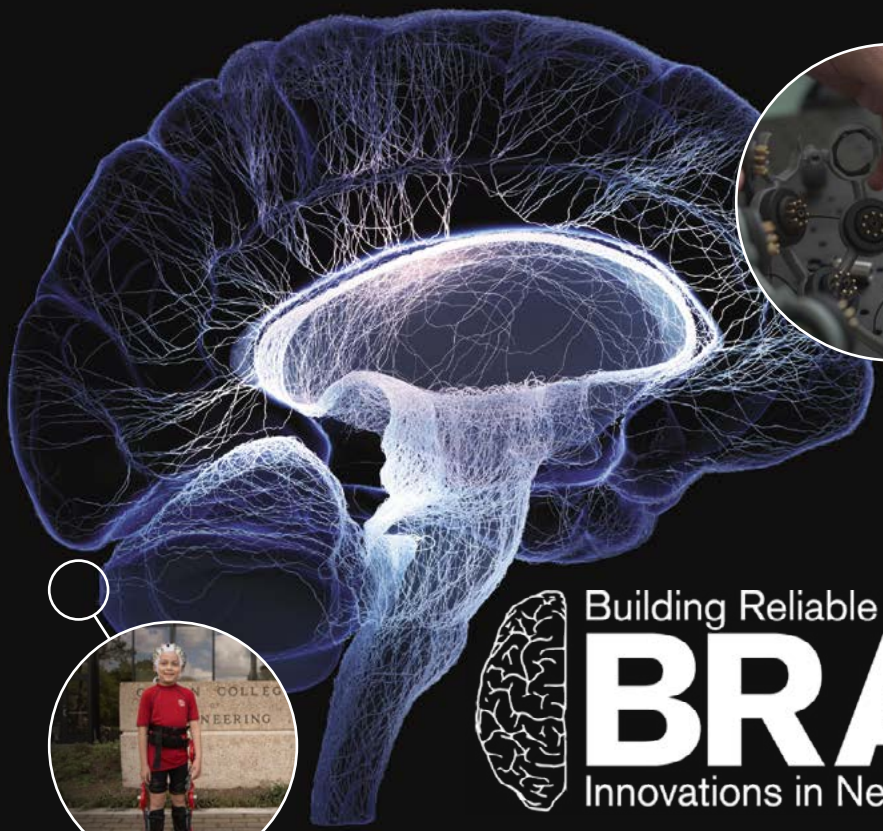
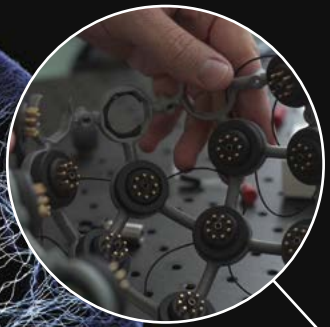




