Electrical and Computer Engineering Newsletter
Spring 2022

THE FUTURE IS WHAT WE DO

ENGINEERED FOR **WHAT'S NEXT.**

CULLEN
COLLEGE OF ENGINEERING
UNIVERSITY of HOUSTON

Letter from the Chair

Dear Colleagues,

I am excited to share our department's progress and introduce some of the novel work to come out of our research labs in the last six months. From self-assembling robots to improved wireless communications across 5G networks, there is no shortage of exciting work going on at UH ECE. We are a very future-focused department, and our faculty continue to receive global acclaim. With 3 National Academy of Engineering faculty, multiple society fellows and most recently, a newly inducted foreign member of the Chinese Academy of Engineering, it is no wonder why we continue to produce such revolutionary work. I hope that you enjoy reading through this sampling of our recent research, and if any of these projects strike your fancy, do not hesitate to reach out to me about collaborative opportunities. Let us continue working towards creating a better, more dynamic future!

Warm Regards,

Badri Roysam, Ph.D
Member, ECEDHA Board of Directors
Hugh Roy and Lillie Cranz Cullen University Professor & Chair
Electrical & Computer Engineering Department
University of Houston

UH ECE **BY THE NUMBERS**

DEGREES AWARDED *(FALL 2021)*

131 B.S.

57 M.S.

19 Ph.D.

ENROLLMENT *(FALL 2021)*

664 UNDERGRADUATE STUDENTS

266 GRADUATE STUDENTS

3 NATIONAL ACADEMY OF ENGINEERING **MEMBERS**

2 SOCIETY FOR AUTOMOTIVE ENGINEERING **FELLOWS**

1 OPTICAL SOCIETY OF AMERICA **FELLOW**

2 NATIONAL ACADEMY OF INVENTORS **FELLOWS**

1 AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE **FELLOW**

1 AMERICAN PHYSICS SOCIETY **FELLOW**

1 CHINESE ACADEMY OF ENGINEERING **MEMBER**

10 NATIONAL SCIENCE FOUNDATION **CAREER AWARDEES**

7 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS **FELLOWS**

1 ROYAL SOCIETY OF CHEMISTRY (UK) **FELLOW**

1 ELECTROCHEMICAL SOCIETY **FELLOW**

3 American Institute for Medical and Biological Engineers **FELLOWS**

1 INTERNATIONAL SOCIETY FOR OPTICS AND PHOTONICS **FELLOW**

ECE STUDENT SOCIETY **EARNS NATIONAL HONOR**

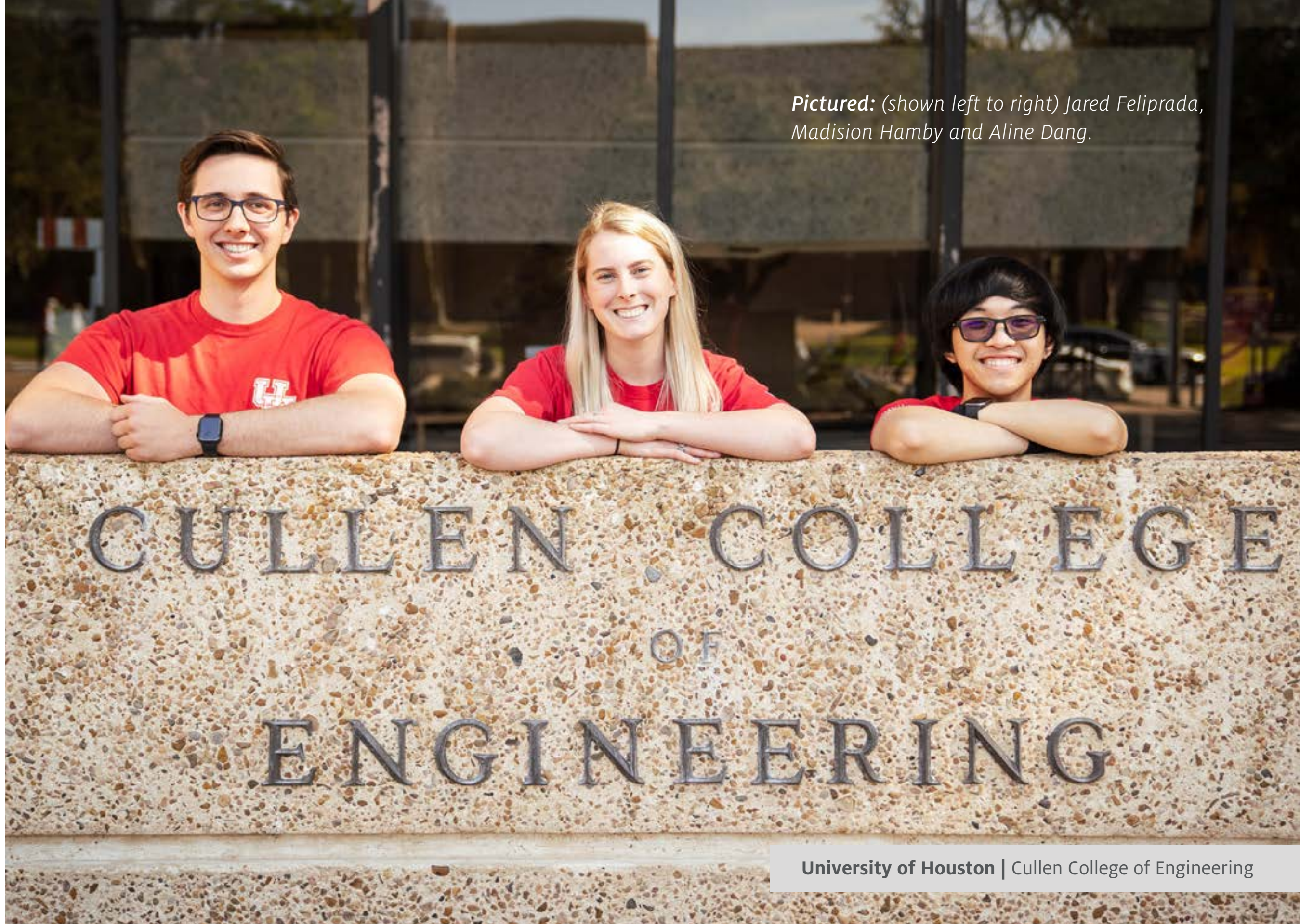
The University of Houston student chapter of Eta Kappa Nu (HKN) – the honors society for the Institute of Electrical and Electronics Engineers (IEEE) – has been selected for the 2020-21 Outstanding Chapter Award from the IEEE-HKN Board of Governors.

