RIT

RESEARCH 2019

Rochester Institute of Technology

A new life for food waste

Also inside: Drones are transforming farming

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A letter from the Vice President for Research

Setting records and moving up

RIT's ascendancy as a national research institution continues. This past year, we set new all-time highs for proposals submitted, research awards, principal investigators, and research expenditures, eclipsing $50 million for the first time.

The year culminated in RIT being classified as a national "R2" institution or "high research activity institution" under the Carnegie Classification of Institutions of Higher Learning.

The R2 designation, the second-highest classification, puts RIT among the top 6 percent of colleges and universities in the nation, those conferring at least 20 research/scholarship doctorates annually and spending a minimum $5 million a year on research.

Not surprisingly, the majority of research proposals were submitted to—and awards were received from—the federal government, with the National Science Foundation leading the way.

We were fortunate to receive two new NSF Faculty Early Career Development Program (CAREER) awards, which brings our total to 10 over the past nine years.

RIT received a record $30.6 million in research funding from the state of New York in fiscal year 2018, and our corporate funding increased by nearly 35 percent.

Highlights related to our state support include a $19.5 million, five-year award from the New York State Department of Environmental Conversation (DEC) to continue operating the New York State Pollution Prevention Institute (NYSP2I) at RIT as well as another $4 million award administered by Empire State Development to NYSP2I for food waste initiatives. We also received a $1.8 million award from the New York State Energy Research and Development Authority for the RIT Clean Energy Incubator.

Another highlight this year was when our Center for Advancing STEM Teaching, Learning and Evaluation (CASTLE) received $1 million from the Howard Hughes Medical Institute to support its Inclusive Excellence Initiative.

The growth of research and graduate education is a pillar of our new strategic plan and is essential for us to achieve our goal of being an outstanding student-centered national technical university. These sponsored research awards provide exactly the kind of experiential learning opportunities we hope to offer to our students.

In this issue, you will see a few great examples of where we are giving students cutting-edge research experiences and training in important areas such as sustainability, collection preservation, cybersecurity, and even precision agriculture.

Best regards,

Ryne Raffaelle
Vice President for Research
and Associate Provost

Table of contents

Innovative solutions take bite out of food waste

Researchers at the Golisano Institute for Sustainability are looking at commercial applications for this biochar material, which is made from dried food waste.

When it comes to identifying creative ways to mitigate food waste, researchers at RIT have been managing a full plate of innovative initiatives over the last decade.

Faced with a growing world population and a shrinking pool of natural resources, the world today faces an unprecedented challenge to provide a resilient food supply—made even more complex by vast inefficiencies and resulting food waste generated across the food supply chain. It's estimated that as much as 40 percent of edible food in the United States ends up in landfills.

RIT—through the Golisano Institute for Sustainability (GIS) and the New York State Pollution Prevention Institute (NYSP2I)—has led a wide variety of initiatives with the food-and-beverage production sector across the Finger Lakes region and the state since the turn of the decade.

Direct business and technical expertise, workforce training, and engineering assessments have reduced operational costs and environmental impacts at leading food companies such as Wegmans Food Markets, North American Breweries, and elsewhere.

"Companies seem to be coming to the understanding that materials that were once considered waste can now be a resource converted to secondary products," said Thomas Trabold, associate professor and sustainability department head at GIS.

A food waste utilization test bed is the latest tool researchers at RIT are using to find alternative uses for dining hall food scraps.

The goal of researchers is to share results with businesses and find a secondary use for waste.

Elizabeth Lamark

Upcycling process

1 Gather
RIT Dining Services has been working on food waste reduction strategies since 2012, including partnering with Enid Cardinal, senior sustainability adviser to the president, to divert organics from the landfill in a number of venues since 2014.

2 Weigh
Sustainability Ph.D. students Diana Rodriguez Alberto, left, and Shweta Arora are weighing the delivered waste to determine its water content, and then further characterizing its properties to determine possible upcycling options, such as animal feed, fuel pellets, or fertilizer.

Food production cluster

Since 2010, Trabold and his colleagues at GIS and NYSP2I have been exploring the needs of food and beverage industries in the areas of food waste reduction, water efficiency, and energy-saving technologies and working with companies to assist them in customizing technologies to achieve the greatest return on investment.

RIT's roots in combating food waste date back to before it was widely seen as a problem.

In 2011, RIT received a $1.5 million "Jobs Accelerator" grant from multiple government agencies to advance the regional competitiveness of the Finger Lakes food cluster. The program—known as the Finger Lakes Food Processing Cluster Initiative—unified and strengthened the "farm-to-fork" cluster in the nine-county Finger Lakes region.

The initiative helped spur job creation and created a career pathway for scores of workers through three key areas:

- The Finger Lakes Food Processing Cluster Advancement Program, which provided assistance to regional food processing businesses, including identifying and implementing technical improvements and sustainable manufacturing process technologies to reduce operating costs and minimize environmental impacts.

1-4 Gabrielle Plucknette-DeVito, 5 Elizabeth Lamark

3 Mix
Rodriguez Alberto, left, and Arora pour excess food—delivered from RIT's dining halls multiple times per week—into a commercial-scale dehydrator located inside RIT's Sustainability Institute Hall.

4 Bake
High temperature coupled with mechanical agitation remove almost all of the starting moisture content to make the mixed food waste ready for storage or further refinement into new products. Energy use, drying rate, and chemical composition of the removed water are monitored.

5 Result
Biochar—the black material Rodriguez Alberto and Arora are working with—comes from further treating the dried food waste at even higher temperatures under reduced oxygen conditions. RIT is researching commercial applications for the biochar material.

• The Finger Lakes Food Processing Cluster Training Program, established to identify and ultimately bridge the gap between the existing workforce skillset and qualifications required by food and agriculture businesses in the region.

• The Finger Lakes Food Processing Cluster Small Business Assistance Program, which provided assistance to small food businesses located in distressed communities.

Since its completion, the program has resulted in the creation of nearly 75 jobs; 26 companies receiving process efficiency and technical assistance significantly reducing their waste/energy/water costs and operating cost savings by $754,000 per year; and the training of more than 600 employees or prospective workers at organizations throughout the Western New York and Finger Lakes region.

NYSP2I received additional funding in 2015-16 through Gov. Andrew M. Cuomo's office to assist the New York State Department of Environmental Conservation in its ongoing efforts to divert food waste from landfills for beneficial uses at food banks and clean energy generation.

Food waste utilization testbed

More recently, RIT received $50,000 in a New York state funding commitment in 2017 to acquire food waste conversion

Thomas Trabold, associate professor and sustainability department head at RIT's Golisano Institute for Sustainability, holds biochar—a high-carbon, fine-grained residue that also has potential for use in printing processes, since it can be used to replace the fossil fuel-based carbon that gives ink its black color.

Elizabeth Lamark

Curbing an appetite for landfill waste

New York State Department of Environmental Conservation (DEC) Commissioner Basil Seggos last June announced $4 million in grant funding for generators of excess wholesome food and food scraps to expand their capacity to donate food or divert it to organic recycling facilities.

New York's large food scraps generators, including supermarkets, restaurants, colleges, and hospitals, generate more than 250,000 tons of wasted food and food scraps each year—some of which is edible food.

The funding is provided by the state's Environmental Protection Fund and is administered by Empire State Development. ESD contracted with the New York State Pollution Prevention Institute (NYSP2I) to operate the funding program.

NYSP2I is working closely with the DEC on a number of initiatives to reduce the generation of food scraps and recycle food scraps that remain, and this funding will help generators expand their sustainability efforts.

"These grants are assisting New York state businesses in reducing waste and capital costs by helping them make important investments in equipment or technologies that will divert food waste from landfill or incineration," said Charles Ruffing, NYSP2I's director.

NYSP2I has worked with New York food companies such as Wegmans Food Markets Inc., LiDestri Food & Drink, Outback Steakhouse, and Foodlink, and has developed tools to support food waste initiatives, including:

- A web-based mapping tool that provides information on organic waste sources and utilizers across New York state.
- Life-cycle assessment tools and methodologies to model and quantify the impacts that food products, services, and processes have on the environment. NYSP2I, for example, developed a model for a project with Wegmans to quantify the influence that food waste disposal processes and the waste transportation method, distance, and utilization have on the greenhouse gas impacts of food waste.
- An interactive database-driven tool to assist food manufacturers in the selection of technologies for solid-liquid separation, waste concentration, and water recovery.
- An online resource for companies to gain information about the benefits of preventing and diverting food waste and how to implement best practices as a business, nonprofit, or municipality.

