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Dear Readers,

It is our great pleasure to provide you with a summary of our many achievements this past year in the Chester F. Carlson Center for Imaging Science. Our greatest achievements are our graduates, at the undergraduate, masters, and PhD levels, and we once again take great pride in our recent degree awardees and the successful careers they have embarked on. This year marks the first year of the CIS Strategic Expansion Plan, which seeks to double the number of PhD graduates and the externally funded research over the course of five years. We have made a great start towards that future, with record numbers of graduates, publications, and research revenues. We continue to work hard at growing our undergraduate program, and with the inception of the joint BS program with the Film and Animation School of RIT’s College of Imaging Arts and Sciences we find our undergraduate classes overflowing for the first time. Several new faculty have joined our ranks and are developing exciting new research programs that expand our scientific capability. Our education and outreach activities have continued to expand as do our relationships with the local school districts and organizations such as the girl scouts. We hope you enjoy reading what we have been up to, and we encourage you to contact us directly or visit our website (www.cis.rit.edu) to learn more or to engage us in collaboration.

Best,

Stefi Baum, Director

University News

September 19, 2008
By Susan Gawlowicz

Challenges of female scientists explored in new essay collection

No one talks about it much, but if you’re a female scientist, you’re faced with it every day: the challenge of being a serious scientist and an ideal mother. Those who haven’t made the choice must decide what they can live with: foregoing motherhood for a career in science or a career in science instead of motherhood, or finding a way to meld the two.

Motherhood, the Elephant in the Laboratory: Women Scientists Speak Out, edited by Emily Monosson and published by ILR Press, is a collection of 34 essays by mother-scientists who share their stories and insights on achieving balance and defining success.

RIT scientist Stefi Baum contributed her insights in the essay, “The Accidental Astronomer,” detailing the career and family choices she made at the outset of her career in the 1980s. Baum is the director of RIT’s Chester F. Carlson Center for Imaging Science and co-chair of the new Astrophysical Sciences and Technology graduate program. She has balanced a successful career inside and outside academia with the domestic demands of being the mother of four children.

In her essay, Baum reflects on timing her pregnancies “so as not to be visibly pregnant” during her early job interviews; giving birth to her first child in a small village in Holland while on a joint post-doctoral fellowship with her husband at the Netherlands Foundation for Radio Astronomy; and returning to work only one week after having had her first son.

“Critical to being able to juggle a scientific career and a young family was having the perfect collaborator—a husband who shared all aspects with me from scientific discovery to baby trips to the doctor,” Baum says. Her husband, Chris O’Dea, is also an astronomer and a professor of physics at RIT.

As director of the Center for Imaging Science, Baum has sought ways to increase the representation of girls in science and women in academia. She started a series of annual programs with the Girl Scouts of Genesee Valley through the center. Baum is also working with Margaret Bailey, Kate Gleason Endowed Chair and associate professor of mechanical engineering, who won a National Science Foundation grant to increase the participation and advancement of women in academic science and engineering careers.

Baum, when at the Space Telescope Science Institute before coming to RIT, headed the engineering division supporting the Hubble ground systems and supervised 140 engineers, scientists and support staff.

In addition, Baum led the team working on a new instrument to be placed on Hubble called the Space Telescope Imaging Spectrograph. Baum and her husband took the family to Cape Canaveral, Florida, to watch the launch of the shuttle carrying the instrument Baum helped develop.
A sixty-second exposure brings out the colors of the Milky Way, set against Nugget Point lighthouse, in southern New Zealand. Taken by 2nd year Imaging Science undergraduate student David Kelbe from Victor, NY, while he was in New Zealand during the Spring and Summer of 2008 on a study abroad.
Imaging Science
Undergraduate Program

Program Coordinator’s Comments
By Carl Savaggio

During my second year as the coordinator of the undergraduate program in Imaging Science, as I have said in the past, I continue to be amazed at everything that these wonderful students are engaged in. The involvement of our undergraduates in research projects outside of the classroom has really skyrocketed and I believe it will further enhance the quality of our graduates and make them an even greater asset to the disciplines that we serve.

Through the RIT-sponsored career fairs in the fall and winter quarters, as well as direct solicitations from many of the large and small corporations in fields related to imaging, any student who wants the opportunity to work during the summer, or even during the academic year, is able to do so. The Center appreciates all the support that the commercial and government sectors have provided by taking on these cooperative educational students and interns.

While we continue to enhance the quality of our program, we also seek to increase the size of your class. Our Associate Director, Joe Pow, and the outreach programs he has assembled and executed, continue to pass on the answer to the question “What is Imaging Science?” to thousands of students, and his work has really paid off in attracting about 90% of our entering students. Webcasts, on-campus programs for high school students, visits to high schools throughout the region, and the summer internship program for high school juniors—Joe has done it all. It is clear that we still need to continue to think of additional ways to build on Joe’s work and many ideas are being discussed and implementation strategies worked on as of this report. We will report back on our progress in the future.

Students who enroll in Imaging Science complete their degree at RIT. Our retention rate continues to be very good—well above 90%. This is in no small part due to the marvelous attention provided by our Academic Coordinator, Sue Chan. For those of you who have been lucky enough to know Sue while you were a student here at RIT, she continues to make everyone’s life a lot easier and allows both the faculty and the students to concentrate on the most important goals of the Center: education and research.

It has been a great year at the Center and I hope that everyone reading this report can in some way stay involved with these great students that we have. Whether it is providing an internship possibility, whether it is visiting campus and talking at our seminar series or to the Friday afternoon meeting of the student chapter of IS&T, or through the sponsorship of a high school senior’s application to our program—it is very rewarding to be a part of the Center.

Curriculum Changes

Two years into our latest iteration of our new curriculum we are very pleased with the way things are going. During this past academic year we enacted a student exchange session twice each quarter where the student body as a whole has an opportunity to voice its opinions to the faculty and administrators of the Center. These sessions have proven to be quite valuable and have resulted in a few changes to our approach that we will be instituting in the coming academic year.

The changes are small, but will hopefully provide a better academic experience. We have removed some redundancy that exists between classes within the department that will allow for additional time to be spent on the new materials presented. As mentioned, these changes are small but necessary as pointed out to us by our students.

We have also revamped our Research Practices class so that portions are moved earlier in the student’s schedule at RIT. This allows our incoming first year students to interact with the third year students preparing proposals for their capstone project as well as the fourth year students who are finishing up their work. This allows the new students to get an idea of what is to come for them and gives them a chance to begin active involvement in undergraduate research much earlier. It is all about engagement and activity, and we are seeing an increase in both of these.

Lastly, we have implemented a 4+1 path into a Masters degree in Imaging Science for all qualified students at RIT. This option allows advanced students to begin taking graduate classes during their fourth year of study, up to 12 credits of which may count as professional elective credit toward their undergraduate degree. This gives them a good head start on these more rigorous classes and allot them time during their fifth year on campus to pursue their research and graduate with a Master’s degree as early as the end of their fifth year. While this is not a path that all students may choose to take, it certainly serves a good number of our underclassmen. Currently, we have three third year students contemplating this path.

The curriculum at the undergraduate level is stable after many years of change. We are excited to have finally achieved this stability and hope that all involved will benefit from the evolution that has taken place.

Student Body

With approximately 50 students, the undergraduate population in Imaging Science continues to be a wonderful collection of aspiring scientists, lab-savvy students, and systems engineers. We expect this group to grow by the addition of undergraduate students this coming year from other colleges and departments at RIT as well as other universities in the region. Currently, we have six transfer student applications, two of which have been accepted, and one committed to enroll in the fall.
Incoming Class Profile (Fall 2008)

At the present time there are 15 applications for admission to the Imaging Science undergraduate program for the 2008-2009 academic year. Of these 15 applications, 13 students have been accepted into the program. At this point in time, eight of these students have committed to joining us in the fall. To complement the eight Imaging Science undergraduate student in their first year are 15 Digital Cinema students (from the College of Imaging Arts and Sciences) that will be in eight of our core classes.

Awards/Recognition

While the undergraduate program remains a small program when compared to other programs in the College of Science, our students are truly exceptional in their performance. The following awards have been bestowed on our students in Imaging Science during the 2007-2008 academic year:

- RIT Outstanding Undergraduate Scholar
  Juliet Bernstein

- John Wiley Jones Scholar
  David Snyder

- Jerry Hughes Scholar
  Paul Romanczyk

- Fitz Scholarship
  Allison Bright

- Carlson Scholars
  Monica Cook
  Mark Giglio
  Karla Hatfield
  David Kelbe
  Christopher Tomkins-Tinch
  Joel Witwer
  David Wright

- Kearse Student Honor Literature Award
  Katie Salvaggio

Internships

- **Juliet Bernstein** / Black River Systems
- **Nicholas Cox** / ITTVIS (Boulder) and Areté Associates
- **Rebecca Brown** / Naval Surface Warfare Center (San Diego) and U. of Texas Health Science Center (San Antonio)
- **Christopher DeAngelis** / Naval Research Laboratories (Washington, DC) and Ball Aerospace (Dayton)
- **Coleen Davis** / Naval Air Warfare Center (Patuxent River) and ITT Space Systems Division (Rochester)
- **Meredith Curtis** / NASA (Goddard) and Estee Lauder (Long Island)
- **Paul Romanczyk** / Eastman Kodak Research Laboratory (Rochester)
- **David Snyder** / Pictometry International (Rochester) (PENDING)
- **Kim Rafferty** / ITT Space Systems Division (Vienna)

Undergraduate Research Experiences Within the Center (by Laboratory)

- **Vision**
  Allison Bright
  Jonathon Purrington

- **Color Science**
  Mark Giglio

- **Remote Sensing**
  David Snyder
  David Nilosek
  Eugenie Song
  Juliet Bernstein
  Jamie Albano

- **Medical Imaging**
  Kim Rafferty
  David Shapiro

- **Astronomical Imaging**
  Paul Romanczyk

PRISM

- David Nilosek
- Coleen Davis
- Christopher DeAngelis
- Rebecca Brown
- Claire MacDonald
- Luis Henry

Study Abroad

- David Kelbe / New Zealand (watch David’s YouTube video at http://www.youtube.com/watch?v=PTtTjQQpm20)
- Joel Witwer / New Zealand
- Christina Kucerak / Australia

Graduates

In 2007, the following students have graduated with a Bachelor of Science degree from the undergraduate program in Imaging Science:

- Jamie Albano
- Russell Barkley
- Luis Henry
- Matthew Risi
- David Shapiro
- Shawn Staudaher

and the following students from other programs at the Institute will be certified with a minor in Imaging Science:

- Robert Brambley (Computer Science, B. Thomas Golisano College of Computing and Information Science)
- Kenneth Fourspring (Microelectronic Engineering, College of Engineering)
- Brian Lindenau (Microelectronic Engineering, College of Engineering)
- Timothy Peterson (Computer Science, B. Thomas Golisano College of Computing and Information Science)
- Stuart Sieg (Microelectronic Engineering, College of Engineering)
Capstone Experiences

During the 2007-2008 academic year, the fourth year students participated in a formal capstone experience through the traditional senior project to prepare them for a specialty within imaging science or for graduate school in the coming year. The following senior projects were carried out and completed as of May 31, 2008:

STUDENT
Jamie Albano

ADVISER(S)
Dr. Emmett Ientilucci (Imaging Science)

TITLE
Stochastic Modeling of Physically Derived Signature Spaces with Application to Target Detection

ABSTRACT

Traditional approaches to hyperspectral target detection involve the application of detection algorithms to atmospherically compensated imagery. Rather than compensate the imagery, we use a physical model to generate target spaces that are then used in detection schemes on uncompensated radiance imagery. This research involves modeling the generated target space through least squares method. The resulting model is composed of a sum of three 3rd-order polynomials in three variables. The variables accounted for in this model result from the atmospheric input parameters supplied to MODTRAN used to calculate the target space vectors. These parameters include visibility, water vapor, and elevation. In post processing, we also include two additional parameters: shape factor and illumination factor.

STUDENT
Russell Barkley

ADVISER(S)
Dr. Risa Robinson (Mechanical Engineering) and Dr. Carl Salvaggio (Imaging Science)

TITLE
Dual Particle Refinement Via Image Restoration Techniques

ABSTRACT

The characterization of two different particles (i.e., red and green), subsequent to a series of image correction methods, would allow for the distinction of the two particle types, and the potential to model the dynamics inside a physical simulation of the alveoli—tiny air sacks in the lungs. Multi-Particle Image Velocimetry (mPIV) provides a visual model for the analysis between air that is exhaled (tidal air) and the air that resides in the alveoli (residual air). This method utilizes a high-speed camera to capture the emission from two different sets of particles that fluoresce at two different wavelengths, while being illuminated by a high-powered laser. The image correction techniques that were applied included: a Weiner Filter for increased sharpness and a reduction in noise; and a Tone Transfer Function (TTF) correcting for the camera's non-linearity. In order to determine the potential for monochromatic images to be used for particle separation several different approaches were analyzed, including: a threshold for particle gray value; radius of the airy disk of each type of particle in vertical and horizontal cross-section; gray value at the location of the peak of the airy disk; and radius of the particle image. The image restoration methods applied to the images produced a linear sharpened image, where the particles represented point sources, and the two types of particles had overlapping characteristics in all of the applied digital separation techniques, even when they were applied simultaneously. Though the image correction was successful, defining characteristics between the red and green particles could be obtained in the future by using a high speed color camera, a shorter wavelength high-powered laser (i.e. Mercury Vapor) and a band reject filter at the wavelength of the laser.

STUDENT
Luis Henry

ADVISER(S)
Dr. Jon Arney (Imaging Science)

TITLE
Analytical Protocol for the Measurement of Differential Gloss

ABSTRACT

The differential gloss (DG) is an area of study in the print industry that has invoked much research. DG is the phenomena where ink on a given substrate would have different specular characteristics than different ink on the same or on a different substrate. Therefore the exploration and characterization of this phenomenon is valuable. To assist in this exploration, a Micro-goniophotometer that has been developed in the Print Research and Imaging Systems Modeling Laboratory (PRISM laboratory) that is run by Dr. Jon Arney will be used. This instrument measures the average irradiance, I, detected for each sample angle, which is then plotted to create a bi-directional reflectance distribution function, BRDF. The goal of this project was to generate an experimental protocol for this Micro-goniophotometer that would allow widespread use. Test target patterns have been developed that consist of ten pattern pairs and one target containing all possible color combinations for a printer's primary ink tones (cyan, yellow, magenta, black). In order to place an actual value on differential gloss, a metric has been proposed. The modulation over the entire and the peak of the BRDF for each specular reflection scan were performed as the metric for this experiment. It was found that the proposed metric and target patterns seemed to provide adequate preliminary results. Psychometric functions will have to be applied to our proposed test target patterns for validation. Once validated, psychovisual tests will have to be performed and compared to test target modulation values results.
STUDENT
Matthew Risi

ADVISER(S)
Dr. Zoran Ninkov (Imaging Science)

TITLE
The Rochester Institute of Technology Multi-Object Spectrometer (RITMOS) : Calibration and Data Analysis
(presented at the NYSTAR/CEIS University Technology Showcase February 2008 at the Rochester Hyatt)

ABSTRACT
The Rochester Institute of Technology Multi-Object Spectrometer (RITMOS) utilizes a Texas Instruments Digital Micromirror Device (DMD) for target selection, instead of the fiber bundles or customized slit masks normally used in multiobject spectroscopy. The 848x600 DMD sits at the telescope focal plane, and allows for an individual pixel's incident energy to be deflected down one of two optical paths. In normal operation, the optical path (referred to as the imaging path) consists of an Offner relay to re-image the DMD onto a CCD detector. The location of desired targets is noted, and these pixels are directed to the second optical path, i.e. the spectroscopy path, which 1200 1/mm transmissions grating to disperse spectra onto a second CCD. For the device to be used effectively, the optical characteristics of the system, including scattering and dispersion, must be understood. We present a description of the system, with limited design details, our experimental setup and procedure for calibration, and the results of our methods on sample data.

STUDENT
Shawn Staudaher

ADVISER(S)
Dr. Navalgund Rao (Imaging Science)

TITLE
A Method for Finding the Point Spread Function of a Single Transducer High Frequency Ultrasound Imaging System

ABSTRACT
The purpose of this research is to find the point spread function of a high frequency single transducer ultrasound (US) imaging system. To do this, a line wire phantom can be imaged to produce a line-spread function. By mathematical means the point spread function can then be derived from the line spread function. The point spread function is a measure of the resolution of the system and can also be used to reduce noise caused by scattering in ultrasound images. One of the problems with high frequency transducers is that there is a large change in resolution when the thickness of the material imaged changes. If there is a method to quickly find the point spread function at a given thickness then the resolution of the system can be known. Also, it is possible to use the point spread function to improve the resolution of the system by using the point spread as a filter and convolving it with the resultant image. Once the point spread function is found in this research then perhaps future research can use the point spread function to develop a method to improve the resolution of the system.

Post-Graduation Plans
• Jamie Albano will be continuing on to graduate school in Imaging Science here at RIT.
• Russell Barkley will be moving to Northern Virginia to begin a career with ITT Space Systems Division.
• Luis Henry will be moving to Northern Virginia to begin a career with Lockheed Martin.
• Matthew Risi will be heading to graduate school at the University of Arizona with a focus on optical sciences.
• David Shapiro is seeking full-time employment.
• Shawn Staudaher will be heading to the University of Wyoming to begin his career as a research staff member in department for Astronomy and Astrophysics.

Closing Remarks
For those of you who have been associated with the Center for Imaging Science (or for you “old-timers” the Photographic Science program) you surely have a fond memory or two of the end of the year Scavenger Hunt. While the recording modality has changed over the years, one thing that has remained the same is the imagination and creative energies of our students. If you would like to view this year’s entries in the Scavenger Hunt (including a valiant effort by the faculty/staff team) please visit http://www.cis.rit.edu/pelz/hunt_08/.
Minors
Imaging Science
Students pursuing a minor in Imaging Science have the opportunity to build a secondary area of expertise in support of their program or other areas of interest. To date, 13 students have graduated with a minor in Imaging Science and several other minors are currently in progress.

