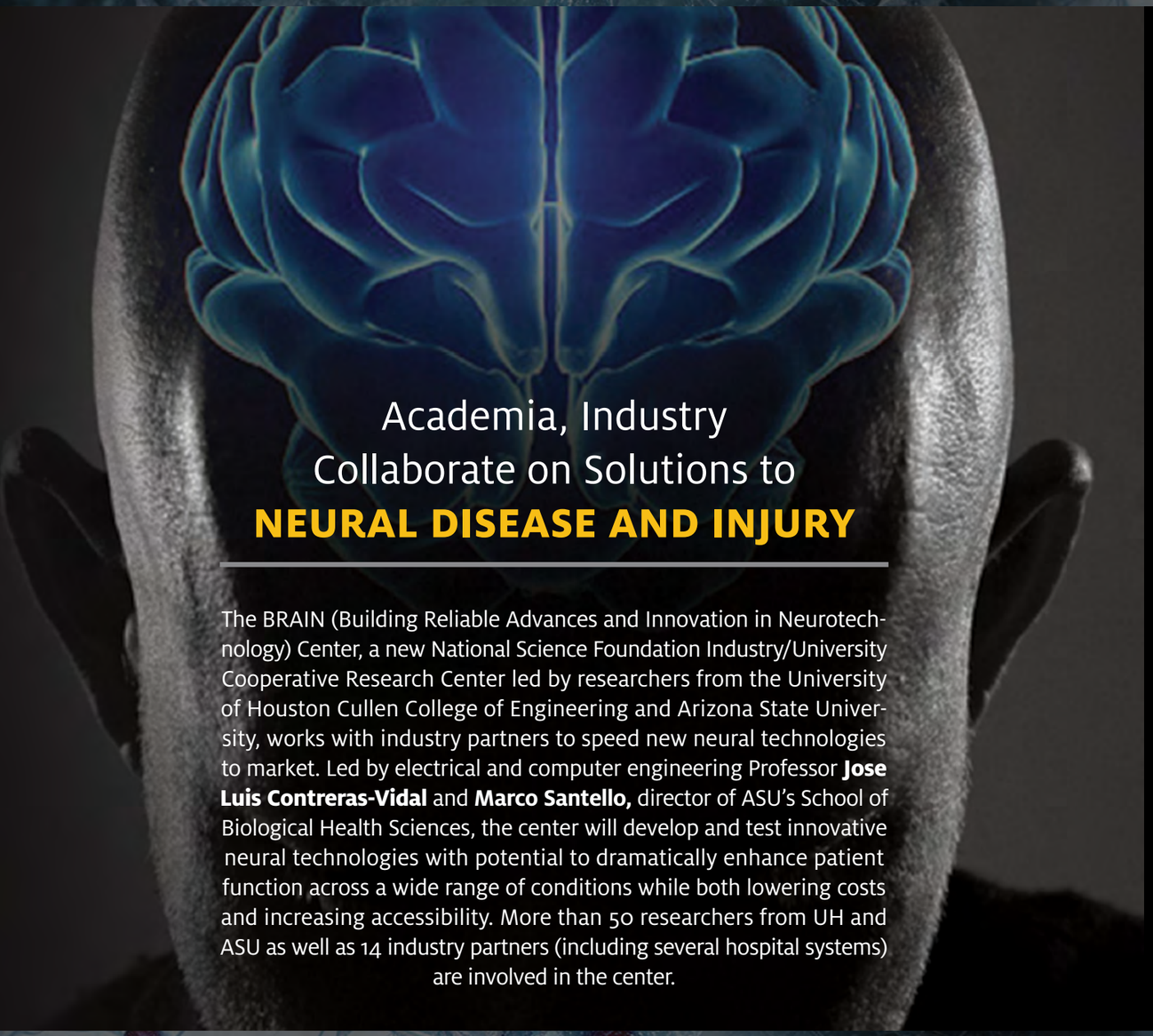
Building Reliable Advances and BRAIN Innovations in Neurotechnology

An Industry-University Cooperative Research Center (IUCRC)

NEUROENGINEERED
FOR WHAT'S NEXT

nsfbrain.org

Supported in part by
NSF Award #2137255, #2137272



Academia, Industry Collaborate on Solutions to **NEURAL DISEASE AND INJURY**

The BRAIN (Building Reliable Advances and Innovation in Neurotechnology) Center, a new National Science Foundation Industry/University Cooperative Research Center led by researchers from the University of Houston Cullen College of Engineering and Arizona State University, works with industry partners to speed new neural technologies to market. Led by electrical and computer engineering Professor **Jose Luis Contreras-Vidal** and **Marco Santello,** director of ASU's School of Biological Health Sciences, the center will develop and test innovative neural technologies with potential to dramatically enhance patient function across a wide range of conditions while both lowering costs and increasing accessibility. More than 50 researchers from UH and ASU as well as 14 industry partners (including several hospital systems) are involved in the center.

