ELECTRICAL & COMPUTER
Engineering Magazine

ece connections

UNIVERSITY OF HOUSTON | DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING FALL 2013

A Message from THE CHAIR

Badri Roysam
Department Chair

Welcome to the first-ever issue of ECE Connections, a brand new magazine from the Electrical and Computer Engineering (ECE) Department at the UH Cullen College of Engineering.

In naming this publication, we were inspired by many ideas, but one word stood out: connections. Interestingly, we were not just thinking of electronic connections. We were thinking of connections between faculty, staff, students, and alumni. Connections between classroom lessons and the real-world application of these lessons. Connections between engineers and dancers. Connections between robots and humans. Connections between cutting-edge researchers and patients. Connections between education, industry, government, and our communities. These are the things of which I am most proud.

ECE students and faculty are often presented with unique and valuable opportunities as a result of these connections. Whether it's in the form of ambitious research collaborations or an international exchange program, ECE students and faculty are "making the connection!"

At the Cullen College of Engineering's ECE department, we aren't just educating the next generation of globally competitive engineers – we are leading the field of electrical and computer engineering with new areas of research, national and international alliances in experimentation and education, and partnerships with industry and government. We share some of these stories in this issue of ECE Connections. Enjoy!

Please feel free to drop me a line at broysam@uh.edu

Visit the ECE department website at www.ee.uh.edu.

Badrinath Roysam

Dr. Badri Roysam
ECE Department Chair
Hugh Roy & Lillie Cranz Cullen Professor

Your support matters! Gifts to the UH department of Electrical and Computer Engineering help fund much-needed scholarships for our students, help us renovate our labs and facilities to be competitive with other Tier-One programs, and help us support the activities of our student organizations. Thank you for continually helping us meet these needs! Give online at https://giving.uh.edu/eng

UH ELECTRICAL & COMPUTER Engineering Magazine

UH Electrical & Computer Engineering Magazine is published by the University of Houston Cullen College of Engineering, Office of Communications.

Director	Audrey Grayson
Editor	Esmeralda Fisher
Contributing Writer	Toby Weber
Graphic Designer	Rachel Ward
Photography	Audrey Grayson Rachel Ward Nine Nguyen Thomas B. Shea

Contact ECE:

Phone	713.743.4500
Email	news@egr.uh.edu
Website	www.ee.uh.edu

Office of Communications
Cullen College of Engineering
University of Houston
E301 Engineering Bldg. 2
Houston, Texas 77204-4009

Phone: 713-743-4220
Fax: 713-743-8240

UNIVERSITY of HOUSTON
CULLEN COLLEGE of ENGINEERING

FEATURES

The Neural **NETWORK**

The Neural Network

Reverse-Engineering the Brain

by Toby Weber

The adult human brain has roughly 100 billion neurons connected by anywhere from 100 trillion to 500 trillion synapses. Another 100 billion to 500 billion glial cells exist in the brain to support neural activity.

These numbers reveal a simple fact: the human brain is more complex than the world's most advanced supercomputer – more advanced than anything humans have ever built, really.

President Barack Obama announced last April that a $100 million initiative was launched to uncover the "enormous mystery" of the human brain in hopes of increasing understanding and treatment of brain disorders. But while the push to understand the staggering complexities of the human brain has only recently become a political priority, for years a network of electrical and computer engineering (ECE) researchers at the University of Houston Cullen College have been investigating exactly how the brain works – and continue to make enormous strides.

Today, their efforts include understanding the effects of binge drinking and exercise on the brain, working to understand how the brain processes sensory information, and developing the next-generation of neural probes. Their efforts will help reveal the guiding principles organizing the billions of cells and trillions of connections that make up the human brain, making one of the world's most powerful instruments an even more powerful tool for advancing science and improving human lives.

Pictured: Badri Roysam and Leigh Leasure discuss imaging results.

PARTY, EXERCISE, REPEAT: Can Exercise Protect the Brain From the Effects of Binge Drinking?

If you've ever lived through a hangover, you are probably already familiar with the unpleasant, lingering side effects that a night of binge drinking can have on the brain: when you wake up the next day, the sunlight seeping through your window burns your retinas, your brain feels like it's coated with goo and it's impossible to focus, let alone think.

But what if hitting the gym prior to hitting the bars could make your hangover the next morning a little less painful? Or, at the very least, what if exercise has a neuro-protective effect, reducing the negative (and oftentimes long-term) effects that binge drinking has on the brain? That's what ECE chair Badri Roysam is trying to find out in a research collaboration with a UH psychology faculty member.

The collaboration with associate professor Leigh Leasure involves the analysis of 3-D images of brain tissues from animal models using Roysam's FARSIGHT software suite. This is a quantitative histopathology tool that can be used to analyze tissue images to identify and quantify cell and tissue alterations caused by binge alcohol consumption, pre- and post-binge exercise, and potential protective drug treatments.

While Leasure has spent much of her career studying the brain in different states and its response to different stimuli, FARSIGHT will enable investigations that are much broader as well as much deeper. While many of her earlier research efforts had to target specific cell or tissue types, "the power of FARSIGHT is to get very precise measurements on many different tissue parameters. We can look at everything from the size of neurons, the number of glia, and the proximity of glial cells to vasculature," she said.

In addition, "we can do hypothesis testing. We can look and see if what we think is going to happen is actually happening. And we can do exploration. What else is going on that we don't know about? We've never had the potential to look at things in a global fashion before."

While their initial work will focus on alcohol and exercise, Leasure and Roysam plan to expand their collaboration to include the study of multiple brain states, including neurodegenerative diseases and aging.

One particular area of interest in all these studies will be the brain's blood vessels and its glial cells, which help maintain chemical balance in the brain and aid in communication among neurons. The glial-vascular complex, said Leasure, is key to supporting the health of neurons. And since glia and vasculature regenerate (while neurons typically don't) they should in many ways be easier to influence, making them good targets for future therapies and medications.

