and became associate professor in the same department in 2011. His research interests include image enhancement and processing, image coding, camera imaging technology and multimedia forensics. He has edited 4 books and co-authored more than 150 papers in international journals, conference proceedings and book chapters. He is a co-inventor of about 15 international patents, reviewer for several international journals, and he has been regularly a member of numerous international conference committees.

Image Enhancement, Deblurring and Super-Resolution

SC468

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course discusses some of the advanced algorithms in the field of digital image processing. In particular, it familiarizes the audience with the understanding, design, and implementation of advanced algorithms used in deblurring, contrast enhancement, sharpening, noise reduction, and super-resolution in still images and video. Some of the applications include medical imaging, entertainment imaging, consumer and professional digital still cameras/camcorders, forensic imaging, and surveillance. Many image examples complement the technical descriptions.

LEARNING OUTCOMES

This course will enable you to:
- explain the various nonadaptive and adaptive techniques used in image contrast enhancement. Examples include PhotoShop commands such as Brightness/Contrast, Auto Levels, Equalize and Shadow/Highlights, or Pizer's technique and Moroney's approach
- explain the fundamental techniques used in image Dynamic Range Compression (DRC).Illustrate using the fast bilateral filtering by Dorsey and Durand as an example.
- explain the various techniques used in image noise removal, such as bilateral filtering, sigma filtering and K-Nearest Neighbor
- explain the various techniques used in image sharpening such as nonlinear unsharp masking, etc.
- explain the basic techniques used in image deblurring (restoration) such as inverse filtering and Wiener filtering
- explain the fundamental ideas behind achieving image super-resolution from multiple lower resolution images of the same scene
- explain how motion information can be utilized in image sequences to improve the performance of various enhancement techniques such as noise removal, sharpening, and super-resolution

INTENDED AUDIENCE

Scientists, engineers, and managers who need to understand and/or apply the techniques employed in digital image processing in various products in a diverse set of applications such as medical imaging, professional and consumer imaging, forensic imaging, etc. Prior knowledge of digital filtering (convolution) is necessary for understanding the (Wiener filtering and inverse filtering) concepts used in deblurring (about 20% of the course content).

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Digital Camera and Scanner Performance Evaluation: Standards and Measurement

SC807

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 12:00 am to 12:00 am

This is an updated course on imaging performance measurement methods for digital image capture devices and systems. We introduce several ISO measurement protocols for camera resolution, tone-transfer, noise, etc. We focus on the underlying sources of variability in system performance, measurement error, and how to manage this variability in working environments. The propagation of measurement variability will be described for several emerging standard methods for; image texture, distortion, color shading, flare and chromatic aberration. Using actual measurements we demonstrate how standards can be adapted to evaluate capture devices ranging from cell phone cameras to scientific detectors. We will also discuss the required elements of software tools, and show how to use Matlab software to develop and perform system evaluation.

LEARNING OUTCOMES

This course will enable you to:
- appreciate the difference between imaging performance and image quality
- interpret and apply the different flavors of each ISO performance method
- identify sources of system variability, and understand resulting measurement error
- distill information-rich ISO metrics into single measures for quality assurance
- adapt standard methods for use in factory testing
- select software elements (with Matlab examples) for performance evaluation programs
- be aware of upcoming standard measurement protocols

INTENDED AUDIENCE

Although technical in content, this course is intended for a wide audience: image scientists, quality engineers, and others evaluating digital camera and scanner performance. No background in imaging performance (MTF, etc.) evaluation will be assumed, although the course will provide previous attendees with an update and further insight for implementation. Detailed knowledge of Matlab is not needed, but exposure to similar software environments will be helpful.

INSTRUCTOR

Peter Burns is a consultant working in imaging system evaluation, modeling, and image processing. Previously he worked for Carestream Health, Xerox and Eastman Kodak. A frequent speaker at technical conferences, he has contributed to several imaging standards. He has taught several imaging courses: at Kodak, SPIE, and IS&T technical conferences, and at the Center for Imaging Science, RIT.

Donald Williams is the founder of Image Science Associates, and formerly with Kodak Research Laboratories. His work focuses on quantitative signal and noise performance metrics for digital capture imaging devices, and imaging fidelity issues. He co-leads the TC42 standardization efforts on digital print and film scanner resolution (ISO 16067-1, ISO 16067-2) scanner dynamic range (ISO 21550) and is the editor for the second edition to digital camera resolution (ISO 12233).

Joint Design of Optics and Image Processing for Imaging Systems

SC965

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

For centuries, optical imaging system design centered on exploiting the laws of the physics of light and materials (glass, plastic, reflective metal, ...) to form high-quality (sharp, high-contrast, undistorted, ...) images that "looked good." In the past several decades, the optical images produced by such systems have been ever more commonly sensed by digital detectors and the image imperfections corrected in software. The new era of electro-optical imaging offers a more fundamental revision to this paradigm, however: now the optics and image processing can be designed jointly to optimize an end-to-end digital merit function without regard to the traditional quality of the intermediate optical image. Many principles and guidelines from the optics-only era are counterproductive in the new era of electro-optical imaging and must be replaced by principles grounded on both the physics of photons and the information of bits.

This short course will describe the theoretical and algorithmic foundations of new methods of jointly designing the optics and image processing of electro-optical imaging systems. The course will focus on the new concepts and approaches rather than commercial tools.

LEARNING OUTCOMES

This course will enable you to:

- describe the basics of information theory
- characterize electro-optical systems using linear systems theory
- compute a predicted mean-squared error merit function
- characterize the spatial statistics of sources
- implement a Wiener filter
- implement spatial convolution and digital filtering
- make the distinction between traditional optics-only merit functions and end-to-end digital merit functions
- perform point-spread function engineering
- become aware of the image processing implications of various optical aberrations
- describe wavefront coding and cubic phase plates
- utilize the power of spherical coding
- compare super-resolution algorithms and multi-aperture image synthesizing systems
- simulate the manufacturability of jointly designed imaging systems
- evaluate new methods of electro-optical compensation

INTENDED AUDIENCE

Optical designers familiar with system characterization (f#, depth of field, numerical aperture, point spread functions, modulation transfer functions, ...) and image processing experts familiar with basic operations (convolution, digital sharpening, information theory, ...).

INSTRUCTOR

David Stork is Distinguished Research Scientist and Research Director at Rambus Labs, and a Fellow of the International Association for Pattern Recognition. He holds 40 US patents and has written nearly 200 technical publications including eight books or proceedings volumes such as Seeing the Light, Pattern Classification (2nd ed.) and HAL's Legacy. He has given over 230 technical presentations on computer image analysis of art in 19 countries.

Perception, Cognition, and Next Generation Imaging

SC969

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 8:30 am to 12:30 pm

The world of electronic imaging is an explosion of hardware and software technologies, used in a variety of applications, in a wide range of domains. These technologies provide visual, auditory and tactile information to human observers, whose job it is to make decisions and solve problems. In this course, we will study fundamentals in human perception and cognition, and see how these principles can guide the design of systems that enhance human performance. We will study examples in display technology, image quality, visualization, image search, visual monitoring and haptics, and students will be encouraged to bring forward ongoing problems of interest to them.

LEARNING OUTCOMES

This course will enable you to:

- describe basic principles of spatial, temporal, and color processing by the human visual system, and know where to go for deeper insight
- explore basic cognitive processes, including visual attention and semantics
- develop skills in applying knowledge about human perception and cognition to engineering applications

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who are involved in the design, testing or evaluation of electronic imaging systems. Business managers responsible for innovation and new product development. Anyone interested in human perception and the evolution of electronic imaging applications.

