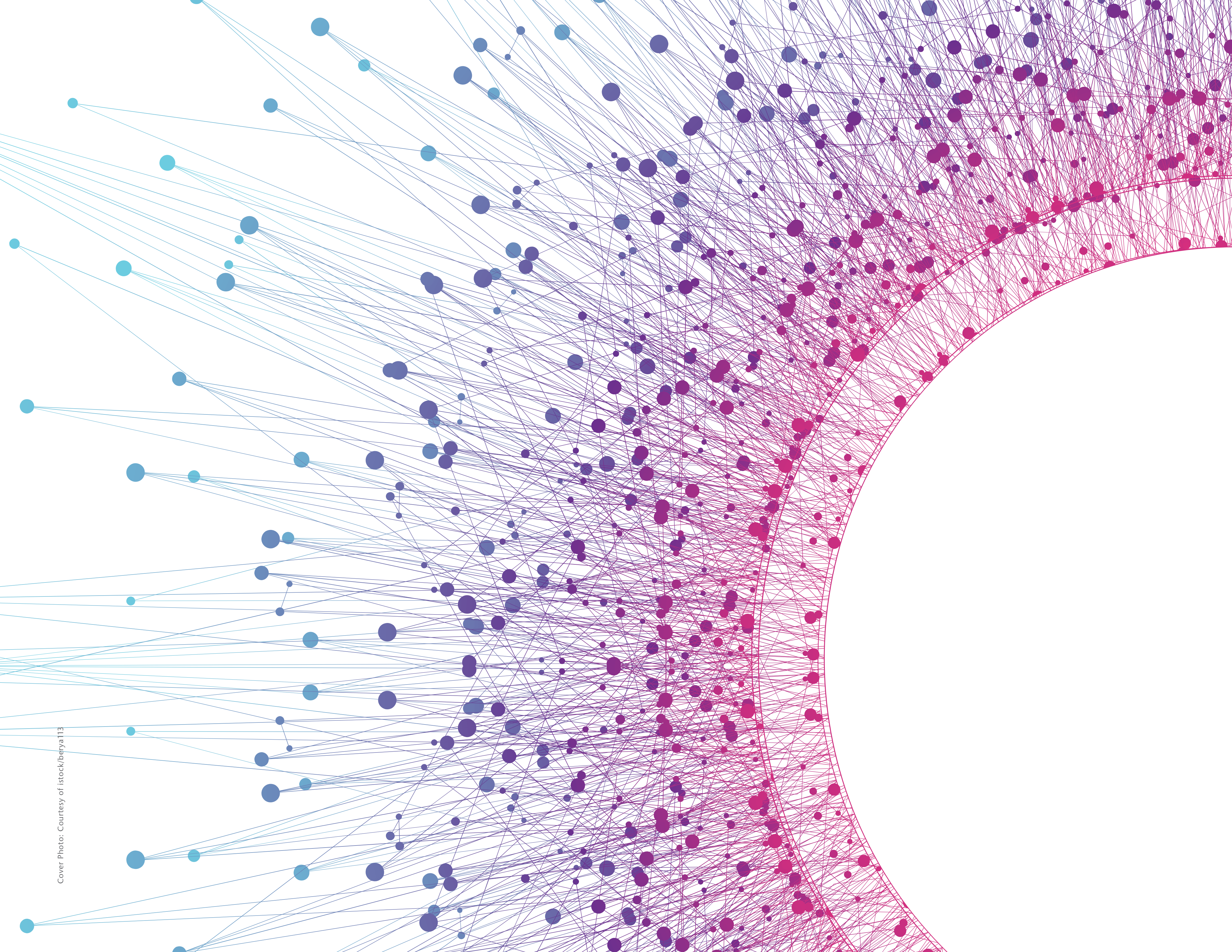
NEW JERSEY INSTITUTE OF TECHNOLOGY

RESEARCH

LINKING LABORATORIES TO LIVES

NJIT



Cover Photo: Courtesy of istock/berya113

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From the Senior Vice Provost for Research

We begin this decade on the cusp of powerful new technological capabilities. Advances in high-powered computing, robotics and nanotechnology-enabled sensors are transforming our society as machine intelligence, robot assistants and point-of-care devices empower individuals to enjoy their lives more purposefully. As our civilization evolves, our expectations of technology — and dependency on it — expand. A major leap in software capacity, for example, in turn puts pressure on hardware to lift our computing abilities to the next level.

And this is where we find ourselves in the unfolding data revolution. As we identify manifold variables shaping our most urgent problems, including changes in the Earth's atmosphere and ecosystems, we look to amplified computing power to analyze streams of data from diverse new sources and reveal potentially consequential interactions among them in real time. Once achieved, these capabilities will prompt new, more difficult questions. How do events well beyond our own atmosphere — varying emissions of electromagnetic radiation at different points in the solar cycle — and energies associated with the terrestrial system affect our planet?

NJIT established the Institute for Data Science last year to marry high-powered computing with data analytics to improve quality of life and shed light on longstanding mysteries such as space weather. Our focus is largely on applications that solve problems people encounter in their daily lives. We look to make improvements in sectors such as health care, financial management, data protection, food safety, traffic navigation and manufacturing.

In this issue, we detail a chemist's search for biomarkers to quantify pain, a chemical engineer's multistep, computer-directed process for creating tissue, and a data scientist's efforts to substantially boost our ability to detect connections and patterns in data from new and emerging sources. We also look at a solar physicist's use of new radio telescope technology to analyze powerful solar flares and determine which explosions have the potential to disrupt our engineered systems, both on land and in space. Our new institute's Center for Big Data works closely with our Institute for Space Weather Sciences, which we established last year. And we speak to a recent graduate with a Ph.D. in computational fluid dynamics who is now a data scientist for the 76ers basketball team.

As data analytics improves our powers of prediction, such as assessing the propensity to develop a particular disease, we also take seriously our responsibility to refine these capabilities for decision-making under variable conditions and risks. Technological advances and ethical deliberations about how we deal with knowledge and uncertainty will shape our thinking. Critically, we must insist the data we depend on when making decisions meets the highest standard of accuracy and integrity, and vigilantly root out bias in our data collection and application.

We must also defend against misinformation. In this publication, you will read about one of our newest faculty members, a computer scientist, who is studying the way political and polarizing messaging moves among social media platforms and morphs to appeal to different audiences.

Elsewhere in this year's issue, we showcase, among other research, our work with the state of New Jersey and our cities to improve water quality; our explorations into extinction mechanisms via research on amber-encased insects from the Late Cretaceous Period; a historian's reflections on the complex, evolving relationship between the Xavante community in the Cerrado of Central Brazil and Western researchers; and a biomedical engineer's use of novel methods to test rehabilitation therapies in the acute period of stroke recovery.

You will also read about students of robotics who are designing automotive systems for model cars that will take to the streets of a miniaturized version of Newark, N.J., as part of a novel assessment platform to evaluate the impacts of connected and automated vehicles on drivers, passengers in autonomous cars and pedestrians. In its applied focus and interdisciplinary nature, with contributions from transportation engineers, computing and networking scientists and robotics researchers, this experiment exemplifies our approach to tackling challenges in the emerging systems that will improve our lives.

Atam P. Dhawan
Senior Vice Provost for Research
Distinguished Professor of Electrical and Computer Engineering

Photo: Oscar Masciandaro

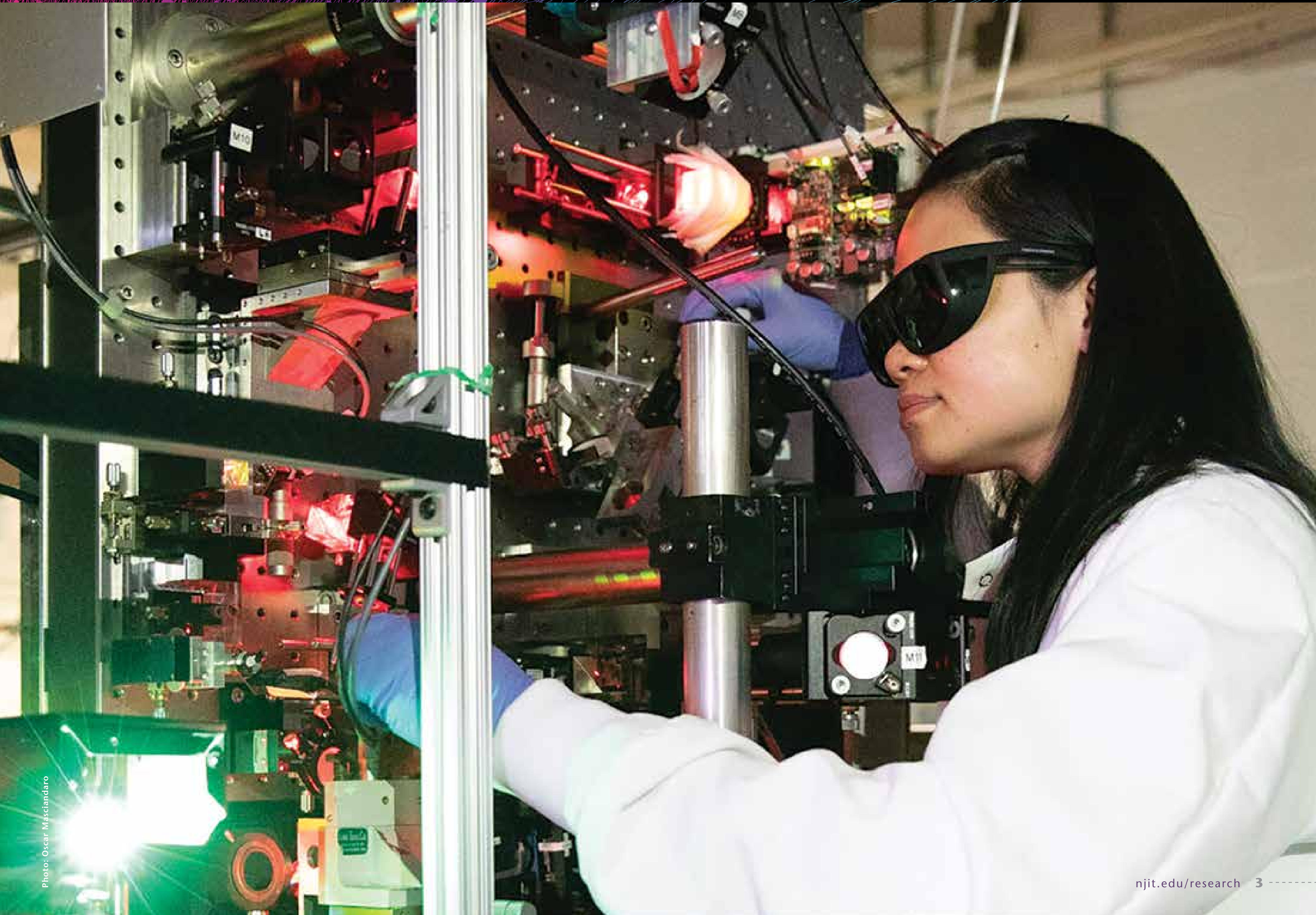


Photo: Oscar Masciandaro

NJIT's automatic geophysical observatories in Antarctica's frozen wilderness house instruments that measure fluctuations in the magnetic lines caused by solar wind and light from the Aurora Australis, the luminous collision of charged particles drawn by the South Pole's magnetic field. They provide continuous data sets of the larger geospace environment, which cannot be captured from instruments orbiting in space.

From Solar Storms to Cyberattacks, Data Science Illuminates the Future

Ten years ago, three engineers ventured into remote regions of Antarctica to connect NJIT's solar instruments there to the internet, allowing scientists on campus, for the first time, to collect real-time data on solar radiation and magnetism. The fluctuations they observe in the Earth's magnetic field signal what's arriving on the Sun's wind and driving systems in the upper atmosphere.

Physicists who observe the Sun through NJIT's Goode Solar Telescope in Big Bear, Calif., and its 13-antenna radio telescope in the Owens Valley also collect data throughout the year from the star itself, peering deep into regions where titanic bursts of energy originate. Together, NJIT's instruments provide insights into fundamental solar physics, but also give a comprehensive view of solar activity over hours, days, months and years.

These capabilities are crucial to solar storm forecasts. When active regions on the surface of the Sun explode, they release powerful bursts of electromagnetic radiation, known as solar flares, and charged particles, known as coronal mass ejections. Collectively, these phenomena cause the bulk of what we call space weather. As the complexity of engineered systems on Earth increases, as new technologies are invented and deployed, and as humans venture ever farther beyond Earth's surface, both human-built systems and humans themselves become more susceptible to the effects of the planet's space environment.

On Earth, these storms can disrupt power grids and cause radio blackouts, among other consequences. Indeed, the specter of a geomagnetic solar storm with the ferocity to disrupt communications satellites, knock out GPS systems, shut down air travel and quench lights, computers and telephones in millions of homes for days, months or even years is a low probability, but high-impact risk. Space scientists, global insurance corporations, and federal space and defense agencies take it seriously.

Last year, NJIT established the Institute for Space Weather Sciences (ISWS) to combine the strengths of the university's physicists and engineers at the Center for Solar-Terrestrial Research with powerful computing and mathematical capabilities at its Center for Computational Heliophysics, which partners with NASA's Advanced Supercomputing Division at the NASA Ames Research Center, and researchers at NJIT's Center for Big Data. These scientists can extract additional information from solar images and data sets, detecting patterns that can be missed by conventional analyses.

"Just as meteorologists are able to track a hurricane and determine where it will make landing, high-resolution observations and high-powered data analytics allow scientists to follow the propagation of the Sun's eruptions and the solar wind," says **Haimin Wang**, the ISWS's director. In response, they might advise spacecrafts to go into safe mode by powering down vulnerable instruments and turning solar panels away from the Sun. Forecasts of radio wave bursts from the Sun would be vital to GPS-guided technologies such as missile launches or self-driving cars.

Amplifying NJIT's predictive capabilities — in manufacturing, health care, financial management, data protection, food safety and traffic navigation, to name a few areas — is also the primary mission of NJIT's new Institute for Data Science. As **David Bader**, the institute's director, puts it, "In addition to understanding what has happened, we wish to predict what will happen."

In cybersecurity, that means creating analytics to defend critical infrastructure from attack, rather than just reacting to a breach by performing forensic analyses of log files. In health informatics, it means detecting diseases in their early stages and developing personalized medicines to cure them. In manufacturing, it means identifying defects before they cause catastrophic failures.

But first, data analysts must collect information from vast and often dispersed streams. Key political and societal data, for example, comes from the global universe of social media; researchers on campus are tracing the spread of information both preceding and following events as it proliferates and jumps from one platform to another, where it is often transformed for new audiences.

The inner world of the body is also teeming with data that is pursued by life scientists on campus. Tiny biosensors with even tinier nanoelectronic parts search for minute genetic changes that may signal disease, the evolution of stem cells in tissue-engineering experiments and the biomarkers that will allow doctors to one day quantify pain.

Contributing information from their experiments to massive databases will allow scientists across the globe to detect large patterns as well as the anomalies that signal important, or even troubling, events. One powerful demonstration of new capabilities was a recent project modeling and simulating what worldwide web traffic looks like on a given day.