Optical Sciences
The optical sciences minor will provide students with a background in a broad set of technologies and techniques for exploiting properties and applications of light. In order to earn the minor, a student must take
(1) A course in each of three fundamental areas of optical sciences:
   a. optical principles
   b. sources of electromagnetic radiation
   c. detectors
(2) Two elective courses (from an approved list) that provide specialization in any of the areas listed in (1).

Astronomy
Astronomy is an interdisciplinary minor offered jointly by the Department of Physics and the Chester F. Carlson Center for Imaging Science, and administered through the Department of Physics. Students will have the opportunity for additional study in astronomy in order to build a secondary area of expertise in support of their program or other areas of interest. To date, 12 students have graduated with a minor in astronomy.

Digital Cinema Program
The RIT School of Film and Animation (SoFA) and CIS continued their partnership for a second year with the BS Digital Cinema program, providing students a science and engineering-based education in the fundamental imaging technologies used in the motion picture industry. By joining a core curriculum in practical filmmaking from the College of Imaging Arts and Sciences and image science from CIS, this program trains students in the art and science of feature film, television, and animation production. Graduates of the Digital Cinema program should enjoy varied career opportunities, from feature film and television post-production to imaging equipment design to essential motion imaging technology research and development. Within the motion picture industry, graduates will command considerable attention thanks to training that places them at a substantial advantage versus more traditional engineering degree recipients.

During its sophomore year, Digital Cinema added two new faculty members to the program. David Long joined as permanent Chairperson for Digital Cinema at the start of the year. Previously with Eastman Kodak's Entertainment Imaging research labs, Long brings experience in color science, film design, and digital systems integration. In February of 2008, Long was one of 4 Kodak scientists recognized with an Academy Award for the design of the Vision2 Color Negative motion picture films. Joining Long at the end of the year also from Eastman Kodak was Ricardo Figueroa. Figueroa worked in digital motion camera research and design as well as field engineering for Kodak's East Coast and Latin American regions.

In 2007-2008, Digital Cinema students along with the BFA students in SoFA moved into a new $4 million facility in the basement of the Gannett building. The new space provides state-of-the art equipment and theaters for the production, post-production, and exhibition of student projects. The facility will further serve as home to expected equipment acquisitions in motion picture film scanning and color grading equipment consistent with that found at top post-production houses around the world.

With the 2008-2009 freshman class, Digital Cinema now boasts over 30 participating students. The connection between the School of Film and Animation and CIS has enriched the experiences for students in both programs and promises to provide even more opportunity for study and research within the rapidly exploding technologies being used in Hollywood and around the world.
The 2007-2008 academic year was significant for the large number of degrees granted. The May 2008 graduation saw a record number of Ph.D. graduates (14) from the Center for Imaging Science. There were also 10 MS degrees granted. The Center for Imaging Science Graduate Faculty continues to grow, with new additions in tenure-track and non tenure-track positions. There are now 42 members of the CIS Graduate Faculty. The Center now has 21 tenure track Faculty, 14 Graduate Program Faculty (previously known as Extended Faculty), three Affiliate Faculty, six Research Professors (at various ranks), and one CIS Fellow. All of these faculty positions give these individuals direct means for participating in CIS research projects and graduate student committees.

Curriculum Changes
With the new core courses largely in place, the focus for graduate level courses shifted to approving new and revised courses in the concentration tracks. The College of Science Curriculum Committee approved courses in Geometrical Optics and Lens Design (1051-736), Pattern Recognition (1051-784), The Human Visual System (1051-720), Photogrammetry (1051-759), Remote Sensing: Systems, Sensors and Radiometric Image Analysis (1051-762), and Remote Sensing: Spectral Image Analysis (1051-763). An important curriculum change to the Ph.D. program credit distribution was approved and implemented immediately during the 2007-2008 school year. The minimum number of course credits was reduced from 72 to 60. The minimum number of research credits remains 27 and the minimum number of total credits remains 99. The effect of the change is that the student and adviser can define a plan of study that has a range of 60 to 72 course credits and a range of 27 to 39 research credits to meet the 99 credit total. This change allows more flexibility in defining study plans and provides the student and adviser the opportunity to put more emphasis on research.

The faculty also approved an early admission program for exceptionally qualified RIT students interested in obtaining an Imaging Science M.S. in as little as five years. Exceptional students (minimum GPA of 3.4 in the appropriate calculus and physics courses) may apply for admission to the MS program in the spring quarter of their junior year. If a positive admission decision is made, it becomes effective the fall quarter after their senior year. During their senior year the students may take up to 12 credits of graduate coursework that will count toward the MS. The remaining 24 course credits and nine research credits can be earned in the first year (and summer) of their graduate program, allowing them to defend their MS thesis as soon as the end of summer quarter in their first year. These students would typically not be eligible for tuition remission because their tight schedules would preclude them serving as a teaching assistant.

Graduate Student Body
There are 91 continuing graduate students pursuing advanced degrees in Imaging Science. These students come from at least nine countries. There were 44 MS students and 47 Ph.D. students enrolled during the 2007-2008 academic year.

Incoming Class Profile (Fall 2008)
There were 27 students admitted to the Imaging Science graduate program for the 2008-2009 academic year. There are 14 Ph.D. students, eight MS students, including both full and part time, and five online MS students. Seventeen of the incoming students are fully funding with tuition and stipend in their first year. The remainder are partially funded or funded by their employers. Industry or government funded graduate students are from the US Air Force, Canadian National Forces, Onyx Graphics, Xerox, Sensor Technologies, and ITT. The new international graduate student body is from Canada, China, India, Iran, and Taiwan.
Student Publications and Presentations

Publication and presentation is a critical aspect of any graduate research program. Imaging Science graduate students published journal articles, conference papers, and attended a wide variety of conferences, gaining valuable communication and networking experiences. The following is a partial list of publications and conference proceedings authored or coauthored by our graduates in the 2007-2008 year.

Selected Journal Articles with Student Authors:


Selected Conference Papers with Student Authors:

Graduates
In May 2008, the following students graduated with a Ph.D. in Imaging Science:

• Andrew J. Adams, Multispectral Persistent Surveillance, Adviser: John R. Schott
• Brent D. Bartlett, Improved Retrieved Reflectance in the Presence of Clouds, Adviser: John R. Schott
• Karl G. Baum, Multimodal Breast Imaging: Registration, Visualization, and Image Synthesis, Adviser: Maria Helguera
• Marvin Boonmee, Land Surface Temperature and Emissivity Retrieval from Thermal Infrared Hyperspectral Imagery, Adviser: John R. Schott
• Michael S. Foster, Using Lidar to Geometrically-Constrain Signature Spaces for Physics-Based Target Detection, Adviser: John R. Schott
• Adam A. Goodenough, In-Water Radiative Transfer Modeling Using Photon Mapping, Adviser: John R. Schott
• Stephen R. Lach, Semi-Automated DIRSIG Scene Modeling from 3D Lidar and Passive Imagery, Adviser: John P. Kerekes
• Mahdi Nezamabadi, The Effect of Image Size on the Color Appearance of Image Reproductions, Adviser: Roy S. Berns
• Derek J. Walvoord, Advanced Correlation-Based Character Recognition Applied to the Archimedes Palimpsest, Adviser: Roger L. Easton, Jr.

• Jason T. Ward, Realistic Texture in Simulated Thermal Infrared Imagery, Adviser: John R. Schott
• Hongqin Zhang, Color in Scientific Visualization: Perception and Image-Based Data Display, Adviser: Mark D. Fairchild
• Yonghui Zhao, Image Segmentation and Pigment Mapping of Cultural Heritage Based on Spectral Imaging, Adviser: Roy S. Berns

In May 2008, the following students graduated with an MS in Imaging Science:

• Farouk H. Bonilla-Mendoza, Adviser: Roger Easton
• Jason T. Casey, A Comparative Analysis of Hyperspectral Target Detection Algorithms in the Presence of Misregistered Data, Adviser: John Kerekes
• Manuel Ferdinandus, Selection of Optimal Background Estimation Methods from Unstructured Detectors, Adviser: John R. Schott
• Gregory Gosian, A Survey of Image Compression Techniques Utilized for Image Acquisition on Various Solar System Probes, Adviser: Carl Salvaggio
• Joseph Handfield, High Resolution Source Localization in Near-Field Sensor Arrays by MVDR Technique, Adviser: Raghuveer Rao
• Laurie A. Hill, Wavefront Sensing in Optical Metrology, Adviser: Zoran Ninkov
• Francisco J. López, Adviser: Roger Easton
• Shari McNamara, Using Multispectral Sensor Wasp-Lite to Analyze Harmful Algae Blooms, Adviser: Anthony Vodacek
• Dean A. Pulsifer, Adviser: John Kerekes
• Megan K. Thompson, Adviser: Harvey Rhody

The following are the post-graduation plans for the students who graduated in May 2008:

• Andrew Adams, USAF, Virginia
• Brent Bartlett, Confero Solutions, Philadelphia
• Karl Baum, CIS postdoc
• Farouk Bonilla-Mendoza, Xerox, Rochester
• Marvin Boonmee, EFILM, California
• Michael Foster, USAF, Virginia
• Adam Goodenough, CIS research staff
• Jason Casey, Logos Technology, Virginia
• Manuel Ferdinandus, USAF, Virginia
• Gregory Gosian, ITT, Rochester
• Laurie Hill, ITT, Rochester
• Stephen Lach, USAF, Virginia
• Yan Li, Rapiscan, California
• Francisco López, Xerox, Rochester
• Shari McNamara, ITT, Rochester
• Mahdi Nezamabadi, Dolby, Pennsylvania
• Dean Pulsifer, Lexmark, Kentucky
• Megan Thompson, Xerox, Rochester
• Derek Walvoord, ITT, Rochester
• Zhen Wang, undecided
• Jason Ward, USAF, Virginia
• Hongqin Zhang, KLA-Tencor, California
• Yonghui Zhao, Xerox, Rochester
ImagineRIT: The Color Science Building was open during the inaugural ImagineRIT Festival in May. There were several demonstrations of ongoing research projects and student research presentations. Here, Color Science M.S. student, Stefan Luka, is pictured reviewing a color science journal in our dedicated surround illumination room capable of being illuminated with 16.7 million colors through fully programmable red, green, and blue LEDs.
Imaging Science Online Program

For the academic year 2007-08, 10 students applied to the MS Imaging Science online program, five students were admitted and of those five, three students enrolled and one changed to a different online program at RIT. A total 61 students enrolled in the 15 courses offered online. In response to faculty and student evaluations, a technical support person was hired to assist faculty with setting up and monitoring the online delivery of course content taught in a simulcast method. The online program continues to serve students at a distance as well as those in the local area. Currently, we have 16 MS students enrolled exclusively through the online program. Employers sponsoring online students include Xerox, Lockheed-Martin, USAF, Hewlett-Packard, Boeing, IBM, Infineon, and CalTech. The following students were certified for the MS Degree/Project Option in 2007-08 and enrolled in at least some of their courses, if not all as in the case of Dean Pulsifer, in an online format:


**Dean Pulsifer**, Comparison of Fusion Techniques Using Spectral and Elevation Data, Project Adviser: John Kerekes (Employer: Lexmark)

**Azary Sherif**, Local Inhibition Motion Detector, Project Adviser: Roger Gaborski (Employer: Xerox)

**Francisco Lopez**, Comparison of Various Methods for Non-Contact Optical Thickness Measurement, Project Adviser: Roger Easton (Employer: Xerox)


Color Science Graduate Program

Graduate Coordinator’s Comments
By Mark D. Fairchild

Overview

RIT offers both MS and Ph.D. Degrees in Color Science; the doctoral program commenced with its first group of students in the Fall of 2007. The curriculum consists of required courses in color science, electives, an MS level research project, and a research dissertation. These are the only graduate programs in the country devoted to this multidisciplinary science. Color science broadly encompasses physics, chemistry, anatomy, physiology, psychology, imaging science, mathematics, statistics and computer science. The programs are designed for students whose undergraduate majors are in these and related disciplines pertaining to the quantitative description of color.

Incoming Class Profile (Fall 2008)

Three students who entered the Ph.D. program in Fall, 2007 passed their qualifying examinations this past spring and are heading into the dissertation phase of the program (they all entered with previous MS degrees). In Fall, 2008 we expect three to four new students to join the program.

2008 Graduates

Three students completed their Color Science MS degrees in the 2007-2008 academic year. They include:

**Stacey Emery Casella**—Canandaigua, NY (Employed by ITT in Rochester)

**Abhijit Sarkar**—Kolkata, India (Entering a Ph.D. Program in France)

**Shizhe Shen**—Shenyang, China (Future TBD)
An infrared mosaic of the power plant and cooling pond in Midland, Michigan, collected during the winter when the pond was partially frozen. False color indicates apparent surface temperature (warm is yellow, cold is blue).
Digital Imaging and Remote Sensing Laboratory (DIRS)

Overview:

During the past year, the Digital Imaging and Remote Sensing Laboratory continued to produce excellent research and graduated a number of students with theses covering a wide range of topics. Dr. John Schott, Director of the lab, was on sabbatical during the 2007-08 academic year and during that time Dr. David Messinger served as the Interim Director. The research group is made up of six faculty, nine full time research staff, and over 30 student researchers at the undergraduate and graduate level. There were 13 graduate theses defended successfully during the past year and the group continues to support a wide range of sponsors on over 20 research projects.

Staff:

The DIRS group consists of six faculty members and nine research staff. CIS faculty members associated with the lab are: Dr. John Schott (Lab Director), Dr. Tony Vodacek, Dr. Carl Salvaggio, Dr. John Kerekes, Dr. David Messinger and Dr. Emmett Ientilucci. Dr. Ientilucci was promoted to the position of Assistant Research Professor in CIS in the spring of 2008. The research staff includes Scott Brown, Dr. Mike Gartley, Dr. Adam Goodencough, David Pogorzala, Nina Raqueno, Dr. Rolando Raqueno, Mike Richardson, Niek Sanders, and Cindy Schultz.

New Research Programs Won:

Thirteen new research programs were successfully funded during the past year. Here we briefly describe some of them:

Dynamic Analysis of Spectral Imagery for Large Area Search Applications, NGA University Research Initiative—This project seeks to use new mathematical approaches from fields such as topology and graph theory to develop new processing schemes particularly aimed at identifying man-made phenomena in large area coverage hyperspectral imagery. It is a collaboration with Dr. Bill Basener in the RIT School of Mathematical Sciences.

Bi-directional Reflectance Distribution Function (BRDF) Emulation, Intelligence Community Postdoctoral Research Fellowship—Under this two-year effort, new methods are being developed to use the DIRSIG radiative transfer modeling tool to emulate BRDF properties of materials, particularly those with contaminated surfaces. These methods will help minimize the need for time-consuming laboratory measurements and provide a wider variety of material properties to be used in scene simulations and exploitation algorithms.

Ice Characterization Using Remote Sensing Techniques, Savannah River National Laboratory, Dept. of Energy—Our collaborators at SRNL have extensive hydrodynamic and thermodynamic modeling capabilities for simulation of industrial cooling ponds. However, these models are less reliable under conditions where the ponds are frozen. Under this program we will be using remote sensing techniques to characterize ice and snow on cooling ponds to use as inputs to their improved modeling capabilities.

Performance-driven Multi-modal Optical Sensor System Modeling, Air Force Office of Scientific Research—This project will study the design and modeling of a multi-modal advanced sensor for remote sensing applications. The project is a collaboration between Dr. Zoran Ninkov (CIS Faculty) and Dr. Alan Raisanen of the RIT IT Collaboratory. Sensors with multiple imaging modalities (e.g., polarimetric, spectral, etc.) using a single focal plane will be investigated through scene simulation and design trade studies.

Common Sensor Payload Image System Modeling, US Army Night Vision Laboratory—The Common Sensor Payload is a package of sensing systems being developed by the US Army. Under this program, we will use the DIRSIG simulation tool to model one of the system imaging capabilities for use in training of analysts and for system performance studies.

Plant Sentinel Biosensors Research, Air Force Research Laboratories Small Business Innovative Research Phase II Grant—This program is a collaboration with Qaim Technologies (Dayton, OH) and Colorado State University to understand the properties and potential uses of genetically modified plants for detection of explosives through plant de-greening. DIRS will be making spectral measurements of the plants and simulating scenarios and sensors with DIRSIG.

Spectral Remote Sensing for Archeology Studies of State Formation and Complex Societies, NASA—This project is a collaboration with Dr. Bill Middleton, RIT Department of Material Culture Sciences, archeologist who specializes in the Zapotec culture of Oaxaca, Mexico. Researchers from the University of Colorado are also part of the research team. Satellite imagery from the Earth Observing 1 platform will be used to develop landscape maps of the Oaxaca region to help understand how the region has changed in the 30 years since the last maps were made, as well as help identify natural resources located at the archeological sites.

Landsat Data Continuity Mission, US Geological Survey—Under this research program, system performance and water quality product generation techniques for the Landsat Data Continuity Mission (LDCM) are being studied. The next Landsat satellite will have new spectral channels and improved system performance allowing for new environmental studies to be conducted using the imagery. DIRS is investigating the use of a new spectral channel in the blue portion of the spectrum for improved atmospheric compensation and water quality estimation.
Two RIT Students on Path to Improving National Security

James Albano and Philip Salvaggio receive scholarships from U.S. Geospatial Intelligence Foundation

The United States Geospatial Intelligence Foundation has awarded scholarships to a pair of Rochester Institute of Technology students. James Albano and Philip Salvaggio will both receive $5,000 towards their education based on academic and professional excellence in a field related to the geospatial intelligence tradecraft.

Geospatial intelligence is used to exploit and analyze satellite imagery and mapping data to reference activities on Earth. This intelligence has the potential to help in matters of national security with the correct applications.

Albano, a 2002 Fairport High School graduate, is a student in the imaging science doctoral program. His current research is in the area of target detection algorithms and modeling.

Salvaggio is a first-year student pursuing a double major in computer science and imaging science. In the past year, he has developed geospatial applications to distribute ground truth data and redesigned the web site and databases at the Digital Imaging and Remote Sensing Laboratory in RIT’s Chester F. Carlson Center for Imaging Science. Salvaggio graduated in June from Webster Thomas High School.

The United States Geospatial Intelligence Foundation awarded 13 students with scholarships this year, totaling $56,000. This is the first year RIT students have received scholarships since the program started in 2004.

