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IMPACT

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Leading Sustainability: A New Center

Research focuses on innovative solutions to complex environmental sustainability challenges

With assistance from energy group PSEG and its charitable foundation, Stevens has unveiled a new sustainability center that will generate leading-edge research in environmental justice, toxics reduction and other key disciplines.

“Anyone who cares about the future, cares about sustainability,” noted Stevens professor **Dibs Sarkar**, who heads the new Stevens Center for Sustainability (SCS). “We are thrilled to establish this new center as a trans-disciplinary hub for developing innovative solutions to complex sustainability problems.”

A generous PSEG Foundation gift of $1.45 million is supporting the establishment and first three full years of SCS’s operation — including up to 58 scholarships for pre-college scholars, 20 undergraduate research scholarships annually and four doctoral scholarships for research to address environmental and energy challenges faced by overburdened communities.

“We are thrilled to receive the continued support of the PSEG Foundation and eager to put this generous gift to work,” said Stevens President Nariman Farvardin. “This is more than a financial contribution; it is an investment in our shared vision for a sustainable future.”

“The programs funded by this grant promise to enrich the academic journey of our students and empower them to tackle the pressing environmental issues of our time.”

PFAS, ENVIRONMENTAL JUSTICE, NEW RESEARCH

Among the research foci of the center are per- and polyfluoroalkyl substances, or PFAS, also known as “forever chemicals.”

In June, the center conducted a day-long summit on PFAS chemicals featuring environmental attorney Robert Bilott, who has led the legal fight to secure reparations, testing and remediation commitments from major chemical concerns. Bilott outlined the growing PFAS crisis, the need for accountability, and future funding and legislative priorities for the audience.

“This is an all-hands-on-deck problem," added Bradley Campbell, a former EPA Regional Administrator, NJDEP Commissioner and member of the White House Council for Environmental Quality. “It really is our social responsibility to learn how to work together across these boundaries.”

A multi-institutional panel of scientific researchers also explored PFAS remediation solutions, while a passionate session on environmental justice featured first-person testimonials and calls for action from communities of color and economically challenged neighborhoods.

“Research will be a strong focus of this center,” notes Sarkar.

Toward that end, he says, SCS research initiatives have begun addressing challenges in broad categories: environmental sustainability, energy sustainability and social and economic sustainability.

In addition to sustainable remediation of PFAS-contaminated systems, initial research priorities include the detection and elimination of heavy metals, including lead; removal of toxic chemicals, pharmaceuticals and microplastics from industrial and municipal wastewater streams and water supplies; and soil remediation through “green” methods such as natural plantings and natural filter materials.

INSIDE HIGHLIGHTS:

stevens.edu/research

Detecting Depression: The Eyes Have It

AI-powered systems spot signs in our eyes, faces

Nearly 300 million people worldwide — about 4% of the global population — are afflicted by some form of depression. But detecting depression can be difficult, particularly when those affected don't (or won't) report negative feelings to friends, family or clinicians.

That's why Stevens professor **Sang Won Bae** is developing several AI-powered systems to non-invasively warn us, and others, we may be becoming depressed.

EYES, FACIAL GESTURES REVEAL MOODS

One system, PupilSense — created with doctoral candidate Rahul Islam — works by constantly taking snapshots and measurements of a smartphone user's pupils and leveraging recent findings that certain pupillary reflexes can be linked to depression.

In an early test, the system analyzed 16,000 snapshots of interactions with smartphones by users. After teaching an AI system to differentiate between normal eye responses and abnormal ones, Bae and Islam processed the data and compared it with self-reported mood. The best iteration proved 76% accurate at flagging instances when subjects did indeed feel depressed.

Bae and Islam are also developing a second device-based system, FacePsy, that parses facial expressions for insights. An early pilot study revealed surprises: Increased smiling, for instance, appeared to correlate not with happiness but signs of depressed mood. Eyes being more frequently opened during morning or evening also associated with potential depression, suggesting outward alertness can mask depressive feelings. Other signals included side-to-side movements of the head.