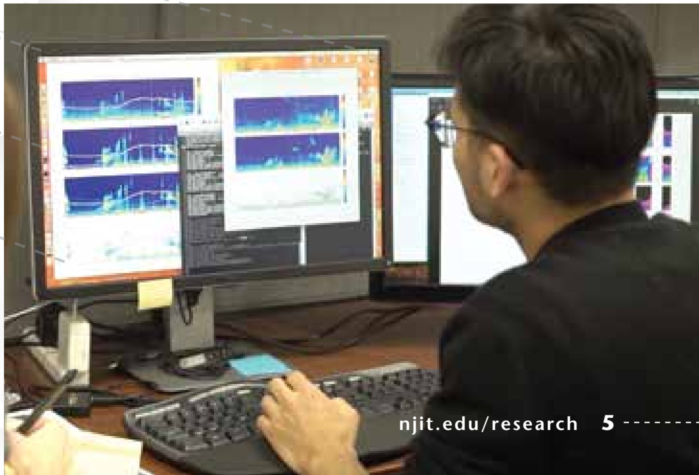
Researchers at the institute's Center for Big Data develop high-performance networking and computing technologies to support these applications, building fast data-transfer systems and efficient workflow processes to help users in various scientific domains, such as climate modeling and supernova research, to move big data over long distances and conduct collaborative analysis.

Work on new machine-learning, data-mining and data-management techniques to address challenges in pattern recognition is aimed at enabling big data analytics and predictive modeling in real-life applications, such as a platform for analyzing user-contributed social media data to identify adverse drug effects.

But to fully exploit the streams of data they collect, computers must first make a major leap in computing ability, which is a second major focus of the institute. Experts in high-powered computing are reconfiguring computers to avoid shuttling back and forth between memory to process data; designing hardware and software in tandem for artificial intelligence in order to execute specific tasks efficiently; custom processing for different domains; and, with huge improvements in graph algorithms, visualizing data in ways that make patterns easily apparent and actionable.

Space weather instruments collect massive numerical data sets over time, for example, which is challenging for physicists to understand. With sophisticated scientific visualization developed within the institute, experts are able to gain new insights into solar weather by creating 3D-immersive views and by allowing scientists to fly through the data, speed up and slow down events in time and gain new understanding by overlaying other sensors and instruments.

Ten years ago, a team of NJIT engineers established internet connectivity at the university's five remote automatic geophysical observatories (AGOs) in Antarctica. Data on solar radiation, magnetism and wind from the AGOs, as well as from instruments at the South Pole and McMurdo stations, streams into a data server in real time at another NJIT site at an observatory in New Jersey's Jenny Jump State Forest.



Photos: Courtesy of NJIT

Pain measurements are currently based on patients' self-reporting, and while some people may intentionally exaggerate their sensations, others may not have the ability to express them. To assess more accurately, Omowunmi Sadik has developed a biosensor to measure two biomarkers that are sensitive indicators of pain.

Quantifying a Powerful, Highly Subjective Sensation

How do we quantify pain? Asked by a doctor at an office visit, one patient's level "2" may be another's emphatic "10." A powerful sensory stimulus, pain triggers both cognitive analysis and emotions, making its objective measurement virtually impossible.

But determining its intensity, and the underlying cause it signals, is critical not only to effective pain management, but to diagnosis and treatment as well.

"So many factors make this challenging. People addicted to opioids may exaggerate their pain and those who come into the emergency room may already be on painkillers. Children, the unconscious and people with disabilities may not be able to describe their symptoms at all. This is a real problem, because pain is protective — it tells us we're in trouble," says **Omowunmi Sadik**, chair of NJIT's Department of Chemistry and Environmental Science, who views pain as "a vital sign, like temperature and blood pressure."

Pain measurements are currently based on patients' self-reporting, using the Wong-Baker Faces Scale or a numerical rating from 1-10. These measures are substantially influenced, however, by an individual's experience; memory, expectations and emotions can modify the perception of pain.

There are currently no precise, biologically based tests to inform the selection of painkillers.

To this end, Sadik has developed a biosensor to measure two pain biomarkers, cyclooxygenase-2 (COX-2) and inducible nitric oxide synthase (iNOS), biochemical compounds that appear in the bloodstream when pain is present, including in cancer patients, and have proved sensitive indicators of true pain. "By verifying them, we hope to separate patients with psychological or secondary pain issues from those with a true etiology of pain."

Her team is testing COX-2 and iNOS in ongoing clinical trials running in three U.S. hospitals. So far, she has measured biomarker levels in the blood samples of 200 patients in these emergency rooms, using a small device that functions like a glucose monitor. Her team has also measured biomarkers in more than 800 Turkish patients.

Some initial results suggested that self-reported pain levels did not show a correlation with the levels of COX-2 and iNOS. The team attributed those responses to various factors, including patients' intake of painkillers prior to participation, their painkiller habit, chronic diseases and the subjectivity of self-reported pain. However, they detected increased levels of COX-2, which is one of three subtypes of an enzyme, in connection with different health issues. COX-1 is usually found in human blood, while COX-2 only appears with chronic pain and COX-3 with a different disease state.

Sadik is working with psychologist **Peter Gerhardstein** and computer scientist **Lijun Yin** at the State University of New York–Binghamton to compare biochemical data gathered by biosensors with facial recognition algorithms to see if there is a correspondence. They are tracking expressions, eye blinks and pupil size, as well as other pain behaviors, including changes in voice and guarded movements.

"The detection and validation of these biomarkers in a subset of diseases could lead us to a transformational new paradigm in objective biomarker discovery for diagnosis and even pain prediction," Sadik says. "Quantifying pain will allow us at the clinical level to diagnose diseases and injuries more precisely, to better assess their severity and to calibrate the level of painkiller needed. With the opioid crisis, this will also be an important tool for physicians, who now have to take someone's word when they say they're in pain."

Ultimately, she'd like to design biological alternatives to opioids, such as painkillers derived from flavonoids (compounds found in fruits and vegetables) that would bind with pain receptors in the body. Two such flavonoids, quercetin and apigenin, have already demonstrated several beneficial health effects when administered together — they are, for example, anti-inflammatory, antiviral, antibacterial and gastroprotective and elevate the bioavailability of chemotherapeutic and antimicrobial agents.

But these naturally occurring flavonoids are poorly soluble and quickly metabolized and degraded. Her group has synthesized phosphorylated derivatives to enhance their solubility and is now studying analogues that can withstand oxidative degradation. They have tested some of these compounds in cancer cell lines and have seen their potential to equal and even surpass the capacity of current medications to reduce the levels of two other biomarkers that signal pain: prostaglandin E2 and nitric oxide.

In the meantime, to expand the base of knowledge around pain, Sadik is contributing samples from her studies to a biomarker database established by the National Institutes of Health's Pain Consortium.

"In 5-10 years, our knowledge will grow astronomically from this collected data," she says.

In her own lab, she has already gleaned insights into different populations of people reporting pain by comparing the blood samples of the Turkish and upstate New York emergency room patients. She notes, "Opioids were found in high levels in the U.S. samples, but low levels in the Turkish."

Photo/left: Oscar Masciandaro Photo/top right: Deric Raymond
Background Photo: Courtesy of iStock/GeorgePeters

Guiding the Journey From Single Cell to Robust Tissue

Tissue engineers zero in on the urgent problems of regenerative medicine: reactivating severed spinal cords, repairing damaged organs and healing wounds. But three decades since their field's inception, they still face a daunting hurdle. While they can create human tissue in the lab, they have little control over where implanted stem cells travel – or even what they become – once they enter the body.

Chemical engineer ROMAN VORONOV is developing a multistep, computer-directed process for guiding and monitoring the journey from single cell to robust tissue. In the lab, he first created a microscopic maze to study cell migration, to see what pathways they take in response to chemical and physical clues. He then created a scaffold with microfluidic channels that will allow him to guide the repair cells – human fibroblasts and mesenchymal stem cells – while taking samples noninvasively to make sure they are evolving into the prescribed tissue – and not becoming cancerous, for example.

He will be able to observe cell movements with a lattice-light sheet microscope, which allows live 3D imaging, that he and his students built from blueprints provided by University of California, Berkeley physicist ERIC BETZIG, who won the 2014 Nobel Prize in chemistry for developing super-resolution fluorescence microscopy.

His ambitious goal is to give the scaffold automated control over nearly all aspects of cell behavior: migration, differentiation, division, tissue generation and deposition, and cell death. To remove human error, the process will be overseen by a computer programmed to respond to regular cell sampling in the scaffold.

The computer will analyze feedback from 3D microscopy observations and chemical and cell samplings as the artificial tissue is being cultured. It will correct deviations from the set parameters by using the microchannels to send appropriate chemical signals and cells to the problematic locations within the tissue, just as the body would do in response to injuries or disease.

"In the body, cells are guided by chemicals released by other cells and tissues under the supervision of the central nervous system," says Voronov. "Artificial tissue is supervised by nothing – this is the problem in conventional tissue engineering I'm trying to fix."

Diagnosing a Solar Flare

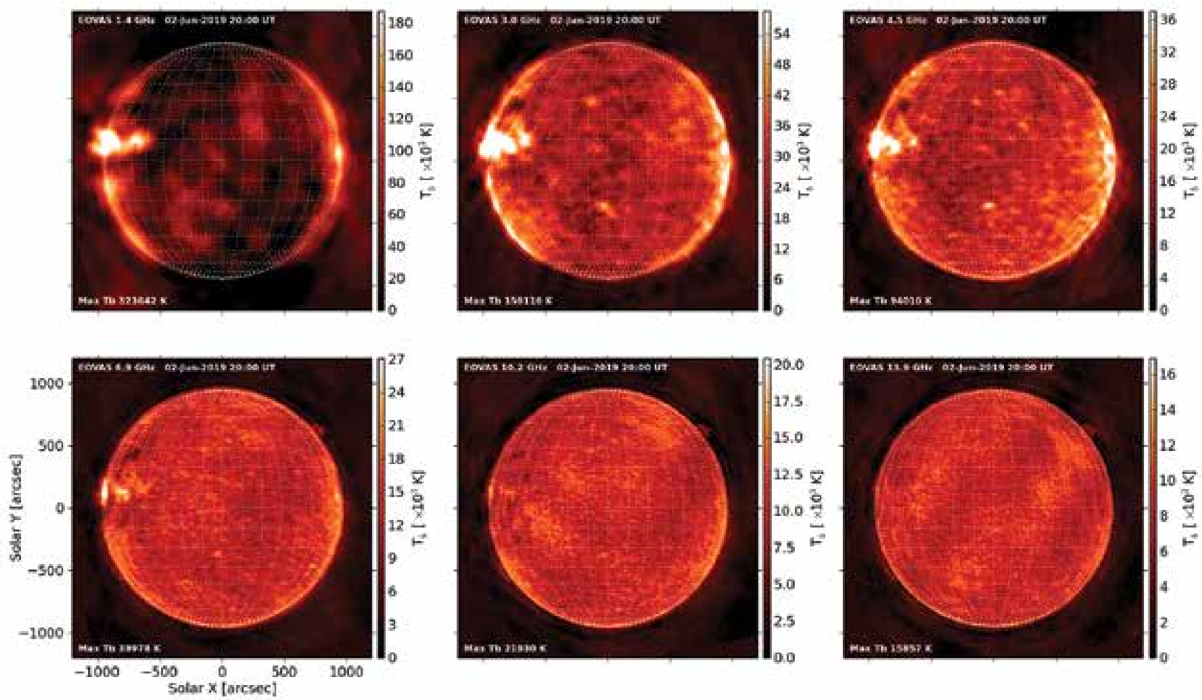
In the fall of 2017, a massive new region of magnetic field erupted on the Sun's surface next to a sunspot, and the ensuing collision of those fields produced a series of solar flares powerful enough to disrupt radio communications on Earth. They were the first flares to be captured, in their moment-by-moment progression, by NJIT's Expanded Owens Valley Solar Array (EOVSA) radio telescope.

The radio images were themselves the first ever to record the dynamic changes in magnetic fields that power the flares. With 13 antennas working together, EOVSA takes pictures at hundreds of frequencies in the 2.5-18 GHz range, including optical, ultraviolet, X-ray and radio wavelength, within a second.

"Before these observations, we had no way to see the vast region of space over which high-energy particles are accelerated and then become available for further acceleration by the powerful shock waves driven by the flare eruption, which, if directed at Earth, can destroy spacecraft and endanger astronauts," says **Dale Gary**, EOVSA's director.

"The connection of the flare-accelerated particles to those accelerated by shocks is an important piece in our understanding of which events are benign and which pose a serious threat," adds Gary, who was involved in the discovery in 2006 that radio bursts can cause failures in Global Positioning System (GPS) receivers, which can affect GPS services over the entire sunlit hemisphere of Earth.

Just over two years after the expanded array began operating, it is automatically generating microwave images of the Sun and making them available to the scientific community on a day-to-day basis. As solar activity increases over the course of the 11-year solar cycle, they will be used to provide the first daily coronal magnetograms, maps of magnetic field strength 1,500 miles above the Sun's surface.



"These daily images provide scientists an overview of the current conditions on the Sun, and reveal the proportion of radio flux attributable to different components of the solar atmosphere, whether from hot coronal loops, magnetic fields in sunspots or the general background surface flux," he notes. "The emission from hot coronal loops affects the upper atmosphere of Earth while the others do not, so it is important to be able to separate them."

Radio emissions are generated by energetic electrons accelerated in the corona, the Sun's hot upper atmosphere. Modern solar physics relies on observations at many wavelengths; radio imaging complements these by directly observing the particle acceleration that drives the whole process. By measuring the radio spectrum at different places in the solar atmosphere, radio imaging becomes a powerful diagnostic of the fast-changing solar environment during these eruptions.

EOVSA, which is funded by the National Science Foundation, is the first radio imaging instrument that can make spectral images fast enough to follow the rapid changes that occur in solar flares. This capability allows the radio spectrum to be measured dynamically throughout the flaring region, to pinpoint the location of particle acceleration and map where those particles travel. Images of solar flares at most other wavelengths show only the visible consequences, sudden brightenings, caused by the accelerated particles, whereas radio emission can directly show the particles themselves.

"One of the great mysteries of solar research is to understand how the Sun produces extremely high-energy particles in such a short time," Gary notes. "But to answer that question, we must have quantitative diagnostics of both the particles and the environment, especially the magnetic field that is at the heart of the energy release. EOVSA makes that possible at radio wavelengths for the first time."

Among other discoveries, scientists at EOVSA have learned that radio emissions in a flare are spread over a much larger region than previously known, indicating that high-energy particles are promptly transported in large numbers throughout the explosive magnetic field bubble called a coronal mass ejection (CME).

"This is important because CMEs drive shock waves that further accelerate particles that are dangerous to spacecraft, astronauts and even people in airplanes flying polar routes," Gary says.

The Expanded Owens Valley Solar Observatory radio telescope sees the entire disk of the Sun and regularly captures simultaneous images at six different radio frequencies. Among other solar phenomena, the 13-antenna instrument provides full-disk maps of coronal temperature and density, as well as measurements of magnetic field strength in active regions. The region of the solar atmosphere that produces the emission comes from near the surface at the highest frequencies (lower panels), but moves outward and higher in the corona as the frequency gets lower (upper panels), enabling imaging akin to a CAT scan of the solar atmosphere. In the images (left), the bright area is a sunspot region appearing on the east limb (on the left side of the disk), while smaller bright spots elsewhere on the disk are compact regions of magnetic field.

Sun Photos: Courtesy of Dale Gary
Photo/top left: Hannah Kum-Biocca, top right: Oscar Masciandaro

A Stroll Through Earth's Magnetic Fields


Hannah Kum-Biocca

Earth's magnetic fields are continuously buffeted by the flow of electromagnetic radiation and energetic charged particles from the Sun that travel through space on the solar wind. Scientists track these changes, using magnetometers on land and in space, to monitor the environment between the Sun and Earth and to better predict the phenomenon known as space weather, with its power to disrupt communications satellites, knock out GPS systems and shut down electrical grids.

These potent forces are largely invisible to people on Earth, however, prompting a solar physicist and an artist who works in virtual and augmented reality to provide a tangible (body-centered, hands-on and real-time) experience of Earth's magnetic fields. Their device arrays those forces in a simulated physical space around the body.