Building Reliable Advances and

BRAIN

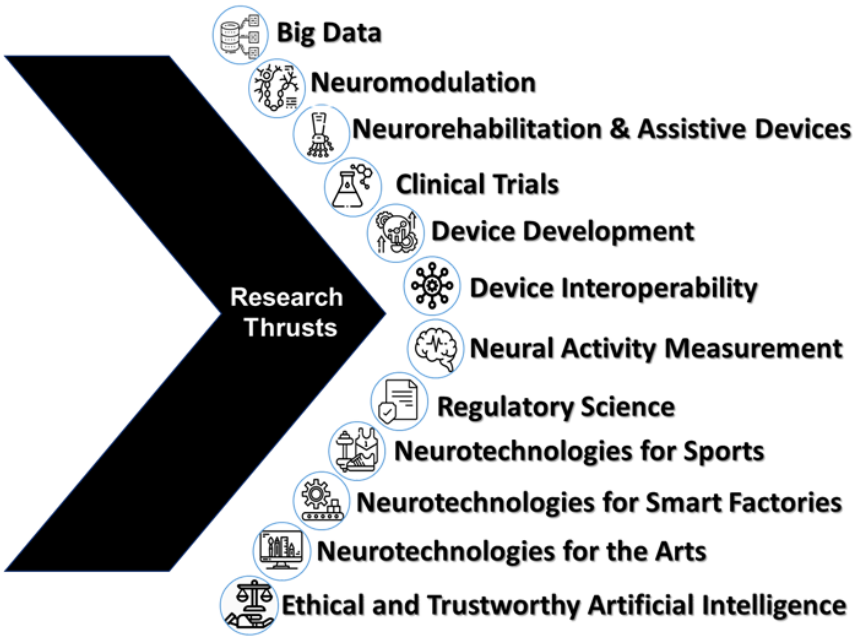
Innovations in Neurotechnology

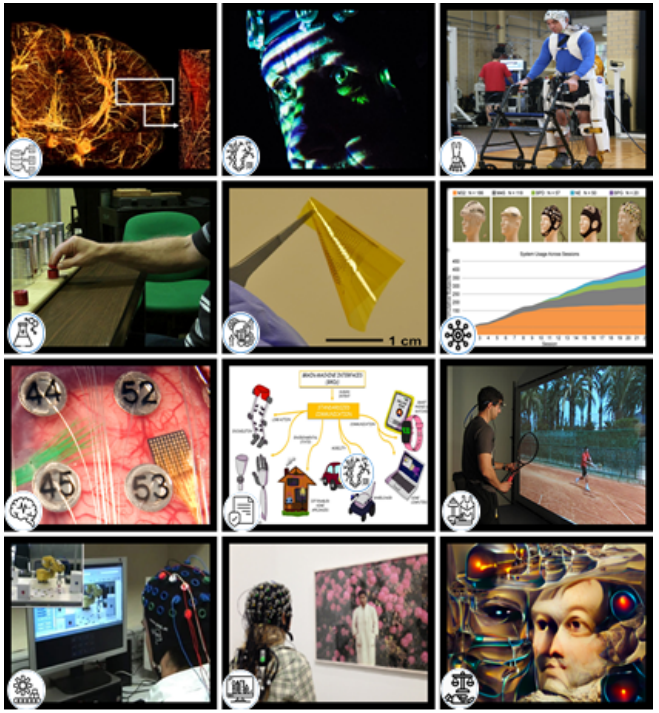
An Industry-University Cooperative Research Center (IUCRC)

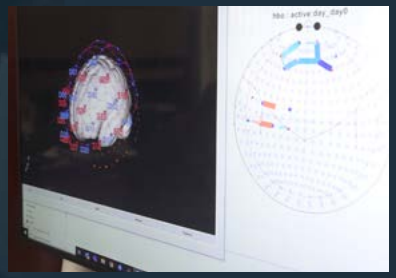
Academia, Industry Collaborate on Solutions to **NEURAL DISEASE AND INJURY**

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 11 industry partners (including several hospital systems) are involved in the center.

