STEVENS
INSTITUTE of TECHNOLOGY
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IMPACT

The research newsletter of Stevens Institute of Technology Spring 2021

Smarter MRI Targets Alzheimer's, Aneurysms

Stanford, Mount Sinai, NIH team with Stevens to develop AI-powered diagnostics

Stevens is pioneering new techniques integrating high-fidelity imaging with AI to detect Alzheimer's disease, cerebral aneurysms and other disorders at early stages — before they become deadly. Partners in the effort include Stanford University, Mount Sinai Hospital and the National Institutes of Health (NIH).

"This research will save lives," says lead investigator Mehmet Kurt, director of Stevens' Center for Neuromechanics. "In five to ten years, I believe, we'll see surgeons using these tools to treat patients."

Zeroing in on tissue stiffness

Kurt serves as co-PI on one NIH-funded initiative to improve earlier diagnosis and treatment of Alzheimer's. The subtle microstructural changes the disease causes in the brain during early stages are difficult to identify with traditional neuroimaging techniques such as MRI, PET or CT scans.

But recent evidence indicates the neurodegeneration characterizing Alzheimer's is also accompanied by tissue softening, which can potentially be measured by newer, more powerful MRI technologies that produce higher magnetic field inductions of up to 7 Tesla (7T). With Priti Balchandani at Mount Sinai Hospital's Icahn School of Medicine, Kurt will create and test a novel framework for producing earlier diagnoses of Alzheimer's.

The teams will integrate multiple analysis tools with the newer, more powerful 7T imaging to produce MRE (magnetic resonance elastography) data on tissue stiffness and produce a uniquely powerful measure of the early biomechanical changes associated with Alzheimer's disease.

The project is titled "Cross-correlation of Biomechanical, Connectomic, and Pathologic Markers in Alzheimer's Disease at 7T MRI."

Intelligent imaging

Kurt is also advancing new methods of algorithmic image processing and analysis in an effort to detect cerebral aneurysms at early stages.

Approximately 30,000 U.S. patients suffer life-threatening aneurysms annually. While some ruptures can be treated if spotted in advance, predicting which aneurysms will burst has proven elusive.

In collaboration with researchers at Stanford and the University of Auckland, Kurt and graduate student Javid Abderezaei have developed a new AI-powered imaging system to identify and treat high-risk aneurysms more quickly and accurately.

The innovation works by algorithmically analyzing minute vibrations in the walls of cerebral blood vessels. Kurt and Abderezaei process 4D flow MRI images, combining multiple MRI scans into video-like sequences with a novel image-processing algorithm that amplifies small movements.

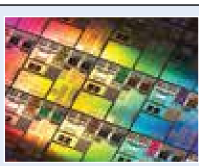
In new research published in *IEEE Transactions in Medical Imaging* (vol. 39, no. 12; pp. 4113-4123), the team tested the system — known as aFlow, or amplified flow imaging — on both computationally simulated aneurysms and small numbers of healthy subjects. In each case, the detected vibrations correlated with local deformations of brain tissue.

The investigators also tested the aFlow system over a 12-month horizon on two patients, one at low risk for aneurysm and another at high risk, again correlating high-frequency motions within the brain's blood vessels with higher risk.

The same techniques will subsequently be studied for application to neurological conditions such as strokes and traumatic brain injuries.

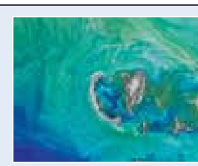
INSIDE HIGHLIGHTS:

stevens.edu/research



New Leap in Photon Generation

AI to Detect Fake News, Conspiracy Theories



NASA Award to Improve Satellite Imagery

Two New NSF CAREER Awards

Two faculty members have been awarded National Science Foundation (NSF) CAREER awards to support projects in bioinspired materials and data analysis, respectively.

Civil engineering professor Weina Meng will work to enhance the mechanical properties of cementitious materials by mimicking the properties and architectures of nacre, a strong, lightweight compound naturally produced by some mollusks.