HYOMIN KIM, an assistant professor of physics at NJIT's Center for Solar-Terrestrial Research, operates the university's network of magnetometers in the polar regions of both hemispheres, including Canada, Norway and Antarctica, and analyzes the data that streams into an NJIT data portal. HANNAH KUM-BIOCCA, an assistant professor of architecture and design, is a computer interface designer and an interactive media artist who specializes in video mapping, virtual and augmented reality, interactive user-experience installations and human-computer interaction.

They have joined forces to simulate and visualize data streaming in from various NJIT magnetometers, using a multiuser augmented reality environment they call AR Vis. Their prototype integrates a set of electromagnetic sensors, a 360-degree grid visualization and several Microsoft HoloLens displays that allow wearers to sense and manipulate virtual objects. They walk through an oscillating grid visualization of the magnetic fields that bend around their moving bodies, while also allowing them to experience how their movements in turn distort the magnetic fields. The interface supports interaction at two scales: the measured electromagnetic fields around a person's physical space and the data-driven, planetary forces from space.

"Virtual, and especially augmented reality, allows us to interact with scientific and big data visualizations in more intuitive ways," Kum-Biocca says. "These visualizations help people to better detect patterns, trends and anomalies in physical forms."

Snapping Foggy Narratives Into Focus

When a patient arrives in an emergency room with high fever, coughing and shivering, the speed of diagnosis and treatment depends on the skills of the medical staff, but also on information. If it's a rare or newly spreading infectious disease, reliance on today's clinical diagnostic methods may not immediately recognize it. Ready access to a variety of data — disease genomics, geospatial maps of its spread and electronic health records — might even predict it.

"When we track communities, for example during global pandemics or for finding influencers in marketing, using data streams rather than static snapshots enables us to follow relationships that change over time," says **David Bader**, director of NJIT's newly established Institute for Data Science. "We want to see how these relationships change, such as in pandemic spread of disease, by following global transportation, disease spread and social interactions, in near-real time."

But that level of gathering, processing and assembly requires new computing capabilities: the capacity to search through massive volumes of data from diverse sources, from unstructured texts and social media to passenger lists and patient records, and the ability to perform complex queries at unprecedented speeds. This is particularly important in health care, he notes, where the speed of diagnosis can stop the spread of deadly diseases in their tracks.

"Big data is used to analyze problems related to massive data sets. Today, they are loaded from storage into memory, manipulated and analyzed using high-performance computing (HPC) algorithms, and then returned in a useful format," he notes. "This end-to-end workflow provides an excellent platform for forensic analysis; there is a critical need, however, for systems that support decision-making with a continuous workflow."

Bader has been working with NVIDIA to develop methods to allow people to stream relationship entities and analytics in continuously updated live feeds through its RAPIDS.ai, an open accelerated data science framework for accelerating end-to-end data science and analytics pipelines entirely on graphics processing units. These graph algorithms, which contain far more memory access per unit of computation than traditional scientific computing, are used to make sense of large volumes of data from news reports, distributed sensors and lab test equipment, among other sources connected to worldwide networks.

In hardware, HPC systems use custom accelerators that assist with loading and transforming data for particular data science tasks. "For instance, we may only need a few fields from electronic patient records archived in storage. Rather than retrieve the entire library before searching records for the information, we could retrieve only the fields necessary for the query, thus saving significant cost," he notes, adding that with accelerators, key tasks will move them closer to the hardware and data storage systems.

He notes that general-purpose computers are reaching a performance plateau as they hit a ceiling on the number of transistors that can be placed on a chip. While exploiting parallelism using multicore processors provided a path forward for some applications, the target is higher-performing, specialized chips designed to perform specific functions such as the Xilinx field-programmable gate array for signal processing or Google's tensor processing unit. Cerebras, he adds, is setting records with the 1.2 trillion-transistors Wafer-Scale Engine for accelerating deep learning.

"The hardware-software co-design for analytics is exciting as we enter a new era with the convergence of data science and high-performance computing. As data are created and collected, dynamic graph algorithms make it possible to answer highly specialized and complex relationship queries over the entire data set in near-real time, reducing the latency between data collection and the capability to take action," Bader says.

These systems are also designed to be energy-efficient and easy to program, while reducing transaction times by orders of magnitude. The goal is for analysts and data scientists to be able to make queries in their subject domain and receive rapid solutions that execute efficiently, rather than requiring sophisticated programming expertise.

"The variety of data we ingest continues to change and we will see data sources we can't envision today. We need to create systems that will be able to ingest them," he says.

Where will this all lead? Bader tells the story of one company's aspiration to turn ranting customers into raving fans by tracking public blogs and social media, identifying them in their customer records and even preemptively responding with fixes and repairs before customers had even contacted the company's support team. A decade ago, Dell reported a 98% resolution rate and a 34% conversion rate turning online "ranters" to "ravers" using social listening.

"We are developing predictive analytics — the use of data to anticipate the future," Bader says. "Instead of understanding what has happened, we wish to predict what will happen."

David Bader, director of NJIT's Institute for Data Science, works on computing initiatives that will help people make sense of large, diverse and evolving streams of data from news reports, distributed sensors and lab test equipment, among other sources connected to worldwide networks.

Photos: Oscar Masciandaro

How Manipulation Migrates Across the Internet

Social media behemoths inhabit security silos, each with its own rules and investigative tools. Their insights into disinformation are inwardly focused. But antisocial, manipulative messages recognize no such boundaries as they are purposely migrated from say, Twitter to Facebook, with related messages crafted for each platform's audience.

To get a better handle on how political and polarizing content moves among platforms, CODY BUNTAIN, an assistant professor of informatics, is tracking messages and identifying when and how they are part of coordinated campaigns. He looks in particular at groups of accounts that post similar content around a specific message while appearing uncoordinated on other topics.

"Though the platforms are responding to these concerns, they are rarely coordinated, and addressing issues on a single platform does not address the underlying threats to spread misinformation, sow discontent, manipulate financial systems and effect changes in political institutions and processes," Buntain notes.

He looks at the features of each platform – Twitter's short messages and Facebook's longer ones, Instagram's images and Reddit's anonymity – that incentivize both prosocial and antisocial messages. Public platforms like Twitter may enable the social capital necessary to start a movement, whereas the anonymous and insular nature of Reddit may foster conspiracy and antipathy.

By examining the messaging habits of social media influencers – in his case, posts on public pages, as well as weblinks to major news organizations, shared by members of Congress – he seeks to understand what information they share and how they share it.

Buntain also analyzes the intersections between news posted by politicians and how often different news sites are reported as pushing fake news, and how well social media users' reports of fake news align with expert assessments of media bias and credibility.

He notes, "By finding groups that align on a single message while sharing disparate content on other topics, we aim to highlight inauthentic behavior and provide individuals with more context about the information they consume."

Q&A

Photo: James Marko

Joining the NBA's Data Revolution

Ivana Seric '17
Data Scientist, Philadelphia 76ers

Q: BEFORE JOINING THE 76ERS, YOU EARNED A PH.D. IN COMPUTATIONAL FLUID DYNAMICS AT NJIT. WHAT DID YOUR RESEARCH ENTAIL?

A: Through a senior-year undergrad research project, I became interested in predicting or modeling fluid behavior on a solid surface — the type of research used for improving nanochips or solar panels.

During my Ph.D. research, I helped develop a novel numerical method for solving fluid equations including the Marangoni Effect, which occurs, for example, when liquids of different surface tension meet. You can see this when "tears of wine" streak down a wineglass. … Alcohol evaporates faster than water creating small pockets of liquid with a higher concentration of water and with greater surface tension. This forces fluid up the glass until droplets pool, become too heavy and fall back down. The model I helped build enabled us to quantify and visualize the dynamics of that effect. I enjoyed working on these problems … coding, processing data, and creating models and visualizations that bring data to life.

Q: HOW HAVE YOUR NJIT EXPERIENCES HELPED YOU IN THE WORLD OF SPORTS DATA SCIENCE?

A: Much of that experience was transferable. I was coding and analyzing a lot of data, and the modeling and simulation work involves similar creativity and cross-processing … essentially taking data and creating a cohesive story for others. Being a basketball player with NJIT and the Croatia national team has helped me transfer those skills to analyzing the data from basketball games. I often speak with coaches in basketball terms about what our data tells us. It's important that they can understand and use our insights in game situations.

Q: WHAT DOES YOUR DAY-TO-DAY INVOLVE?

A: In the 76ers' research and development department, my role involves analyzing game data and attending coaches meetings to report what trends we see in our team or an opponent. I prepare reports that involve data-based profiles of opponents, detailing their tendencies, what they struggle with and how we can exploit their weaknesses.

Q: HOW DOES YOUR TEAM USE DATA TO STRATEGIZE?

A: In 2013, the NBA installed camera systems in every arena that track the ball and every player on the court at 25 frames per second. When a game ends, the league sends this data to every team. We get about a million rows of data a game. It's enormous compared to box scores and play-by-play data we were limited to before, and requires much more processing and machine-learning skills. Along with player movement, we can tag interactions throughout games. For example, we can break down every pick-and-roll play in a game, the outcome, players involved or defensive scheme deployed. We can collect and analyze these many types of data points for strategizing.

Q: WHAT MAJOR TECHNOLOGIES OR TRENDS DO YOU SEE COMING IN THE FUTURE?

A: Along with technology we have in terms of video processing and image recognition, a lot more may be possible beyond just tracking players' X, Y locations on the court. I can see advances in pose data, such as capturing players' arm positions, or to detect where a player is facing.

Q: WHAT'S ON THE HORIZON FOR YOU?

A: I truly enjoy working on basketball data and being involved in our on-court strategy. I want to do more outreach events focused on girls in STEM and/or sports who may be discouraged by the lack of women in those fields. I want them to see that it is possible to succeed in STEM and sports.


Photo: Oscar Maccandaro

Engineering Stars

Bob Ellis '98 M.S.
Chief Engineer, Princeton Plasma Physics Laboratory

Q: WHAT DREW YOU TO MECHANICAL ENGINEERING?

A: I majored in mechanical and aerospace engineering as an undergraduate at Princeton and thought I was going to be an aircraft guy. But then I had an internship at a tennis racket factory and became fascinated by the design of production equipment. These were open-ended problems; the R&D engineers would walk through the factory and if they saw a process that could be automated, they would design a machine to do that. This is high-stakes engineering. If you're making a machine to tighten tennis racket strings and it goes down, you've got 300 people twiddling their thumbs.

Q: IS THERE A BASIC DESIGN CHALLENGE FOR FUSION REACTOR ENGINEERS?

A: As mechanical engineers, we deal with heat transfer and thermal stress problems. The solid surfaces inside the reactor — the plasma-facing components — get up to 1,700 degrees Celsius and the plasma itself is millions of degrees. But the components we design are also subject to electromagnetic forces and so, just as the space shuttle's engineers design for both thermal loads and atmospheric forces, we need to take electromagnetic forces into account as well. The big challenge in designing for both is that material properties that help the thermal performance tend to result in higher electromagnetic forces.

Q: WHAT ARE SOME DEVICES YOU'VE BUILT?

A: We design diagnostic devices, including lots of magnetic sensors. They're sensitive to fluctuating fields and measure their rate of change. The reactor's magnets, 1 Tesla on our NSTX-U, are what keep the hydrogen ions close together for long enough as they orbit along their field lines, so they collide and fuse. You have to know what your magnetics is doing to control the plasma. In stars, gravity takes care of that. High plasma density is also essential for fusion to work and we measure it with interferometers that use microwave and infrared waves. We also design devices to heat and maintain the plasma. I worked on high-power radio frequency heating for nearly 20 years.

Q: WHAT ARE SOME HIGHLIGHTS OVER YOUR CAREER?

A: I designed an ion cyclotron antenna for Alcator C-Mod, a U.S. Department of Energy-funded tokamak at MIT. The very high (8 Tesla) electromagnetic fields there resulted in high forces on the antenna. I also designed several steerable microwave launchers for General Atomics and for a machine in Korea. These devices steer a 1-megawatt beam of radio waves to a precise location in the plasma where a local instability, or tearing mode, breaks the toroidal magnetic field lines, which then reconnect to form a magnetic "island" that leaks energy. My launcher locks onto it for a fraction of a second and eliminates it. If you don't, the plasma will disrupt.

Q: HOW WOULD YOU DESCRIBE FUSION'S PROGRESS OVER THE PAST FIVE DECADES?

A: Fusion is a triple product — the three components are temperature, plasma density and the time a plasma is confined. To date, some groups have done better on temperature, some better on density and some better on time — the best so far is around 400 seconds. There was a run-up in the '90s that saw us get very close to breakeven — as much energy out as in. That was exciting. I think with ITER, the most powerful reactor ever built, coming online in France in the next few years, people are ready for another exciting run. With its superconducting magnets, it's planning on pulses of 400-600 seconds. As engineers, we have to make components that are compatible with these more extreme operating environments.

Q: CAN WE CHART FUSION ENERGY'S FUTURE?

A: My biggest hope now is getting well beyond breakeven, because that's a big political milestone that anyone in the world can relate to. It would mean commercial power down the road. But that day will come not because of energy scarcity or climate change concerns, but because someone invented something better. And that's hard to predict. The Stone Age didn't end because the world ran out of stones. With the first Marconi transmitter and the first diesel train, it's that first little sputtering creation that barely works that's so important, because it sets a completely different course to a better world.

Healing New Jersey's Troubled Waters

Getting the Lead Out of Newark's Drinking Water

As Newark races to replace thousands of lead-based pipes that feed drinking water into homes, the city faces another urgent challenge: stopping the heavy metal from leaching into the water supply while the massive remediation effort is underway.

That's where NJIT's environmental engineers come in. To mitigate exposure over the life of the project, expected to take up to 30 months, a research team is working with the city to develop chemical methods to prevent lead-shedding corrosion in as many as 18,000 service lines stretching from the water main into dwellings.

"As environmental engineers widely acknowledge, our understanding of the complexities around pipe corrosion and the release of metals continues to evolve. And so must our treatments," says **Taha Marhaba**, chairman of NJIT's Department of Civil and Environmental Engineering and a specialist in analytical techniques for pollution detection. "Our team of faculty and students is developing a real-time picture of Newark's water system, in which variable water quality conditions affect the release of lead, and optimizing treatments for this dynamic environment."

Lead in pipes can become soluble and transportable if oxidized by flowing water, particularly in aging infrastructure. For 25 years, corrosion prevention in the city's largest service area, which draws water from reservoirs in the Pequannock River system, consisted of injecting a chemical, silicate, into the water supply. It formed a protective layer of material over the interior surface of the pipe to prevent lead from mobilizing. But testing determined that silicate was no longer effective.

Using X-ray diffraction analysis, the NJIT team assessed the composition of the corrosion in a service line and found that in addition to elemental lead, lead oxides were the compounds most present in the pipe scales. Scanning electron microscopy revealed iron, aluminum, silicon, magnesium and calcium deposits.

"With the introduction of new sources of water, conditions changed. Water quality, including pH, temperature, and organic and inorganic material in runoff, plays a big role in the effectiveness of anti-corrosives," says **Lucia Rodriguez-Freire**, an assistant professor of environmental engineering who studies the transformation of contaminants and their migration pathways.

With a team of graduate students, she launched a study this past summer of excavated service lines to determine the effectiveness of a new corrosion-control chemical with an affinity for metal surfaces, orthophosphate, which was introduced into the water system last May. While widely used as a corrosion inhibitor in other water systems, successfully stabilizing lead, its introduction is not in and of itself an optimal solution, the researchers say.