The foundation is a not-for-profit educational corporation dedicated to promoting the geospatial intelligence tradecraft. Its focus is on the development and application of geospatial intelligence to address national security objectives.

For more information on the foundation, visit www.usgif.org

Scientists peer through frozen ‘cooling lake’ to gauge energy production

October 17, 2008
By Susan Gawlowicz

Once a week, starting in November and running through April, a small plane will fly overhead in Midland, Michigan, taking images of a frozen lake attached to a power plant. RIT graduate student May Arsenovic will travel to Midland throughout the winter to verify the ground data.

Arsenovic, a doctoral candidate in the Chester F. Carlson Center for Imaging Science, is working with CIS professor Carl Salvaggio, and a team of research faculty to study the frozen cooling lake for the U.S. Department of Energy’s Savannah River National Laboratory.

The DOE-funded project, worth $949,971, will develop technology to monitor energy production at power plants in some foreign countries.

The cooling lake in Midland was picked because it is the only one in the United States that freezes. It is much bigger than it needs to be to cool the power plant and, as a result, the amount of hot water discharged into the lake cannot warm the entire body of water in the winter. The overcapacity of the cooling lake harkens to discarded plans to build a nuclear facility at the site. Public outcry led to the construction of a smaller gas-powered plant instead.

Studying the frozen cooling lake poses many challenges for Salvaggio’s team as it seeks to remotely gather information obscured by a layer of ice and snow. The scientists are interested in the thermal turbulence that takes place when the hot-water discharge mixes with the cold water in the lake. The melt hole created as the hot water pours into the lake is their main source for deducing the power levels produced at the site.

“The research aspect of this project will investigate how ice acts as an insulator and determine how much energy is kept inside the lake because there’s an ice layer over it,” Salvaggio says.

His team will measure the temperature of the hot water with thermal infrared imagery. The scientists will also calculate the thickness and insulating capacity of the snow and ice with passive microwave remote sensing—which has a longer wavelength than infrared.
Explore Ancient Mexico

Archaeologist Uses Satellite Imagery to Explore Ancient Mexico

RIT Professor Bill Middleton uses novel approach to study Zapotec culture

Satellite imagery obtained from NASA will help archeologist Bill Middleton peer into the ancient Mexican past. In a novel archeological application, multi- and hyperspectral data will help build the most accurate and most detailed landscape map that exists of the southern state of Oaxaca, where the Zapotec people formed the first state-level urban society in Mexico.

“If you ask someone off the street about Mexican archeology, they’ll say Aztec, Maya. Sometimes they’ll also say Inca, which is the wrong continent, but you almost never hear anyone talk about the Zapotec,” says Middleton, acting chair of the Department of Material Culture Sciences and professor in the Department of Sociology and Anthropology at Rochester Institute of Technology. “They had the first writing system, the first state society, the first cities. And they controlled a fairly large territory at their zenith—250 B.C. to 750 A.D.”

The process of state formation varied across the Zapotec realm. Sometimes it involved conquest, and other times it was more economically driven. Archeologists like Middleton are interested in different aspects of society that emerged in the process, such as social stratification and the development and intensification of agriculture and economic specialization.

Middleton’s study will explore how the Oaxacan economy and environment changed as the Zapotec state grew and then collapsed into smaller city-states. Funding from NASA and National Geographic will also help Middleton build a picture of how climate and vegetation patterns have changed over time.

“For the past 4,000 years, human activities have been a factor in environmental change,” Middleton says. “And there are some parts of Mesoamerica that we have pretty good evidence that the environment we see today is the catastrophic result of ancient agricultural practices.”

Middleton will focus on two sites in the Chichicapam Valley located in between two of the major arms of the central valleys of Zapotec. The National Geographic-funded portion of the study began last summer when he documented important archeological sites and selected candidates for excavation.

Imagery from Earth Observing 1 and Landsat satellites obtained over three years will help Middleton identify the natural resources found at archeological sites. He will work with colleagues John Kerekes and David Messinger along with graduate student Justin Kwon in RIT’s Chester F. Carlson Center for Imaging Science to analyze the large amounts of data taken at different wavelengths of the electromagnetic spectrum. Their own research uses similar techniques to analyze urban landscapes, and inspired Middleton to apply the technology to archeological landscapes.

“We are excited to be collaborating with Bill in this application of remote sensing technology to archeological study,” says Kerekes. “This project shows a true strength of RIT with an environment that allows physical scientists and engineers like us to easily work together with a social scientist like Bill.”

Adds Messinger: “Applications of remote sensing have long been a motivating factor for our technology work in the field of remote sensing, and the chance to work closely with an end-user here at RIT is a fantastic opportunity for our students and faculty. By learning more about how the technology can help in this application, we will be in a much better position to guide our future sensor development and algorithmic research.”

The technology works by differentiating materials on the ground on the basis of reflected light. Objects that look the same in visible light may have very different reflective properties when sampled across the spectrum.

“When you put the data back together as a picture you begin to see things you couldn’t see before, and you can make distinctions that to your eyes look the same,” Middleton says.

Satellite imagery covering more than 30,000 square kilometers will help Middleton identify different plant species, environments and ecosystems, and acres of arable land or mineral resources surrounding particular sites.

“We can start looking at the relationship between ancient cities and ancient human settlements in a way that no one has really been able to do before,” Middleton says.

The new landscape map will also show how development has changed the region since the first survey conducted 30 years ago.

“We will be able to compare the then-and-now images and be able to make a very good assessment of what we have lost in the past several decades as a result of development,” Middleton says.

Another aspect of the NASA-funded project will focus on environmental change. This part of the study, done in conjunction with colleagues at the University of Colorado at Boulder will analyze plant microfossils in sediment samples collected from a variety of locations, including areas where streams expose sediment layers 10,000 years old.

“Roughly 10,000 years ago, Oaxaca was wetter than it is today,” Middleton says. “Today it’s classified as semi-arid, and the dominant vegetation in the valley is thorn-scrub forest. Ten thousand years ago, it was a grassland and there were horses there.”
NASA's SOFIA Observatory. Courtesy of NASA.
Laboratory for Imaging Algorithms and Systems (LIAS)

Overview

The Laboratory for Imaging Algorithms and Systems was founded in 2001 to develop imaging systems and algorithms and carry them to the point of prototypical use. LIAS operates 4 airborne imaging systems. Imagery from these sensors is processed into georeferenced images for integration and display with standard geographic information systems (GIS).

The systems include:

- **WASP**: High performance visible/IR (RGB, SWIR, MWIR, LWIR) mapping system
- **WASP LITE**: Low cost, light weight 7 band imaging system with reconfigurable spectral filters
- **MISI**: 70 band visible, 10 band infrared imaging spectrometer
- **CAMMS**: compact, lightweight mapping system for light aircraft or UAV applications

Imaging algorithms are developed by the group, often in collaboration with the DIRS laboratory, for the extraction of information from remote sensing imagery. A camera geometry calibration laboratory with a unique imaging cage has been constructed for the calibration of infrared and visible camera equipment. An airborne system software architecture has been developed to manage real-time collection, processing and delivery of image and sensor information to end users such as emergency responders.

The LIAS Ground Station Laboratory develops sensors that can be deployed on the surface or in the water to monitor environmental parameters for environment and emergency response monitoring. The ground sensor systems and the airborne systems can be used together to provide an integrated view of the environment using imagery and sensor data.

The WASP system is unique in its ability to do rapid image collection in both visible and infrared bands and its ability to process and deliver the imagery to users in various locations in real-time. The airborne data processing (ADP) architecture supports sensors, algorithms and communications as modules in a network environment. This enables distributed processing between remote and ground stations and immediate response to users. The uniqueness of this framework led Leica Geosystems, Inc. to name LIAS a Center of Excellence in Photogrammetry and Remote Sensing.

LIAS is made up of a lead faculty member, associated research faculty and staff, and laboratory staff. The faculty lead is Harvey Rhody, and associated faculty and research staff include Eli Saber, John Kerekes, John Schott, Vincent Amuso, Soheil Dianat, David Messinger, Carl Salvaggio, Bob Kremens, and Don Light. The LIAS staff include Don McKeown, Jason Faulring, Bob Krzaczek and Bill Hoagland. Graduate students who are working on laboratory supported or related projects are Xiaofeng Fan (Rhody), Prudhvi Gurram (Saber).

LIAS is housed on the third floor of the IT Collaboratory building where it moved in 2006. The current facilities include about 10,000 square feet of laboratory space for the construction and calibration of equipment and the development of software systems.

Major Projects in 2007

**SOFIA Data Cycle System (DCS)**—This year saw the continuation of the grant for the development of the DCS for the Stratospheric Observatory for Infrared Astronomy (SOFIA). This project was begun several years ago to develop a complete observation management system for general investigators for this major NASA observatory. The DCS was successfully delivered for integration this year. Bob Krzaczek is the lead software architect on this project which is undergoing the final stages of integration at NASA. The SOFIA Data Cycle System is a novel component of the observatory and will be in daily use when the observatory begins flying in late 2008. Figure 1 shows the layout of the SOFIA observatory on a specially modified Boeing 747.

**Integrated Sensing Systems Initiative (ISSI)**—ISSI is a program that follows on the highly successful WASP program. The WASP system, originally conceived as a new airborne system for the detection and mapping of wildfires in support of the US Forest Service, was successfully demonstrated as a tool for disaster response and law enforcement during 2007. A key objective is to demonstrate the integration of WASP imagery information products into the disaster response workflow. Demonstration participants included New York State Electric and Gas (NYSEG), Monroe County Office of Emergency Management, New York State Department of Environmental Conservation, and the New York State Police.

RIT conducted a demonstration flight over a river area that had flooded the previous year and during which a flood map was built over a three-day period. In the RIT demonstration, the same flood area, over 40 linear miles, was mapped in less than two hours. Figure 2 shows a mosaic of the RIT image map overlaid on a LANDSAT image base map. The inset shows the detailed resolution that is available in the mosaic. The resolution of the satellite image base map is only about 50ft and the mosaic imagery from the RIT system is about 1ft.

![Figure 1: NASA's SOFIA Observatory](image)
Development of the WASP system has progressed to include the use of a digital data downlink that transfers geo-referenced imagery to a ground station from the aircraft in realtime as the imagery is collected. Thus the WASP system has demonstrated multi-band visible and infrared imaging capability, on-the-fly geo-referencing of the imagery to a map, and realtime delivery of the imagery to a remote ground station.

Technology Transfer Projects—LIAS under sponsorship from the New York Office for Science, Technology, and Innovation (NYSTAR), and in collaboration with Geospatial Systems Inc. (GSI) has delivered to GSI a very lightweight, and compact integrated airborne mapping camera system suitable for installation in small unmanned aerial vehicles (UAVs). This system, called CAMMS, is the prototype for a new product introduced by GSI called the Tactical Airborne Mapping and Surveillance System (TAMSS) as seen in Figure 3.
NGA University Research Initiative (NURI)—The goal of this three-year NURI project is the development of semi-automated tools for the construction of models such as those used in DIRSIG from a variety of imagery and sensor data. We are in the third year of this project and have succeeded in the development of techniques to register imagery from visible and infrared airborne camera systems (WASP and WASP Lite) as well as Lidar imagery and some line scanner hyperspectral imagery (MISI). This past year we integrated feature extraction tools and the ability to construct 3D models as shown in Figure 4.

Group Publications


Prudhvi Gurram, Eli Saber and Harvey Rhody, “A Novel Triangulation Method for Building Parallel-Perspective Stereo Mosaics”, Electronic Imaging Symposium, San Jose, CA, Jan 2007

Seminars and Presentations


Harvey Rhody, Automated Imagery Analysis & Scene Modeling, NARP Symposium, September 13-15, 2006, Washington, DC
RIT and Geospatial Systems Inc. Unveil New Airborne Imaging System

Technology advances use of remote sensing in homeland security and incident response

Geospatial Systems Inc. and Rochester Institute of Technology recently completed a joint project demonstrating a compact, rapidly-deployable airborne imaging system for emergency and tactical applications. The system greatly enhances image quality, resolution and geo-positioning capabilities, while also reducing the setup and installation time required for airborne deployment.

Geospatial Systems is currently commercializing the technology as part of their TerraPix platform product line for airborne survey and mapping. The TerraPix system is designed for use in homeland security, incident response, asset monitoring and defense. The TerraPix is already being installed in an unmanned aerial vehicle for a U.S. Army urban surveillance program, and in a UAV for a U.S. Navy sponsored project.

"Geospatial Systems is pleased to combine our leading-edge technologies and products with the educational resources of RIT to make advances in the airborne imaging market," says Maxime Elbaz, president and CEO, Geospatial Systems Inc. "Equipping emergency response teams with the essential tools to provide the highest quality assistance to the community is a project we are very proud to take part in."

"Our long-standing partnership with Geospatial Systems continues to demonstrate the value of pairing the talent and expertise of a university with the drive and innovation of industry," adds Harvey Rhody, director of the Laboratory for Imaging Algorithms and Systems within the Chester F. Carlson Center for Imaging Science at RIT.

As part of the joint effort, Geospatial Systems donated a TerraPix sensor controller, along with one of their high-precision KCM digital imaging modules to the Laboratory for Imaging Algorithms and Systems. The research partnership focused on integrating the imaging system payload, including the geo-positioning device, as well as improving the system’s ability to process and compress high volumes of data and stream it over a digital data link. The project was co-funded by Geospatial Systems, RIT, and the New York State Foundation for Science, Technology and Innovation.

April 3, 2008
By Susan Gawlowicz

RIT scientists ‘feel the burn’ of wildfire research

Scientists from RIT recently helped the U.S. Forest Service collect information about wildfire behavior, atmospheric dynamics and fire effects in controlled burns in Florida and Georgia as part of an exercise called Rx-CADRE—Prescribed Fire Combustion-Atmospheric Dynamics Research Experiments. Robert Kremens, research professor, and Jason Faulring, systems integration engineer, in RIT’s Chester F. Carlson Center for Imaging Science, joined wild land fire managers and researchers from around the country during the first week of March for wildfire experiments at Eglin Air Force Base in Florida and at the Jones Ecological Research Center near Newton, Ga. Researchers used a variety of ground-based and airborne instruments to observe the controlled fires. Data collected from the experiments will help fire managers model and predict the behavior of fires influenced by fuel type, fuel loading, local weather and other variables. "Over 40 of the nation’s best fire scientists participated in what I believe is the most instrumented wild land fires ever," Kremens says. "Five fires were flown in one week, collecting what I believe to be the best data set ever obtained from any wild land fire experiment. I have no doubt we will be studying these events for a long time." RIT participation included the development and deployment of several critical ground-based sensor systems and an airborne fire-mapping camera system. Pre-positioned ground-based sensors monitored various fire characteristics as the fire progressed, says Donald McKeown, distinguished researcher in RIT’s Laboratory for Imaging Algorithms and Systems. Faulring operated the fire-mapping camera system from the back of a light aircraft flying over the fires and continuously photographed the progress of the burn.

The camera is a lightweight version of the Wildfire Airborne Sensor Program RIT developed for the U.S. Forest Service, and is dubbed "WASP-Lite." It is equipped with color and thermal infrared cameras and an inertial navigation system to precisely map fire location. The WASP-Lite sensor is installed in an aircraft provided by Kucera International, an aerial mapping company, McKeown says. RIT joined several other organizations who participated in this testing operation.
This high dynamic range image of the Golden Gate Bridge was captured 30 minutes after sunset with a series of nine bracketed exposures by Dr. Mark Fairchild. It is rendered for low dynamic range displays or printers using an iCAM-based model of local adaptation in the human visual system.
Munsell Color Science Laboratory (MCSL)

Laboratory Director’s Comments
By Roy S. Berns

Overview
The Munsell Color Science Laboratory was founded at the Rochester Institute of Technology (RIT) in 1983 through a gift from the Munsell Color Foundation, Inc. The laboratory is part of the Chester F. Carlson Center for Imaging Science in RIT’s College of Science. It was created, and continues to operate, with the vision of being the preeminent academic laboratory dedicated to color science education and research and the preferred source of educated color scientists for industry, academia, and government. The following four objectives guide the MCSL faculty, staff, and students in their endeavors to fulfill this vision.

1) To provide undergraduate and graduate education in color science,
2) To carry on applied and fundamental research,
3) To facilitate spectral, colorimetric, photometric, spatial, and geometric measurements at the state of the art, and
4) To sustain an essential ingredient for the success of the first three—namely, liaison with industry, academia, and government.

Staff
MCSL is made up of a group of RIT faculty who have joined together with a commitment to the lab’s objectives and its collaborative funding along with the graduate students, technical and administrative staff, and visitors that they supervise and advise. Current faculty associated with MCSL include Roy S. Berns (Richard S. Hunter Professor of Color Science, Appearance, and Technology), Mark D. Fairchild (Professor), James Ferwerda (Associate Professor), Mitchell Rosen (Research Assistant Professor), Noboru Ohta (CIS Affiliate Professor), and Garrett Johnson (CIS Affiliate Professor). Current staff include David Wyble (Associate Scientist), Lawrence Taplin (Assistant Scientist), and Valerie Hemink (Administrative Assistant).

Research Themes
Research in MCSL can be organized into these general themes:

1) Colorimetry including metrology, psychophysics, and tolerance formulae modeling,
2) Image appearance and modeling including psychophysics and HDR displays,
3) 3-D imaging of paintings including BRDF measurements and computer-graphics rendering,
4) Spectral color reproduction including multi-spectral capture, multi-ink inkjet printing, and spectral color management,
5) Art conservation science,
6) Immersive displays,
Facilities

The laboratory has been housed in RIT’s Color Science Building (Bldg. 18) on the south side of campus since the fall of 2003. Previously the laboratory was housed in the Carlson (76) and Gannett (7B) buildings. The current facilities encompass about 8000 square feet dedicated to color science education and research. They include student, faculty, and staff offices, a teaching laboratory (Franc Grum Color Science Learning Center), several research laboratories (Intelligent Lighting, Pixel Liberation Prototyping, Color Measurement, Spectral Imaging, Display and Perception) and support facilities. The facilities have been equipped with several million dollars worth of instrumentation and systems through a long history of external research funding and corporate donations.

