WORKSHOP

“IMAGING AND OPTICS: RESEARCH AND EDUCATION”

Friday, November 19, 2004
8:45 am – 3:15 pm

Sokol Room – Science Building
Montclair State University Campus, Montclair, NJ

Organized by

The Center for Imaging and Optics

Dr. Stefan Robila
Dr. George Antoniou
Dr. Angel Gutierrez

with support from

http://www.csam.montclair.edu/~cio/w2004/
"Imaging and Optics : Research and Education"

November 19, 2004
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Montclair State University Campus, Montclair, NJ

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8:45 - 9:00
Registration

9:00 - 9:30
Opening, organization, announcements
Dr. Dorothy Deremer, Chair, Computer Science Department, Montclair State University

9:30 - 10:00
Multispectral Imaging: From Airborne Sensors to Mainstream Computer Vision to the Classroom
Dr. Dr. Elli Angelopoulou, Stevens Institute of Technology

In 1972 NASA launched its first airborne multispectral sensor, LANDSAT-1. Since then the field of remote multispectral/hyperspectral sensing has evolved worldwide. (Check NASA's latest sensor, AVIRIS, at http://aviris.jpl.nasa.gov for today's schedule of airborne multispectral sensing). The majority of the multispectral work is done by geosciences, and has only very recently started trickling into mainstream computer vision. Though many of aspects of multispectral imaging have already been addressed in the last 30 years, its employment in combination with regular digital cameras raises new challenges. In this talk we will give a brief background on multispectral imaging followed by its use within the visible range. We will present some recent results on how we have successfully retrieved imperceptible information from applying multispectral analysis within the visible spectrum. We will also discuss how we engaged a diverse collection of students (from business majors to computer science, and from undergraduate to post-doctoral students) in different aspects of multispectral imaging.

10:00 - 10:30
Imaging beyond the Visible in the Short Wave Infrared with Indium Gallium Arsenide
Dr. Martin Ettenberg, Sensors Incorporated

The short wave infrared wavelength band (0.9 – 2.6 µm) is a relatively new wavelength band for imaging applications. The band has been used for fiber optic telecommunications for over 20 years, relying heavily on InGaAs lattice matched to InP substrates as the detector material. The improvements in this material now allow imaging and spectroscopy in this wavelength band with very high sensitivity and large resolution arrays at lower costs. This now opens up many industrial, commercial, and military imaging applications. This talk will review the applications for this technology as well as the direction of the current research.

10:30 - 11:00
Digital Image Watermarking
Dr. Yun-Qing Shi, New Jersey Institute of Technology

In the past a few years, digital data hiding has extracted tremendous interests from research community. It is expected that data hiding will play an important role in cyber security and information assurance. In this talk, the fundamental concepts, principles, and applications of digital image watermarking, also referred to as digital image data hiding, will be addressed. In
particular, the examples, research issues, and applications of reversible image data hiding will be presented.

11:00 - 11:30  
**Rotation Invariant Texture Classification**  
*Dr. Hong Man, Stevens Institute of Technology*

We present a rotation invariant texture classification method using a special directional filter bank (DFB) and support vector machine (SVM). This method extracts a set of coefficient vectors from directional subband domain, and models them as multivariate Gaussian densities. Eigen-analysis is then applied to the covariance metrics of these density functions to form rotation invariant feature vectors. Classification is based on SVM, which only takes non-rotated images for training and uses images at various rotation angles for testing. Experimental results have shown that this DFB is very effective in capturing directional information of texture images, and the proposed rotation invariant feature generation and SVM classification method can in fact achieve relatively consistent classification accuracy on both non-rotated and rotated images.

11:30 - 12:00  
**Imaging and Image-Processing for Nondestructive Evaluation**  
*Dr. Shreekanth A. Mandayam, Rowan University*

Nondestructive evaluation (NDE) refers to systems and processes that be used to ascertain the integrity of components without impairing their usefulness. Concerns regarding ageing infrastructure (aircraft, gas pipelines, bridges and roadways) in the United States have prompted universities, research labs and funding agencies to launch a concerted effort to improve the state-of-the-art in estimating system health. Imaging and image-processing techniques play critical roles in NDE.

Since its inception in 1998, the NDE Lab in the College of Engineering at Rowan University has pioneered the application of a variety of imaging techniques for the nondestructive evaluation and characterization of three-dimensional shapes. Using a combination of imaging, digital image processing, artificial neural networks and advanced scientific visualization techniques, faculty, students and industrial collaborators have addressed a wide range of 2-D and 3-D shape characterization problems. This presentation will describe ongoing research and education activities in the NDE lab. Current projects include - Defect characterization in gas transmission pipelines using magnetic, thermal, acoustic and ultrasonic imaging; Shape characterization of aggregates of sand particle shapes using optical and X-ray imaging; Identification and segmentation of radiodense tissue in mammograms using digital image processing.