Rich Kiley

equipment that is assisting companies seeking to effectively reduce, eliminate, and/or "upcycle" food processing and retail wastes.

Upcycling—also known as creative reuse—is the process of transforming byproducts, waste materials, or useless or unwanted products into new materials or products of better quality or for better environmental value.

In all, the state funding supported a $408,000 total investment to create a food waste upcycling testbed, located on RIT's main campus.

"This testbed is serving as a resource to help the food industry evaluate and implement new technologies," Trabold said. "It also is strengthening companies' economic position and worker skills through effectively utilizing waste that is now sent to landfills."

GIS is employing food waste treatment technology and equipment in the food waste utilization testbed—the goal of which is to share results with businesses—by using excess food from RIT's dining halls, he added.

According to Enid Cardinal, senior sustainability adviser to the president, RIT Dining Services has been working on food waste reduction strategies since 2012, when Recover Rochester, a student club, was formed.

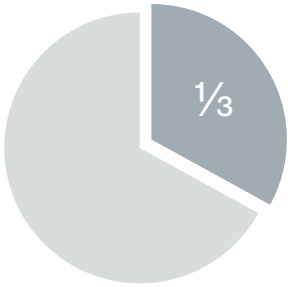
"When Gracie's switched all of its carry-out options to reusable takeout containers in 2013, RIT was one of the first universi-

Callie Babbitt, Golisano Institute for Sustainability associate professor, says imperfect foods discarded by grocery stores and consumers as well as crops left in the field are among some of the complex issues fueling food waste. “The social, economic, and environmental impacts from food waste really add up when you look at the entire supply chain.”

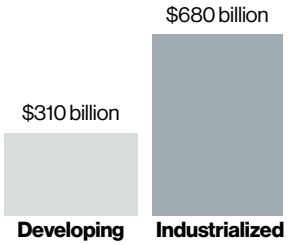
Elizabeth Lamark

By the numbers

The statistics behind food waste are staggering. The Food and Agriculture Organization of the United Nations estimates:

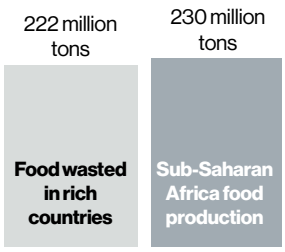


- Roughly one-third of the food produced in the world for human consumption every year—approximately 1.3 billion tons—gets lost or wasted.



- Food losses and waste amount to roughly $680 billion in industrialized countries and $310 billion in developing countries.

- In developing countries, 40 percent of losses occur at post-harvest and processing levels while in industrialized countries, more than 40 percent of losses happen at retail and consumer levels.



- Every year, consumers in rich countries waste almost as much food (222 million tons) as the entire net food production of sub-Saharan Africa (230 million tons).

ties to make that switch," she said. "Dining Services has also been partnering with my office to divert organics from the landfill in a number of its venues since 2014."

On the research front, Trabold also is leading a team studying how best to optimize fermentation growth parameters in the production of filamentous fungal mycelium, used by therapeutic New York state mushroom producer Leep Foods, a company based in Rochester.

The yearlong project is studying the potential of GIS's commercial project partner using excess whey—a common waste product in the yogurt industry—in stirred tank reactors as a production resource for the commercial mushroom industry.

RIT researchers and students also are conducting an economic assessment of whey and its scalability as a food waste upcycling and re-use alternative to wastewater treatment for the New York state dairy industry.

The research is made possible by a nearly $50,000 grant from FuzeHub, a not-for-profit organization that provides small- to medium-sized manufacturing companies in the state with guided access to technical and business resources.

NSF grant funding key research

Callie Babbitt, an associate professor at GIS, recently surpassed the midway point of a nearly $1 million award from the National Science Foundation (NSF) researching sustainable solutions for minimizing and managing the growing and complex challenges of food waste generated across the food supply chain.

The four-year project involves an interdisciplinary research collaboration with faculty from six RIT colleges.

Babbitt's research team is studying how innovative technologies, waste management systems, and policies can reduce the volume and environmental impacts of food waste—while at the same time creating economic growth and maximizing efficient use of energy and water resources.

"There are huge losses that become apparent when we look at the entire supply chain—from excess crops, wastes from food processing, imperfect or 'ugly' foods discarded by grocery stores and restaurants, not to mention food that is purchased but then spoils, goes past its expiration date, or isn't ultimately wanted by consumers," Babbitt said.

"The social, economic, and environmental impacts from food waste really add up," she added.

"An average American household may spend up to $1,500 every year on food that goes straight to a landfill. We're missing opportunities to feed hungry families, wasting the vast water and energy resources that went into producing the food, and creating new environmental impacts, like greenhouse gas emissions from food waste disposal."

Rich Kiley

Tim Bauch '16 (imaging science), left, senior lab engineer and drone pilot, supervises students in preparing the RIT-developed MX1 imaging payload for flight over an agricultural field.

Nina Raqueno

Drones are coming soon to a farm near you

Drones are adding a new level of precision to agriculture, giving farmers digital tools for cultivating better and more profitable crops.

"The machinery that large farms use—big combines and sprayers—they can take input from GPS and it automates the application process of fertilizer, for example," said Carl Salvaggio, RIT professor of imaging science. "This technology can also spatially tell you where to harvest to get the best crop product."

Salvaggio and Professor Jan van Aardt are developing imaging systems at RIT that could make drones commonplace on farms in western and central New York, enhancing the Finger Lakes region's focus as a food hub, while creating the supporting technology and software companies.

Salvaggio, who leads RIT's signature research program in unmanned aerial systems (UAS) imaging, offers some ideas on how drones can help farmers.

For instance, accurate measurements of soil nutrients and moisture level, disease risk, and plant maturity could take the guess work out of predicting harvesting and processing schedules. Information captured by specialized imaging technology could also reduce the need for chemical controls, by indicating where, when, and how much to apply.

RIT's remote sensing expertise could also establish technical standards that ensure the scientific integrity of the fledgling industry.

Salvaggio, who primarily conducts research for the defense industry, is taking the lead in atmospheric compensation, calibration of imagery, and radiometric processing to ensure continuity in imagery collected over time.

It's a point of pride for the RIT researcher; if the imagery isn't adjusted for atmospheric differences between scenes, dramatic changes in illumination between a sunny morning and an overcast afternoon will skew the data and lead to misinformed decisions at the farm level.

"A lot of people are flying without calibrating their data, and they're providing data that, to them, looks right," Salvaggio said. "There is so much promise in these systems, but if you lose the faith of the farmer, you're never going to get it back, and that could make an industry flourish or totally bankrupt it."

A regional collaboration of strategic partners, called the FARMS (Fostering Agricultural ReMote Sensing) Alliance, is developing both the unmanned aerial systems technology and the best practices for using it.

Van Aardt is leading this National Science Foundation-funded project focused on remote-sensing applications in snap bean production.

The crop is economically important to New York as one of the biggest producers of processed and fresh market snap beans, following Wisconsin and Florida. The U.S. Department of Agriculture, in 2015, ranked snap beans as the fifth largest vegetable crop, in terms of acreage, with a $416 million market value.

The availability of a commercialized imaging product for managing white mold, predicting crop ripeness, and estimating the snap bean yield could have a big impact on farmers.

That is welcome news to Jeff Johnson, agricultural manager at the Seneca Foods Corp. location in Geneva, N.Y., who has been talking to van Aardt for years about the need for a better way of managing crops with imaging technology. Johnson is responsible for growing 10,000 acres of snap beans for one of the nation's largest vegetable processors and relies on crop scouts to monitor the ripening pods and look for signs of white mold.