INSTRUCTOR

Bernice Rogowitz founded and co-chairs the SPIE/IS&T Conference on Human Vision and Electronic Imaging (HVEI) which is a multi-disciplinary forum for research on perceptual and cognitive issues in imaging systems. Dr. Rogowitz received her PhD from Columbia University in visual psychophysics, worked as a researcher and research manager at the IBM T.J. Watson Research Center for over 20 years, and is currently a consultant in vision, visual analysis and sensory interfaces. She has published over 60 technical papers and has over 12 patents on perceptually-based approaches to visualization, display technology, semantic image search, color, social networking, surveillance, haptic interfaces. She is a Fellow of the SPIE and the IS&T.

Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence

SC812

Course Level: Intermediate
CEU 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

We will examine objective criteria for the evaluation of image quality that are based on models of visual perception. Our primary emphasis will be on image fidelity, i.e., how close an image is to a given original or reference image, but we will broaden the scope of image fidelity to include structural equivalence. We will also discuss no-reference and limited-reference metrics. We will examine a variety of applications with special emphasis on image and video compression. We will examine near-threshold perceptual metrics, which explicitly account for human visual system (HVS) sensitivity to noise by estimating thresholds above which the distortion is just-noticeable, and supra-threshold metrics, which attempt to quantify visible distortions encountered in high compression applications or when there are losses due to channel conditions. We will also consider metrics for structural equivalence, whereby the original and the distorted image have visible differences but both look natural and are of equally high visual quality. We will also take a close look at procedures for evaluating the performance of quality metrics, including database design, models for generating realistic distortions for various applications, and subjective procedures for metric development and testing. Throughout the course we will discuss both the state of the art and directions for future research.

Course topics include:
- Applications: Image and video compression, restoration, retrieval, graphics, etc.
- Human visual system review
- Near-threshold and supra-threshold perceptual quality metrics
- Structural similarity metrics
- Perceptual metrics for texture analysis and compression – structural texture similarity metrics
- No-reference and limited-reference metrics
- Models for generating realistic distortions for different applications
- Design of databases and subjective procedures for metric development and testing
- Metric performance comparisons, selection, and general use and abuse
- Embedded metric performance, e.g., for rate-distortion optimized compression or restoration
- Metrics for specific distortions, e.g., blocking and blurring, and for specific attributes, e.g., contrast, roughness, and glossiness
- Multimodal applications

LEARNING OUTCOMES

This course will enable you to:
- gain a basic understanding of the properties of the human visual system and how current applications (image and video compression, restoration, retrieval, etc.) that attempt to exploit these properties
- gain an operational understanding of existing perceptually-based and structural similarity metrics, the types of images/artifacts on which they work, and their failure modes
- review current distortion models for different applications, and how they can be used to modify or develop new metrics for specific contexts
- differentiate between sub-threshold and supra-threshold artifacts, the HVS responses to these two paradigms, and the differences in measuring that response
- establish criteria by which to select and interpret a particular metric for a particular application.
- evaluate the capabilities and limitations of full-reference, limited-reference, and no-reference metrics, and why each might be used in a particular application

INTENDED AUDIENCE

Image and video compression specialists who wish to gain an understanding of how performance can be quantified. Engineers and Scientists who wish to learn about objective image and video quality evaluation.

Managers who wish to gain a solid overview of image and video quality evaluation. Students who wish to pursue a career in digital image processing. Intellectual Property and Patent Attorneys who wish to gain a more fundamental understanding of quality metrics and the underlying technologies. Government laboratory personnel who work in imaging.

Prerequisites: a basic understanding of image compression algorithms, and a background in digital signal processing and basic statistics: frequency-based representations, filtering, distributions.

INSTRUCTORS

Thrasyvoulos N. Pappas received the S.B., S.M., and Ph.D. degrees in electrical engineering and computer science from MIT in 1979, 1982, and 1987, respectively. From 1987 until 1999, he was a Member of the Technical Staff at Bell Laboratories, Murray Hill, NJ. He is currently a professor in the Department of Electrical and Computer Engineering at Northwestern University, which he joined in 1999. His research interests are in image and video quality and compression, image and video analysis, content-based retrieval, perceptual models for multimedia processing, model-based halftoning, and tactile and multimodal interfaces. Dr. Pappas has served as co-chair of the 2005 SPIE/IS&T Electronic Imaging Symposium, and since 1997 he has been co-chair of the SPIE/IS&T Conference on Human Vision and Electronic Imaging. He has also served as editor-in-chief for the IEEE Transactions on Image Processing from 2010 to 2012. Dr. Pappas is a Fellow of IEEE and SPIE.

Sheila S. Hemami received the B.S.E.E. degree from the University of Michigan in 1990, and the M.S.E.E. and Ph.D. degrees from Stanford University in 1992 and 1994, respectively. She was with Hewlett-Packard Laboratories in Palo Alto, California in 1994 and was with the School of Electrical Engineering at Cornell University from 1995-2013. She is currently Professor and Chair of the Department of Electrical & Computer Engineering at Northeastern University in Boston, MA. Dr. Hemami's research interests broadly concern communication of visual information from the perspectives of both signal processing and psychophysics. She has held various technical leadership positions in the IEEE, served as editor-in-chief for the IEEE Transactions on Multimedia from 2008 to 2010, and was elected a Fellow of the IEEE in 2009 for her for contributions to robust and perceptual image and video communications.

Media Processing and Communication

Image and Video Forensics: Recent Trends and Challenges New

SC1130

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

The widespread adoption of digital content over traditional physical media such as film has given rise to a number of new information security challenges. Digital content can be altered, falsified, and redistributed with relative ease by adversaries. This has important consequences for governmental, commercial, and social institutions that rely on digital information. The pipeline which leads to ascertain whether an image has undergone to some kind of forgery leads through the following steps: determine whether the image is "original" and, in the case where the previous step has given negative results, try to understand the past history of the image.

Although the field of information forensics is still young, many forensic techniques have been developed to detect forgeries, identify the origin, and trace the processing history of digital multimedia content. This course provides an overview of information forensics research and related applications. Also we examine the device-specific fingerprints left by digital image and video cameras along with forensic techniques used to identify the source of digital multimedia files. Finally, an overview of the recent trends and evolution, considering the updated literature in the field, will be provided.

LEARNING OUTCOMES

This course will enable you to:
- describe forensics systems for commercial and scientific imaging applications
- explain how imaging data are processed and how proceed to detect forgeries
- list specifications and requirements to select a specific algorithm for your imaging application in the forensics context
- recognize performance differences among imaging pipeline technologies
- become familiar with current and future imaging technologies and applications

INTENDED AUDIENCE

This course is intended for those with a general computing background, and is interested in the topic of image and video processing. Students, researchers, and practicing engineers should all be able to benefit from the general overview of the field and the introduction of the most recent advance of the technology.

INSTRUCTOR

Sebastiano Battiato received his degree in computer science from University of Catania and his Ph.D. in computer science and applied mathematics from University of Naples in 1999. From 1999 to 2003 he was the leader of the “Imaging” team at STMicroelectronics in Catania. He joined the Department of Mathematics and Computer Science at the University of Catania as assistant professor in 2004 and became associate professor in the same department in 2011. His research interests include image enhancement and processing, image coding, camera imaging technology and multimedia forensics. He has edited 4 books and co-authored more than 150 papers in international journals, conference proceedings and book chapters. He is a co-inventor of about 15 international patents, reviewer for several international journals, and he has been regularly a member of numerous international conference committees.

