STEVENS INSTITUTE of TECHNOLOGY
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IMPACT

The research newsletter of Stevens Institute of Technology Fall 2020

Responding to COVID-19

Novel lung therapies, mask nanotechnology, ventilators among recent Stevens innovations

As the COVID-19 pandemic continues worldwide, Stevens researchers have shifted into high gear, designing and testing therapies, devices and systems to assist. Ongoing and new efforts include research in disease treatment, filtration technology, ventilator technology and social media analysis.

Injectable therapies, lung regeneration

A number of Stevens' efforts focus on treatments for those in respiratory distress, including from COVID-19.

Supported by the National Institutes of Health, researcher Carrie Perlman is investigating sulforhodamine B (SRB) as a novel therapeutic candidate. While the mechanism of the compound's action is not yet fully understood, two investigations by Perlman's team found the injections lowered surface tension, reduced ventilation injury and improved oxygenation in model systems.

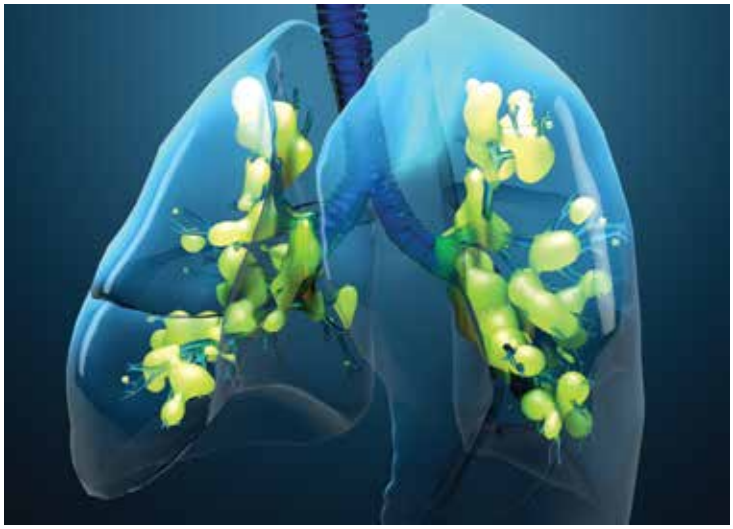
SRB injections provide a potentially safer alternative to existing medical surfactants, which are administered via the trachea, reports a forthcoming study accepted for publication by the *Journal of Applied Physiology*.

Stevens biomedical engineer Jinho Kim works to improve the regeneration of donor lungs, 80% of which are unsuitable for transplant. Kim's method replaces damaged lung cells with healthy epithelial cells, improving tissue function and quality. To enhance the process, Kim also devised a novel robotic bronchoscope.

Postdoctoral researcher Alcendino Jardim-Neto created a novel tubing circuit to connect multiple patients to single ventilators. The devices can be built for $50 or less per unit.

Enhanced filtration, AI

Another team works to enhance mask technologies, using novel nanotechnology. Most N95 masks are manufactured of polypropylene molten in an extruder, shaped into strands and stretched into fibers by hot air. However, the process presents a challenging bottleneck during outbreaks: machinery is complex and time-intensive to build, install and replace.



Vice Provost for Research and Innovation Dilhan Kalyon is developing nanofibrous membrane meshes that may prove more effective at protecting against viral particle transmission. His team's novel twin-screw extrusion and electrospinning process has been demonstrated as highly effective for engineering tissue scaffolds, implants and catalytic meshes.

Antiviral materials can also be incorporated into the meshes. In one prototype produced by Kalyon's group for catalysis applications, nanoparticles of silver, gold, platinum and palladium were deposited on nanotubes as small as 20-30 nanometers wide. The method was previously described in *Nanoscale* (2014, 6: 8527-8530); Kalyon's team is applying for patent protection for the process.

Researchers are responding to COVID-19 on other fronts as well. Two COVID-focused hackathons attracted participation from leading industry and academic institutions including MIT, Harvard University, Stanford University, Facebook and Mount Sinai Hospital.