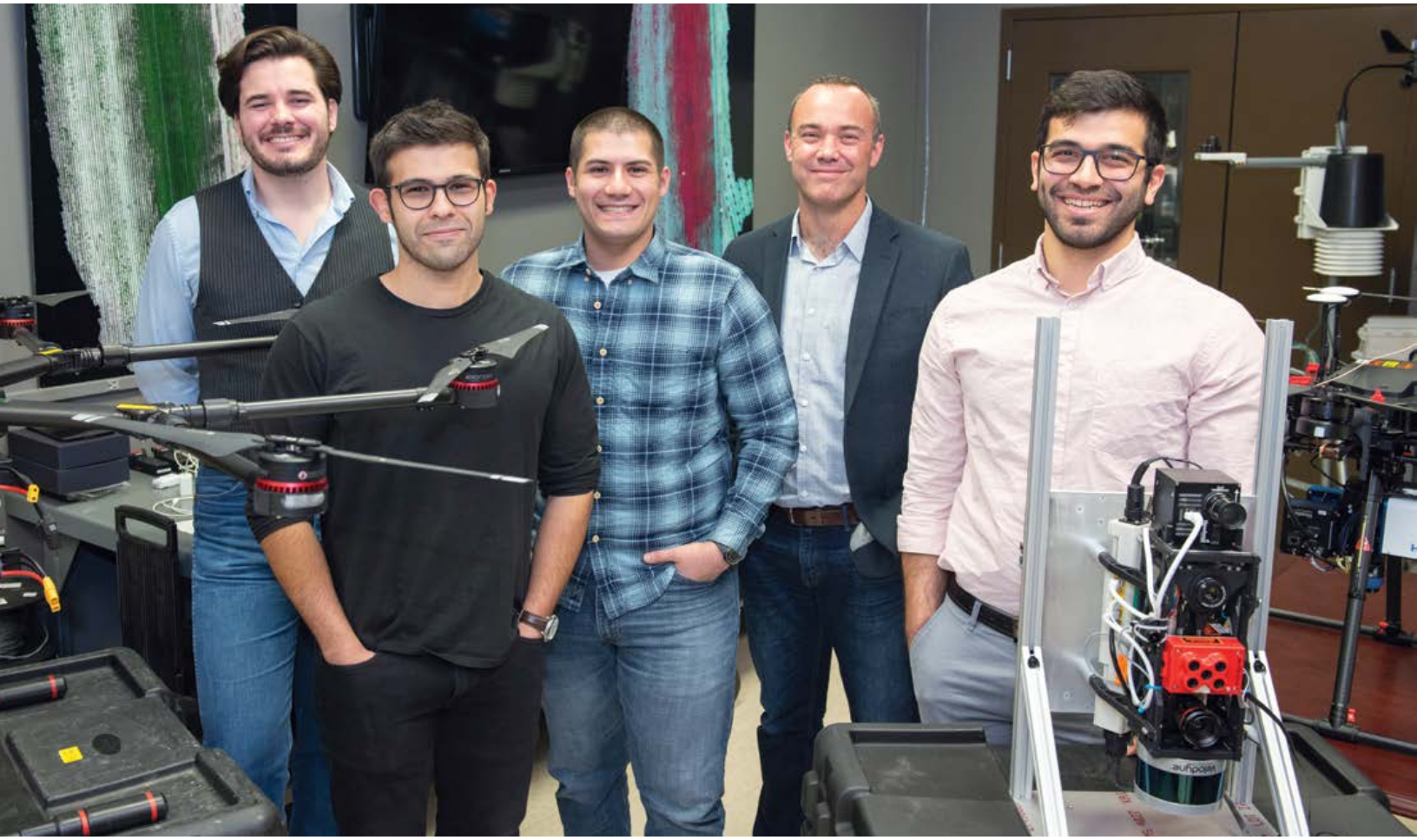
Gabrielle Plucknette-DeVito

Professor Carl Salvaggio is developing imaging systems to help farmers.

"When we send people out to the field, they are walking a path," Johnson said. "We send a drone over the field, it can see the whole field. In theory, we can have a better picture of that whole field than our person does by just walking through it, and labor is becoming more expensive and harder to find."

The crops are staggered because the processing plant can handle only so many tons per day, and the tight operating schedule isn't negotiable.

Gabrielle Plucknette-DeVito



Jan van Aardt, back, professor of imaging science, and his graduate students use imaging systems on drones to develop precision agriculture practices. Left to right are: Ethan Hughes, MS student; Ali Rouzbeh-Kargar, Ph.D. student; Ronnie Izzo, MS student; and Amirhossein Hassanzadeh, Ph.D. student.

"In our world, there's a 24- to 72-hour window when the beans are ripe," Johnson said. "It's critical from our planning standpoint knowing when those fields will be ready to harvest."

The challenge of predicting plant maturity is pushing the limits of remote sensing. Van Aardt is combining hyperspectral imaging to capture light signatures and LiDAR (light detection and ranging) sensors to build a spatial, three-dimensional or topographic picture. "We're trying to fly a drone, look at a snap bean plant—not even the pods—and see if there is a signal in the plant that tells us the pods are mature or ripe," he said.

And when it comes to white mold, van Aardt and imaging science MS student Ethan Hughes are identifying the spectral and structural indicators that influence pesticide timing and disease risk. "We want to see—even before the mold occurs—if we can predict where disease incidence will be the highest, so farmers can spray only in those areas," van Aardt said.

"Remote sensing techniques in agriculture hold the promise of standardizing crop assessments with a scientific accuracy not possible from manual observations," said Sarah Pethybridge, assistant professor of plant pathology at Cornell University.

A white-mold expert, Pethybridge, along with Julie Kikkert at Cornell's Cooperative Extension, are already developing risk models for snap beans with Salvaggio and van Aardt for an ongoing U.S. Department of Agriculture study.

RIT researchers fly this DJI-Matrice 600 unmanned aerial system platform over crop fields with a high-end imaging system that collects data .

GPS-embedded reference targets placed in each scene enable precise geo-location and registration of image data.

Pethybridge's project inspired van Aardt to form the FARMS Alliance.

"From the exploratory research done with RIT, we have good spectral signatures to detect flowers, which is an important step in identifying optimal timing of pesticides for white-mold control," Pethybridge said.

The goal for Salvaggio and van Aardt is to get the information products into the farmers' hands.

"We use expensive sensors with hundreds of spectral or color channels, but we actually only want to identify five or fewer channels that are useful for specific applications," van Aardt said. "Then we can transition those five channels into a more affordable sensor that a farmer or a service provider could use operationally."

Susan Gawlowicz

Other agricultural projects

Drone data collection
RIT is leading the FARMS (Fostering Agricultural ReMote Sensing) Alliance to develop and commercialize drone data collection and analytics for the agricultural industry. The project is supported with a $750,000 National Science Foundation grant and brings together strategic partners in the Finger Lakes region. The core research and technology transfer team includes RIT's Chester F. Carlson Center for Imaging Science, Saunders College of Business, Venture Creations technology business incubator, Cornell University and Cooperative Extension; the FARMS Advisory Council and Commercial Partners consists of Harris Corp., Agrinetix LLC, Headwall Photonics, Seneca Foods, Love Beets, and Farm Fresh LLC.

Risk models for white mold
RIT researchers are collaborating on two agricultural studies led by Cornell University—one focused on developing risk models for white mold on snap beans for the U.S. Department of Agriculture's Critical Agriculture Research and Extension Program, and the other to evaluate the table beet production for improved profit and sustainability for Love Beets.

Solving world hunger
Improved safety of unmanned aerial systems (UAS) and drone control software has paved the way for the Federal Aviation Administration to relax restrictions on commercial drone flight. The integration of drones into the national airspace will position the United States to take a stronger role in the global $32.4 billion UAS agriculture market, according to an independent analysis from PrecisionHawk Inc. The technology and data analytics provider collaborates with RIT researchers and has provided the use of its drone platforms.

Agricultural drone imaging has emerged as the dominant focus of RIT's unmanned aerial systems imaging program, a signature research area. Digital agriculture techniques could help feed the world's growing population, which the United Nations predicts, by 2050, will reach 9.8 billion and will demand a 70-percent increase in food production from 2006.

Solving global problems with precision agriculture resonates with students in the Chester F. Carlson Center for Imaging Science, said Carl Salvaggio, who leads the signature research initiative. The potential benefits in the agriculture drone industry have sparked interest among students who see a way to make a humanitarian difference.

"We have a lot of students who want to contribute to solving this global food production need," he said. "It's exciting that we can attract a new kind of student to imaging science."

Packaging solutions improve product shelf life and sustainability

> We're trying to balance performance and biodegradation. One question we are tackling is how can we develop materials with this balance?

Images of plastic bags and bottles clogging beaches and oceans have some calling for a ban on all such products.

But packaging experts say it's not that easy to eliminate a highly effective material that is in so many things people use every day, from bread bags and milk cartons to pouches for blood products and vials for pills.

Instead, researchers at RIT are looking to strike a balance: Find a way to produce plastics that retain their best qualities and yet are more environmentally friendly.

Carlos Diaz-Acosta, associate professor of packaging science in RIT's College of Engineering Technology, believes plastic products are good at what they do, and if disposed of correctly, could do little or no harm to individuals or to the environment.

"People think they can live without packaging," he said. "Yet, some traditional plastics are super efficient. They are produced with minimum energy and perform well. We're trying to balance performance and biodegradation. One question we are tackling is how can we develop materials with this balance?"

