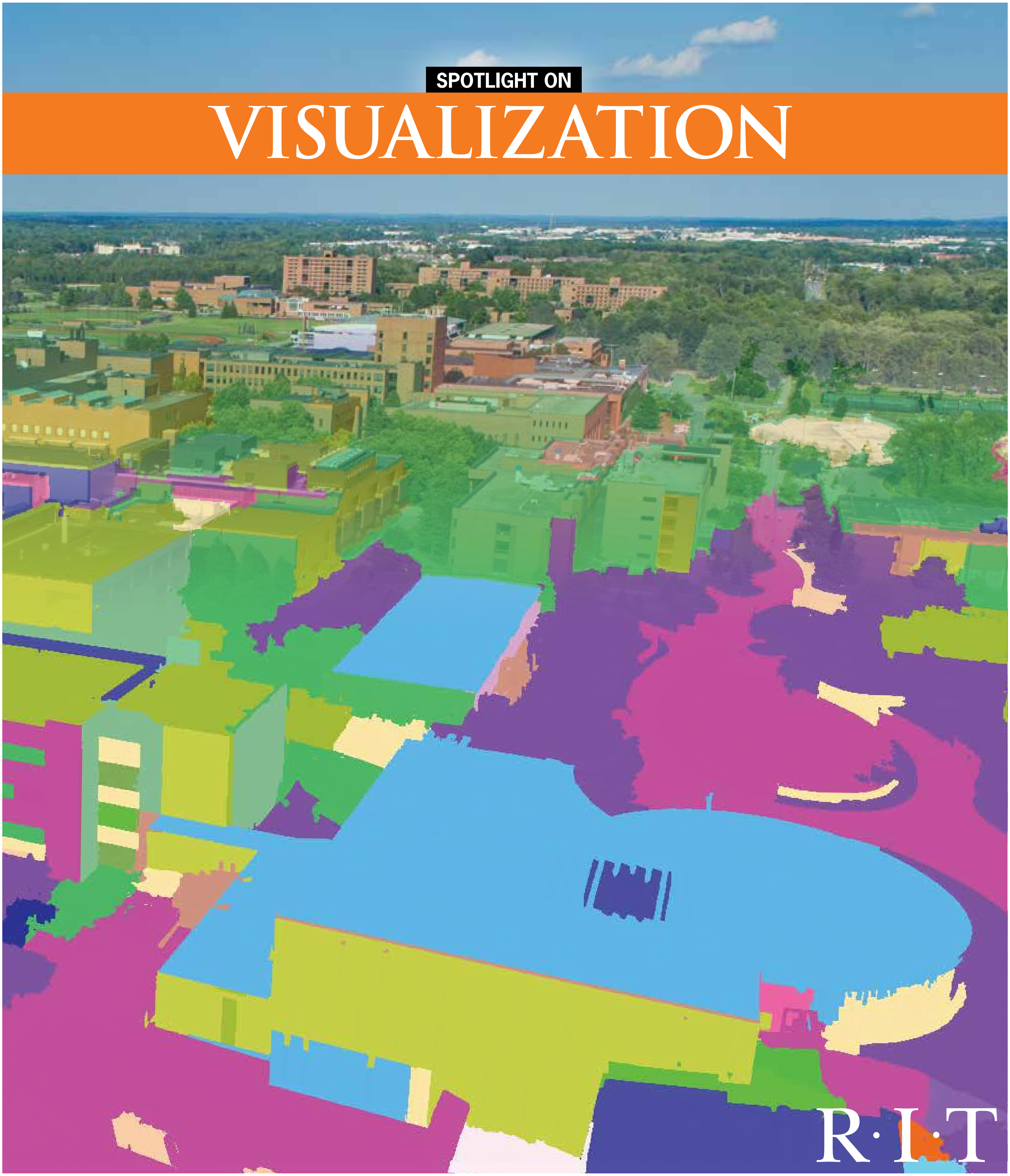
RESEARCH at RIT

The Rochester Institute of Technology Research Report

Fall/Winter 2013-14

SPOTLIGHT ON

VISUALIZATION



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The Rochester Institute of Technology
Research Report–Fall/Winter 2013-14

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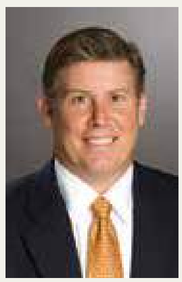
Visualization is in our DNA

Visualization—forming mental visual images or putting something into an understandable visible form—is both an art and a science. RIT is known for its culture of cultivating right-brain and left-brain thinkers. This intersection of ways of thinking promotes the creativity and innovation that are the hallmarks of RIT.



Whether it's imaging, human perception, or photonics, RIT's breadth and depth of expertise in this area of visualization is exceptional.

RIT's long tradition of excellence in the visual arts and sciences dates back to our roots. In this issue of *Research at RIT* we'll look at the history of the Chester F. Carlson Center for Imaging Science and the launch of the university's first Ph.D. program in imaging science. Who could have predicted that in the 21st century we would be walking around with devices that could take and share images instantaneously? We are inundated with images.

How we perceive the world around us and take in all this visual stimulation is another area of research at RIT. The Multidisciplinary Vision Research Laboratory, formerly known as the Visual Perception Laboratory, focuses on the fundamental questions as to how humans use visual perception during complex tasks. One of the current projects in the lab studies how geologists perceive scenes at geological sites and discovers ways to analyze huge amounts of data from a real-world environment.

Our eyes and brain process all of this visual imagery subconsciously. RIT is developing computing technologies to effectively process large volumes of data and distinguish objects. This concept—known as image segmentation—is being used in a wide variety of industries. You'll read about RIT's research in this area.

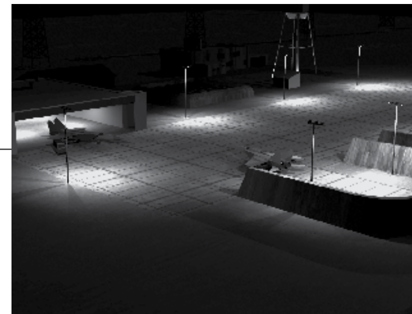
With RIT's rich history in visualization and the burgeoning field of digital media, it's no surprise that RIT has created a new research and development center on campus called MAGIC (Media, Arts, Games, Interaction and Creativity) to promote the exchange of ideas and information and to create digital media platforms. The synergy surrounding MAGIC is exciting! Read about the center's vision and some of the projects currently underway.

I hope you enjoy *Research at RIT*! As always, I look forward to your feedback about our research endeavors.

Best regards,

Ryne Raffaelle
Vice President for Research
and Associate Provost

Inside this Issue



1980
John Schott starts the Digital Imaging and Remote Sensing Laboratory

1983
Munsell Color Science Laboratory founded

1985
Center for Imaging Science forms

1986
John Schott and Carl Salvaggio build first version of Digital Imaging Remote Sensing Image Generation (DIRSIG), a simulation-modeling tool that is still used today by aerospace companies and the government

1989
Chester F. Carlson Center for Imaging Science dedicated

History of Imaging Science

by Kelly Sorensen

As the field of imaging science has evolved, so has RIT's world-renowned program by the same name. Grown out of RIT's photo science curriculum and transformed into the internationally recognized Chester F. Carlson Center for Imaging Science, the program draws high-caliber faculty and both undergraduate and graduate students from all over the world, and brings in millions in research funding.

Evolution of Photo Science to Imaging Science

When RIT began its photographic technology program in 1930, the focus was on the principles and practice of film photography and understanding the science of materials and processes. The program was renamed to photographic science in the mid 60s. As the technology evolved from film to electronic imaging to digital, photographic science morphed into imaging science.

In 1985, the Center for Imaging Science formed. It was the university's first research and teaching center bringing together traditional disciplines such as physics, mathematics, and optics with newer ones like computer science.

The technology has changed, but solving problems, conducting research, and providing students with a multi-disciplinary education remain at the core of the Center's mission. Last year, the Chester F. Carlson Center boasted externally funded research expenditures of more than $6 million.

RIT's Schott at Kick-Starting Research and a Ph.D.

In the early '80s, RIT was looking to ramp up its research and start a doctoral program in imaging science. A key figure in that transformation has been John Schott. Schott was 29 years old when he came to RIT. He had completed his Ph.D. in environmental science/remote sensing at Syracuse University and was working at Cornell Aeronautical Laboratories, now Calspan. Schott's specialty is remote sensing— specifically, the quantitative data analysis of remotely sensed images of the Earth such as evaluating the quality of a body of water or assessing the health of vegetation. Schott also works with the defense/military community.

Dr. Ronald Francis, longtime head of the department of photographic science, recruited Schott in 1980.

"I wasn't even thinking about changing jobs, but I ended up coming to RIT and never looked back," says Schott. "I got to do remote-sensing work, but much more importantly,

1989
RIT launches its first Ph.D. program in imaging science, the first and only imaging science doctoral program in the nation

1993
Xerox research scientist Bob Loce earns RIT's first Ph.D.

2000
Robert Johnston, archeologist, former dean of the College of Fine and Applied Arts, along with professor Roger Easton, begin work on recovering text from the 10th century Byzantine manuscript Archimedes Palimpsest

2000
Smithsonian's National Museum of American History invites Hunter Professor Roy Berns to be part of preservation efforts on flag that inspired "The Star-Spangled Banner"

2000
Anthony Vodacek begins work on a wildland fire detection and monitoring system that uses near infrared and thermal remote sensing with aircraft and satellite sensors. NASA-funded project is called FIRES (Forest Fire Imaging Experimental System).

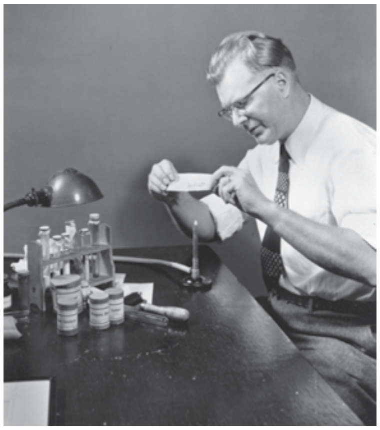
the university wanted me to spin up research."

Schott's remote-sensing work led to RIT's first major grant in 1981 for NASA's Landsat program. Schott knew that research and a doctoral program had to go hand in hand.

"I didn't want to create a Ph.D. program," says Schott. "I wanted to do state-of-the-art research, but I knew we couldn't do research without doctoral students."

The process to bring a Ph.D. program to fruition took nearly a decade. The RIT Board of Trustees had to amend the university's charter to allow for doctoral programs and once that was complete the charter had to be approved by New York state.

Among those board members championing the Ph.D. program and the need to grow research was Robert Kohler, who had graduated from RIT in 1959 with a bachelor of science in photographic science and technology. Kohler's career in the intelligence community included working at the Central Intelligence Agency, Lockheed Martin, and TRW Avionics and Surveillance Group. Kohler met then-RIT President M. Richard Rose at a dinner in Washington, D.C., and the two discussed an imaging science doctoral program. Kohler was an advocate of the idea because the intelligence community, among other industries, needed talented graduates. Kohler joined the Imaging Science Advisory Board in the mid '80s and then two years later became a member of the university's Board of Trustees.



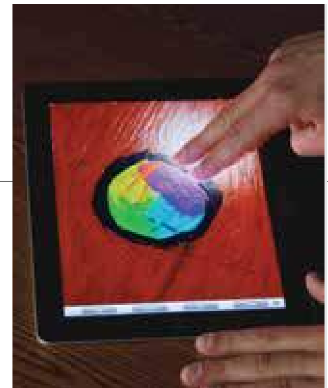
Inventor of Xerography: RIT's Chester F. Carlson Center for Imaging Science is named in honor of Chester Carlson.