Findings were presented in October at the ACM International Conference on Mobile Human-Computer Interaction (MobileHCI).

Catching Gravity Particles in the Act

A team led by Stevens physics professor **Igor Pikovski** has proposed an exciting novel method to detect single gravitons, thought to be the quantum building blocks of gravity — one of the universe's fundamental forces. Making that experiment real should be possible with quantum technology, adds the group, in the near future.

Such an experiment was long thought impossible, but Pikovski, graduate students Germain Tobar and Thomas Beitel and postdoctoral researcher Sreenath Manikandan may have cracked its code.

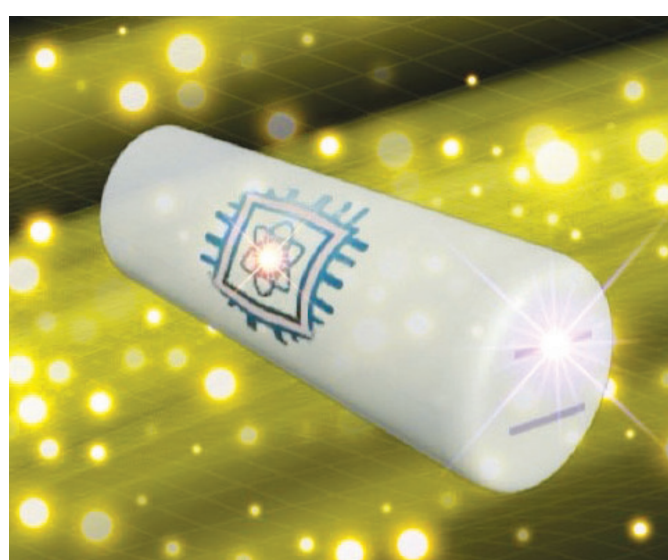
NEW DETECTORS; MASSIVE STAR COLLISIONS

Linking gravity with quantum mechanics remains one of physics' greatest challenges. In any quantum theory of gravity, single indivisible particles, called gravitons, should occur. Detectors like the U.S.-based LIGO facilities can confirm the existence of gravitational waves, which theoretically contain large numbers of gravitons — but a single graviton itself has yet to be detected.

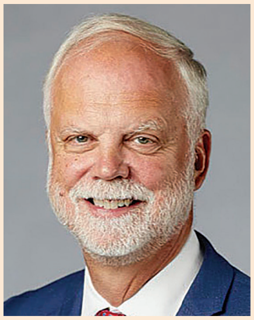
Pikovski's team designed their ingenious experiment by pulling data on previously measured gravitational waves, such as those that arrived in 2017 after a collision of two Manhattan-sized, extremely dense neutron stars. First the team calculated the parameters that optimize the absorption probability for a single graviton, then demonstrated how a Weber bar-type resonator — fitted with novel quantum sensing technology — could be cooled to its lowest energy and set vibrating slightly by the passage of a gravitational wave.

Each discrete change in energy, known as a quantum jump, would indicate a single graviton being "seen." The necessary quantum-sensing technology to detect these tiny yet critical jumps at the proper scale doesn't quite yet exist, notes Pikovski, but advances in the field continue.

The group's experiment was published in *Nature Communications* in August.



PFAS, MICROPLASTICS, CLIMATE CHANGE: NEW CHALLENGES, NEW RESEARCH



During the 1970s, America was consumed with the challenge of clear, demonstrable environmental threats: clean air, clean water, toxics reduction. Waterways had essentially functioned as open sewers for centuries. Airborne emissions were also largely unchecked. Waterfowl were dying or failing to reproduce because of harmful substances such as mercury, DDT and dioxin detected in the sediments of rivers and lakes.