Alternative materials

RIT packaging science researchers are developing cost-effective alternatives to petroleum-based plastic made with biodegradable polymers. These materials keep products fresher longer and are sustainable for the environment.

But there are trade-offs—there is no one single material that is best across the package development process.

By continually improving alternative materials and disposal options, as well as itemizing data about these options, companies can choose appropriate materials and designs for consumer products.

Polylactic acid is one of the alternative materials being used by Diaz-Acosta and colleagues in RIT's Golisano Institute for Sustainability.

Used in products such as food containers, once processed, polylactic acid could help reduce landfill waste by employing anaerobic digestion, a biochemical process in which microorganisms digest organic matter to produce methane-rich bio-gas—a renewable energy source.

The team is also testing how "active oxygen scavenging films" might extend the life of bread and decrease mold production.

These oxygen-inhibiting chemicals, familiar to consumers as the small sachets in product boxes, are integrated with film produced for bread bags.

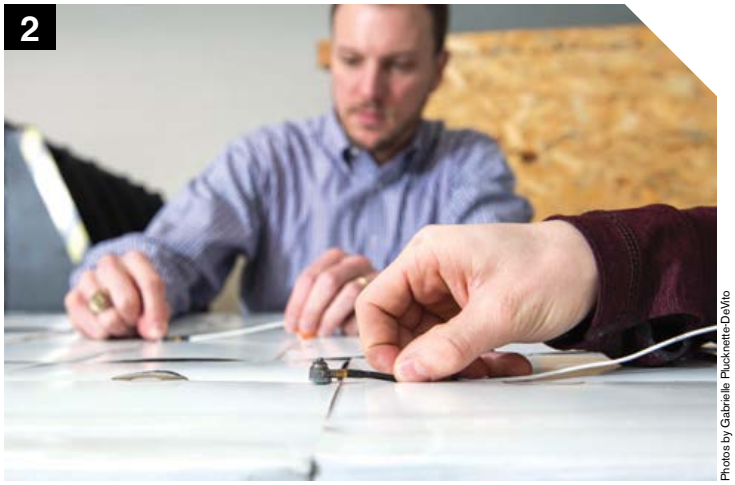
Early test results indicate this multi-layered improvement in bag film extends bread freshness.

Carlos Diaz-Acosta, associate professor of packaging science, is developing sustainable packaging solutions to help reduce waste and keep foods fresher longer. Food waste has been identified as an international problem, accounting for 45 percent of material in U.S. landfills.

Gabrielle Plucknette-DeVito

The Packaging Science Dynamics Lab is both a teaching facility and a site for corporate partners to perform testing. Packaging science undergraduates from left are Theresa Klingshirn, Mitchel Dickerson, and Matt Michael.

Gabrielle Plucknette-DeVito



Photos by Gabrielle Plucknette-DeVito

1 In the Dynamics Lab, packages that will be transported are unitized together with different blends of stretch film to help protect products and to ease transport on pallets that might be found in warehouses or used on vehicles.

2 Sensors are put on the palletized goods in preparation for a variety of simulations of rigorous conditions that could be found during transportation.

3 Results of the vibration, shock, and compression tests help researchers and corporate clients determine how to better protect both products and packages to reduce waste due to damage.

Alternative processes

The plastics themselves are only part of the problem.

Retrofitting current manufacturing processes because of new materials and the way they need to be recycled or composted is also important.

Diaz-Acosta; Changfeng Ge, professor of packaging science; and Mark Olles, associate professor of mechanical engineering technology, are awaiting patent confirmation on a thermodynamic process they developed to improve production of foam trays for transporting goods such as fruits and vegetables.

The cushioning materials they produced from agricultural waste, and the new process they developed to form the cushioning materials, could be a key step in transitioning traditional manufacturing and recycling processes to dispose of alternative materials.

Producing a substance that does its job—such as protecting goods during transport—is also key. Researchers have been seeing increased damage in shipments that use newer, lighter materials and thin films.

Twenty years ago, water bottles had thicker walls and were more structurally rigid, said Kyle Dunno, assistant professor of packaging science.

"Now, my 4-year-old can crush a bottle," he said. "We are driving out unneeded packaging materials, but at what costs? We look at reduction—of materials primarily—as a big opportunity. With some of the reduction in packaging materials, there is an increase in load failures."

Dunno and his packaging science colleagues are teaching their students about the range of information needed to make strategic decisions along the packaging supply chain, including what happens during transportation and distribution. Having that information allows packaging engineers to design appropriately, selecting materials to

Kyle Dunno, assistant professor of packaging science, is working to develop new, sustainable materials as well as ways to improve overall packaging development processes.

Gabrielle Plucknette-DeVito

The path of a package

RIT researchers across campus have come together with expertise that impacts important changes and improvements to the entire packaging supply chain. Here are some examples of their work toward a more circular economy for packaging in each of the areas:

New materials and development

Researchers are experimenting with new materials made from agricultural waste and using water to make foams.

Production filling

They are testing the strength of packages and packaging options before distribution.

Distribution

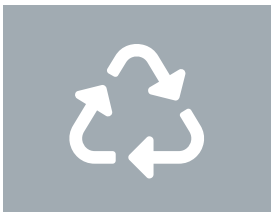
They are looking at the impact of transportation on the shelf life of packaged products.

Store and e-commerce

Researchers are studying how packaging and distribution changes to include brick-and-mortar stores and e-commerce.

Use by consumers

They are exploring how consumers influence and improve future package designs.



Reuse, recycle, and dispose

Their research helps make future packaging reuseable, recyclable, and biodegradable.

isolate or dissipate damage.

New materials and sustainable practices have also made an impact on the packaging supply chain. Decisions made in one area affect another part of the system—sometimes dramatically. The transition to plastic alternatives, while evolving, is not yet a mainstream practice, but that is shifting.

"We see the growth in population, it correlates with the growth in plastics, and an increase in things. We are a society dependent on technology; one of those technologies is plastic," Diaz-Acosta said. "Plastics provide that safety, hygiene. It is idealistic to want a society without plastics, but that mindset also pushes us to think in a different way and to develop alternatives. We have to keep our options open."

Michelle Cometa

About packaging science at RIT

Packaging is about getting things correct—the correct amount of the right material with the right kind of design for the right fit in the supply chain, said Daniel Johnson, professor and chair of the department of packaging science in RIT's College of Engineering Technology.

Johnson leads a multidisciplinary department that provides students with opportunities to explore career options along the packaging supply chain using state-of-the-art facilities and software combined with faculty expertise, design projects, and co-op experiences.

National corporations also seek the department's expertise in product, materials, and distribution testing.

Current faculty research reflects industry trends, including a long-time focus on sustainability, circular economy, and the impact of e-commerce.

Faculty-researchers, students, and corporate partners have numerous laboratories available, such as the American Packaging Corp. Center for Packaging Innovation as well as the Packaging Science Dynamics Lab.

"Our curriculum has the content about what high-performing packaging would be in both brick-and-mortar and e-commerce environments," Johnson said. "That dynamic drives innovation in packaging."

That innovation is encouraged in design and project experiences—from classes where students in packaging science, graphic design, and industrial design create prototypes for popular consumer products to course work where students help rework packaging options for local and regional companies.

Jennifer Jae Gutierrez, executive director, said the Image Permanence Institute "has always looked to the field to identify preservation needs and challenges," and will do so again with assessment initiatives that will help define IPI's future research agenda.

Gabrielle Plucknette-DeVito

Informing the preservation of cultural heritage collections

For the second time in its nearly 35-year existence, RIT's Image Permanence Institute (IPI) is at a turning point.

Devoted to scientific research that supports the preservation of library, museum, and archives collections, IPI's original focus at its founding in 1985 was the preservation of photography, microfilm, cinema, and other forms of recorded information.

In the 1990s, IPI's most significant contributions related to new approaches for quantifying collection risks and rates of deterioration. Libraries, archives, and museums at that time were particularly concerned with the alarming rate at which cellulose acetate-based materials were actively deteriorating.

Laboratory experiments at IPI demonstrated that as cellulose acetate film deteriorates—creating its own acidic environment—the rate of deterioration accelerates and significant loss of collection materials can occur in a short amount of time. Accelerated aging studies conducted at IPI demonstrated the potential of low temperature and low humidity storage environments to minimize the chemical decay of cellulose acetate film.

"IPI has always looked to the field to identify preservation needs and challenges," said Jennifer Jae Gutierrez, executive director of the research center in the College of Art and Design. "Our focus today is identifying how to address the needs that span across collections through research, resource development and deployment, and professional training opportunities."