Sponsors

Andrew W. Mellon Foundation
Apple
Avian Technologies
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National Institute of Health (NIH)
Nikon
ONYX Graphics
Philips
Ed and Bobbi Przybylowicz
Samsung
Sony
X-Rite

Scholarship

In the past year, MCSL students, faculty, and staff published over 50 journal papers and conference proceedings. Several, highlighting our breadth, are listed below. Further details on MCSL activities and publications can be found at the lab website, www.cis.rit.edu/mcsl or specifically in recent MCSL Annual Reports, www.cis.rit.edu/mcsl/about/AnnualReports.php.

Selected Journal Publications


Experimental iPixLab classroom in the Color Science Building displaying a portion of high resolution image of Van Gogh’s “Starry Night.”
Infinite Pixel Liberation (iPix)
Laboratory

Activity Comments

By Mitchell Rosen, Director

An approach to Smarter Classrooms is part of the iPixLab’s efforts involving a simple idea to wallpaper classrooms with images, movement and sound using networked digital projectors. This has taken hold and is inspiring professors across campus to dive into a new way of teaching. The approach is flexible and easily adapted to traditional learning environments as well as more experimental, active classrooms. A variety of immersive and wide-view displays can now be found on campus. The prototype immersive classroom shown below is in use in the Color Science Building. Here a portion of a high-resolution spectral image of Van Gogh’s “Starry Night” is being examined. Roy Berns’ spectral imaging group digitally photographed the painting at the Museum of Modern Art earlier this academic year using specialized hardware.

The iPixLab is dedicated to realizing the concept of liberated media—content that is set free from the confines of the traditional capture and presentation modalities. Concepts include ambient imaging, wide-view, immersive-view and environmentally adaptive media creation and presentation, transient modalities that include networked participatory instantiation, and aspect-ratio-free media that self-organize for optimal use of encountered physical display modes.

A research laboratory of the Center for Imaging Science in the College of Science, iPixLab takes advantage of the Center’s strengths in fundamental understanding of the underlying technologies for digital capture, image processing, and display and printing sciences to create new systems that “set the pixels free.” The iPixLab was established in 2007 and has partnerships with researchers across and outside the Institute including with the Golisano College of Computing and Information Sciences, the College of Imaging Arts and Sciences, the College of Liberal Arts and the Rochester Museum and Science Center. The Lab is directed by Mitchell Rosen and is partially funded from a gift from the Carlson Charitable Trust.

Ongoing research projects include ambient capture techniques, 360-degree cameras, portable wide-view displays and big-screen technologies. Standards and video processing to support device-independent specification of immersive media is under investigation. In partnership with the Rochester Museum and Science Center immersive, interactive exhibits are being designed and implemented for summer and fall deployment.
Detector test system in the RIDL: This is where all imaging detectors are characterized at the RIDL.
Rochester Imaging Detector Laboratory

Laboratory Director's Comments
By Dr. Don Figer

Overview
The Rochester Imaging Detector Laboratory (RIDL) founded in 2006, enjoyed a year of expansion, growth, and discovery. During the academic year, RIDL hired two additional post-doctorates and a data analyst to work on our mission of identifying massive stars and clusters in the galactic center. These augment our instrumentation development for two major science missions in the next twenty years: the Large Synoptic Survey Telescope (LSST) and the Supernova Acceleration Probe (SNAP). On both missions, the RIDL provides crucial information related to prototype sensors that make these missions so powerful for answering key questions about our universe. In addition, we have made progress in an area that is new to us—designing and fabricating low noise, radiation hardened detectors for a broad range of future Earth and space-bound applications. While some of our goals include detector testing, characterization, and research and development, the staff is deeply involved in scientific discovery. During the year, Ben Davies and Don Figer published their findings on newly discovered massive star clusters, which provide the unique opportunity to study the pre-supernova evolution of massive stars, and the blue- to red-supergiant ratio at uniform chemical content.

Grants and Contracts

New

NASA:
- A Radiation Tolerant Detector for NASA Planetary Missions, June 07-June 09, $592,000
- A LIDAR Imaging Detector for NASA Planetary Missions, Award Pending, $546,711
- “The Journey of a Photon:” High School Student Involvement in Developing their Community’s Understanding of Detector Science for the International Year of Astronomy/Year of Science (2009) and Beyond, Dec 07-June 09, $44,850

Stanford University
- KPNO Observations, Oct 07-Feb 08, $53,880

Stanford Linear Accelerator Center
- Research and Development related to the Large Synoptic Survey Telescope (LSST) camera, Oct 07-Sept 08, $25,000

Current

NYSTAR
- Faculty Development Award, May 06-June 09, $727,900

NASA
- A Very Low Noise CMOS Detector Design for NASA, Jan 07-Jan 10, $847,000
- UC Davis—Applying Detector Advances to LSST Camera, Jan 06-July 07, $125,879

Faculty and Staff
RIDL’s director is Dr. Don Figer who joined RIT as a result of a NYSTAR Faculty Development, grant, which highlights New York State’s commitment to assisting universities develop new areas of expertise leading to economic development. Figer has teamed together with faculty member Zoran Ninkov, Lead Instrument Developer, in proposing and winning numerous NASA grants for the research and development of novel detectors that will fly in future NASA space missions.

Other staff members who assist RIDL with its mission include Brandon Harold, Technician; Zoltan Makai and Christine Trombley, Data Analysts; Jingjing Zhang, Assistant Scientist; Dan Smialek, Administrative Coordinator; and four Post Doctorates: Ben Davies, Quingfeng Zhu, Lucy Hadfield, and Maria Messineo.
November 13, 2008
By Susan Gawlowicz

**RIT earns $2.8 million to design parts for ‘super’ telescope**

The Gordon and Betty Moore Foundation recently awarded RIT $2.8 million to design, develop and build a zero-noise detector for the future Thirty Meter Telescope. Expected to be operational in the next decade, the telescope’s light-collecting power will be 10 times that of the largest telescopes now in operation.

The detector’s new sensing technology promises to penetrate the darkness of space with the greatest sensitivity ever. It could also have applications on Earth to improve everything from cell phone cameras to secure communications and surveillance systems. RIT scientist Donald Figer will lead the project.

Imaging sensors produce their own “noisy” signal that often degrades images, especially under low-light conditions. The noise can sometimes be seen as the grainy, salt-and-pepper speckling found in pictures snapped in a dark room. In applications like astrophysics, that noise can do more than ruin a picture; it can mean the difference between making a discovery or not.

According to Figer, the zero-noise detector employed with the Thirty Meter Telescope will have the same sensitivity as a combination of today’s detectors and a 60-meter telescope for probing the farthest reaches of the universe.

“You could quadruple the power of a telescope just by using this detector,” says Figer, director of the Rochester Imaging Detector Laboratory at RIT’s Chester F. Carlson Center for Imaging Science. “Or you can do the same thing by making a telescope twice the size, but then we’re talking a cost of billions of dollars and taking on a monumental engineering challenge.”

“Don’ts detector research represents a technological leap forward for astrophysics and for a variety of industrial and commercial applications, as well,” says RIT President Bill Destler. “The Rochester Imaging Detector Laboratory was established at RIT with the help of the New York State Foundation for Science, Technology and Innovation. In just three years, it has gained stature as an epicenter for imaging innovation.” Figer will lead a team of scientists from RIT and Massachusetts Institute of Technology’s Lincoln Laboratory to create a detector unlike any available today. “This detector will have more earthly applications too. For instance, you’ll be able to see things in low-light conditions, especially from twilight down to the darkness of the darkest night,” Figer says. “For some applications, it will be the difference between seeing nothing and seeing everything.”

June 19, 2008
By Susan Gawlowicz

**Figer’s research leads to Nature report on celestial eruption**

One of the most powerful eruptions in the universe might have spun an infrared ring around a rare and exotic star known as a magnetar—a highly magnetized neutron star formed in a brilliant supernova explosion of a massive star. A paper published in the May 29 issue of Nature announces the detection of the elliptical ring or shell around the dead star known as SGR 1900+14. Observations obtained from NASA’s Spitzer Space Telescope in 2005 and 2007 suggest the ring was produced by a giant flare originally detected in 1998. Stefanie Wachter, research scientist at NASA’s Spitzer Science Center at the California Institute of Technology, led the study, which links the origin of the magnetar to a nearby cluster of massive stars, whose light is dominated by two red supergiants at the center. “Out of 400 billion stars in our galaxy, there are about a dozen magnetars that we know of,” says Donald Figer, professor at RIT’s Chester F. Carlson Center for Imaging Science and a co-author of the study. “Discovering the ring is groundbreaking because it discovers some other phenomenon associated with, and physically near, a magnetar. And when you know so little about an object, each new morsel you can gather up is very important.” Figer is the director of the Rochester Imaging Detector Laboratory at the Carlson Center for Imaging Science. He joined RIT through a faculty development program grant awarded by the New York State Foundation for Science, Technology and Innovation. He is also part of a team, led by Rolf Kudritzki of University of Hawaii, that recently won time on the world’s largest telescope, the W.M. Keck Observatory, to make additional measurements of the magnetar. The stellar eruption may result from stress induced by the magnetic field dragging on the rapidly spinning star. A fissure in the surface of the magnetar creates a “starquake,” akin to earthquakes. The biggest variety of these eruptions can temporarily produce over a thousand times more energy than all of the stars in a galaxy.

May 15, 2008
By Susan Gawlowicz

**LIDAR Imaging Detector Could Build ‘Super Road Maps’ of Planets and Moons**

RIT effort could extend NASA science capabilities for planetary applications

Technology that could someday “MapQuest” Mars and other bodies in the solar system is under development at Rochester Institute of Technology’s Rochester Imaging Detector Laboratory (RIDL), in collaboration with Massachusetts Institute of Technology’s Lincoln Laboratory.

Three-Dimensional “super roadmaps” of other planets and moons would provide robots, astronauts and engineers details about atmospheric composition, biohazards, wind speed and temperature. Information like this could help land future spacecraft and more effectively navigate roving cameras across a Martian or lunar terrain.

RIT scientist Donald Figer and his team are developing a new type of detector that uses LIDAR (Light Detection and Ranging), a technique similar to radar, but which uses light instead of radio waves to measure distances. The project will deliver a new generation of optical/ultraviolet imaging LIDAR detectors that will significantly extend NASA science capabilities for planetary applications by providing 3-D location information for planetary surfaces and a wider range of coverage than the single-pixel detectors currently combined with LIDAR.

The device will consist of a 2-D continuous array of light sensing elements connected to high-speed circuits. The $647,000 NASA-funded program also includes a potential $589,000 phase for fabrication and testing.

“The imaging LIDAR detector could become a workhorse for a wide range of NASA missions,” says Figer, professor in RIT’s Chester F. Carlson Center for Imaging Science and director of the RIDL. “It could support NASA’s planetary missions like Europa Geophysical Orbiter or a Mars High-resolution Spatial Mapper.”

LIDAR works by measuring the time it takes for light to travel from a laser beam to an object and back into a light detector. The new detector can be used to measure distance, speed and rotation. It will provide high-spatial resolution topography as well as
measurements of planetary atmospheric properties—pressure, temperature, chemical composition and ground-layer properties. The device can also be used to probe the environments of comets, asteroids and moons to determine composition, physical processes and chemical variability.

Working with Figer are Zoran Ninkov and Stefi Baum from RIT and Brian Aull and Robert Reich from Lincoln Laboratory. The team will apply LIDAR techniques to design and fabricate a Geiger-Mode Avalanche Photodiode array detector. The device will consist of an array of sensors hybridized to a high-speed readout circuit to enable robust performance in space. The radiation-hard detector will capture high-resolution images and consume low amounts of power.

The imaging component of the new detector will capture swaths of entire scenes where the laser beam travels. In contrast, today’s LIDAR systems rely upon a single pixel design, limiting how much and how fast information can be captured. “You would have to move your one pixel across a scene to build up an image,” Figer says. “That’s the state of the art of LIDAR right now. That’s what is flying on spacecraft now, looking down on Earth to get topographical information and on instruments flying around other planets.”

The LIDAR imaging detector will be able to distinguish topographical details that differ in height by as little as one centimeter. This is an improvement in a technology that conflates objects less than one meter in relative height. LIDAR used today could confuse a boulder for a pebble, an important detail when landing a spacecraft.

“You can have your pixel correspond to a few feet by a few feet spatial resolution instead of kilometer by kilometer,” Figer says. “And now you can take LIDAR pictures at fine resolutions and build up a map in hours instead of taking years at comparable resolution with a single image.”

The imaging LIDAR detector will be tested at RIDL in environments that mimic aspects of operations in NASA space missions.

In addition to planetary mapping, imaging LIDAR detectors will have uses on Earth. Other applications include remote sensing of the atmosphere for both climate studies and weather forecasting, topographical mapping, biohazard detection, autonomous vehicle navigation, battlefield friend/foe identification and missile tracking, to name a few.

“There is an increasing demand for highly accurate three-dimensional data to both map and monitor the changing natural and manmade environment,” says Ninkov, professor of imaging science at RIT. “As well as spaceborne applications there are terrestrial applications for LIDAR systems such as determining bridge heights, the condition of highways and mapping coastal erosion as sea heights rise.”

August 14, 2007
By Susan Gawlowicz, University News

New Imaging Detectors Could Take Snapshots from Deep Space

RIT-UR team to develop radiation-hardy detectors

Snapshots from space may someday confirm the presence of lakes and oceans on Europa—one of Jupiter’s moons—and on other planetary bodies. Imaging detectors that capture information from every wavelength in the electromagnetic spectrum could detect the presence of liquid methane or hydrocarbons, the stew that just might sustain microbial life forms.

An imaging detector under development by a team of scientists from Rochester Institute of Technology and University of Rochester promises to revolutionize future NASA planetary missions with technology that could withstand the harsh radiation environments in space. The team won $592,000 from the NASA Planetary Instrument Definition and Development Program to design, build and test a detector that should be resilient against radiation damage. The lightweight device will be smaller and consume less power than technology currently in use. The novel readout circuitry design will give the device a radiation tolerance not possible in standard optical detectors.

“All these benefits will lead to lower mission costs and greater scientific productivity,” says Donald Figer, director of the Rochester Imaging Detector Laboratory at RIT and lead scientist on the project. “But, ultimately, radiation immunity is the focus.”

Figer’s team includes Zeljko Ignjatovic from UR, Zoran Ninkov from RIT, Melissa McGrath from NASA Marshall Space Flight Center and Shouleh Nikzad from NASA Jet Propulsion Laboratory.

“Our detector captures images directly in the digital domain at the pixel level rendering subsequent signal transmission less susceptible to cosmic radiation environment,” says Ignjatovic, assistant professor of electrical and computer engineering.

The new detector is based on a technology created by Ignjatovic and his colleagues at UR in which each pixel reads and converts its signal from analog to digital immediately upon capture. Standard optical detectors lack this capability. Instead, signals must travel along a line of sensors to reach a readout circuit. This wastes energy and leaves the signal vulnerable to radiation damage that degrades the circuit over time.

“Radiation tolerant detectors are a critical need for NASA in the continued exploration of the solar system,” says McGrath, chief scientist in the Science and Mission Systems Office at NASA Marshall Space Flight Center.

“In space astronomy and planetary missions, detectors are frequently the critical pacing item,” adds Stefi Baum, director of the Chester F. Carlson Center for Imaging Science at RIT. “By developing detectors with greatly reduced noise properties and greatly enhanced tolerance to radiation damage—the chief lifetime limiter of detectors in space—the collaboration should dramatically improve the reach of sensitivity and lifetime of the missions to explore and understand the nature of the planets with which we share our solar system.”

Testing the overall system will determine how the sensors hold up in cryogenic environments where the detector is cooled to very low temperatures, imitating conditions in space. The device will be tested at RIT in the Rochester Imaging Detector Laboratory, a new facility established to develop detector technologies for next-generation ground-based and space telescopes.

The new imaging detector under development will boast a dynamic range and greater short wavelength sensitivity. Figer believes the detector could become a key technology for future planetary missions in the most severe radiation environments. The detector technology could figure heavily in missions under consideration for NASA’s Discovery, Mars Exploration and New Frontiers programs.

The detector might someday be used to capture hyperspectral imaging from a platform orbiting the outer planets or their satellites. Cameras looking down on Europa could take a picture of every wavelength at every pixel.

“We could use that information to figure out if there are lakes of water on Europa or hydrocarbons on Titan,” Figer says. “We can figure out the composition of a surface without having to land on it, which we might want to do 10 years later. Then we would know where to land.”
Publications
Manser, K. 2008. Fabrication of a Photodetector Array on Thin Silicon Wafers, ImagineRIT Festival
Pontillo, D. 2008. SIDECAR ASIC Characterization, ImagineRIT Festival
Seshadri, S. 2007. Comparing the low-temperature performance of megapixel NIR InGaAs and HgCdTe imager arrays, SPIE, 6690
Singh, N. 2008. Sigma-delta Analog to Digital Converter for CMOS ImageSensor, ImagineRIT Festival
Yu, Young Sam 2008. Spot Projector System for the Measurement of Intra-pixel Response, ImagineRIT Festival

Equipment/facilities
The RIDL has over 1800 square feet of lab space containing a cryogenic camera system, class 10,000 clean room, Signatone probe station, optical bench, light sources, monochromator, motion control stage, circuitry and data analysis workstations, and other equipment.
Detector Development in RIDL: A Very Low Noise CMOS Detector Design for NASA

Figer, Ninkov, Zhang, Ignjatovic (U of R) NASA

The purpose of this project is to design, fabricate, develop, and test a novel new detector for NASA space missions. These missions rely on low noise array detectors that must operate in the harsh radiation environment of space. Most current missions use CCDs for their optical detectors. While these devices have low noise (a few electrons) at the beginning of mission life, they are gradually degraded by radiation damage. The design we propose will address this, and several other problems.

Our device will deliver lower noise, lower power consumption, much larger dynamic range, and greater radiation immunity than presently available CCD and CMOS detectors. In addition, it will allow much greater operational flexibility. All of these benefits will lead to lower mission cost and greater scientific productivity. Our design efforts will produce a new multiplexer having application over a large wavelength range, spanning from UV to mid-infrared, via hybridization to a variety of light-sensitive materials, i.e. silicon, HgCdTe, InSb, InGaAs, Si:As, and Ge:As. The new device will also have applications for homeland safety, i.e. in surveillance in low light conditions on our nation’s borders and in battlefield platforms on UAVs.