Artificial intelligence and systems experts continue analyzing data and developing AI to pinpoint hotspots and study quarantine conditions. Stevens also launched two new symposia focused on the pandemic.

INSIDE HIGHLIGHTS:

stevens.edu/research

Harvesting Clean, Renewable Energy from Waves

DOE backs design, testing of generators that ride the sea

A Stevens effort supported by the U.S. Department of Energy is expected to produce breakthrough technology for generating electric power from the world's ocean waves.

Lead investigator and Davidson Laboratory director Muhammad Hajj believes the technology will be ready for off-grid applications within five years.

"The right device could be a game-changer for renewable energy," he says.

Novel designs, converters, electronics

The team, working with Virginia Tech and Resolute Marine Energy (RME), will bring several innovations to wave-harvest technology.

Generation devices typically consist of large, wide platforms moored to the sea floor, riding passing waves. Flaps are oscillated by wave action, turning a generator.

Hajj's team will optimize the spacing, orientation and control of the flaps, maximizing the energy generated while also enhancing stability. The platform's power takeoff system will also be upgraded with a controllable motion rectifier that converts the irregular motions of waves into steady, unidirectional generator rotation.

Preliminary calculations indicate the new designs could double the energy-capturing surface of units while reducing generation costs, or LCOE, by 40% and also reducing the variability of the power generated.

Stevens' leading-edge Davidson Lab wave tank will be used to analyze a scaled-down version of the device prototype and test hydrodynamic designs.

NSF Greenlights Fintech Center

Stevens to lead; Georgetown, RPI, UBS among participants

The National Science Foundation has selected Stevens Institute of Technology's School of Business to create and lead the nation's first Industry-University Cooperative Research Center (IUCRC) with a focus on the science of financial technology.

The initial project will operate for one year and draw in additional experts from disciplines including computer science, information systems and mathematics.

"Our faculty have done incredible work in topics like optimization, portfolio structuring, asset valuation and AI and machine learning," said Gregory Prastacos, dean of Stevens' business school, noting industry participation will be robust.

"The IUCRC will not only help us bring our work to the companies that would benefit from these insights, it also gives us another channel to engage industry and better understand the unique challenges they face."

Topics of inquiry will include cybersecurity, high-frequency market automation, technology risk and regulation, commercialization, and applications of the blockchain, quantum computing, natural language processing and artificial intelligence to the finance industry.

"Finance wasn't previously viewed as a science field," noted Stevens professor George Calhoun, who will co-direct the initiative. "Now markets are high tech and very dependent on new and emerging technology."

Science Is More Important Than Ever

I think it is fair to say that the current academic year is one of the most challenging of our professional careers. The balancing of public health concerns with the educational needs of our students and the need to begin, continue or complete our existing research cannot be easy for leadership.

But we can take comfort in the fact that research by talented investigators continues to emerge worldwide — both to directly address the COVID-19 crisis and to confront many other societal challenges. Some of this research has taken place virtually, some in laboratories. Some of it has been conducted on campus, some of it is being done from our homes.

I have seen both types of research continue here at Stevens, and I cannot thank our own faculty enough for continuing to focus on research, serve our students and advocate good science.

In this issue of IMPACT, you will read about Stevens' response to COVID-19, including a novel lung injection therapy, advances in filter nanotechnology, a lower-cost ventilator system and a new method of rehabilitating donor lungs for transplant.

You will also read about a number of exciting Stevens applications of artificial intelligence. Indeed, the university will welcome a new director of our Stevens Institute of Artificial Intelligence (SIAI) in January, Dr. Jason Corso, who joins us from the University of Michigan. We offer our thanks to SIAI founding director K.P. "Suba" Subbalakshmi, who has guided the institute diligently and energetically since its founding in April 2018.

Additional articles in this issue describe newly funded projects in brain injury and disease; wave energy harvesting; biofeedback; and large-software security. Please reach out to me anytime if you wish to learn more about this fine work or to collaborate in any way with Stevens.

Wishing you good health and a successful fall semester.