Image Quality and Evaluation of Cameras In Mobile Devices

SC1058

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

Digital and mobile imaging camera system performance is determined by a combination of sensor characteristics, lens characteristics, and image-processing algorithms. As pixel size decreases, sensitivity decreases and noise increases, requiring a more sophisticated noise-reduction algorithm to obtain good image quality. Furthermore, small pixels require high-resolution optics with low chromatic aberration and very small blur circles. Ultimately, there is a tradeoff between noise, resolution, sharpness, and the quality of an image.

This short course provides an overview of “light in to byte out” issues associated with digital and mobile imaging cameras. The course covers, optics, sensors, image processing, and sources of noise in these cameras, algorithms to reduce it, and different methods of characterization. Although noise is typically measured as a standard deviation in a patch with uniform color, it does not always accurately represent human perception. Based on the “visual noise” algorithm described in ISO 15739, an improved approach for measuring noise as an image quality aspect will be demonstrated. The course shows a way to optimize image quality by balancing the tradeoff between noise and resolution. All methods discussed will use images as examples.

LEARNING OUTCOMES

This course will enable you to:
- describe pixel technology and color filtering
- describe illumination, photons, sensor and camera radiometry
- select a sensor for a given application
- describe and measure sensor performance metrics
- describe and understand the optics of digital and mobile imaging systems
- examine the difficulties in minimizing sensor sizes
- assess the need for per unit calibrations in digital still cameras and mobile imaging devices
- learn about noise, its sources, and methods of managing it
- make noise and resolution measurements based on international standards

o EMVA 1288
o ISO 14524 (OECF)/ISO 15739 (Noise)
o Visual Noise
o ISO 12233 (Resolution)

- assess influence of the image pipeline on noise
- utilize today’s algorithms to reduce noise in images
- measure noise based on human perception
- optimize image quality by balancing noise reduction and resolution
- compare hardware tradeoffs, noise reduction algorithms, and settings for optimal image quality

INTENDED AUDIENCE

All people evaluating the image quality of digital cameras, mobile cameras, and scanners would benefit from participation. Technical staff of manufacturers, managers of digital imaging projects, as well as journalists and students studying image technology are among the intended audience.

INSTRUCTOR

Dietmar Wüller studied photographic sciences at the University of Cologne. He owns a test lab for digital photography and has been testing digital cameras and scanners for German magazines and manufacturers since 1997. He is the editor of the ISO scanner standards (ISO 21550 and ISO 16067) and the vice chairman of the photography section in the German DIN. He also chairs the digital photography working group in the European Color Initiative (ECI).

Kevin Matherson is a senior image scientist in the research and development lab of Hewlett-Packard’s Imaging and Printing Group and has worked in the field of digital imaging since 1985. He joined Hewlett Packard in 1996 and has participated in the development of all HP digital and mobile imaging cameras produced since that time. His primary research interests focus on noise characterization, optical system analysis, and the optimization of camera image quality. Dr. Matherson currently leads the camera characterization laboratory in Fort Collins and holds Masters and PhD degrees in Optical Sciences from the University of Arizona.

High Dynamic Range Imaging: Sensors and Architectures

SC967

Course Level: Intermediate
CEU: 0.65 $570 Members | $680 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course provides attendees with an intermediate knowledge of high dynamic range image sensors and techniques for industrial and non-industrial applications. The course describes various sensor and pixel architectures to achieve high dynamic range imaging as well as software approaches to make high dynamic range images out of lower dynamic range sensors or image sets. The course follows a mathematic approach to define the amount of information that can be extracted from the image for each of the methods described. Some methods for automatic control of exposure and dynamic range of image sensors and other issues like color and glare will be introduced.

LEARNING OUTCOMES

This course will enable you to:
- describe various approaches to achieve high dynamic range imaging
- predict the behavior of a given sensor or architecture on a scene
- specify the sensor or system requirements for a high dynamic range application
- classify a high dynamic range application into one of several standard types

INTENDED AUDIENCE

This material is intended for anyone who needs to learn more about quantitative side of high dynamic range imaging. Optical engineers, electronic engineers and scientists will find useful information for their next high dynamic range application.

INSTRUCTOR

Arnaud Darmont is owner and CEO of Aphesa, a company founded in 2008 and specialized in image sensor consulting, the EMVA1288 standard and camera benchmarking. He holds a degree in Electronic Engineering from the University of Liège (Belgium). Prior to founding Aphesa, he worked for over 7 years in the field of CMOS image sensors and high dynamic range imaging.

COURSE PRICE INCLUDES the text *High Dynamic Range Imaging: Sensors and Architectures* (SPIE Press, 2012) by Arnaud Darmont.

HDR Imaging in Cameras, Displays and Human Vision

SC1097

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 1:30 pm to 5:30 pm

High-dynamic range (HDR) imaging is a significant improvement over conventional imaging. After a description of the dynamic range problem in image acquisition, this course focuses on standard methods of creating and manipulating HDR images, replacing myths with measurements of scenes, camera images, and visual appearances. In particular, the course presents measurements about the limits of accurate camera acquisition and the usable range of light for displays of our vision system. Regarding our vision system, the course discusses the role of accurate vs. non-accurate luminance recording for the final appearance of a scene, presenting the quality and the characteristics of visual information actually available on the retina. It ends with a discussion of the principles of tone rendering and the role of spatial comparison.

LEARNING OUTCOMES

This course will enable you to:
- explore the history of HDR imaging
- describe dynamic range and quantization: the ‘salame’ metaphor
- compare single and multiple-exposure for scene capture
- measure optical limits in acquisition and visualization
- discover relationship between HDR range and scene dependency ; the effect of glare
- explore the limits of our vision system on HDR
- calculate retinal luminance
- put in relationship the HDR images and the visual appearance
- identify tone-rendering problems and spatial methods
- verify the changes in color spaces due to dynamic range expansion

INTENDED AUDIENCE

Color scientists, software and hardware engineers, photographers, cinematographers, production specialists, and students interested in using HDR images in real applications.

INSTRUCTOR

Alessandro Rizzi has been researching in the field of digital imaging and vision since 1990. His main research topic is the use of color information in digital images with particular attention to color vision mechanisms. He is Associate professor at the Dept. of Computer Science at University of Milano, teaching Fundamentals of Digital Imaging, Multimedia Video, and Human-Computer Interaction. He is one of the founders of the Italian Color Group and member of several program committees of conferences related to color and digital imaging.

John McCann received a degree in Biology from Harvard College in 1964. He worked in, and managed, the Vision Research Laboratory at Polaroid from 1961 to 1996. He has studied human color vision, digital image processing, large format instant photography, and the reproduction of fine art. His publications and patents have studied Retinex theory, color constancy, color from rod/cone interactions at low light levels, appearance with scattered light, and HDR imaging. He is a Fellow of the IS&T and the Optical Society of America (OSA). He is a past President of IS&T and the Artists Foundation, Boston. He is the IS&T/OSA 2002 Edwin H. Land Medalist, and IS&T 2005 Honorary Member.