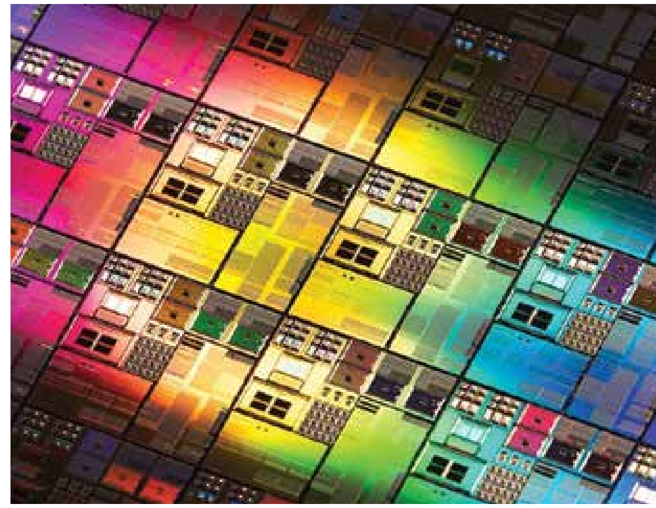
The newly developed materials will have broad applications for building and transportation infrastructure construction, energy facilities and aerospace.

In her project, "Consecutive Assembly-and-Mineralization Processed Calcium-Silicate-Hydrate Nacre with High Specific Flexural Strength and Fracture Toughness," Meng's team will design and control the growth of novel calcium-silicate-hydrate mesocrystals to form nacre structures using fabrication techniques such as freeze casting, controlled mineralization, organic phase infiltration and hot-pressing. Machine learning tools will also be deployed in the design process.

Electrical and computer engineering professor Hang Liu will pursue algorithm and system co-designed methods to power the development of more rapid, efficient and effective graph analytics in his NSF project, "An Algorithm and System Co-Designed Framework for Graph Sampling and Random Walk on GPUs."

He will build upon his previous research in graph sampling and random walk methods, both of which substantially reduce the graph size and required computing power to perform complex analysis on real-world graphs. Liu plans to create scalable techniques that can take advantage of existing computing facilities and future exascale systems to accommodate graphs at the trillion-edge scale, providing a foundational tool for practitioners in academia, national research laboratories and industry.

Potential applications include pandemic modeling and research, circuit design and software vulnerability evaluation.



Leap Forward in Photon Generation

100-fold gain in efficiency

Stevens researchers have developed a novel quantum circuit that can readily be integrated with other optical components, paving the way for high-speed, reconfigurable and multifaceted quantum devices.

The method is up to 100 times more efficient than those previously demonstrated, enabling the creation of tens of millions of entangled photon pairs per second from a single microwatt-powered laser beam.

"It has long been suspected this was possible in theory, but we're the first to show it in practice," says Yuping Huang, director of the university's Center for Quantum Science and Engineering. "This is a milestone for quantum technology."

Racetracks of light

To create photon pairs, researchers trap light in carefully sculpted nanoscale microcavities. As laser light circulates in the cavities, photons resonate and split into entangled pairs. But the systems are inefficient, requiring hundreds of millions of photons to produce a single entangled photon pair.

Working with graduate student Zhaohui Ma and research scientist Jiayang Chen, the Huang group built upon its own previous research to carve high-quality, racetrack-shaped microcavities from flakes of lithium niobate crystal. The cavities internally reflect photons with very little loss of energy, enabling light to circulate longer and interact with greater efficiency. By fine-tuning temperature and other factors, the team created an unprecedentedly bright source of entangled photon pairs, allowing pairs to be produced with far greater quality — while dramatically reducing the energy needed to power quantum components.

The ultimate goal of the work, notes Huang, is to power quantum-based devices efficiently and inexpensively. The advance was reported and detailed in *Physical Review Letters* (125, 263602).

Unlocking the Power of Student-Faculty Research, Commercialization

As we continue through the spring semester, we all send our best wishes to those coping with the effects of COVID-19. More than ever, it is important to draw together resources when attacking challenges such as this pandemic.

At Stevens, we place a premium on the importance of faculty-student collaboration when developing new research, testing it, and proceeding through the process of technology commercialization.

Stevens devotes considerable support to faculty and students with ideas and intellectual property that hold market potential, including the one-year Launchpad and four-year iSTEM mentorship programs in entrepreneurship and innovation for selected undergraduates. When we created iSTEM, our goal was to recruit and encourage particularly creative students to innovate new ideas and develop them into potential ventures from year one.

Each spring, the annual Stevens Innovation Expo showcases hundreds of student team projects involving the development of new research, products and services.

In this issue of IMPACT, you will read about collaborative student-faculty efforts to develop more intelligent medical imaging methods, components for quantum computers, false-news detection technologies and novel classes of compounds with medication potential, among other innovations.

You will also learn about two recent examples of Stevens research that have produced tangible benefits through commercialization. As we continue to couple the incredible creativity of students with the steady guidance of accomplished faculty and thought leaders, our technology development research will increasingly result in commercialization with widespread societal benefits.