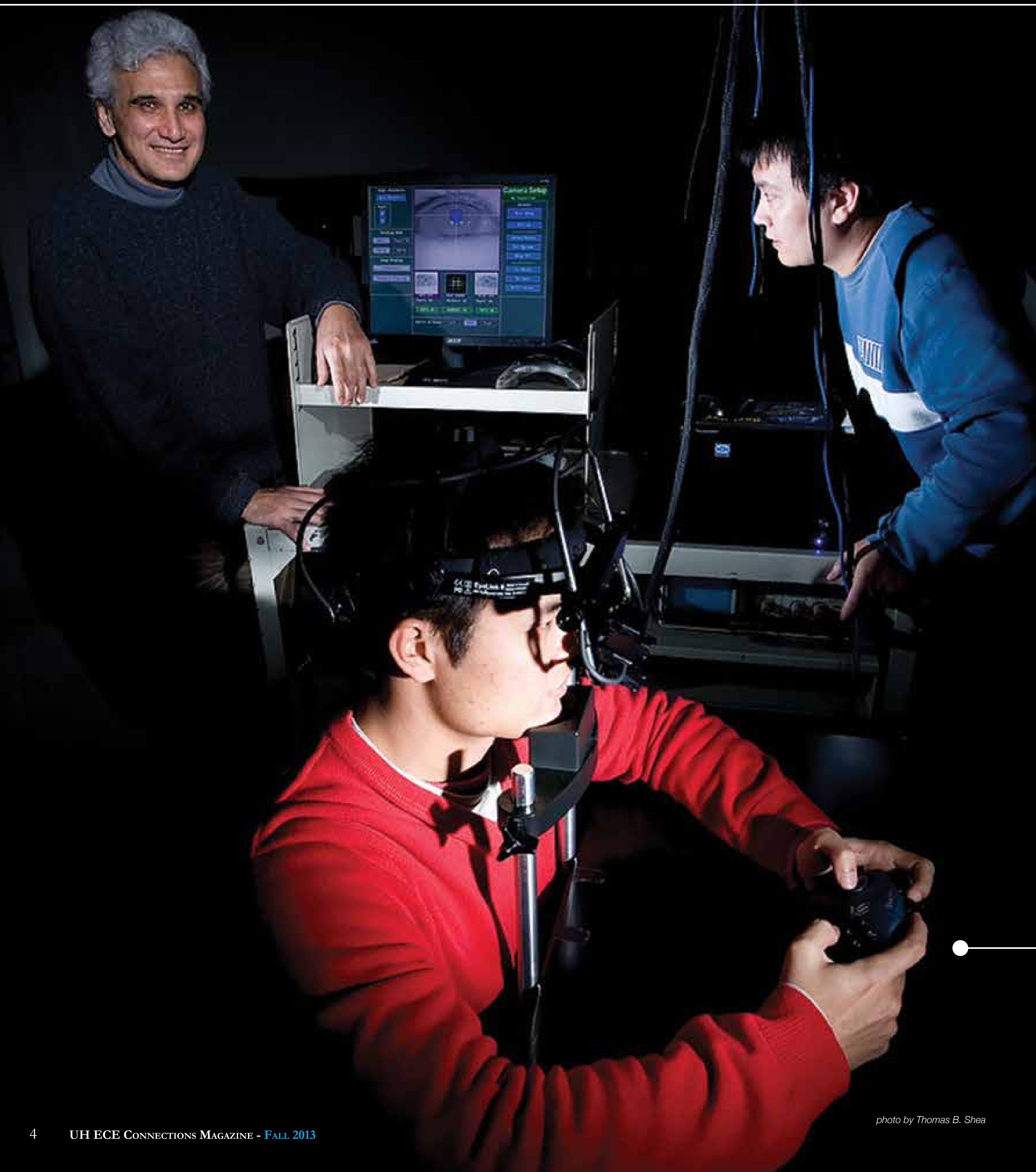


photo by Thomas B. Shea

Bringing Vision INTO FOCUS

Here's an interesting *phenomenon:*

Take out a video camera — or these days, a smart phone — hit record, and move it back and forth quickly. What you end up with is a blur. Now quickly swing your head up and down or side to side.

Practically everything in your field of view stays focused.

Pictured: Professor Haluk Ogmen (top left) determines the reference frames the human brain uses to bring objects quickly into focus.

The difference, obviously, is the brain. While the lens of the eye and the retina operate much like a camera, registering a three-dimensional scene on a two-dimensional surface, the brain uses a complex process to recognize and bring into focus objects that we barely glance at. Discovering the details of this process, the rules by which the brain lets us see the world clearly, is one of the major research thrusts of Haluk Ogmen, professor of electrical and computer engineering and biomedical engineering, and executive director of the UH Center for Neuroengineering and Cognitive Science.

According to Ogmen, the brain, working with the visual system, is able to keep focus through reference frames, which are essentially coordinate systems quickly formed by the brain. These frames are often based on something physical, such as a stationary object that allows humans to focus and identify a moving one — think of a car driving past a house. Reference frames can also be created out of something abstract. The knowledge of how a person moves, for example, allows us to bring into focus in a split second anyone who walks in our field of vision.

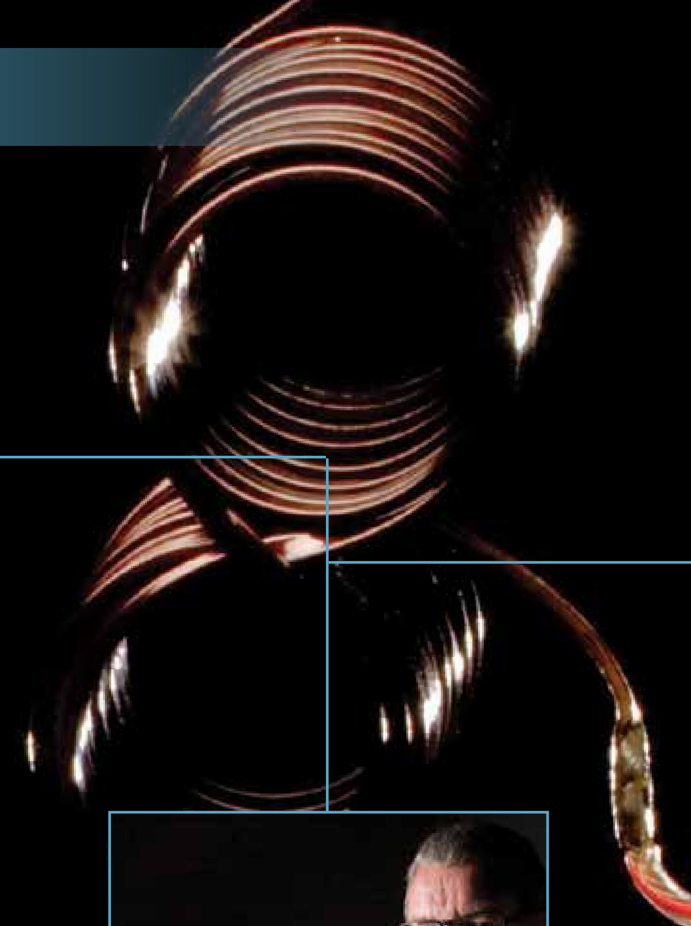
Ogmen's research is trying to determine the rules for creating these reference frames. How, for example, does the brain register different movements to create reference frames? Are there different reference frames for objects that are close to us versus far away? What are the brain's rules for creating reference frames for objects of different sizes? And what role do these reference frames play in storing our visual experiences in our memory and retrieving them later?

To answer these questions, Ogmen creates visual stimuli that can fairly be described as optical illusions. "The idea," he said, "is to take a hypothesis and express it in a visual stimulus that has two opposite perceptual outcomes, one supporting the hypothesis and the second refuting it. By measuring the outcome, I can test my hypothesis about how the brain creates reference frames."

This research currently focuses on simply determining what reference frames the brain uses and the rules for creating them. As it progresses, though, Ogmen plans to explore what parts of the brain are at work in creating reference frames. Using functional magnetic resonance imaging, which reveals brain activity based on blood flow, he will determine the general locations of the brain that are at work in the formation of specific reference frames. Neuroscientists can then use that information to delve into the behavior of particular neurons or neuron groups.

This knowledge about how reference frames are formed, according to Ogmen, could aid in the creation of computer vision systems that can track and recognize more accurately objects in natural scenes, and even contribute to navigation systems developed by robotics experts.

"Computers beat the brain in many tasks, like large number multiplication and database searches," he said. "But there are other tasks that no computer even comes close to what we can do. In the area of navigation, the most powerful supercomputers cannot even match insects. So what's missing are the engineering design principles that capture the fundamentals of biological information processing. That's my goal as an engineer, to reverse-engineer vision, memory, and cognition and see how our brains and minds work."



Making SENSE *of things*

Efforts to learn how and when particular areas of the brain work together could get a huge boost thanks to a new device under development by a team of ECE researchers.

Ben Jansen, a professor of electrical and computer engineering with a joint appointment in biomedical engineering, along with electrical and computer engineering faculty members Ji Chen, Bhavin Sheth, and Ph.D. student Ruoli Jiang have developed the concept for a "dynamic coil" that generates an electromagnetic field to stimulate different areas of the brain in practically any order, combination and timeframe. Their work is featured on the cover of the May 2013 issue of IEEE Transactions on Neural Systems and Rehabilitation Engineering.

The device is a far more advanced version of the present stimulus coil currently deployed in transcranial magnetic stimulation (TMS), a widely used technique for studying the brain.

In typical TMS research, an electric current is run through a metallic coil, creating a magnetic field. The coil can be placed on the skull to either induce or interrupt activity in the section of the brain that lies just below.

This technique, though, limits brain researchers to affecting only one section of the brain at a time, which is a major hindrance, said Chen. "If a researcher with a standard coil wants to see how different parts of the brain work together, he or she has to physically move the coil from one place on the skull to another. That's slow and inaccurate and it really limits the usefulness of TMS."

The dynamic coil solves this problem with a grid of conducting wires integrated into a mesh that is placed on the subject's skull.