RESEARCH THRUST AREAS

- Big Data
- Neuromodulation
- Neurorehabilitation & Assistive Devices
- Clinical Trials
- Device Development
- Device Interoperability
- Neural Activity Measurement
- Regulatory Science
- Neurotechnologies For Sports
- Neurotechnologies For Smart Factories
- Neurotechnologies For The Arts
- Ethical & Trustworthy Artificial Intelligence

UNDERSTANDING THE BRAIN IN REAL LIFE

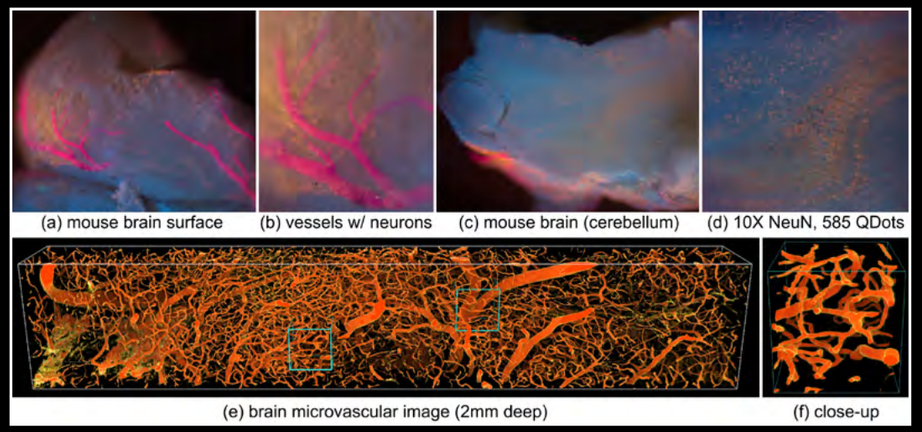
Luca Pollonini, Fullbright fellow and associate professor of engineering technology, is developing a multimodal wearable neuroimaging system that enables investigating the brain in everyday life and in interaction with other brains. The device integrates electroencephalography, functional near infrared spectroscopy and other sensing techniques into a lightweight device to be used in schools, museums, and urban and rural households for seamlessly collecting and sharing information about the brain in health and disease, and across the lifespan.

THOUGHT-CONTROLLED ROBOTIC EXOSKELETON

Offers Promise of Mobility to Children With Spinal Cord Injuries

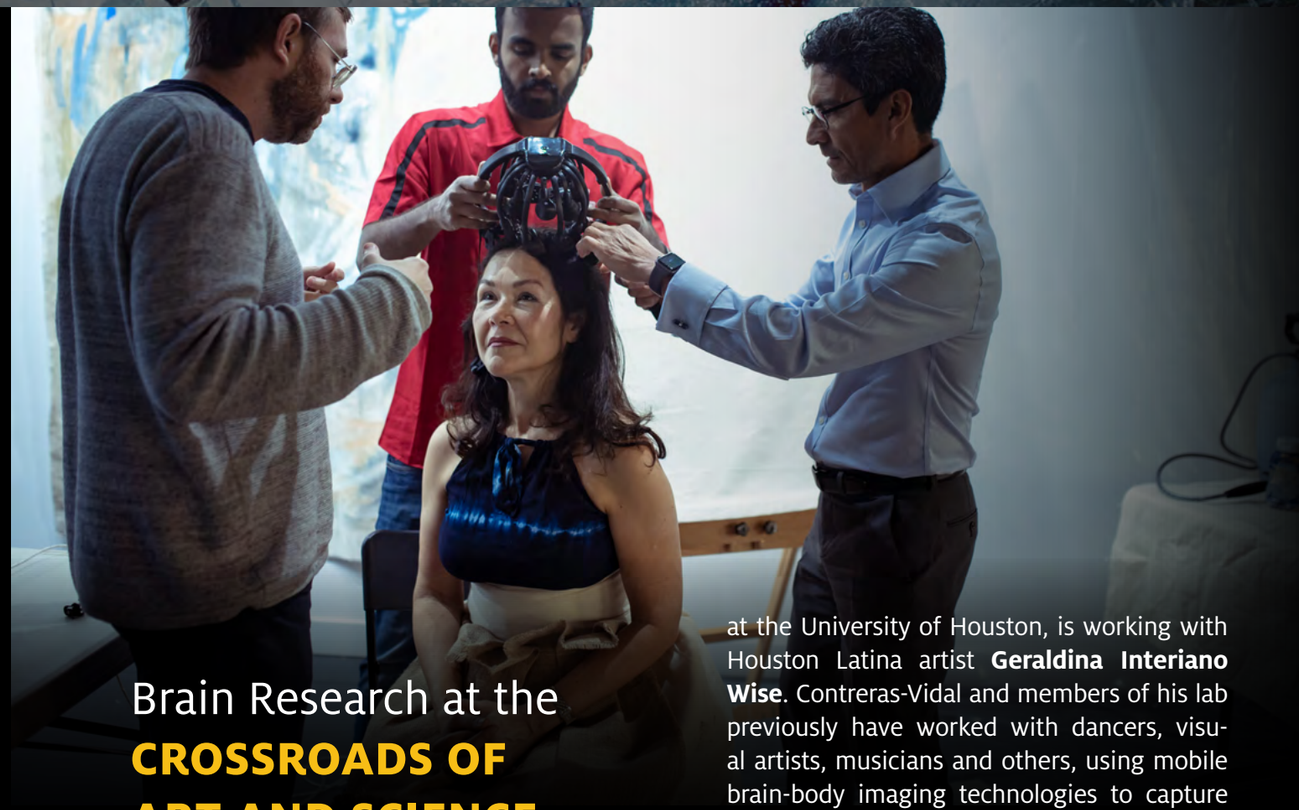
Robotic exoskeletons controlled by the power of patients' thoughts will be used to both diagnose and rehabilitate children with cerebral palsy and spinal cord injuries in a new project led by **Jose Luis Contreras-Vidal,** Hugh Roy and Lillie Cranz Cullen University Professor of electrical and computer engineering and director of the BRAIN Center. The pediatric exoskeletons are being tested in collaboration with TIRR Memorial Hermann, the best rehabilitation hospital in Texas and second best in the nation. The trial will involve children between 4 and 8 years of age, with the goal of making the exoskeletons available to the public within three years, pending FDA approval.