Madison Hamby, the group's president, was quick to praise the hard work of the group's members for the honor.

"Receiving the outstanding chapter award is a true testament to the amount of work the officers have put in over the past few years," she said. "The Epsilon Epsilon chapter was recently reinstated at UH, and the majority of our years as an organization have been virtual due to COVID-19. In order to ensure that the Epsilon Epsilon chapter succeeds at UH, the officers have always made certain that there are activities available to our members. I believe that finding ways to host fun and exciting events virtually led us to receiving the outstanding chapter award."

In addition to Hamby, Ekta Chaurasia (Vice President – External), Jared Feliprada (Vice President-Internal), Aline Dang (Treasurer), Colby Inman (Recording Secretary) and Dana Dailey (Corresponding Secretary) serve as officers.

The chapter extends an invitation to upper-level undergraduate students in Electrical and Computer Engineering, Electrical Engineering Technology, and Computer Science at the beginning of each semester. All members must be in the top fourth of the junior class or top third of the senior class. Graduate students who have completed at least one semester at UH are also welcome to join.



Pictured: *(shown left to right) Jared Feliprada, Madision Hamby and Aline Dang.*

Pictured: *Yan Yao in his research lab*

$4.4M TO DEVELOP **CLEAN ENERGY TECHNOLOGIES**

University of Houston researchers have received $4.4 million from the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) for two projects developed in the Cullen College of Engineering and Texas Center for Superconductivity at the University of Houston (TcSUH).

The funding is part of the ARPA-E OPEN 2021 program, which prioritizes financing technologies that support novel approaches to clean energy challenges. The University's two projects were among 68 from across the United States that were awarded grants totaling $175 million.

Cullen College of Engineering Professor of Electrical and Computer Engineering **Yan Yao** and his research team were awarded $3.4 million to develop a lithium and transition metal-free battery with high-energy and fast charging. Yao's battery uses magnesium anodes instead of lithium and organic materials in place of transition metal-based cathodes. The battery provides a transportation energy storage solution that could be charged quickly and comparable to state-of-the-art lithium-ion batteries.

Cullen College Assistant Professor of Electrical and Computer Engineering Harish Krishnamoorthy and his team received a $1 million grant to build gallium nitride-based miniaturized pulsed power system architecture for mission critical applications. In the near term, Krishnamoorthy's project will have a health care application. His team will build a battery-operated handheld nuclear magnetic resonance device for lab use or to perform mobile magnetic resonance imaging (MRI) measurements. Researchers from Harvard University and Schlumberger will be sub-recipients of the grant. Krishnamoorthy's colleague in UH's electrical and computer engineering department, Professor Kaushik Rajashekara is a co-project investigator on the grant.

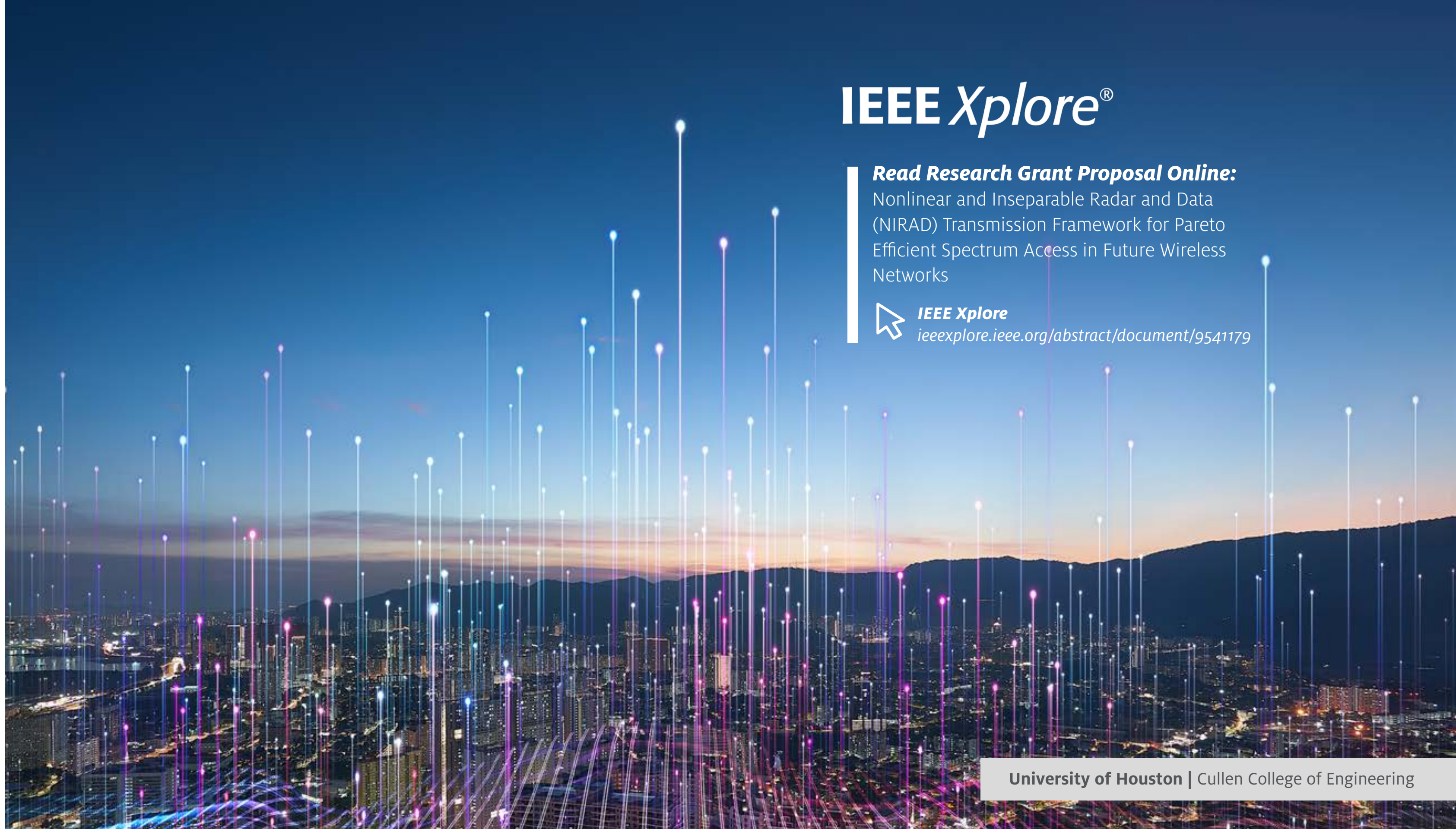
UNITING WIRELESS COMMUNICATIONS FOR 5G, 6G

AND BEYOND NETWORKS

A professor at the University of Houston's Cullen College of Engineering has received a substantial grant from the National Science Foundation to support his research into improving the energy and spectrum efficiency of wireless networks.