Interpixel Capacitance

Baum, Figer, Ninkov NASA, NYSTAR, ITT

Pixels in both hybridized and monolithic complementary metal-oxide semiconductor CMOS detector arrays may couple capacitively to their neighboring pixels. The mechanism is illustrated here. This “interpixel capacitance” can significantly distort the characterization of conversion efficiency and modulation transfer function, MTF, in CMOS devices. These effects have been largely unaccounted for in measurements to date. This effect was first discovered at RIT and the results of this coupling have been investigated. Compensation methods for these errors are described and applied to silicon P-I-N array measurements. The measurement of Poisson noise, traditionally done by finding the mean square difference in a pair of images, needs to be modified to include the mean square correlation of differences with neighboring pixels.

Hybridization of CID Arrays

Ninkov NYSTAR, Thermo

The purpose of this project is to develop a cost- and time effective method to enable the automated thinning of CMOS focal plane arrays. Thinned devices are especially needed for applications in spectroscopy, medical imaging, remote sensing and astronomy. Thinned arrays have much better performance, especially in terms of quantum efficiency in the blue/UV. At present the technology for thinning focal plane arrays is more an art than a science and is not scalable to thinning the hundreds of arrays. We have developed a process for flip chip bonding of CID CMOS arrays (see illustration on the right) and plan to proceed with thinning these devices. Final polish will be done using Magneto Rheological Finishing to produce a little-damaged back surface.
Radiation-Tolerant Detector for NASA Planetary Missions

Figer, Ninkov, Zhang, Ignjatovic
(U of R) NASA

The purpose of this project is to design, fabricate, develop, and test a novel detector that will revolutionize future NASA planetary space missions in the area of radiation tolerance, low noise, low power, and low mass. These missions rely on low noise array detectors that must operate in the harsh radiation environment of space. Most current missions use CCDs for their optical detectors. While these devices have low noise (a few electrons) at the beginning of mission life, they are gradually degraded by radiation damage. Our device will deliver lower noise, lower power consumption, much larger dynamic range, greater short wavelength sensitivity, and greater radiation immunity than presently available CCD and CMOS detectors. In addition, it will allow much greater operational flexibility. All of these benefits will lead to lower mission cost and greater scientific productivity. Our design efforts will enable a broad range of applications, including demanding hyper-spectral imaging in the most severe radiation environments in the Solar System. They will help NASA to achieve science objectives for future planetary missions now being considered by the Discovery, Mars Exploration, and New Frontiers programs.

Our design uses low power CMOS circuits that are arranged in high density packaging within individual pixels. The low noise readout is achieved by sampling the signal using a sigma-delta analog-to-digital (A/D) circuit with a feedback path that restores charge to the charge collection node. The keys to its performance are the close proximity of the conversion circuit to the photo generated charge, oversampling nature, and noise-shaping property of the in-pixel sigma-delta A/D converter. These properties allow our design to highly attenuate the photodetector reset noise, DC offset related fixed-pattern noise, and readout transistor thermal and 1/f noise. Since the design is insensitive to threshold voltage variations of the readout transistor, we believe that our design will be less susceptible to radiation transients and long-term damage that can cause shifts in the readout transistor performance parameters.

A Deterministic Approach to Back Thinning CMOS Sensors

Ninkov
NYSTAR/CEIS

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Research and Development related to the Large Synoptic Survey Telescope (LSST) camera

Figer
DOE/Stanford Linear Accelerator Center

This work includes evaluating the Large Synoptic Survey Telescope (LSST) guider prototypes in the Rochester Imaging Detector Laboratory during FY08. RIT’s role in the camera effort will be to develop, in partnership with SLAC and partner organizations, the guider sensor needed to complete the R&D phase of LSST. Pending availability of prototypes to evaluate, it is anticipated that at least one Teledyne H4RG or H2RG plus a SIDECAR ASIC will be evaluated. A final test report will be the deliverable. The test report will include performance measurements for parameters that are relevant to the LSST Guider application, including: dark current, read noise, quantum efficiency, inter-pixel capacitance, well depth and linearity. These measurements will be reported for full-frame readout, as well as window mode readout. In addition, the measurements will be reported over a range of operating conditions, such as flux levels, wavelengths, temperature, and readout speed.

RIDL camera mounted to the 2.1-m telescope at the Kitt Peak National Observatory in Tucson, AZ.
LIDAR Imaging Detector Could Build ‘Super Road Maps’ of Planets and Moons

RIT effort could extend NASA science capabilities for planetary applications

By Susan Gawlowicz, University News Services

Technology that could someday “MapQuest” Mars and other bodies in the solar system is under development at Rochester Institute of Technology’s Rochester Imaging Detector Laboratory (RIDL), in collaboration with Massachusetts Institute of Technology’s Lincoln Laboratory.

Three-Dimensional “super roadmaps” of other planets and moons would provide robots, astronauts and engineers details about atmospheric composition, biohazards, wind speed and temperature. Information like this could help land future spacecraft and more effectively navigate roving cameras across a Martian or lunar terrain.

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“The imaging LIDAR detector could become a workhorse for a wide range of NASA missions,” says Figer, professor in RIT’s Chester F. Carlson Center for Imaging Science and director of the RIDL. “It could support NASA’s planetary missions like Europa Geophysical Orbiter or a Mars High-resolution Spatial Mapper.”

LIDAR works by measuring the time it takes for light to travel from a laser beam to an object and back into a light detector. The new detector can be used to measure distance, speed and rotation. It will provide high-spatial resolution topography as well as measurements of planetary atmospheric properties—pressure, temperature, chemical composition and ground-layer properties. The device can also be used to probe the environments of comets, asteroids and moons to determine composition, physical processes and chemical variability.

Working with Figer are Zoran Ninkov and Stefi Baum from RIT and Brian Aull and Robert Reich from Lincoln Laboratory. The team will apply LIDAR techniques to design and fabricate a Geiger-Mode Avalanche Photodiode array detector. The device will consist of an array of sensors hybridized to a high-speed readout circuit to enable robust performance in space. The radiation-hard detector will capture high-resolution images and consume low amounts of power.

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“You would have to move your one pixel across a scene to build up an image,” Figer says. “That’s the state of the art of LIDAR right now. That’s what is flying on spacecraft now, looking down on Earth to get topographical information and on instruments flying around other planets.’’

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The imaging LIDAR detector will be tested at RIDL in environments that mimic aspects of operations in NASA space missions. In addition to planetary mapping, imaging LIDAR detectors will have uses on Earth. Other applications include remote sensing of the atmosphere for both climate studies and weather forecasting, topographical mapping, biohazard detection, autonomous vehicle navigation, battlefield friend/foe identification and missile tracking, to name a few. “There is an increasing demand for highly accurate three-dimensional data to both map and monitor the changing natural and manmade environment,” says Ninkov, professor of imaging science at RIT. “As well as spaceborne applications there are terrestrial applications for LIDAR systems such as determining bridge heights, the condition of highways and mapping coastal erosion as sea heights rise.’’

Donald Figer was recruited by Rochester Institute of Technology’s Chester F. Carlson Center for Imaging Science through a faculty development program grant awarded by the New York State Foundation for Science, Technology and Innovation. The grant provides interim state assistance to help attract distinguished faculty throughout the world to New York’s academic research centers, and to retain leading researchers already in New York Institutions of Higher Education.
2008 RIT Multidisciplinary Senior Design (MSD) Program members. A program developed by the Kate Gleason College of Engineering (KGCE) to offer multidisciplinary capstone projects which challenge engineering students from a variety of technical disciplines to work together as teams to accomplish a complex, practical project.
Printing Research and Imaging System Modelling Lab

Laboratory Director’s Comments:
By Dr. Marcos Esterman

Overview

The PRISM Lab is focused on two key areas; Print Image Quality and Sustainability in Printing. In November of 2007, PRISM hosted its first research round-table which included participation from Eastman Kodak, Hewlett-Packard, and Xerox. The intent of the meeting was to discuss common challenges that manufacturers of electrophotographic printers are facing. An important theme that emerged was the integration of sustainability criteria into technical decision-making. As a result, PRISM has launched a new program in this area. Due to the success of the first round-table, plans are underway to make this an annual event. Additionally, infrastructure has been developed for the characterization of toner-based print image quality. This has involved the construction and calibration of two independent devices for the controlled fusion of toner onto paper. One device is a roller-based system, which mimics the configuration of the fuser within typical printer systems, and the other is a stamp-based system designed to separate the effects of pressure and temperature for analysis of the initial, irreversible step in the fusing process. Both provide for the quantitative control of the impulse function (pressure versus time) applied to a toner/paper system, with provisions for both static and dynamic temperature control. Output from these devices can be examined with a variety of traditional image analysis instruments and with a unique new type of micro-goniophotometer developed in the PRISM lab. In parallel with these instrument development projects, research has been done to couple instrumental and perceptual metrics of image quality. In the context of these sponsored research projects, PRISM has supported several student projects for academic credit. These have included both individual thesis projects and multi-disciplinary team projects through the Kate Gleason College of Engineering.

Faculty and staff:

Dr. Marcos Esterman, (mxeeie@rit.edu) Laboratory Director, CIS graduate program faculty, and Associate Professor, KGCOE (Industrial & Systems Engineering). Marcos’ expertise is in the modeling of engineering systems, the development of robust design methods, and in product and process development.

Dr. Jonathan Arney, (arney@cis.rit.edu) Professor, CIS, Jon’s expertise is in physical and optical measurements of materials and the mechanistic analysis of printing processes.

Ms. Susan Farnand, (farnand@cis.rit.edu) Staff Scientist (CIS), Susan’s expertise is in vision and psychometrics, color science, and the application of these sciences to product and process development.

Dr. Juan Cockburn, (Juan.Cockburn@rit.edu) Associate Professor, KGCOE (Computer Eng.), Juan’s expertise is in the modeling of control systems and the design of robust, nonlinear control systems.

Dr. Franziska Frey, (fsfpph@rit.edu) Associate Professor, McGhee Professor, School of Print Media, Franziska is a member of the Center’s graduate program faculty. Her expertise is in the digitization of cultural heritage materials, digital fine art printing, and digital asset management.

Summary of Current Research Interests:
- Mechanism of fusing in dry toner electrophotography
- Optical and physical interactions of toners and inks with papers
- Development of analytical protocols for assessment of print image quality
- Application of uncertainty modeling and robust control theory to printing systems
- Evaluating the image quality gap between digital printing and offset lithography

Summary of Service in Imaging and Printing:

Members of PRISM have served active roles in imaging and printing through service on committees and support of professional conferences. In particular, Susan Farnand has participated with the WG04 committee on Print Image Quality under the auspices of SC 28 Office Equipment committee of ISO, designing psychophysical test procedures to be used in international experimentation leading to new and updated standards on image quality assessment. Susan also co-chaired the Image Quality Systems Performance conference at the Electronic Imaging Symposium in San Jose, CA. Marcos Esterman is currently the program chair for the 2008 ASME International Design Engineering and Technical Conferences Design for Manufacturability and Life-Cycle Conference and will be the Conference Chair in 2009 for the same conference.
Graduate Thesis and Dissertation Topics:

PRISM's contribution to academic degree programs has been focused on increasing student opportunities in print imaging technology. Toward this end we have supported thesis projects for several graduate students as well as one independent study project, as described below.

Mr. Carl Smith: Ph.D. Dissertation Title “The Analysis of Specular Reflections from Printed Surfaces” Mr. Smith is a second year graduate student in CIS and is working with PRISM on the development of instrumentation and analytical protocols for the optical characterization of printed images.

Mr. Fermin Colon-Lopez: Ph.D. Dissertation Title “A Model of Electrophotographic Printing That is Independent of the Halftone Algorithm”. Mr. Colon-Lopez has been a part time graduate student in CIS for many years, earned a MS in Imaging Science, and is expected to complete his dissertation by the end of the current academic year.

Mr. Sourabh Dargan: MS Thesis Title “Application Of The Operating Window Concept To Improve Fuser Reliability: A Case Study On Failure Modes Of Hot & Cold Offset” Mr. Dargan is a second year graduate student in Industrial and Systems Engineering and is working with PRISM to apply the operating window concept to a well-known fuser failure to see if new insights can be gained from this method.

Mr. Alvaro Rojas: MS Thesis Title “A Selection Framework for Derivative Product in Changing Platforms “. Mr. Rojas is a second year graduate student in Industrial and Systems Engineering. While his thesis work is not directly related to PRISM, Mr. Rojas has been the lead research assistant on development of the fuser test-beds. He has taken the feasibility prototypes developed by the Multidisciplinary Design program and made them working lab instruments.

Mr. Jared Russell: MS Thesis Title “Modeling and Control of a Toner Fusion Process: An Integrated Approach”. Mr. Russell is a dual degree BS/MS student in Computer Engineering and is working with PRISM to develop the control systems for both fuser-test beds.

Ms. Alicia Tejada Abreu: MS Thesis Title: TBD. Ms. Tejada Abreu is a first year graduate student in Industrial and Systems Engineering and will be working with PRISM over the next year to develop a systems dynamics model of the barriers that are preventing firms from integrating sustainability criteria into their R&D decision-making. This modeling will be based on interviews that include a major printer manufacturing company.

Undergraduate Projects:

PRISM also has a commitment to provide research opportunities to undergraduates at RIT.

Mr. Luis Henry: Thesis Title: “Analytical Methods for the Characterization of Differential Gloss in Printed Images”. This work was performed as a senior research project. The results of the project were reported both in Mr. Henry’s senior thesis and in reports to Hewlett-Packard, which provided support for the project. The analytical technique is currently being used in further studies of print image quality.

Mr. Christopher DeAngelis: Thesis Title: “Design of an Analytical Imaging System for Catalytic Converters”. This work was performed as a senior research project. The results of the project were reported both in Mr. DeAngelis’ senior thesis and in reports to AirFlow, Inc. which provided support for the project. The project led to the development of a unique method for characterizing wash-coat catalytic material applied to porous screens.

Ms Coleen Davis: Thesis Title: “Quantitative Correlation Between Instrumental and Psychometric Analysis of Print Bronzing”. The background literature study for this work has been carried out, and laboratory work will be conducted in the coming months as Ms Davis’ senior research project. “Bronzing” is a chromatic gloss effect seen particularly in ink jet images, and preliminary analysis shows that the microgoniophotometer can be used to characterize the effect.

Mr. Dave Nilosek: Project Title: “The Absolute Calibration of a Micro-goniophotometer”. This work was not a thesis project for academic credit but was done by Mr. Nilosek as a paid undergraduate laboratory assistant. Mr. Nilosek contributed significant original work to the project and is a coauthor of the manuscript published by the Journal of Imaging Science & Technology, as well as a paper on the measurement of differential gloss published in the proceedings of IS&T’s Non-Impact Printing Conference.

Ms Claire MacDonald: Project Title: “The Correlation Between Visual Attributes of Print Gloss and Micro-goniophotometric Parameters”. Ms MacDonald is a paid undergraduate laboratory assistant working jointly with Amey and Farnand to demonstrate improved instrumental techniques for predicting visual gloss attributes.
Senior Undergraduate Engineering Design Projects:

A particularly successful way in which the PRISM lab has contributed to RIT academic opportunity has been through the sponsorship of projects in the RIT Multidisciplinary Senior Design (MSD) Program. This is a program developed by the Kate Gleason College of Engineering to offer multidisciplinary capstone projects. These projects challenge engineering students from a variety of technical disciplines to work together as teams to accomplish a complex, practical project. Professor Esterman is a member of the KGCOE MSD teaching team and steering committee as well as a graduate program faculty member in CIS and has devoted a significant amount of time to the development of this unique educational opportunity.

Over the past year, the PRISM lab has sponsored two of these projects.

- Project Title: “The Development of a Microgoniophotometer”. The goal of this senior design project was to start from the experimental bench-top microgoniophotometer developed by Dr. Arney and develop a self-contained unit that would improve the ease of use of data collection in the lab. The team consisted of two mechanical, one electrical and one computer engineers.

- Project Title: “The Design And Development Of A Roller-Based Fuser Test Bed”. This Senior Design project was sponsored by the PRISM lab for the design and construction of a unique instrument for the analysis of the thermal, optical, and mechanical behaviors of dry toner in the image fixig process of laser printers. The design team involved five senior engineering students in KGCOE representing two from mechanical and three electrical engineering.

Funded Research: (totaling $284,000)

Funding over the past year has been primarily from Hewlett-Packard Corporation in Boise, ID, Eastman Kodak, and the Print Industry Center. Specific projects are shown below.

Applied Analytical Tools for Use with the Micro-Goniophotometer—Jon Arney, PI, Susan Farnand, Co-PI. The successful development of the Micro-Goniophotometer led to the need to develop analytical protocols for the characterization of a variety of specular print quality attributes. Specific emphasis was placed on the quantitative analysis of differential gloss, gloss banding, and gloss bronzing. Elements of this work provided the senior undergraduate projects by Henry, MacDonald, and Davis described earlier.

Prototype of RIT Micro-Goniophotometer—Jon Arney, PI, Marcos Esterman, Co-PI. Previous work in PRISM has shown that a more thorough analysis of gloss can be accomplished with very little additional effort using the RIT Micro-Goniophotometer as compared to a traditional gloss meter. Indeed, the Micro-goniophotometer has been shown to provide information comparable to scanning goniophotometers currently on the market, but with a significant reduction in complexity and cost. For this reason, a Senior Engineering Design project was developed to explore and produce a β prototype for a commercial instrument. The project enabled a group of Engineering students to experience a real multidisciplinary design problem that led to significant advances toward potential commercialization of the instrument.

Optical Analysis of Toner Fusing Thermo-Mechanical Analysis—Jon Arney, PI, Marcos Esterman, Co-PI. This project involved the thermo-mechanical analysis of printing substrates and of toner materials. Unlike traditional equilibrium thermo-mechanical techniques, this project involved the irreversible transformations that occur to toner and paper during the first impulse (pressure vs. time) applied in the development process.

Warranty Modeling—Marcos Esterman, PI. This project is developing models used in product warranty and reliability prediction.