Dilhan M. Kalyon
Vice Provost for Research and Innovation

AI to Predict Alcohol Abuse, Intervene

A new smartphone-based sensing technology promises to predict heavy drinking episodes before they occur, paving the way for interventions. Stevens researcher Sang Won Bae developed the binge-drinking detection system with Carnegie Mellon University and the University of Pittsburgh Medical Center.

Bae's group collected data from a set of university student volunteers using the mobile sensing framework known as AWARE, including user location, motion, communications and social interaction as well as date, time, battery status and WiFi use.

Analysis revealed that subjects more likely to unlock or use phones during daytime hours were also more likely to engage in drinking heavily later. Remaining at a single location all day was also more likely to correlate with drinking. Conversely, long phone calls during a day correlated with less intense drinking that night.

Later, in pilot tests of 140 subjects over 14 weeks, an algorithm developed using these data points proved highly accurate at predicting episodes of heavy drinking.

The system may also be useful for predicting abuse of substances such as opioids or other behaviors and conditions in at-risk populations, adds Bae.

CARNEGIE, MOUNT SINAI JOIN STEVENS TO STUDY BRAIN INJURY, DISEASE

Stevens mechanical engineering researcher and Center for Neuromechanics founding director Mehmet Kurt leads a team that received $2 million in support from the National Science Foundation (NSF) in July for a series of collaborative investigations in brain science.

The initiative, "Tackling Brain Diseases with Mechanics: A Data-Driven Approach to Merge Advanced Neuroimaging and Multi-Physics," will combine novel medical imaging and analysis methods, computational modeling and mechanical testing to probe the mechanical properties of brain tissues. The team hopes to enable earlier diagnosis and prevention of neurological disorders such as stroke, traumatic brain injury and dementia.

Carnegie Mellon University professor Yongjie Zhang, Stevens professor Johannes Weickenmeier and Icahn School of Medicine at Mount Sinai neuroimaging research program director Priti Balchandani will collaborate on the work.

APPLIED SCIENCE

Sonic Biofeedback, 'Sneaker Lab' Health Technologies Advance

Two Stevens biomedical engineering faculty members continue pursuing innovations in motion control, biofeedback and rehabilitation technologies.

Researcher Antonia Zaferiou was awarded the largest CAREER award in NSF Directorate for Engineering history to support investigations of sonification, a form of biofeedback, to train older adults to improve their balance, movement and control.

Zaferiou designs wearable systems that generate sounds during movement. The sound feedback is "tuned" as people tune their movement patterns, such as turns made while walking.

"A large portion of research focuses on straight-line walking and stationary balance maintenance, but we don't always walk in a straight line or on even ground in the real world," she notes. "We are constantly maneuvering and adjusting to interact with our environments."

Currently, Zaferiou is designing a wearable sound biofeedback system to teach older adults specific balance strategies to reduce the risk of dangerous falls.

Monitoring gait, improving movement

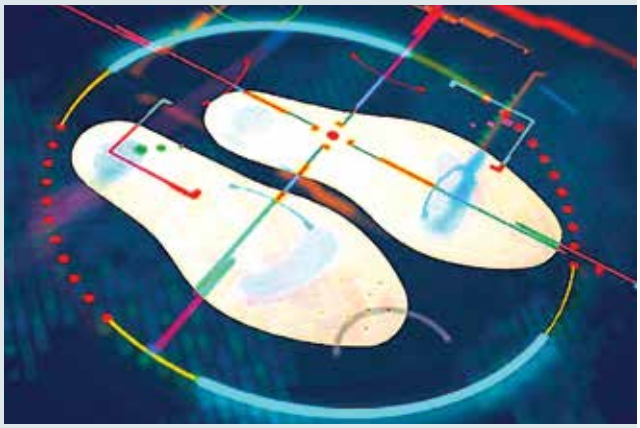
Another project, an artificial intelligence-powered smart insole, transforms footwear into portable motion-analysis laboratories.

The work, by CAREER award-winning researcher Damiano Zanotto, can precisely measure walking functions in patients with movement disorders or musculoskeletal injuries and also benefit recreational athletes. The system was described in *IEEE Transactions on Neural Systems and Rehabilitation Engineering* (Volume 28, Issue 4).