RESEARCH THRUST AREAS

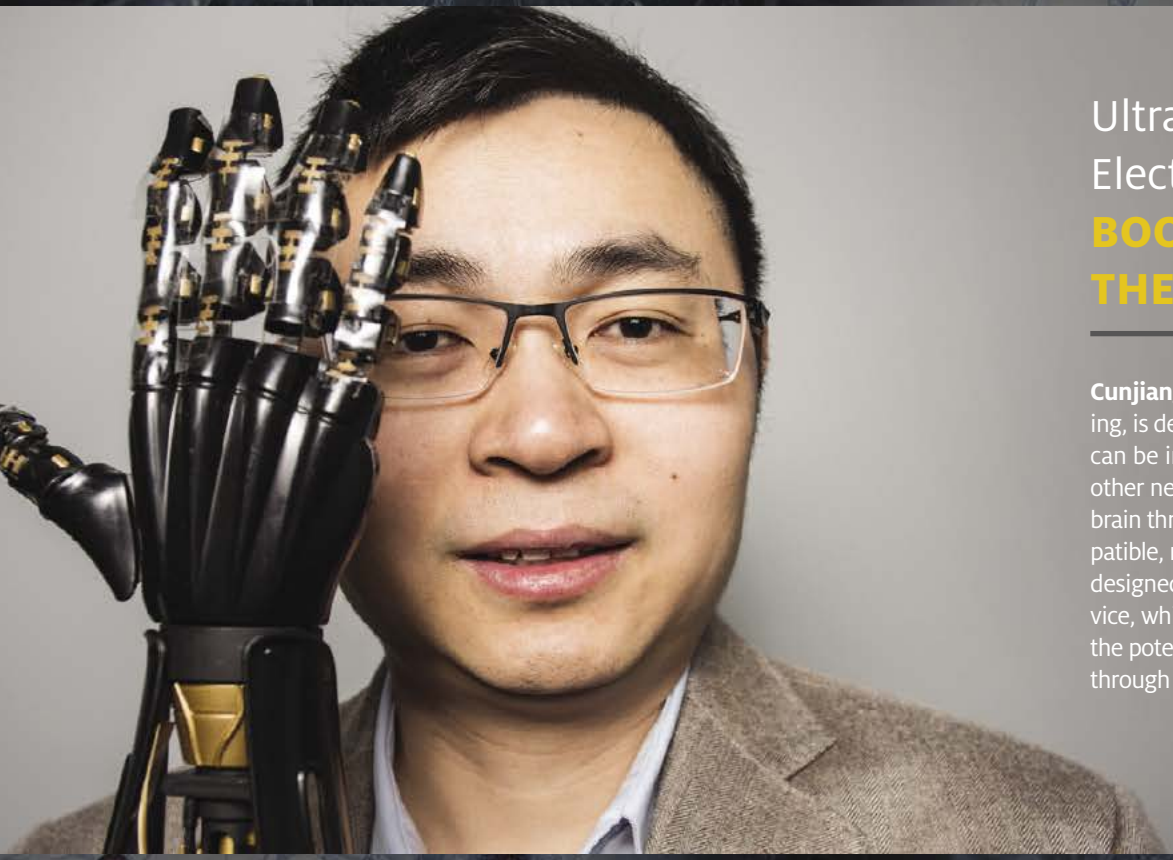






UNDERSTANDING THE BRAIN IN REAL LIFE

Luca Pollonini, assistant 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.



Ultra-Thin, Soft and Compatible Electronics to **BOOST UNDERSTANDING OF THE BRAIN**

Cunjiang Yu, Bill D. Cook Assistant Professor of mechanical engineering, is designing ultra-thin and soft electronic devices and systems that can be integrated with the brain to diagnose and treat diseases and other neural conditions. These devices, which can be implanted in the brain through a minimally invasive procedure, are made up of biocompatible, nano-structured materials and ultra-thin networked structures designed to be as soft and stretchable as human brain tissue. The device, which will have similar mechanical properties of brain tissue, has the potential to revolutionize brain research — something not possible through conventional or existing tools.

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 inside of Contreras-Vidal's lab in a 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**

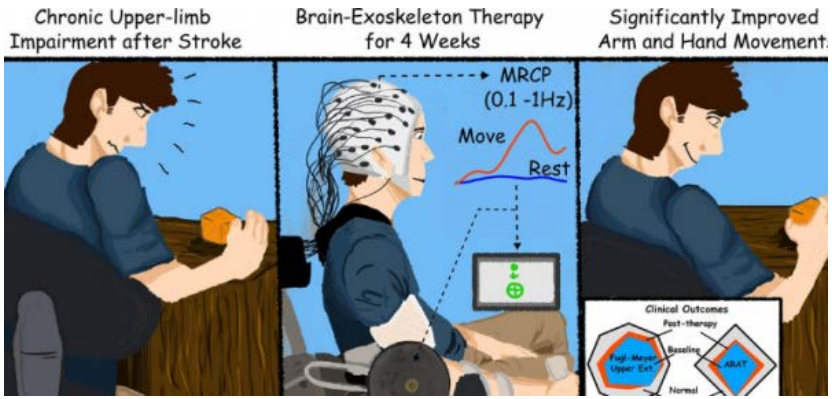
Researchers are gaining a better understanding of what happens in the brain when people experience art and creativity, which could offer benefits far beyond the art world. **Jose Luis Contreras-Vidal,** Hugh Roy and Lillie Cranz Cullen Distinguished Professor of electrical and computer engineering at 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