Understanding and Interpreting Images

SC1015

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

A key problem in computer vision is image and video understanding, which can be defined as the task of recognizing objects in the scene and their corresponding relationships and semantics, in addition to identifying the scene category itself. Image understanding technology has numerous applications among which are smart capture devices, intelligent image processing, semantic image search and retrieval, image/video utilization (e.g., ratings on quality, usefulness, etc.), security and surveillance, intelligent asset selection and targeted advertising.

This tutorial provides an introduction to the theory and practice of image understanding algorithms by studying the various technologies that serve the three major components of a generalized IU system, namely, feature extraction and selection, machine learning tools used for classification, and datasets and ground truth used for training the classifiers. Following this general development, a few application examples are studied in more detail to gain insight into how these technologies are employed in a practical IU system. Applications include face detection, sky detection, image orientation detection, main subject detection, and content based image retrieval (CBIR). Furthermore, realtime demos including face detection and recognition, CBIR, and automatic zooming and cropping of images based on main-subject detection are provided.

LEARNING OUTCOMES

This course will enable you to:
- learn the various applications of IU and the scope of its consumer and commercial uses
- explain the various technologies used in image feature extraction such as global, block-based or region-based color histograms and moments, the "tiny" image, GIST, histogram of oriented gradients (HOG), scale-invariant feature transform (SIFT), speeded-up robust features (SURF), bag of words, etc.
- explain the various machine learning paradigms and the fundamental techniques used for classification such as Bayesian classifiers, linear support vector machines (SVM) and nonlinear kernels, boosting techniques (e.g., AdaBoost), k-nearest neighbors, .etc.
- explain the concepts used for classifier evaluation such as false positives and negatives, true positives and negatives, confusion matrix, precision and recall, and receiver operating characteristics (ROC)
- explain the basic methods employed in generating and labeling datasets and ground truth and examples of various datasets such as CMU PIE dataset, Label Me dataset, Caltech 256 dataset, TrecVid, FERET dataset, and Pascal Visual Object Recognition
- explain the fundamental ideas employed in the IU algorithms used for face detection, material detection, image orientation, and a few others
- learn the importance of using context in IU tasks

INTENDED AUDIENCE

Scientists, engineers, and managers who need to familiarize themselves with IU technology and understand its performance limitations in a diverse set of products and applications. No specific prior knowledge is required except familiarity with general mathematical concepts such as the dot product of two vectors and basic image processing concepts such as histograms, filtering, gradients, etc.

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Image Enhancement, Deblurring and Super-Resolution

SC468

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course discusses some of the advanced algorithms in the field of digital image processing. In particular, it familiarizes the audience with the understanding, design, and implementation of advanced algorithms used in deblurring, contrast enhancement, sharpening, noise reduction, and super-resolution in still images and video. Some of the applications include medical imaging, entertainment imaging, consumer and professional digital still cameras/camcorders, forensic imaging, and surveillance. Many image examples complement the technical descriptions.

LEARNING OUTCOMES

This course will enable you to:
- explain the various nonadaptive and adaptive techniques used in image contrast enhancement. Examples include PhotoShop commands such as Brightness/Contrast, Auto Levels, Equalize and Shadow/Highlights, or Pizer's technique and Moroney's approach
- explain the fundamental techniques used in image Dynamic Range Compression (DRC).Illustrate using the fast bilateral filtering by Dorsey and Durand as an example.
- explain the various techniques used in image noise removal, such as bilateral filtering, sigma filtering and K-Nearest Neighbor
- explain the various techniques used in image sharpening such as nonlinear unsharp masking, etc.
- explain the basic techniques used in image deblurring (restoration) such as inverse filtering and Wiener filtering
- explain the fundamental ideas behind achieving image super-resolution from multiple lower resolution images of the same scene
- explain how motion information can be utilized in image sequences to improve the performance of various enhancement techniques such as noise removal, sharpening, and super-resolution

INTENDED AUDIENCE

Scientists, engineers, and managers who need to understand and/or apply the techniques employed in digital image processing in various products in a diverse set of applications such as medical imaging, professional and consumer imaging, forensic imaging, etc. Prior knowledge of digital filtering (convolution) is necessary for understanding the (Wiener filtering and inverse filtering) concepts used in deblurring (about 20% of the course content).

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Objective and Subjective Image Quality Camera Benchmarking

SC1049

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Monday 8:30 am to 5:30 pm

This course explains methodologies to assess image quality of photographic still image or motion picture capture device. The course will go through all the major image quality attributes, the flaws that degrade those attributes, their causes and consequences on subjective perception. One important goal of the course is to provide a clear understanding of all attributes, how they can be visually assessed in real life picture from many examples images, as well as the physical phenomenon that can degrade image quality.

The course thoroughly explains subjective evaluation methodologies, then objective measurement methodologies relying on existing standards from ISO, I3A/CPIQ and beyond, with many practical examples; how objective measurement metrics are related to subjective perception, methods to correlate objective metrics with subjective perception; and how one can build a benchmarking protocol with objective measurements from a capture use case perspective (such as consumer, landscape, sports,...) to an output use case perspective (such as handheld display, HDTV, photobook,...).

LEARNING OUTCOMES

This course will enable you to:
- identify defects that degrade image quality in natural images and what component of the camera should/could be improved for better image quality
- build up an image quality lab and master measurement protocols
- select best key components to build a camera (best sensor for a given price, best ISP on the market,...)
- judge the overall image quality of a camera
- evaluate the impact various output use cases have on overall image quality
- compare the image quality of a set of cameras
- define subjective test plans and protocols
- setup benchmarking protocols depending on use cases

INTENDED AUDIENCE

Image scientists, engineers, or managers who wish to learn more about image quality and how to evaluate camera performance for various output use cases. A good understanding of imaging and how a camera works is assumed. Anyone involved in photographic or motion picture imaging will benefit from this course.

INSTRUCTOR

Jonathan Phillips is a senior image quality scientist in the camera group at NVIDIA. His involvement in the imaging industry spans over 20 years, including two decades at Eastman Kodak Company. His focus has been on photographic quality, with an emphasis on psychophysical testing for both product development and fundamental perceptual studies. His broad experience has included image quality work with capture, display, and print technologies. He received the 2011 I3A Achievement Award for his work on camera phone image quality and headed up the 2012 revision of ISO 20462 - Psychophysical experimental methods for estimating image quality - Part 3: Quality ruler method. He completed his graduate work in color science in the Center for Imaging Science at Rochester Institute of Technology and his chemistry undergraduate at Wheaton College (IL).

Computer Vision and Imaging in Transportation Applications New

SC1131

Course Level: Intermediate
CEU: 0.35 $300 Members | $355 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course introduces the attendee to applications in the transportation industry that employ imaging, computer vision, and video processing technologies. The class begins with a survey of key topics in transportation falling under three broad categories: safety, efficiency, and security. Topics include driver assistance, traffic surveillance and law enforcement, video-based tolling, monitoring vehicles of interest, and incident detection. The second part of the course provides a more in-depth treatment of state-of-art approaches to selected problems such as vehicle license plate recognition, vehicle occupancy estimation, speed enforcement, driver attention monitoring, and sensing of road and environmental conditions. Where necessary, background material on relevant computer vision concepts will be covered, such as image segmentation, object detection, classification, recognition, and tracking, and 3D camera geometry.