Southwest National Pediatric Device Innovation Consortium's Pediatric Device Prize, SWPDC, SXSW



Revolutionizing **THREE-DIMENSIONAL BRAIN IMAGING**

David Mayerich, Cullen College of Engineering Associate Professor and CPRIT scholar in cancer research, is leading researchers in the development of a new microscope with the potential to revolutionize three-dimensional brain imaging. This technology, known as Serial Ablation Lathe Tomography (SALT), utilizes recent advances in fluorescent imaging that limit the penetration of ultraviolet light into biological samples. The SALT microscope collects images from the tissue surface, and then cuts the imaged tissue away to reveal deeper layers. This produces a high-resolution three-dimensional volume representing the digitized sample. This research was recently awarded a non-provisional patent through the University of Houston, as well as $60,000 in seed funding for further development over the next two years. The goal of this work is to replace existing 3-D imaging techniques that are extremely expensive and time consuming, increasing the availability of 3-D microscopy for research into the brain and other complex tissues.



Brain Research at the **CROSSROADS OF ART AND SCIENCE**

Researchers are gaining a better understanding of what happens in the brain when people experience art and creativity, which could offer benefits far beyond the art world. **Jose Luis Contreras-Vidal,** Hugh Roy and Lillie Cranz Cullen Distinguished Professor of electrical and computer engineering at the University of Houston, is working with Houston Latina artist **Geraldina Interiano Wise**. Contreras-Vidal and members of his lab previously have worked with dancers, visual artists, musicians and others, using mobile brain-body imaging technologies to capture brain activity in real time.

The goal isn't just to produce an ah-ha moment but to consider bigger questions, including whether a symbiosis of artificial intelligence and neuroengineering can redefine human creativity, as well as whether the data collected can be used to improve traditional art therapy models and promote overall wellbeing.

UNIVERSITY OF HOUSTON

The IUCRC BRAIN is a partner in the NSF Partnerships for Innovation (PFI) project (award #1827769) with BRAIN clinical partner TIRR Memorial Hermann. The project is entitled PFI-RP: Brain-controlled Upper-Limb Robot-Assisted Rehabilitation Device for Stroke Survivors.

TAPPING THE BRAIN To Boost Stroke Rehabilitation

Stroke survivors who had ceased to benefit from conventional rehabilitation gained clinically significant arm movement and control by using an external robotic device powered by the patients' own brains. **Jose Luis Contreras-Vidal,** director of the Non-Invasive Brain Machine Interface Systems Laboratory at the University of Houston, said testing showed most patients retained the benefits for at least two months after the therapy sessions ended, suggesting the potential for long-lasting gains. He is also Hugh Roy and Lillie Cranz Cullen Distinguished Professor of electrical and computer engineering. The trial involved training stroke survivors with limited movement in one arm to use a brain-machine interface (BMI), a computer program that captures brain activity to determine the subject's intentions and then triggers an exoskeleton, or robotic device affixed to the affected arm, to move in response to those intentions. The device wouldn't move if intention wasn't detected, ensuring subjects remained engaged in the exercise.
https://stories.uh.edu/2022-stroke-rehab/index.html

REU SITE AWARD #2150415: Research Experiences for Undergraduates

For 10 weeks each summer, undergraduate students from across the country get the chance of a lifetime on the UH campus – becoming engineering researchers in the Cullen College's Research Experience for Undergraduates (REU). This past summer, the Cullen College hosted **"Neurotechnologies to Help the Body Move, Heal and Feel Again,"** an REU program funded by the National Science Foundation.

The program is designed to inspire bright and motivated undergraduates to pursue graduate education and careers in science and engineering research. Participants in the program worked closely with leading neural engineers and neuroscientists at the BRAIN Center, contributing to the development of innovative medical devices including diagnostics, neural interfaces, medical robotics and other ongoing cutting-edge research in neural, cognitive and rehabilitation engineering. To date, 63 undergraduate students from 37 universities and 21 high-school students have completed the program.