"Because every water system is different, we have to take other factors into account, such as chemicals in the water, varying seasonal temperatures and weather conditions that can increase runoff," notes Rodriguez-Freire. "Surface water quality is complex and dynamic. Our research in Newark is giving us a better understanding of how seasonal changes can affect water composition and quality."

"Ultimately, we will try to pinpoint the best treatment strategies as water conditions

Newark Mayor Ras Baraka (second from right) announces plans to replace thousands of lead-based pipes that feed drinking water into city homes. Lucia Rodriguez-Freire, an assistant professor of environmental engineering at NJIT, and Taha Marhaba, chairman of NJIT's Department of Civil and Environmental Engineering (to his left), are working with the city and David Smith of contractor CDM Smith (far right) to prevent the heavy metal from leaching while the project is underway.

Photo: Tracey Regan

change. We can study how environmental factors such as pH and temperature affect lead-leaching kinetics under variable doses of orthophosphate in water," adds **Wen Zhang**, another member of the team, who develops water treatment technologies such as chemically reactive membrane filtration systems. The NJIT team is working with the city's consultant, engineering and construction firm, CDM Smith, on the pipe analysis and corrosion control.

In January, the team set up a lab on campus to continue testing for the presence of lead in excavated pipes and to determine how well orthophosphate is building up in the service lines to block corrosion, an electrochemical process. Team members traveled last fall for training at the EPA's Office for Research and Development in Cincinnati, currently the only lab in the country to perform these tests. They are receiving requests from other cities in New Jersey concerned about lead in their drinking water from aging infrastructure.

The engineers also will determine whether the chemicals should be injected at different points in the distribution system other than at the water treatment plant. We need to optimize treatment distribution as well," Marhaba notes.

Following training and certification this fall by inspection professionals, NJIT undergraduate and graduate students will evaluate pipe replacements to make sure they are being done correctly.

Lead in drinking water is associated with serious health effects in people, especially children, causing damage to the central and peripheral nervous system, learning disabilities, shorter stature, impaired hearing, and impaired formation and function of blood cells, the team notes. The EPA's goal is to eliminate it from drinking water entirely.

Environmental engineer Lucia Rodriguez-Freire studies how contaminants from the 500-acre Ringwood Mines/Landfill Superfund Site in the New Jersey Highlands move through the region's wetlands, accumulating in water, sediment and plants, and how they interact and alter each other. Pollutants from the sprawling site have been found at high concentrations in the neighboring lands of the Ramapough Lenape Nation Turtle Clan, longtime hunters and foragers in the area.

Photo: Lucia Rodriguez-Freire team

In announcing the program last year, Newark Mayor Ras Baraka said, "As an older, urban community, Newark has outdated lead service lines, and we look forward to modernizing our infrastructure and reducing risk for Newark's families."

Stabilizing a Superfund Site in the Pristine Highlands

In a northern section of New Jersey's forested Highlands, a protected region that supplies a third of the state's potable water, sits the 500-acre Ringwood Mines/Landfill Superfund Site, a stretch of land scarred by abandoned pits and mineshafts, open waste dumps and a shuttered industrial landfill. Pollutants from the sprawling site have been found at high concentrations in the neighboring lands of the Ramapough Lenape Nation Turtle Clan. A wire fence separates them.

With a grant from the U.S. Geological Survey, environmental engineer **Lucia Rodriguez-Freire** is studying how contaminants from the site, a mix of organic pollutants such as benzene and 1-4 dioxane, heavy metals and a class of chemicals known as PFAS, move through the region's wetlands and accumulate in the water, sediment and plants.

"Additionally, we want to know how those industrial chemicals interact with one another and the microorganisms in the soil, and how they alter each other. Plant roots, for example, secrete polysaccharides that enhance microbial activity that transforms metals, affecting their bioavailability," says Rodriguez-Freire, director of NJIT's Laboratory of Applied Biogeochemistry for Environmental Sustainability.

In addition to holistic environmental testing, she is conducting a series of lab experiments to study the way pollutants are absorbed and degraded by plants.

"Ultimately, we want to come up with mechanisms that transform contaminants to prevent their mobilization, or enhance their plant uptake. Our objective is to minimize human and animal exposure," says Rodriguez-Freire, who has developed novel processes to extract and stabilize metals at abandoned mining sites in the Rocky Mountains.

"In some cases, we might want the plants to absorb the pollutants — and then we'd remove them. With other vegetation, particularly if it's eaten by people or animals, we'd want to prevent uptake," she says. "It's possible to treat the soil by adding compounds that stop heavy metals from moving, like calcium or compost, or introducing compounds that promote plant uptake, such as citrate or the synthetic chemical EDTA, which bind with ions, making them more soluble and mobile, thus more readily taken in by plants."

In Xavante Territory, the Researched Recruit the Researchers

Rosanna Dent
Assistant Professor, Federated History

Every year, with the dry season, come the researchers. They arrive with audio recorders, microscopes and glucose meters. They bring backpacks filled with GPS recorders, cameras and field notebooks. They ask endless streams of questions about how to live in the Cerrado of Central Brazil. The Xavante community members who receive and host us are long accustomed to these visits.

My scholarship on the history of research in Xavante territory asks: What would it be like to be studied again and again? Why would a community consent to host sometimes-hapless outsiders year after year? What I find is that, over time, indigenous subjects have developed creative strategies for engaging and directing researchers and our resources. They have learned to capitalize, when possible, on the potential of our presence to help address the dire political, cultural and health implications of colonialism. It is a precarious strategy, as peddling soft influence is far from foolproof, but over time Xavante villagers have learned to influence their researchers, drawing us in unexpected directions and changing our fields of study.

Non-Xavante scholars have been traveling to the Indigenous Territories of Pimentel Barbosa and Wedezé since the 1950s. The first anthropologist, David Mayberry-Lewis, arrived shortly after the community there accepted diplomatic relations with the Brazilian government. He appeared in the wake of a violent and continuing process of "pacification," implemented by the federal government to open up the Brazilian interior to colonization and agricultural production. Brazilian expansionism was an ambitious project, predicated on the elimination — through assimilation, disease, informal violence or extreme containment — of the hundreds of indigenous groups who claimed and continue to claim the territory as their own. So-called pacification also opened paths for those interested in extracting knowledge from the cultural, linguistic and biological human diversity that indigenous peoples hold.

Building on Mayberry-Lewis's first accounts of Xavante society, a stream of academics followed. They hailed from across the disciplines of health and human sciences. They turned their attention to Xavante genes, bodies, culture and language, convinced their studies of an indigenous group they saw as "more natural" could reveal universal laws about being human. In the 1960s, Wedezé village hosted geneticists as they developed an interdisciplinary methodology for human genetics research that would be replicated around the globe. The 1970s and 1980s brought anthropologists who used ecological and sociolinguistic approaches to human societies to contest portrayals of indigenous societies as self-contained social systems, insulated from colonial impact. Public health researchers followed, elucidating mechanisms of infectious disease and providing the most comprehensive studies of social determinants of health in lowland South American indigenous societies.

But as the scholars arrived to observe, their subjects were also becoming experts in research — perhaps more specifically in researchers. Attentive to scholars' interests and habits, villagers began to construct their own ideas of scholarship. They considered what it was that set this brand of outsider apart from the government officials, missionaries, neighboring ranchers and even tourists who often visited. Leaders, embroiled in long and tiring political struggles to protect their lands, started to see visiting scholars as potential allies. They began to make political demands. They began to recruit their own researchers.

I, too, was willingly recruited. I first made the trip to the nearby town of Água Boa, Mato Grosso in 2014, to meet with a group of leaders from the village of Pimentel Barbosa. I had been studying the Xavante's scientists, tracking their correspondence with one another, examining their transnational and transdisciplinary collaborations. I was hesitant to engage directly with the communities they studied. There is too long a history of Western scholars objectifying indigenous people. Their scholarship often failed to benefit the people they studied. But evidence mounted that Xavante leaders and community members actively cultivate their relationships with those who study them. Far from passive participants, over time they have learned strategies to direct their academic visitors to projects that better — though not always — serve their interests.

Top/Middle: Historian of Science Rosanna Dent discusses her ongoing work reassembling the dispersed archive of research on the Xavante community in separate sessions with the men and women of the village. She and her collaborators are recovering and digitizing photographs, audio recordings, publications and other documentation of Xavante families, social life and the territories of Pimentel Barbosa and Wedezé.

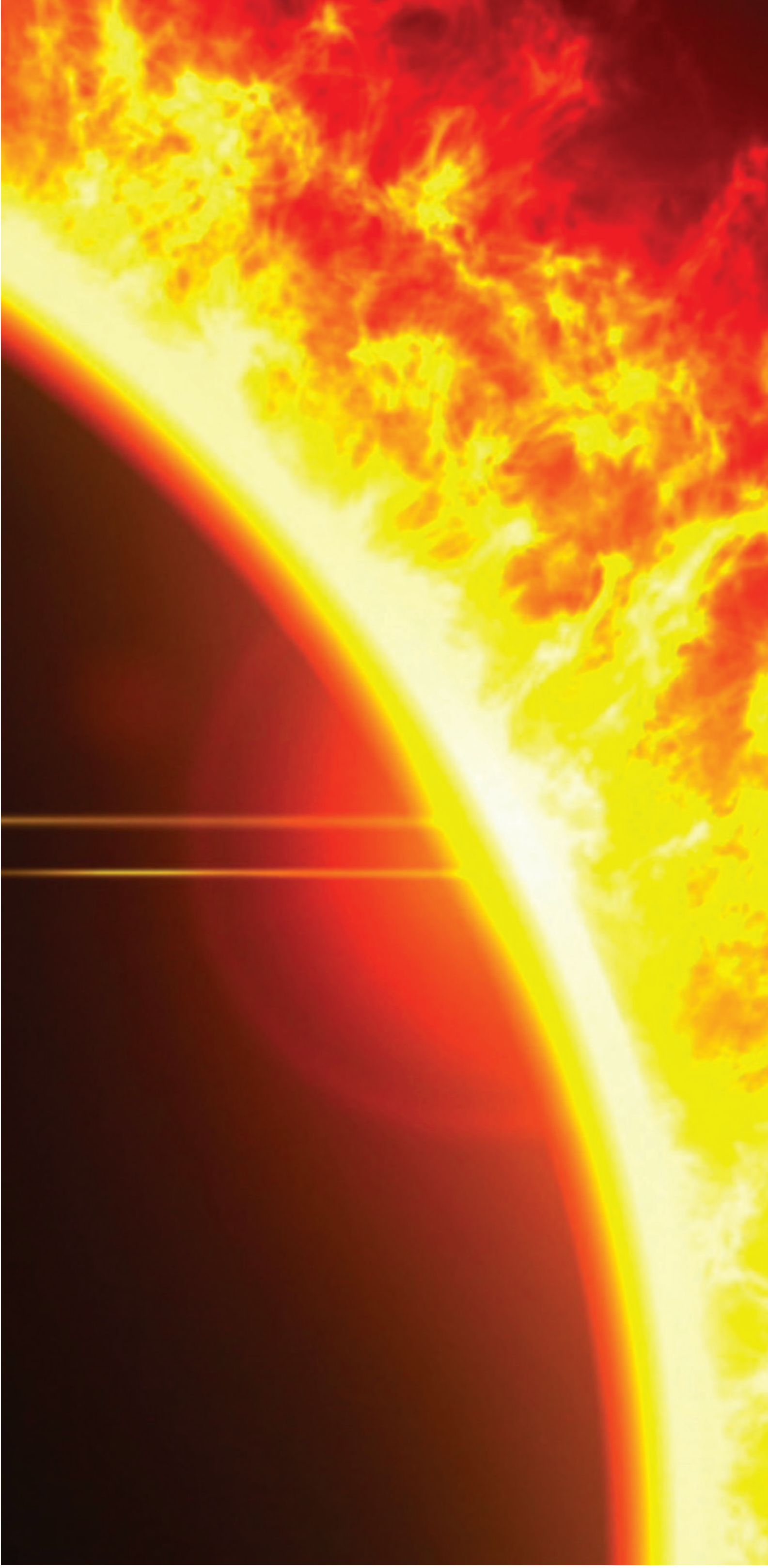
Bottom/left to right: Researchers Rosanna Dent, José Rodolfo Mendonça de Lucena, James R. Welch and Caio Bibiani in Xavante territory in Central Brazil during the 30-day spiritual initiation ritual, *darini*, that takes place every 15 years. Welch and Bibiani are painted because they were participating that day, respectively, as a spiritual guard (*dama'ai'a'wa*) and a spiritual singer (*zö'ra'si'wa*).

Photo/top: Romeu Xavante
Photo/middle: Lincoln Dure'we Xavante
Photo/bottom: Mauricio Oliveira

In Água Boa, I asked them if and how my work might be of interest to them. They spoke of their desire to access the research that had been done about them. "I want to learn about researchers' work through our conversation, through you," leader Tsuptó Buprewen Wa'iri Xavante told me. "You can access this material. As [the elders] said, they think this work is important." My interest in understanding their experience of research — the conflict, hope, disappointments and close personal relationships at the undocumented core of human subjects research — suddenly became a resource for them to recover the materials that outsiders had collected about them over decades of visits.

My ongoing work, in collaboration with colleagues from three Xavante villages and academic institutions in Brazil and the United States, is reassembling the dispersed archive of research. We are recuperating and digitizing photographs, audio recordings, publications and other documentation of Xavante families, social life and the territories of Pimentel Barbosa and Wedezé. Village residents are reunited, sometimes for the first time, with images of their grandparents or other loved ones who have passed away. Elders are narrating Xavante history not only for their grandchildren or for a single curious anthropologist, but for digital recordings that will link and annotate historical images with the histories Xavante want to tell.

Watching a Solar Flare Unfold, Moment by Moment, in a Decade of Pictures



In the lower reaches of the corona, the Sun's fiery atmosphere, small-scale magnetic fields break apart and form new connections in the already stressed magnetic environment prior to a solar flare. Driven by motions in the photosphere (the star's surface), bundles of rope-like magnetic fields rotate and twist around a common axis in the colorful chromosphere just above it, before erupting. As the flare explodes in the energy-dense corona, it sets sunspots on the surface spinning faster. As the flare's bright ribbons cross the sunspot, they are followed by a coronal rain of plasma that condenses in the cooling phase shortly after eruption, showering the visible surface of the Sun where it lands in brilliant explosions.

NJIT'S BIG BEAR SOLAR OBSERVATORY

sits at the end of a 1,000-foot causeway that juts deep into California's Big Bear Lake, and at an elevation of well over a mile. The lake waters absorb the Sun's heat, reducing the ground level turbulence caused by rising heat, and the typically cloudless sky invites viewing on an average of 286 days a year.

After NJIT took over operation of the observatory from Caltech, university scientists decided to replace its 65-centimeter telescope with one two-and-a-half times that size. It took seven years to build and received first light in 2009. Its unique off-axis optical configuration, with no hole in the center of its mirror, optimizes the number of photons it collects and constrains light dispersion to sharpen the contrast in its images.

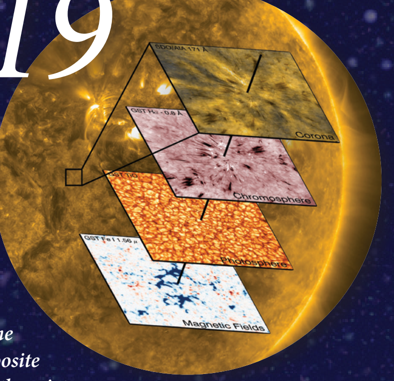
Not only did they create the largest solar telescope in the world at 1.6 meters, they spent the next decade fitting it with unique instruments that provide unprecedented high-resolution observations — free from atmospheric turbulence — that reveal fine features of sunspots, filaments, jets and flares as they unfold in near real time. By also capturing light in the infrared and neighboring regions of the spectrum, they are able to precisely measure magnetic fields.