All of IPI's early research on the inherent vices of photographic materials pointed to the critical role of environmental conditions—specifically temperature and relative humidity—on the impact of material decay, both natural aging and other forms of deterioration.

This led IPI to broaden its research focus almost two decades ago to include virtually any materials found in cultural institutions worldwide by also focusing on the role of environmental management in preserving cultural heritage collections.

Support from federal and private foundations is critical in the development and dissemination of IPI's research. The Andrew W. Mellon Foundation, the National Endowment for the Humanities, the Institute of Museum and Library Services, and the Samuel H. Kress Foundation are all supporting 2019-20 projects.

Current IPI research initiatives include projects that will inform the recovery of water-damaged inkjet prints in cultural institutions that have experienced water emergencies, and improving preservation environmental management strategies.

Additional education initiatives include workshops and webinars about the identification and care of digitally printed materials, training allied professionals in collecting institutions how to establish sustainable environmental management programs, and enhancing IPI's online web resource Graphics Atlas.

As Gutierrez marks her second year as head of the academic research center—arriving on campus after distinguishing herself with conservation roles at the University of Arizona and University of Delaware—IPI continues to evolve to meet the preservation challenges of cultural institutions, and upcoming assessment initiatives will help define IPI's future research agenda.

Grant to assess research needs

A grant awarded late last year from the Mellon Foundation will support assessment initiatives to inform and strengthen IPI's short- and long-term research goals and institutional planning.

"The vast majority of libraries, archives, and museums around the world do not have scientific researchers on staff to research solutions to the challenges associated with preserving cultural heritage collections," Gutierrez noted.

"These cultural institutions depend on large federal and privately funded institutions with robust research programs, national and international

Jennifer Burger

Daniel Burge, left, senior research scientist at IPI, teaches a workshop on digital print preservation at the Ringling Museum in Sarasota, Fla. IPI offers workshops in multiple regions throughout the United States.

University of Kansas Libraries

Christopher Cameron, sustainable preservation specialist at IPI, uses an infrared camera to evaluate temperature variations in collection storage at University of Kansas Libraries.

preservation organizations, and a small number of university-based research centers to address their preservation research needs," she added. "IPI has been a valuable contributor to this important need for nearly 35 years."

As IPI plans for long-term research goals that will best serve the preservation needs of collecting institutions, the Mellon-funded initiative will enable research that will engage and solicit critical feedback from collections staff, preservation researchers, and conservation educators throughout the preservation community to identify critical research needs and priorities in the field.

"Through the Mellon grant, our research program will become a facilitator for national conversations about preservation research," Gutierrez said.

"It is hoped that working meetings that are part of this project will also serve as pilots for future meetings and establish a new role for IPI's research program as a facilitator of multi-institutional preservation research discussions and collaborations," she added. "Establishing a network for regularly discussing preservation research needs and current initiatives at various institutions will enhance research planning at both IPI and throughout the preservation research community."

As IPI prepares to mark its 35th anniversary in the fall of 2020, Gutierrez and her staff have begun plans to host a collaborative symposium at RIT that will include professional development workshops and sessions on such topics as modern inkjet preservation, chaired by IPI researchers. IPI held a symposium at the Library of Congress in Washington, D.C., in 2010 to mark its 25th anniversary.

Gutierrez is excited for what lies ahead.

"This is a good time to take a step back and look at the field's needs and determine how we best position ourselves going forward," she said. "There's a lot of great research happening now, and looking ahead and planning for what comes next is exciting."

Rich Kiley

Research and education projects

The Image Permanence Institute, an academic research center in RIT's College of Art and Design, has a full slate of research projects through 2019-20.

The impact of temperature transitions, short-term and seasonal, on the moisture content of library and archive collections

Description: A three-year research project focused on the impact of environmental transitions on moisture content in library and archive collections.
Funded by: National Endowment for the Humanities, Division of Preservation and Access, Research and Development Program
Project period: January 2018-December 2020
Funding awarded: $349,149
Principal investigator (PI): Jean-Louis Bigourdan, senior research scientist

Digital print preservation: education and training for cultural heritage professionals

Description: A two-year project designed to educate and train cultural heritage professionals on the proper identification and care of modern, digitally printed materials.
Funded by: National Endowment for the Humanities, Division of Preservation and Access, Education and Training Program
Project period: January 2018–December 2019
Funding awarded: $195,049
PI: Daniel Burge, senior research scientist

Evaluating the potential for freezing and freeze drying to improve water emergency outcomes for inkjet prints

Description: A three-year research project to determine if freezing and freeze drying are safe and effective for recovery of modern museum inkjet print collections affected by water emergencies.
Funded by: Institute of Museum and Library Services, National Leadership Grant for Museums Program
Project period: October 2018-September 2021
Funding awarded: $453,054
PI: Daniel Burge, senior research scientist

Enhancing the educational value and longevity of Graphics Atlas

Description: A one-year project to enhance IPI's online resource Graphics Atlas (www.graphicsatlas.org), an interactive digital resource that guides users through a process of identification and characterization of graphic print media.
Funded by: Samuel H. Kress Foundation, Digital Resources Grant Program
Project period: January 2019–December 2019
Funding awarded: $17,000
PI: Al Carver-Kubik, research scientist

Training sustainable environmental management teams for cultural institutions

Description: A two-year project focused on improving and increasing the capacity of humanities collections professionals to independently establish and maintain sustainable environmental management programs.
Funded by: National Endowment for the Humanities, Division of Preservation and Access, Education and Training Program
Project period: January 2019–December 2020
Funding awarded: $199,801
PIs: Christopher Cameron, sustainable preservation specialist, and Kelly Krish, preventive conservation specialist

Assessment initiatives for institutional planning at the Image Permanence Institute

Description: An 18-month project including two assessment initiatives that will inform and strengthen institutional planning at IPI.
Funded by: The Andrew W. Mellon Foundation, Scholarly Communications Program
Project period: January 2019–June 2020
Funding awarded: $165,000
PI: Jennifer Jae Gutierrez, executive director

RIT cyber fighters go deep on Tor security

Recognizing that the internet is not always secure, millions of people are turning to the Tor anonymity system as a way to browse the World Wide Web more privately.

However, Tor has been found to have its own vulnerabilities, including an attack known as website fingerprinting. This has a team of faculty and students from RIT's Center for Cybersecurity researching the extent of the problem and ways to address it.

Led by Matthew Wright, director of the center, and supported by a series of projects funded by the National Science Foundation, the team aims to think like future attackers so it can develop defenses that will last. The result: creating new attacks and defenses that use the latest advances in deep learning.

"Deep learning has proven to be effective in so many applications," said Wright, who is also a professor of computing security. "From self-driving cars to voice recognition in smart home speakers—it's just a matter of time before attackers take advantage of those same techniques."

Global Cybersecurity Institute

Construction is underway for RIT's Global Cybersecurity Institute, which will help the university become a nexus of cybersecurity education and research.

The three-story facility will include a cyber learning experience center, a simulated security operations center, labs, and offices. The institute will address the critical workforce needs in cybersecurity through education and professional development programs.

It is expected to open in July 2020 and will be the first facility of its kind in upstate New York.

Privacy for all

With more than 8 million daily users, Tor has become a popular free tool for activists, law enforcement, businesses, military, people living in countries with censorship, and even regular privacy-conscious individuals.

"When journalists need to communicate more safely with whistleblowers and dissidents, they often use Tor," said Wright. "We need this more secure way to access the internet because it's essential to our freedom of speech and privacy."

Wright explained that Tor creates a secure browsing experience by encrypting all its connections and sending traffic on a path through several random servers, rather than making a direct connection to the user's desired website. It protects against snooping on which sites a user visits, such as sites on sensitive issues like religion, health, or politics.

With the website fingerprinting attack, local eavesdroppers or internet service providers can collect the encrypted traffic and identify which website the user is visiting based on specific patterns in the traffic. While hackers can't actually see what a user did on the website, they have already learned something that the user is trying to protect.

Deep fingerprinting

Tor developers were considering two defenses against website fingerprinting that could cut the attack's accuracy in half.

Payap Sirinam, a computing and information sciences Ph.D. student, was tasked with exploring the potential for deep learning in the website fingerprinting attack.