NIH RESEARCH EDUCATION AWARD #R25 HD106896

Neuromotor Skill Advancement for Post-baccalaureates (NSAP)

The goal of this research training program, directed bv **Profs. Contreras-Vidal** and **Pranav Parikh** at the IUCRC BRAIN Center is to provide didactic and hands-on activities focusing on the development of highly specialized and highly sought-after technical skills to study the brain with the intention to complement and enhance the training of therapists, clinical and research fellows, and orthotists and prosthetists from a diverse community for neurorehabilitation and neuroengineering research with the goals of improving health and well-being of children and adults and meeting the nation's biomedical, behavioral and clinical research needs using emergent technologies. Experts at Texas Medical Center (TMC) institutions, including Texas Woman's University, the University of Texas Medical Branch and TIRR Memorial Hermann, and the faculty from the BRAIN Center are leveraging unique facilities, extensive expertise and mentoring experience to provide state-of-the-art training in neuroimaging, neuromodulation, and neurorehabilitation engineering. Our NSAP faculty mentors include Profs. Stacey L. Gorniak, Shih-Chiao Tseng, Jinsook Roh, Charles S. Layne, Luca Pollonini, and Gerard E. Francisco.

2022 INTERNATIONAL WORKSHOP ON THE NEURAL AND SOCIAL BASES OF CREATIVE MOVEMENT

Wolf Trap National Park for the Performing Arts

The workshop, co-organized by BRAIN Center Director Jose Contreras-Vidal, recruited for the first time an exceptionally wide range of scientists, engineers, and clinicians to exchange ideas with, and to integrate knowledge and experience among creative movement professionals and other performing artists. Its primary goals were to encourage all participants to reach beyond the confines of their expertise to explore the science of learning to move, how the creative process is manifested in the brain, and how it can be harnessed to enhance health and the quality of life. The workshop included the world premiere of LiveWire, an innovative collaboration between scientists, musicians, and dancers who donned EEG brain caps to visualize brain-to-brain communication, while performing a new work centered around a new string quartet by artistic director Anthony Brandt, set to choreography by Andy and Dionne Noble.

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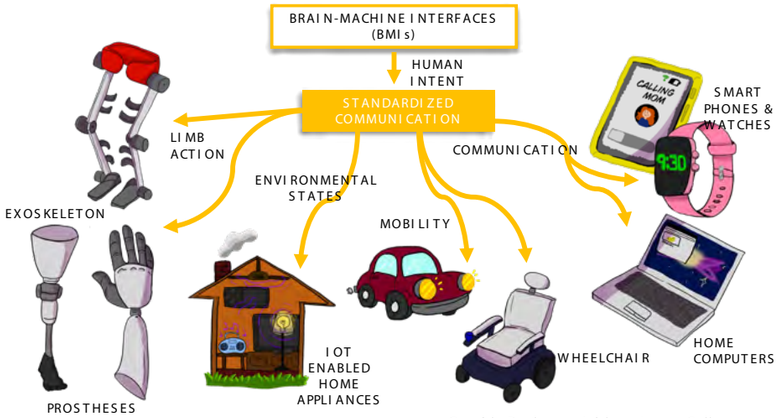


Graphic Designer: Adriana Lopez Cajigas
(IUCRC BRAIN University of Houston)

REGULATORY SCIENCE

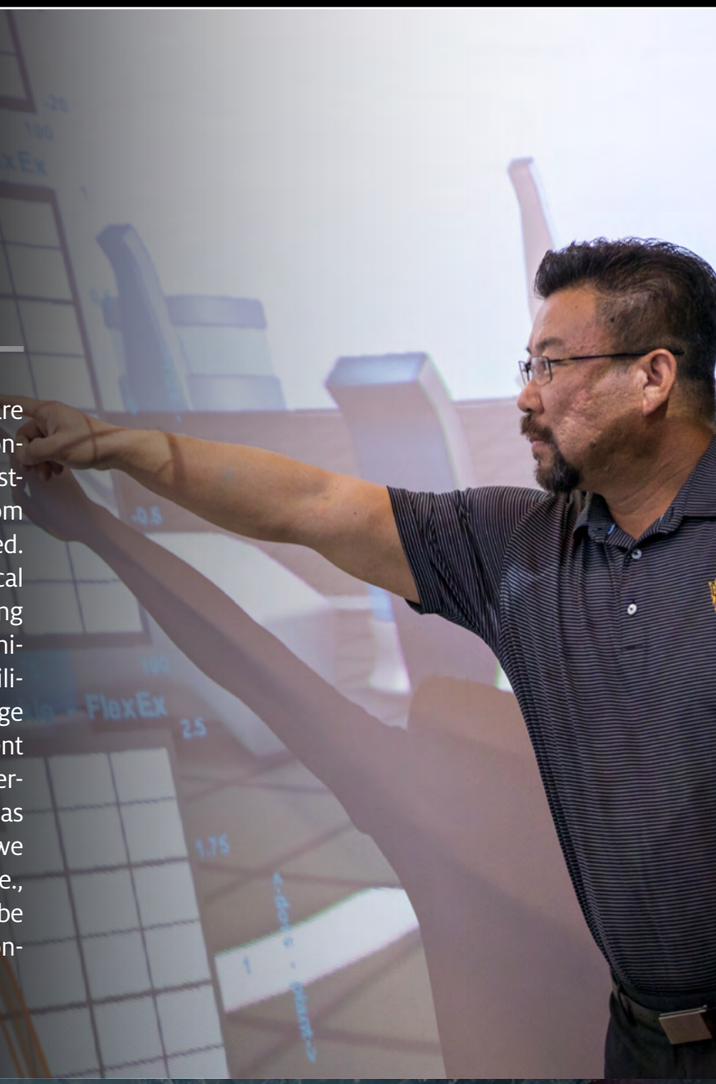
Prof. Contreras-Vidal, co-director of IUCRC BRAIN is a leading advocate for research on regulatory science, standards and neuroethics. BRAIN is a member of the US BRAIN Initiative. Some of the BRAIN Center initiatives include:

- **Regulatory Science:** How do we manage neurotechnologies that skirt the line between medical and consumer applications and what can be done to ensure consumer safety?
- **Standards and Interoperability:** What new standards for brain-machine interfaces are required to accelerate development and translation while promoting innovation?
- **'BMI-of-Things':** What new medical and consumer applications would benefit from BMIoT technologies?

ARIZONA STATE UNIVERSITY

MEASURING CONCUSSIONS on the Sideline

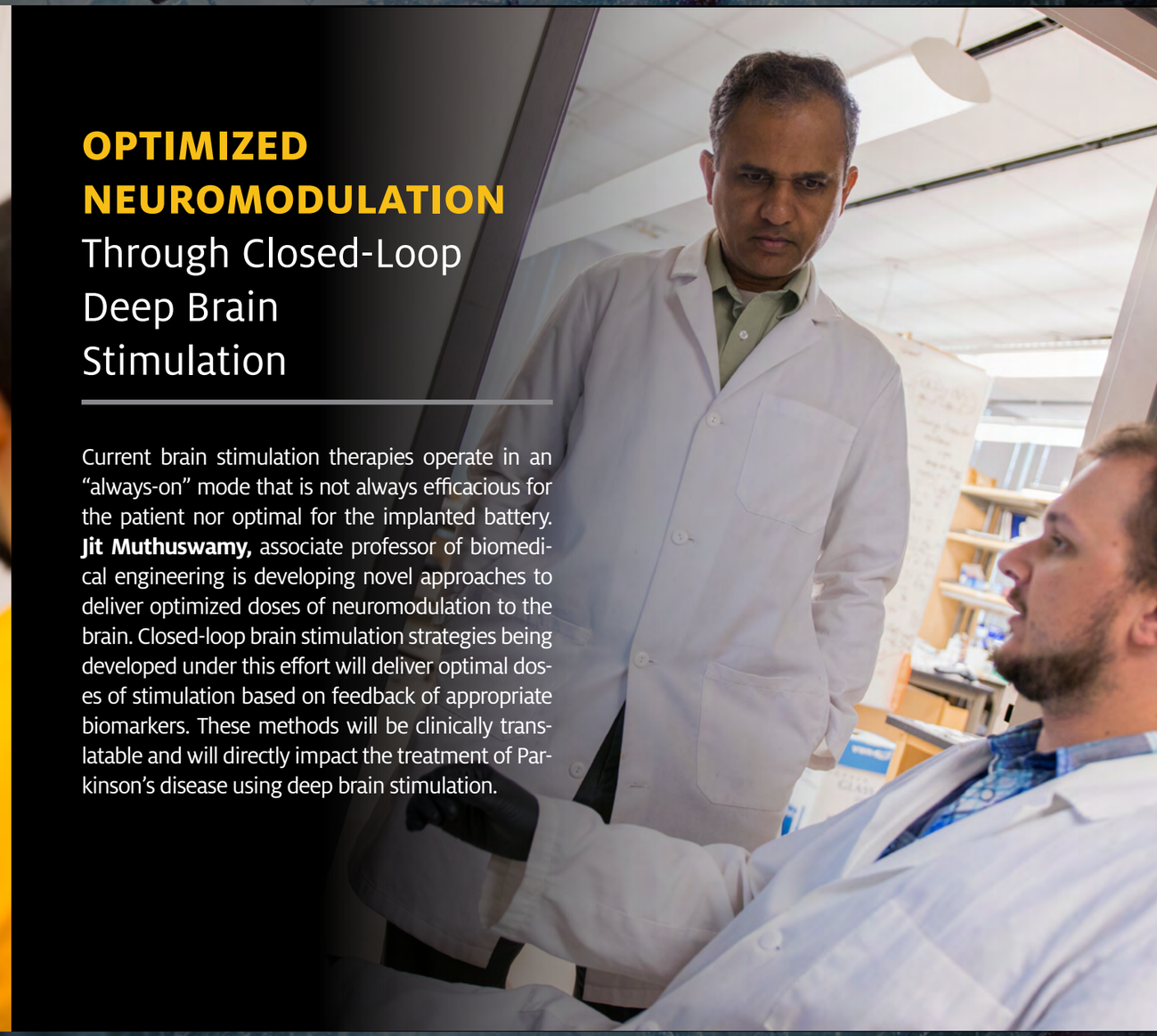
Current concussion assessment systems are difficult to meet in the conditions where concussion events may occur, i.e., an isolated testing environment that removes the player from the field and conditions that are highly biased. **Thurmon Lockhart,** professor of biomedical engineering and biological design, is designing a sideline concussion assessment system to initially detect the effects of concussion on stability that cannot be easily detected. One challenge associated with sideline concussion assessment system is that the highly demanding tasks performed prior to the concussion event may bias the stability measures of sway. In our study, we discovered the effects of physical intensities (i.e., HR) on balance or sway complexities that can be successfully used in the field for measuring concussion and many other health conditions.