"I led the charge saying that this was the kind of thing that RIT had to do," says Kohler, now a trustee emeritus. "Rochester was the imaging capital of the world and if a technical institute in Rochester, New York, had to be good at anything it was imaging. The majority of the board didn't believe that RIT should be in the Ph.D./research business, that our hallmark was as a teaching institution that produced craftsmen and technologists for the community."

Schott, Kohler, and Rose were among those who persuaded the board to move forward, and in December 1989, the New York State Board of Regents officially approved RIT's first Ph.D. program. Since its inception, 113 students have graduated from the doctoral program that draws students from all over the world, with physics, electrical engineering, and optical science/engineering as the top degree programs feeding the Ph.D.

A Center is Built

Upon its formation, the Center operated out of offices and laboratories in Frank E. Gannett Hall. In 1985, RIT received a federal appropriation of $11.1 million, half of which went toward the completion of the Microelectronic Engineering Building and the remainder went toward the construction of the Chester F. Carlson Center for Imaging Science, named in recognition of the founder of xerography as well as a generous donor to RIT.



2002
Professor Jeff Pelz and alumnus Jason Babcock invent a wearable eyetracker

2003
Wildfire Airborne Sensor Program (WASP) created: a multi-spectral imaging system that combines infrared and high-resolution visible digital "mapping" cameras with GPS

2004
Robert Johnston and alumnus Lucanus Morgan conduct image restoration on Dead Sea Scrolls in collaboration with Xerox and Eastman Kodak

2005
Roger Easton and P.R. Mukund begin preserving Hindu texts

2006
Multi-disciplinary Vision Research Lab created

2007
Color Science Ph.D. launched, RIT's fourth doctoral program

2009
RIT and University at Buffalo form Information Products Laboratory for Emergency Response (IPLER)

Chester Carlson's daughter, Catherine Carlson, attended the center's dedication ceremony on Oct. 28, 1989, and accepted the naming honor in his memory.

"Although Chester Carlson prized his anonymity, it seems right to honor a man who has contributed so much to the well-being of so many people and to the technological advancement of the 20th century," said Carlson in her remarks.

"He had a great affection for this institute and would be proud of the leading, comprehensive university RIT has become. RIT has indeed honored this great man by naming this center for imaging science for him."

Imaging leaders from as far away as London and Tokyo attended the dedication.

The 70,000-square-foot facility opened with 20 laboratories, five classrooms, 40 offices, five seminar and tutorial rooms, and a 150-seat auditorium.

"Everyone from the faculty up to the director treated the Center like a new home," says Schott. "There wasn't a crumb on the floor. It was an exciting time for all of us."

Center Veterans

Schott is part of a group of veteran faculty members who have been at RIT since the Center's inception.

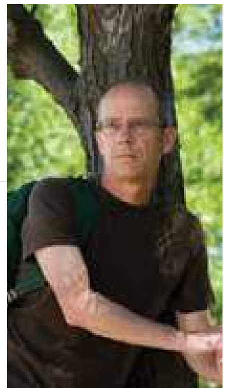
Among the others is Mark Fairchild, who started at RIT as a student. Fairchild, a native of Trumansburg, N.Y., recalls riding in the car with his parents down Jefferson Road and peering out the window at the campus. He told his dad he wanted to go to college there, but his dad emphatically said it was too expensive.

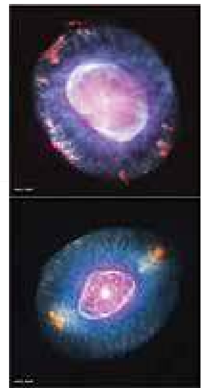
> *"He [Chester F. Carlson]had a great affection for this institute and would be proud of the leading, comprehensive university RIT has become. RIT has honored this great man by naming this center for imaging science for him."*
>
> *—Catherine Carlson*

"I loved photojournalism and my parents and I ended up coming here on a tour when I was in high school," says Fairchild, associate dean of research and graduate education in the College of Science and director of the program of color science. "We ran into a psychology professor, whose name I don't recall, and he mentioned the photo science program. We went over to check it out and noticed all the job postings on a bulletin board. I was always good at science, but had never thought about it as a job."

Fairchild started in 1982 in the photographic science department as a photographic science and instrumentation major, pursuing the BS/MS program. When he graduated in 1986, the imaging science program had begun. Fairchild believes he's the first master's graduate from the program.

Jeff Pelz also came to RIT as a student. Initially majoring in the fine arts photography program, he discovered pretty quickly that he didn't want to be a fine arts photographer, but a photo scientist. He approached Ron Francis, nicknamed "Doc" about changing his major to photo science and instrumentation. Extremely doubtful,





2010 Researchers shoot aerial imagery for Haiti earthquake relief efforts

2010 Center launches Innovative Freshman Experience—incoming imaging science students are challenged with building an imaging system as a team from scratch, replacing the traditional lecture/lab sequence

2011 Creation of the Laboratory for Multiwavelength Astrophysics (LAMA)

2011 Anthony Vodacek leads a MacArthur Foundation-funded study to benchmark the Lake Kivu region in Rwanda.

2012 Astronomer Joel Kastner heads international team using Chandra X-ray Observatory to image a set of planetary nebulae

Carlson Center Directors

1985	Willem Brouwer
1985-1986	Bob Desmond
1986-1992	Rodney Shaw
1992-1994	Robert Johnston*
1994-1996	Edwin Przybylowicz*
1996-1997	Harvey Rhody*
1997-2003	Ian Gatley
2003-2004	Ron Jodoin*
2004-present	Stefi Baum

**Interim director*

Francis told Pelz he would need to take a series of science courses and successfully complete the summer transfer course. Pelz eventually completed the undergraduate photo program, then entered the master's of science photo science program via the summer transfer course.

"It was essentially a 10-week bootcamp in photo science, eight hours a day, five days a week of classes and labs. I loved it," says Pelz. Pelz completed his MS thesis with Willem Brouwer, the Center's first director. Brouwer sparked Pelz's interest in vision and encouraged Pelz to pursue his doctorate at the University of Rochester's Center for Visual Science. Today, Pelz is the co-director of the Multidisciplinary Vision Research Laboratory in the Carlson Center.

Harvey Rhody, who will retire from RIT in May 2014 after 44 years, initially was part of the electrical engineering faculty. He joined the Carlson Center under director Rodney Shaw's tenure. Rhody recalls Shaw asking him what he was going to do his first year.

"I told him I was going to figure out what imaging science was," says Rhody.

Rhody did figure it out and began working on computer vision, developing courses in multiple-view imaging, or how to derive 3D information from multiple images of a scene. Rhody served as interim director from 1996-1997.

"The Carlson Center initially reported to the College of Graphic Arts and Photography and then was moved out of the college as a stand-alone unit," says Rhody. "This was considered temporary. Imaging science faculty members were consulted about where would be the best fit and we decided to join the College of Science. I worked with the College of Science dean at that time, Bob Clark, to help the Center make that transition. We started looking for a permanent Center director and ended up recruiting Ian Gatley."

Gatley served as Center director from 1997 to 2003 until he was named dean of the College of Science. Ron Jodoin then split his time as interim director of the Center while serving as associate dean of the College of Science as RIT conducted a national search. In 2004 RIT hired Stefi Baum, an astronomer who had worked at the Space Telescope Institute (STScI), the science operations center for the Hubble Space Telescope and the next-generation space telescope, the James Webb Space Telescope. Baum has served as the Center's director for nine years.

"The neatest thing about the Center and why I came here is because it achieves this interdisciplinary fusion of multiple fields," says Stefi Baum, director of the Chester F. Carlson Center for Imaging Science. "It's also truly focused on student education and at the forefront of research. Those two aspects have never diverged from each other and it's hard to find that combination anywhere else. Our students go on to great careers in academia or, more commonly, in industries such as medical imaging, the environment, defense, aerospace, nanoimaging, and the tech industry. Students can pick where they want to make a contribution through imaging."

On the Web

Chester F. Carlson Center for Imaging Science
www.cis.rit.edu

Photo technologist: Jeffrey Harris' first job out of college with the CIA was processing film taken by reconnaissance satellites. A cargo plane, similar to the one above, would make a midair pickup of the film canister over the Pacific Ocean. Photo courtesy of the Smithsonian's National Air and Space Museum

Career Dedicated to Helping Maintain National Security

by Kelly Sorensen


Jeffrey Harris

For Love of Country and RIT

When Jeffrey Harris began his career at the Central Intelligence Agency 35 years ago, his first job was to process rolls of long thin film from reconnaissance satellites.

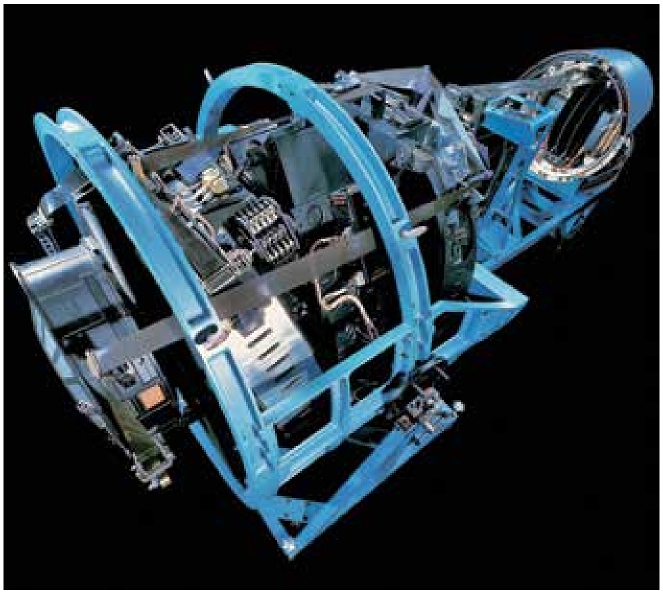
"The satellite's film canister would reenter the atmosphere from space and then with a parachute over the Pacific Ocean it would be caught midair by an Air Force cargo plane," says Harris. "I got the job of opening the 'film bucket' to get the film processed and copied as quickly as possible to gain important world insights for our government. I immediately had to put to work what I had learned at RIT. It was nice to have so much responsibility early in my career."

Harris graduated from RIT in 1975 with a bachelor's degree in photographic science and instrumentation. He shares the credit with his mother for deciding to attend RIT.

"I remember it was love at first sight when we visited the campus. My mom discovered RIT's program. She knew I was good at science. I liked imaging systems, but didn't want to be a professional photographer. RIT had the only program that allowed you to do what we now call imaging science."

Ron Francis, Al Rickmers, and John Carson—all professors in RIT's department of photographic science during Harris' time at RIT—taught him about chemistry, statistical quality control, and optics.

"My professors were consulting for companies and they would bring these real-world experiences back to the classroom. We learned about the cost and utility of collecting test points, something that businesses have to deal with all the time. The fact that RIT is closely aligned with industry is a real advantage for its students."



Corona film capsule, which is on display at the Smithsonian's National Air and Space Museum in Washington, D.C. Harris presented the Corona equipment to the museum during a ceremony in 1995 after the program was declassified. Photo courtesy of National Air and Space Museum

Reconnaissance satellite: The Corona KH-4B Camera and Discoverer XIII Film Return Capsule. It was the most advanced camera system used in Project Corona, the world's first photoreconnaissance satellite program. Photo by Eric Long, National Air and Space Museum

Throughout his career working in both government and industry, Harris had a front-seat view as the technology to maintain national security evolved from film to digital. He worked his way up the ranks within the intelligence community, serving in senior national leadership positions. In 1994 he became the director of the National Reconnaissance Office (NRO) providing direct support to the secretary of defense and the CIA director.

During his government tenure as NRO director from 1994 to 1996, the United States intervened in the conflict in Bosnia-Herzegovina. He recalls briefing President Bill Clinton and First Lady Hillary Clinton about the crisis and showing them images of the genocide.