I encourage anyone interested in these programs, or in partnering with Stevens, to contact me directly at 201.216.5280 or **research@stevens.edu**.

Wishing you a safe and healthy spring.

My best,

Dilhan M. Kalyon
Vice Provost for Research and Innovation

AI to Detect Fake News, ID Conspiracy Theories

Two lines of inquiry at Stevens are producing detection algorithms that can accurately classify information as true or false.

"Deceivers are always working to learn how to game the detection systems you are building," notes researcher K.P. (Suba) Subbalakshmi, who leverages artificial intelligence (AI) and machine learning to separate fact from fiction online. "It is always a cat-and-mouse game."

Working with doctoral students Mingxuan Chen and Ning Wang, Subbalakshmi developed a novel AI to detect truth in written social media content based on the words and styles used.

The system begins by scanning and encoding written content into a matrix. Next, analytic features measure frequency of verb use, richness of description and other aspects of written communication. The AI also analyzes characteristics of the user accounts sharing information.

After testing several versions on a large dataset of social media posts, the group found its best prediction model performed better than 11 existing false-news detection systems.

"There's a debate in AI about whether an AI system should rely exclusively on latent features without any need for handcrafted features," notes Subbalakshmi. "This study made a pretty strong case that human expertise-derived features are both necessary and beneficial."

Next the team will incorporate image analysis into the detection system.

A second line of inquiry involves analyzing the relationships between entities in content.

Computer scientist Yue Ning develops algorithms trained on open-source datasets, incorporating knowledge graphs into detection algorithms. False relationships between facts are a hallmark of conspiracy theories, notes Ning, and automatically detecting their appearance in written content can produce a useful flag that a communication may not be truthful.

Ning's research group is also analyzing recently emerging datasets of COVID communications, such as news stories and social media posts, for additional insights and to develop predictive tools.

Annual Flooding, Intense Hurricanes

Stevens, Princeton predict climate effects

New research predicts regular 100-year and 500-year floods on New York's Long Island by the end of this century.

Using projected climate data for an extreme greenhouse gas concentration scenario over the next eight decades, Stevens' Reza Marsooli and Princeton University researcher Ning Lin conducted high-resolution numerical simulations for various scenarios to probabilistically project climate change's impacts on the flood levels induced by hurricane-type storms.

Sea level rise and changing patterns of hurricane climatology would significantly impact western Long Island, they found, increasing storm surges and wave hazards. Their modeling projects the historical 100-year flood level could become a once-in-nine-year flood level by the mid-21st century and then become annual as soon as the end of this century.

The 500-year flood level, a rare flood level last seen during Hurricane Sandy, would become three times more frequent by mid-century and would be reached as often as once every *four* years by 2100.

The model also predicts larger future storm waves and slower, more intense regional hurricanes. Marsooli and Lin's work appears in the journal *Climatic Change* (163, 2153–2171).

NASA Award to Improve Satellite Imagery

NASA has awarded Stevens physicist Knut Stamnes approximately $450,000 to develop algorithms to improve satellite images of the planet.

The project, "Laser Beam (Lidar) Propagation in the Atmosphere-Ocean System in Support of Active Remote Sensing from Space," will address the ways in which light scatters as it passes through layered material such as the Earth's atmosphere, degrading the quality of satellite images and other remotely acquired sensing data.

Stamnes, an expert in the creation of mathematical algorithms to describe how radiation transfers through layered material, develops algorithms that process color images of coastal and open oceans, snow and ice fields, and coral reefs.

The team plans to develop and test novel algorithms against data sourced from a laser scanning instrument on the Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite, a joint U.S.-French climate analysis venture.

NIH GREEN-LIGHTS DRUG DISCOVERY EFFORTS

A pair of Stevens drug discovery initiatives have been awarded nearly $1 million in new support from the National Institutes of Health (NIH).

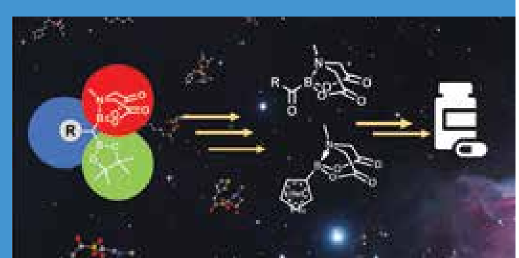
Chemistry professor Abhishek Sharma's laboratory received a $460,000 grant to develop chemical synthesis methods that will broaden the availability of researchers' molecular building blocks, enhancing the ability to develop new therapeutic agents.