TAKING HOLD:
Research Focuses on Brain-Hand Connection

Marco Santello is the Director of the BRAIN Center, the School of Biological and Health Systems Engineering and the Neural Control of Movement Laboratory (NCM), which is dedicated to motor control and learning research. The NCM Laboratory provides a setting for undergraduate, graduate, and postgraduate research on human motor control, as well as for performing collaborative research. The major research foci of the laboratory are control and cortical mechanisms of object grasping, sensorimotor integration, psycho-physics, and the effects of musculoskeletal and neurological disorders on hand control. Advances in robotics technology, design development, and testing of next generation prosthetic hand technology hold promise and the potential for improving the efficacy of rehabilitation of hand function following surgery as well as neuromuscular and neurodegenerative diseases such as stroke, dystonia, and carpal tunnel syndrome.

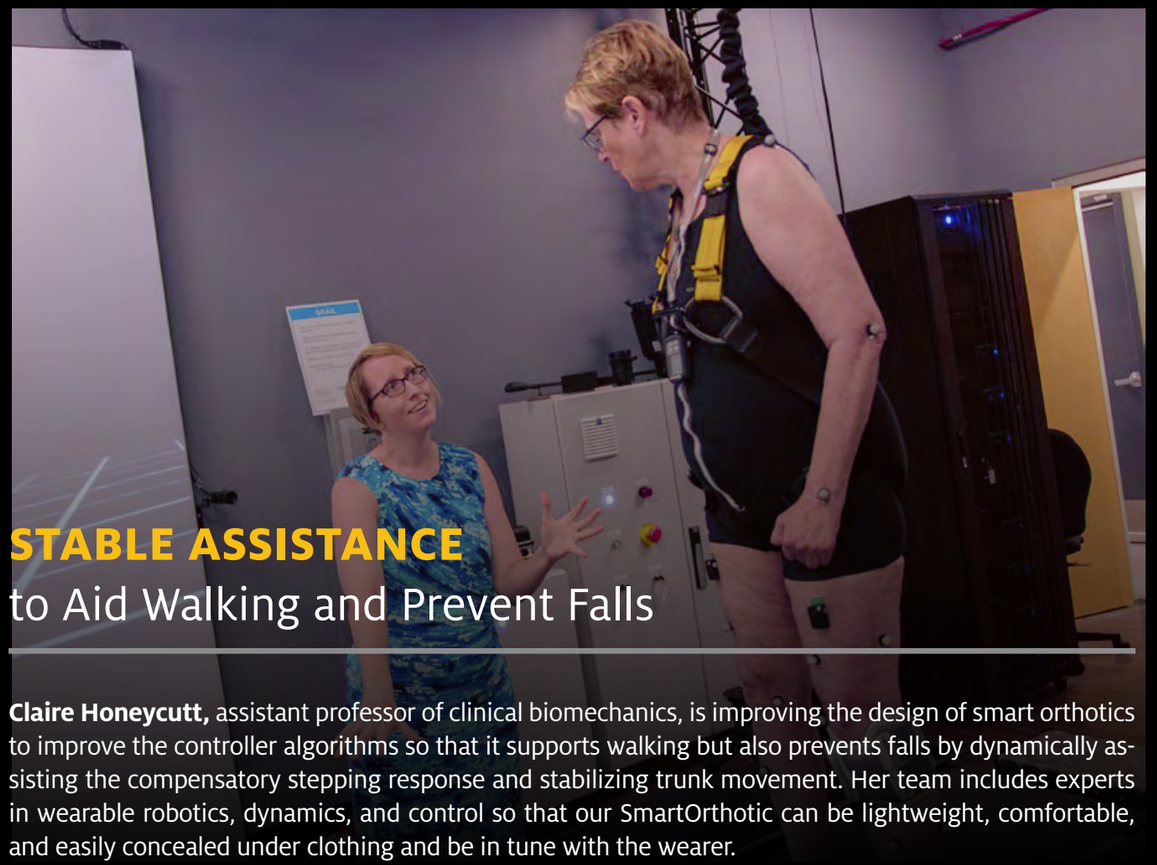
OPTIMIZED NEUROMODULATION
Through Closed-Loop Deep Brain Stimulation



Current brain stimulation therapies operate in an "always-on" mode that is not always efficacious for the patient nor optimal for the implanted battery. **Jit Muthuswamy,** associate professor of biomedical engineering is developing novel approaches to deliver optimized doses of neuromodulation to the brain. Closed-loop brain stimulation strategies being developed under this effort will deliver optimal doses of stimulation based on feedback of appropriate biomarkers. These methods will be clinically translatable and will directly impact the treatment of Parkinson's disease using deep brain stimulation.