"One of the jobs I had was to try to identify how we could use the imagery to keep the noncombatants safe from the Serbians who were shelling their villages. We put together a program approach to create safe enclaves in an effort to protect them and better leverage the United Nations' peacekeepers. It was exciting to be able to share with policy makers and our military the best information possible while at the same time developing state-of-the-art systems to advance the mission's capabilities."

Harris says to see your role have an impact on helping to sustain world peace has been gratifying.

He worked on top-secret programs like Corona, Hexagon, and Gambit, all of which are now declassified. These satellite-imaging programs, which began in the '60s, provided critical intelligence about the Soviet Union during the Cold War era.

As NRO director, Harris presented the Corona's camera equipment to the Smithsonian's National Air and Space Museum in Washington, D.C., during a formal ceremony in May 1995. Many who had worked on the Corona systems were invited to attend. Corona's first successful flight of recovering film from space was in 1960.

"The ceremony was quite emotional- there were a lot of tears. All of these people thought none of their work would ever be declassified. They had never been able to tell their families what they did for their jobs. It was wonderful for them to be publicly thanked by their country."

When Harris left the NRO in 1996, he became president of Space Imaging, now called DigitalGlobe, a private company that provides high-resolution satellite imagery to global customers including Google Earth.

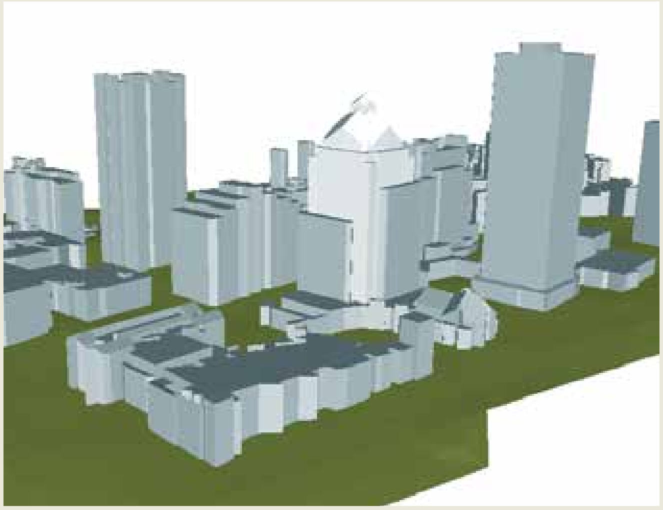
"We were the first to create a new commercial enterprise of selling satellite images to farmers, map makers, environmentalists, and city planners."

After Space Imaging, Harris returned to his defense roots at Lockheed Martin Corp. He built space and ground systems for military, civil, and intelligence applications. He had the opportunity to work on weather, GPS, and communication satellites as well as Hubble and the international space station.

Now semi-retired, Harris is a consultant and enjoys giving back to his alma mater. Harris is a member of RIT's Board of Trustees, the College of Science Advisory Board and the Center for Imaging Science Advisory Board.

"My career has been a fabulous journey. I owe it all to RIT!"

A three-dimensional point cloud derived using the RIT Digital Imaging Remote Sensing structure from motion workflow using more than 400 images collected over downtown Rochester, N.Y., by the Exelis WAMI (Wide Area Motion Imaging) sensor. The point cloud contains in excess of 2,000,000 individual points geographically positioned in space.



Automatically extracted three-dimensional facetized models of buildings in downtown Rochester from point cloud data. These models can be utilized in synthetic image generation, games, imported to Google Earth, or used in any 3D modeling environment.

Academia and Industry Collaborate to Automate 3D Imagery

Imagine having 3D models at the ready for better understanding of war zones, or to highlight disaster impact such as building damage, or even to develop a realistic 3D gaming environment of downtown Rochester, for example.

RIT, along with industry partners, has been researching how to create automatic high-quality 3D models or reconstructions using airborne imagery and algorithm-based methodology. Imaging scientists and graduate students from the Chester F. Carlson Center for Imaging Science along with MBA students and professors from the Saunders College of Business have been working with Exelis, Pictometry International, and Lockheed Martin on the Consortium for 3D Innovation. The alliance is funded by a $1 million National Science Foundation (NSF) Accelerating Innovation Research (AIR) grant and matching funds from the corporate partners.

Google and Apple offer apps in which one can see 3D models of urban features and landscapes. Such a model involves a labor-intensive, expensive process that requires using photographs, analysts, and artists to fill in the details.

"If searching for a landmark like the Empire State Building, if you looked close enough it appears to be an artist's photorealistic rendition on the side of the building," says Carl Salvaggio, professor in the Digital Imaging Remote Sensing Laboratory. "An analyst/artist has gone in and picked points on the building to develop and refine a 3D model and then supplemented it with photorealistic renderings. You are never going to be able to reconstruct every feature or city in the world if someone has to do it manually."

The models could be used in various industries such as national defense, emergency response, urban planning, and agriculture.

"There is a need for visualization of forests to understand the ecological implications of deforestation and associated carbon emissions/sequestration events, or for modeling 3D species habitats, among other applications. 3D models of vegetation, for instance, will become increasingly important in the future for municipalities needing to map urban areas and forests," says Jan van Aardt, associate professor in the Digital Imaging and Remote Sensing Group.

MBA students brainstormed potential market segments. After building a scoring matrix and conducting in-depth research with potential customers, they determined the top four market segments are first responders; viewshed analysis—for example, placement of cellphone towers; the gaming industry; and the military.

Steve Schultz, co-founder of Pictometry and the company's chief technology officer, says Pictometry sells 3D models to various industries, including first responders, government agencies, school districts, and urban planners. However, it's an expensive product because of the labor involved.

"From this project, we are picking the best algorithms and the ultimate goal is to develop fully automated 3D models," says Schultz. "If we could automate 60 to 70 percent of the work and have to manually create only 30 to 40 percent of the work, we've generated savings that can be passed on to the customer."

Noah Snavely, a professor at Cornell and the co-inventor of Microsoft's Photosynth, partnered with RIT on this project. Snavely is one of the pioneers in generating 3D images from multiview 2D imagery. His work has mined the Web for millions of images of the city of Rome and created 3D reconstructions using an algorithm known in the computer vision community as "structure from motion." This algorithm automatically determines the camera placement and the direction in which each image was shot, as well as the 3D structure of the scene. RIT took Snavely's concept a step further, by extracting 3D coordinates from airborne image pixels and generating 3D "point clouds," and finally, figuring out how to put the data onto a map of the world. For example, one of Salvaggio's imaging science Ph.D. students, Shaohui Sun, produced a 3D model of the buildings in downtown Rochester from point cloud data extracted from aerial imagery.

"Shaohui created the 3D model with only geometry," says Salvaggio. "To be able to reconstruct the complex rooftops, like the one on the Bausch and Lomb Building for example, with no artist involved in the process, that's huge. When you consider the need for transformative science, as the NSF requires, this is what we are doing here."

Cowboys Stadium was the site of RIT's 28th Big Shot community photography project (www.rit.edu/bigshot). While RIT photographers shot an extended exposure, more than 2,400 volunteers provided the primary light source for the image using flashlights or handheld camera flash units. The final image was a 30-second exposure at F16. To view the 3D reconstruction go to http://i.minus.com/ibt7R6QqjYaPvX.gif.

Carl Salvaggio

Cowboys Stadium in 3D

For the first time in RIT's Big Shot history, the nighttime community photography project entered a new dimension of the 3D kind.

Carl Salvaggio, professor in the Chester F. Carlson Center for Imaging Science, and two imaging science Ph.D. students, Katie Salvaggio (no relation) and David Nilosek, produced a three-dimensional reconstruction of Cowboys Stadium, home of the Dallas Cowboys. Salvaggio and his students, along with a dozen undergraduate photography students from the College of Imaging Arts and Sciences, tested out this image-processing technique at night to build a 3D model.

Salvaggio and his team knew they would face challenges because of the stadium's glass façade.

"The most important step in doing a three-dimensional reconstruction is to find a point in one image and find its matching point in another image," says Salvaggio. "The problem with glass is there are no features. You either see through it or you see a reflection. If you move, the reflected objects change their physical position."

Prior to heading to Arlington, Texas, for the March 23 event, the students did a test reconstruction of Student Innovation Hall, a curved glass structure on the RIT campus.

"We tried it both during the day and at night a week before the Big Shot. We shot images and processed the data and it failed miserably."

They had also planned to mount the cameras on light poles in the Cowboys Stadium parking lot, but the poles posed their own problems. Wind gusts would move the poles slightly and the artificial light pouring off the poles would backscatter into the cameras. The students ultimately shot the images off of tripods.

The imaging science team arrived early in Arlington and shot images for three solid days and processed the data. All were failed attempts because of the reflections, but one last attempt the night before the Big Shot worked. Shooting after sundown, there was only internal light coming from the stadium and no external light being reflected from surrounding objects. The features remained in the same positions and provided good matches between images.

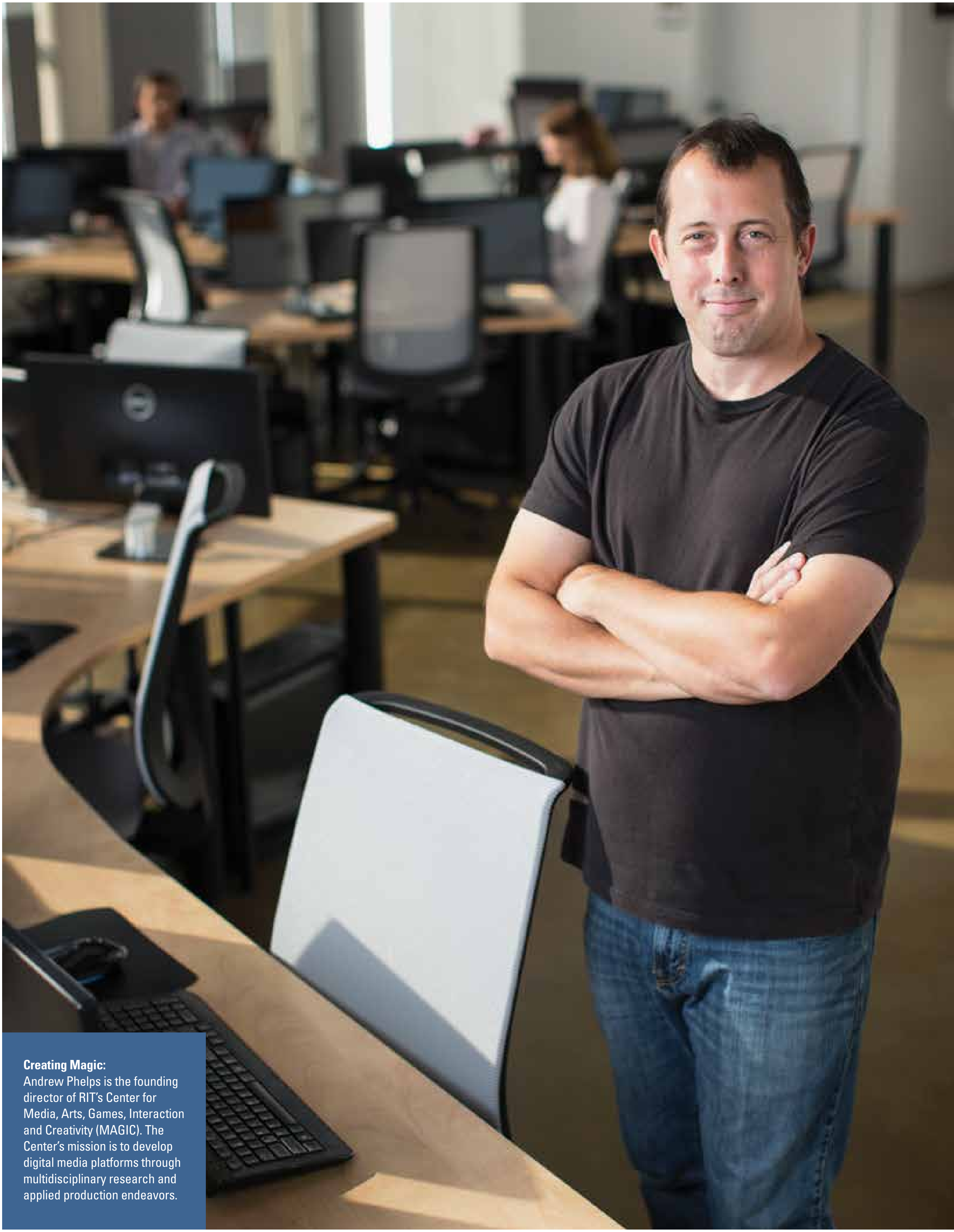
A Big Shot photograph is made with light provided by volunteers who use flashlights or camera flash units to "paint" a particular area of the landmark while RIT photographers shoot an extended exposure. All other lights are turned off.