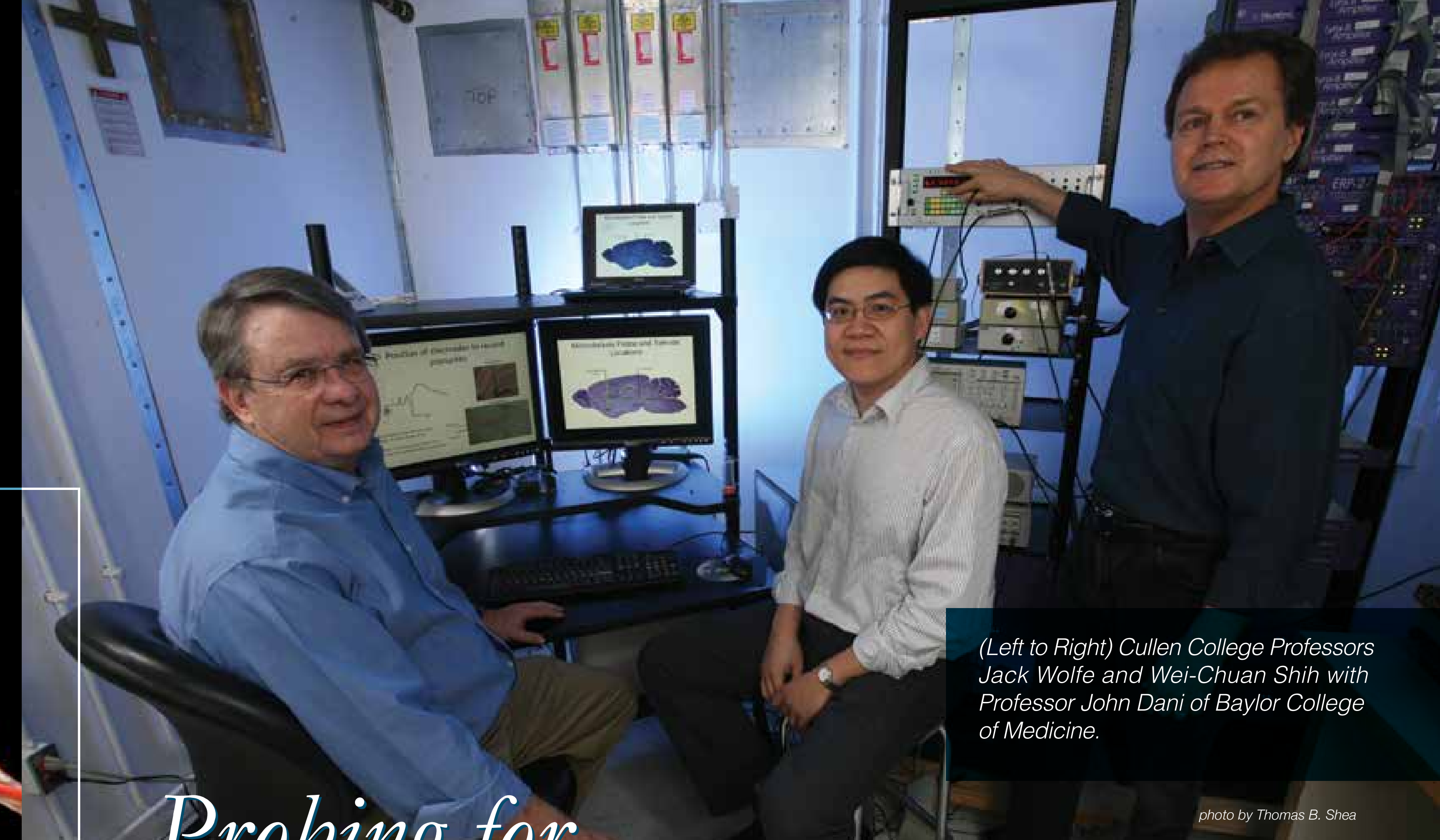
Using a computer interface, researchers will be able to program the device to generate an electric current at specific intersections of the wire grid. This will allow them to induce a magnetic field at practically any point on the skull and hence impact essentially any part of the brain's surface.

The biggest benefit of the dynamic coil will come from being able to program these fields to turn on or off in specific orders, combinations and times, Jansen said. "This provides the researchers with maximum flexibility when they want to study how different parts of the brain interact. All they have to do is program the dynamic coil to meet the guidelines of their experiment."

Pre-set sequences of magnetic fields, for instance, could be used to study behavior, learning, rehabilitative therapy and much more, said Sheth.

"If you really want to study how different parts of the brain interact, you've got to be able to stimulate these sections one after the other, very quickly. The dynamic coil gives researchers the control to do that. This should be very useful for many different areas of neural research."

(Top to Bottom) Ben Jansen, Bhavin Sheth (right), Ji Chen. Photos by Thomas B. Shea.



(Left to Right) Cullen College Professors Jack Wolfe and Wei-Chuan Shih with Professor John Dani of Baylor College of Medicine.

photo by Thomas B. Shea

Probing for INFORMATION

In order to understand the brain, researchers must first have the tools to analyze how the brain works on the cellular level.

ECE professors Wei-Chuan Shih and Jack Wolfe are teaming up with professor John Dani at Baylor College of Medicine and Gopathy Purushothamanat with Vanderbilt University School of Medicine to develop such tools. The neural sensing probe they are creating could help unlock information down to the workings of individual neurons at multiple levels of the brain simultaneously.

When neuroscientists want to study how neurons react to optical stimulation, they generally rely on two separate probes, explained Shih. One of these probes stimulates the cells by delivering light to a specific area of the brain. The other consists of four thin twisted wires that are clipped along the same plane. This probe, called a tetrode, ideally will record the reactions of nearby neurons stimulated by the light probe at the single neuron level.

Using two probes, though, creates uncertainty. "Once you insert the probes into the brain, you don't know exactly where they are in relation to one another," said Shih. This makes it difficult to know if a tetrode is picking up information from the same neurons stimulated by the light delivery probe.

To address this problem, the researchers have combined light delivery and the tetrode into a single device.

At the core of this probe is a single strand of optical fiber just a few inches long. Using lithography, the researchers have been able to print directly on the fiber sets of electrodes and thin film wires that record and transmit information on brain activity resulting from light stimulation. This eliminates the problem of uncertain results caused by two different probes.

Even more impressive, they are able to print more than one set of electrodes on a single fiber and to do so at varying distances from one another. This, Shih said, should allow researchers to monitor neurons in different layers of the brain simultaneously with a single probe, a research technique that has not been previously available.

"This probe gives researchers the ability to study different layers of the brain at the same time. No one has done that before. Even if you have just two sets of tetrodes, it would be unprecedented," Shih said.

making ece connections

"The ECE Department is working hard to build lasting connections to create opportunities and advancement."

NASA-Sponsored Student Team

Develops Innovative Small Satellite Antenna Designs

by Audrey Grayson

Pictured: NASA Sponsored Student Team (above); Transparent Demo Antennas (right)

Robert Provence, a NASA aerospace engineer, had a problem.

For over 12 years, Provence has been designing and developing small satellites called "CubeSats" for NASA. In this time, Provence has seen the design of CubeSats improve drastically – with one exception: the antennas for CubeSats have remained more or less the same since the beginning, and these antennas are, as Provence says, a problem.

And a fairly big one, at that. According to Provence, in his more-than-a-decade of experience with launching small satellites into space, about half of these satellites experienced antenna-related issues.

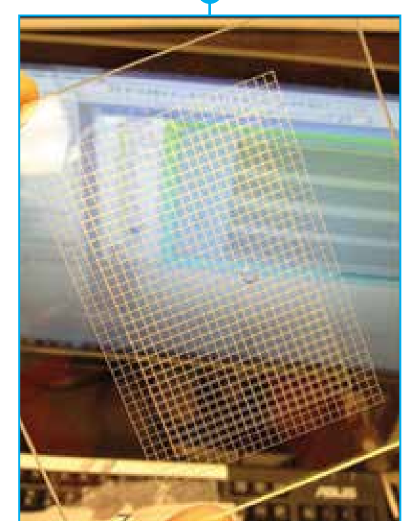
But Provence was lucky. As a graduate of and current lecturer in the UH Cullen College of Engineering's Department of Electrical and Computer Engineering (ECE), Provence had easy access to what he described as "a lot of brilliant ECE knowledge."

"There is a lot of cross-pollination between NASA and UH, especially in this department," Provence explained. "So I started talking about our antenna problem with professors here, got them excited about it, and then [ECE professor] John Glover said, 'Our students could do this for you with a senior design project.'"

Provence agreed, presented the current problems with the cube satellites to a group of ECE students, and let them run with it. "I told them my dream for a new small satellite antenna, and they not only made it a reality, they made it far better than I ever expected."

Moreover, the student team achieved their goal in a mere three months and with very little overhead cost to design and develop their antennas.

"These students just move faster than NASA could have – they don't see the limitations, they only see the possibilities, the opportunities," Provence said. "And the best part is that they did this entirely by themselves. All I did was present them with the problem."