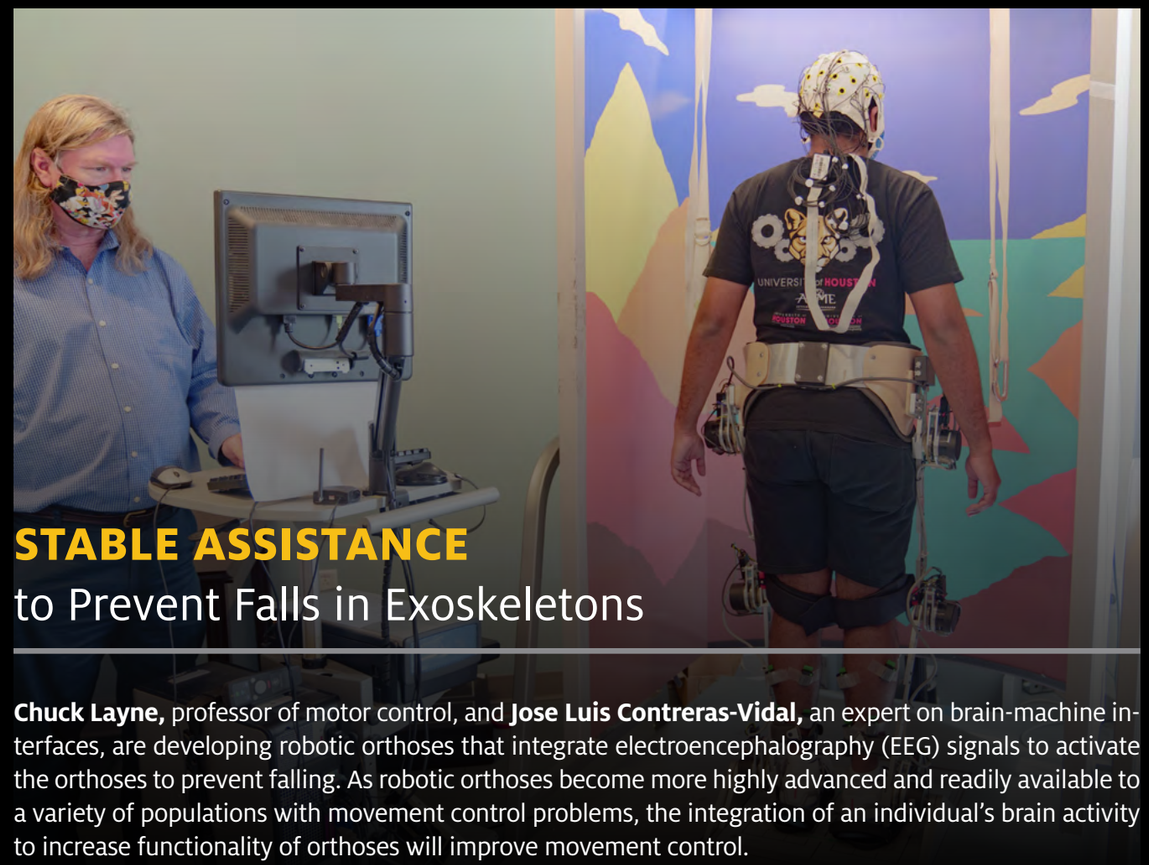
ARIZONA STATE UNIVERSITY AND UNIVERSITY OF HOUSTON

SYNERGISTIC APPROACHES TO FALL PREVENTION



STABLE ASSISTANCE
to Aid Walking and Prevent Falls

Claire Honeycutt, assistant professor of clinical biomechanics, is improving the design of smart orthotics to improve the controller algorithms so that it supports walking but also prevents falls by dynamically assisting the compensatory stepping response and stabilizing trunk movement. Her team includes experts in wearable robotics, dynamics, and control so that our SmartOrthotic can be lightweight, comfortable, and easily concealed under clothing and be in tune with the wearer.



STABLE ASSISTANCE
to Prevent Falls in Exoskeletons

Chuck Layne, professor of motor control, and **Jose Luis Contreras-Vidal,** an expert on brain-machine interfaces, are developing robotic orthoses that integrate electroencephalography (EEG) signals to activate the orthoses to prevent falling. As robotic orthoses become more highly advanced and readily available to a variety of populations with movement control problems, the integration of an individual's brain activity to increase functionality of orthoses will improve movement control.