The evening of the Big Shot, the RIT photographers shot four exposures with more than 2,400 volunteers manned with flashlights around the stadium. In between each exposure, the imaging science and photography students slightly moved their tripods along the stadium's perimeter to end up with 48 different views.

"Everything just came together," says Salvaggio. "It was luck. If it weren't a Big Shot scenario, this would not have worked. The flashlights were great because the reflections were going up to the sky and not reflected directly to our cameras. That worked really nicely."

The data had to be color corrected before being processed because the algorithms, which rely on color to find matches, would pass over pixels of the same object if the colors did not match. Ryan Harriman, a biomedical photographic communications major, color corrected the images. Then using a Russian-produced commercialized software called Photoscan, Nilosek knit together the 48 images of the stadium to produce a three-dimensional model.

"It was great having the imaging science program do something special for this Big Shot," says Michael Peres, associate administrative chair in the School of Photographic Arts and Sciences and one of the Big Shot organizers. "The students were innovating and problem-solving right up until we started shooting the exposures. To my knowledge, no one has ever made a 3D rendering of a timed exposure, so it's pretty cool to be in that company."



Creating Magic:
Andrew Phelps is the founding director of RIT's Center for Media, Arts, Games, Interaction and Creativity (MAGIC). The Center's mission is to develop digital media platforms through multidisciplinary research and applied production endeavors.

'Magic' Formula for Creating and Commercializing Digital Media

by Scott Bureau

In a world where people are constantly plugged in, it's important to understand the experiences we have with digital media. RIT's new Center for Media, Arts, Games, Interaction and Creativity (MAGIC) hopes to blur the lines between the arts and sciences, and between technology and expression.

One-of-a-Kind Approach

The Center is devoted to the burgeoning field of digital media—a field that is changing the way we communicate, the way we learn, and even the way we think. It will provide a broad range of research, development, education, and entrepreneurial activities in support of the exploration of media, arts, games, social interaction, and digital creativity.

The MAGIC Center is comprised of two parts: the RIT Laboratory for Media, Arts, Games, Interaction and Creativity, a nonprofit university-wide research and development laboratory; and MAGIC Spell Studios, a for-profit production studio that assists in efforts to bring digital media creations up to marketplace standards and commercialization.

"The Center will seek to engage a wide variety of faculty, staff, students, and partners to promote cross and multi-disciplinary collaboration wherever and whenever possible," says Andrew Phelps, founding director of the MAGIC Center. "In addition, MAGIC will strongly encourage and promote entrepreneurial activities for these projects."

Developed from a series of discussions between RIT President Bill Destler and Phelps, the Center seeks to bridge many of the barriers between academia and digital media research and production. While RIT's Center does borrow aspects of digital media programs from several other universities, including Stanford University and University of Wisconsin–Madison, it is adapted to fit RIT's unique structure. It's designed to provide both research and applied production solutions that continue to enhance RIT's exploration of digital and interactive media, games, social software, free and open-source software, simulation, visualization, etc.

"In the digital media field, it's important to remember if you do what someone else has already done before, you're dead," Phelps says.

Digital Media Crosses Boundaries

RIT's official history in digital media dates back to 2001, with the formation of the B. Thomas Golisano College of Computing and Information Sciences and the first course in game programming, taught by Phelps, the former director

Magic Components: The MAGIC Center is located in the newly renovated Student Innovation Hall. MAGIC is comprised of a university-wide research and development laboratory and MAGIC Spell Studios, a for-profit production studio.

Roundtable Discussions: RIT hosted New York State Sen. Martin Golden (right), chairman of the Senate Select Committee on Science, Technology, Incubation and Entrepreneurship on Oct 22. The MAGIC Center was the site of roundtable sessions called "Growing Computer and Video Game Development in New York." Pictured at left is MAGIC Center Director Andrew Phelps.

Projects In Development

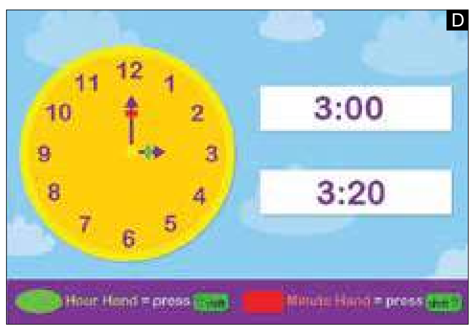
A Mosaic is a collaboration between RIT and the J. Paul Getty Museum in Los Angeles to explore the use of games and mobile applications to engage children and adults with the Getty Villa collection. Led by associate professor Elizabeth Goins and associate professor Christopher Egert, the iPod Touch game prototype uses narrative story and battles, along with hidden object and puzzle games to take the user around the Villa's galleries. As museumgoers find and discover objects, they may begin to see the museum as a fun place that people want to explore.

B Lemonade Stand is an open-source project originally developed in FOSS@MAGIC. It is designed to test children about fractions, working with money, estimation, and other math topics. Currently running on the XO laptops, this project will continue to develop as new students join each year.

C Mindgamers, a physiologically-controlled videogame, is designed for people diagnosed with anxiety and/or autism spectrum disorder. The game goal is for players to have their "best day" in school. A team of mental health and game design students and professionals work on the project, including Laurence Sugarman, director of the Center for Applied Psychophysiology and Self-Regulation at RIT's Institute of Health Sciences and Technology and clinical associate professor in pediatrics at the University of Rochester School of Medicine and Dentistry; Steve Jacobs, professor from IGM; and Robert Rice Jr., director of clinical internships in the Mental Health Counseling Program at St. John Fisher College.

D SkyTime is an educational game designed to teach children how to tell time. It was made for the Sugar Learning Platform, which was originally developed for the One Laptop per Child XO computer. It also runs on conventional laptops and PCs. The students read the time displayed on a digital clock and try to match it using an analog clock.

E Just Press Play (JPP) will continue to engage students in the MAGIC Center by helping them navigate the barriers to academic and social success. Funded by a gift from Microsoft Research and developed by RIT's faculty, staff, and students, the project introduces a game layer to enhance the student experience. Moving forward, the project will expand to support more of the campus beyond IGM. The infrastructure and tools will move to the cloud, so that researchers and designers at other schools and universities can begin to craft their own experiences using the core of the JPP toolset.



of RIT's School of Interactive Games and Media (IGM). Many majors throughout RIT dip into the pool of digital media—including but not limited to new media design in the College of Imaging Arts and Sciences, new media marketing in the Saunders College of Business, and communication and media technology in the College of Liberal Arts—and there is also a growing focus within the university on "digital humanities."

"The university had developed pockets of expertise in digital media, with a wealth of individuals doing interesting things in the game design, digital humanities, and new media design spaces," says Phelps. "However, RIT is a large campus and people were having difficulty communicating and sharing ideas."

Enter the MAGIC Laboratory—a university-wide, multi- and cross-disciplinary hub where faculty, staff, student researchers, artists, and practitioners come together to create, contextualize, and apply new knowledge to digital media. This work reaches into a multitude of related fields and disciplines, including not only science, technology, engineering, and math, but also their intersection with the arts and humanities. The lab acts as the intellectual and creative home for affiliated faculty from within the School of Interactive Games and Media, as well as faculty affiliates

Got Game: Phelps discusses ideas with game design and development students in the main area of Student Innovation Hall. A surround projection system, with nine projectors, has been installed for presentations and for students to use to develop visualization concepts.

Collaboration and Communication: A lounge area in Student Innovation Hall is a meeting place for student-innovators and entrepreneurs.

from across the university.

"I envision the space as a place for those water-cooler conversations to happen," says Elizabeth Goins, an assistant professor of fine arts and the museum studies program in RIT's College of Liberal Arts. "People from overlapping fields will come together to collaborate and make projects more dynamic."

Goins says the MAGIC Center will make it easier to recruit student artists and game designers for her projects. Students in her Interactive Design for Museums course—a project-based class that challenges museum studies and game design and development students to actually build a game for a selected museum—can also use the Center's resources.

A New Kind of University Research Center

"The university structure is set up as an excellent learning environment for acquiring knowledge, but not for commercial production," Phelps says. "In today's world, particularly in digital media, it's really difficult to ascertain meaning in your research without really going and seeing its effect on the public and the marketplace."

Some universities encourage their faculty to stay professionally active and have their own companies and production studios. But in establishing MAGIC Spell Studios, Phelps wanted to have faculty members' work aligned with the university. He also noticed that not everyone wants to deal with all the business management extras that come with owning a company.

"Some people love running a business, but I found that many students and faculty just want to make creative products that they can put out in the marketplace without the overhead or that they aren't motivated to create a business until their second or third product," Phelps says. "If the university can act as a third-party publisher, we have more time to focus on research and creative activity."

The MAGIC Center is designed to bridge the gap between research and prototyping, which is a common output of academia, with the ability to bring commercial scale and support to projects.

Full House: The MAGIC Center kicked off its speaker series with *The New York Times* and *WIRED* magazine writer Clive Thompson Oct. 28. The event was standing room only.

This allows the research and design to have a greater impact on the public than it would in a normal academic setting.

"The commercial production side of the Center also allows the university to employ the financial concepts that make digital media studios work," says Phelps. "Being able to embed a production studio directly into the student experience will provide true professional experience and an amazing learning opportunity."

Students Can Build It

Walking into the MAGIC Center, visitors will see faculty and students experimenting, designing, and developing their ideas, with plans to create a finished product. Some projects are funded by outside grants, while others are fully or partially funded by the MAGIC Center.

One student group found success with SkyTime, an educational game designed to teach kindergarten through second grade students how to tell time. It was initially developed as a class project in a Humanitarian Free and Open Source Software course designed by Stephen Jacobs, a professor in RIT's School of Interactive Games and Media. After the class, the team of four student-designers from throughout RIT continued to develop the game through the FOSS@MAGIC initiative.

"Today's projects can't be built with a group of students from a single major," says Adam Smith, an associate professor and program chair of the new media design program and affiliate faculty member in the MAGIC Center. "The MAGIC Center is helping to bring together students in an organized team environment that follows the conventions of industry and project planning to implement these solutions."

In July, SkyTime was selected for the White House Champions of Change event, which honors civic hackers who are doing extraordinary things with technology. The team has since tested the game at an elementary school in North Carolina and developed a Spanish version of the game.

"I'm excited to see the MAGIC Center help extend successful student projects after the course has ended," says Jennifer Kotler, a fourth-year medical illustration major from Merrick, N.Y., who works as an artist/designer for FOSS@MAGIC. "The SkyTime team has had the amazing opportunity to continue improving our game, and I can't wait to see where it goes next."