Hard work by dedicated researchers — and bipartisan action by legislators — helped turn the tide with sweeping regulations, assessments and mitigation technologies. But newly emerging complex threats to human and ecological well-being now demand we again take rapid and judicious action.

Synthetic PFAS/PFOS, known as forever chemicals, harm our health and can persist for thousands of years. Microplastic particles from a wide variety of products have infiltrated our waterways, body tissues, even wildlife in the Arctic. And the growing specter of climate change brings more powerful weather systems, dangerous storm surges and ravaging wildfires.

Fortunately, Stevens is perfectly positioned to attack each of these sustainability challenges in unique, interdisciplinary ways — and we have begun doing so. The recent creation of the **Stevens Center for Sustainability (SCS)** was a major step forward in this effort. Under the able leadership of Dr. Dibs Sarkar, SCS will advance leading-edge research in environmental justice, toxics remediation, sustainability assessment and planning and a host of other areas. See this issue's cover story to learn more.

Stevens is also contributing new research, knowledge, solutions and dialogue to these challenges on multiple fronts:

- **Forever chemicals.** Our legacy as an engineering institution has informed our work to eliminate and treat toxic materials. Stevens faculty have patented filtration technologies for arsenic, lead and other heavy metals and are currently developing greener methods of removing PFAS chemicals from soil and water.

- **Microplastics**. Our researchers are tackling the growing threat of microplastics, which have infiltrated global ecosystems and are increasingly linked to human health concerns such as heart disease. Multiple faculty are studying the mechanics of plastic transport and developing advanced techniques for measuring, quantifying and characterizing plastic particles in water. Stay tuned.

- **Climate change.** As detailed in the Spring 2024 issue of **IMPACT**, our Davidson Lab creates key four-day prediction and warning tools to alert the metropolitan New York region to threats, helping save lives and preserve businesses. Our capacity will soon be expanded to including flooding of inland waterways, as well, aided by generous state and federal support.

It is an urgent moment for both the planet and human health, and Stevens is up to the task. I encourage you to watch this space.

Enjoy the rest of your fall semester and a restful holiday break.

All my best,

Ed Synakowski
Vice Provost for Research & Innovation

Stevens Co-Founds Renewable-Energy Center

Michigan, Texas A&M-Corpus Christi join in effort to boost marine resources

Stevens has been approved by the National Science Foundation (NSF) as a founding partner for a new Industry-University Cooperative Research Center (IUCRC) that aims to develop marine energy resources to power a "blue" economy.

The Growing Ocean Energy Technologies and the Blue Economy (GO Blue) Center launched November 1 as a collaborative effort among Stevens, the University of Michigan and Texas A&M-Corpus Christi.

Industry partners joining the IUCRC will gain access to the three universities' laboratory and testing facilities — including Stevens' historic Davidson Lab and its leading-edge wave/towing tank, already used to test scale models of many marine energy converters — as well as faculty and student talent, early and royalty-free access to intellectual property, federal funding opportunities and NSF-funded internship programs.

In addition to its technical development component, the center will assess the societal, environmental and economic impacts of new wind, wave and tidal power facilities for coastal communities and coastal industries such as aquaculture. The IUCRC will also confront related energy challenges in the maritime domain, such as decarbonizing maritime transportation.

Initial funding from NSF will be for up to $2.2 million and extend through fall 2029.

When Star Trekking, Diversity Is Best

With two American astronauts unexpectedly remaining aloft on a space mission eight months longer than planned, space teamwork is suddenly a hot topic. What kinds of crews work best together?

Stevens professor **Hao Chen** wanted to find out.

Working with doctoral student Iser Pena, Chen simulates missions to understand the crew mixtures that might perform best on lengthy missions such as those currently proposed to Mars.

The duo used agent-based modeling techniques to design simulated crew members equipped with varying strengths, weaknesses, backgrounds, experience levels and fitness levels. Then they ran a complex simulation of a 500-day mission, pitting crews of six quite similar astronauts against six quite different from each other. The simulation drew upon a host of psychological, organizational and other data and theory to factor in time, stress, fatigue and personal engagement on performance.