NASA's Problem, ECE's Solution

Despite all of the cutting edge technology that goes into the development and launch of small satellites into space, the standard wire whip antennas used on these satellites are more or less the same as an antenna you'd buy off of the shelf for your car, for instance.

These bulky, wire antennas are fitted to CubeSats much like bunny ears on an old television set – the antennas reach obtrusively into space from each side of the satellite. In addition to being obtrusive, these wire antennas are prone to mechanical breakage.

And then there's the issue of launching satellites with wire whip antennas into space. Since the antennas must conform to the body of the satellite during launch to avoid hitting debris or burning up, the wire whip antennas must be closed in a pod, only to be deployed after the satellite is in orbit. This requires the antenna to be ejected by way of a spring or some other mechanical device.

However, mechanical failures are common in antenna deployment – and without an antenna, a satellite's mission in orbit is suddenly for naught: it cannot send any data back to earth.

"I knew we had a weakness," Provence said. "I actually tried to design a new antenna myself a few years ago, but I couldn't get it to work." And this is exactly where a group of ECE students step in to save the day.

Engineering the Future *of Small Satellite Antennas*

"Think of a cell phone," said Richie Dettloff, one of the four ECE students on the senior design team. "Your cell phone has an antenna, but it's hidden inside it. The antenna is built into the circuit board."

Team leader Nicole Neveu, Mauricio Garcia, Joseph Casana and Dettloff set out to design an antenna for small satellites using the same idea behind cell phone antennas. They worked with faculty advisors Ji Chen and David Jackson, both professors in the ECE department.

However, one big problem remained: even if the satellite's antenna is built into the body of the satellite, much like a microstrip antenna inside of a cell phone, it will still block the light from hitting the satellite's solar panels. In order to design an antenna that was transparent enough to allow sunlight to pass through it, the students built their antennas using three different approaches.

In one approach they used a meshed metallic conductive surface made out of silver to make the microstrip antennas. Transparency was achieved by virtue of the meshed surface, in much the same way as the door to your microwave oven is partially transparent. In the second approach, a film of transparent metal, indium tin oxide (ITO) was used. In both of these approaches, the antennas had to be fabricated on special glass or quartz substrates that were also transparent, so that light could pass through the entire antenna package.

In the third approach, a microstrip antenna was meandered around the edges of the CubeSat to avoid blocking the majority of the solar panel that was on the face of the CubeSat. Both of the transparent designs achieved a 90 percent transparency and could be mounted directly onto the solar panel wall of the satellite.

At this point, the student team achieved two important specifications: the antennas they designed had no mechanical components and were transparent enough not to block too much sunlight from hitting the solar panels. However, both the students and their NASA sponsors were pleasantly surprised by a third discovery: "We achieved a performance five times better than wire whip antennas," Richie explained. "A big concept in engineering is that a gain in one area usually leads to a loss in another area, so the fact that we did this and still achieved better performance than the wire whip antenna is very exciting."

Moreover, the antenna design they developed turned out to be much cheaper to produce than a traditional wire whip antenna, which can cost up to $2,000. The student team's antenna designs max out at about $500 to produce.

Provence could not have been happier with the result. **"There is still much to be done – this is a first step in a growing field – but what an exciting first step!"**

But Provence wasn't the only one impressed by the ECE students' designs: Last April, the team won first place at both the Texas Symposium on Wireless and Microwave Circuits and Systems poster competition held at Baylor University and the poster competition held at the Capstone Design Conference held at the UH Hilton.

Making the NASA Connection

One of the pleasant outgrowths of the senior design teams' success, according to Jackson, was the possibility of the collaboration leading to a job or internship for the soon-to-be-ECE-graduates.

"This project in particular helped these students get their foot in the door at NASA," Jackson explained. "The team's work is really impressive and they developed some truly novel antenna designs. There is a good chance they've created something NASA can actually use."

And the NASA connection was not at all lost on the ECE students involved in the senior design project. "I am so glad I came to UH and not somewhere else," said team leader Nicole Neveu. "I am very privileged to have had this opportunity to collaborate with NASA."

"When you hear you're working with NASA, you know you're going to have to meet a very high standard in order for your work to be considered NASA-quality," she continued. "We chose to do this project knowing it wouldn't be easy. That's why we chose it – we wanted to do something that would make an impact, that would be hard to pull off."

from TEXAS *to* Taiwan

International Student and Faculty Exchange/Research Collaboration

by Audrey Grayson

To develop joint research efforts and provide opportunities for students to participate in academic exchange programs, the University of Houston signed a Memorandum of Understanding (MOU) with National Tsing Hua University (NTHU) in 2011.

Now, three members of the ECE department have returned back to the UH Cullen College of Engineering from their stay at NTHU in Taiwan to share the fruits of their research collaborations and academic exchanges with the rest of the college.

Nick von Sternberg, a Ph.D. student in the ECE department at the Cullen College, spent his spring semester taking courses at NTHU as part of the student exchange aspect of the MOU. ECE research assistant professor Wei Wu and ECE professor Steven Pei also spent the month of April at NTHU, serving as a visiting assistant professor and adjunct professor, respectively.

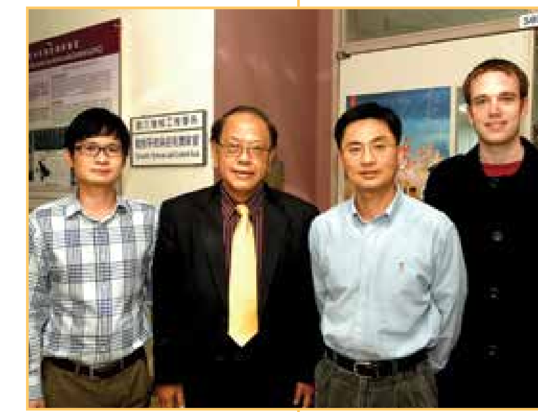
As part of his obligations as visiting assistant professor, Wu gave a seminar on scalable graphenetronics at the end of his one month tenure at NTHU. UH was selected to partner with National Tsing Hua University because of its ongoing graphene-related research.

In 2010, when Wu was still a Ph.D. student at the Cullen College, he was among several UH Cullen College of Engineering researchers and students highlighted on the cover of *Nature Materials* and as a frontispiece in *Advanced Materials*. These articles outlined a new method patented by former ECE research assistant professor Qingkai Yu and Pei for the creation of single-crystal arrays of graphene, making the material a manufacturable nanotechnology for electronic devices and integrated circuits.

One of the highest ranked institutions in Taiwan, National Tsing Hua University is planning to develop a center dedicated to graphene research. The MOU outlines the interest of both institutions in developing a collaborative program specific to R&D of graphene-related two-dimensional materials and devices.

"The two universities have a lot of common interests, and it is a good idea and strategy to follow-up the individual faculty-to-faculty cooperative and collaborative work with an institution-to-institution MOU umbrella document in order to encourage and facilitate other faculty and programs to seek relationships that are mutually beneficial," said Pei, who represented UH when the MOU was first signed by both universities during the visit of a delegation of Texas Representatives to Taiwan in 2011.