LEARNING OUTCOMES

This course will enable you to:
- explain the broad impact of imaging and computer vision towards enhancing safety, efficiency, and law enforcement in transportation applications
- acquire a solid understanding of the basic concepts in computer vision required for transportation imaging, including object detection, classification, recognition, tracking, and camera calibration from transportation-related images and videos
- be familiar with state-of-art approaches and current challenges in applications, such as vehicle license plate recognition, vehicle occupancy estimation, driver assistance, traffic law enforcement, and sensing of road conditions

INTENDED AUDIENCE

Scientists, engineers, technicians, and managers who wish to learn more about how to use imaging, video, and computer vision concepts to address important problems in the transportation domain. Attendees must be familiar with basic digital image and video processing and representations. Familiarity with basic concepts in computer vision is a plus – although we will quickly review the needed background.

INSTRUCTOR

Raja Bala received a Ph.D. in Electrical Engineering from Purdue University and is currently a Principal Scientist and Project Leader in the Xerox Research Center Webster. His research interests include mobile imaging, computer vision, video processing, and color imaging. Dr. Bala has taught many successful conference courses in color and digital imaging and has served as adjunct faculty member in the School of Electrical Engineering at the Rochester Institute of Technology. He holds over 100 U.S. patents, has authored over 90 publications in the field of digital imaging, and has served as Associate Editor of the Journal of Imaging Science and Technology. He is a Fellow of the Society for Imaging Science and Technology.

Robert Loce received an MS in Optical Engineering from the University of Rochester and a PhD in Imaging Science from Rochester Institute of Technology. He is currently a Research Fellow and Technical Manager in the Xerox Research Center Webster. His current research activities involve leading an organization and projects into new video processing and computer vision technologies that are relevant to transportation and healthcare. He has over 90 publications and 175 patents in the areas of digital image processing, image enhancement, imaging systems, and optics. He is a Fellow of SPIE and a Senior Member of IEEE. He is currently an associate editor for Journal of Electronic Imaging, and has been and associate editor for Real-Time Imaging, and IEEE Transactions on Image Processing.

Perception, Cognition, and Next Generation Imaging

SC969

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 8:30 am to 12:30 pm

The world of electronic imaging is an explosion of hardware and software technologies, used in a variety of applications, in a wide range of domains. These technologies provide visual, auditory and tactile information to human observers, whose job it is to make decisions and solve problems. In this course, we will study fundamentals in human perception and cognition, and see how these principles can guide the design of systems that enhance human performance. We will study examples in display technology, image quality, visualization, image search, visual monitoring and haptics, and students will be encouraged to bring forward ongoing problems of interest to them.

LEARNING OUTCOMES

This course will enable you to:
- describe basic principles of spatial, temporal, and color processing by the human visual system, and know where to go for deeper insight
- explore basic cognitive processes, including visual attention and semantics
- develop skills in applying knowledge about human perception and cognition to engineering applications

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who are involved in the design, testing or evaluation of electronic imaging systems. Business managers responsible for innovation and new product development. Anyone interested in human perception and the evolution of electronic imaging applications.

INSTRUCTOR

Bernice Rogowitz founded and co-chairs the SPIE/IS&T Conference on Human Vision and Electronic Imaging (HVEI) which is a multi-disciplinary forum for research on perceptual and cognitive issues in imaging systems. Dr. Rogowitz received her PhD from Columbia University in visual psychophysics, worked as a researcher and research manager at the IBM T.J. Watson Research Center for over 20 years, and is currently a consultant in vision, visual analysis and sensory interfaces. She has published over 60 technical papers and has over 12 patents on perceptually-based approaches to visualization, display technology, semantic image search, color, social networking, surveillance, haptic interfaces. She is a Fellow of the SPIE and the IS&T.

Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence

SC812

Course Level: Intermediate
CEU 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

We will examine objective criteria for the evaluation of image quality that are based on models of visual perception. Our primary emphasis will be on image fidelity, i.e., how close an image is to a given original or reference image, but we will broaden the scope of image fidelity to include structural equivalence. We will also discuss no-reference and limited-reference metrics. We will examine a variety of applications with special emphasis on image and video compression. We will examine near-threshold perceptual metrics, which explicitly account for human visual system (HVS) sensitivity to noise by estimating thresholds above which the distortion is just-noticeable, and supra-threshold metrics, which attempt to quantify visible distortions encountered in high compression applications or when there are losses due to channel conditions. We will also consider metrics for structural equivalence, whereby the original and the distorted image have visible differences but both look natural and are of equally high visual quality. We will also take a close look at procedures for evaluating the performance of quality metrics, including database design, models for generating realistic distortions for various applications, and subjective procedures for metric development and testing. Throughout the course we will discuss both the state of the art and directions for future research.

Course topics include:
- Applications: Image and video compression, restoration, retrieval, graphics, etc.
- Human visual system review
- Near-threshold and supra-threshold perceptual quality metrics
- Structural similarity metrics
- Perceptual metrics for texture analysis and compression – structural texture similarity metrics
- No-reference and limited-reference metrics
- Models for generating realistic distortions for different applications
- Design of databases and subjective procedures for metric development and testing
- Metric performance comparisons, selection, and general use and abuse
- Embedded metric performance, e.g., for rate-distortion optimized compression or restoration
- Metrics for specific distortions, e.g., blocking and blurring, and for specific attributes, e.g., contrast, roughness, and glossiness
- Multimodal applications

LEARNING OUTCOMES

This course will enable you to:
- gain a basic understanding of the properties of the human visual system and how current applications (image and video compression, restoration, retrieval, etc.) that attempt to exploit these properties
- gain an operational understanding of existing perceptually-based and structural similarity metrics, the types of images/artifacts on which they work, and their failure modes
- review current distortion models for different applications, and how they can be used to modify or develop new metrics for specific contexts
- differentiate between sub-threshold and supra-threshold artifacts, the HVS responses to these two paradigms, and the differences in measuring that response
- establish criteria by which to select and interpret a particular metric for a particular application.
- evaluate the capabilities and limitations of full-reference, limited-reference, and no-reference metrics, and why each might be used in a particular application

INTENDED AUDIENCE

Image and video compression specialists who wish to gain an understanding of how performance can be quantified. Engineers and Scientists who wish to learn about objective image and video quality evaluation.

Managers who wish to gain a solid overview of image and video quality evaluation. Students who wish to pursue a career in digital image processing. Intellectual Property and Patent Attorneys who wish to gain a more fundamental understanding of quality metrics and the underlying technologies. Government laboratory personnel who work in imaging.

Prerequisites: a basic understanding of image compression algorithms, and a background in digital signal processing and basic statistics: frequency-based representations, filtering, distributions.

INSTRUCTORS

Thrasyvoulos N. Pappas received the S.B., S.M., and Ph.D. degrees in electrical engineering and computer science from MIT in 1979, 1982, and 1987, respectively. From 1987 until 1999, he was a Member of the Technical Staff at Bell Laboratories, Murray Hill, NJ. He is currently a professor in the Department of Electrical and Computer Engineering at Northwestern University, which he joined in 1999. His research interests are in image and video quality and compression, image and video analysis, content-based retrieval, perceptual models for multimedia processing, model-based halftoning, and tactile and multimodal interfaces. Dr. Pappas has served as co-chair of the 2005 SPIE/IS&T Electronic Imaging Symposium, and since 1997 he has been co-chair of the SPIE/IS&T Conference on Human Vision and Electronic Imaging. He has also served as editor-in-chief for the IEEE Transactions on Image Processing from 2010 to 2012. Dr. Pappas is a Fellow of IEEE and SPIE.