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.



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.

REU SITE AWARD #1757949:
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.

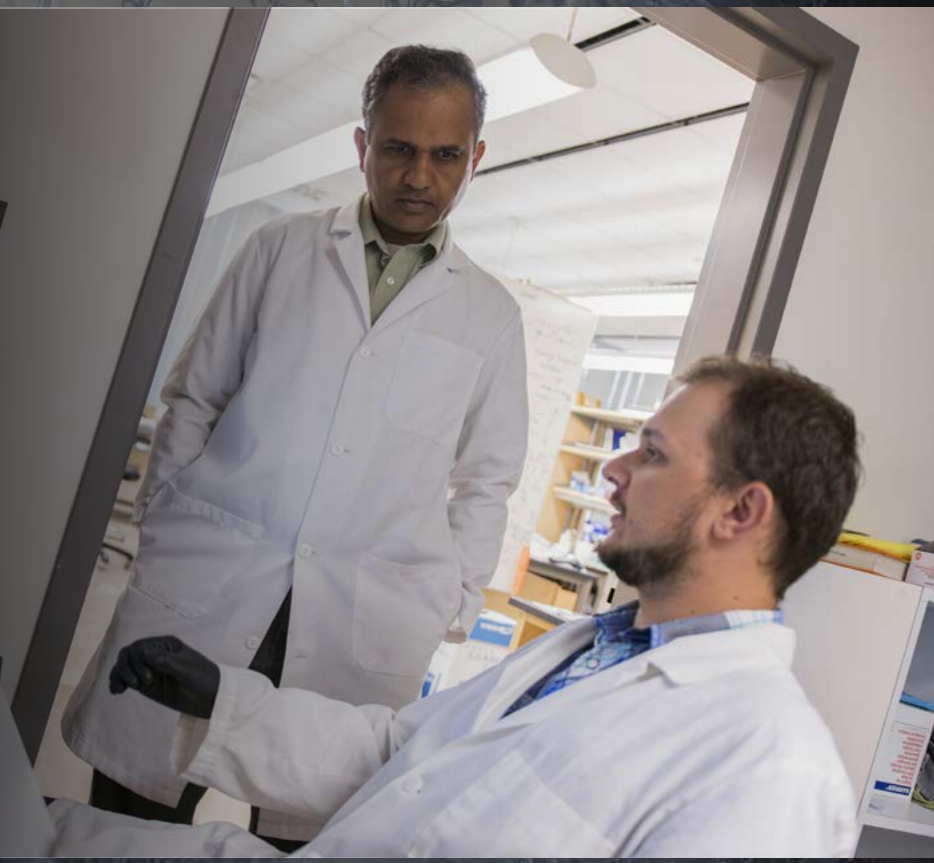
The program is designed to inspire bright and motivated undergraduates to pursue graduate education and careers in science and engineering research. Participants in the program worked closely with leading neural engineers and neuroscientists at the BRAIN Center, contributing to the development of innovative medical devices including diagnostics, neural interfaces, medical robotics and other ongoing cutting-edge research in neural, cognitive and rehabilitation engineering. To date, 48 undergraduate students have completed the program, and 14 high school trainee students have participated.

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 bio-markers. These methods will be clinically translatable and will directly impact the treatment of Parkinson's disease using deep brain stimulation.