Minding the Gap: Evaluating the Image Quality of Digital Print Technologies Relative to Traditional Offset Lithography—Susan Farnand, PI. In recent years digital print engines have made marked strides in increasing their level of image quality. What was once a ragged, de-saturated and uninspiring color document can now be made sharp and vibrant. This difference between the image quality of digital printers relative to offset lithographic presses is shrinking. But, just how big is this difference? What particular image quality parameters contribute most to the difference? And how much does this difference even matter to the end user? The objective of this project was to examine these questions by evaluating the image quality gap between digital print technologies and offset lithography and determining the importance of this gap on end users. It was found that there were significant differences in perceived value of prints made on digital versus offset printing equipment, with the prints on coated media made on offset equipment being generally preferred, while the prints on uncoated media made on digital printers were frequently assigned higher value.
Evaluating the Image Quality of Digital Print Technologies Relative to Traditional Offset Lithography (Year II)

—Susan Farnand, Ph. The results of the investigation of the image quality gap between digital print technologies and offset lithography conducted in 2007 suggest that digital print engines have indeed made marked progress in recent years in increasing their level of image quality. This study found that for some images and applications, the prints provided by digital printers were valued as highly or even higher than for the offset lithographic prints. This was the case only for uncoated media, however. The dependence on the media of the comparative difference in image quality was not particularly surprising, although the degree of dependence given two high quality cover stocks was perhaps somewhat unexpected. To further explore this difference and to verify trends suggested by the initial study, additional investigation is proposed. The objective of this follow-on project is to further evaluate the image quality gap between digital print technologies and offset lithography with particular attention to the media used.

Journal Publications:


Conference Proceedings:


Imaging Science undergraduate, Monica Cook, demonstrates the latest portable eye tracking system.
Dr. Kirsten Condry joined RIT in 2006 as an assistant professor in the Psychology department, following five years as a research associate at Harvard University. Dr. Condry’s research will expand the age range of the observer pool in the MVRL to infants as young as four months old; her research examines the development of visual perception and cognition in infants and young children. Her research on infant vision focuses on the development of a modal completion and perception of visual illusions. Her current research extends recent findings by examining infant eyetracking of partly-occluded objects. Her research on cognitive development includes a series of studies examining how toddlers learn the meaning of number words and counting. Dr. Condry graduated with a BA in Psychology from Swarthmore College, and a Ph.D. in Developmental Psychology from the University of Minnesota. Before her work at Harvard University, she worked for two years at M.I.T. with Elizabeth Spelke as a post-doctoral fellow. Before her work at Harvard University, she worked for two years at M.I.T. with Elizabeth Spelke as a post-doctoral fellow.

Research in the area of Visual Perception in the Center continued to grow over the past year, the lab’s second year. The Multidisciplinary Vision Research Laboratory (MVRL), a joint program of the Carlson Center for Imaging Science and the College of Liberal Arts, grew significantly in this, its second year. In addition to Co-Directors Jeff Pelz from Imaging Science and Andrew Herbert from RIT’s Psychology program, and Mitch Rosen from Imaging Science, two new faculty members joined the MVRL this year.

The MVRL continues to expand the instrumentation available for research and teaching. In addition to the binocular Dual-Purkinje Image eyetracker, the head-mounted eyetracking systems from Applied Science Laboratories and ISCAN, and the RIT wearable eyetracker, the MVRL acquired two new systems this year. The first is a remote eyetracking system from ASL that integrates software-based face tracking. By tracking the position of key features from a position 60cm away from the observer, the system keeps a high-speed camera focused on the observer’s eye via an internal relay mirror. While the system can be used with any observer, the system will be especially valuable for use with infants. The second system is a new eyetracker from Positive Science, a startup formed by a CIS alum. Unlike competing systems that rely on special-purpose hardware to monitor the position of the eye, the new system uses an off-the-shelf computer, significantly reducing the cost.

Dr. Lindsay Schenkle came to RIT in 2006 from Seton Hall University in New Jersey. Dr. Schenkle is extending eye-movement research in the Multidisciplinary Vision Research Lab into patient populations; her area of research is pediatric clinical psychology. Before her appointment at Seton Hall, she was the Clinical and Research Coordinator at the University of Illinois at Chicago’s Pediatric Mood Disorders Clinic and Bipolar Disorders Research Program in the Center for Cognitive Medicine and Institute for Juvenile Research. Now an assistant professor in RIT’s psychology department, she is working with students in the MVRL to study pediatric bipolar patients’ facial emotion processing.

The multidisciplinary nature of the MVRL is evident in the mix of students in the lab. Students working in visual perception over the last year range from Ph.D. students to high school interns, with students from different majors at RIT collaborating on projects. Imaging Science Ph.D. candidates Feng Li and Susan Munn (nee Kolakowski) are the senior students in the lab. Feng Li is finishing this year, his research culminating with a project in which observers’ eye movements are monitored as they watch video sequences on hand-held mobile devices while riding in automobiles. In addition to monitoring their gaze, he has instrumentation to record their head motion, the motion of the hand-held displays, and of the automobile. Sue Munn is using her system that determines an observer’s position and point-of-regard over time to automatically extract complex, three-dimensional gaze patterns of observers as they navigate natural surroundings. The promise of eyetracking can only be fully realized if the challenge of analyzing the huge amount of data can be met. Sue’s work is aimed at meeting that challenge.

Leanne Stefano is a student in RIT’s new MS program in Applied Experimental and Engineering Psychology. Working under the direction of Andrew Herbert in the MVRL, her thesis work is examining the effectiveness and efficiency of video-conferencing by monitoring the gaze behavior of participants in various videoconferencing conditions. The MVRL’s large display capability includes three 70” Hitachi ES70 VisionCube displays. Leanne’s experiments include a comparison of observers’ performance as they perform a number of tasks while communicating via two of the 70” displays with high-definition cameras, to their performance while communicating via two desktop computers with built-in cameras.

Becca Brown and Christina Kucerak are Imaging Science students doing their senior research projects in the MVRL. Becca is working with Drs. Condry and Pelz, developing the MVRL’s infant eyetracking capability. She is developing a software suite to import and analyze data from the MVRL’s new remote eyetracker that will be used with infants. Christina is working with Dr. Pelz to examine the putting performance of golfers. Using RIT’s wearable eyetracker to monitor their gaze, and a high-speed magnetic tracking system to monitor their stroke, she is re-examining earlier research that addressed the relationship between a golfer’s gaze throughout the putting process.

Jonathan Winkle and Tristan Conley are psychology majors working in the MVRL this year. Jonathan has been working with Dr. Condry on establishing the infant eyetracking lab and Tristan has been working with Dr. Herbert on a project studying how observers deploy their attention in complex environments.

Jonathan Purington, a junior in the Imaging Science program, has been working with Drs. Pelz and Herbert on a study of gaze behavior of observers as they walk on surfaces with different markings. Following up on previous research, Jonathan is using new instrumentation developed at RIT to determine whether previously published findings were artifacts due to limitations in previously available instrumentation.

The MVRL hosted four high school interns this summer as part of the Carlson Center’s annual internship program. A.J. Lanphere from Honeoye Falls-Lima High School, Jane Petzoldt from Midlakes High School in Clifton Springs, and Erika Murphy and Matt Hart from Victor High School supported ongoing research in the laboratory and worked on two group projects. They designed, executed, and analyzed an experiment examining observers’ patterns of eye movements as they searched images, and they used a new high-speed digital camera to capture image sequences of a range of eye movement types at 300 frames per second.
Publications


The BrainWeb phantom was used to create synthetic PET and MRI images. FusionViewer was used to fuse these images.
Biomedical Imaging Laboratory

Overview

To develop innovative ways to visualize, analyze, and characterize biological tissues and synthetic materials by means of multimodal medical imaging devices.

Staff

The lab hosts two full time faculty, Drs. María Helguera and Naval Rao. This year saw the addition of a post-doc position filled by a recent program graduate, Dr. Karl Baum.

Research in the lab was conducted and supported by a number of students:

- Karl G. Baum, CIS Ph.D. Candidate. Multimodal imaging and synthetic image generation.
- Joseph Lawson, ME MS Candidate. Ultrasonic characterization of ceramics.
- Kevin MacNamara, High School Intern. Responsible for implementing software to support digital geometric phantoms.
- Christopher McDade, ME MS Candidate. High frequency ultrasound c-scan imaging system design and fabrication.
- Di Lai, CIS Ph.D. Candidate. Application of independent component analysis to ultrasound speckle.
- Raj Pai Panandiker, CIS Ph.D. Candidate. Ultrasonic characterization of layered media.
- Kimberly Rafferty, CIS Undergraduate. Evaluation of multimodal display techniques.
- David Shapiro, CIS Undergraduate. Ultrasonic characterization of gloss properties.
- Stephanie Shubert, CIS MS Candidate. Ultrasonic characterization of nerves.
- Derek Walvoord, CIS Ph.D. Candidate. Automatic detection of fiducial skin markers in PET and MRI.
- Andrew Michael, CIS PhD Candidate.

Research Projects

Ultrasound Materials Characterization

Powder Coated Metal Plates: The aim of this study was to establish a relationship between the mechanical properties of a powder coating, extracted using ultrasonic analyses, and the extent of its curing. This study was necessitated by the fact that most current methods either focus on in-process temperature monitoring or on laboratory analysis of powder samples and not on post-curing characterization of industrial samples. Working towards the objective, the study involved investigating powder coating films by employing transmission mode ultrasound involving multiple reflections to extract the dimensionless material descriptor, tan(δ). It has been demonstrated that trends observed in the mechanical properties of the coatings extracted by processing the ultrasonic signal corresponded to those experimentally extracted using mechanical testing. Results are shown in Figure 1 for 3 different curing times:

![Multispectral tan(δ) in film](image)

**Fig. 1 Multispectral tan(δ) in film (Multiple reflections).**

Geopolymeric Materials: This project is conducted in collaboration with Dr. Benjamin Varela in the Mechanical Engineering Department. Current methods of determining the elastic modulus and Poisson’s ratio for geopolymeric materials are limited by the destructive nature of compressive strength and bending testing analysis techniques. Since these tests are not repeatable, there is no means of evaluating whether measured properties are a result of the actual materials or the effect of possible mechanical defects. This study applies a relationship between the speed of sound through a material and its elastic properties to determine the elastic modulus and Poisson’s ratio of geopolymeric samples. In addition to these elastic properties, the density, percent pore volume, average pore diameter and standard deviation of pore diameter were also evaluated. These material characteristics were determined as a relationship to the Si:Al ratio of sodium activated metakaolin based geopolymers with Si:Al ranging from 1.49 to 6.4. It was found that lower Si:Al values were consistently around 8.5 GPa in samples above 3.1 Si:Al ratio. The Poisson’s ratio for each sample decreased proportionally to the Si:Al ratio with a maximum value of 0.22 and a minimum value of 0.05.

Scattering Anisotropy Effect on Nerve Images:

The objective of this research is to design a rigorous method to characterize nerve fibers using an ultrasound imaging system. This will allow successful application of regional anesthesia, which is safer and has fewer complications than general anesthesia, particularly in elderly and obese patients. Nerves are not always aligned parallel to the surface of the skin making them challenging to detect. The intensity and appearance of nerves in B-scan images varies with viewing angle. Using a tissue phantom and a high frequency 15 MHz transducer our goal is to define the relationship between the signal from the nerve and viewing angle. If a relationship can be developed, tracking of the nerves and correction of B-scan images can be implemented in software.
Multimodal Breast Imaging

The thrust of this project, which is conducted in collaboration of Dr. Andrzej Krol from SUNY Upstate, focuses on the field of Multimodality Image Fusion and Visualization of breast tissue. This is a rapidly evolving field due to the constant upgrading and improvement of medical imaging and computational systems. This project provides an approach for taking information currently collected from different imaging modalities that do not share the same piece of equipment and presenting it in a more cohesive way via image processing techniques.

Registration: Registration of images acquired from different scanners is accomplished using a finite element method technique supported by the use of fiducial skin markers. Automatic fiducial marker recognition is accomplished via an algorithm based on a MACH (maximum average correlation height) filter, a class of composite correlation filters that allows for shift and rotational invariance, i.e. if the input image is translated by some amount, the filter output will shift by the same amount. The algorithm detects the locations of fiducial skin markers in both PET and MRI image stacks and uses this output to automatically register these image volumes. This shift is estimated by the location of the correlation peak. Correlation filters can be designed to achieve noise tolerance and discrimination among other properties. The process is shown in schematic way in Figure 2.

Visualization: Little research has been devoted to finding the optimum viewing techniques for multimodal medical images. This is in part due to the relative rarity of multimodal data sets until the recent clinical availability of PET/CT scanners. However, as imaging technology evolves and further advantages get discovered the importance of fusion techniques becomes apparent. An application was developed for investigating fusion techniques and viewing multi-image data sets. The viewer provides both traditional and novel tools to fuse 3D inter- and intra-modal data sets. Fused projection displays (e.g., maximum intensity projection) are also supported. A plug-in interface exists for rapid implementation of new fusion techniques. This viewer provides a framework supporting future multimodal image visualization efforts. A snapshot is shown in Figure 3.

Fig. 3 A screenshot of a fused data set. The three orthogonal images on the left are from the MRI data set, and the three orthogonal images on the right are from the PET data set after the application of a red color table. The three orthogonal images in the center are from fusing the MRI and PET images using the weighted average fusion plug-in. In essence the MRI image gets colored based on the PET intensity values. Not only can we see the anatomical structure, but we can also see the metabolic activity for each structure.

While a number of fusion techniques have been developed and investigated, one in particular, generated by a genetic algorithm, has shown promise. The algorithm searches for a fusion technique that satisfies specific properties, and by satisfying these properties information from the images fused can be directly extracted from the fused image by an observer. To test the validity of fusion based visualization techniques, a number of techniques were selected to conduct a study with four radiologists from the Department of Radiology at SUNY Upstate Medical University. This initial study clearly demonstrated the need and benefit of a joint display and emphasized the benefits of the genetic algorithm fused images over other fusion techniques currently available in literature.

Fig. 4 Examples of color tables produced by the genetic algorithm are shown in (a) and (b). Joint PET/MRI images created using the new color tables are in (c) and (d). The MRI and PET images that were fused are shown in (e) and (f).
Fig. 5 Mesh representing selected internal structures of the breast.

**Image Synthesis:** Obtaining “ground-truth” data in medical imaging is an almost impossible quest when pathology reports are not available. One way to circumvent this limitation is by creating digital synthetic phantoms with the appropriate physical properties and characteristics that can be imaged using digital simulators. Digital simulators can be used to study system design, acquisition protocols, reconstruction techniques, and evaluate image processing algorithms. Specifically in this work, simulated images can aid in the evaluation of the registration procedure, and provide data for studies accessing the ability of radiologists to use specific visualization techniques. In addition to providing a precise ground truth, they can be used to save significant time and money compared to finding volunteers, and arranging and paying for scanner time.

A breast phantom has been designed to support current and future projects on breast imaging. The phantom, when combined with appropriate physical properties, can be used to generate synthetic MRI and PET breast images. The phantom contains ten different tissues including adipose tissue, areola, blood, bone (rib), ductal tissue, Cooper's ligament, lobule, muscle (pectoral), skin, and stroma connective tissue. Some elements in the phantom are shown in Figure 5.

**Fusion Techniques applied to MRI Mapping of the Schizophrenic Brain**
Steffi Baum, in collaboration with Vince Calhoun at the Mind Institute at the University of New Mexico, continued research with PhD student Andrew Michael (stationed at the Mind Institute) on Multimodal Brain Imaging, Fusion and Diagnosis of Schizophrenia.

**Selected Publications and Presentations**

**Grants and Research Funding**
University of Rochester, in collaboration with Dr. Dogra, “Prostate Tissue Characterization with High-Frequency Ultrasound,” $100,000, 2007-2008.
Department of Energy Mind Institute Graduate Fellowship, $55,000.
UNYCHRO, in collaboration with Dr. Andrzej Krol (SUNY Upstate) and Dr. Axel Wismueller (University of Rochester), “Simultaneous Visualization of Multidimensional Image Data for the Diagnosis of Cancer,” $60,000, pending.
High school interns May Cheung and Ralieq Boswell preparing materials for a test target, which will be characterized using magnetic resonance imaging. Their work, supervised by Professor Joe Hornak, was presented at the annual College of Science Undergraduate Research Symposium.
Magnetic Resonance Imaging Laboratory

Research Group Leader’s Comments
By Professor Joseph Hornak

Overview

The RIT Magnetic Resonance Laboratory is a research and development laboratory devoted to solving real world problems with magnetic resonance. The past academic year was a productive one for the RIT Magnetic Resonance Laboratory. We made breakthroughs in three major research areas: magnetic resonance imaging (MRI) phantoms, nuclear magnetic resonance (NMR) signals of hydrated natural sands, and the interaction of the MRI contrast agent gadodiamide with copper as it relates to Nephrogenic Systemic Fibrosis (NSF).

On the phantom front, we successfully developed an MRI phantom filler material with a low dielectric constant and high conductivity, which eliminates common artifacts found in images of phantoms. We developed a three-dimensional phantom for determining the point spread function and linearity of an MRI system anywhere in a 10×10×10 cm volume without the need to reposition the phantom. The respective corporate sponsors are currently evaluating these discoveries for commercialization.

We finished a study of the NMR spin-lattice relaxation rate (R1) of hydrated natural sands finding the relationship between R1 and sand grain diameter, paramagnetic metal content in the sand grains, and magnetic field strength. Our findings will have an impact on the use of NMR Sounding to locate subsurface aquifers. This work was presented at the Experimental NMR Conference held in Asilomar, CA in March and the Symposium on the Application of Geophysics to Engineering and Environmental Problems in Philadelphia in April.

Our study of gadodiamide has shown that of all the paramagnetic first row transition metal ions, it only interacts with copper. The interaction results in a material with a higher R1 than either the copper or gadodiamide, and may help explain the higher concentration of copper in the urine of patients administered gadodiamide. This work was presented at the International Society for Magnetic Resonance in Medicine meeting in Toronto in May.

Staff News

Sangyun Moon, a MS Imaging Science student at RIT, continues his work on MRI resolution phantoms and measuring MRI system performance specifications.