What drove this ambitious modernization was impatience to move ahead on fundamental investigations of solar physics: the evolution of solar eruptions such as flares and coronal mass ejections, the mechanisms that heat the Sun's corona and particle acceleration in the solar wind.

On a practical level, they sought to further our understanding of space weather — the powerful bursts of electromagnetic radiation, energetic charged particles and magnetized plasma from the Sun with their power to disrupt engineered systems on Earth and in space — and to predict it.

Photos: Courtesy of BBSO

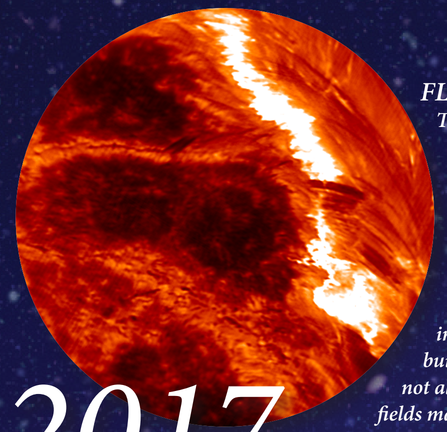
2019



SOLAR SPICULES

How energy from the Sun is transferred to the star's upper atmosphere, heating it to 1 million degrees Fahrenheit and higher – temperatures that are vastly hotter than the surface – is a central mystery of solar physics. Recent images detail one likely mechanism: jets of magnetized plasma known as spicules that erupt continuously across the Sun's expanse and travel at speeds of around 100 kilometers per second, in some cases into the corona. "When magnetic fields with opposite polarities reconnect in the Sun's lower atmosphere, these jets of plasma are powerfully ejected," says solar physicist **Wenda Cao**, *the director of Big Bear Solar Observatory.*

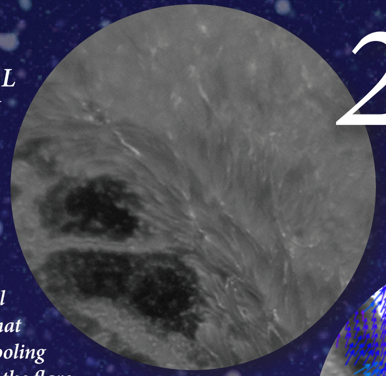
2017



FLARE TRIGGERS

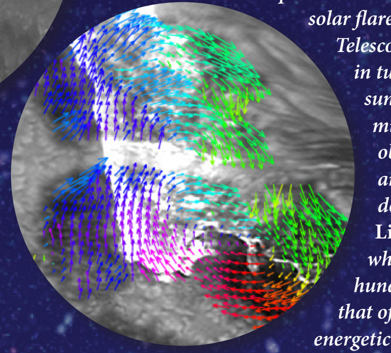
The emergence of small-scale magnetic fields in the lower reaches of the corona, which break apart and form new connections in an already stressed magnetic environment, appear to be precursors, perhaps triggers even, of solar flares. While flares are generally believed to be powered by what is known as free energy – energy stored in the corona that is released by twisting magnetic fields – an international team led by NJIT suggested that the buildup of coronal energy in the upper atmosphere may not alone be sufficient. A strong twist in the fine magnetic fields may create the instability to start the eruption.

CORONAL RAIN



A recent solar flare, with its bright flare ribbons seen crossing a sunspot, is followed by coronal rain – plasma that condenses in the cooling phase shortly after the flare, showering the visible surface of the Sun where it lands in brilliant explosions. The images show how energy is transferred from one region of the Sun to another during flares, says research professor **Ju Jing**, *in this case "from the corona where it has been stored to the lower chromosphere tens of thousands of miles below it, where most of the energy is finally converted into heat and radiated away."*

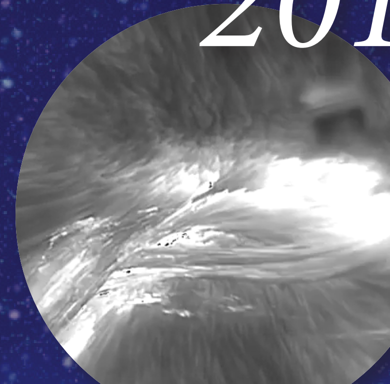
2016



WAGGING THE PHOTOSPHERIC DOG

The turning motion of sunspots, concentrations of magnetic fields on the Sun's surface, or photosphere, causes energy to build up that is released in the corona in the form of solar flares. Images from the Goode Solar Telescope revealed a surprise: Flares, in turn, have a powerful impact on sunspots, causing them to rotate at much faster speeds than are usually observed before they erupt. "It's analogous to the tail wagging the dog," says research professor **Chang Liu**, *in noting that the corona, which has a plasma density about a hundred million times smaller than that of the photosphere, is "much less energetic and forceful."*

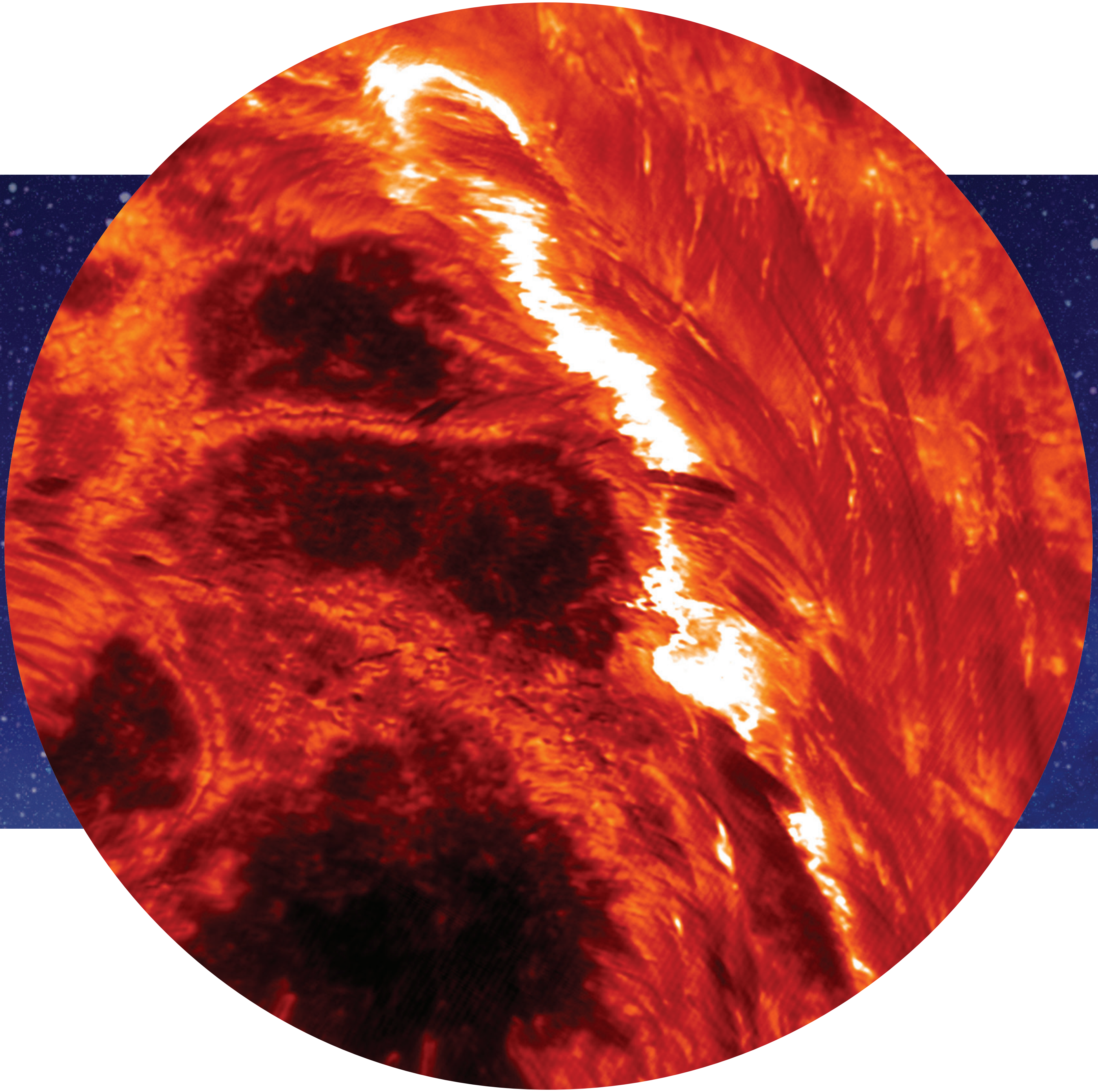
2015



SOLAR FLUX ROPES

Bundles of magnetic fields that together rotate and twist around a common axis, called solar flux ropes, are captured for the first time at their point of origin in the chromosphere. These unprecedented images trace the formation of an S-shaped bundle from which a set of loops peel off and grow upward into a multistrand flux rope within a few minutes. NJIT scientists can now distinguish between mild twists and those severe enough to cause space weather, notes **Haimin Wang**, *director of NJIT's Institute for Space Weather Sciences, who likened the eruptions to the energy release following the buildup of tension between tectonic plates.*

discoveries



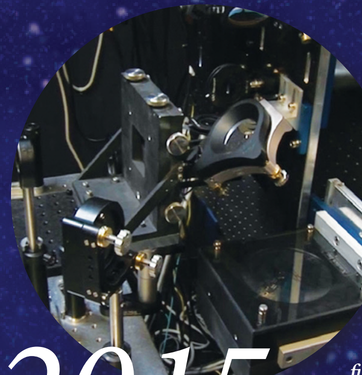
instruments

2017

MULTI-CONJUGATE ADAPTIVE OPTICS

The multi-conjugate adaptive optics device, which sits downstream of the aperture of the telescope, is a groundbreaking new method developed by NJIT to correct images of the Sun distorted by multiple layers of atmospheric turbulence. It provides scientists with the most precisely detailed, real-time pictures to date of solar activity occurring across vast stretches of the star's surface. The Goode Solar Telescope now produces simultaneous images, for example, of massive explosions such as solar flares and coronal mass ejections that are occurring at approximately the same time across large structures such as a 20,000-mile-wide sunspot in the Sun's photosphere.

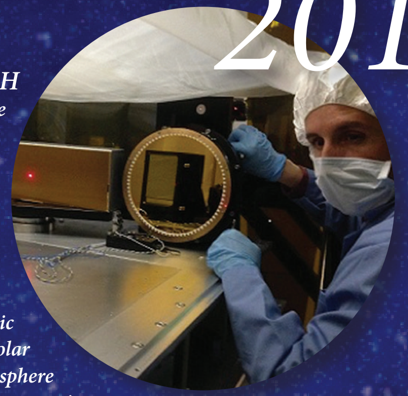
2015



NEAR-INFRARED IMAGING SPECTROPOLARIMETER

Now in its second generation, the near-infrared imaging spectropolarimeter images the magnetic fields of the lower solar atmosphere, spanning from the photosphere to the base of the corona. Each image is recorded in the near-infrared portion of the electromagnetic spectrum, a region beyond what the human eye can see, spanning from 1.0-1.7 microns. The instrument provides the best current diagnostics of upper chromospheric magnetic fields that enable mapping of the vector field at the base of the solar corona.

2013



CRYOGENIC SOLAR SPECTROGRAPH

Cryogenic solar spectrograph (CYRA) focuses on the near-infrared solar spectrum between 1 and 5 microns, an unexplored region which is not only fertile ground for photospheric magnetic diagnostics, but also provides a unique window into the chromosphere lying atop the photosphere. It is the first fully cryogenic spectrograph in any solar observatory. Used to probe magnetic fields in various solar features as well as the quiet photosphere, CYRA provides 3D extrapolations of the solar magnetic field and more accurate boundary conditions for solar activity models. Its enhanced observations of the chromosphere in the carbon monoxide spectral bands yield a more precise understanding of energy transport in the solar atmosphere.

2011

VISIBLE IMAGING SPECTROMETER

The visible imaging spectrometer (VIS) provides high-resolution observations in the same portion of the electromagnetic spectrum as the human eye, or the visible wavelength range. With the use of Big Bear Solar Observatory's adaptive optics system, the instrument observes fine-scale structures on the surface of the Sun that match the natural limitations of nature. VIS has generated unprecedented observations of small-scale magnetic processes on the Sun, including the evolution of fine structures in sunspots. **Wenda Cao**, *the observatory's director, is now working with his team on a second generation VIS instrument that will broaden the instrument's spectral and spatial fields of view.*

Model Cars With Human Drivers Take to the Streets of a Miniaturized Newark

In a robotics lab spilling over with 3D-printed parts, engineering students are gutting toy trucks, SUVs, sedans and two-door Mini Coopers and refitting them with custom-designed systems: laser-cut side mirrors, wheels that can parallel park and a braking system that employs algorithms to control an electric motor, thus enabling soft and hard breaking, idling and taxiing.

Now tooling around **Cong Wang**'s Control Automation Robotics Lab, where they are guided by remote drivers at gaming-style steering wheel and pedal control stations, the cars will soon be deployed on the streets of a miniaturized Newark, N.J., where they will share the right of way with autonomous cars controlled by computers and remotely operated pedestrians. Three tiny video cameras, facing in different directions, sit in the driver position of each remotely steered car and a LIDAR scanning range finder spins on the roof to continuously survey the surroundings so drivers can respond to conditions on the road.

The model city, with its signalized intersections, access ramps and mix of roads and highways, is a novel assessment platform designed by **Jo Young Lee**, an associate professor of civil engineering, to evaluate the impacts of connected and automated vehicles (CAVs) on drivers, passengers in autonomous cars and pedestrians. Through crowdsourced experiments conducted over the internet, test participants will play each of these parts using virtual reality interfaces so that Lee and his collaborators, including Wang, an assistant professor of electrical and computer engineering, and **Guiling "Grace" Wang**, a professor of computer science, can evaluate their responses.

"Autonomous cars pose challenges since they are programmed to respond to general rules of the road, while drivers and pedestrians don't strictly follow them," notes **Nishaant Goswamy**, a junior majoring in computer engineering who spent last summer in Cong Wang's lab working on the camera vision system, among other automotive elements.

"Sometimes people change lanes without signaling or don't come to a complete stop at a stop sign. Pedestrians jaywalk and may expect drivers to stop for them," he adds. "Using this platform, we will study the drivers' responses to complicated driving situations, including the number of lane changes they make, the driving distance between the cars, and obedience to traffic laws such as stop, yield and speed limit signs."

While the goal of CAV technology is to make driving safer and more efficient, there is still little information on human responses to these cars, team members say. Without understanding their sense of safety and comfort, as well as their physical reactions, such as steering and braking, it will be difficult to deploy them on the road.

Existing evaluations depend heavily on computer simulations, which researchers say can't fully capture reactions. Using crowdsourced cyber-physical reality, which relies on visual and force feedback from human subjects, they aim to create a more realistic test. They will measure behavioral reactions, such as steering maneuvers and acceleration or deceleration, and are developing methods to assess emotional responses such as safety awareness and degree of comfort.

Photo right: (left to right) Carlos Maranon, Zarin Rahman, Nishaant Goswamy and Alexis Brice developed automotive systems for a fleet of toy vehicles (photo left) that will drive on the streets of a miniaturized Newark, N.J., in an experiment designed to evaluate the impacts of connected and automated vehicles on drivers, passengers in autonomous cars and pedestrians.

Photo/left: Deric Raymond
Photo/right: Oscar Masciandaro

For the students, the challenge is to create sophisticated systems that mimic a real driving experience that will fit into cars as small as 9 inches long. Many of their efforts went through several iterations. Before arriving at the three-camera system, for example, Goswamy says he helped design a prototype of a camera placed at the focal point of a cone mirror that would reflect a 360-degree circular image of the car's surroundings. He then used algorithms to unwrap the image into a distortion-free, wide-scale panoramic view that would display the front windshield, side views and back windshield.