The New Look of Innovation

The MAGIC Center is housed in the newly renovated Student Innovation Hall. The space is shared by MAGIC, the Simone Center for Student Innovation and Entrepreneurship and the Innovative Learning Institute (ILI).

The fish-bowl shaped space features a production studio, a state-of-the-art computer lab, and entrepreneurial coaching and meeting facilities.

"The new space was developed to enable the MAGIC Center to achieve its mission as a leader in research and exploration of digital media, allow the Innovative Learning Institute to avail itself of some of the newest interactive media for education, and encourage collaboration and innovation among student-entrepreneurs in the Simone Center," says Ryne Raffaelle, RIT vice president for research and associate provost. "The synergies that exist between gaming and interactive media, education and entrepreneurship are undeniable. By co-locating elements of MAGIC, the Simone Center and ILI, we are better able to create an experience for our students that can't be matched anywhere else in the country."

On the Web

MAGIC Center
magic.rit.edu

The Simone Center
rit.edu/research/simonecenter

The Innovative Learning Institute
www.rit.edu/ili

Making Movies of a Galaxy Far, Far Away

Hans-Peter Bischof

Computer scientist Hans-Peter Bischof produces highly choreographed visualizations to illustrate complicated and complex processes like the merger of black holes.

"My role is to take the data from a simulation and create something visual the brain can understand," says Bischof. "I'm like a movie director directing a script."

Bischof, a professor in the B. Thomas Golisano College of Computing and Information Sciences, works with his colleagues in the Center for Computational Relativity and Gravitation to visualize data generated by large-scale simulations.

To create the mini-movies, he executes hundreds of thousands of lines of computer code into a visualization framework system called Spiegel. Bischof, along with some of his students, created Spiegel.

The visualization system can't automatically direct the view of the scene to the events that are of interest to scientists, but Bischof can program Spiegel to move a view to a given position, create a new view, and add illumination to the artificial objects.

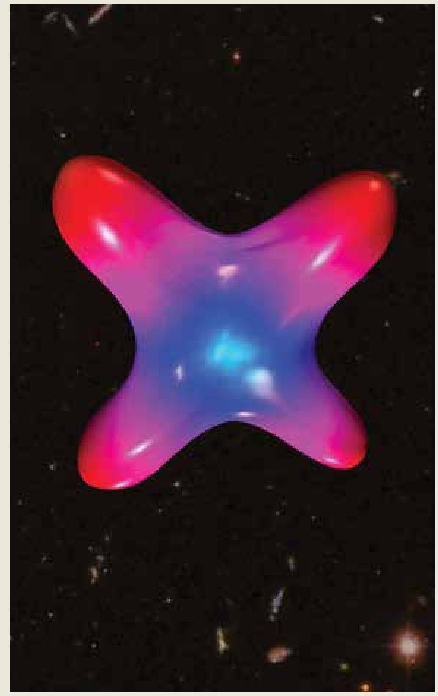
"We can watch the speed and distance of the black holes," says Bischof. "As they get closer to each other, the gravitational pull increases and they collide. With these movies, you can actually see it happen."

The timeline to create a movie can take anywhere from minutes to months depending on the complexity of the visualization and the amount of data. Bischof has created thousands of movies.

Bischof recently presented his visualization framework at MSV'13—the 2013 International Conference on Modeling, Simulation and Visualization Methods.

In addition to black hole collisions, Bischof has made movies to visualize the structures of proteins, the effects of the Black Death pandemic on the world's population, and a building complex extrapolated from laser-point data.

To view some of Bischof's movies, go to http://ccrg.rit.edu/movies.



Movie making: A visualization of the power radiated during a black hole merger.

AstroDance: A Collaboration Between the Right Brain and Left Brain

Thomas Warfield

Using visualization to convey complex concepts such as the origins of black holes and gravitational pull of particles in the universe was a main goal of AstroDance, an innovative performance group that used live dancers, narration, multimedia imagery, and film to help teach its audiences about astrophysics.

The group of nine deaf, hard-of-hearing, and hearing dancers performed more than 20 times from August 2012 through July 2013 in seven states and Washington, D.C., for thousands of audience members in schools and community events.

The show was created and choreographed by Thomas Warfield, director of dance at the National Technical Institute for the Deaf. AstroDance was a joint project among RIT's College of Science, B. Thomas Golisano College of Computing and Information Sciences, and NTID's Performing Arts program. It was intended to provide deaf, hard-of-hearing, and hearing children and adults with general information and basic concepts from the fields of gravitational physics and astrophysics while engaging them in an enjoyable and interesting theatrical experience.

Funded by the National Science Foundation, much of the spectacular, animated galactic imagery was produced by RIT computer scientist Hans-Peter Bischof. RIT astrophysicist Manuela Campanelli, Insight Lab director Jake Noel-Storr and several other RIT artists and scientists also worked to create AstroDance. Erin Auble, a faculty member in NTID's cultural and creative studies program, coordinated all of the visual technology and set design.

Teaching astrophysics through dance: Deaf and hearing dancers perform AstroDance. Photo credit: Erin Auble, RIT/NTID

"What we were presenting was basically an experimental idea to expand our perception of what science is, seeing it from different perspectives and also extending the parameters of how dance can impact our lives," Warfield says.

"Our alliance of science and art presented in this kinesthetic and visual format I believe opens our thinking more broadly, blends our intellect and our imagination, and allows for greater access to diverse understanding," Warfield says. "I believe it has helped us reshape our conversations about right brain versus left brain. There isn't a competition or hierarchy—there is one brain. Whether a scientist or artist, dancer or astrophysicist, we use both sides of our brain. Our learning is integrated. Our understanding is integrated. Our expression is integrated. That is the story of AstroDance."

Virtual Field Trips: Using eye-tracking technology developed at RIT, researchers from RIT's Multidisciplinary Vision Research Lab are able to analyze how both novice and expert geologists from the University of Rochester perceive geologically-active areas in the United States. Here, geologists look at a site impacted by an earthquake in California. Each circle illustrates a fixation. The diameter of the circle indicates how long geologists spent looking at a particular area.

What Are You Looking At?

by Matt Gregory

The eyes are the windows into the soul. Variations of this ancient proverb have been used in the works of numerous poets and authors, including William Shakespeare. The meaning behind the phrase implies that it is possible to determine someone's inner personality just by looking into a person's eyes. While that may or may not be possible, researchers at RIT are taking a much more scientific approach to studying what a person's eyes can tell us about cognition.

Fixated on Geological Activity-
How Novices Learn in the Field

The Multidisciplinary Vision Research Laboratory, or MVRL, studies how humans extract visual information, and how that information is used to make decisions and guide actions. This research is done through the use of eye-tracking equipment that actively monitors the position of the subjects' eyes in order to determine what they are looking at. The research can be applied to many different fields, including linguistics, computer science, psychology, marketing, and geology.

The geological applications of eye tracking are currently a main focus of the lab. A five-year research grant from the National Science Foundation has allowed researchers from RIT and the University of Rochester (UR) to travel to various locations in California and Nevada to study the differences between how novice and expert geologists perceive scenes in the field. They have travelled through many geologically active areas, including the Sierra Nevada mountain range, formed by the movement of tectonic plates, and Death Valley, and the adjacent basins formed by the same movement. UR geophysicist John Tarduno leads the students and experts on the 10-day field trip, and Robert Jacobs, a brain and cognitive science professor

at UR, leads the team's analysis of cognitive and perceptual learning.

"A major component of geology is about what you can see and what you can experience," says Tommy Keane, an RIT imaging science doctoral student. "Being able to go out and have geologists look at scenes in the field will enable us to learn a great deal about how novices and experts see and learn."

This research aims to improve geology education. By studying how a novice explores a scene, and comparing it with how an expert examines the same scenes, the researchers hope to reveal search patterns that can be used to teach novices how to better identify geologically significant features in a scene.

Keane, who earned his bachelor's and master's degrees from RIT in electrical engineering, and Thomas Kinsman, an RIT imaging science doctoral student, are part of a team working on improving the way in which the immense amounts of data from the mobile eye-tracking devices are processed. Currently, it takes 15-20 hours to process the data from a single eye tracker, and much of the work has to be done by hand. Along with other researchers, Keane and Kinsman are attempting to add more automation that will serve to streamline the process—no small task.

"There is a lot of ambiguity and complexity in the analysis of these data," says Keane. "We have to analyze not only where people look, but also how long they look there, how many times they come back to a point, and the order in which they look at things."

Most of their efforts to date have focused on developing new methods of capturing, analyzing, and evaluating the complex data. The research has shown that traditional low-level metrics, such as how long individuals look at each point in the scene, or how large individual eye movements are, do not reveal differences between novices and experts. Higher-level metrics that measure the cyclical

Jeff Pelz: co-director of the Multidisciplinary Vision Research Laboratory at RIT.

Geology review: Following an eye-tracking session, John Tarduno, UR geophysicist, describes how shifting tectonic plates formed the geology of the west coast of the United States.

Data analysis: Thomas Kinsman (left) and Tommy Keane, imaging science doctoral students, are developing tools to allow RIT to analyze the eye-tracking data. Kinsman is working on capturing the gaze position and Keane is working on analyzing the viewing patterns.

nature of the participants' viewing patterns have revealed the subtle differences between the groups.

Technological Approach

RIT was one of the first universities to pioneer wearable eye-tracking devices, which afford the ability to study eye movements in real-world environments instead of a laboratory. Jason Babcock, an alumnus of RIT, perfected the system in the late 1990s and now runs his own company called Positive Science, which manufactures eye trackers. Currently, the MVRL uses 12 mobile eye trackers—more than any other research facility in the world.

Jeff Pelz, Frederick Wiedman professor and co-director of the Multidisciplinary Vision Research Laboratory, who describes himself as a 'gadget guy,' says that one of the goals of the MVRL is to develop new systems to allow researchers to keep pushing the envelope in vision

Anatomy of an eyetracker: A close-up view of an eye tracker worn by Monica Cook, an imaging science doctoral student. The eyetracker is made up of two cameras; a scene camera above her eye, and an eye camera below the eye. The scene camera captures the image of the scene and the eye camera captures the image of the eye. An infrared LED illuminates the eye.

Gaze Patterns: A number of individual frames from the video eye tracker (top image) and the bottom image shows a series of gaze movements from across the scene.

On site: Jason Babcock (front), an RIT alumnus and the owner of Positive Science, prepares the laptops at a geological site prior to the start of an eye-tracking experiment.

experiments. As technology advances, so too does the MVRL's approach to eye tracking.

"We have to keep up with the available technology," says Pelz. "Cameras are smaller, lighter, higher resolution, and have higher frame rates than ever before. We're exploring environments with eye trackers that would have been impossible 10 years ago."

Keeping up with technology may present some challenges, but keeping up with the human eye presents entirely different ones. The eye makes some of the fastest movements of any part of the human body. That's why it is crucial for researchers in the MVRL to take advantage of the newest cameras and computers.

The mobile eye tracker currently utilizes an Apple MacBook Air in a backpack, hooked up to a wearable headset that uses a pair of cameras and an infrared LED to record eye movements. Weighing in at less than three pounds, the MacBook system is lighter than the older camera-based system that was used for the job. In a pilot project underway in the lab, funded in part by a CIS micro grant and RIT's Kate Gleason College of Engineering, Dorin Patru, professor in electrical engineering, is working toward a wearable computer that weighs only a few ounces, thereby increasing the mobility of the device even further.

Sometimes, however, simple technologies are required to facilitate eye tracking. While working outdoors in places such as California, researchers had to wear large hats to shield the eye trackers from direct sunlight. The eye trackers utilize a small infrared LED, which is limited in power, making it difficult to detect due to the large amount of infrared light coming from the sun.