The project, "Modular Approaches to Unusual Borylated Heterocycles Using Novel Acylborons and Alpha-Hydroxy Borons as Enabling Tools," will focus on expanding the chemical space in which novel structures of medicinally important molecules — specifically, heterocyclic drugs — can be developed.

Heterocyclic molecules are important in the generation of novel therapeutic agents that can address the challenges of drug resistance in cancer, bacterial infections and viral infections.

Professor Junfeng (James) Liang was also awarded approximately $460,000 by the NIH for his project, "Membrane-Acting Peptides."

Derived and extracted from food products such as cereal grains, eggs and milk, naturally occurring bioactive peptides affect a number of human physiological processes, acting at some sites as endocrine or paracrine signals



and at others as neurotransmitters or growth factors. They have been demonstrated to have antimicrobial, antifungal, antiviral and antitumor properties.

Liang's team will explore new approaches to peptide design for wide biological and pharmaceutical application.

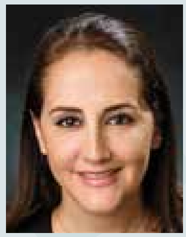
NEWS & NOTES

Jose Ramirez-Marquez co-published findings with **UNICEF** in *Child Abuse & Neglect* on "Using Social Media Data for Assessing Children's Exposure to Violence During the COVID-19 Pandemic." Collaborators included Pouria Babvey, Fernanda Capela and Carlo Lipizzi at Stevens and Claudia Cappa and Nicole Petrowski of UNICEF.

Johannes Weickenmeier was awarded approximately $840,000 to participate in a **National Institutes of Health** (NIH)-funded research program to investigate dementia, "The Clinical Significance of Incidental White Matter Lesions on MRI Amongst a Diverse Population with Cognitive Complaints (INDEED)." The program is co-led by **UC Davis School of Medicine** and **The University of Texas Health Science Center**.

The Department of Defense (DoD) awarded $2.3 million to the Stevens-led **Systems Engineering Research Center (SERC)** consortium to support the creation of a new Acquisition Innovation and Research Center (AIRC) within SERC.

Marcin Iwanicki and **Shang Wang** received approximately $420,000 from the **National Cancer Institute** for their project, "High-Resolution Dynamic Imaging of Ovarian Cancer Metastasis Post Chemotherapy." The researchers will collaborate with **Fox Chase Cancer Center**.



Yeganeh Hayeri and **Saeed Vasebi** co-authored "Air Emission Impacts of Low-Level Automated Vehicle Technologies in U.S. Metropolitan Areas" for *Transportation Research Interdisciplinary Perspectives* (7 [2020]: 100194).

Antonia Zaferiou received $125,000 from the Interdisciplinary Rehabilitation Engineering Research Career Development Program (IRE-K12), an **NIH**-supported program, to further her research and student mentorship in movement and rehabilitation studies.

Roxana Rahmati, a Ph.D. candidate in environmental engineering, was awarded top prize for her presentation at the 36th Annual International Conference on Soils, Sediments, Water, and Energy organized by the Association for Environmental Health and Sciences (AEHS) Foundation.

Darinka Dentcheva and **Brendan Englot** received approximately $900,000 from the **Office of Naval Research** to support a three-year project investigating multi-robot systems, "Risk-Averse Learning and Control for Distributed Dynamical Systems with Partial Information." Stevens will collaborate with **Rutgers University** researcher Andrzej Ruszczynski on the work.

Shima Hajimirza received two awards totaling approximately $570,000 from the **National Science Foundation** for investigations into improving the energy efficiency of thin-film solar cells and the use of computational modeling to more accurately measure the response of materials to radiation and heat.

STUDENT INNOVATION

Detecting Depression, Using AI

Stevens-developed system scans written text for hallmarks of depressed mood

An experimental AI appears to detect depression with very high accuracy by analyzing content such as social media posts.

Fulbright recipient Rida Zainab M.S. '20 co-created the system with electrical and computer engineering professor Rajarathnam "Mouli" Chandramouli.

"Depression affects one in 15 adults each year, 300 million people worldwide," notes Chandramouli. "We believe this is a step toward making a difference."

Spotting linguistic patterns

A number of previous empirical studies had demonstrated how certain linguistic characteristics can be correlated to likely symptoms of depression and possibly predict self-destructive behavior. Depressed writers use disproportionately more words describing sadness, for example, and also display increased self-focus and thrill-seeking when writing.