Sheila S. Hemami received the B.S.E.E. degree from the University of Michigan in 1990, and the M.S.E.E. and Ph.D. degrees from Stanford University in 1992 and 1994, respectively. She was with Hewlett-Packard Laboratories in Palo Alto, California in 1994 and was with the School of Electrical Engineering at Cornell University from 1995-2013. She is currently Professor and Chair of the Department of Electrical & Computer Engineering at Northeastern University in Boston, MA. Dr. Hemami's research interests broadly concern communication of visual information from the perspectives of both signal processing and psychophysics. She has held various technical leadership positions in the IEEE, served as editor-in-chief for the IEEE Transactions on Multimedia from 2008 to 2010, and was elected a Fellow of the IEEE in 2009 for her for contributions to robust and perceptual image and video communications.

Mobile Imaging

Image Quality and Evaluation of Cameras In Mobile Devices

SC1058

Course Level: Intermediate
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

Digital and mobile imaging camera system performance is determined by a combination of sensor characteristics, lens characteristics, and image-processing algorithms. As pixel size decreases, sensitivity decreases and noise increases, requiring a more sophisticated noise-reduction algorithm to obtain good image quality. Furthermore, small pixels require high-resolution optics with low chromatic aberration and very small blur circles. Ultimately, there is a tradeoff between noise, resolution, sharpness, and the quality of an image.

This short course provides an overview of "light in to byte out" issues associated with digital and mobile imaging cameras. The course covers, optics, sensors, image processing, and sources of noise in these cameras, algorithms to reduce it, and different methods of characterization. Although noise is typically measured as a standard deviation in a patch with uniform color, it does not always accurately represent human perception. Based on the "visual noise" algorithm described in ISO 15739, an improved approach for measuring noise as an image quality aspect will be demonstrated. The course shows a way to optimize image quality by balancing the tradeoff between noise and resolution. All methods discussed will use images as examples.

LEARNING OUTCOMES

This course will enable you to:

- describe pixel technology and color filtering
- describe illumination, photons, sensor and camera radiometry
- select a sensor for a given application
- describe and measure sensor performance metrics
- describe and understand the optics of digital and mobile imaging systems
- examine the difficulties in minimizing sensor sizes
- assess the need for per unit calibrations in digital still cameras and mobile imaging devices
- learn about noise, its sources, and methods of managing it
- make noise and resolution measurements based on international standards

o EMVA 1288
o ISO 14524 (OECF)/ISO 15739 (Noise)
o Visual Noise
o ISO 12233 (Resolution)

- assess influence of the image pipeline on noise
- utilize today's algorithms to reduce noise in images
- measure noise based on human perception
- optimize image quality by balancing noise reduction and resolution
- compare hardware tradeoffs, noise reduction algorithms, and settings for optimal image quality

INTENDED AUDIENCE

All people evaluating the image quality of digital cameras, mobile cameras, and scanners would benefit from participation. Technical staff of manufacturers, managers of digital imaging projects, as well as journalists and students studying image technology are among the intended audience.

INSTRUCTOR

Dietmar Wüller studied photographic sciences at the University of Cologne. He owns a test lab for digital photography and has been testing digital cameras and scanners for German magazines and manufacturers since 1997. He is the editor of the ISO scanner standards (ISO 21550 and ISO 16067) and the vice chairman of the photography section in the German DIN. He also chairs the digital photography working group in the European Color Initiative (ECI).

Kevin Matherson is a senior image scientist in the research and development lab of Hewlett-Packard's Imaging and Printing Group and has worked in the field of digital imaging since 1985. He joined Hewlett Packard in 1996 and has participated in the development of all HP digital and mobile imaging cameras produced since that time. His primary research interests focus on noise characterization, optical system analysis, and the optimization of camera image quality. Dr. Matherson currently leads the camera characterization laboratory in Fort Collins and holds Masters and PhD degrees in Optical Sciences from the University of Arizona.

High Dynamic Range Imaging: Sensors and Architectures

SC967

Course Level: Intermediate
CEU: 0.65 $570 Members | $680 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course provides attendees with an intermediate knowledge of high dynamic range image sensors and techniques for industrial and non-industrial applications. The course describes various sensor and pixel architectures to achieve high dynamic range imaging as well as software approaches to make high dynamic range images out of lower dynamic range sensors or image sets. The course follows a mathematic approach to define the amount of information that can be extracted from the image for each of the methods described. Some methods for automatic control of exposure and dynamic range of image sensors and other issues like color and glare will be introduced.

LEARNING OUTCOMES

This course will enable you to:

- describe various approaches to achieve high dynamic range imaging
- predict the behavior of a given sensor or architecture on a scene
- specify the sensor or system requirements for a high dynamic range application
- classify a high dynamic range application into one of several standard types

INTENDED AUDIENCE

This material is intended for anyone who needs to learn more about quantitative side of high dynamic range imaging. Optical engineers, electronic engineers and scientists will find useful information for their next high dynamic range application.

INSTRUCTOR

Arnaud Darmont is owner and CEO of Aphesa, a company founded in 2008 and specialized in image sensor consulting, the EMVA1288 standard and camera benchmarking. He holds a degree in Electronic Engineering from the University of Liège (Belgium). Prior to founding Aphesa, he worked for over 7 years in the field of CMOS image sensors and high dynamic range imaging.

COURSE PRICE INCLUDES the text *High Dynamic Range Imaging: Sensors and Architectures* (SPIE Press, 2012) by Arnaud Darmont.

HDR Imaging in Cameras, Displays and Human Vision

SC1097

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Monday 1:30 pm to 5:30 pm

High-dynamic range (HDR) imaging is a significant improvement over conventional imaging. After a description of the dynamic range problem in image acquisition, this course focuses on standard methods of creating and manipulating HDR images, replacing myths with measurements of scenes, camera images, and visual appearances. In particular, the course presents measurements about the limits of accurate camera acquisition and the usable range of light for displays of our vision system. Regarding our vision system, the course discusses the role of accurate vs. non-accurate luminance recording for the final appearance of a scene, presenting the quality and the characteristics of visual information actually available on the retina. It ends with a discussion of the principles of tone rendering and the role of spatial comparison.

LEARNING OUTCOMES

This course will enable you to:
- explore the history of HDR imaging
- describe dynamic range and quantization: the 'salame' metaphor
- compare single and multiple-exposure for scene capture
- measure optical limits in acquisition and visualization
- discover relationship between HDR range and scene dependency ; the effect of glare
- explore the limits of our vision system on HDR
- calculate retinal luminance
- put in relationship the HDR images and the visual appearance
- identify tone-rendering problems and spatial methods
- verify the changes in color spaces due to dynamic range expansion

INTENDED AUDIENCE

Color scientists, software and hardware engineers, photographers, cinematographers, production specialists, and students interested in using HDR images in real applications.

INSTRUCTOR

Alessandro Rizzi has been researching in the field of digital imaging and vision since 1990. His main research topic is the use of color information in digital images with particular attention to color vision mechanisms. He is Associate professor at the Dept. of Computer Science at University of Milano, teaching Fundamentals of Digital Imaging, Multimedia Video, and Human-Computer Interaction. He is one of the founders of the Italian Color Group and member of several program committees of conferences related to color and digital imaging.