Originally named the Visual Perception Lab, the MVRL has grown considerably over its 20-year history under the leadership of Pelz and co-directors Anne Haake, professor and associate dean for research and scholarship in RIT's B. Thomas Golisano College of Computing and Information Sciences, and Andrew Herbert, professor and chair of the psychology department in RIT's College of Liberal Arts. About five years ago, the lab was renamed to reflect its multi-disciplinary approach to research.

"The MVRL is a lot more than just a collection of rooms," says Pelz. "We wanted the name of the lab to reflect the fact that the research involves students, staff, and faculty from several colleges, departments, and disciplines across RIT. The faculty benefit greatly from the fact that we have undergraduate and graduate students actively involved from imaging science, psychology, motion picture science, computer science, linguistics, interpreting, and engineering, to name a few. We think the students benefit from

Medical imaging: Recorded explanations combined with the gaze patterns from dermatologists reviewing images are helping to train medical students in diagnosing skin lesions.

On the road: A driver's gaze is tracked while commuting to work. The cross-hair indicates where the driver is paying attention as he approaches the intersection.

an environment where faculty from all the colleges come together to collaborate."

Looking and Thinking

Imagine what it would be like if you could see what people were thinking. You could learn quite a bit about people's brains. In a sense, eye tracking does exactly this.

"People don't typically think about where they are looking," says Pelz. "If you can keep track of where people look, you can keep track of people's cognition."

The key to success, according to Pelz, is that eye tracking must be externally observable and must not interfere with the subject. If the subject has to consciously think about where they are looking, this will taint the results.

"The assumption, of course, is that people are thinking about what they are looking at," he says. "If this is true, eye tracking becomes a powerful tool to measure cognitive processes and cognitive load."

The wide variety of research that has been done at the MVRL reflects the strong connection with vision and the brain. Past research has included examining the eye movements of automobile drivers on the road, doctors while examining patients' images and deaf and hard-of-hearing people while viewing a presentation and following an interpreter.

Cecilia Ovesdotter Alm, assistant professor of English in RIT's College of Liberal Arts, is part of a multidisciplinary team, led by Haake, working on a research project to create a multi-modal content-based image retrieval system. The goal of the research, funded by the National Science Foundation and the National Institutes of Health, is to leverage several modes of input from experts viewing images. In the current work, trained dermatologists explain to physician assistant students how they reach a diagnosis from a medical image. The eye movements of the dermatologists are recorded along with their spoken explanations.

Alm and the students working on the project are developing new methods to extract meaning from the synchronized combination of gaze patterns and utterances, with the goal of using the results to build new teaching systems for medical students.

Alm, who is a computational linguist, says the lab is a good example of how interdisciplinary research produces positive results. "It provides a new perspective to work with people from other areas of expertise," says Alm. "I think the Multivisionary Research Laboratory reflects the very spirit of RIT."

On the Web

Multidisciplinary Vision Research Laboratory
www.cis.rit.edu/mvrl

NSF Project between RIT and UR
http://geovis.cis.rit.edu

Virtual Tour of the Human Body

Paul Craig

Richard Doolittle

Unraveling the mysteries of the human body and illustrating those findings in a scientifically accurate and visually spectacular fashion is the goal of the Human Visualization Project.

Students from the College of Health Sciences and Technology and the College of Science have created never-before-seen virtual images of organs, tissues, cells, and molecules.

They've produced 3D images of the pancreas, kidney, spleen, skeleton, nervous system, liver, and ear.

The Human Visualization project began in 2005 under the leadership of Richard Doolittle, vice dean of the College of Health Sciences and Technology, and Paul Craig, head of the School of Chemistry and Materials Science.

"We want to show a human visually from all levels—from the organs to the tissues to the cells to the molecules," says Craig. "We want to look at all levels, because if we look at the impact of a drug on the body, for example, sometimes it's at the molecular level or it may affect the overall nervous system. We would like to be able to show that."

Craig says it's primarily medical illustration students who work on creating the visualizations. Based on current scholarly articles and the known science, the students interpret the processes and then create the images.

Visualization illustrating how alcohol interferes with GABA inhibitory receptors in the brain.

Valerie Altounian, a 2013 graduate of the medical illustration program, produced visualizations illustrating how alcohol interferes with the actions of GABA (gamma-aminobutyric acid) inhibitory receptors in the brain. Altounian first created drawings and used Maya 3D software to produce the final visualizations. This project was part of a team effort under the direction of Dr. Caroline Easton, professor of forensic psychology in RIT's College of Health Sciences and Technology, to create visualizations of a range of drug interactions to illustrate the relationship between substance abuse and partner violence.

"The ultimate goal is not only to create videos for doctors treating victims of partner violence, but to educate the victims and their abusers about the impact of the destructive behavior," says Doolittle.

Since the project's inception, Doolittle and Craig have presented the visualizations at various conferences including the American Association of Anatomists and the Canadian Association for Pharmacy Distribution Management.

Guiding Viewer Attention in a Subtle Way

Reynold Bailey

When looking at a computer screen or a photograph, the human eye is naturally drawn to faces, or regions of bright color or high contrast.

Reynold Bailey, associate professor of computer science in the B. Thomas Golisano College of Computing and Information Sciences, has developed a technique called subtle gaze manipulation that guides the viewer's eyes about a scene and can draw attention to objects that may not be visually prominent but may still be important for some task, such as tumors in mammogram images or camouflaged targets in a photograph.

The National Science Foundation awarded Bailey a Faculty Early Career Development grant to develop his work in this area.

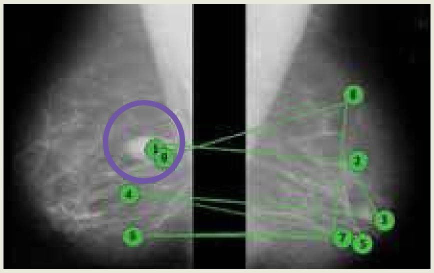
"Subtle gaze manipulation involves modulating the brightness of pixels on a digital image, but the modulations appear only in the viewer's peripheral vision," says Bailey. "The modulations draw attention to specific areas, but are terminated by the time the viewer's eyes get there. We want the viewers to focus on the actual image content rather than on the changing brightness that we use to attract their attention."

In one study, Bailey tested the technique on mammograms to guide attention to anomalies like tumors. A radiologist reviewed a series of mammograms and her eye movements were recorded using a desktop eye tracker.

"We then used that eye-tracking data to guide a group of novices who knew nothing about radiology or mammography. We showed them the images and then modulated the pixels along where the expert looked, so the novices were in essence mimicking the radiologist's eye movements."

The findings showed that subtle gaze manipulation increased the chances of the novices discovering the tumor. And even after a short break of examining mammograms and with gaze manipulation turned off, the novices continued to perform better than a control group.

Bailey says subtle gaze manipulation could be used as a tool to train medical professionals, drivers, and pilots.



Mammogram: Image of a simplified scanpath of an expert radiologist. A potential tumor is circled in purple.

"Our studies have found that by guiding someone's attention we can improve their spatial understanding and their recollection of size, shape, and location of objects. Training in various areas still boils down to a master working with an apprentice, but subtle gaze manipulation could be used to improve training efficiency."

Bailey is currently developing and testing various approaches to extend the concept of gaze manipulation beyond digital imagery to include real-world environments.

To learn more about Bailey's work, go to https://sites.google.com/a/g.rit.edu/gaze-manipulation/.

Campus scenes captured by image segmentation technology: Using still photographs of several campus locations and the university's mascot Ritchie (top right), RIT researchers segmented them into separate components based on color, gradient, and texture information—key steps in image analysis and computer vision technologies.

Image Detectives

By Michelle Cometa

A persistent challenge in image segmentation technology is to develop a system that can distinguish objects with the precision of the human eye and the processing capacity of the human brain. Developing computer applications to recognize, extract, and classify distinguishing characteristics of static and video images for image segmentation is a challenge being met by RIT researchers.

Capturing Data Through Image Segmentation

RIT researchers are developing some of the most sophisticated computing technologies to process static and advanced-video images through image segmentation—a process defined as the partitioning of an image or video stream into pixel sets of specific objects and object components. Distinguishing those objects and components has inherent challenges: recognizing textures, color gradation, and object groupings, determining correct placement of objects, as well as being able to confidently rely on computer applications to systematically recognize, isolate, and process these and other distinguishing characteristics of objects within images. Using image segmentation provides a means for more accurate analysis of images—whether monitoring natural resources adjacent to urban areas for flood prevention, observing buildings or facilities and detecting variations or damage to infrastructure after a natural disaster, or finding anomalies in areas for target detection and surveillance.

Eli Saber, professor of electrical engineering in RIT's Kate Gleason College of Engineering, developed a complex algorithm that prompts the segmentation technology. This platform technology is being used across various industries from biomedical applications to security and surveillance, from entertainment and resource recovery to advanced printing. The algorithm and subsequent processing technology has been successfully used to improve the analysis of multiple static images, compressing data within the images to build three-dimensional models. Saber and his research team have begun expanding the concept to video imaging, capturing multiple moving images, and extracting data.

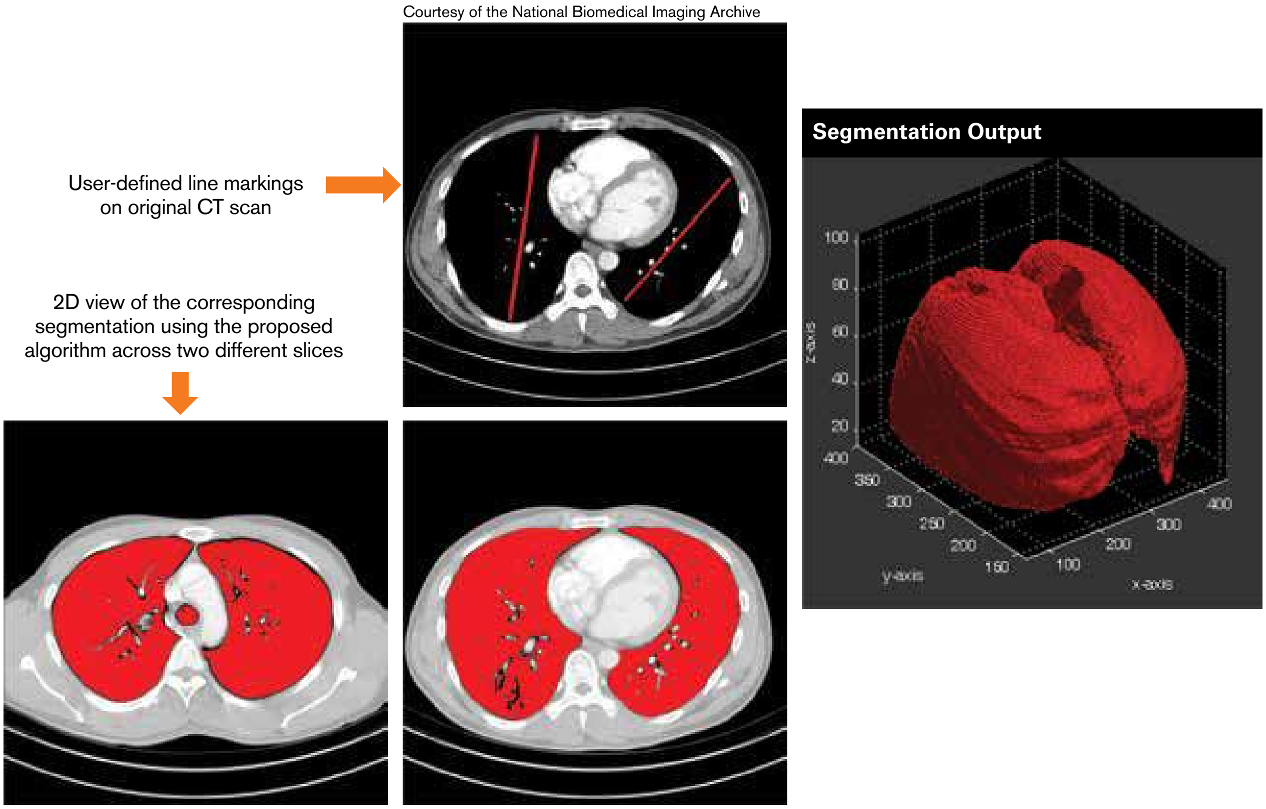
Saber has collaborated with David Messinger, director of the Digital Imaging and Remote Sensing Laboratory in the Chester F. Carlson Center for Imaging Science, and the two have developed applications to address image segmentation demands utilizing this multidimensional, computing algorithm—called MAPGSEG (multi-resolution adaptive and progressive gradient-based color image segmentation)—developed at RIT in conjunction with Hewlett-Packard Company.