Leveraging those prior insights, Zainab then developed a novel algorithmic system to scan written text and score the likelihood a writer is experiencing depression.

The system analyzed 16,000 passages from the popular social media platform Reddit, selected for its lengthy text passages and author anonymity. The AI was able to accurately predict when a writer carried depressive affect nearly 90% of the time in early tests.

Potential applications include unobtrusive mental health assessment technologies that could potentially be used in counseling or intervention, say the researchers. The work was presented at the Association for Computing Machinery's annual Knowledge Discovery and Data Mining (KDD) Workshop on Designing AI in Support of Good Mental Health.

ABOUT STEVENS

Stevens Institute of Technology is a premier, private research university situated in Hoboken, New Jersey, overlooking the Manhattan skyline. Since our founding in 1870, technological innovation has always been the hallmark and legacy of Stevens' education and research. A range of academic and research programming spanning business, computing, engineering, the arts and other fields actively advances the frontiers of science and leverages technology to confront our most pressing global challenges. Stevens is home to two national research centers of excellence as well as interdisciplinary research programs in artificial intelligence and cybersecurity; data science and information systems; complex systems and networks; financial systems and technologies; biomedical engineering, healthcare and life sciences; and resilience and sustainability. Stevens is currently in the midst of executing a 10-year strategic plan, *The Future. Ours to Create.*, which is growing and transforming the university, further extending the Stevens legacy to create a forward-looking, far-reaching institution with global impact.

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INNOVATION APPLIED

Preventing Ozone Loss, Converting Toxics

The U.S. forest products industry uses approximately 10 million tons of methyl bromide annually as a fumigant to treat wood and kill wood-boring insects and larvae before export.

About half of this gas is released into the atmosphere irretrievably during or after fumigation. Although it is a human neurotoxin, the chemical is also used worldwide to treat soil, fruits and vegetables.

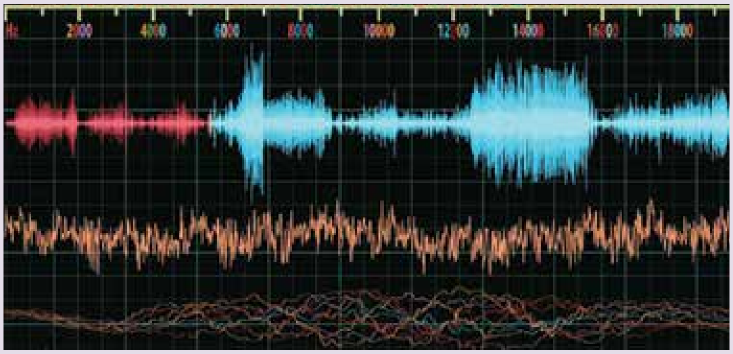
To address the impact on human health and the environment, Stevens is collaborating with a forest products partner to capture the ozone-depleting gas. In addition to slowing the growth of the ozone hole in Earth's atmosphere, the process could benefit the food and chemical industries.

Professor Adeniyi Lawal developed a novel method to transform methyl bromide into less harmful, more commercially valuable by-products. Working with corporate partner Patriot Hardwoods and doctoral student Lin Zhou Ph.D. '17, he designed a system that recaptures residual gas after wood treatment.

The recaptured methyl bromide is mixed with a solution of metallic hydroxide and alcohol buffers in a scrubber system. The compound reacts with the hydroxide, forming harmless potassium bromide; unused metallic hydroxides and alcohol by-products are then recycled through the scrubber system.

The potassium bromide can be separated, stored and sold for use in applications ranging from medicine to photography.

The process is being reviewed for patent protection, says Lawal.



$3.3 Million Contract to Develop Harbor, Maritime Security

Stevens' STAR (Sensor Technology & Applied Research) Center has signed a $3.3 million contract with security firm iModalGround to inform development of a widely available underwater security system.

Research supported by the award will continue the development of a patented acoustic system that can detect, classify and monitor intruders in harbors, on rivers and lakes and in the open ocean. The system is built upon the patented Stevens Passive Acoustic Detection System (SPADES) technology.

The new collaboration will adapt the technology for commercial uses. Acoustic data collected by sensors will be processed using classification algorithms and libraries, facilitating real-time alerting capabilities and providing a novel solution for detecting both underwater and surface threats.

"This underwater acoustic sensor system prototype will meet the needs of the private sector and may be used across all industries including tourism, transportation and logistics," notes STAR Center Director Hady Salloum.