Zhu Han, Ph.D., Moores Professor of Electrical and Computer Engineering and a fellow of the IEEE and AAAS, is the author of the research grant proposal, "Nonlinear and Inseparable Radar And Data (NIRAD) Transmission Framework for Pareto Efficient Spectrum Access in Future Wireless Networks." The proposal was accepted and provided $249,999 in funding under the NSF's SWIFT initiative – Spectrum and Wireless Innovation enabled by Future Technologies.

According to the abstract written by Han, "The study devises a nonlinear and inseparable radar and data (NIRAD) transmission scheme, in which the functions of communications and radar sensing are integrated in the same waveform and use the same hardware. In contrast to linearly superimposed communications and radar sensing, the NIRAD scheme integrates both functions in an inseparable manner, thus allowing each to fully exploit the resources of the other."



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Read Research Grant Proposal Online:
Nonlinear and Inseparable Radar and Data (NIRAD) Transmission Framework for Pareto Efficient Spectrum Access in Future Wireless Networks

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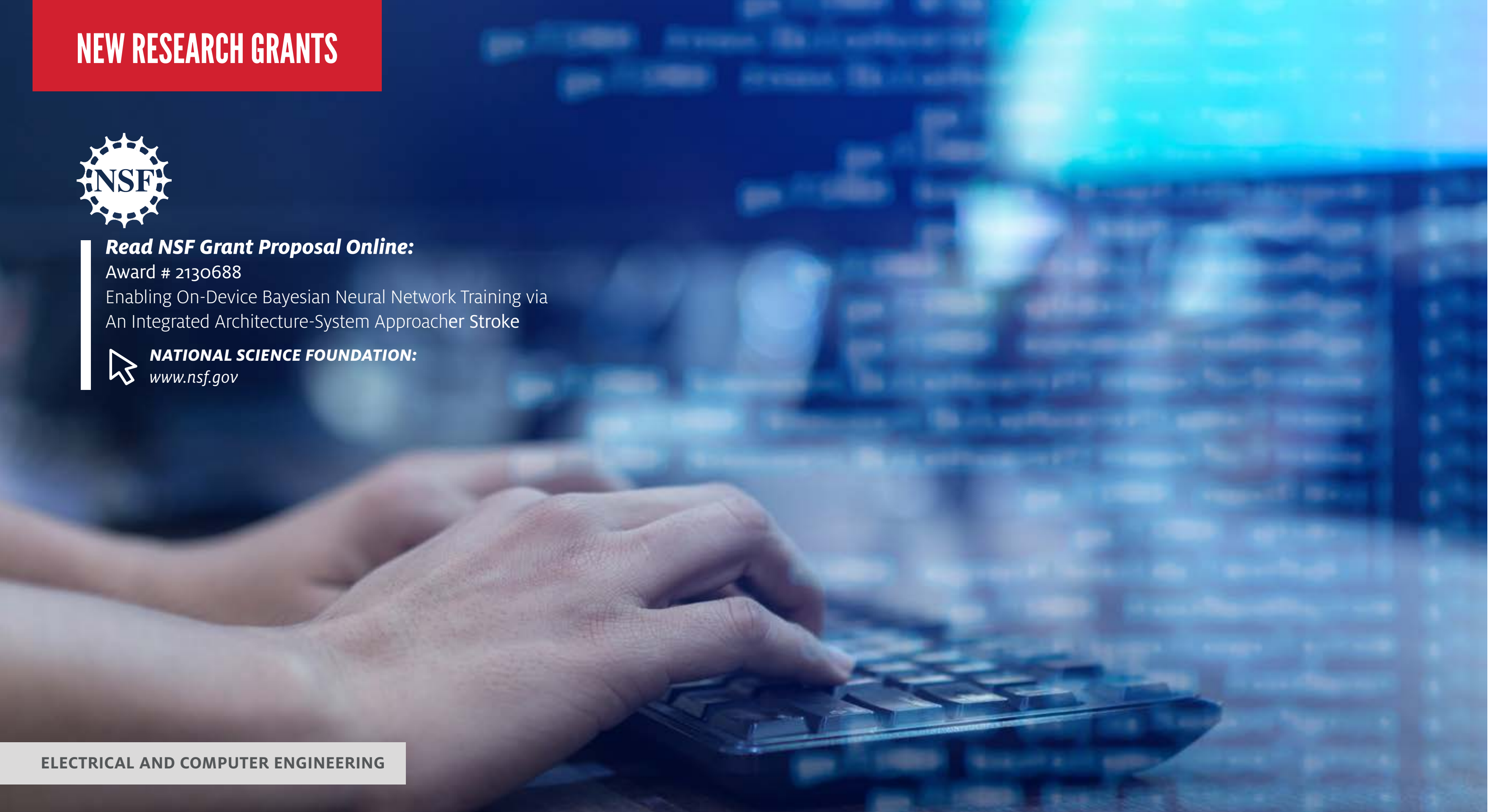


Read NSF Grant Proposal Online:
Award # 2130688
Enabling On-Device Bayesian Neural Network Training via An Integrated Architecture-System Approacher Stroke

NATIONAL SCIENCE FOUNDATION:
www.nsf.gov

IMPROVING NEURAL NETWORK ENERGY

A Cullen College of Engineering professor has received just shy of $500,000 from the National Science Foundation to study how to make the decision-making networks in devices like self-driving cars and medical imaging devices more efficient.

Xin Fu, Ph.D., an associate professor of Electrical and Computer Engineering, received $499,999 in funding for her grant proposal, "Enabling On-Device Bayesian Neural Network Training via An Integrated Architecture-System Approach."

Fu described her research as looking at ways to improve the energy needs of products that rely on machine learning, which is one of her research interests.