12:00 - 1:00  
**Lunch Break**
1:00 - 1:30
**Interactive Pattern Discovery with Large Imaging Databases**  
*Dr. Tin Kam Ho, Bell Labs, Lucent Technologies*

Advances in digital imaging technologies have led to accumulations of large data archives with rich multimedia contents, enabling both targeted pursuits and open-ended explorations of many kinds. A recent example is the Virtual Observatory that supports sharing of diverse and massive databases containing images, spectra, and catalogs among astronomical researchers. To maximize its advantages, flexible and effective data analysis tools that can handle large data volumes, diverse data types, a wide range of objectives, and highly variable demands on speed are in critical need. We discuss our experiences with Mirage (http://www.cs.bell-labs.com/who/tkh/mirage), a prototypical software for interactive pattern discovery, and its applications in the Virtual Observatory. We focus on how to organize the analysis tool to lay a solid foundation for meeting these requirements and enabling continuous growth.

1:30 - 2:00
**Magnetic Resonance Imaging: A Signal Processing Perspective**  
*Dr. Fred Fontaine, Cooper Union*

There is a significant collaborative research effort on magnetic resonance imaging (MRI) systems involving faculty, undergraduate and first year graduate engineering students at The Cooper Union and biomedical researchers and doctoral students at the Weill Medical College of Cornell University. The research focuses on the development of magnetic coil arrays and accompanying data acquisition systems and signal processing algorithms. In this talk, MRI is described from a signal processing perspective, with emphasis on the data acquisition process and sampling patterns in the spatial frequency domain. The talk also presents some of the potential benefits of magnetic coil arrays, as opposed to conventional single detection coil MRI systems, and peculiar problems that arise in angiography (imaging blood flow and the heart).

2:00 - 2:30
**Submitted presentations**

**Texture Classification in Tangent Space**  
*Cheng Ling, Stevens Institute of Technology*

Fisher kernel method was recently proposed to incorporate probabilistic (generative) models and discriminative methods for pattern recognition (PR). This method use parameter derivatives of log-likelihood calculated from probabilistic model(s), "Fisher scores", to generate statistical feature vectors. It is followed by discriminative classifiers such as "support vector machine" (SVM) for classification. In this presentation we study the potential of Fisher kernel method on texture classification. A hybrid system of "independent mixture model" (IMM) and SVM is introduced to extract and classify statistical texture features in wavelet-domain. Compared to existing methods that apply Bayesian classification based on wavelet domain "energy signatures" (ES) and stand along IMM, the new hybrid IMM/SVM method is able to achieve superior performance. Experimental results are presented to demonstrate the effectiveness of this proposed method.
Supporting Experimental Research in Secondary Schools
Michael T. Roche, Kristin Beck, High Technology High School

High Technology High School is a pre-engineering career academy administered by the Monmouth County Vocational School District. This specialized secondary school requires all students to propose, conduct and communicate an experimental design and data analysis project during their sophomore year. Some students elect to continue their research experience as upperclassmen. We are proposing a joint presentation by a high school science teacher and student. The presentation will focus on how we support student research projects in many areas, including optics, at the high school level. A current senior project in optics (as described below) will be featured in the presentation. Research conducted last summer suggested that transmission holography could be used for optical encryption. Because holograms record interference patterns and not the actual images, extracting data from the hologram itself is difficult without the correct reference beam. After recording holograms with simple optical masks in both the reference and object beams, I am currently attempting to examine the image quality of the resulting play back under two different conditions: a reference beam with the optical mask, and one without.

2:30 - 3:00
Interdisciplinary Research in Computer Science – the Case for Hyperspectral Imagery
Dr. Stefan Robila, Montclair State University

The presentation will discuss our experience in using interdisciplinary research topics to create undergraduate projects in the context of Computer Science education. Given the difficulty level required in many current research directions, as well as the fact that the interdisciplinary involves non-Computer Science knowledge, it is becoming increasingly challenging to attract students in the faculty’s area of specialization. Our experience is based on research of hyperspectral images, a type of data where the spectral measurement is performed using hundreds of narrow contiguous wavelength intervals. The approach proposed is the identification of clear problems that can be solved in relatively short amount of time. The experience that will be described can be extended to other areas of interdisciplinary research.

3:00 – 3:15
Wrap - up
Bios of the speakers

Elli Angelopoulou is an Assistant Professor in the Computer Science Department at Stevens Institute of Technology. She earned her Ph.D. in Computer Science in 1997 from the Johns Hopkins University. She specializes in computer vision and particularly in photometry, the field of inferring shape and material information from image data. She has numerous publications in computer vision conferences and journals. Her research is supported by both industry and National Science Foundation grants, including an NSF-CAREER grant on multispectral imaging. She also teaches a variety of college courses ranging from freshmen Introduction to Scientific Computing courses to graduate courses on Computer Vision.