Once the team's model ran the numbers, which group had the right stuff?

"While both teams performed roughly the same on the simulated mission, the 'diverse' team scored slightly higher overall," Chen reports. "This indicates diversity in a planned space mission is a strength."

"The higher stress levels, yet better performance, of those heterogeneous teams could be attributed to the diverse perspectives and problem-solving approaches they bring to the table and mission," adds Pena.

Findings were presented at the 2024 AIAA ASCEND (Accelerating Space Commerce, Exploration, and New Discovery) conference in August.

AI FAIRNESS: A NEW TOOL

Stevens, working with Carnegie Mellon University (CMU), has proposed a new method to improve the equity of decisions and predictions made by AI. The work, by Stevens business professor **Violet Chen** and CMU's Derek Leben, draws on social welfare optimization theory and techniques.

Algorithmic systems do attempt to ensure groups are equally screened or represented in, for example, mortgage decisions. But what if being denied a mortgage has a larger negative impact on certain groups (say, first-time homeowners) and is less consequential to others?

Chen and Leben propose working these social factors and considerations into the mix when creating and deploying AI. Specifically, they recommend alpha-fairness techniques, which produce a balance between perfect fairness and more holistic benefit for all.

The research was presented at the International Conference on the Integration of Constraint Programming, Artificial Intelligence, and Operations Research earlier this year, where it received a Best Paper Award.

IN SATURN'S VOLCANOES, HINTS OF LIFE?

Enceladus, the sixth-largest of Saturn's moons, is known for its remarkable cryovolcanoes — huge geysers spurting from cracks in Enceladus' frigid shell that blast jets of water and ice into space.

Those jets, which even feed material to one of Saturn's rings, represent a tantalizing challenge for researchers who believe the subsurface ocean in which they originate could possibly sustain extraterrestrial life.

Stevens researcher **Jason Rabinovitch**, working with Caltech and NASA's Jet Propulsion Laboratory (JPL), is exploring the source of these volcanoes.

"It is essentially the same mechanism that causes a shaken-up can of soda to explode when you pop it open, on a much bigger scale," he explains.

His team used computer simulations to model cryovolcanoes powered by dissolved gasses such as methane and hydrogen, including modeling of Enceladus' hidden ocean and the geometry of fissures that give rise to cryovolcanoes.

"Understanding how the plume operates will be crucial as we plan experiments and interpret data and begin to figure out what's really going on beneath that moon's surface," Rabinovitch says.

Sampling those volcanoes' jets, he adds, would reveal much about the subsurface environment — including whether or not this ocean could support life. The work was published in the *Journal of Geophysical Research: Planets*.

NEWS & NOTES

The Stevens-led **Systems Engineering Research Center** was awarded a contract for up to **$520 million** by the **Department of Defense (DoD)**.

The university received **$7.25 million** from the New Jersey legislature to advance **artificial intelligence** research and education and **$1 million** in federal appropriations to build new **flood prediction** and extreme event warning systems.

Cancer biologist **Marcin Iwanicki** began a year-long Science and Technology Policy Fellowship at **National Science Foundation** (NSF) headquarters in Arlington, Virginia.

Stevens launched **NJ FAST**, an entrepreneurship accelerator hub, in partnership with **Prudential**, New Jersey's economic development authority, and leading venture-capital platform **Plug and Play**.

Damiano Zanotto will collaborate with **Columbia University** on a **$2.2 million**, four-year project funded by the **National Institutes of Health** (NIH) to develop earlier detection of childhood neuromuscular disorders.

Lung-function expert **Jinho Kim** will be part of a separate **$6.8 million, NIH-funded** project to conduct tissue engineering research at Columbia.