John McCann received a degree in Biology from Harvard College in 1964. He worked in, and managed, the Vision Research Laboratory at Polaroid from 1961 to 1996. He has studied human color vision, digital image processing, large format instant photography, and the reproduction of fine art. His publications and patents have studied Retinex theory, color constancy, color from rod/cone interactions at low light levels, appearance with scattered light, and HDR imaging. He is a Fellow of the IS&T and the Optical Society of America (OSA). He is a past President of IS&T and the Artists Foundation, Boston. He is the IS&T/OSA 2002 Edwin H. Land Medalist, and IS&T 2005 Honorary Member.

Image Enhancement, Deblurring and Super-Resolution

SC468

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course discusses some of the advanced algorithms in the field of digital image processing. In particular, it familiarizes the audience with the understanding, design, and implementation of advanced algorithms used in deblurring, contrast enhancement, sharpening, noise reduction, and super-resolution in still images and video. Some of the applications include medical imaging, entertainment imaging, consumer and professional digital still cameras/camcorders, forensic imaging, and surveillance. Many image examples complement the technical descriptions.

LEARNING OUTCOMES

This course will enable you to:
- explain the various nonadaptive and adaptive techniques used in image contrast enhancement. Examples include PhotoShop commands such as Brightness/Contrast, Auto Levels, Equalize and Shadow/Highlights, or Pizer's technique and Moroney's approach
- explain the fundamental techniques used in image Dynamic Range Compression (DRC).Illustrate using the fast bilateral filtering by Dorsey and Durand as an example.
- explain the various techniques used in image noise removal, such as bilateral filtering, sigma filtering and K-Nearest Neighbor
- explain the various techniques used in image sharpening such as nonlinear unsharp masking, etc.
- explain the basic techniques used in image deblurring (restoration) such as inverse filtering and Wiener filtering
- explain the fundamental ideas behind achieving image super-resolution from multiple lower resolution images of the same scene
- explain how motion information can be utilized in image sequences to improve the performance of various enhancement techniques such as noise removal, sharpening, and super-resolution

INTENDED AUDIENCE

Scientists, engineers, and managers who need to understand and/or apply the techniques employed in digital image processing in various products in a diverse set of applications such as medical imaging, professional and consumer imaging, forensic imaging, etc. Prior knowledge of digital filtering (convolution) is necessary for understanding the (Wiener filtering and inverse filtering) concepts used in deblurring (about 20% of the course content).

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book "Digital Image Compression Techniques" and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Understanding and Interpreting Images

SC1015

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Tuesday 1:30 pm to 5:30 pm

A key problem in computer vision is image and video understanding, which can be defined as the task of recognizing objects in the scene and their corresponding relationships and semantics, in addition to identifying the scene category itself. Image understanding technology has numerous applications among which are smart capture devices, intelligent image processing, semantic image search and retrieval, image/video utilization (e.g., ratings on quality, usefulness, etc.), security and surveillance, intelligent asset selection and targeted advertising.

This tutorial provides an introduction to the theory and practice of image understanding algorithms by studying the various technologies that serve the three major components of a generalized IU system, namely, feature extraction and selection, machine learning tools used for classification, and datasets and ground truth used for training the classifiers. Following this general development, a few application examples are studied in more detail to gain insight into how these technologies are employed in a practical IU system. Applications include face detection, sky detection, image orientation detection, main subject detection, and content based image retrieval (CBIR). Furthermore, realtime demos including face detection and recognition, CBIR, and automatic zooming and cropping of images based on main-subject detection are provided.

LEARNING OUTCOMES

This course will enable you to:

- learn the various applications of IU and the scope of its consumer and commercial uses
- explain the various technologies used in image feature extraction such as global, block-based or region-based color histograms and moments, the “tiny” image, GIST, histogram of oriented gradients (HOG), scale-invariant feature transform (SIFT), speeded-up robust features (SURF), bag of words, etc.
- explain the various machine learning paradigms and the fundamental techniques used for classification such as Bayesian classifiers, linear support vector machines (SVM) and nonlinear kernels, boosting techniques (e.g., AdaBoost), k-nearest neighbors, .etc.
- explain the concepts used for classifier evaluation such as false positives and negatives, true positives and negatives, confusion matrix, precision and recall, and receiver operating characteristics (ROC)
- explain the basic methods employed in generating and labeling datasets and ground truth and examples of various datasets such as CMU PIE dataset, Label Me dataset, Caltech 256 dataset, TrecVid, FERET dataset, and Pascal Visual Object Recognition
- explain the fundamental ideas employed in the IU algorithms used for face detection, material detection, image orientation, and a few others
- learn the importance of using context in IU tasks

INTENDED AUDIENCE

Scientists, engineers, and managers who need to familiarize themselves with IU technology and understand its performance limitations in a diverse set of products and applications. No specific prior knowledge is required except familiarity with general mathematical concepts such as the dot product of two vectors and basic image processing concepts such as histograms, filtering, gradients, etc.

INSTRUCTOR

Majid Rabbani has 30+ years of experience in digital imaging. He is an Eastman Fellow at Kodak and an adjunct faculty at both RIT and University of Rochester. He is the co-recipient of the 2005 and 1988 Kodak Mees Awards and the co-recipient of two Emmy Engineering Awards for his contributions to digital imaging. He is the co-author of the 1991 book “Digital Image Compression Techniques” and the creator of six video/CDROM courses in the area of digital imaging. In 2012 he received the Electronic Imaging Distinguished Educator Award from SPIE and IS&T for 25 years of educational service to the electronic imaging community. He is a Fellow of SPIE, a Fellow of IEEE, and a Kodak Distinguished Inventor.

Objective and Subjective Image Quality Camera Benchmarking

SC1049

Course Level: Advanced
CEU: 0.65 $525 Members | $635 Non-Members USD
Monday 8:30 am to 5:30 pm

This course explains methodologies to assess image quality of photographic still image or motion picture capture device. The course will go through all the major image quality attributes, the flaws that degrade those attributes, their causes and consequences on subjective perception. One important goal of the course is to provide a clear understanding of all attributes, how they can be visually assessed in real life picture from many examples images, as well as the physical phenomenon that can degrade image quality.

The course thoroughly explains subjective evaluation methodologies, then objective measurement methodologies relying on existing standards from ISO, I3A/CPIQ and beyond, with many practical examples; how objective measurement metrics are related to subjective perception, methods to correlate objective metrics with subjective perception; and how one can build a benchmarking protocol with objective measurements from a capture use case perspective (such as consumer, landscape, sports,...) to an output use case perspective (such as handheld display, HDTV, photobook,...).

LEARNING OUTCOMES

This course will enable you to:

- identify defects that degrade image quality in natural images and what component of the camera should/could be improved for better image quality
- build up an image quality lab and master measurement protocols
- select best key components to build a camera (best sensor for a given price, best ISP on the market,...)
- judge the overall image quality of a camera
- evaluate the impact various output use cases have on overall image quality
- compare the image quality of a set of cameras
- define subjective test plans and protocols
- setup benchmarking protocols depending on use cases

INTENDED AUDIENCE

Image scientists, engineers, or managers who wish to learn more about image quality and how to evaluate camera performance for various output use cases. A good understanding of imaging and how a camera works is assumed. Anyone involved in photographic or motion picture imaging will benefit from this course.