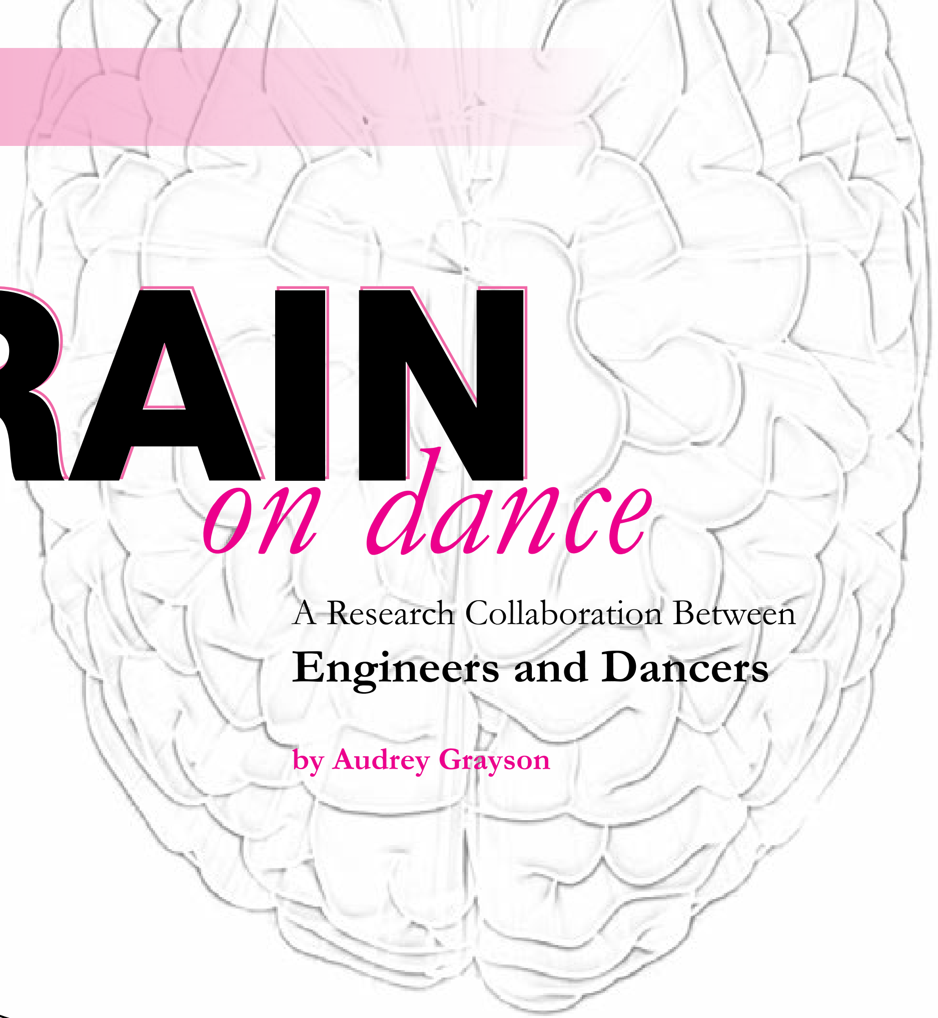
Pei was appointed as an NTHU adjunct professor during his visit to Taiwan in April. He and NTHU Professor Jeng-Chung Chen are now jointly supervising NTHU graduate student Su-Ling Li as part of the graphene research collaboration supported by a gift from HYEneTek Corp., a subsidiary of a Taiwanese semiconductor company.



"The two have a lot of common interests, and it is a good idea and strategy... to seek relationships that are mutually beneficial."- *Steven Pei*

Pictured left to right: Dr. Steven Pei, Dr. Wei Wu, and Ph.D. student Nick von Sternberg.

Your BRAIN *on dance*



A Research Collaboration Between
Engineers and Dancers

by Audrey Grayson

Karen Studd is a professional dancer, devoting much of her waking hours to practicing and perfecting her discipline. And today is no different – she is moving slowly, methodically, gracefully across the room with such softness it's as if she's a ghost, weightless and transparent. In a room full of silent spectators, all eyes are on Studd as she dances her way across the room.

Studd, a tenured professor of dance at George Mason University, is no stranger to this type of performance. But there's something different about today's rendition: Studd is donning an EEG brain cap which records her brain signals and inertial sensors that record her body movement while she dances, her performance is taking place inside of a research laboratory, and her audience comprises student and faculty researchers from the UH Cullen College of Engineering.

This is more than just another dance performance for Studd – this is groundbreaking research on the effects that dancing has on the brain, and she has been chosen to play the starring role in this pilot study titled "Your Brain on Dance: The neural symphony of expressive movement."

In a unique collaboration between the University of Maryland's Department of Dance and the University of Houston's Laboratory for Noninvasive Brain-Machine Interface (BMI) Systems, dancers and engineers are teaming up to learn more about what goes on inside the brain when one dances - the 'neural symphony' of expressive movements.

Funded by an ADVANCE grant from the National Science Foundation, Karen Bradley, head of the dance program at the University of Maryland, joined forces with ECE professor Jose "Pepe" Contreras-Vidal. They first met in 2011 when they collaborated on a demonstration at the Kennedy Center for the Performing Arts in Washington DC to visualize brain activity during dance. Since much of Pepe's research focuses on the development of noninvasive tools for recording brain signals – such as his EEG skull cap, which looks much like a swimmer's cap dotted with electrodes – this partnership between dancer and engineer seemed only natural.

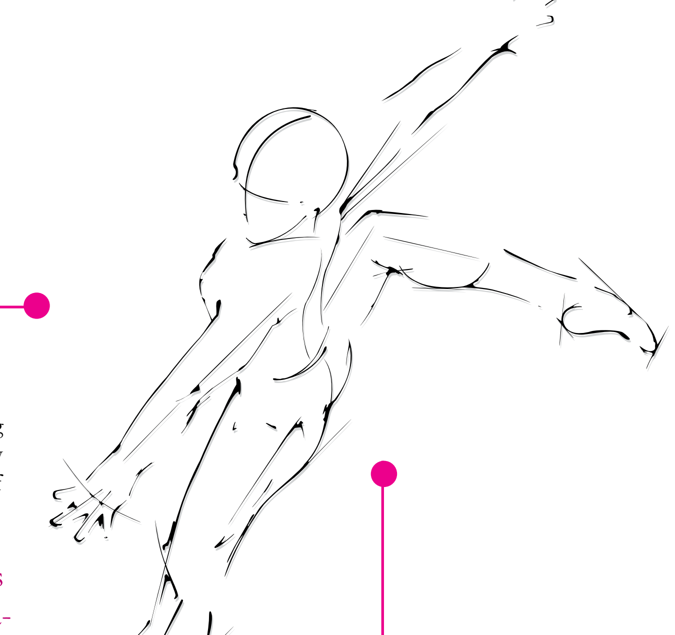
The hope is that this research will shed some light on brain-wave patterns associated with particular expressive movement. Once researchers obtain a better understanding of the brain signals associated with expressive dance, they may also gain insight into the therapeutic implications of dance and the movement arts.

Moreover, Pepe hopes this study will help inform some of his own research on the development of lifelike robotic limbs and exoskeletons for paralysis patients.

"The results of this research will inform important breakthroughs in identifying the components of individual human personality, which will help with communicating emotion and expression in fields like robotics, artificial limbs and animation," Pepe and Karen explained. "Our hope is that, one day, this research will help inform how avatars could eventually express what a physically and/or neurologically-compromised individual is trying to communicate."

After analyzing their pilot data, they plan to submit a collaborative grant to the National Science Foundation to transform the way that engineering and the performing arts can learn from each other while uncovering solutions to some of the most devastating challenges of physical and neurological disability in the world.

To learn more about this research, please visit:
http://yourbrainondance.wordpress.com



Pictured: Karen Bradley, Jose "Pepe" Contreras-Vidal, and Karen Studd test the EEG skull cap.

Professor Wins NAVY YOUNG INVESTIGATOR GRANT *to develop safer, more powerful batteries*

by Toby Weber

A professor with the University of Houston Cullen College of Engineering is working to make safer and longer-lasting batteries for everything from electric vehicles to Navy vessels.

Yan Yao, assistant professor in the ECE department and Robert A. Welch Professor at the Texas Center for Superconductivity at the University of Houston (TcSUH), is developing alternatives to popular lithium-ion batteries, which are used to power much of the modern world. To carry out this work, he recently received a $660,000 award from the U.S. Navy's Office of Naval Research Young Investigator Program (ONR YIP).

This program seeks to partner with outstanding scientists and engineers in the early stages of their research careers and support their research and teaching efforts. The competition in past years has been intense. Last year, 369 proposals were submitted, but only 25 were funded. This year just 16 young investigators received funding.

"I am honored to be selected as an ONR YIP recipient just six months after I started my independent career at UH," Yao said. "I am extremely grateful to the ONR for their invaluable support in developing safer and more powerful battery technology, which is critical to energy security and independence. I am indebted to the strong support from the dean, my department chair, and the TcSUH center."

Lithium ions are commonly used in batteries because they are light and have a high energy density, which allows them to hold large amounts of energy in a small space, said Yao. Lithium, though, is expensive. Even worse, lithium-ion batteries often develop dendrites – essentially fibers of material that can compromise a battery's structure and cause them to catch fire and even explode under certain conditions.

Yao, then, is developing batteries that use magnesium ions and aluminum ions, which are safer and potentially cheaper than lithium-based batteries. In addition, these two ions are also both multivalent, meaning they have multiple extra electrons and therefore greater potential energy density than lithium ions.