"This project targets at energy-efficiently training Bayesian Neural Networks (BNNs) locally on mobile devices," she said. "BNNs are generally used in real-world AI applications that request reliable and robust decision-making, like autonomous driving and medical image diagnosis. In this project, we will explore hardware-software co-designed methods to significantly reduce the computation workloads and memory accesses required by BNN training. This will enable the BNN training on the resource-constrained mobile devices."

LEGO INSPIRES
SELF-ASSEMBLING BLOCKS

As he puts it, **Aaron T. Becker**, Ph.D., an Associate Professor in the Electrical and Computer Engineering Department at the Cullen College of Engineering, is interested in finding "a new type of small-scale manufacturing method, with the precision of modules, the reusability of Legos, and the self-assembly of DNA."

Now, Becker has received a $299,963 grant from the National Science Foundation for his proposal, "Magnetically-Controlled Modules with Reconfigurable Self-Assembly and Disassembly." It is research that has grown from his initial CAREER award, and from collaborations with colleagues in Dallas and Germany.

Becker said his research is ultimately about using self-assembly and magnets to improve things like health outcomes. He used an example of self-assembly in a surgery setting, wherein a medical robot could self-assemble inside of the body, no longer requiring a large, painful incision. Becker's goal is to create small, magnetic building blocks, which can then be used to build structures and modules that can be assembled and disassembled.

Read NSF Grant Proposal Online:
Award # 2130793
Magnetically-Controlled Modules with Reconfigurable Self-Assembly and Disassembly.

NATIONAL SCIENCE FOUNDATION:
www.nsf.gov

Pictured: *Aaron T. Becker*

FEDERATED LEARNING OVER 5G DEVICES

A pair of researchers from the Cullen College of Engineering have received $500,000 from the National Science Foundation to lower energy consumption and service delay, two key components of federated learning's practical implementation in wireless networks.

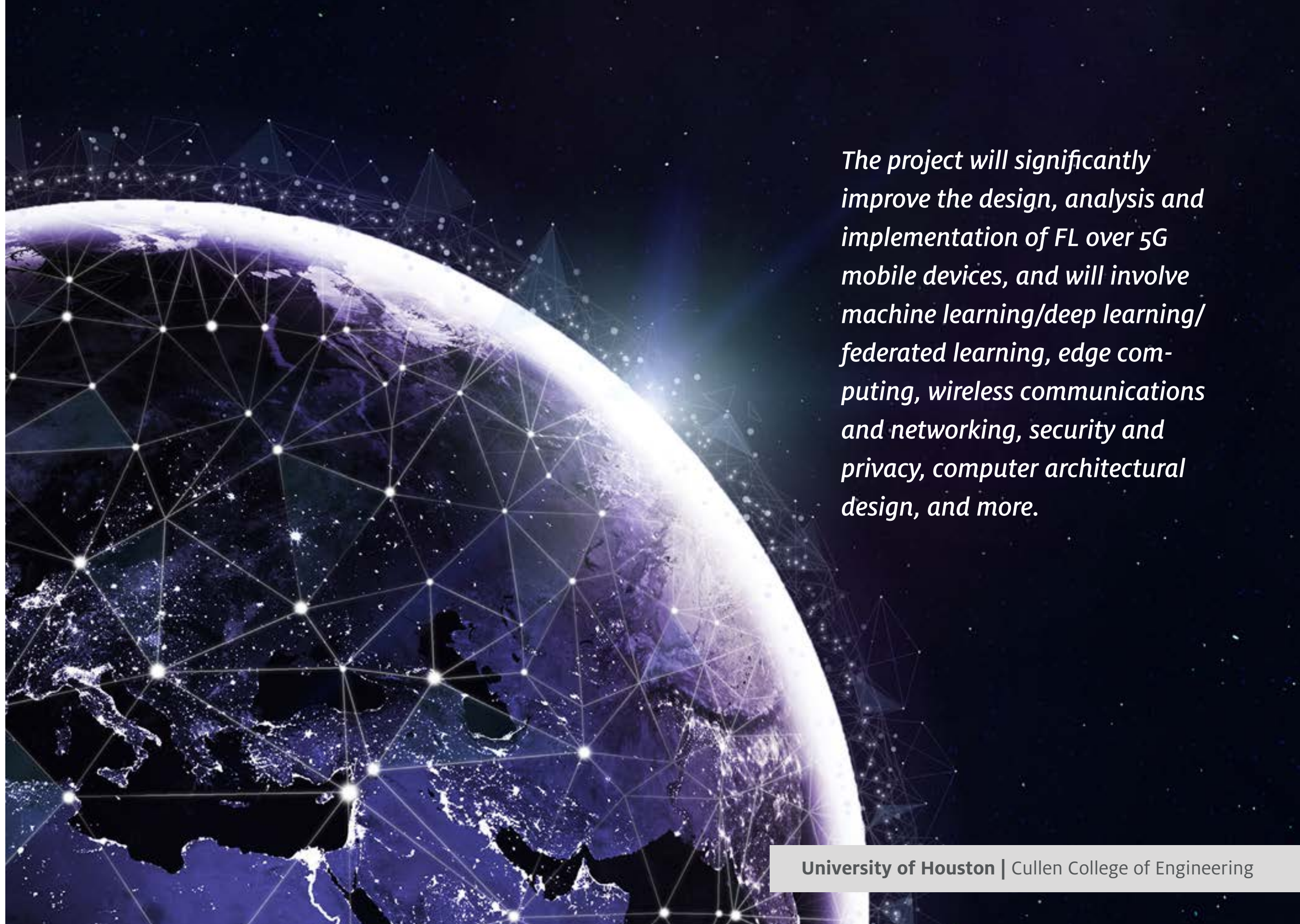
Miao Pan, Ph.D., Associate Professor of Electrical and Computer Engineering, is the principal investigator for the grant, "Towards Federated Learning over 5G Mobile Devices: High Efficiency, Low Latency, and Good Privacy." **Xin Fu**, Ph.D., Associate Professor of ECE as well, is a co-PI for the project. The funding comes from the Computer and Network Systems (CNS) Core program of the NSF for collaborative research.

According to the abstract for the grant, recent emerging FL allows data sources to collaboratively train a global model without sharing their privacy sensitive raw data. However, due to the huge size of the deep learning model, its downloads and updates generate significant amounts of network traffic which exerts a great burden to existing telecommunications infrastructures.

The project will significantly improve the design, analysis and implementation of FL over 5G mobile devices, and will involve machine learning/deep learning/federated learning, edge computing, wireless communications and networking, security and privacy, computer architectural design, and more.