Developing university, corporate, and industry relationships: Eli Saber, professor of electrical and microelectronic engineering in RIT's Kate Gleason College of Engineering, leads collaborations in the development of image segmentation technology for applications that span diverse industries, from biomedicine to surveillance technologies.

"Partitioning generates a reduced and relevant data set for high-level operations such as rendering, indexing, classification, compression, content-based retrieval, and multimedia applications," says Saber, who leads the Image, Video and Computer Vision Laboratory in the engineering college.

This type of partitioning, or segmentation, comes naturally to humans. The human eye views and distinguishes numerous images daily, and the brain processes the information in real time. Developing a simulated environment to perform similar tasks is the basis of the MAPGSEG algorithm. It can selectively access and manipulate individual content in images based on desired level of detail. MAPGSEG is a solution that computationally meets the demands of many practical applications involving segmentation and can be a reasonable compromise between quality and speed that lays the foundation to do fast and intelligent object/region-based, real-world applications of color imagery, Saber adds.

Today, some of those segmentation applications of color imagery are being adapted for biomedical imaging, object recognition, and surveillance. Saber and Messinger are bringing



Defining and locating tumors: Image segmentation technology extracts specific data from multiple CT-scan slices, the thin cross-section of images, to compose a three-dimensional view, in this case locating a growth in a human lung. Analysts define line markings, and the image segmentation algorithm extracts specific slices that show anomalies in body cavities. This can reduce the number of CT-scan slices a radiologist must view to determine the exact location and size of a tumor, and potentially allow for improved analysis and location accuracy.

to fruition improvements to, and unique solutions for, these applications and others.

Successful Integration of Biomedical Image Segmentation

MAPGSEG works within CT-scan software to expose tumors, revealing a more accurate reading of actual size, weight, location, and density. The application is integrated into RECIST measurements—Response Evaluation Criteria in Solid Tumors—measurements commonly used by physicians to mark the baseline tumor size, then further, as a comparative measure of the tumor's response to treatment.

Radiologists often look at 100 or more progressive slides of a mass taken by a CT scan. The physician manually compiles the origination and extension points, or vectors, of the tumor found on the slides.

"Our segmentation technology runs in the background; it segments the tumor across the slices, and provides a volume measurement," Saber explains. "That RECIST measurement triggers our segmentation. Think of it as seeding. The seed will grow and spread through the entire image and begins to grow to find the tumor using our algorithm segmentation techniques. It pulls the 'images' out of all the appropriate screens, and compiles them to the full image of the tumor."

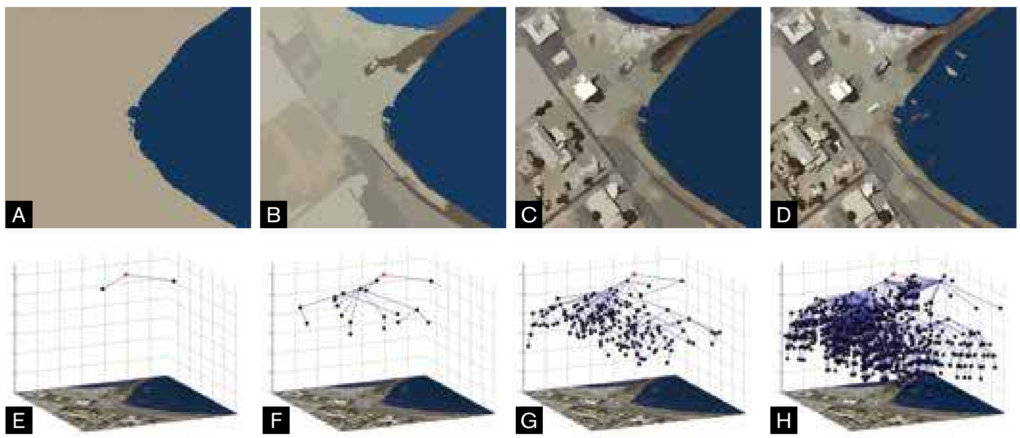
The work done by Saber and his research team has not gone unnoticed. He and Sohail Dianat, head of RIT's electrical and microelectronic engineering department, worked with DataPhysics on a project to help improve its next-generation CT-scan technology. The California company announced in 2011 that it would open a new product development facility in Rochester. One of the reasons cited for its move was its proximity to RIT and Saber's research activities in image segmentation.

DataPhysics is only one of several corporate connections Saber has fostered since coming to RIT in 2004. Since that time, he has secured more than $3 million in external funding with companies such as HP, Lenel, Varian Semiconductors and Ortho-Clinical Diagnostics—a Johnson & Johnson Company—a broad representation of industries that are incorporating image segmentation into their respective business applications to better understand image components, image compressions, modeling, and imaging search functions.

This is especially true in the analysis of remotely sensed images from satellite and sensor technologies. Developments in these areas have increased the quantity of high-resolution images faster than researchers can process and analyze data manually.

Saber and Messinger are developing advanced intelligence processing technologies to handle those large volumes of data in a timely manner, and to effectively

Scene WorldView-2 sensor courtesy DigitalGlobe© (Image: Al-Masirah Island Oman)



Segmenting satellite imagery of urban landscapes: Aerial still photography is segmented for analysis by partitioning the varied objects captured in the image (a-d) and building a scale-tree (e-h). The nodes in the scale-tree represent objects, of various sizes, in the image that have been extracted and indexed for further analysis and to correspond to the spatial structure of the original image. The process allows analysts to understand the data structure and enables the computing system to recognize specific objects.

distinguish objects, scale, complexity, and organization using MAPGSEG, the foundational technology of static, two-dimensional image segmentation.

Analyzing Satellite and Advanced Video Images Effectively

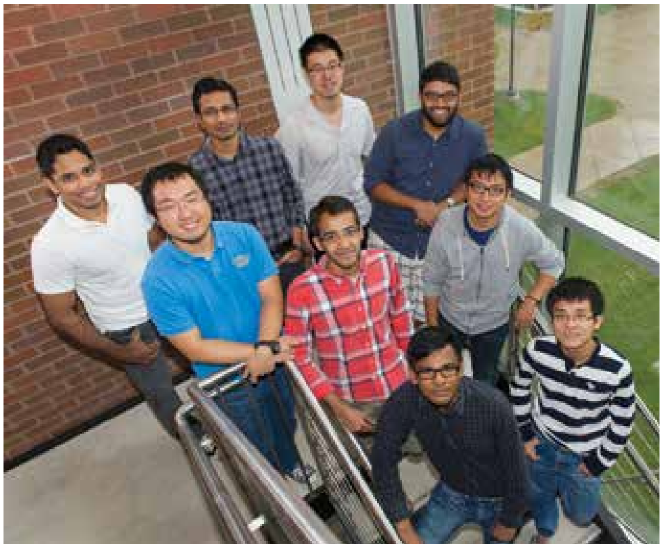
With the advent of more capable sensors and unmanned aerial vehicles, images can be acquired at higher rates. Saber and Messinger are exploring the use of topological features to improve classification and detection results and focusing on development of a segmentation methodology to differentiate the unique cues of moving and still objects derived from full-motion video capture.

They received more than $1 million in federal funding this past spring for two separate but related research projects: “Spatiotemporal Segmentation of Full Motion Airborne Video Imagery” and “Hierarchical Representation of Satellite Images with Probabilistic Modeling.” The aim is to provide an effective foundation that will assist analysts in tasks such as target detection and recognition, classification, change detection, and multisensor information fusion. Breaking down high-resolution images into groupings based on size and spectral similarity serves as an essential step in reducing the complexity, by first deconstructing the image by scale, and then organizing it in a hierarchical fashion, Saber explains.

The process has multiple benefits including being able to combine data collected from multiple sensors, a representation that allows for the organization and sorting of a large area, and the ability to query topological information to help analysts examine objects and corresponding elements, giving contextual information about a scene. It also utilizes probabilistic modeling to quantify, with a high degree of certainty, the quality and reliability of the information.

Partitioning the digital frames into non-overlapping, specific regions, or objects—from a three-dimensional viewpoint, and events or shots from a sequential perspective—facilitates selective access and manipulation of individual content. This is essential in establishing the foundation for high levels of analysis, enhancement, classification, storage, and compression of full-motion video to extract intelligence information, says Sankaranarayanan Piramanayagam, an imaging science doctoral student from Chennai, India, working on the project.

“We treat video as a three-dimensional volume, and partition the data into meaningful spatiotemporal regions or shots. We are trying to extend and optimize the current segmentation framework for full-motion video imagery. We are trying to think like an analyst—figure out a specific



Student-researchers teaching computers to understand images: Student-researchers work on different aspects of the evolving image segmentation technology bringing together expertise from graduate and doctoral students in RIT's Kate Gleason College of Engineering and the Chester F. Carlson Center for Imaging Science.

Challenges in video segmentation: The foundational MAPGSEG algorithm has been used successfully for analyzing still imagery and is being adapted for advanced video and remotely sensed images.

or anomalous event, beyond motion detection, from a full-length video sequence," says Piramanayagam.

The overall concept is like taping an entire NFL game, but being able to program a system to isolate and compile only touchdown plays, for example. This simple analogy does not, however, convey the system complexity needed to produce a sophisticated "highlight reel" of data in image form.

The researchers' approach begins with the estimation of motion from the input video, providing appropriate cues for moving versus still objects, and foreground versus background information. Following this, a three-dimensional, spectral, or motion-based, edge detection method is performed to extract significant gradient information of spectral changes across the volume. More specifically, locations with small gradient magnitudes are congregated together and uniquely labeled to identify a set of seeds that initialize sub-volume formation. The outcomes expected include selective access and manipulation of full-motion video content, rapid analysis and interpretation of full-motion videos, an object-orientated, scale-space analysis, and widespread military and geospatial intelligence applications.

"It all comes down to efficiently handling large amounts of image data collected from satellites and video streams, which are not necessarily big images, but I can collect video for hours," says Messinger, who is also an associate research professor in the Carlson Center and oversees multidisciplinary research using remote-sensing techniques for archaeology and disaster management. He served as an aerospace engineer at Northrop Grumman before coming to RIT in 2002. "You'd like to be able to download the data, have it go into a computer system and have it reduce that eight hours of video down to 20 minutes that somebody has to look at, just the highlights, so they can process the information to make decisions."

Use of video images becomes an additional and important variable in the segmentation processing equation. Computers interpret object information from images and video as a two-dimensional plane, unlike humans, who understand an object's three-dimensional aspects, says Saber.

"Once objects have been identified and indexed, an analyst can target objects rather than individual pixels," he adds. "We struggle in doing the proper video segmentation intelligently. How do computers form this recognition that we as humans have understood for most of our lives? How do you get the computer to recognize images the same as humans would do it? It is a problem that is largely unsolved and difficult."