Martin Ettenberg joined Sensors Unlimited Inc. in August of 1997 and has been the principal investigator on over six Phase I and Phase II Small Business Innovative Research (SBIR) programs plus several military and commercial camera development programs. He led the development of the first room temperature night-vision-capable InGaAs short wave infrared (SWIR) camera. This camera demonstrated a factor of 20 improvements in detectivity over the prior state-of-the-art. He also directed the team that fabricated the first 640x512 lattice-matched InGaAs camera. He conducted the effort to extend the current wavelength cutoff of the InGaAs focal plane arrays. That program successfully extended the image cutoff wavelength from 1.7 m to 2.0 m in a 320x240 focal plane array. Dr. Ettenberg has been the driving force behind Sensors Unlimited’s imaging product line, introducing four new camera products in the last year. His work now focuses on the development of novel cameras and optoelectronic devices including longer wavelength InGaAs cameras extending to 2.5 m and smaller SWIR cameras for unmanned aerial vehicles. Dr. Martin H. Ettenberg graduated with a Masters and a Ph.D. degree from the University of Virginia Dept. of Materials Science and Engineering in January of 1995 and May of 1997 respectively. He also received his BS in Materials Science and Engineering from Cornell University in 1992. His graduate research involved the fabrication and construction of semiconductor thermoelectric materials and devices. He managed to produce the first advancement in room temperature thermoelectric cooling in over 20 years.

Fred L. Fontaine received his Ph.D. in Electrical Engineering from Stevens Institute of Technology in 1990, M.S. in Mathematics from the Courant Institute of NYU in 1990, and M.E and B.E. in Electrical Engineering from Cooper Union in 1987 and 1986, respectively. He has been at Cooper Union since 1987, where he is Professor of Electrical Engineering, and Chairman of the Department of Electrical & Computer Engineering. His primary interests are in the areas of multiresolution imaging, robust signal processing, digital communications and applied mathematics.

Tin Kam Ho is a Member of Technical Staff in the Computing Sciences Research Center of Bell Laboratories. Her interests are in pattern recognition, data mining, and computational modeling and simulation. She received a Ph.D. in Computer Science from SUNY at Buffalo in 1992. She is Editor-in-chief of the journal Pattern Recognition Letters, and has served on the editorial board of several other journals. In 1999 she received the ICDAR Young Scientist Award for her contributions to document image analysis and recognition. She is a Fellow of IAPR, and has received 6 U.S. patents for her work in pattern recognition and image analysis.

Hong Man received the B.S. degree from Soochow University, China, in 1988, the M.S. degree from Gonzaga University in 1994, and the Ph.D. degree from Georgia Institute of
Technology in 1999, all in Electrical Engineering. He joined Stevens Institute of Technology in 2000, and currently he is an assistant professor in the Department of Electrical and Computer Engineering. He is serving as the director for Visual Information Environment Laboratory at Stevens, the director for Computer Engineering undergraduate program in the ECE department, and the coordinator for NSA Center of Academic Excellence in Information Assurance in the School of Engineering. He is a member of the IEEE and ACM. He served as member of organizing committee for IEEE International Workshop on Multimedia and Signal Processing (MMSP) 2002 and 2005, member of technical program committee for IEEE Vehicular Technology Conference (VTC) Fall 2003, and IEEE/ACM International Conference on E-Business and Telecommunication Networks (ICETE) 2004. He is a committee member on IEEE SPS TC for Education. He was an active contributor to the ISO/ITU JPEG 2000 image coding standard.

Stefan Robila has obtained his B.S. in computer science in 1997 from University of Iasi, and the M.S. and Ph.D. in computer science in 2000 and 2002 respectively from Syracuse University. Dr. Robila is the recipient of the Wilbur LePage Scholarship for Outstanding Doctoral Candidate in Engineering awarded by Syracuse University in 2002. He is currently with Montclair State University’s department of Computer Science and the director of the Center for Imaging and Optics. Dr. Robila’s interests in remote sensing are related to efficient processing of the data through either new methods or implementation of distributed algorithms for old ones. Dr. Robila has reviewed for National Science Foundation, for several remote sensing journals such as IEEE Transactions on Geosciences and Remote Sensing, IEEE Geosciences and Remote Sensing Letters, Canadian Journal of Remote Sensing, International Journal of Remote Sensing, and conferences in remote sensing, computer science and information technology. He is a member of the Remote Sensing Applications Division of the American Society for Photogrammetry & Remote Sensing (ASPRS).