Current analysis technologies, such as camera-based motion capture systems and force plates, are expensive and impractical outside the lab, says Zanotto, director of Stevens' Wearable Robotic Systems Lab.

His team's SportSole technology uses accelerometers and gyroscopes to monitor movement and orientation while force sensors detect plantar pressure, making up to 500 readings per second — a fivefold improvement over existing wearables.

The system also incorporates AI, algorithmically extracting key parameters and data. An onboard microcontroller can deliver real-time gait analysis for instant feedback and insights useful when rehabilitating.



Zanotto's team has received provisional patent protection for the system and will work to build mobile and other applications of the technology.

NSF Awards $1.9 Million to Probe Cybersecurity

Stevens researchers have been awarded National Science Foundation (NSF) support for two new collaborative projects to investigate cybersecurity and privacy under the auspices of NSF's Secure and Trustworthy Cyberspace (SaTC) program.

Computer science researcher Jun Xu will lead one collaborative initiative with Northwestern University, "Rethinking Fuzzing for Security." The effort will work to improve methods for uncovering vulnerabilities in software that can be exploited by malicious actors; the Stevens-Northwestern group is particularly interested in large, complex software of the sort used in web browsers and server-side programs.

Xu's team will work to improve a technique known as fuzzing used to detect and test hidden vulnerabilities in complex software by making large quantities of random inputs. The team's objective: to create more intelligent, targeted testing methods.

The second SaTC project will draw upon social science perspectives to investigate issues of privacy and bias in the learning models that underpin many current artificial intelligence systems.

Xu, computer scientist Wendy Wang and social scientist Yu Tao will collaborate on "Privacy for All: Ensuring Fair Privacy Protection in Machine Learning." The Stevens team will explore weaknesses and biases in cyber defenses.

NEWS & NOTES

Christos Christodoulatos and the **Center for Environmental Systems** were awarded $3 million from the **Department of Defense** (DoD), via the U.S. Army's Combat Capabilities Development Command, to pursue a two-year project, "Industrial Base Resilience Initiative," at DoD munitions facilities.

Nick Parziale was awarded $1.2 million by the **Office of Naval Research** (ONR) Multidisciplinary University Research Initiative for collaborative investigations with the **University of Minnesota** on hypersonic travel. The project, "Particulate and Precipitation Effects on High-Speed Flight Vehicles," aims to advance understanding of hypersonic flows and materials' responses in Earth's atmosphere. Parziale's group will focus on hypersonic wind tunnel experimentation and light-gas-gun experiments.

Parziale and **Brendan Englot** received prestigious **Young Investigator Program (YIP)** awards from the **ONR** totaling approximately $1 million. Parziale will perform research to measure transitional and turbulent hypervelocity air flows, while Englot will investigate robot mapping artifical intelligence applications.

Jinho Kim co-authored "Xenogeneic cross-circulation for extracorporeal recovery of injured human lungs" for ***Nature Medicine*** (Volume 26, pp. 1102–1113), describing new methods of rehabilitating donor lungs. **Columbia University** and **Vanderbilt University** researchers contributed as well.

Johannes Weickenmeier received approximately $425,000 from the **National Institutes of Health** (NIH) to support continued investigations into the toxic proteins that contribute to neurodegenerative disease.

Mehmet Kurt also received approximately $475,000 from the **NIH** to collaborate with **Mount Sinai Hospital** on a project, "Cross-correlation of biomechanical, connectomic, and pathologic markers in Alzheimer's disease at 7T MRI," aimed at improving diagnosis of the disease.

Athula Attygalle co-authored "Biosynthetic origin of benzoquinones in the explosive discharge of the bombardier beetle *Brachinus elongatulus*" in *The Science of Nature* (Volume 107; article 26) about the chemical processes of a toxin produced by the insect. **University of California, Berkeley** and **University of Arizona** researchers also contributed alongside the Stevens team.