"This was a novel achievement, because we had to 3D-print the cone-shape mirror and develop new algorithms to undistort the image to adjust it to the scale of the car," he says. Ultimately, they decided not to use it, however. While using one camera allowed them to capture images speedily, the picture was ultimately too distorted. They had to develop special image-compression methods for the three-camera replacement to speed up the streaming.

"For the LIDAR, we had to create the smallest device possible and it took us three generations," says **Carlos Maranon**, a sophomore majoring in electrical engineering who helped design and program it. He also coded the vehicle's feedback system so that data it collected — speed, LIDAR position, distance readings and camera feedback — would appear as a graph on the main display screen viewed by the remote driver.

Wang's students are currently working on an onboard GPS tracking unit.

"This project is highly interdisciplinary; it draws on skills from several different areas, such as transportation engineering, computing, networking and robotics," he notes. "The students are very creative and willing to try out a lot of different ideas. They don't all work, but even the failures help us move ahead. They also come up with some quite novel ideas that inspire the team and become part of the design."

Meet Samantha Lomuscio: Cosmic Gamma-Ray Hunter

Exploring remote, exotic locations is a long-standing tradition among college students. For applied physics major **Samantha Lomuscio** '20, that destination is Jupiter, nearly 390 million miles away.

Working with an astrophysicist at the American Museum of Natural History (AMNH), where she conducted high-energy astrophysics research last summer, her goal is to detect the solar system's largest planet in a way that has never been done successfully — through gamma-ray emissions.

With a billion times the energy of visible light, these emissions reveal phenomena from supernova explosions, solar flares, merging neutron stars, supermassive black holes and cosmic rays. She chose Jupiter because its magnetic field structure is similar to red dwarf stars, which are capable of hosting planets that potentially support life.

"Ideally, we'd directly study how the dynamics of gamma-ray emissions and the intense magnetic fields of these stars might affect or pose threats to this possibility, but these stars are too far away, so we turned to Jupiter," Lomuscio explains.

Stretching nearly 30 million kilometers wide, Jupiter's magnetosphere is strong enough to trap and accelerate charged particles within its field, producing belts of radiation thousands of times stronger than Earth's Van Allen belts. Streams of high-energy particles accelerated to almost the speed of light, known as cosmic rays, propagate within Jupiter's magnetosphere and interact with the gas-rich atmosphere of the planet, creating nuclear reactions that generate gamma rays. Jupiter's nearest moon, Io, spits out ions that create a ring of charged particles around the planet.

Under the mentorship of Timothy Paglione, a professor of physics and astronomy at York College/CUNY and resident research associate at AMNH, she obtained nine years of gamma ray emission data recorded by NASA's Fermi Gamma-ray Space Telescope (Fermi) — an international space observatory that images high-energy particles. She quickly discovered an obstacle.

"As time passes, Jupiter appears to traverse the sky. … The Fermi telescope generates an all-sky image that captures photon counts every three hours, but it was not designed to track an individual object as it moves over time," says Lomuscio. "Also, in its transit, Jupiter crosses paths with the Galactic plane, the Sun, the moon and a few other strong gamma-ray sources that completely drown out a potential source to detect from Jupiter."

To resolve the problem, she developed a Python routine to generate the coordinates of any solar system object as defined in NASA's Jet Propulsion Laboratory's library, syncing that with Fermi's all-sky image data. She also programmed a filter that excluded gamma-ray data when Jupiter was near a bright gamma-ray source, such as the sun.

"We are still trying to detect a clear congregation of photons at Jupiter, which would indicate a gamma-ray source. So far, we've been able to successfully use our routine with Fermi to track gamma-ray signatures that follow Jupiter's coordinates each day over a nine-year period," explains Lomuscio. "We haven't received a clear detection yet due to the very bright sources behind Jupiter, so we are modifying our tracking routine to essentially filter out the nine-year gamma-ray record from Jupiter's background."

At the American Museum of Natural History, Samantha Lomuscio is conducting one of the most extensive high-energy observations of Jupiter attempted yet.

Photo: Oscar Masciandaro
Jupiter Photo: Courtesy of NASA

An Amputee Acquires a Prosthetic Finger From a Capstone Team

Photo: Deric Raymond

Photo: Tracey Regan

Ricardo Garcia and Madison Taylor (left) hold the prosthetic finger they developed for their senior capstone project last year for Adam Zanellato (right) who lost his index finger while sawing.

After a table saw severed the top of his right index finger, Adam Zanellato, a 20-year-old cabinet-maker at the time, had to relearn basic hand maneuvers such as how to write and hold a fork. There were no affordable prosthetics on the market to help him regain dexterity. Several years later, he still found it hard to pick up coins from a table.

A year and a half ago, he decided to restart his search and began by contacting a friend in medical school for leads. The woman, an NJIT graduate, made this recommendation: present his dilema as a research project to students in the university's biomedical engineering department, which has a strong focus on rehabilitation. She contacted **Sergei Adamovich**, director of NJIT's Center for Rehabilitation Robotics, who agreed to supervise a team with the help of **Ashley Mont**, a third-year Ph.D. student who specializes in robotic exoskeletons.

A team of four — **Ricardo Garcia**, **Ashe Pignataro**, **Madison Taylor** and **Giovanna Nolan** — quickly agreed to make it their senior capstone project and promised Zanellato that they would build him a prosthetic finger.

"With our specialized technologies and printing capabilities, the possibilities for design and customization are endless," Mont notes, adding, "I had worked with each of these students and knew that if any team of undergraduates could succeed, they could."

"This was not a theoretical exercise. We wanted to make sure our prosthetic was functional — that Adam was able to grip with strength and dexterity, hold utensils and even some tools, while also being able to lift small objects," says Garcia, the project leader, adding that the team submitted their project for review by the university's Institutional Review Board to develop a legal framework for where and how the device could be used. Four visits to campus and 10 prototypes later, Zanellato now wears it at home for simple tasks.

Their finger, which features an artificial interphalangeal (hinge) joint system, uses the force generated by the remaining part of the finger to power it, thus mimicking normal finger flexion and extension. To make it affordable, they developed a method for manufacturing it with a 3D printer, using strong but inexpensive materials.

"In terms of design, a key challenge was making sure that it could be easily reproduced if damaged by simply reprinting a part," Taylor notes.

Their goal was to make the device look more and more like a finger without sacrificing the mechanics, while they said that every tweak to the geometry had a story behind it. When it pinched, they added a curve.

Their invention won first prize in the university's undergraduate TechQuest Challenge on Innovation Day last year. It has since acquired a name — The DeXter — and a professional description: "a body-powered finger prosthetic for subjects with amputations distal to the proximal interphalangeal joint." The team recently filed a patent on their invention through NJIT and is seeking to commercialize it.

"It's very unusual that students have the chance to design a prosthetic for a specific person," Adamovich says, "but that's what made this project so exciting."

Research at NJIT: By the Numbers

R1
Carnegie Classification® of Institutions of Higher Education research ranking

115
research institutes, centers and laboratories

3
space missions in 2020 containing NJIT research instruments

24
NJIT instruments in Antarctica

130
undergraduates on campus last summer working on funded research projects

50+
amber-encased prehistoric insect species in biologist Phillip Barden's lab

281
patents and intellectual property assets held by NJIT faculty

4,035
hours of 3D printing in NJIT's Makerspace in 2019

1
number of peaks in Antarctica named after Distinguished Research Professor of Physics Louis Lanzerotti

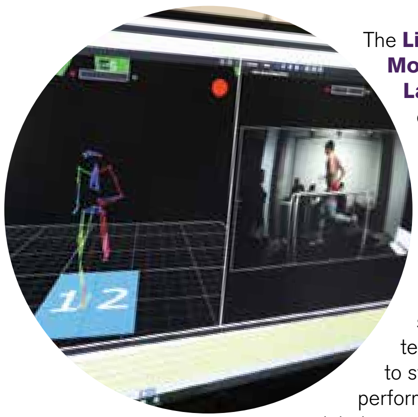
Since 2015:

76%
increase in external research funding

12
winners of National Science Foundation CAREER Awards

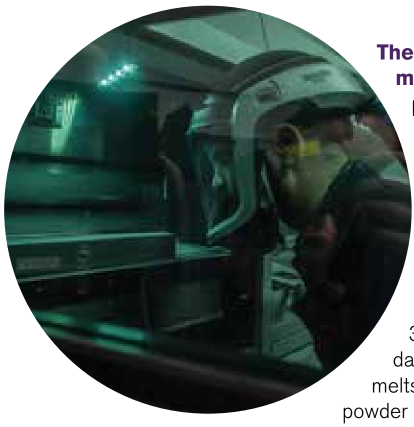
$3 MILLION
spent on undergraduate student research stipends

Wearing an Oculus Quest, with four cameras built into the headset that track the user's head and hand positions, middle and high school students enter the world of augmented and virtual reality educational experiences developed by faculty and students in the **NJIT MIXR Laboratory**, where they learn computational thinking, algorithms and binary math.



The **Life Sciences Motion Capture Lab** decodes the complexities of human movement using infrared cameras, an instrumented treadmill, electromyography and inertial sensors. This technology is used to study human performance, sports injuries, musculoskeletal disorders and the use of assistive devices, such as robotic exoskeletons, to improve human movement.

NJIT's recently opened **Microfabrication Innovation Center** houses equipment and a cleanroom environment for the fabrication of microelectronic, nanoelectronic and microfluidic devices and sensors. Its rooms are free of potentially contaminating particles larger than a micron; the highest-level cleanroom is limited to 100 1-micron particles in a cubic meter of air.



The EOS m280 metal 3D printer produces components by means of additive manufacturing – fully automatically, without tools and based directly on 3D CAD design data. Its fiber laser melts fine metal powder and the printer builds components – vehicle parts for student club teams and intricate device components for industrial partners – layer by layer.

The transmission electron microscope (TEM) sends a beam of electrons through objects to capture fine details of structures as tiny as atoms. Used by NJIT chemists, pharmaceutical engineers, materials scientists and others, the TEM elucidates structures of crystals, for example, which can be manipulated to alter material properties.

The seven-axis robot arm, IRB 4600, performs tasks ranging from picking-and-placing, milling, drawing and even three-dimensional printing. Architecture and design students are building attachments, or effectors, for the arm that have it sorting bricks by color and then stacking them accordingly with a pneumatic gripper.

Photos: Oscar Masciandaro/Oculus Quest, TEM, Robot Arm
Deric Raymond/Motion Capture Lab, Microfabrication Innovation Center, 3D Printer

NJIT Collaboration Raises Prehistoric Hell Ants to Life

One of the most fearsome-looking insects to crawl the Earth in the Late Cretaceous Period was surely "Vlad the Impaler" *(Linguamyrmex vladi)*, a long-extinct species of "hell ant" (haidomyrmecine) with scythe-like mandibles and a metal-reinforced horn on its forehead.

A team of evolutionary biologists led by NJIT's **Phillip Barden** discovered the ant and its unique head structure encased in Burmese amber from Kachin State, Myanmar, in 2017. They named it after the infamous Wallachian ruler from the 1400s that inspired Bram Stoker's Dracula, because they think it may have skewered its insect prey and consumed their hemolymph in vampire-like fashion.

What piqued their interest in particular, however, was the role Vlad's highly specialized horn may have played in the species' own extinction.

"*Linguamyrmex vladi* is a very visually striking example of extinction," says Barden, director of NJIT's Laboratory of Evolutionary Pattern and Process. "We believe the ant sequestered metals into its clypeal horn to prevent impaling itself as it punctured its prey. … However, we have evidence suggesting that some hell ants became increasingly specialized on specific prey that went extinct, meaning that once their prey underwent extinction, the hell ants would have had no way of 'backing out' of their adaptations to survive … like if you owned a business that invested every cent it had in beepers in the early 1990s."

The team was able to quickly gain insights into *Linguamyrmex vladi*, because, unlike many other types of fossils that are often highly partial, the insect fossil record, including more than 750 ant species, is often preserved almost entirely whole in amber.

"Amber can preserve the entire organism, sting to head, and we can then CT scan these fossils to create 3D reconstructions in high fidelity to learn more about the morphology and ecology of *Linguamyrmex vladi* and other extinct ants. Because they offer such a rich data set, we can compare what we find with the rest of the ant fossil record to hone in on features that lead to extinction."

Based on his work at NJIT and as a research associate at the American Museum of Natural History, Barden is leading a project to bring Vlad and its long-extinct relatives back to life, digitally of course. His research team is applying imaging and design technology to virtually reconstruct the ancient anatomy of the hell ant and its relatives — providing some of the first detailed, 3D models that illustrate how these long-lost insects used their distinct biological traits to become successful predators of their day.

"The fossil record for ants as social insects starts about 100 million years ago with Vlad and others, which featured elongated metal horns and a lot of bizarre adaptations we no longer see today," says Barden. "We lose this rich diversity around the end of the Cretaceous Period when nonavian dinosaurs began to drop out of existence. An overarching goal we are working toward is solving the puzzle of this massive extinction involving the earliest social insects. Our ability to visualize and assess this ancient diversity means that we are widening our sampling pool for understanding patterns involved in the evolution of life."

Barden's lab uses light microscopes and X-ray microcomputed tomography to gather details about the species' morphology and biomechanics. One of his collaborators, NJIT physicist **John Federici**, applies imaging technology relatively new to paleontology, called terahertz time-domain spectroscopy, to identify in submillimeter resolution elements of the ants' prehistoric environment and microhabitat that are locked within the amber.

"Amber is an amazing window into the past," Barden remarks. "Liquids and gas can be trapped inside, allowing us to ask questions about the atmospheric composition of the Earth 100 million years ago. The ants and other small organisms preserved inside are essentially frozen in time, containing physiological elements that reveal new details about ancient ecosystems or evolution on Earth more broadly."

Based on his work at NJIT and the American Museum of Natural History, evolutionary biologist Phillip Barden leads a collaboration to reconstruct ancient "hell ants" from the time of the dinosaurs, including one vampiric ant species with a penchant for feeding on its prey using mammoth-like mandibles and a blood-sucking horn.

Photos: Oscar Masciandaro

At NJIT's Idea Factory, architect **Martina Decker** led a team of industrial design students who used design software to digitally reconstruct the heads, antennae and jaw structures of hell ants based on image scans and photomicrographs taken of the fossils. The team then translated their designs into 3D-printed physical models — incorporating materials such as resin, silicone and other industrial products to create museum-quality casts that have since been showcased at the American Museum of Natural History and the Intrepid Sea, Air and Space Museum, both in New York City.

"Some fossils almost looked like they had been exploded into little bits and pieces within the amber, so there has been a constant back-and-forth between different types of media to build the models," Decker recounts.

Barden, meanwhile, continues to characterize a number of newly found ant species from the deposit site that yielded Vlad, as well as species from sites in India, the Dominican Republic and even here in New Jersey.

"We are describing a number of never-seen-before species, including one with bifurcated horns and serrated teeth that looks like it has a chain saw for a head. … It's unreal," says Barden. "There's a ton of amber material to analyze from these deposit sites, so there are more species coming and more models to make."

What Can Ants Tell Us About the Next Humanitarian Crisis?