Brittany Lipchick, a BS chemistry student at RIT continued her work on the interaction of the MRI contrast agent Omniscan® with transition metals. She was awarded a Summer Research Fellowship for 2008 from the RIT College of Science.

Melissa Monahan, a MS mechanical engineering student spent the summer in the lab learning about magnetic resonance imaging and helping with the study of the interaction of the MRI contrast agent Omniscan® with transition metals.

Jennifer Swartzenberg, a BS chemistry student at RIT, joined the lab in November. She is working on projects referring to the interaction of the MRI contrast agent Omniscan® with transition metals. She was awarded a Summer Research Fellowship for 2007 from the RIT College of Science.

Dr. Robert G. Bryant, Professor of Chemistry at the University of Virginia, continued a collaboration with the lab measuring NMR spin-lattice relaxation rate values of hydrated synthetic and real sand as a function of magnetic field.

Gianni Ferrante, President of Stelar, s.r.l, Mede, Italy, continued his collaboration with the lab measuring NMR spin-lattice relaxation rate values of hydrated real sand as a function of magnetic field.

Yana Goddard, Post Doctoral Associate in the laboratory of Prof. Bryant at the University of Virginia, collaborated with the lab measuring NMR spin-lattice relaxation rate values of hydrated synthetic and real sand as a function of magnetic field.

Dr. Sandip Sur, Director of the NMR facility in the Chemistry Department at the University of Rochester continued a collaboration working on the electron paramagnetic resonance (EPR) of quartz sands.
Grants and Contracts
An exploration into the development of MRI phantom filler materials—INVIVO Corp., 2007-2008, $60k.
The Structure of the Components of a Mixture of Cu Plus Gd(DTPA-BMA) —RIT COS, 2008, $3k.

Publications

Conference Presentations
J.P. Hornak, MRI: Where We Are At and Where We Are Going, Plenary Lecture, American College of Veterinary Radiology Annual Scientific Meeting, Chicago, IL, November 2007.

New Equipment and Facilities
The lab acquired an AEA Technologies vector impedance analyzer for tuning radio frequency coils.
We constructed an RF dielectric probe for measuring the dielectric constant and resistivity of solutions from 100 kHz to 200 MHz. This probe was essential to the study of filler materials for MRI phantoms.
Dr. Ben Davies was the lead researcher who discovered two “supernova factories”, rare clusters of Red Supergiant (RSG) stars, located in the Galactic Bar of the Milky Way. This image is a color composite of Cluster 1. Blue represents hot interstellar gas, stars show up as green and hot dust shows as red. The RSGs are the bright stars in the center.
Astronomical Imaging

Overview

The Astrophysical Sciences and Technology group within the Center for Imaging Science continues to thrive; with professors Joel Kastner, Don Figer, Stefi Alison Baum, Zoran Ninkov, and David Axon, continuing active research agendas in collaboration with the Department of Physics, their many post doctoral fellows, research scientists, graduate and undergraduate students, as well as high school interns, conduct research dedicated to understanding the nature and evolution of the universe in which we live. Astrophysical Sciences and Technology encompasses the development of leading-edge instrumentation, observation and interpretation, theoretical physics, and modeling using the latest computation and mining of large astronomical datasets.

By Professor Joel Kastner

Academic year 2007–08 was a challenging one for Kastner. On sabbatical as Visiting Astronomer at the Laboratoire d’Astrophysique de Grenoble (LAOG), France, he needed to take a crash course in French, attempt to understand and appreciate the intricacies of French breads, wines, and cheeses, and endure cross-country skiing at dizzying altitudes in the French Alps. Somehow, he survived this ordeal and—moreover—pushed ahead in key young star and evolved star research areas, renewing old collaborations and beginning new ones in the process. Kastner’s sabbatical began and ended with breakthrough results from his graduate students Montez and Yu on high-energy radiation from the regions surrounding dying, Sun-like stars (known as planetary nebulae). Montez’s discovery of the accidental detection of a planetary nebula (PN) by the Chandra X-ray Observatory inspired Kastner to write an essay on serendipity in science for the Chandra Chronicles (see http://chandra.harvard.edu/chronicle/0307/ngc5315/index.html) and led to a comprehensive paper on the X-ray emission properties of these objects. Then, as the academic year waned, Yu, Kastner, and their MIT and Technion (Israel) colleagues completed and submitted a paper describing their detailed study of the first X-ray grating spectrum of a PN, conclusively demonstrating that the PN BD+303639 exhibits extreme carbon and neon enrichment and iron depletion.

Related to these results, Kastner and colleagues published a lengthy study of the natures of the 250 most infrared-luminous objects in the Milky Way’s nearest neighbor galaxy, the Large Magellanic Cloud (LMC). They found that the dominant IR-bright population in the LMC consists of cool, evolved stars ejecting carbon-rich dust and gas.

It was also a year for improving our understanding of disks around stars of all ages and masses. Kastner, longtime LAOG colleague T. Forveille, new LAOG colleague P. Hily-Blant, and B. Zuckereman (UCLA) used radio-wave molecular spectra obtained at the 30-meter telescope of the Instituto de Radio Astronomia Millimetrique (Pico Veleta, Spain) to infer that the disk orbiting the mysterious dusty star BP Piscium may be the result of the breakup of a close stellar or planetary companion and to explore the chemistry of a disk in orbit around a nearby, young (15 million-year-old) binary star. Meanwhile, ongoing research with former RIT postdoc Catherine Buchanan (now at the U. of Melbourne, Australia) on a class of massive, dying, but still white-hot stars in the LMC shows that most if not all such objects are surrounded by dusty disks and/or dusty nebulae that are most likely the remnants of the formation of such stars.

Finally, in July 2008, Kastner and LAOG hosts T. Montmerle and J. Bouvier organized an intimate international workshop (attended by 10 young-star researchers from 5 countries) on high-energy radiation from star-disk interactions in young stars. The strong ties Kastner forged with his LAOG colleagues—not to mention the bread, wine, cheese, and skiing—are likely to draw him back to Grenoble for shorter-term visit(s) in the near future.

Kastner’s group’s research is supported by grants from NASA via the Chandra X-ray Observatory Science Center, the Spitzer Space Telescope Science Center, the XMM-Newton Guest Observer Program at NASA Goddard Space Flight Center, and the NASA Astrophysics Data Analysis program.
Faculty and Staff

Professor Joel Kastner, BS Physics, University of Maryland, 1981, MS, Astronomy, UCLA, 1986, PhD, Astronomy, UCLA, 1990

Graduate Students

Young Sam Yu: PhD, 4th year, graduation anticipated academic year 2008-09. Title: High-resolution X-ray imaging and spectroscopy of planetary nebula wind shocks.

Rudy Montez: PhD, 2nd year. Title: X-ray imaging of planetary nebulae and related objects.

Grants


“Hot Gas and Cool Dust around B[e] Supergiants,” Smithsonian/Chandra X-ray Center, $42,953 (awarded summer 2007, 1 year)

“Hot Gas and Cool Dust around B[e] Supergiants,” Spitzer Space Telescope Science Center at JPL/CalTech; $7,475 (awarded summer 2007, 2 years)


“The XMM-Newton Serendipitous Survey of Planetary Nebulae,” NASA ROSES Astrophysics Data Analysis program, $159,000 (awarded Feb. 2008, 2 years)

“BP Psc: Chandra Takes a Close Look at a Pre-Main Sequence Star-Disk-Jet System,” Smithsonian/Chandra X-ray Center, $65,285 (one year, award pending)

Publications: Refereed


Publications: Non-refereed


Massive Star Research

Research Group Leader’s Comments
By Dr. Don Figer

Overview
During this year, the astronomers involved with the Massive Star research project have proposed and won observation time targeting young stellar clusters throughout the Galaxy. The Milky Way study project group meets on a weekly basis to plan and discuss their scientific research. The goals of the project are to discover the majority of the massive stars in the Galaxy. With this sample, we plan to identify the most massive star in the Galaxy and define the upper limit to the masses of stars. During the year Ben Davies and Don Figer published their findings on newly discovered massive star clusters at the galactic center, which provide the unique opportunity to study the pre-supernova evolution of massive stars, and the Blue-to-Red-Supergiant ratio at uniform metallicity.

Research Staff
Ben Davies, Post Doctorate; Ph.D. in Astrophysics, University of Leeds; MS in Physics, 2003; University of Leeds; BA in Physics with Astrophysics, 2003, University of Leads
Don Figer, Director; Ph.D. in Astronomy, UCLA, 1995; MS in Astronomy, University of Chicago, 1992; BA in Physics, Math, Astronomy, Northwestern University, 1989
Lucy Hadfield, Post Doctorate; Ph.D. in Astrophysics, University of Sheffield, 2006; MPhys in Physics with Astronomy, 2003
Zoltan Makai, Data Analyst; BS in Astronomy, University of Szeged, 2006
Maria Messineo, Post Doctorate; Ph.D. in Astronomy, Leiden University, 2004; MS in Astronomy, Bologna University, 1997
Christine Trombley, Data Analyst; BS in Astrophysics and Physics, Michigan State University, 2007
Quingfeng Zhu, Post Doctorate; Ph.D. in Astrophysics, University of Texas, 2006; MS Astrophysics, University of Science and Technology of China, 1999; BS in Physics, University of Science and Technology of China, 1996

New and current grants/contracts
• The Pre-Supernova Mass-Loss of RSGs, Aug. 2007–July 10, $80,885
• The Most Massive Stars, Feb., 2006–Feb., 2009, $795,528
• Massive Star Clusters, Aug., 2006–Sept., 2008, $30,000
• Mid-infrared spectroscopy of Luminous Blue Variables, $21,812

Selected Publications
Dr. Ben Davies was the lead researcher who discovered two “supernova factories”, rare clusters of Red Supergiant (RSG) stars located in the Galactic Bar of the Milky Way.


Figer, D. 2008. Massive Star Formation in the Galactic Center, STScI May Symposium


A ghostly ring stretches seven light-years around the corpse of a massive star called SGR 1900+14, as seen by NASA’s Spitzer Space Telescope. This “stellar corpse” is actually a magnetar, which still slowly pulsates with X-rays and continues to have a super-strong magnetic pull.
Dr. Don Figer was a coauthor on the study that was reported in the May 2008 publication of Nature.
New Science Enabled for Hubble

After an exhaustive 12-month project, work at the Center for Imaging Science, in collaboration with the Stewart Observatory (University of Arizona), has enabled an exciting new avenue of astrophysical research with the Hubble Space Telescope. The project, led by Assistant Research Scientist Dr Dan Batcheldor, has calibrated the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) to a level that can detect minute degrees of polarization. These levels are expected at the hearts of transition Active Galactic Nuclei (AGN), which may hold the final key to unlocking the wide variety of observed AGN classes, and in the debris disks around newly formed stars where planet formation may be occurring.

Figure 1: The calibration pointings used in the NIC2 camera of NICMOS.

The observations were designed to remove all of the detector nuances in each of the detector Q1-4 quadrants and in each of the POL0-240L polarizers.

As the type of imaging polarimetry used by NICMOS relies on detecting variations in the number of incoming photons on the order of less than 1%, it was essential to carefully examine, and work around, all detector anomalies that may produce an artificial polarimetric signal. To that end, an elegant pattern (Fig. 1) of pointed observations on a variety of stars, with known polarizations, was made. The results of the project, due to be published in August 2008, now allow astrophysicists to reliably detect a polarization of only 1%.

The near infrared operating wavelengths of NICMOS, its high spatial resolution and this new calibration, combine to produce a powerful instrument capable of peering through the dust surrounding many fascinating objects. Continuing work in the Center will now allow scientists to determine the polarization characteristics of these objects with unprecedented accuracy and on an unrivaled scale.

Extragalactic Astronomy: Active Galaxies and Galaxy Clusters

Professors Stefi Baum and Chris O’Dea (Physics), along with research Scientist Jake Noel-Storr (see also the Insight Laboratory), continued their investigations into the nature of the central engine in the nuclei of the most active of galaxies, studying their infrared, radio, optical, and ultraviolet properties. At the same time the group won a major new grant and observing time on a key project for the new Herschel Space Telescope to be launched spring of 2009. This project is to study the properties of the intracluster medium surrounding the central dominant galaxies that lie at the very heart of clusters of galaxies. Hot gas should be condensing out of the hot intracluster medium and condensing onto the galaxy in the form of molecular and atomic matter. This same matter may make its way to the centers of these enormous galaxies, fueling star formation and feeding the black hole that sits at the very heart of the galaxy. In turn the accretion of matter onto the black hole creates jets of matter, which spew energy out into the cluster, reenergizing the hot medium. Many undergraduates participated in the work in our group, as well as one Master’s student in imaging science.
University News

August 21, 2008
By Susan Gawlowicz

Astrophysics degree becomes RIT’s fifth Ph.D. Program

Breakthroughs in astrophysics could reshape our understanding of the universe in the next decade. Observations of gravity waves could prove Einstein’s theory of general relativity, or tip physics on its head. Other missions using ground-based telescopes and space probes will pry into dark matter and dark energy—a mysterious material and a force puzzling 21st century astrophysicists. RIT is gaining a reputation in the realm of astrophysics at this exciting time, with faculty contributing to research initiatives that blend science fiction and reality. This fall, RIT will launch its fifth doctoral program, in astrophysical sciences and technology. The program brings together scientists from different disciplines within the College of Science to explore Einstein’s theory of relativity, young and dying stars, centers of galaxies and black holes, and the technology to make new observations. The program will depart from traditional astrophysical studies that focus mainly on theoretical and observational aspects of the discipline by adding the characteristic RIT twist of technology and applied science. An equal emphasis on theory, observational astronomy, and sensor and instrument development will set RIT’s program apart from others. Students will have the opportunity to earn master’s and doctoral degrees in three distinct tracks: the emerging field of astro-informatics and computational astrophysics; astronomical instrumentation and the development of new technologies for application in astronomy and space science; and astrophysics. The program will draw heavily upon faculty from the Chester F. Carlson Center for Imaging Science, the Department of Physics and the School for Mathematical Sciences who are international experts in the areas of extragalactic astronomy (particularly the study of the centers of galaxies and stellar evolution), computational astronomy and numerical relativity, and instrumentation. David Axon, head of the physics department, will codirect the new program with Stefi Baum, director of the Center for Imaging Science. “Astrophysics is a discipline where learning by doing is absolutely key,” says Ian Gatley, dean of the College of Science. “It involves building technology, using technology and modeling phenomena using computers, and all of those are really very big issues indeed for RIT and its students.”
TEM of silicon nanocrystals. Scale bar is 50 nm. Inset is an electron diffraction pattern imaged with the TEM that confirms the material is indeed Si.
Nanoimaging Laboratory
NanoImaging Research Laboratory

The NanoImaging Lab has just completed its second year of operation. The formation of the Lab was an initiative between the Physics Department and CIS, and has two complementary themes: (1) Image materials at the nano level and (2) Fabricate imaging devices using nanomaterials. The Lab is divided into three facilities: Microscopy, Fabrication and Evaluation of Imaging Devices, and Nanoparticle Synthesis.

Microscopy. We have initiated several collaborations over the past year. Working with Prof Tom Smith’s research group in Chemistry, we imaged in the transmission electron microscope (TEM) siloxane polymer particles. Ongoing work focuses on correlating polymer particle size and structure with synthesis methods. Prof Matt Miri’s group, also of Chemistry, is synthesizing high-density polyethylene particles in a starch binder with a goal of developing largely biodegradable plastic film. We are using the TEM to image the polymer particles to characterize their size, size distribution, and morphology. Example images from these two projects are shown in Fig. 1.

Fabrication and Evaluation of Imaging Devices. We continue to build our expertise in fabrication of organic-based light-emitting devices (LEDs). Our ultimate goal is to fabricate hybrid devices in which inorganic nanocrystals are the light-emitting element and the organic layers are used for strictly electron and hole transport. A necessary prerequisite to that goal is building devices that use the organic material to emit light. These are commonly called organic light-emitting devices (OLEDs), which are further characterized on the basis of whether the devices use small molecules that are vacuum evaporated to form the device structure (SMOLEDs) or polymeric materials that are typically fabricated by spin-coating techniques (PLEDs). We are just beginning our study of PLED devices.

We have also initiated collaborations with two faculty members in the Microelectronics Engineering Dept. With Prof Santosh Kurinec we are exploring sample preparation of semiconductor devices for imaging in cross section in the TEM (XTEM). For this project we are using an ultramicrotome that prepares uniformly thin (~50 nm) cross sections with the aid of a diamond knife. The goal is to be able to identify distinct layers in the device and examine the integrity of layer interfaces. Prof Davide Mariotti’s research is in nanofabrication and we are imaging materials and devices fabricated by his students. Example images are shown in Fig. 2.

We have made much progress in the SMOLED category and are now reproducibly fabricating devices whose optoelectronic characteristics are consistent with those published in the scientific literature. Figure 3 shows some of our results, including a schematic cross section of the device. Holes are injected from the bottom of the device via the indium tin oxide (ITO) layer and the polymer buffer layer (PSS:PEDOT) and finally into the hole transport layer (TPD). Meanwhile electrons are injected from the top via the aluminum cathode and LiF layers into the electron transport layer (Alq3). With balanced charge injection, which is part of the optimization of the device structure, the electrons and holes meet in the Alq3 layer and form an exciton, which decays by emitting a photon (green in this device structure). We are now focused on exploring the efficiency of these devices as a function of layer position and thickness. Optimization of the thickness and placement of the LiF buffer layer is important to optimizing the device. Additionally, a study of the cathode material and thickness is critical for balancing charge injection, since it is usually the electron injection and transport that controls the balancing of charges in the device. Personnel involved: Omkar Vyavahare and Nikita Surve, both graduate students in the Materials Science & Engineering program.