INTERNATIONAL BRAIN SITE AFFILIATES

MIGUEL HERNANDEZ UNIVERSITY OF ELCHE (SPAIN)

A NEW CLASS OF BRAIN-MACHINE

for commanding lower limb robotic exoskeletons

Jose M. Azorin, Full Professor and Director of the Brain-Machine Interface Systems Lab at Miguel Hernandez University of Elche (Spain), is leading a project focused on developing a new class of non-invasive brain-machine interfaces based on EEG signals that are not only able to control lower-limb exoskeletons for walking and stopping them safely, but also to send them commands for increasing/decreasing their speed, or stopping them if unexpected obstacles appear. This new class of brain interfaces is being tested in the main Spanish hospital for spinal cord injury people, the National Hospital for Paraplegics (Toledo, Spain), that is collaborating in this research. The goal is to provide walking assistance to people with locomotion difficulties inside and outside the clinic environment.

TECHNOLOGICO DE MONTERREY (MEXICO)

PiBOT:

Robotic platform for biometric and mobility applications

The project lead by **Dr. Jorge Lozoya**, a researcher and professor at the Tecnologico de Monterrey, together with a team of researchers, postgraduates, undergraduate students, and industry partners, involves the development of a robotic platform for research on autonomous, biometric parameters measurements, medical assistance, and last mile delivery.

The technology integrated in PiBOT allows it to perform automated navigation, biometric (temperature, fingerprint, voice, face) recognition, and human-robot interaction. PiBOT can be used in medical and industrial field applications such as: biomechanical analysis of pedestrians and workers, safe distance and face mask detection, remote medical assistance for patient monitoring and virtual interaction.

A MESSAGE FROM
the Chairman of the Industry Advisory Board

A modest investment into BRAIN membership gives our small business the leverage and big returns that would not be possible otherwise. We get to work side by side with billion-dollar biotech firms, interact with federal regulatory agencies, have a say in selecting cutting-edge projects, have the choice to commercialize novel devices, and be a part of the neurotechnology revolution.

Sridhar Madala
BRAIN IUCRC IAB Chair
President, Indus Instruments

A MESSAGE FROM
the Co-Chair of the Industry Advisory board

By participating in the BRAIN Center, our researchers and clinicians have direct input into the design and development of the Center's cutting-edge technologies to improve the health and wellbeing of orthopedic and neurology patients. Our research collaborations with BRAIN faculty ensure our clinicians and patients have first access to the newest innovations which help The CORE Institute **Keep Life in Motion!**

Marc Jacofsky
IUCRC BRAIN IAB Co-Chair
Chief Scientific Officer, The CORE Institute

Some of the benefits of membership are:

-Networking with peers at other businesses,
-Collaborating with world class researchers at premier institutions worldwide,
-Helping advance state-of-the-art neurotechnology
-Benefiting from the results with rights to the associated intellectual property.

INDUSTRY PARTNERS

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PROSPECTIVE SITES JOINING THE IUCRC BRAIN IN 2023:

- **Georgia Tech**, Michelle LaPlaca, Site Director
- **University of Maryland Baltimore County**, Ramana Vinjamuri, Site Director
- **West Virginia University**, Peter Konrad and Radhey Sharma, Site Co-Directors

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STEAM + ART-SCIENCE OUTREACH EVENTS COMING IN 2023:

Engineers in Real Life (EIRL): Inspiring the next generation of STEM researchers!

In 2016, Engineers in Real Life (EIRL) was conceived as a way to give students without access to professionals the ability learn more about the careers available to engineers and the many different types of engineering degrees. By bringing in engineering teams from different industry sectors, K-12 students are able to interact with the many different types of engineers, see how they work together to bring projects to life, and learn more about the requirements of the different engineering programs, including electrical, computer and biomedical engineering. This outreach program is now being headed by the BRAIN Center in collaboration with the local School District (CCISD.net), the local PTA (CLHSPTSA.org), and IEEE (IEEE.org) and is offered at no-cost to all K-12 students. The next in-person event will be on February 25th, 2023 from 9am – noon at Clear Lake High School, 2929 Bay Area Blvd, Houston, Texas 77058. For more information, info@EgrIRL.org or www.EngineersIRL.org.

The Slowest Wave

This art-science performance investigates the brain dynamics of dancers while they are performing Butoh, a type of postmodern dance that originated in Japan, through the use of EEG Brain Waves.
February 10, 2023, at the University of Houston Student Center South Theater, Houston

Diabelli 200

Diabelli 200, marks the 200th anniversary of Beethoven's Diabelli Variations, and in collaboration with music composer Anthony Brandt and neuro-engineer Dr. Pepe Contreras-Vidal will explore the neural synchrony between the performers and changes in brain activity throughout the performance. Brandt will use Diabelli's waltz and Beethoven's approach to the variations as inspiration for excerpts of his own variations, scored for flute, clarinet, piano, percussion, violin, and cello.
February 24 and 25, 2023, at the Wortham Center's Cullen Theater, Houston.

Building Reliable Advances and **BRAIN** Innovations in Neurotechnology

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to discuss the opportunities for your company to be a part of this center.

Together, we will revolutionize the treatment of brain disorders.

nsfbrain.org

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