INSTRUCTOR

Jonathan Phillips is a senior image quality scientist in the camera group at NVIDIA. His involvement in the imaging industry spans over 20 years, including two decades at Eastman Kodak Company. His focus has been on photographic quality, with an emphasis on psychophysical testing for both product development and fundamental perceptual studies. His broad experience has included image quality work with capture, display, and print technologies. He received the 2011 I3A Achievement Award for his work on camera phone image quality and headed up the 2012 revision of ISO 20462 - Psychophysical experimental methods for estimating image quality - Part 3: Quality ruler method. He completed his graduate work in color science in the Center for Imaging Science at Rochester Institute of Technology and his chemistry undergraduate at Wheaton College (IL).

Perception, Cognition, and Next Generation Imaging

SC969

Course Level: Introductory
CEU: 0.35 $300 Members | $355 Non-Members USD
Sunday 8:30 am to 12:30 pm

The world of electronic imaging is an explosion of hardware and software technologies, used in a variety of applications, in a wide range of domains. These technologies provide visual, auditory and tactile information to human observers, whose job it is to make decisions and solve problems. In this course, we will study fundamentals in human perception and cognition, and see how these principles can guide the design of systems that enhance human performance. We will study examples in display technology, image quality, visualization, image search, visual monitoring and haptics, and students will be encouraged to bring forward ongoing problems of interest to them.

LEARNING OUTCOMES

This course will enable you to:
- describe basic principles of spatial, temporal, and color processing by the human visual system, and know where to go for deeper insight
- explore basic cognitive processes, including visual attention and semantics
- develop skills in applying knowledge about human perception and cognition to engineering applications

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who are involved in the design, testing or evaluation of electronic imaging systems. Business managers responsible for innovation and new product development. Anyone interested in human perception and the evolution of electronic imaging applications.

INSTRUCTOR

Bernice Rogowitz founded and co-chairs the SPIE/IS&T Conference on Human Vision and Electronic Imaging (HVEI) which is a multi-disciplinary forum for research on perceptual and cognitive issues in imaging systems. Dr. Rogowitz received her PhD from Columbia University in visual psychophysics, worked as a researcher and research manager at the IBM T.J. Watson Research Center for over 20 years, and is currently a consultant in vision, visual analysis and sensory interfaces. She has published over 60 technical papers and has over 12 patents on perceptually-based approaches to visualization, display technology, semantic image search, color, social networking, surveillance, haptic interfaces. She is a Fellow of the SPIE and the IS&T.

Perceptual Metrics for Image and Video Quality in a Broader Context: From Perceptual Transparency to Structural Equivalence

SC812

Course Level: Intermediate
CEU 0.35 $300 Members | $355 Non-Members USD
Sunday 1:30 pm to 5:30 pm

We will examine objective criteria for the evaluation of image quality that are based on models of visual perception. Our primary emphasis will be on image fidelity, i.e., how close an image is to a given original or reference image, but we will broaden the scope of image fidelity to include structural equivalence. We will also discuss no-reference and limited-reference metrics. We will examine a variety of applications with special emphasis on image and video compression. We will examine near-threshold perceptual metrics, which explicitly account for human visual system (HVS) sensitivity to noise by estimating thresholds above which the distortion is just-noticeable, and supra-threshold metrics, which attempt to quantify visible distortions encountered in high compression applications or when there are losses due to channel conditions. We will also consider metrics for structural equivalence, whereby the original and the distorted image have visible differences but both look natural and are of equally high visual quality. We will also take a close look at procedures for evaluating the performance of quality metrics, including database design, models for generating realistic distortions for various applications, and subjective procedures for metric development and testing. Throughout the course we will discuss both the state of the art and directions for future research.

Course topics include:
- Applications: Image and video compression, restoration, retrieval, graphics, etc.
- Human visual system review
- Near-threshold and supra-threshold perceptual quality metrics
- Structural similarity metrics
- Perceptual metrics for texture analysis and compression – structural texture similarity metrics
- No-reference and limited-reference metrics
- Models for generating realistic distortions for different applications
- Design of databases and subjective procedures for metric development and testing
- Metric performance comparisons, selection, and general use and abuse
- Embedded metric performance, e.g., for rate-distortion optimized compression or restoration
- Metrics for specific distortions, e.g., blocking and blurring, and for specific attributes, e.g., contrast, roughness, and glossiness
- Multimodal applications

LEARNING OUTCOMES

This course will enable you to:
- gain a basic understanding of the properties of the human visual system and how current applications (image and video compression, restoration, retrieval, etc.) that attempt to exploit these properties
- gain an operational understanding of existing perceptually-based and structural similarity metrics, the types of images/artifacts on which they work, and their failure modes
- review current distortion models for different applications, and how they can be used to modify or develop new metrics for specific contexts
- differentiate between sub-threshold and supra-threshold artifacts, the HVS responses to these two paradigms, and the differences in measuring that response
- establish criteria by which to select and interpret a particular metric for a particular application.
- evaluate the capabilities and limitations of full-reference, limited-reference, and no-reference metrics, and why each might be used in a particular application

INTENDED AUDIENCE

Image and video compression specialists who wish to gain an understanding of how performance can be quantified. Engineers and Scientists who wish to learn about objective image and video quality evaluation.

Managers who wish to gain a solid overview of image and video quality evaluation. Students who wish to pursue a career in digital image processing. Intellectual Property and Patent Attorneys who wish to gain a more fundamental understanding of quality metrics and the underlying technologies. Government laboratory personnel who work in imaging.

Prerequisites: a basic understanding of image compression algorithms, and a background in digital signal processing and basic statistics: frequency-based representations, filtering, distributions.

INSTRUCTORS

Thrasyvoulos N. Pappas received the S.B., S.M., and Ph.D. degrees in electrical engineering and computer science from MIT in 1979, 1982, and 1987, respectively. From 1987 until 1999, he was a Member of the Technical Staff at Bell Laboratories, Murray Hill, NJ. He is currently a professor in the Department of Electrical and Computer Engineering at Northwestern University, which he joined in 1999. His research interests are in image and video quality and compression, image and video analysis, content-based retrieval, perceptual models for multimedia processing, model-based halftoning, and tactile and multimodal interfaces. Dr. Pappas has served as co-chair of the 2005 SPIE/IS&T Electronic Imaging Symposium, and since 1997 he has been co-chair of the SPIE/IS&T Conference on Human Vision and Electronic Imaging. He has also served as editor-in-chief for the IEEE Transactions on Image Processing from 2010 to 2012. Dr. Pappas is a Fellow of IEEE and SPIE.

Sheila S. Hemami received the B.S.E.E. degree from the University of Michigan in 1990, and the M.S.E.E. and Ph.D. degrees from Stanford University in 1992 and 1994, respectively. She was with Hewlett-Packard Laboratories in Palo Alto, California in 1994 and was with the School of Electrical Engineering at Cornell University from 1995-2013. She is currently Professor and Chair of the Department of Electrical & Computer Engineering at Northeastern University in Boston, MA. Dr. Hemami's research interests broadly concern communication of visual information from the perspectives of both signal processing and psychophysics. She has held various technical leadership positions in the IEEE, served as editor-in-chief for the IEEE Transactions on Multimedia from 2008 to 2010, and was elected a Fellow of the IEEE in 2009 for her for contributions to robust and perceptual image and video communications.

About the Symposium Organizers

IS&T, the Society for Imaging Science and Technology, is an international non-profit dedicated to keeping members and others apprised of the latest developments in fields related to imaging science through conferences, educational programs, publications, and its website. IS&T encompasses all aspects of imaging, with particular emphasis on digital printing, electronic imaging, color science, photofinishing, image preservation, silver halide, pre-press technology, and hybrid imaging systems.

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