EH Yang co-authored "Enabling room temperature ferromagnetism in monolayer MoS_2 via in situ iron-doping" for ***Nature Communications*** (Volume 11, article 2034). **RPI**, Columbia, **Brookhaven National Laboratory** and **University of Rochester** researchers also contributed.

Examining Risks, Benefits of Flood Defenses

As Hurricane Sandy battered the New York City metro area in 2012, 18 fatalities occurred on Staten Island's eastern shore. A waterfront berm, intended as protection from floods and storm surges, was likely the unintended cause of some of these deaths.

That's the conclusion of a Stevens team led by researcher Philip Orton and doctoral candidate Fanglin Zhang, who published the findings in *Natural Hazards* (Volume 103, pp. 57–85).

The team used a hydrodynamic model to demonstrate how the berm forced the surge to rise 50% faster than it otherwise would have. Unintended effects on local settlements should be considered carefully when designing defenses to extreme weather and climate change, the authors concluded.

Orton also recently studied gated storm surge barriers proposed for the mouth of the Hudson River estuary. Supported by the National Oceanic and Atmospheric Administration (NOAA) and the New York State Energy Research and Development Authority, doctoral candidate Ziyu Chen co-published the investigation with Orton in the *Journal of Marine Science and Engineering* (2020, 8[9], 725).

While gated barriers would protect riverside property, the gates would need to be closed very frequently as climate change-driven sea level rise continues, they found. During smaller flood events, surges may need to be prevented using other methods; building or raising seawalls, one option, is costly and should be considered on a neighborhood-by-neighborhood basis, they noted. The University of Central Florida collaborated in the work.

Stevens Institute for Artificial Intelligence
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AI INSTITUTE NAMES NEW DIRECTOR

University of Michigan artificial intelligence expert Jason Corso will join Stevens in January 2021 to direct the growing Stevens Institute for Artificial Intelligence (SIAI), the university announced. SIAI includes more than 50 faculty researchers from all four Stevens schools.

Corso, who will assume the duties of SIAI founding director K.P. (Suba) Subbalakshmi, has spent more than 20 years investigating computer vision, video captioning, robotics and data science.

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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UNDERGRAD INNOVATION

Urban Energy Analysis

A team of four Stevens undergraduate data scientists is bringing new perspectives to urban energy flows — and receiving national recognition.

The team, mentored by Professor Philip Odonkor in Stevens' School of Systems and Enterprises, placed first and second in two categories of a national data challenge in August for their comprehensive analysis of relationships and patterns in Chicago's climate, energy usage, building stock and demographics.

The competition was sponsored by the Department of Energy's Oak Ridge National Laboratory, which supplied raw datasets on building stocks, climate and energy use.

"These are remarkable insights, given our team spent only three to four weeks on the project, partly spent learning new analysis and visualization tools," notes Odonkor.

Among the team's conclusions: the northern and southern portions of downtown Chicago differ considerably in building stock, energy usage and energy efficiency. The city also has discernible microclimates of both temperature and wind gradient that likely impact energy usage as well.

The Stevens team, consisting of undergraduates Ronald Estevez, Samantha Inneo, John Schneiderhan and Daniel Wadler, was awarded Best Lightning Talk in the conference for its two-minute presentation as well as second-best Conference Paper. More than 50 teams participated.

Secure Videoconferencing

A grandmother clicks a link on her computer browser and chats with 14 family members. An accountant in South Africa discusses finances with clients. A U.S. doctor checks in safely and remotely on a patient's recovery from COVID-19.

All use a new videoconferencing and chat software tool, SecureMeeting, developed by two Stevens undergraduate researchers under the guidance of Professor Mukund Iyengar this spring and rolled out at the height of the global health crisis to support remote office work and telemedicine.

The software was created over a period of six months by computer engineering students Andrew D'Angelo and Bryan Kyritz.

Their platform works within web browsers using WebRTC, a Javascript-based code layer that enables voice and video capabilities on a web page. Personal data is never shared with the software nor other users, and meetings are encrypted securely end-to-end throughout. For now, the software will remain free, says Iyengar.