Read NSF Grant Overview Online:
Award # 2107057
Towards Federated Learning over 5G Mobile Devices: High Efficiency, Low Latency, and Good Privacy.

NATIONAL SCIENCE FOUNDATION:
ww.nsf.gov



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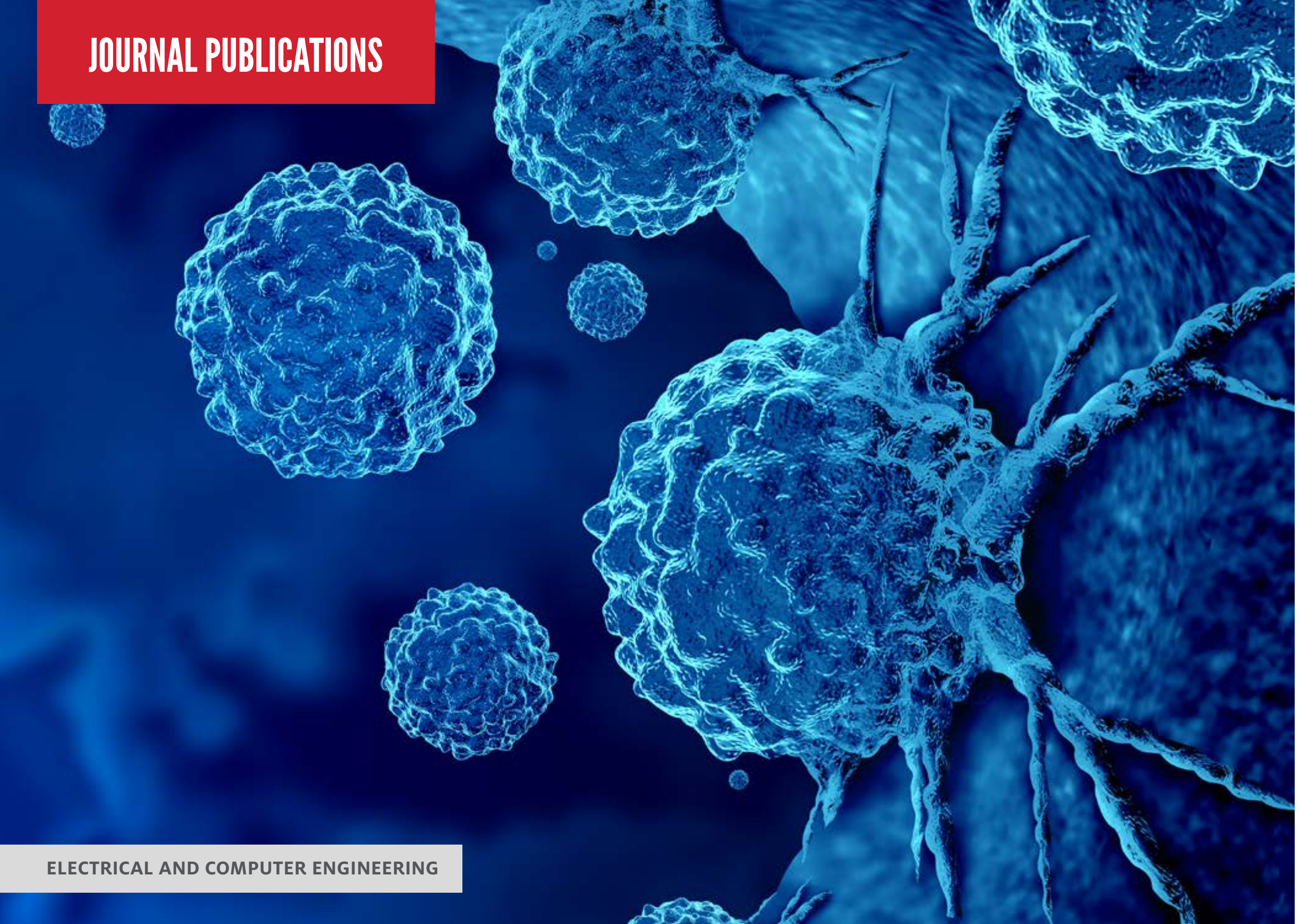


ADVANCING **RAPID CANCER DETECTION** AND MONITORING

When it comes to cancer detection, size matters. Traditional diagnostic imaging cannot detect tumors smaller than a certain size, causing missed opportunities for early detection and treatment. Circulating tumor exosomes are especially small cancer biomarkers and easy to miss. These nanovesicles are composed of molecules that reflect the parental cells. But, because they are tiny (~30-150nm in diameter) and complex, the precise detection of exosome-carried biomarkers with molecular specificity is elusive.

Until now, reports **Wei-Chuan Shih**, Ph.D., Professor of Electrical and Computer Engineering at the University of Houston's Cullen College of Engineering, in *IEEE Sensors Journal*.

"This work demonstrates, for the first time, that the strong synergy of arrayed radiative coupling and substrate undercut can enable high-performance biosensing in the visible light spectrum where high-quality, low-cost silicon detectors are readily available for point-of-care application," said Shih. "The result is a remarkable sensitivity improvement, with a refractive index sensitivity increase from 207 nm/RIU to 578 nm/RIU."

Technically speaking, Shih has restored the electric field around nanodisks, providing accessibility to an otherwise buried enhanced electric field. Nanodisks are antibody-functionalized artificial nanostructures which help capture exosomes with molecular specificity.

DEVELOPING IMAGING TECHNIQUES TO UNDERSTAND

HOW DENDRITES FORM IN BATTERIES

As the world lessens its dependence on fossil fuels, industries and manufacturers are turning to lithium-ion batteries to power the machines that make modern life possible. These batteries power electric vehicles, mobile phones, drones, vacuum cleaning robots and other machines and will be an essential component to the energy transition.

But there's a problem with lithium-ion batteries: as they age and are charged, they develop dendrites. A research team from the University of Houston is trying to solve the dendrite problem by investigating how these structures grow on batteries.

Dendrites are spiky structures that accumulate on the batteries' anodes. These structures reduce the life of the batteries, hinder their ability to hold a charge and can short-circuit machines potentially causing safety hazards like battery fires.

"By understanding how dendrites grow on batteries, we can identify chemical and physical solutions to prevent the growth of dendrites, which is necessary to develop the next generation of batteries," said **Xiaonan Shan**, assistant professor of electrical and computer engineering at UH's Cullen College of Engineering.