Amro Farid was awarded **$1.7 million** by the **NSF** to collaborate with **MIT, Florida State University** and **SUNY-Buffalo** in an investigation of a potential transactive energy service in New Hampshire.

Xiaojun Yu was awarded **$2 million** by the **DoD** to advance treatment of peripheral nerve injuries.

Jon Miller was awarded **$1 million** to collaborate with the New Jersey Department of Environmental Protection as part of a suite of projects funded through **NOAA** that will develop and implement climate resilience in U.S. coastal areas.

Materials scientist **EH Yang** was co-awarded U.S. patent #11961669 B2 for "Stretchable Supercapacitors with Vertically-Aligned Embedded Carbon Nanotubes."

Feng Liu was awarded approximately **$440,000** by the **NIH** to investigate methods of modeling and localizing the brain regions that produce epileptic seizures.

Zhou Feng was awarded **$600,000** by the **NSF** to explore algorithmic methods of optimizing microchip and circuit design in collaboration with **NXP Semiconductors**.

Diagnosing Infant Ocular Disorders, Using AI

When infants are born prematurely, a host of serious health issues can occur. One of those issues is retinopathy of prematurity (ROP), an eye disorder and loss of vision that can quickly progress. If it's caught immediately, however, ROP can be treated and even reversed.

To develop a new, AI-powered way of speeding up those diagnoses, Stevens has been awarded nearly $2.2 million by the National Institutes of Health (NIH).

The Multi-PI R01 award to MPIs **Jennifer Kang-Mieler** and **Yu Gan** will also involve close collaboration with both Oregon Health and Science University (OHSU) and the University of Illinois-Chicago (UIC).

As they build a diagnostic tool, Kang-Mieler and Gan will first create an expert dataset depicting ROP pathology in medical imaging that will serve as a foundation for training an AI system to accurately identify the condition.

"Even the very best data on ROP is limited by the relatively small number of cases," explains Kang-Mieler. "For some ophthalmological diseases, there are hundreds of thousands of approved images being studied by AI. However, that's not the case for this disorder."

To surmount that challenge, Kang-Mieler and Gan will collect animal ROP images and process them, extracting the most useful predictive features from the images, then using them to teach an AI model to generate the best-possible synthetic images of human ROP by employing generative AI image-translation techniques.

This new, synthetic image data can then be used to train neural networks that will assist ophthalmologists in spotting ROP or tracking the progression of the disease.

"This is a new approach to addressing data scarcity in medical generative AI," notes Gan.

The teams will carefully validate all imagery and processes through a series of checkpoints, they add, with the aid of both human ophthalmological experts and algorithmic methods.

NIH's initial funding for the project will extend through summer 2028.

ABOUT STEVENS

Stevens Institute of Technology is a premier, private research university in Hoboken, New Jersey, overlooking the Manhattan skyline. Since its founding in 1870, technological innovation and entrepreneurship have been the hallmarks of Stevens' education and research. Academic and research programs spanning finance, computing, engineering and the arts expand the frontiers of science and leverage technology to confront the most challenging problems of our time. Stevens is home to multiple national centers of excellence as well as leading-edge scholarship and research centers in disciplines such as artificial intelligence, including the Stevens Institute for Artificial Intelligence (SIAI); business and finance, including the Center for Research toward Advancing Financial Technologies (CRAFT); energy and sustainability, including the Stevens Center for Sustainability (SCS); health and medicine, including the Center for Healthcare Innovation (CHI); quantum science and engineering, including the Center for Quantum Science and Engineering (CQSE); and urban and coastal resilience, including the Davidson Laboratory.

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Is AI the COVID Test of the Future?