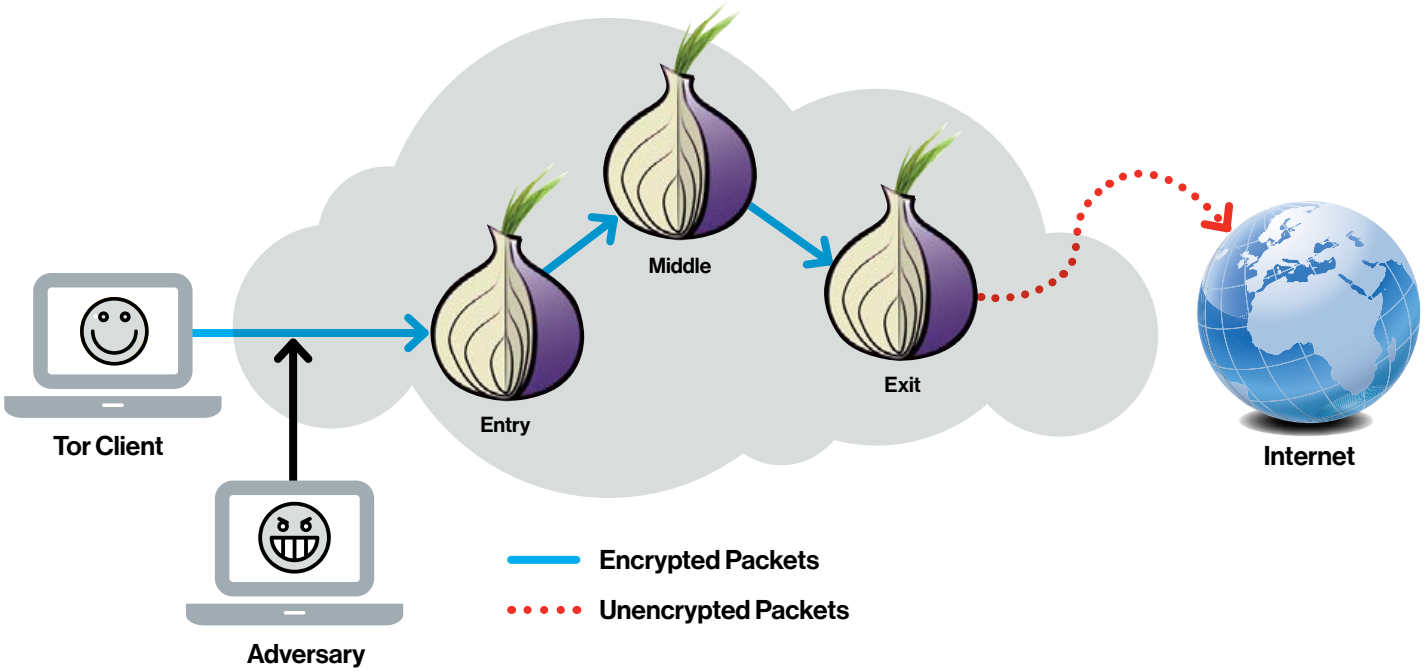
Adversaries are going to develop this technology themselves anyway, so the RIT team wanted to figure out how future attacks might work.

While the first website fingerprinting attack used machine-learning classifiers with manually developed features to analyze traffic, the team's new attack would use deep learning, which extracts features automatically.

"You manually train a machine-learning computer to recognize patterns in web traffic that humans can't see—that's why it's so good at this attack," said Sirinam, who is from Thailand. "By using deep learning, attackers are essentially able to spend less time training, while finding even more patterns that they can use to identify a website."

The RIT team's new attack, called Deep Fingerprinting, was based on a Convolutional Neural Network (CNN) that was designed using cutting-edge deep-learning methods. The attack automatically extracts

Elizabeth Lamark



The website fingerprinting model, above, shows how attackers bypass a Tor user's privacy by collecting the user's network traffic. Attackers feed that traffic into a trained machine-learning or deep-learning classifier and can then identify particular websites that users visit. Researchers hope to negate attacks by better understanding exactly how deep-learning classifiers work and using the artificial intelligence to the advantage of users.

features from packet traces and does not require handcrafting features for classification.

After thousands of hours running trace experiments in a closed-world setting, the new attack outperformed all previous state-of-the-art website fingerprinting attacks. The attack was 98 percent effective against Tor. Even against existing defenses, Deep Fingerprinting had more than 90-percent accuracy.

The Deep Fingerprinting project included work from Sirinam; Professor Wright; Marc Juarez, a Ph.D. student at the Belgian research university KU Leuven; and Mohsen Imani, a former Ph.D. student of Wright's at University of Texas at Arlington. A paper on the NSF-sponsored work was a finalist for an Outstanding Paper Award, placing it in the top 1 percent of all submitted papers, at the 2018 ACM Conference on Computer and Communications Security in Toronto.

"Now that we know which defenses aren't going to work against the new top-level attacks, it's up to us to create defenses that do," said Sirinam.

Upping our defense

Nate Mathews, a fourth-year computing security major, finds it fun to work with really difficult and ambiguous problems. However, the dilemma he's currently trying to solve is one that his mentor created.

Working together with Sirinam, Mathews is trying to better understand why the Deep Fingerprinting attack is so effective, in order to develop a defense that can stop it.

Mathews describes deep learning as a black box. Researchers put data in and output arrives at the other end. But it's difficult to see the inner workings of the box.

"If we could figure out which data features the deep learning thinks is important, we can identify the particular regions to defend," said Mathews, who is from Ross, Ohio.

To help visualize which parts of a trace are most important to the classification decision made by deep learning, the team is applying the GradCAM technique. Traditionally used in image classification, GradCAM generates heatmaps that show what parts of the trace the deep learning algorithm is focusing on.

Using their findings, Mathews and Sirinam are proposing ways to add fake packets to these important parts of the trace, which can confuse the deep-learning algorithms.

"It's like adding noise to a picture of a cat, so you can hide what kind of animal it is," said Wright. "You can add noise to the entire picture, but that's expensive in our setting. But if we can obscure the ears and the face, it might be enough."

Saidur Rahman, a computing and information sciences Ph.D. student, and Aneesh Yogesh Joshi, a computer science master's degree student from India, are also developing a new defense strategy that is meant to trick the deep learning.

Known as the adversarial examples

Every week, the cybersecurity research team meets for a "scrum" to discuss the latest updates on their Tor security projects and bounce ideas for new attacks and defenses off each other.

Gabrielle Plucknette-DeVito

defense, it uses deep learning to add packets and modify website traces in a way that causes the classifier to misclassify.

"We borrowed the idea from the domain of computer vision, where you can distort patterns in the model," said Rahman, who is from Bangladesh. "This defense can make Facebook traffic look like Google traffic."

Before implementing any new defense, the team needs to complete thousands of experiments in closed-world and more realistic open-world settings. They also need to take bandwidth and latency overhead into account. If a defense is going to slow the system down to a halt, users may find that the benefits no longer outweigh the cost.

Bolstering the attacks

Taking it one step further, the experts at RIT are trying to find other attacks they could use to test the robustness of their defenses.

They are developing Tik-Tok, an attack that uses packet timing information. Prior attacks discounted timing information because the characteristics change on each visit to a site, making it hard to extract patterns.

"We saw this as a largely untapped resource and something that might benefit from adding deep-learning classifiers," said Rahman. "We selected and extracted eight new timing features that provide a lot of value."

Preliminary results indicate that Tik-Tok could be a successful attack in the future.

Sirinam is also developing a new attack and subsequent defense as the last part of his dissertation. Using a branch of deep learning that he borrowed from facial recognition, he plans to create an attack that is more realistic than Deep Fingerprinting.

While the Deep Fingerprinting model may require 1,000 examples from each website to classify correctly, the new n-shot learning with triplet networks concept allows a classifier to learn from only five examples.

"N-shot learning is like an eco-car that requires fewer resources and has reasonably good performance, while the sports car—like Deep Fingerprinting—requires rich resources in order to perform at its best," said Sirinam. "This shows the danger of website fingerprinting attacks, even with less powerful adversaries, so we need to figure out a way to stop them."

Wright said that throughout these research projects, the Tor community has been an amazing partner and appreciative of RIT's efforts. Many of these defenses could be implemented on Tor in the next two to three years.

"We know that our defenses will likely be broken in the future—that's the nature of cybersecurity," said Wright. "But we are coming up with solutions that will help people around the world stay safe for the time being, and I think that's what really matters now."

Scott Bureau

A. Sue Weisler

Shal Khazanchi, a professor of management in Saunders College of Business, studies workspace design—including at Rochester-based engineering and architecture firm Bergmann Associates, pictured here—and its impact on employee relationships.

Is modern office design helping employees?

Can modern office spaces really determine whether employees thrive or fail? Yes they can, according to new research that examines how physical workspace design impacts interpersonal relationships, employee success, and productivity.