But, it is also a problem that the team is solving, producing a knowledgebase that would be adaptable for identifying structures, objects of various sizes, shapes, and timescales, Messinger adds.

"It has to be flexible enough to capture all of that information in multiple spatial and temporal scales," he says. "I want to be able to process it to extract information automatically, so I can make the process more efficient for the end user."

On the Web

RIT Electrical and Microelectronic Engineering
www.rit.edu/kgcoe/eme

Chester F. Carlson Center for Imaging Science
www.cis.rit.edu

Technology Advancements Help Medical Illustrators to Optimize Visualization

Jim Perkins

As imaging technologies become more sophisticated, the role and importance of today's medical illustrator is increasing dramatically.

Medical illustration, also known as biomedical visualization, is the practice of intricately representing medicine and science in digital, modeling, or printed form. Medical illustrators are specially trained artists with advanced education in the biomedical sciences, digital media, and the principles of visual communication.

"Interactivity between the surgeon, patient, and imaging used to fall outside the traditional realm of medical illustration, but that's not the case anymore," says James Perkins, professor and graduate director of the medical illustration program in RIT's College of Health Sciences and Technology. "It's not uncommon for medical illustrators to collaborate with physicians, scientists, and other health care professionals to translate complex scientific information into visual imagery that supports medical education, science research, and patient care."

Perkins, an expert in the visual communication of complex biomedical subject matter, is an award-winning illustrator of more than 40 medical textbooks and consults with major medical publishers.

Carrying on the work of Dr. Frank H. Netter, hailed as the greatest medical illustrator of our time, Perkins contributes most of the molecular and cellular art to a wide range of titles still bearing Netter's name.

While much of today's medical illustrations continue to be used in textbooks, modern-day medical illustrators regularly find themselves working in three dimensions, creating anatomical teaching models, patient simulators, and facial prosthetics for Web-based media.

RIT's graduate program in medical illustration is one of only five such programs in North America, and the university is the only one to offer both graduate and undergraduate programs. The two-year graduate program combines training in human anatomy (with complete cadaver dissection), histology (the cellular structure of organs), and pathophysiology (the study of disease) with extensive training in 2D and 3D digital graphics, interactive media, and animation.

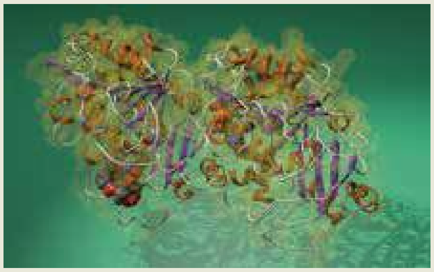


Illustration of the protein alpha-beta tubulin, which makes up microtubules in the cell. Microtubules are part of the cell's internal "skeleton" and play an important role in processes such as mitosis.

Perkins believes today's advancements in imaging modalities such as 3D modeling and other animation techniques will be able to help solve increasingly difficult visualization challenges that surgeons and computer scientists encounter.

"Creative thinking applied to design, 3D modeling, and animation techniques employed by medical illustrators will help shape the future of pre-surgical planning and intra-operative guidance," Perkins predicts. "This integration of the roles of surgeon and medical illustrator will lead to techniques that correlate with improved patient outcomes."

RIT Center for Detectors Advances Astronomical Instrumentation

Don Figer

RIT scientist Don Figer, director of the Center for Detectors, is collaborating with Raytheon Visions Systems to advance a new family of large-format infrared detectors grown on silicon wafer substrates.

NASA and the National Science Foundation awarded RIT $1.1 million and $1.2 million, respectively, to design, fabricate, and test the hybrid detectors developed by Raytheon, one of the leading providers of detectors and focal plane arrays for ground-, airborne-, and space-based applications.

RIT-Raytheon detectors could represent a leap forward in infrared astronomy by increasing the size of infrared detectors, improving performance, and lowering cost. The technology someday could support future NASA missions to understand the nature of dark matter and dark energy, find Earth-like exoplanets, and enhance NASA's Planetary Science and Earth Science space missions to study weather, climate, and air pollution. The NSF-funded portion of the project could help realize large ground-based telescopes and impact the fields of remote sensing and medical imaging.

"The search for dark energy and dark matter are the major goals for space astronomy missions in the next decade, according to the National Research Council's Decadal Survey," Figer says. "High-performance detectors are also essential for the Wide Field Infrared Survey Telescope, the mission envisioned to achieve this goal."

For the last 15 years, scientists have pursued the use of silicon substitutes in the quest for large infrared detectors. Until now, the crystal lattice mismatch between silicon and infrared materials has stymied advancement, causing defects that generate higher dark current and noise, reduce quantum efficiency, and increase image persistence.

The wide commercial application of silicon, and the existing infrastructure built around the semiconductor industry, would drive down the cost of building detectors based on silicon substrates. Silicon's high-volume production and large format make silicon wafers an attractive alternative to Cadmium Zinc Telluride wafers.

Small-scale, precious, and expensive Cadmium Zinc Telluride wafers are in standard use now. Raytheon's novel technique deposits light-sensitive material onto silicon substrates while maintaining high vacuum throughout the multistep process. The material growth is done with molecular beam epitaxy, a technique common to the semiconductor industry and pivotal to moving beyond the constraints inherent in the standard infrared detector technology.

The Raytheon VIRGO 2Kx2K infrared detector is much like the ones RIT and Raytheon will design, fabricate, and test.

The RIT-Raytheon device will have broad wavelength coverage that extends from the optical to the infrared in standard-sized arrays of 1,024 by 1,024 pixels or 2,048 by 2,048 pixels and will scale upward to 14,000 by 14,000 pixels. This leap reflects the Center for Detectors' strategic goal to build and use advanced astronomical instrumentation, Figer says.

"Raytheon has come up with an innovation to combine the silicon wafer with the mercury cadmium telluride light-sensitive layer in a way that could end up dominating the field of infrared detectors for the next 20 years," Figer says. "It could push the boundaries of what is possible."

Research Awards and Honors

by Kelly Sorensen

RIT values the research contributions of its faculty, staff, and students. Below are some members of the RIT community who have received recent international, national and university recognition.

Trustees Scholarship Awards

The Education Core Committee of the RIT Board of Trustees awards up to three Trustees Scholarship awards each year to RIT faculty who demonstrate outstanding academic scholarship. In 2013, two RIT professors were recognized with the award:

Seth Hubbard is an associate professor of physics and microsystems engineering in the College of Science. Hubbard is also a member of the NanoPower Research Laboratory. His research focuses on quantum photovoltaics devices, materials growth and device design as well as novel sensors using nanostructures. Hubbard has been the principal investigator (PI) or co-principal investigator on more than 35 grants and contracts totaling more than $10 million.

Brian Landi is an associate professor in the chemical and biomedical engineering department in the Kate Gleason College of Engineering. His research interests include carbon nanotube characterization and devices, next-generation lithium ion batteries, and advanced wire/cable technology. Landi is the co-author of 95 publications including journal articles, conference proceedings, and book chapters. He's presented at more than 100 professional conferences and is the principal investigator or co-PI for more than $5 million in funding.

Graduate Research Fellowships

Two graduate students, Erika Mesh and Philip Salvaggio, have been awarded Graduate Research Fellowships from the National Science Foundation for their research in the fields of science and engineering.

Erika Mesh is a doctoral student studying computing and information sciences in the B. Thomas Golisano College of Computing and Information Sciences. She primarily researches software engineering process improvement for computational software engineering domains. She is a graduate research assistant with RIT's Laboratory for Environmental Computing and Decision Making.

Philip Salvaggio is an imaging science and computer science graduate student in the Chester F. Carlson Center for Imaging Science. He is studying the computer modeling of complex and novel optical systems, such as sparse optical systems. Salvaggio is the past recipient of the Abraham Anson Memorial Scholarship and the Central New York Student of the Year Award from the American Society for Photogrammetry and Remote Sensing. Fellows benefit from a three-year annual stipend of $30,000 along with a $10,500 cost of education allowance for tuition and fees.

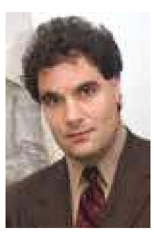
International and National Recognition

David Messinger has joined the editorial board for *Optical Engineering*, the journal of the International Society for Optics and Photonics, or SPIE, which publishes peer-reviewed papers reporting on research and development in optical science and engineering. Messinger is the director of the Digital Imaging and Remote Sensing Laboratory at RIT's Chester F. Carlson Center for Imaging Science. He will serve as an associate editor for Optical Engineering in the area of spectral and polarimetric imaging.

Roy Berns, the Richard S. Hunter Professor in Color Science, Appearance and Technology in the Munsell Color Science Laboratory, has won the prestigious Deane B. Judd Award for a lifetime of outstanding contributions to the field of color science. The Judd award celebrates Berns' contributions to color science education, color difference formulae development, spectral-based imaging systems, measurement of total appearance, and the digital rejuvenation of artwork.

R. Roger Remington, Vignelli Distinguished Professor of Design, has been inducted into the Alliance Graphique Internationale (AGI)—an exclusive group of the world's leading graphic artists and designers. Remington was instrumental in the development of RIT's Vignelli Center for Design Studies and is the author of four books on design history.

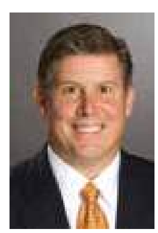
Maria Helguera has been named the Wedd Visiting Professor Chair at the University of Rochester Medical Center department of pharmacology and physiology. She's serving in this role while on sabbatical from RIT's Chester F. Carlson Center for Imaging Science. At UR, Helguera will continue her work on ultrasound techniques for the creation and quantitative characterization of artificial tissues with UR professors Diane Dalecki and Denise Hocking.



Joseph Fornieri, professor of political science, has been named a senior fellow at Alexander Hamilton Institute for the Study of Western Civilization. Fornieri, a renowned Abraham Lincoln scholar, is the author of *Abraham Lincoln's Political Faith*, an acclaimed scholarly work that explores Lincoln's religion and politics. He has a new book coming out in May 2014 called *Abraham Lincoln, Philosopher Statesman*. The Alexander Hamilton Institute, named for the first U.S. secretary of the treasury, promotes excellence in scholarship through the study of freedom, democracy, and capitalism.

Satish Kandlikar, professor of mechanical engineering, was awarded the 2012 Heat Transfer Memorial Award by the American Society of Mechanical Engineers for outstanding research contribution in the field. It was given for outstanding research contributions in boiling heat transfer, particularly in mini- and micro-channels; for establishing international conferences dealing with transport phenomena in small channels; and for editorial work on handbooks and journals.

Twyla Cummings, senior associate dean of the College of Imaging Arts and Sciences and a professor in the School of Media Sciences, was among the newest inductees into the print industry's Women of Distinction program, sponsored by the OutputLinks Communications Group, a global marketing and publishing firm. The program recognizes and celebrates the achievements of exceptional women in print communications and graphic arts from around the world. Cummings was recognized during the PRINT 13 trade show in Chicago.



Ryne Raffaelle, RIT vice president of research and associate provost, served as the Conference General Chair of the 39th annual IEEE Photovoltaic Specialists Conference. Raffaelle is also a member of the IEEE Electron Devices Society.

About This Section

This listing is a sample of awards and honors that have been received by RIT faculty and staff over the past year. For more information, please visit www.rit.edu/news.

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For two decades, *U.S. News & World Report* has ranked RIT among the nation's leading comprehensive universities. RIT is featured in *The Princeton Review*'s 2013 edition of *The Best 377 Colleges* as well as its 2013 *Guide to 322 Green Colleges. The Fiske Guide to Colleges 2011* lists RIT among more than 300 of the country's most interesting colleges and universities.

Contact Information

To learn more about research opportunities on campus, contact us directly or through the RIT research website at **www.rit.edu/research**.

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