Shan and his team have developed a "novel in-situ" 3D microscopy to image and study the localized electrochemical environments and understand where dendrites start forming in batteries. Using the 3D microscope, small cameras and other computer imaging technology, Shan and his team were able to geometrically map out how a battery initially develops dendrites.

The findings were recently published in the journal *Advanced Energy Materials*.

REAL-TIME COVID-19 INFECTION **RISK ASSESSMENT SYSTEM**

In this pandemic era, have you ever wondered when the best time to go run an errand might be, maybe when your grocery store is the least crowded, so you could reduce the chance of being exposed to a contagious disease?

Well, there could soon be an app for that.

In fact, implementation of a real-time COVID-19 infection risk assessment and mitigation (RT-CIRAM) system is already underway in the lab of **Albert Cheng**, professor of Computer Science and Electrical & Computer Engineering at the University of Houston. Cheng presented his plans at the Institute of Electrical and Electronics Engineers (IEEE) conference HPC (High Performance Computing) for Urgent Decision Making and will publish the work in *IEEE Xplore*.

To figure out the best times to avoid crowds and accomplish activities outside the home, while minimizing the risk of COVID-19 infection, the mobile phone system will analyze up-to-date data from multiple open sources.

Pictured: *Jiming Bao in his research lab testing a new fluid that light can cut*

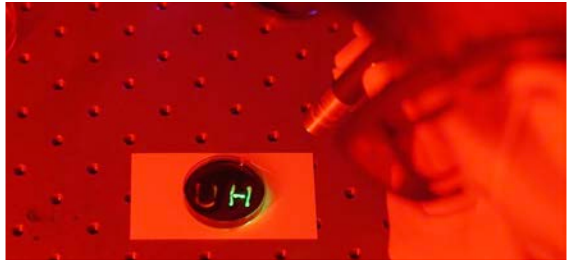
A NEW FLUID THAT **LIGHT CAN CUT**

Jiming Bao, professor of electrical and computer engineering at the University of Houston, has developed a new fluid that can be cut open by light and demonstrated macroscopic depression of ferrofluid, the kind of fluid that can be moved around with a magnet.

The new method of molding and deforming water has potential applications in adaptive optics, mass transport and microfluidics manufacturing and molding of micro and nanostructures. Weighty implications for something that can be done with a few ingredients found at home.

“New optothermocapillary fluids were created by mixing transparent lamp oil with different candle dyes. They can be cut open by sunlight and be patterned to different shapes and sizes using an ordinary laser show projector or a common laser pointer,” reported Bao in *Materials Today*. “Laser driving and elevation of optotherocapillary fluids, in addition to the manipulation of different droplets on their surface, were demonstrated as an efficient controlling method and platform for optofluidic operations.”

Optothermocapillary fluid refers to fluid in which the surface tension (capillary force) is strongly dependent on temperature, thus can be easily changed by lasers because lasers can generate a surface temperature gradient. Bao is reporting a giant depression and rupture in optothermocapillary fluids under the illumination of laser and sunlight.



Pictured Above: *Scientists in the Bao lab shaping water with lasers into a familiar shape (UH).*

BIOMED, ECE, MCGOVERN **COLLABORATION LEADS TO NEW EPILEPSY RESEARCH**

A recently published paper from a team of researchers and students from multiple departments at the Cullen College of Engineering and the McGovern Medical School at UTHealth proposes a way to provide real-time, continuous tracking for the 50 million people living with potential seizures from epilepsy world-wide.

While a drug regimen can control many symptoms of epilepsy, according to the paper's authors more than 90 percent of people with the disorder will still experience seizures. With real-time monitoring, a closed-loop system can be developed – making sure a person is only given treatment at the most effective times, to prevent or to cut off seizures.

The research was truly a collaborative effort between multiple departments at the college and outside of it, as the paper has nine listed authors, eight of which are at UH.

The senior author of the paper is **Rose T. Faghih**, Ph.D., Assistant Professor of Electrical and Computer Engineering, and a member of the BRAIN Center. The first author for the paper is **Alexander Steele**, a doctoral student of **Jose Luis Contreras-Vidal**, Ph.D., Hugh Roy and Lillie Cranz Cullen Distinguished Professor and Director of the NSF IUCRC BRAIN Center. Steele and fellow student author Sankalp Parekh wrote the paper as part of a course, "State-Space Estimation with Physiological Applications," taught by Faghih.

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Read Journal Publication Online:

A Mixed Filtering Approach for Real-Time Seizure State Tracking Using Multi-Channel Electroencephalography Data