Shal Khazanchi, professor of management in RIT's Saunders College of Business and an expert in relationships at work, said that physical space can encourage the formation of some relationships, while hindering others.

Proximity to other employees, workspace assignment, privacy, and crowding all play significant roles in both building and straining relationships. The goal of her research is to provide the first step in assessing the impact—positive or negative—of the variations in spatial designs found in the modern office space.

"Spatial elements work through relationship-building mechanisms, including the frequency of face-to-face communication, content, and duration of communication among employees, and the extent to which space allows employees to display and promote their own identities and affiliations," said Khazanchi.

Her interest in this topic stems from her own experience as an immigrant who had to adapt to build relationships in different types of workspaces.

But Khazanchi warns that these spatial elements can also strain relationships and even create negative or toxic relationships if employers are not careful when creating workspaces.

According to her research, the most effective workspaces are those that balance the conflicting elements of office space design.

For example, if a workplace has low walls, employers must consider how this lack of privacy will impact employee relationships. While low privacy may encourage problem solving, it can jeopardize the formation of close interpersonal social connections.

"Many modern workplaces are opting to create wide-open workspaces for employees, believing this always leads to reduced costs and enhanced collaboration and communication," she said. "While this may be the case in some instances, employers should offer flexible spatial solutions such as communal gathering spots and/or huddle spaces that promote task relationships, which can increase employee creativity."

Research has shown that when people have positive interpersonal connections, they are happier, less depressed, experience greater satisfaction with life, and even live longer, Khazanchi said.

Vienna McGrain

The Air Force Office of Scientific Research funded project will use the hyperspectral video system shown above, which was developed by Associate Professor and Frederick and Anna B. Wiedman Chair Charles Bachmann, left.

Tracking vehicles with hyperspectral data

Matthew Hoffman

A classic scenario plays out in action films ranging from *Baby Driver* to *The Italian Job*: Criminals evade aerial pursuit from the authorities by seamlessly blending in with other vehicles and their surroundings. The Air Force Office of Scientific Research (AFOSR) has RIT researchers utilizing hyperspectral video imaging systems that make sure it does not happen in real life.

While the human eye is limited to seeing light in three bands—perceived as red, green, and blue—hyperspectral imaging detects bands across the electromagnetic spectrum beyond what the eye can detect.

This high-resolution color information can help people better identify individual objects from afar. The AFOSR awarded a team of researchers led by principal investigator Matthew Hoffman, an associate professor and director of the applied and computational mathematics MS program, a nearly $600,000 grant to explore if hyperspectral imaging systems can do a better job at tracking vehicles and pedestrians than current methods.

"It is very challenging to track vehicles from an aerial platform through cluttered environments because you cannot really see a vehicle's shape as well, and a lot of machine-learning computer algorithms are based on shapes," said Hoffman. "Trees, buildings, other cars, and a lot of things can potentially confuse the system. As hyperspectral video technology has improved, we believe we can use color information to more persistently track targets."

Hoffman will work closely with researchers from RIT's Chester F. Carlson Center for Imaging Science. The project will use a hyperspectral video system developed by Associate Professor Charles Bachmann.

The challenge with using hyperspectral imaging is that it produces massive amounts of data that can't all be processed at once, so Hoffman and his team are also tasked with creating a process to efficiently use the information on demand.

The team will use the Digital Image and Remote Sensing Image Generation model developed by RIT's Digital and Remote Sensing Laboratory to develop a new dynamic, online scene-building capability that helps re-track targets after they have passed by obstacles. The three-year project got underway in December. The goal this year is to develop the system's infrastructure and the team hopes to begin testing at the start of year two.

Luke Auburn

Mark Benjamin

RIT/NTID assistant professor Jason Nordhaus is studying dying stars and hidden celestial bodies that often lead to the stars' deaths.

Astrophysicist confirms dying stars theory

NASA

A dying star that was once about five times the mass of the sun is at the center of the Butterfly Nebula, pictured here, which is about 3,800 light-years away in the constellation Scorpius. The central star itself cannot be seen because it is hidden within a doughnut-shaped ring of dust.

A revolutionary technique developed by an astrophysicist at RIT could allow for a better understanding of the fates of solar systems when their stars cease to shine.

Jason Nordhaus, a National Technical Institute for the Deaf assistant professor of physics and a program faculty member in RIT's astrophysical sciences and technology Ph.D. program, has developed a system of complex 3D super-computer algorithms able to pinpoint the existence of previously undiscovered planets and celestial bodies associated with dying stars.

His research is partially funded by a three-year grant from the NASA/Space Telescope Science Institute.

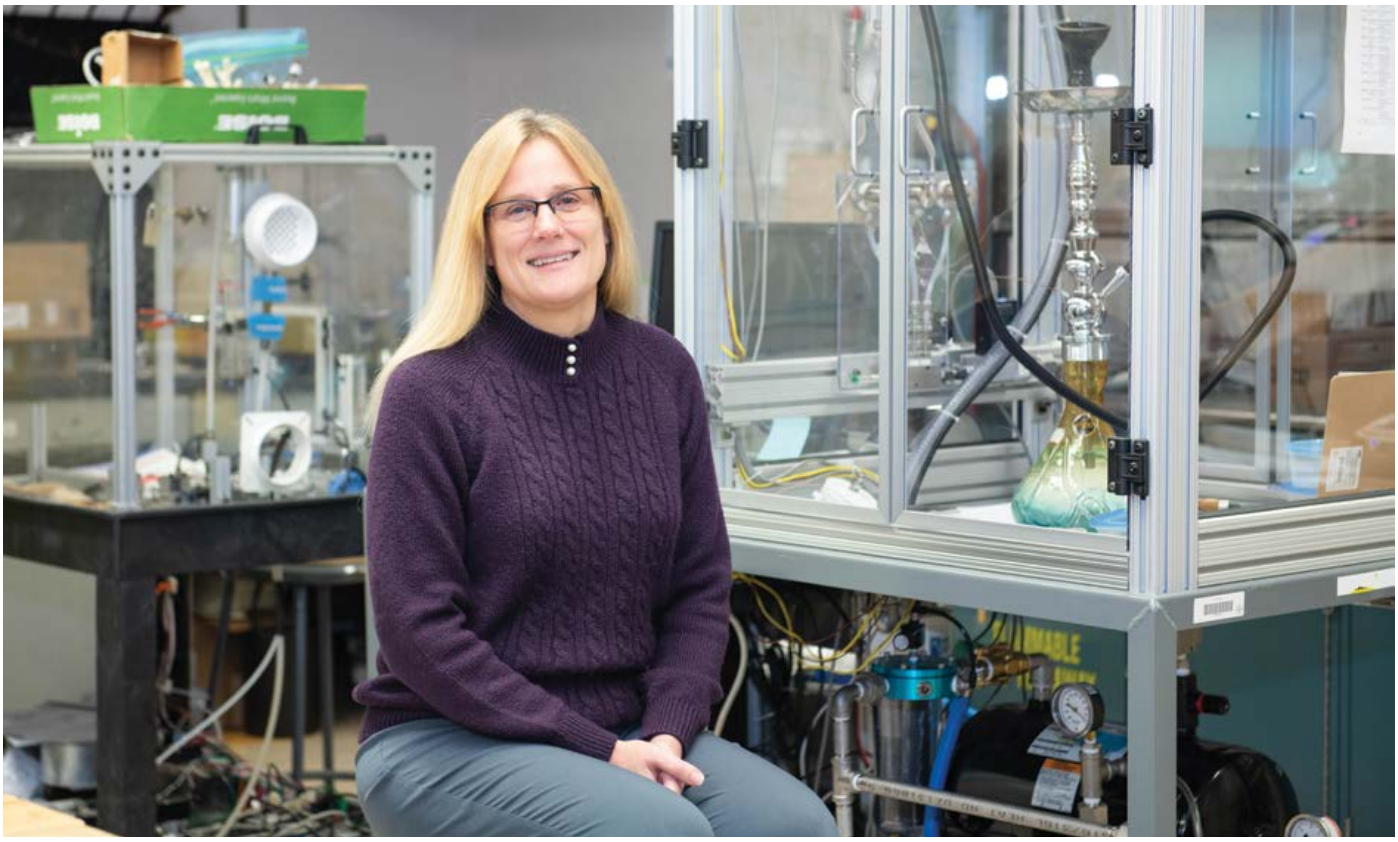
"In the past decade, we have discovered that this process of death that produces these spectacular images is linked to the presence of another star or planet in the system," he said. "However, large amounts of dust that mask these companions make them difficult to directly detect."