The problem lies in how these ions actually behave in batteries, where they must move through dense crystal structures in order to reach the devices they power. Due to Coulumb's Law, which governs how electrically charged particles interact, magnesium ions and aluminum ions move much more slowly through these crystals than lithium ions. As a result, real-world batteries that use these ions are larger, heavier and store less energy than their lithium ion counterparts.

Yao's solution for this problem is a novel one. "We want to modify the existing battery materials to increase the mobility of the magnesium or aluminum ions so they can diffuse [either during charging or discharging] faster than they did before modification," he said.

This work, said Yao, has both basic and applied science aspects. He and his research team will collaborate with experts in conducting atomic-scale simulations to predict how the multivalent ions move inside different crystal structures. They will verify their findings against in-situ transmission electron microscopy experiments, where they will be able to view actual ion movement.

They will then turn their attention to the practical applications of their research, building, testing and optimizing new batteries.

While it will probably take years for shoppers to find devices that use Yao's research on store shelves, the potential for such multivalent ion batteries is undeniable. "The energy density of these batteries is potentially four times higher than state-of-the-art lithium ion batteries," said Yao. "This would mean cell phones that hold a charge for days and electric vehicles that cost less and can go much farther on a single charge. There's great potential here."

Newly-Launched Small Satellite Research Lab *Receives NASA funding*

by Audrey Grayson

Ji Chen

David Jackson

Thanks to ECE faculty members David Jackson and Ji Chen, the University of Houston will be among only 13 universities chosen by NASA to design and develop new small satellite technologies.

With seed funding provided by the Cullen College of Engineering, Jackson and Chen launched a research program at the college just last May to develop antennas for small satellites – called "cubesats." Now, Jackson and Chen will receive up to $100,000 from NASA beginning this fall to continue their research.

Small satellites are generally classified as those that weigh less than 500 lbs. Compared to their larger counterparts, they are less expensive to build and to launch into orbit. These cost factors make it practical to operate multiple satellites in coordination, providing the benefit of redundancy: if one is damaged or malfunctions, others can pick up the slack.

Antennas remain one of the challenges to the use and reliability of small satellites, however. Most small satellites rely on antennas that are mechanically deployed after launch. These mechanical systems can easily become damaged during launch, Chen said, making the entire satellite essentially worthless.

Jackson and Chen, then, are working to develop antennas that can be etched directly onto the solar cells that power these satellites. "We don't want any moving parts," said Chen. "By etching an antenna on a solar cell, we can make it rigid. There's no mechanical deployment."

The actual etching isn't a challenge, noted Chen. The real work comes in finding the right patterns to etch in order to facilitate reliable communication among small satellites and between an individual satellite and earth.

Jackson, Chen, and their student research team will be working side-by-side with engineers and scientists from NASA with the ultimate goal of transforming small spacecraft technologies.

UH Seed Funding Supports New Research
in catalysis, nanofabrication

by Toby Weber

Ask any professor: A good idea alone isn't likely to receive serious research funding. Big awards almost always have some data that supports the project, that shows the researcher's idea should work.

In a classic catch-22, though, getting this data itself takes money. Materials for experiments, graduate student time, lab space, computing power – none of these are free.

One solution is seed funding, small awards that allow professors to gather the data they need to win the big grants. Two Cullen College of Engineering faculty members recently won awards from the University of Houston's own seed funding program, GEAR or Grants to Enhance and Advance Research, which are awarded by the university's Division of Research. Each will receive $30,000 to support their new ideas.

This year, one of the GEAR awards went to ECE's associate professor Stanko Brankovic. Brankovic will use the funds to develop a new method of fine-tuning the properties of catalysts, which are used to set in motion or speed up chemical reactions.

In particular, he's working with platinum monolayer catalysts, which consist of atoms of platinum measuring just a few billionths of a meter forming a thin layer of material that actually takes part in these chemical reactions.

The atoms of this catalytic material often come together to form clusters. At the nanoscale, the size and shape of these clusters results in an unusual phenomenon: The clusters create within themselves some type of strain or stress. This comes in two varieties: compressive strain, in which the clusters push in on themselves, or tensile, in which they pull out.

These strains can have a major impact on catalyst performance, Brankovic said. The tensile strain sends more electrons to the surface of the particle, speeding up the chemical reactions they're meant to impact, while compressive strain has the opposite effect and result.

By changing how these catalysts are made, Brankovic believes he can adjust the type and amount of strain they experience. This should allow him to fine-tune catalyst performance. The result would be nanoparticles and nanocluster catalysts that are far more efficient, and hence far less expensive, than those being used today.

"Modern catalysis is all about getting more from less," said Brankovic. "Depending on the size and shape of these clusters, you can see a difference in performance of a couple hundred percent. What that means is if you hit the right spot in terms of size, you can use a factor of three or four times less of a catalyst."

While Brankovic has some experimental and computational data to support this approach to catalyst synthesis, for many funding bodies, it's just not enough to justify a big grant. Support from GEAR, he said, should allow him to get enough data to win a larger award in the future.

"I work with platinum and gold, which are expensive, so it's difficult for us to finance the search for new data. That's why GEAR is a good program and I appreciate it. It gives me latitude to attack a field with a new idea," he said.

ECE Hosts *Well Logging* CONFERENCE

by Toby Weber

About 30 researchers gathered at the University of Houston Cullen College of Engineering in May to discuss the latest in nuclear well logging—science of gathering and interpreting data from petroleum wells, often during drilling, through gamma radiation signals.

The group comprised members of the Society of Petrophysicists and Well Logging Analysts, said Richard Liu, ECE professor and director of the Cullen College's Well Logging Lab.

According to Liu, there are two main forms of nuclear well logging: gamma, which relies on readings of radiation naturally emitted by rock formations, and gamma gamma, where radiation is shot at the formations and data interpretations are based on the radiation that returns to the source.

Nuclear logging, Liu noted, makes up only about 20% of the well logging field. About 70% of well logging is based on reading the electrical properties of rocks, particularly their electrical resistivity.

The changing nature of petroleum drilling and retrieval is introducing new challenges to the resistivity-based logging, Liu added. In typical rock formations, low resistivity indicates that there is little to no petroleum present. But in shale formations, which are becoming increasingly important sources of petroleum, especially in the United States, low resistivity does not indicate a lack of petroleum.

"How do we identify shale and shale layers that have oil and gas? So far this problem is not well studied," said Liu. "We're working with companies to find indicators of petroleum. For example, the dielectric constant, dispersion characteristics, conductivity, maybe resistivity. We think we can combine them with other measurements to identify shale layers with oil and gas."

Another area Liu and his research team are exploring involves horizontal drilling. Given the high price of oil, petroleum companies are today retrieving resources from relatively thin layers of rock that lie roughly horizontal. These companies have equipment capable of being steered while drilling horizontally. What they lack, however, is a good way to ensure that the drill stays within its targeted layer of rock.

Traditional methods of well logging, Liu said, aren't able to immediately locate the top and bottom of resource-rich rock layers. The Well Logging Lab, then, is developing new analytical methods that can produce this information in real time.

If history is any guide, their work in these areas should prove to be very valuable. Evidence: the Well Logging Lab receives most of its support from industry through a fee-based consortium. The consortium, also directed by Liu, provides its members with technical reports and support, addresses technical challenges and works to develop new technologies requested by its members. Its membership roster includes many of the largest companies in the petroleum industry, including BakerHughes, BP America, Chevron, China National Logging, ExxonMobil, Halliburton, Saudi Aramco, Schlumberger, Oliden Technology, and Weatherford Energy Services.

Richard Liu

"Traditional methods of well logging, Liu said, aren't able to immediately locate the top and bottom of resource-rich rock layers. The Well Logging Lab, then, is developing new analytical methods that can produce this information in real time."

ECE Inventors:

Faculty Inventions Recognized

by UH's Intellectual Property Committee

In the past 10 years, the amount of intellectual property generated and the number of patents issued to the University of Houston have steadily increased, along with the revenues generated from these efforts. This is in no small part due to the ingenuity and aggressive research efforts of many ECE faculty members.

Recently, a group of UH inventors were invited to a luncheon sponsored by the Division of Research wherein the campus inventors were honored for their achievements in intellectual property generation. Each inventor was presented with an award from UH President Renu Khator and Dr. Rathindra Bose, vice chancellor and vice president for research and technology transfer.