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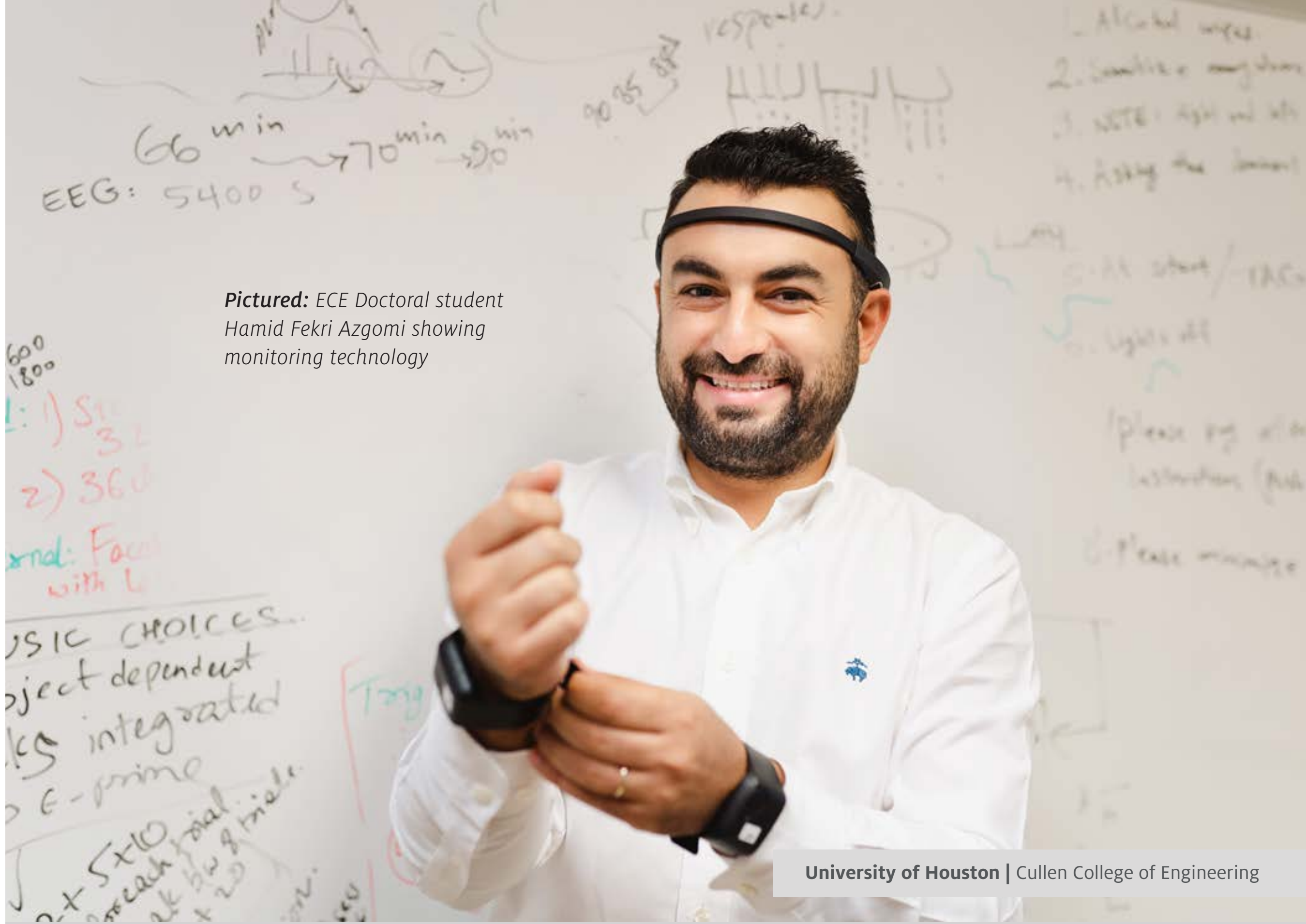
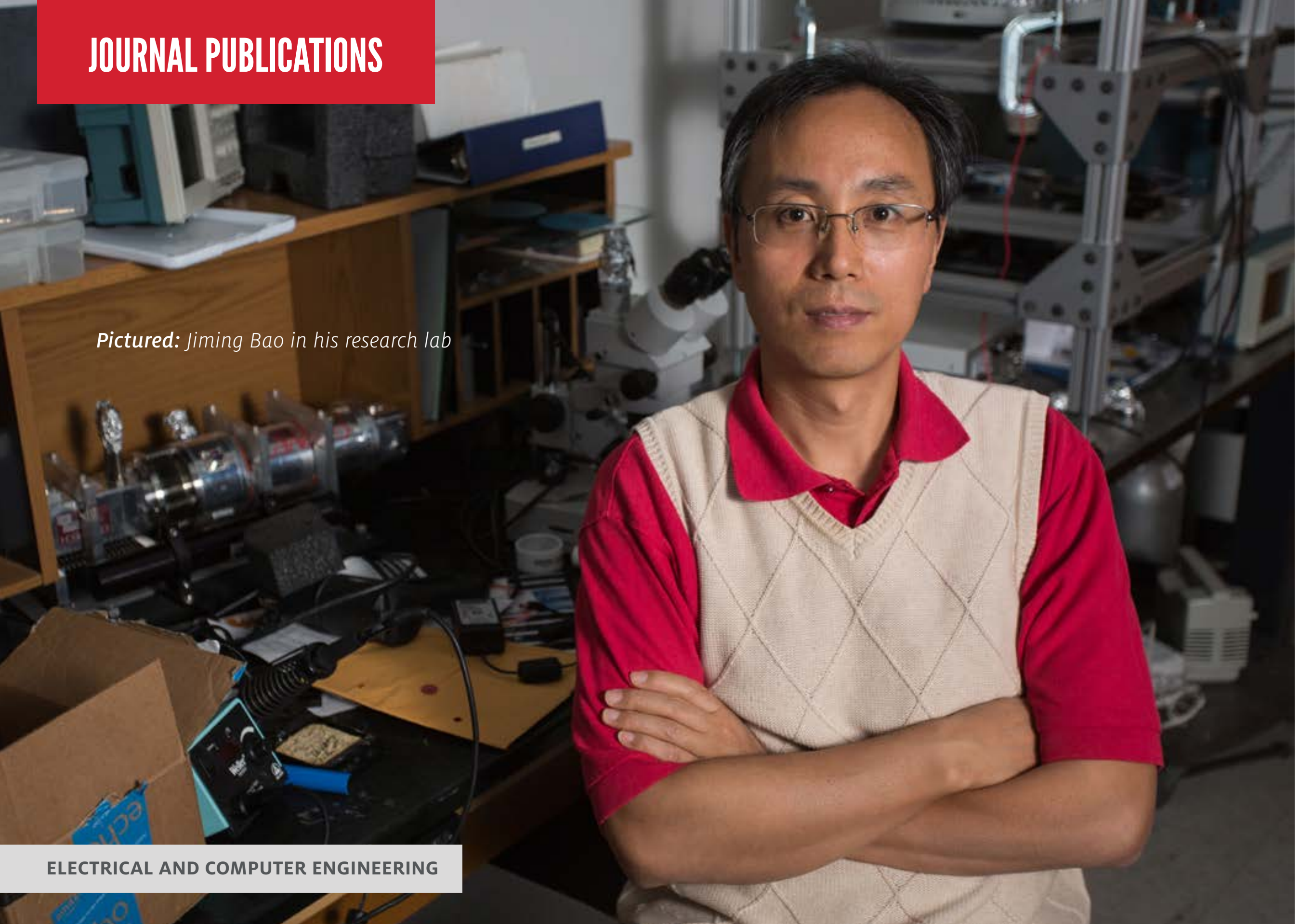
ieeexplore.ieee.org/abstract/document/9541179



Pictured: *ECE Doctoral student Hamid Fekri Azgomi showing monitoring technology*



Pictured: *Jiming Bao in his research lab*

A METHOD TO CREATE UPWARD WATER FOUNTAIN IN DEEP WATER

A pair of University of Houston engineers have discovered that they can create upward fountains in water by shining laser beams on the water's surface and have published their research in *Materials Today Physics*.