Simon Garnier

Ant Photo: Courtesy of iStock/Chadked

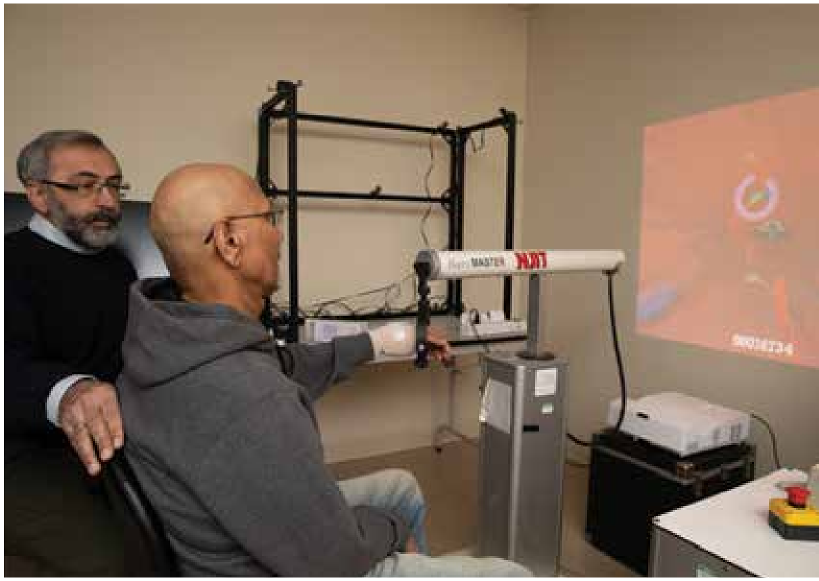
Biologist SIMON GARNIER, who explores the intelligent collective behavior of ants, or "swarm intelligence," believes there are few better model systems for understanding our migration dynamics than ant colonies, which organize in ways that share distinct similarities with human transportation networks, traffic organization and collective emergency responses. He's developing computational models that predict human mass migrations – driven by everything from famine caused by climate change to economic recessions.

"Ants migrate just as we do, based on disruptive environmental factors such as food shortages or threats from other colonies. They transmit a great deal of information and social feedback within the colony about the places they've visited, primarily via pheromones and tactile signals, which influence when and where migration will occur," says Garnier, an associate professor of biology and recipient of a 2019 Young Faculty Award from the Defense Advanced Research Projects Agency (DARPA).

In his SwarmLab, Garnier's team is introducing ant communities to a video-recorded environment of interconnected "habitat boxes," each with nesting and foraging areas, in which they will manipulate conditions, such as altering the nutrient content of food or habitat temperature. Using computer vision algorithms and deep neural networks, they will collect data on individual behavior and colony-wide social interactions as the ants migrate box-to-box in response to these stimuli. They will track the global state of the population and its distribution, as well as the status of each ant: its origin, the origins of ants it interacts with, its physiological state and its exposure to threat or other forms of danger.

Garnier will use the data to validate modeling approaches that best identify drivers of a mass migration, detect its onset and predict its outcome.

"Just as we use different models to predict the weekly weather from those to forecast climate change, we want to recommend appropriate models for predicting migrations during an event like Hurricane Katrina versus a conflict-driven migration from Syria," says Garnier. "In the long term, we want to model the complex dynamics of climate change-related migrations."



A Virtual Reality Workout for Stroke-Damaged Brains

Wearing a pair of 3D glasses, a woman sits before a large monitor in an acute rehabilitation therapy room, placing cups on shelves in a virtual kitchen. A robotic arm helps support her partially paralyzed arm, gently guiding the virtual hand that holds the cup when she misses the target.

It has been two weeks since Ruth Just, a registered nurse, had a stroke while she herself was caring for patients. She is surprised by how exhausting it is to play a simple virtual reality (VR) game that feels "like a cardiovascular workout." Eager to get back to work, however, she seized the opportunity to potentially improve her chances of regaining her strength and range of motion after a blood clot damaged the area of her brain that controls her right arm.

"By focusing on a task, and not on inabilities, I found I wanted to push myself. Playing a game tricks the brain into performing repetitive movements that might otherwise seem dull," says Just, who notes that she is now able to write "somewhat legibly."

She is one of 26 participants so far in a clinical trial run by **Sergei Adamovich**, director of NJIT's Center for Rehabilitation Robotics, that tests the efficacy of intensive training in the acute period following a stroke.

"We think intensive, hand-focused upper limb training shortly after a stroke may improve the recovery of both fine and gross motor skills. The timing and the intensity of the training in the first 5-60 days are important. What we're trying to determine is when and how much," he says of the National Institutes of Health-funded trial, for which he hopes to recruit nearly 100 more patients.

Despite the logistical challenges of conducting rehabilitative research in an acute care setting and the patients' own physical limitations, Adamovich views it as an opportune time. There is a limited period of heightened plasticity following a trauma, when the brain is working overtime to re-establish neural connections, between the "hand control" region of the cerebral cortex and the limb, that were damaged. "We are retraining the brain, as well as muscles and joints," he says.

By using haptic robots in VR gaming, he and his longtime collaborator, **Alma Merians**, chair of the Department of Rehabilitation and Movement Sciences at Rutgers University, deliver hand and arm training when patients' motion and strength are severely limited. The robots provide assistance so they can perform movements they might not otherwise be able to. The use of VR gaming motivates and engages them.

He and Merians are pioneers in the use of interactive virtual environments for upper extremity rehabilitation. They created their first VR therapies for stroke survivors and children with cerebral palsy nearly two decades ago and have developed a library of exercise games that subjects play with their arms and fingers while robots assist as needed. Easily adaptable to the needs of individuals, they also provide strong visual stimulation of the brain that may facilitate the recovery of brain areas responsible for these motions.

"The challenge is that hand movements do not recover

Photos/left: Oscar Masciandaro, right: Courtesy of NJIT

LEFT: To destroy spaceships in this virtual reality game, Thakur Singh, a patient recovering from a stroke in late December, must move his impaired arm into position and then squeeze a trigger. Sergei Adamovich, designer of the virtual reality-based therapy, looks on. RIGHT: By placing virtual cups on a three-level shelf, patients with stroke-damaged limbs regain fine and gross motor skills, but also help the brain re-establish neural connections between the "hand control" region of the cerebral cortex and the hand.

well due to the numerous muscles that need to work together very precisely," Adamovich says. "This fine control requires a large number of cortical cells working in synchrony."

In a virtual piano game, participants try to mimic a tune by moving the arm and the appropriate finger to move a virtual finger on the correct key. Success is determined, among other measures, by how much the player is able to move the finger relative to other fingers of the hemiparetic hand, and on whether the amount of flexion exceeds the threshold value defined by an adaptive algorithm that makes the game more or less difficult "on-the-fly," based on the individual's success rates. Adaptive algorithms also signal the robots to provide more or less assistance as needed depending on the person's progress, among other modifications. Thakur Singh, a highly skilled welder, said the exercises "keep my hand moving — wrist turning and thumb squeezing — like when I'm working."

While monitoring their patients' physical progress, Adamovich and his collaborators also study the underlying neural circuits engaged by their training and whether these circuits are also mediating training-induced recovery, and if their integrity can be used to predict the responsiveness to the VR therapy — that is, if the impact of the early intervention observed six months post-stroke can be predicted by the cortical reorganization evaluated immediately after the therapy.

By using transcranial magnetic stimulation on the area of the brain that controls the hand, they can measure how well the brain is connected to it and create a map of the motor cortex that shows which connections are the strongest. Through electroencephalography, they can also determine how well various brain areas are connected.

Adamovich notes, "My colleagues and I work on several projects that focus on more fundamental questions of how the brain controls body movements, both in neurologically healthy people and those with various motor disorders. To me, combining neuroengineering with clinical research is the most rewarding."

The Hunt for a More Precise Diagnosis and Treatment of ADHD

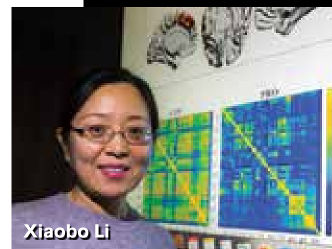


Photo: Deric Raymond

Believed to affect nearly 10% of children in the United States, attention-deficit/hyperactivity disorder (ADHD) is one of the most commonly diagnosed neurodevelopmental disorders. Clinical assessments are based on subjective measures, however, principally observations by parents and teachers of symptoms such as impulsive behavior, difficulty focusing and high frustration levels. To date, there are no quantitative measures.

XIAOBO LI, director of NJIT's Computational Neuroanatomy and Neuroinformatics Laboratory, is seeking a more precise diagnosis of the disorder by identifying and quantifying its biomarkers.

"Without definitive biological data we run the risk of misdiagnosing ADHD. It has been confused with autism spectrum disorder and anxiety in children, for example," Li notes. "If we misdiagnose it, then we can also mistreat it."

She collaborates with pediatricians and neuropsychologists for patient referrals, while her team collects all of the clinical, behavioral and neuroimaging measurements. She uses structural magnetic resonance imaging (MRI) to study the brain's anatomy and functional MRI to measure neural activity and interactions while children are paying attention and performing tasks.

"We've found both structural and functional deficits in the brains of children with ADHD," she says. "We see structural underdevelopment and functional alterations associated with the thalamus, including reduced gray matter volume, and its abnormal interactions with the frontal and occipital cortices."

What drew Li to ADHD research is her overarching interest in the brain itself, "the most complicated organism in the world," as she puts it. Rooted in computational analysis, she takes a quantitative approach to analyzing its disorders. She aims to fill in the gap of missing quantifiable biomarkers in the fields of neurobiology and neuroimaging by creating systematic models of these criteria that can aid in clinical diagnoses of cognitive deficits associated with an array of severe brain disorders, starting with ADHD.

"With today's medications and behavioral therapies, we're merely controlling the behaviors associated with ADHD. By targeting biomarkers, we'll tackle the underlying causes of the disorder and cure it."

The Idea Factory

The Idea Factory, which sprawls through several rooms of an old, retrofitted basement, with gadgets, electronic devices and materials stashed on tables and floors, is a place where laboratory research takes on shape and functionality. The office's treasure trove includes a multispectral camera that captures images in several wavelengths, fossilized prehistoric insects digitally reconstructed and translated into 3D-printed physical models, and a fleet of autonomous sensor robots for cave exploration.

Early on in her career, founder **Martina Decker**, an associate professor of architecture and design and the lab's director, became intrigued with materials science, creating walls that regulate sound level, hydrogels that boost plant growth and artificial muscles that can regulate thermal transfer in building skins. "What really gripped me was working with materials at nanoscale, and with my many collaborators, inventing new ones molecule by molecule."

The Idea Factory has broadened Decker's scope exponentially. She and her students collaborate with physicists, mechanical engineers, environmental scientists, biologists and others. "What we bring to the team are both insights into materials and a user-focused design process," she says. "Our job is to determine how we actually use these inventions and turn them into products."

Cave Bots

Exploring caves and tunnels is dark and often dangerous work. Some are too narrow, winding and deep for humans to enter at all. In partnership with physicist **John Federici's** AddLab, a team of engineers, industrial designers, computer scientists and physicists took on the challenge of exploring all-terrain, GPS-denied environments by creating a fleet of robots to navigate them. Their networked squadron centers around a box-shaped mothership that carries minibots under its top frame that it releases to reach places it can't access. Differently sized and outfitted with a variety of sensors, such as cameras and radioactivity detectors, the robots are programmed to communicate with each other and the operator through a mesh network. The team worked in subgroups under the guidance of Decker and the AddLab's **Sam Gatley** on pieces of the project: designing the mothership, building the minibots, programming the robotic fleet, creating sensor packages and enabling the mesh network. A "nerdbot" (network emergency repair dropbot) is dispatched to fix nodes in the network to restore communications. "You can't have a Swiss Army knife-type robot that would be responsible for all functions," as **Nicholas Warholak** '19 puts it. "The distributed approach drew on our creativity."

Seed Bombs

Composed of compost and seeds and encased within thin clay shells, Decker and her graduate student **Nahin Shah's** seed bombs come with their own automated sprinkler system in the form of hydrogel granules that absorb moisture from their surroundings, retain it and then release it over time. The polymers they chose are extremely hydrophilic, sucking in water and swelling up to 400 times their own weight. The original idea was to support plant growth in arid parts of the world, which are expanding as temperatures rise. Decker and Shah tested a variety of plants from different regions, including wheatgrass, onions and radishes. They were watered only at the start to simulate sparse rainfall. Beyond their ability to retain moisture, the hydrogels perform another important function — by swelling, they push the seeds farther apart from each other.

Biodigester

Globally, more than a third of the food produced goes to waste. In the United States alone, 33 billion pounds of food are jettisoned each year; most of it is tossed into landfills, where

it produces methane, a potent greenhouse gas. Composters do recover nutrients from their organic waste, but none of its energy. Decker and **Jay Meegoda**, an NJIT professor of environmental engineering, are designing a new generation of small anaerobic biodigesters, suitable for restaurants and cafeterias, that would produce both. Used in the agricultural sector and in wastewater treatment facilities to harness methane and carbon dioxide to generate power, the recovery of nutrients and energy from food waste is time-intensive (eight weeks or more), which has proved to be a barrier to more widespread adoption. They propose to cut that in half.

Martina Decker's Idea Factory is a place where laboratory research across disciplines, from prehistoric "hell ants," to cave-navigating robots, to biodigesters, takes on shape and functionality. "What we bring to the team are both insights into materials and a user-focused design process," Decker says. "Our job is to determine how we actually use these inventions and turn them into products."

Photos: Oscar Masciandaro

The slurry byproduct from their biodigester will be applied as compost to NJIT's landscaping, and the methane gas will be used in laboratory experiments. With further regulatory approval, they will refine their design with a pressure equalizer to connect the gas generated to the heating gas system. Decker's job is to convert Meegoda's technology into an accessible, and intriguing, appliance that people will use, starting on the NJIT campus.

Acoustic Tile

A soft robot, the acoustic tile modifies interior walls to manipulate sound. Composed of two layers of silicone connected to air pumps that are activated by a microcontroller, the device can change the surface of a wall from entirely flat to a more complex morphology, such as protruding air bubbles. The different surfaces influence the absorption, diffusion and reflection of sound — the flat surface can reflect sound better into the room while the soft bubbles absorb sound waves. The device could be programmed to respond to sensors or controlled by people to tune concert venues, for example.

The Future of Public Spaces in a Digital Culture

Gernot Riether

Since the debut of the printing press, information technology has transformed public spaces. Notably, access to free newspapers in coffee houses in the early 18th century prompted their proliferation as communications centers and cultural hubs in cities around the world. Nearly three centuries later, free Wi-Fi and laptops turned them into mobile offices. With smartphones, social and political organizers are able to swiftly summon up location-specific flash mobs and protest gatherings by hitting "send."

But it is the future role of information technology – as a force that purposefully shapes public spaces – that most concerns GERNOT RIETHER, director of NJIT's School of Architecture. He's keenly interested in its power to deepen our democracy.

"The way information technology reframes public spaces for a digital culture will depend on us," Riether notes.

In his recently published book "Urban Machines: Public Space in a Digital Culture," written with New York Institute of Technology's MARCELLA DEL SIGNORE, he describes public spaces in cities and towns as historically shaped by the tension between municipalities and economic forces. He asks, "But where is the citizen in these processes of creation?"

Equipped with IT (including programming and app development capabilities), data collected by cities from citizens and devices (on traffic management and transportation systems, among other services) and a free internet connection, anyone can be a planner.

In designing a piece of furniture for downtown Atlanta called "Urban Blanket" (see photo on inside back cover), Riether and his former students at Kennesaw State University "activated a public space in a car-centric city" and boldly created a new paradigm within it. Built from thin sheets of HI-MACS, a very strong material, their design was optimized for mobile device users with curves that cradle people of different sizes and access to Wi-Fi and charging stations. Able to accommodate 20 people, the undulating form also serves as a living room or office for larger groups. Atlanta's biking community has adopted it as a meeting space, as have people looking for an alfresco workout spot. Riether says he hopes to inspire more grassroots planning, noting, "If we don't do it, large corporations will."