![Fig. 1. (Left) Polymer particle imaged in the TEM. Scale bar 50 nm. (Right) High-density polyethylene particles images in the TEM. Scale bar 100 nm.](image1)

![Fig. 2. Example of the cross sectional imaging we hope to achieve in the XTEM project. XTEM micrograph of hafnium oxide and molybdenum films on silicon deposited by sputtering (reactive for HfO2). The micrograph shows 6.9 nm of interfacial silicon dioxide.](image2)

![Fig. 3. (Upper left) Image of working display prototype. (Upper right) Schematic of device. (Lower left) I-V characteristics of device. (Lower left) Electroluminescence spectra of device.](image3)
Nanocrystal Synthesis. We have a long history of synthesizing nanocrystals starting with silver halide nanocrystals (100’s of nm diameter) and have now evolved to other nanocrystals of a few or tens of nm diameter. These latter nanocrystals are composed of CeO2 and are currently intended for a nonimaging application (see Fig. 4.) These are grown by an aqueous precipitation route that is “green” and inherently scalable. The techniques we are developing can be readily applied to other compositions that have more imaging relevance. Personnel involved: Gary DiFrancesco, Associate Scientist. Project supported by Cerion Energy, Inc.

Course and Outreach Support. The Microscopy Facility has become a popular resource for supporting various CIS/COS/COE courses. In the last year it has been used to support Introduction to Microscopy Using Light, Electrons, and Scanning Probes, Imaging Science Fundamentals (two sections), Imaging Science First Year Seminar, Frontiers in Science (two sections), and Introduction to Nanotechnology. In addition, the Microscopy Facility has supported outreach events including two CIS Open Houses, Nanotechnology Week, the CIS High School Intern program, and a cooperative venture between CIS and the Rush-Henrietta School District.

Images as Art. Finally, the use of scientific images as art has recently become a valuable tool for engaging the public in science and technology. This was emphasized recently during the ImagineRIT Festival. The following image of a “Giant Asteroid” was taken with our SEM and entered in the competition.

Fig. 4. TEM image of CeO2 nanoparticles along with their size-frequency histogram. Inset is an electron diffraction pattern that confirms that the particles are CeO2.

Fig. 5. SEM image of a grain of sand.
Graduate Program Faculty Activities
By Dr. Mike Kotlarchyk:

  http://www.worldscibooks.com/materialsci/4339.html


Other Graduate Program Faculty Activities:

Dr. Ryne Raffaelle, Professor of Physics and Microsystems Engineering, Director, NanoPower Research Laboratory. Professor Raffaelle’s expertise is in the areas of nano-materials for space power, wide bandgap solar cells, and quantum dots.

Dr. Tom Smith, Professor of Chemistry and Microsystems Engineering. Dr. Smith’s expertise is in the areas of organic chemistry and polymer chemistry.
Imaging session for the Archimedes palimpsest was shot at the Walters Art Museum in Baltimore with our prototype multispectral imaging system. The system uses fiber optics to convey different bands of illumination from the LED sources to the manuscript. The transmissive illumination is being used in this shot. An updated version of this system will be used to image selected pages of a palimpsest at the Walters Art Museum in early March 2009, and to reimagine several critical pages of the Archimedes palimpsest.
Historical Manuscript Restoration

Imaging of Historical Manuscripts
By Roger L. Easton, Jr.

Activities in this area were directed primarily at three artifacts: the Archimedes Palimpsest, the Waldseemüller Map, and the Charter of the City of Annapolis.

The work on the Archimedes Palimpsest project was dominated by a month-long imaging session in August 2007, during which time the entire book was re-imaged with a new camera and illumination system. The images of several pages showed interesting and thus far unexplained infrared features that may assist the scholarly readings. The images were processed by Dr. Keith Knox in Hawaii. The X-ray fluorescence images and the 1906 Heiberg photographs were registered to the images from 2007 by Allison Bright, an undergraduate student in the Center. All images (> 1 TByte of data) have now been posted online at http://archimedespalimpsest.net/ under a Creative Commons license, which means that any person can process/use/publish these images under the terms of that license.

The results of this imaging session were reported at the Archimedes Palimpsest Colloquium, Texts, Traditions, and Technology at the Eötvös Collegium in Budapest, Hungary in September, 2007. Other invited talks on the subject were presented at the RIT President's Roundtable in October 2007, the University of New Mexico and the Rochester Museum and Science Center in February, 2008, and the RIT Summer Mathematics Institute in July, 2008. A technical talk, "Computer Image Analysis in the Study of Art" in San José, California in January, 2008 was also presented to the SPIE Conference 6810.

The work on the Archimedes Palimpsest also penetrated popular culture, when the team consulted with the scriptwriter and prop team for the movie "National Treasure: Book of Secrets." The design of the system “used” in the movie to image the page from the diary of John Wilkes Booth was based on an earlier version of the system designed by the Archimedes Palimpsest imaging team.

The so-called “Waldseemüller Map” was the first printed map that specifically names “America.” The map, called "Universalis Cosmographia," was a map of the world originally published in April, 1507 by Martin Waldseemüller. The United States Library of Congress purchased a copy of the map in 2001 for $10 million. Prior to long-term encasement and display, the conservation staff of the library desired to assess the condition of the map. The imaging team for the Archimedes Palimpsest was contacted, and along with Ken Boydston of Megavision, Inc., imaged the twelve sheets of the map at different resolutions and under different illumination conditions. These images have been delivered to the Library of Congress for study. This work was reported at a presentation in the series Topics in Preservation Science at the Library of Congress in March 2008. The relationship begun here has led to additional work for the Library and also has resulted in a submission to the NSF competition for Science and Technology Centers. This work also led to a contact with Dr. Edward Papenfuse, Archivist of the State of Maryland, to image what had been thought to be the original copy of the Charter of the City of Annapolis in May 2008. Claire Mac Donald, undergraduate student in the Center, participated in the imaging and is processing the data for her senior project.
An “Immersitorium” — Digital Omnidirectional Multimedia Environment
The R·I·T Insight Lab for Science Outreach and Learning Research, led by Dr. Jake Noel-Storr and Dr. Stefi Baum, continues to develop, test and deliver cutting edge science education and outreach activities, and research the effectiveness of all learners, in domains centered in Astronomy, Imaging Science, and all sciences in general.

We have active collaborations across campus with faculty and staff in the College of Science, Golisano College of Computing and Information Sciences, College of Liberal Arts, and the College of Imaging Arts and Sciences. We are actively in the process of seeking funding for research and programs in the areas shown to the left, along with funding to support the infrastructure necessary to conduct educational research within CIS and beyond.

In 2007-08 the lab supported nine students earning credit for independent studies in astronomy, science education and digital immersive environments / collaboration. We employed three students on co-op to work on our projects, along with another eight undergraduate researchers, four high school interns, and an honors pre-freshman.

The lab developed a new interdisciplinary science class for R·I·T Honors students — “Frontiers of Science” — which brought together faculty from across the College of Science to deliver four weeks of lecture on cutting edge research topics, followed by six weeks of interactive activities and laboratory visits to expose students to the research occurring on the R·I·T campus.

Extending the partnership with the American Astronomical Society the lab is becoming responsible for coordinating many of the K-12 and Educator outreach efforts of the society. In particular we are coordinating the plans to host educator workshops and a K-12 AstroZone event prior to each of the society’s conferences (held twice a year nationwide), ensuring that our outreach extends nationally. We are developing a new partnership with the American Geophysical Union and NASA Goddard Spaceflight Center to run “Exploration Station”, a spin-off of AstroZone, at the start of each one of their two annual meetings held around the United States.

At the first ImagineRIT festival held this May, the Insight Lab (and its students) won a supporting sponsor ribbon for our “Immersed in Science” digital immersive cube which we had on display in the Gordon Field House.

A major part of the lab’s mission has become to develop digital immersive environments and associated science education content. A master’s student in information technology has been working with our lab on his thesis on understanding effective practices and learning outcomes from this type of educational practice.
If a high acuity internal representation were built up over multiple fixations, it should be easy to detect small differences between images.
Grants Awarded

- NSF CreativeIT “Collaboratorium for Interdisciplinary Creativity” (PI: Jon Schull [Golisano College]; Co-PI: Jake Noel-Storr) To develop and build a unique tinkerable space for novel, technology enabled collaboration and immersive teaching.

- NASA ROSES E/PO Supplement “The Journey of a Photon” (Science PI: Don Figer; E/PO Lead: Jake Noel-Storr) To work with a group of high school students to produce a museum quality digital immersive production on the Journey of a Photon (from astrophysical source to detector).

- NASA ROSES E/PO “NASA Family Science Nights (Evaluation)” (PI: Jake Noel-Storr) To evaluate and research learning occurring at the monthly NASA family science nights held at Goddard Space Flight Center.

Publications and Presentations


- “Reaching Out and Impacting Local Communities” Drobnes & Noel-Storr, in Spark: The AAS Education Newsletter, Issue 4

- “AstroTrek: Astronomical Learning Expeditions” Noel-Storr, 210th Meeting of the AAS

- “Willingness to Pay for a Clear Night Sky: Use of the Contingent Valuation Method” Simpson, Noel-Storr & Winebrake, 209th Meeting of the AAS (poster)

- “Effectively Engaging Family Groups in Learning Astronomy” Noel-Storr, 209th Meeting of the AAS (poster)


- “What’s Up? Elementary School Classroom Activities from the Association for Astronomy Education”, 2007 NSTA National Convention (workshop)
Erica Murphy, an RIT summer intern from Victor High School, describes her research in the area of visual perception to the visiting UR interns.
Prospective Student Outreach Programs

I. CIS Intern Program
CIS ran its CIS High School Intern program for the ninth consecutive summer in 2008. A total of 15 students were accepted as interns. For the first time this year, the RIT interns were given the opportunity to interact with a group of high school students participating in a similar intern program at the University of Rochester. The UR interns, who worked on research in the area of bioengineering, visited the labs used by their imaging science counterparts, hosted a tour of their UR labs for the RIT interns, and worked together with the RIT interns on peer reviews of each group’s final presentations.

The following table lists the names of the 2008 RIT imaging science summer interns, as well as their high school and the research group they worked with.

<table>
<thead>
<tr>
<th>Name</th>
<th>High School</th>
<th>Research Group</th>
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</thead>
<tbody>
<tr>
<td>AJ Lanphere</td>
<td>Honeoye Falls Lima</td>
<td>Visual Perception</td>
</tr>
<tr>
<td>Erika Murphy</td>
<td>Victor</td>
<td>Visual Perception</td>
</tr>
<tr>
<td>Matt Hart</td>
<td>Victor</td>
<td>Visual Perception</td>
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<tr>
<td>Jane Petzoldt</td>
<td>Midlakes</td>
<td>Visual Perception</td>
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<tr>
<td>Tom Colosky</td>
<td>Honeoye Falls Lima</td>
<td>Astronomy</td>
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<tr>
<td>Nicole Staie</td>
<td>Rush Henrietta</td>
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<td>Basma Eid</td>
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<tr>
<td>Kevin McCabe</td>
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<tr>
<td>Alex Long</td>
<td>Bloomfield</td>
<td>Remote Sensing</td>
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<tr>
<td>Laura Serio</td>
<td>Churchville Chili</td>
<td>Remote Sensing</td>
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<tr>
<td>Upasana Marwah</td>
<td>Pittsford-Mendon</td>
<td>Document Restoration</td>
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<tr>
<td>Gretchen Smith</td>
<td>Nazareth Academy</td>
<td>MRI</td>
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<tr>
<td>Nicole Conway</td>
<td>Canandaigua</td>
<td>MRI</td>
</tr>
<tr>
<td>April Harding</td>
<td>Churchville Chili</td>
<td>Nanoimaging</td>
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<tr>
<td>Gary Menezes</td>
<td>Webster Schroeder</td>
<td>Ultrasound</td>
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II. College and Careers
A total of 105 prospective students attended the summer’s annual “College and Careers” events in 2008. Participating students chose from among two CIS workshop offerings—one with an astronomy theme and the Center’s longest running workshop, “Make Your Own Hologram” which has been a part of College and Careers for the past seven years.

III. Classroom Visits
CIS personnel made classroom visits to, or hosted groups from, the following schools in the past year:

- Victor Intermediate School
- Gates-Chili Middle School
- Kenney Middle School
- Victor Junior High School
- East High School
- Midlakes High School
- Seaton School
- Canandaigua Academy
- Churchville-Chili High
- Rush-Henrietta HS
- Edison Tech High School
- Bloomfield High School

IV. Special Projects
—Workforce Innovations Conference: The Monroe County School-Business Partnership (MCSBP), a service for school districts coordinated by Monroe #1 BOCES, offered a new Youth Workforce Innovations Conference for sophomore high school students enrolled in its ten member school districts. The conference was designed to align with the Workforce Innovation for Regional Economic Development (WIRED) initiative with the goal of having students learn about regional workforce areas offering high potential for future employment. Joe Pow presented an imaging science overview to over 50 students at this event.

—Girl Scouts: CIS sponsored a number of events designed to make girls aware of educational and career opportunities in the fields of math and science. Specific events included career fairs, astronomy overnighters, and training sessions for troop leaders.

—ImagineRIT: CIS sponsored four booths at this inaugural event, designed to showcase RIT’s culture of innovation and creativity. Two of the CIS displays won prestigious Sponsor’s Awards —“Immersive Imaging for Science Education” by Dr. Jake Noel-Storr, and “Eye Tracking in the Real World” by Dr. Jeff Pelz.

—NOVA Academy: CIS Associate Director, Joe Pow, taught an 8-week workshop on the fundamentals of imaging science to a group of students from Rush-Henrietta High School and Edison Tech High School. This workshop will be offered again to another group of students in early 2009.
RIT’s first Ph.D. recipient follows trail to invention

By Kathy Lindsley, Jan. 19, 2009

In 1993, Bob Loce received the first doctoral degree awarded by RIT, thereby becoming the first person in the world to earn a Ph.D. in imaging science.

By then, he already held more than 15 patents.

Today, the Xerox principal scientist has more than 100 U.S. patents to his credit, reaching that milestone before reaching his 50th birthday last year. He has not stopped inventing: Another 40 potential patents are in the pipeline.

Loce talks about his work as if nothing could be more fun that developing a “Method of Selective Edge Softening and Rendering for the Suppression of Halo,” the subject of his 100th patent.

“At Xerox, you’re encouraged to invent,” he says. “If you write proposals that seem promising, you get to work on your own ideas.”

Loce has been particularly productive. Fewer than 20 Xerox scientists have as many patents, and of those, “I’m on the young end,” he says.

“If you’re going to invent, you have to be comfortable presenting your ideas. You have to be open to criticism. I think that’s an advantage I had,” he says. “I was never afraid to get criticized.”

Loce grew up in Rochester and joined Xerox as a lab technician in 1981 after receiving an associate’s degree in optical engineering from Monroe Community College.

“It was a great job,” he says. “I was working with Xerox scientists, Coming scientists. It was wonderful.”

While working full-time at Xerox, he earned his B.S. in 1985 in Photographic Science from RIT’s College of Continuing Education. Meanwhile, he was already writing patent proposals, and his first patent was issued in 1987. Loce completed an M.S. degree in Optical Engineering from the University of Rochester, then returned to RIT for the Ph.D. program—RIT’s first—all while on the job at Xerox.

“RIT had the right mix of theory, concepts and broad subjects as well as specific applications for me,” he says. He was able to immediately apply his academic work to projects at Xerox, including his Ph.D. thesis research. The thesis ultimately became a book, *Enhancement and Restoration of Digital Documents: Statistical Design of Nonlinear Algorithms* (SPIE Press, 1997).

By the time Loce was working on the Ph.D., it had become a bit easier to juggle work, school and family life: Xerox allowed him two days a week to devote to the doctoral program. The investment paid off well for the company.

“Among Bob’s many contributions are inventions that provided a foundation for Xerox’s transition from light lens technology to products based on laser imaging, inventions that made highlight color printing possible, and more recently, inventions covering image processing technology used in the iGen3 Digital Production Press and the Xerox Nuvera digital printers,” says Sophie Vandebroek, chief technology officer and president of the Xerox Innovation Group. “In addition to his own inventions, he has mentored many other researchers, helping to sustain our culture of innovation in the Xerox labs.”

More recently, Loce has been working on development of image processing methods for color electronic printing. He has publications and many patents in the areas of halftoning, digital image rendering, optics, imaging systems, and digital image enhancement.

A few years ago, Loce and associates developed a multiplexed imaging process he has publicized as “switch-a-view.” The process allows multiple color images to be printed on top of each other. Different images show up when viewed under different colors of light.

“This was one of the more fun things we’ve done,” he says. But its unlikely that it will become part of a Xerox product, he says. At some point, Xerox could license the technology to another company. That potential source of revenue makes it worthwhile to pursue almost any good idea.

Even ideas that fail are valuable. “You don’t expand the boundaries of your technology by always working on a sure thing. You have to advocate for ideas that are risky but could have a significant pay off, and you have to be comfortable with a few failures. Unless you are failing 10 to 20 percent of the time, you are probably being too conservative in generating ideas and inventing new technologies,” Loce says.

Loce frequently works with the company’s intellectual property experts. In 2002, he passed the U.S. patent bar exam, making him a registered patent agent.

When he’s not pursuing scientific discovery, Loce likes to take on outdoor challenges. He has climbed some of the highest mountains in North America. For instance, to celebrate completion of his Ph.D. in 1993, he climbed Popocatepetl, an 18,000-foot volcano in Mexico. In the past few years, he has spent a great deal of his vacation time hiking and camping in the Adirondacks with his sons, ages 10 and 13. He recently spent a week of very challenging backcountry hiking in the Wrangell Mountains in Alaska.

As a kid, he rode horses on the site of today’s RIT campus—land that was then owned by his grandparents, Dominic and Francis Bianchi.

“When I was growing up, I wanted to be a farmer or scientist,” he recalls. “I was of the generation that was inspired by the Apollo astronauts.”

He has enjoyed his career choice and believes that Rochester is an ideal place for a technologist or scientist.

“Rochester really is a center of invention. Forbes magazine ranked Rochester first in innovation with the highest number of patents issued per worker. Invention is part of the Rochester identity and we need to let the world know about it. We inventors and city leaders shouldn’t rest until we hear Silicon Valley say they are the Rochester of California.”
You can support the Center's academic, research, and outreach missions by making a contribution through the RIT web site. Just visit www.rit.edu/giving, and click on the "Ways To Give" button. Be sure to specify in the "comments" box exactly how you want your gift to be used. For example, "apply my gift to the imaging science high school intern program." Your generous donation will help ensure that the Center maintains its well-deserved reputation as the world leader in imaging education and research.