Dr. Mark Clarke, Chair of the Intellectual Property Committee at UH, says he hopes that this event in honor of our campus inventors will become an annual occurrence. "I think establishment of this ongoing event is a long overdue recognition for those UH faculty actively involved in the generation of intellectual property and related patents on campus," Clarke explained.

In his closing remarks at the luncheon, Clarke reminded the campus inventors of their outstanding contributions to the university and scientific community. "I would like not only to congratulate each of you on your success as an inventor and an innovator, but to remind you that your contributions are valuable not only in the area of intellectual property generation, but that they greatly enhance the academic and research fabric of the University."

Of the 23 inventors honored at the event, **seven were ECE faculty members**. They include:

Dr. John Wolfe, primary inventor for two patents titled "Device and method for manufacturing a particulate filter with regularly spaced micropores" and "Method for translating a structured beam of energetic particles across a sub-strate in template mask lithography."

Dr. Paul Ruchhoeft, co-inventor for two patents titled "Device and method for manufacturing a particulate filter with regularly spaced micropores" and "System and method for nano-pantography."

Dr. Yuhua Chen, primary inventor for the patent titled "Methods for non-wavelength-converting multi-lane optical switching."

Dr. Alex Ignatiev, co-inventor for two patents titled "Method of using a switchable resistive perovskite microelectronic device with multi-layer thin film structure" and "Switchable two terminal multi-layer perovskite thin film resistive device and methods thereof."

Dr. Jaroslaw Wosik, primary inventor for two patents titled "Superconducting loop, saddle and birdcage MRI coils capable of simultaneously imaging small nonhuman animals" and "Superconducting loop, saddle and birdcage MRI coils," as well as co-inventor for the patent titled "Intraluminal magneto sensor system and method of use."

Dr. George Zouridakis, primary inventor for the patent titled "Device and software for screening the skin."

Dr. Ioannis Kakadiaris, primary inventor for the patent titled "Automated method for human face modeling and relighting with application to face recognition."

"Dr. Dave" wins CAREER Teaching Award

Students and fellow professors at the Cullen College of Engineering know Dave Shattuck as one of the best teachers around. Now he's been recognized as exactly that by the University of Houston.

Shattuck, an associate professor of electrical and computer engineering and the college's associate dean for undergraduate programs, won the Career Teaching award at last night's UH Faculty Awards Ceremony. The honor recognizes professors "who have demonstrated excellence in teaching over the course of their careers." Only one such award is given each year. To be eligible faculty must have at least 20 years experience at UH.

"This is a great honor," said Shattuck. "Teaching is what I like the most. When I had the opportunity about 12 years ago to devote basically all my time to things associated with that, I jumped at it. "

Shattuck, aka "Dr. Dave," joined the Cullen College in 1982 and within just a few years was making a major impact on undergraduate education. In 1985 he led the successful overhaul of the curriculum for the circuit analysis course, one of the foundational classes in the department.

Similarly, just more than a decade ago he oversaw the successful redesign of the entire ECE undergraduate curriculum. According to Stuart Long, ECE professor and then department chair, "it was [Shattuck] who was responsible for the high standards and the multifaceted nature of the revisions. As a result of these sweeping changes, our courses have remained as models for other departments for over a decade."

In addition to his efforts on the college and department levels, Shattuck's work in the classroom is widely admired. He is known to take steps to make lectures engaging through props or music while maintaining high-quality and rigorous instruction.

Students, in turn, sense the pleasure he derives from teaching and respond to it. His student evaluation scores are regularly among the highest in his department and students actively seek out the courses he teaches.

Said one Cullen College alumnus who took multiple classes from Shattuck, "Dr. Dave's attitude and what he projected was, 'I'm happy to be here, I love my profession, I care about you guys, we are going to learn now. I'm going to stretch your brains but we are also going to have fun, or at least I am going to while teaching - so please join me.'"

fun | FACULTY *Stories*

Fundraising for MS: ECE Professor Pedals From Houston to Austin in MS 150

by Audrey Grayson

On any other given day, you would probably find ECE professor Jose Luis Contreras-Vidal – or "Pepe," for short – inside of his UH Laboratory for Noninvasive Brain-Machine Interface Systems. Typically, Pepe would be surrounded by eager graduate and undergraduate student helpers as he works to develop cutting-edge brain-machine interface (BMI) systems which allow paralysis patients to control robotic limbs using only their thoughts.

Pepe devotes a great deal of his time, energy, and research efforts to developing novel devices and robots that help paralysis patients regain their mobility and, therefore, their independence and quality of life.

But for two days in April, Pepe was supporting one group of paralysis patients in a different way altogether: by strapping on his helmet, slipping into his cycling shorts, and hitting the pavement on his bicycle.

Pepe was one of more than 10,000 cyclists pedaling the 180 miles from Houston to Austin as part of the 29th annual BP MS 150. This two-day fundraising bike ride – the largest of its kind in North America – is organized by the National Multiple Sclerosis (MS) Society and is sponsored by BP.

There are 100 MS bike rides in cities all over the U.S., but the BP MS 150 serves as the top fundraising ride for the National MS Society nationwide. "I chose to ride the MS 150 Houston to Austin bike ride to help increase awareness for multiple sclerosis (MS), which is a progressive neurological disease that affects the quality of life and independence of people in many different ways, including paralysis," Pepe explained.

The BP MS 150 aimed to raise $18 million this year to fund cutting-edge research for MS, such as Pepe's own work on developing BMI systems and robotic exoskeletons to help paralysis patients regain movement in their limbs.

"I also want to support patients with MS, not only by developing novel biomedical devices and neurorobots in my UH laboratory, but also by helping to raise funding for research that will lead to new discoveries and treatments for MS," Pepe said.

The money raised from the bike ride will also be used to support programs and services benefiting the nearly 400,000 Americans living with MS.

A Brief History of Dogs

by ECE Professor Stuart Long

by Audrey Grayson

"I can't imagine how anyone's life wouldn't be more fulfilling with a dog,"

explained Stuart Long, a professor in the Cullen College's ECE department.

Long is an official expert on electrical and computer engineering and an unofficial expert on dogs. In fact, he facilitated a talk this year at the UH Honors College fundraising event "The Great Conversation" about the origin of dogs, alongside ECE associate professor David Shattuck.

"The Great Conversation" event for the UH Honors College takes place each year, consisting of a reception followed by a multi-course dinner. During the meal, guests discuss a topic that has been predetermined for their table and led by a UH faculty member or another expert.

Long's topic of choice for the discussion he facilitated was, of course, the origin and history of dogs. His presentation was aptly titled, "From Wolf to Woof: The Origin of Dogs." In his discussion with the group, Long focused primarily on the evolution from wolf to dog, as well as the now-infamous research on domesticated foxes conducted by Soviet scientist, Dimitri Balyaev.

But beyond a scientific interest in the evolutionary origins of dogs, Long also harbors a deep personal interest in man's best friend. Long is the proud owner of a Great Dane named Grayson (whose coat is an impossible shade of silver-blue), and is dog-grandpa to three golden retrievers whom he refers to as his "granddogs."

"Dogs give to people unrestricted, unconditional love," Long said. "No matter what happens during the day, when I come home and walk through the door, my dog is always happy to see me."

And Great-Dane-Grayson's particular brand of devoted, tireless love for his human counterparts even earned him the title of certified therapy dog. Long and Grayson are proud members of Faithful Paws Pet Therapy Program, sponsored by the Bellaire United Methodist Church in Houston. Together, the pair have visited hospitals, hospices, nursing homes, and even college campuses to share the healing and therapeutic power of unconditional love.

ECE's Trombetta *performs with* JAZZ *ensemble*

by Esmeralda Fisher

ECE associate professor Len Trombetta has been musical since childhood.

He started playing the saxophone in 8th grade, and the clarinet four years before that. He was part of a big band group in high school, and in college studying physics at Rensselaer Polytechnic Institute. During graduate work at Lehigh University, he directed a student-run band for a couple of years. In New Jersey he briefly played with a rehearsal band. Then he arrived in Houston.

At a club on Almeda-Genoa (now defunct), he heard about a man named Conrad Johnson, famous in the area.

"One night he showed up," Trombetta said. "He said, 'I could use a sax player for my big band,' and I said, 'Great, I have some big band experience.'" This was circa 1987, and Trombetta has been a member of the Conrad Johnson Orchestra ever since.