Allocating Limited Resources for Megaprojects on Deadline

Photos: Oscar Masciandaro

For much of her career, **Oya Tukel**, dean of NJIT's Martin Tuchman School of Management and a professor of supply chain management, has researched problems in resource-constrained project scheduling that can cause significant delays, particularly for large, complex projects that require thousands of activities.

In developing a new product, think of how limited manpower and materials may negatively affect project scheduling and the production line, and, in turn, increase the time to reach the marketplace. In launching late, the product, along with the business behind it, may then face greater competition from other businesses with similar products and also miss the window of consumer interest.

Tukel has analyzed research findings since the 1950s concerning project management and scheduling, and the impact of limited resources across a range of industries. On the whole, she has found that resources have often been thought to be plentiful and available when they actually were not, and as a result, project managers have had to frequently abandon their production schedules.

Constrained resources are by definition not always available when needed. With human resources, for instance, while they are considered renewable — "Every day I'm here. I used my eight hours yesterday, but I have another eight hours today, so I'm a renewable resource," says Tukel — project activities can compete for them and conflict can ensue. "Human resources

Oya Tukel is expanding her ongoing research in resource-constrained project scheduling with an examination of how project manager performance affects project performance.

cannot be allocated to tasks simultaneously, so we need to determine which project task gets priority and is scheduled first," she notes.

"And then there are nonrenewable resources that you consume as the project progresses and you deplete eventually," she adds. Materials and money are prime examples.

To develop her own project scheduling algorithms, Tukel has reviewed commonly used project management software platforms, including Primavera and Microsoft Project. Her research yielded heuristic algorithms for creating feasible project schedules when there are tasks requiring resources that are limited. For example, one algorithm involved analyzing the order of task implementation and predicting whether delaying specific tasks to reduce or resolve resource conflicts would negatively affect project completion and, if so, by how much time. Through this process, the algorithm also evaluated all possible scheduling solutions and ascertained which one resulted in the shortest delay to finishing a project.

Using universally accepted data in this area representing resource-limited projects that managers typically face in real life — such as new product development and construction and information systems projects — Tukel then tested her algorithm and compared its performance with that of other heuristics. She found her algorithm improved resource allocation, leading to projects finishing earlier.

Recently, she has moved beyond project scheduling and limited-resource allocation to research other areas of managing projects that include how a business's culture and a project manager's background affect performance — which subsequently can have an impact on overall project efficiency and performance. For her study, Tukel solicited Fortune 500 companies to allow her to interview their project managers responsible for leading large, complex projects. With permission granted by one well-known corporation, and collaborating with faculty at The University of Memphis, she has crafted an extensive survey with mostly open-ended questions. These inquiries concern the project managers' job-related strengths, shortcomings and skills, as well as their career history and work engagement, and internal and external networking. She also includes scales rating vigor, dedication and absorption on the job.

To date, Tukel has recorded in-person interviews with approximately 20 of the company's project managers. She has begun analyzing the responses to identify similar terms, shared traits and other commonalities. She looks to determine correlations between these data points and project-manager performance, and ultimately project performance.

Many of the project managers "indicated that not having an industry certification like PMP (Project Management Professional) is something that bothers them. They feel they are not as good as their colleagues that do," she says of her early findings, noting that PMP certification, which is challenging and time-consuming, signifies possession of important competencies and a full body of knowledge in project management.

The results of her research on project-manager performance will be applicable to any project no matter the size, Tukel points out. She intends to report her discoveries both to the Fortune 500 company and in a paper to be submitted to a professional journal on project management.

Investigating the Investment Environment

While shares in foreign firms known as American depositary receipts (ADRs) can help diversify investors' portfolios and fetch high returns, they also pose risk in countries where protections for investors are limited and firms' information environments – the quality, quantity and timing of earnings releases – are unpredictable or opaque.

Finance researchers ZHIPENG (ALAN) YAN and XINYUAN (STACIE) TAO are examining how the stock-price activity of ADRs, which are traded in the U.S. financial market and denominated in U.S. dollars, reflect these uncertainties.

Using Thomson-Reuters' financial database, they developed a sample size of 44 developed and underdeveloped countries, and reviewed and summarized for each one the number of earnings announcements at a given number of firms over 22 years – focusing on the timing of release of these announcements to assess levels of information leakage, as measured by ADR stock-price volatility. They also aggregated World Bank data on governance indicators, including regulatory quality and rule of law.

One early finding: When earnings announcements are managed well, greater volatility occurs just around the announcement window. This signifies good governance, because it indicates information has not been leaked during the normal period. Among poorly governed countries, however, there is less difference between volatility within the event window and the normal period and even improvement in country governance does not benefit the information environment.

Data at the firm level paints another story. In well-governed countries, differences across firms do not matter much to ADR investors, because the overall information environment is good. "But for a country with poor management, it's the opposite," Tao, an assistant professor of finance, says. "The level of information leakage can vary greatly across firms, so investors need to do their research. Firm factors are more important than the country itself."

She and Yan are mining more evidence to support their analysis, with plans to also explore how U.S. investors can best trade ADRs.

"These securities are a convenient way for U.S. investors to invest overseas," says Yan, an associate professor of finance. "If you focus on U.S. stocks, you give up the much bigger pie of the global economy."

New Faculty

COLLEGE OF SCIENCE AND LIBERAL ARTS

Julie Ancis, professor of psychology and director of the cyberpsychology program (Fall 2020), specializes in diversity, multicultural competence, the interaction of psychology and technology, and women's legal experiences. She most recently served as associate vice president of diversity at the Georgia Institute of Technology.

Omowunmi Sadik, distinguished professor of chemistry and department chair, focuses on research that spans surface chemistry, energy and the environment, along with the development of new sensors and measurement approaches for solving problems in biological systems, including early diagnosis of cancer, DNA testing, detection of pain biomarkers and food safety.

Farnaz Shakib, assistant professor of chemistry, is a theoretical and computational chemist who researches the excited-state dynamics of electrons and protons, which is the basis of energy-conversion reactions in photosynthesis, fuel and solar cells. Her goal is to design green and sustainable "artificial photosynthesis" energy resources.

Zuofeng Shang, associate professor of mathematics, researches various aspects of machine learning, including big data theory and deep learning theory that are applicable to the analysis of massive data emerging from everyday life, such as internet searches, social networks, mobile devices, satellites, genomics and medical scans.

Xiaonan Tai, assistant professor of biology (Fall 2020), combines geospatial observations obtained from remote sensing and ground instruments with physics-based modeling to investigate ecosystems' responses to global environmental change, including resistance to drought. Tai seeks to improve our understanding of spatially dynamic feedbacks and couplings between plant biological and hydrological processes.

Junjie Yang, assistant professor of physics, focuses on the study of quantum materials that exhibit ferroelectricity and magnetism simultaneously, and which have potential for use in actuators, switches and magnetic field sensors, as well as applications in ultralow energy and ultrafast data storage technologies.

HILLIER COLLEGE OF ARCHITECTURE AND DESIGN

Hyojin Kim, associate professor of architecture, specializes in energy efficiency and indoor environmental quality (IEQ) in the design of next-generation buildings. Using computer simulation and field measurements, she develops new metrics and methods for evaluating low-energy building systems and technologies in terms of their energy efficiency and IEQ performance.

Vera Parlac, associate professor of architecture, explores the intersections of architecture and biology, materials science, soft robotics, computation and digital fabrication. She is developing a kinetic façade system that uses pneumatics to provide adaptive shading, reducing energy consumption in buildings.

NEWARK COLLEGE OF ENGINEERING

Fatemeh Ahmadpoor, assistant professor of mechanical and industrial engineering, studies the mechanics and physics of 2D materials, as well as electromechanical coupling in soft materials, with applications in biophysics and soft robotics. Her research on the interaction of nanomaterials with biological systems has implications for drug delivery systems and the detection of nanotoxicity.

Samaneh Farokhirad, assistant professor of mechanical and industrial engineering, explores fundamental and practical questions in complex fluids and soft matter, focusing on the development of novel computational and theoretical models for the design and optimization of deformable nanoparticles used for targeted drug delivery and diagnostic applications.

Jonathan Grasman, assistant professor of biomedical engineering, develops tissue models to understand how nerves grow into repairing tissues, with an emphasis on cell-biomaterial interactions. He seeks to develop mechanisms to repair large volumetric muscle loss by identifying relationships between blood vessels and axons to improve outcomes in regenerating skeletal muscle tissue.

William H. Pennock, assistant professor of civil and environmental engineering (Fall 2020), seeks to expand municipal drinking water treatment globally by improving gravity-powered treatment technology, free of electricity and moving parts, as well as studying the fluid mechanics and chemistry governing coagulation, which is an upstream process for most treatment.

Joshua Young, assistant professor of chemical and materials engineering, uses computational methods to explore and design 2D materials, complex oxides and electrolytes for energy and electronics applications, including batteries, photovoltaics and memory devices. Young also generates large data sets and employs machine-learning algorithms to link atomic-scale features to properties of interest.

MARTIN TUCHMAN SCHOOL OF MANAGEMENT

Aichih (Jasmine) Chang, assistant professor of business data science, engages in data-focused research in diverse sectors: maximizing service quality in hospital operations; identifying efficiencies in the coffee bean supply chain in developing countries; text analytics of financial news for investors; and the use of blockchain technology to improve supply chain efficiency and performance.

Alberto Martín-Utrera, assistant professor of finance, employs machine-learning techniques to construct robust investment strategies, including the development of investment portfolio plans that consider real-world frictions such as transaction costs, which are normally disregarded in empirical asset pricing models, but are of special interest to investors and financial institutions.

YING WU COLLEGE OF COMPUTING

David A. Bader, distinguished professor of computer science and director of the Institute for Data Science, works at the intersection of data science and high-performance computing, with applications in cybersecurity, massive-scale analytics and computational genomics. He has been the lead scientist in programs such as DARPA's High-Productivity Computing Systems in collaboration with IBM.

Cody Buntain, assistant professor of informatics, applies large-scale analysis to study social media and the larger information ecosystem. He focuses on how individuals engage socially and politically and respond to crises and disasters in online spaces. He also works with political scientists to detect and track online interference in elections.

Jacob Chakareski, associate professor of informatics, conducts research to integrate nontraditional emerging wireless technologies, such as free-space-optics and millimeter waves that transmit data using very high electromagnetic wave frequencies, to enable the ultrahigh data rates and ultralow latencies required by next-generation, societal, virtual reality/augmented reality applications.

Salam Daher, assistant professor of informatics, uses augmented reality (AR) to combine virtual content with the real world, such as 3D modeling of human characters in synthetic environments. Her AR patient simulators, called Physical-Virtual Patients, allow health care educators to experience real-time physical tactile cues such as temperature and pulse in simulated patients.

Przemyslaw Musialski, associate professor of computer science, focuses on computer graphics and computational fabrication, especially in connection with the processing of geometric shapes. Musialski's aim is to support designers who are creating new products directly on the computer, averting the need to manufacture preliminary prototypes while in development.

Tomer Weiss, assistant professor of informatics, specializes in visual computing, including virtual simulation of physically embodied artificial intelligence agents, and algorithmic content creation for virtual, augmented and other immersive reality media. In recent work, he has developed software used for automatically furnishing interior spaces and simulated the movement of crowds.

Pan Xu, assistant professor of computer science, works on artificial intelligence and operations research, an interdisciplinary field that uses mathematical techniques to solve large-scale optimization problems in the real world. He focuses on problems featuring uncertain inputs that arise in e-commerce, internet advertising, crowdsourcing markets, data mining, databases and revenue management.

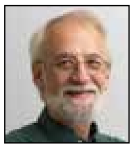
Photos: Oscar Masciandaro

ACCOMPLISHMENTS

AMERICAN ACADEMY OF OPTOMETRY FELLOW

Tara Alvarez, professor of biomedical engineering, studies the links between a visual disorder and the brain, and develops novel devices to identify and treat it. The disorder, convergence insufficiency, is a biomarker for concussion, for which she is developing diagnostic tools in collaboration with major children's hospitals.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE FELLOW



Dale Gary, distinguished professor of physics, studies processes on the Sun that produce radio emissions and examines them for clues about the mechanisms that accelerate charged particles to high energies in solar flares. He created NJIT's 13-antenna Expanded Owens Valley Solar Array to peer into the genesis of flares.

AMERICAN CHEMICAL SOCIETY FELLOW

Kevin Belfield, dean of NJIT's College of Science and Liberal Arts, specializes in research on organic photonic materials, especially two-photon absorbing materials in 3D optical data storage. He also applies two-photon imaging technology to improve early cancer detection and study the development of early-stage Alzheimer's disease.

AMERICAN CONCRETE INSTITUTE FELLOW

Matthew P. Adams, assistant professor of civil and environmental engineering, is an expert on cement material chemistry who researches the durability of hydraulic cement-based systems. He studies the links between the durability and chemistry of concrete with a focus on novel and sustainable materials.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA) YOUNG FACULTY AWARD

Simon Garnier, associate professor of biology, explores intelligent collective behaviors in social species, also known as "swarm intelligence." Garnier is now studying the migration behavior of ant colonies using computer vision and machine learning to develop computational models that help predict human mass migrations.

FULBRIGHT SCHOLAR

Casey Diekman, associate professor of mathematical sciences, applies modeling, simulation and dynamical systems analysis to investigate mechanisms underlying the sleep/wake cycle. At the University of Exeter, he studies how the electrical activity of the brain's master clock is linked to circadian rhythms in gene expression.

HUGO AWARD

Elsa Sjunneson-Henry, adjunct professor of humanities, is an author and editor recognized for her contributions as co-editor-in-chief of Uncanny Magazine's special issue of short stories, nonfiction essays and poems titled "Disabled People Destroy Science Fiction" — an anthology that aims to "put disabled voices at the center of the narrative."

NATIONAL ACADEMY OF INVENTORS FELLOW

Nirwan Ansari, distinguished professor of electrical and computer engineering, is a pioneer in the field of communications and networking whose patent on ATM networks formed the backbone for broadband access and later FIOS networks. His work on authentication technologies is used in anti-counterfeiting and fingerprinting applications.

NATIONAL SCIENCE FOUNDATION CAREER GRANT

Ioannis Koutis, an associate professor of computer science, works in algorithm design. With his grant, he researched spectral analysis of networks and developed novel theoretical insights that led to faster, improved network embedding algorithms that can, for example, better identify clusters of data, including on social networks.

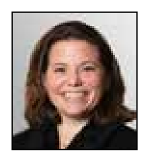
NATIONAL SCIENCE FOUNDATION CAREER GRANT

Mengyan Li, assistant professor of environmental science, researches and develops water treatment technologies for municipal, industrial and agricultural settings. With his grant, he is investigating bacteria and enzymes that are effective in remediating the commingled groundwater pollutants, 1,4-dioxane and chlorinated solvents.

PRESIDENTIAL AWARD FOR EXCELLENCE IN SCIENCE, MATHEMATICS AND ENGINEERING MENTORING

Howard Kimmel, professor emeritus of chemical engineering, co-founded NJIT's Center for Pre-College Programs in 1979 to expand access to scientific and technological fields among traditionally underrepresented populations and to improve the teaching of science and mathematics in secondary and elementary schools.

STEVEN VOGEL YOUNG INVESTIGATOR AWARD



Brooke Flammang, assistant professor of biological sciences, applies biomechanics and bioinspired robotics to explore evolutionary selection of morphology and function. Her current work includes research into how fish may be a proxy for understanding the evolution of tetrapod locomotion and new technology in underwater adhesion.

Photos: Oscar Masciandaro

Urban Blanket: **See sidebar, page 35.**

Photo: Gernot Riether

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