Nordhaus said that when a star dies, its physical size drastically increases and changes its shape.

Nordhaus' technique was previously used to infer the presence of a hidden planet in the dying star L2 Puppis, which was later detected by the Atacama Large Millimeter Array, a collection of radio telescopes in northern Chile.

This summer, Nordhaus will work with deaf, hard-of-hearing, and hearing students to study four systems for which Nordhaus has comprehensive data obtained over the past two decades. They are hoping that their 3D computer simulations will help determine which planets survive the death of their parent stars and which are ultimately destroyed.

Vienna McGrain



Gabrielle Plucknette-De Vito

Risa Robinson, professor and director of the Respiratory Technology Laboratory, studies the safety of different types of e-cigarette devices.

Behavior is key in new e-cigarette research

Risa Robinson has taken a different approach to assessing e-cigarette usage, and it has turned up some attention-getting results.

Robinson studies users in their own environments, puffing on their own e-cigarettes, rather than on test machines in lab settings. And what she has found is that they are puffing as much, if not more, than traditional cigarette users, resulting in potentially higher exposure to harmful substances.

Her team's work on the safety of different types of e-cigarette devices and flavored juices is among the foundational information the Food and Drug Administration is seeking to regulate e-cigarettes.

"Over the years, we've been trying to figure out whether these electronic cigarettes were actually safer products," said Robinson, a professor of mechanical engineering in RIT's Kate Gleason College of Engineering. An expert in fluid dynamics and particle deposition, she researches the effects of cigarette smoke on lungs and moved into assessing the effects of e-cigarettes as they became more popular.

Early experiments on e-cigarettes, done mostly in labs, predicted lower emissions from a single puff. The problem, Robinson noted, was users were not actually puffing that way. When she began research into the health risks of e-cigarettes, she found there weren't adequate tools to collect the data she needed. So as a mechanical engineer, she built her own.

E-cigarette devices have evolved since they were first introduced more than 10 years ago, and Robinson's lab team has produced a variety of ergonomically designed monitors that collect important information about usage and emissions.

"We have monitors that we've developed that can track puffing by day, time, and amount, and we can figure out the characteristics of every puff taken over time. From this we can determine exactly what exposure a user is getting and what specific constituents they are being exposed to. This helps us determine if a current or emerging product is actually low risk," she explained.

Tests in a lab setting, on a machine that simulates smoking, might show two comparison products looking identical in safety standards. But when the products are used in the field by actual users with the team's original monitoring device, a wireless Personal Use Monitor, there are differences.

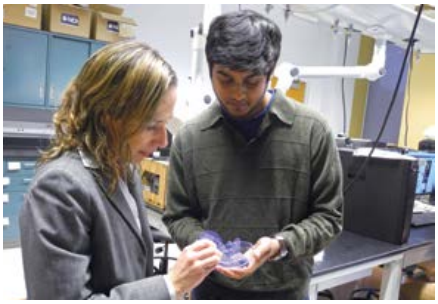
"Use behavior is key. What we are trying to do is get our behavior data into the regulation, so that we can show a more meaningful assessment of risk," she said.

Michelle Cometa

Solving today's challenges

Matthew Dye is working with a team of researchers to study how languages change over time.

Sungyoung Kim, far right, has been researching new audio engineering technology trends.



Iris Rivero, left, evaluates a 3D-printed biopolymer structure for tissue engineering with doctoral student Srikanthan Ramesh.

Changing languages

New research is helping scientists around the world understand what drives language change, especially when languages are in their infancy. The results will shed light on how the limitations of the human brain change language and provide an understanding of the complex interaction between languages and the human beings who use them.

The project is funded by a $344,000 National Science Foundation grant and is led by principal investigator Matthew Dye, an assistant professor and director of the Deaf x Laboratory at RIT's National Technical Institute for the Deaf.

Dye and his research team are examining Nicaraguan Sign Language, which was "born" in the 1970s. Using machine-learning and computer vision techniques, the team is looking at old video recordings of the language and measuring how it has changed over the past 40 years.

The recent birth and rapid evolution of Nicaraguan Sign Language has allowed them to study language change from the beginning, on a compressed time scale. They are asking whether languages change so they are easier to produce, or whether they change in ways that make them easier for others to understand.

Initial results challenge a long-held notion that signs move toward the face in order to be easier to understand.

Sound of history

Advanced audio technologies being developed are helping to preserve the unique sounds of historic sites from recording studios in Nashville, Tenn., to a pre-Columbian archeological site in Peru.

Sungyoung Kim, an associate professor of audio engineering technology, is leading a team developing a set of tools using advanced augmented and virtual reality technology to preserve and replicate the acoustics of historical venues. The project brings attention to the overlooked work in preserving aural heritage.

"The project focuses on auralization rather than visualization of soundscapes so that people can aurally experience the target space even if that space is one day demolished," Kim said.

Auralization is a process to simulate a unique acoustical environment, or a sound field, in a virtual or physical space. Currently, preservation of images and visual information is a research trend, yet without appropriate auditory information, visual representation of cultural heritage in any format could mislead users.

The team received a three-year grant from the National Endowment for the Humanities for $347,702 to focus on spaces considered culturally, architecturally, and temporally distinct examples of rare aural heritage.

3D-printed platforms

New 3D printing techniques are providing a way for an RIT researcher to create platforms to help regenerate human tissue that allows the body to heal itself more effectively. This work could reduce the need for human organ donations in the future.

Iris Rivero

Iris Rivero, department head of industrial and systems engineering, has found that compatible combinations of polymers and biomaterials can be successfully used to fabricate "scaffolds," 3D-printed structures that signal the body to begin its own tissue regrowth.

This research moves a step closer to the possibility of "smart," 3D-printed bone, skin, and cartilage tissue replacement.

"Sometimes organs in the body, due to the magnitude of damage or compromised immunology, are not able to repair themselves, and we have to come up with external alternatives to help them replace themselves," said Rivero. "What we are seeing today is bioprinting as a technology capable of generating customized platforms that can trigger the necessary signals needed to assist the body to repair itself."

Shaping the future

Matthew Hartensveld, a microsystems engineering Ph.D. student, is at home in RIT's clean room. His work integrating gallium nitride nanowire transistors and LED technologies could be used to fabricate more cost-effective and energy-efficient display devices—from flat panel TVs to military displays.

Gabrielle Plucknette-DeVito

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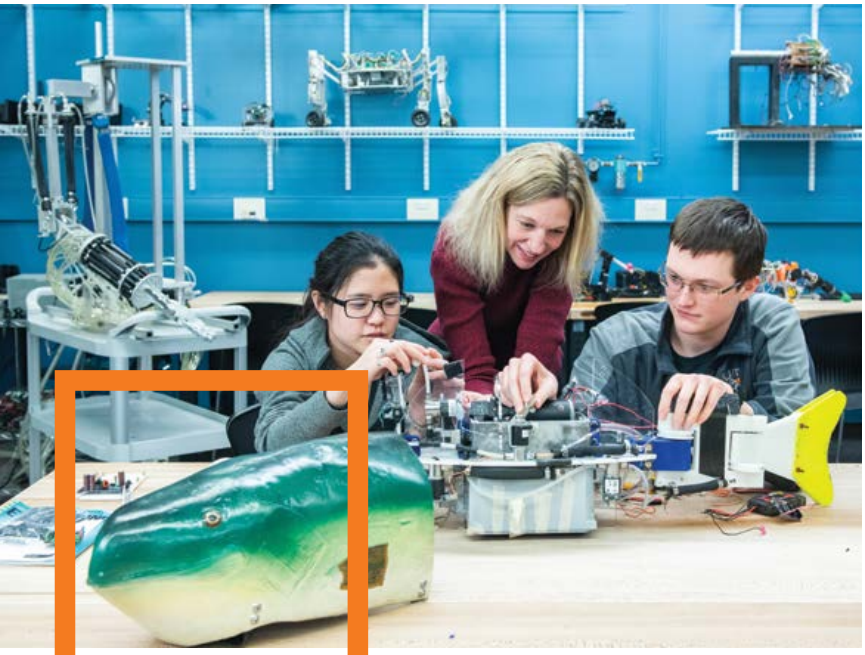

Faculty and students at RIT are evolving one of nature's oldest designs. This project started with keen observation of the simple yet powerful muscle movements of the common river trout. After collaborating with ecologists, designers, and several types of engineers, they created a fully submersible robot fish. The effects aren't just felt in the classroom. The technology inside can be adapted to create a new wave of prosthetics. When creativity and innovation collide, you're on to something life-changing.

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