Conrad Johnson was a preeminent musician and educator who directed the Kashmere Stage Band, a high school group that grew to distinction under Johnson's tutelage in the 1960s and 1970s. The band crisscrossed the nation, attending high school music festivals and conferences, winning 42 out of 46 contests. A documentary titled Thunder Soul recounts the energy of the man and the era that put jazz on the map in Houston.

"Conrad always thought the band could be famous," said Trombetta. "He wanted to showcase jazz generally using the big band as a vehicle. I have a lot of respect for what Conrad was doing." The group, now led by James Williams, Jr., strives to carry on Johnson's vision. A recent performance at the Hobby Center's Zilkha Hall, featuring famed trumpeter Sean Jones, was very well received, coming together after some tightly focused rehearsals.

Yet the local jazz scene isn't as prevalent as that of other large metropolitan areas. "You really have to dig it out of the woodwork to find [jazz]," Trombetta mused. Even with the size of the city and the number of music fans, in Houston, jazz is enjoyed like fine wine: quality over quantity.

That's ok with the members of the Conrad Johnson Orchestra. While some of them are professional musicians, most of the band members have day jobs, like Trombetta. Gigs are rare, but the camaraderie of rehearsals keeps the members involved.

The musically-talented engineering professor may seem paradoxical, but it's not as unusual as one might think. Trombetta notes he has encountered many engineers and scientists who have musical tendencies, an image that runs counter to the popular notion of the linear, logical thinker.

Whether the practice of music informs the practice of engineering remains to be seen, but Trombetta recognizes a correlation between the artistic process of music and teaching. "I like to think that teaching involves creative effort in the way you approach people," he said. "The way I approach teaching and the way I interact with students is probably a little different than other folks, maybe because of the music, or the other way around.

"The first time I took lessons in jazz improvisation, my teacher told me, 'I can't teach you to play jazz. I can show you a few things and give you some exercises, but you have to figure this out.' It's the same with teaching electrical engineering to students." Trombetta sees his role as a guide, a facilitator. "I care about whether people learn something or not, and I'll push myself to make sure that people understand what's going on. Students should be led to learn things by giving them examples. You show them what's going on, you give them help when they need it or ask for it. I can't teach anybody to do electrical engineering, but I can teach you some things and show you what to do to figure this out."

ROBOTS & LASERS

First-Year Honors Engineering Projects

by Esmeralda Fisher

The Undergraduate Electronics Lab in the Cullen College of Engineering bustles with activity as freshman engineering students craft robots from scratch.

First-year Honors Engineering students are guided by Dr. Diana De La Rosa-Pohl, a lecturer in the UH department of Electrical and Computer Engineering. ENGI 1100: Introduction to Engineering is a project-oriented, team-based course that gives honors students from all engineering majors a practical foundation in problem-solving and creative thinking.

In the first semester, students become adept at MATLAB and LabVIEW. During the second semester, students apply their programming skills to the task of target acquisition. Today, students are training their robots to shoot a laser at "Darth Tater."

"Right now we're working on code, telling the computer how to analyze different colors of an image," said Juan Gallegos, a mechanical engineering major. Beyond building and programming the bot, students are encouraged to think about the real-world application of what they create. Gallegos and his classmate Shehwaz Rassiwalla, a chemical engineering major, state that such a robot could benefit law enforcement. "For SWAT teams, in instances where you have to go inside a building with hidden suspects, I think it'd be better to have a robot go in first," said Gallegos.

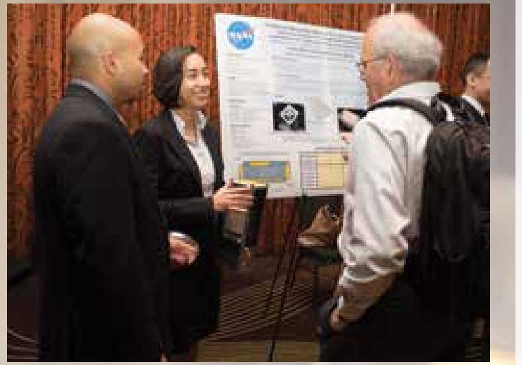
Maria Lalata and Julia Lin, both chemical engineering majors, said that robots could also be used for personalized medicine. "Our practical purpose is to use robots to make diagnosing more effective, and building upon and improving existing technology," said Lin.

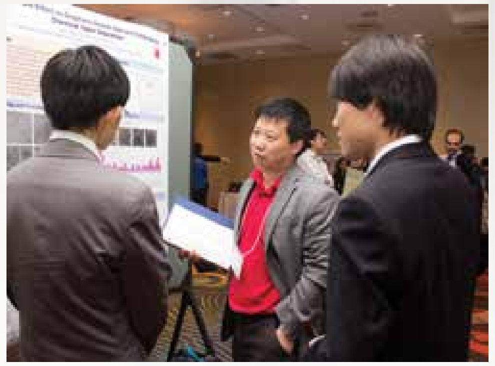
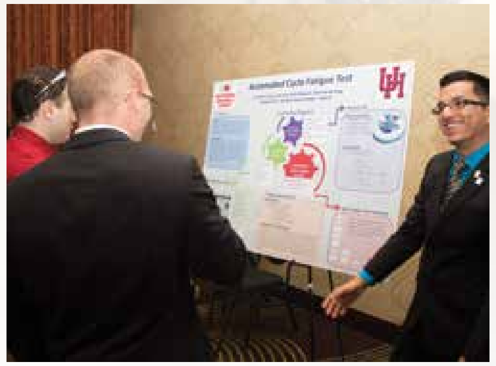
The Honors Engineering Program is jointly offered by the Cullen College of Engineering and The Honors College as a program that cultivates community among honors students pursuing an engineering degree, and provides an enhanced academic experience through project-based courses, mentorship opportunities and visits with industry partners.

Celebrating Innovation at ECE Conference

by Esmeralda Fisher






The UH department of Electrical and Computer Engineering recently hosted the Capstone Design and Graduate Research Conference at the UH Hilton. The day-long event included technical sessions in which graduate and undergraduate student research and projects were presented.

Giving engineering students an opportunity to apply presentation and networking skills is the primary goal of the conference, now in its ninth year.

Technical sessions included research in neural sensing and bioengineering; energy and power solutions; noninvasive biosensing; imaging for biomedical applications; electromagnetics for nanoparticles, materials, and devices; and imaging for bio- and nano-structures.

In addition to an exchange of ideas, the conference also illuminates evolving, cross-disciplinary opportunities in research and development for electrical and computer engineering scholars.

Students who gave outstanding presentations during the conference were honored at the closing awards ceremony. The winner of the Urvish Medh Memorial Award for best overall presentation was Jingting Li for Laser-Based Active-Illumination Hyperspectral Microscopy with Multi-Modal Imaging Analytics. Xiyao Xin won Outstanding Oral Presentation of Wireless Energy Transmission for Geophysical Applications. Szu-Te Lin received the outstanding poster presentation award for Localized Surface Plasmon Resonance in Gold Nanoisland and Nanoporous Gold Substrates.

Capstone design poster presentation awards went to undergraduate teams two and three: Transparent Microstrip Antennas for CubeSat Applications, given by Joseph Casana, Richie Dettloff, Mauricio Garcia, and Nicole Neveu; and Cube Satellite: Embedded Design, with team members Safa Alghafli, Keith Chambles, Cesar Figueroa and TheLam Nguyen.

Nicholas Hawkins, Thang La, David Tran and Henry Truong won the oral presentation award for Dry, Noninvasive, Wireless EEG System.

Stephen Pitman won first place in the elevator talk competition, and Nicole Neveu took second place.

The conference was generously supported by NASA, Shell, National Oilwell Varco, LyondellBasell, and the University of Houston.

UNIVERSITY of HOUSTON | ENGINEERING

Department of Electrical and Computer Engineering
UH Cullen College of Engineering
N 308 Engineering Building 1
Houston, Texas 77004-4005

Starting STEM Early

STEM programs for elementary schools are designed to capture the imaginations of young children and introduce them to science, technology, engineering and math in a fun and captivating way. Thanks in part to a grant from Schlumberger, Cullen College professor Jose Luis Contreras-Vidal and Cullen College undergraduate students Dylan Quiroz and Ly Ha Le (pictured), are taking robots to Houston-area elementary school classrooms. Contreras and his undergrad students use these dancing, soccer-playing robots to do their part to inspire young students to pursue science and engineering careers.