Jiming Bao, professor of electrical and computer engineering at UH, and his postdoctoral student **Feng Lin**, attribute the finding to a phenomenon known as the Marangoni effect, which causes convection and explains the behavior of water when differences in surface tension exist.

Inspired by his previous work, the successful simulation of inward surface depression in a shallow liquid, Bao increased the depth of ferrofluid in his current simulation. Ferrofluid is a so-called "magic" liquid and is best known for its astonishing surface spikes generated by a magnet.

"Understanding the distinct surface deformation in liquids with different depths helps unravel the dynamics of the surface deformation process," said Bao.

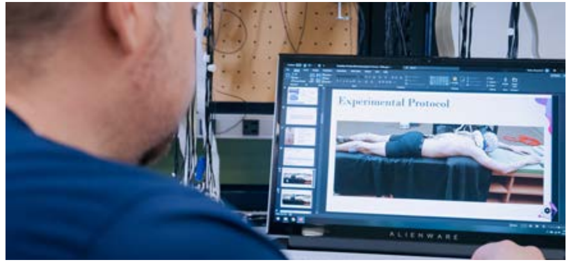
Bao used a low-power (<1 W) continuous-wave laser beam to create a non-uniform surface temperature field to induce the Marangoni effect. To understand the distinct deformations between deep and shallow liquids, he varied the liquid layer thickness while keeping the laser beam the same. The laser fountains and the depth-dependent transition from surface indentation to laser fountain have never been reported in literature, probably because they are not anticipated by any existing theory.

MADE OF STEELE: BRINGING PARTNERSHIPS TO PROSTHETICS

In August 2018, former active duty Marine, **Alexander Steele**, joined UH ECE Professor Jose "Pepe" Luis Contreras-Vidal's lab as a National Science Foundation Veteran Research Fellow. Contreras-Vidal is the Hugh Roy and Lillie Cranz Cullen Distinguished Professor and the director of the NSF IUCRC BRAIN Center at the Cullen College of Engineering. The following year, Steele was chosen as a University of Houston and Houston Methodist Research Institute Graduate Fellow In Translational Research. As a result, he also works in the Neuromodulation and Recovery lab led by Dr. Dimitry Sayenko, which is how he met Dr. Amir Faraji, a neurosurgeon.

Steele served as the connective tissue for the two to then submit a research proposal to the TIRR Foundation for Mission Connect. "Decoding the language of the spinal sensorimotor networks using non-invasive electrospinography" received a $150,000 grant from the program in October 2021.

Ideally, the partnership will allow each professional to offer their expertise to the other, in order to improve patient outcomes and research potential. For example, sensors employed by Contreras-Vidal could give insight into how the brain is responding — or not — following a severe spinal cord injury. On the other side of the equation, Faraji is a surgeon that can provide direct feedback from patients about what rehab devices are practical and needed, and how patients are responding to them. Steele joked that he was the "spinal cord" of the pairing, in a way.



Pictured Above: *Steele shows a proposal for using surface EMG sensors on the spine to decode the language of spinal sensorimotor networks to improve outcomes for patients experiencing spinal cord injuries.*

Pictured:
Alexander Steele

FACULTY

ACCOLADES

KAUSHIK RAJASHEKARA

ELECTED

2022

CHINESE ACADEMY OF ENGINEERING (CAE) MEMBER

for his 18+ years of visits and lectures in China

AWARDED THE

2021

IEEE MEDAL FOR ENVIRONMENTAL AND SAFETY TECHNOLOGIES

by the Institute of Electrical and Electronics Engineers

Kaushik Rajashekara, a Distinguished Professor in the Electrical and Computer Engineering Department at the Cullen College of Engineering, has gained another prestigious membership affiliation, thanks to his visits and his lectures in China, which started about 18 years ago.

The Chinese Academy of Engineering (CAE) is the highest honorary and advisory academic institution in that nation's fields of engineering sciences and technology, with prestige similar to the U.S. National Academy of Engineering (NAE). Rajashekara was elected for the CAE, which is the highest academic title in China.

Rajashekara served as the chief technologist for Electric Power & Control Systems at the Rolls-Royce Corporation from May 2006 through 2012, before transitioning into a Distinguished Professor of Engineering role at the University of Texas at Dallas from August 2012 through August 2016. Rajashekara joined the Cullen College of Engineering in September 2016.

In addition to his membership in the CAE, Rajashekara is also a member of the NAE (2012) for contributions to electric power conversion systems in transportation, and a Fellow of the U.S. National Academy of Inventors (2015). He is also a Foreign Fellow of the Indian National Academy of Engineering (2012).

In 2019, the Institute of Electrical and Electronics Engineers' Power Electronics Society presented him with the inaugural Vehicle and Transportation Systems Achievement Award. This was followed by the IEEE Medal for Environmental and Safety Technologies in 2021.

FACULTY

ACCOLADES

ZHU HAN

PLACED IN THE
2021
HIGHLY CITED RESEARCHERS™ RANKING

Cited 52,947 times (Google Scholar) and 37,933 citations since 2016

AWARDED THE
2021
KIYO TOMIYASU AWARD

from the Institute of Electrical and Electronic Engineers

Each year, Clarivate identifies the world's most influential researchers – the select few who their peers have most frequently cited over the last decade. In 2021, 6,602, or about 0.1 percent, of the world's researchers, in 21 research fields and across multiple fields, have earned this exclusive distinction. Of the total, 3,774 are recognized in specific fields and 2,828 for cross-field performance.

The 2021 Highly Cited Researchers™ ranking includes University of Houston researcher **Zhu Han**, Moores Professor of electrical and computer engineering.

Han has been cited 52,947 times, according to Google Scholar, with 37,933 citations since 2016. He has an H-Index of 91 in the past five years. His research is primarily in the fields of game theory, wireless networking and security, data analysis, and smart grid technology. He was the 2021 recipient of the Institute of Electrical and Electronic Engineers' Kiyo Tomiyasu Award.

He was pleased to be recognized by Clarivate again, first qualifying for the ranking in 2017, and earning the distinction every year since.

CULLEN COLLEGE

The University of Houston
Cullen College of Engineering

The University of Houston Cullen College of Engineering addresses key challenges in energy, healthcare, infrastructure and the environment by conducting cutting-edge research and graduating hundreds of world-class engineers each year. With research expenditures topping $40 million and increasing each year, we continue to follow our tradition of excellence in spearheading research that has a real, direct impact in the Houston region and beyond.

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The Future

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