Yun Q. Shi joined the Department of Electrical and Computer Engineering at the New Jersey Institute of Technology, Newark, NJ since 87, and is currently a professor there. He obtained his B.S. degree and M.S. degree from the Shanghai Jiao Tong University, Shanghai, China; his M.S. and Ph.D. degrees from the University of Pittsburgh, PA. His research interests include visual signal processing and communications, digital multimedia data hiding and information assurance, applications of digital image processing, computer vision and pattern recognition to industrial automation and biomedical engineering, theory of multidimensional systems and signal processing. Some of his research projects are currently supported by several federal and New Jersey State funding agencies. He is an author/coauthor of more than 160 papers in his research areas, a book on Image and Video Compression, and three book chapters on Image Data Hiding. He holds two US patents and has five other US patents pending. He is the chairman of Signal Processing Chapter of IEEE North Jersey Section, an editorial board member of International Journal of Image and Graphics, a member of IEEE CASS Technical Committee of Visual Signal Processing and Communications as well as Technical Committee of Multimedia Systems and Applications, a member of IEEE SPS Technical Committee of Multimedia Signal Processing, an Associate Editor of IEEE Transactions on Circuits and Systems II. He was an IEEE CASS Distinguished Lecturer, a co-general chair of IEEE 2002 International Workshop on Multimedia Signal Processing, a formal reviewer of the Mathematical Reviews, an Associate Editor for IEEE Transactions on Signal Processing, the guest editor of several special issues on several journals, one of the contributing authors in the area of Signal and Image Processing to the Comprehensive Dictionary of Electrical Engineering.
The combined talents of everyone aligned with SPIE contribute to new scientific discovery. Collective knowledge provides the base on which the next generation of scientists and engineers can explore the promise of light. For its part, the Society provides more than $700,000 annually in scholarships, grants, and financial support to encourage scientific and technological education and innovation. SPIE is a not-for-profit society that has become the largest international force for the exchange, collection and dissemination of knowledge in optics, photonics and imaging. Founded in 1955, SPIE is the growing legacy of those who seek to learn, discover and innovate by building a better world with light.

**Society Vision:** SPIE will serve the international technical community as the premier provider of education, information, and resources covering optics, photonics, and their applications.

**Society Mission:** The mission of SPIE-The International Society for Optical Engineering is:

- To serve our members and the international engineering and science communities by providing high quality information and educational products and services.
- To create global forums that provide interaction of members of the optics and photonics communities with each other, with those in other technical disciplines, and with their suppliers and customers.
- To organize conferences and educational programs on emerging technologies, capture the information presented there, and rapidly transfer this information to those who need it.

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The Department of Computer Science offers an ABET accredited B.S. and a M.S. in Computer Science and participates in interdisciplinary degree offerings such as Science Informatics (combines computer science with various areas of science). The current enrollment is 150 undergraduate and 60 graduate students. The Department offers an excellent education focused on hands-on experience, quality of teaching, and student involvement in research. In addition, the Department is actively involved in outreach activities involving high school teachers and students. These activities include short summer courses in novel science topics.

The Department has 14 full time faculty with extensive expertise in all fields of Computer Science and background in other sciences such as mathematics and electrical engineering. The Department of Computer Science currently houses a wide variety of high-performance computing equipment running a number of operating systems. Laboratories for both instructional and research purposes are available. The Department maintains active research groups in systems and image processing, remote sensing, bioinformatics, databases, high performance and parallel computing, etc.
The Center for Imaging and Optics originates from active research focused on vision, optics and image processing of faculty within the Computer Science Department at Montclair State University. The Center brings together the research side of our activity with the course preparation and offering and constitutes an identifiable entity in the organization of K-12 and community colleges outreach programs. Faculty affiliated with the center have taught or are teaching courses in various imaging and optics fields such as Computer Graphics, Pixel and Image Processing, Pattern Recognition, etc. The center has been founded through an educational grant provided by The International Society for Optical Engineering (SPIE)

Laboratories affiliated with the Center:

Remote Sensing Laboratory (RSL)
http://www.csam.montclair.edu/~robila/RSL/

Areas of research: Remote Sensing (Independent Component Analysis, Hyperspectral Sensors, New Applications Based on Off-the-Shelf Technologies, Distributed Processing of Remote Sensed Data, Image Processing (Information Hiding in Images, Change Detection). The laboratory is equipped with state of the art imaging devices (such as SOC 700, 0.43 –to 0.9 microns, 120 bands), computers and processing software (Matlab, Envi, Hyperspectral Analysis Toolkit, Multispec, Adobe Photoshop, etc.) and lighting sets. – Dr. Stefan A. Robila

Image Processing and Systems Laboratory (IPSL)
http://www.csam.montclair.edu/~antoniou/ipsl.html

Areas of research: Digital Imaging, Bioinformatics, FPGA/VHDL Applications, Palm-based Applications, Digital Logic, Multidimensional System Theory and Signal Processing – Dr. George Antoniou