Stevens-developed system accurately spots COVID, pneumonia in X-ray images

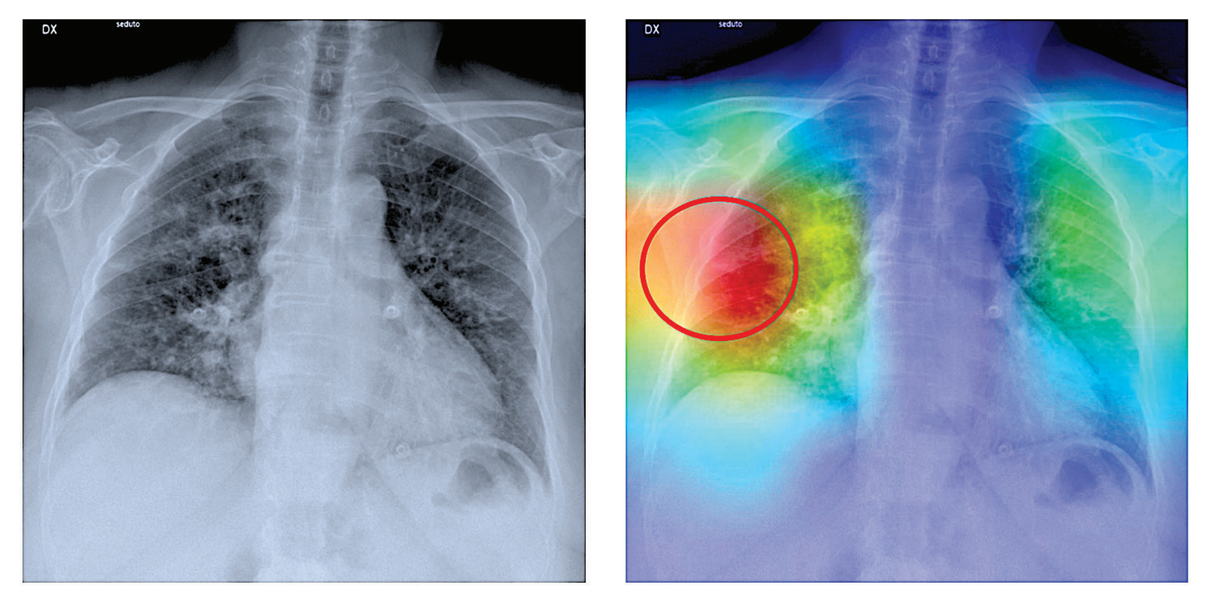
More than 2 billion chest X-rays are captured each year worldwide to diagnose respiratory diseases. But radiologists properly trained to read all those images carefully are in short supply.

To address this challenge, Stevens professor **Ying Wang**, working with doctoral advisee Ishan Aryendu, has created a new AI system to do just that.

In early tests, the duo's AI-powered prediction system (known as RAIDER, for Rapid AI Diagnosis at Edge using Ensemble Models for Radiology) has proven highly accurate at flagging both COVID and pneumonia cases from X-rays. It's also compact, produces rapid diagnoses and doesn't use much power.

"We believe this model could help physicians quickly identify and diagnose both known and newly emerging respiratory diseases from chest radiographs," says Wang, "providing high precision with minimal system requirements."

Wang and Aryendu began by randomly clipping nearly 600 X-ray images of confirmed COVID-infected lungs, plus nearly 20,000 images of lungs diagnosed with viral pneumonia, from image banks. Additional images of healthy lungs were added as a control and all were resized, converted to grayscale and contrast-enhanced.



They then fed more than 360 chest X-rays into both MobileNetV2 and SqueezeNet, two neural networks that powerfully classify images using lean-computing techniques, to see if they could correctly detect confirmed diagnoses.

The results were remarkable. The system proved 97% to 98% accurate at diagnosing COVID-19 and viral pneumonia from imagery, powered only by a single low-power Raspberry Pi 5 board.

RAIDER could also be tuned to identify newly emerging diseases that present worrying imagery but whose images don't match what's known about the damage patterns of existing respiratory diseases, adds Wang, informing rapid response before outbreaks accelerate.

The research was reported in *IEEE Access* [Vol. 12] in August.