ARIZONA STATE UNIVERSITY

MEASURING CONCUSSION
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 and that cannot be easily deceived. 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.

GOAL: TO INSPIRE, EMPOWER, AND CONNECT

aspiring entrepreneurs
in neural engineering

The BRAIN Center hosted the IEEE Neurotechnology Entrepreneurship Workshop for Graduate trainees (Masters, PhDs, Post-Doctorate, Medical) in 2019. This workshop provided intensive and rigorous training in the areas of: ideation, market analysis, customer and stakeholder analysis, intellectual property, regulatory affairs, reimbursement, valuation, and fundraising. As part of this workshop, students were given challenges prevalent in the neurotechnology industry and presented their startup solutions to industry leaders. Additionally, students were given the opportunity to network with industry and academic leaders in the neurotechnology field.

SYNERGISTIC PROJECTS BETWEEN ASU AND UH

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

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 on 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.

PiBOT:
Robotic platform for biometric and mobility applications

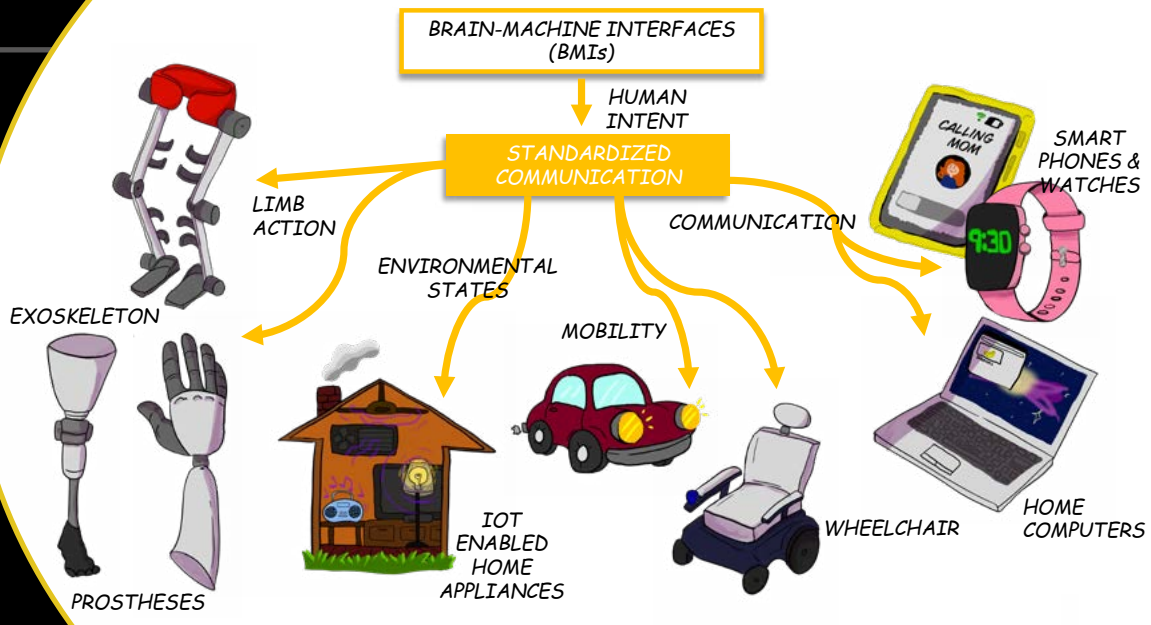
The project lead by **Dr. Jorge Lozoya**, a researcher and professor at the Tecnologico de Monterrey, together with a team of researchers, postgraduates, undergraduate students, and industry partners, involves the development of a robotic platform for research on autonomous, biometric parameters measurements,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

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?



GRAPHIC DESIGNER: ADRIANA LOPEZ CAJIGAS (IUCRC BRAIN University of Houston).

https://doi.org/10.1109/OJEMB.2021.3059161

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

Some of the benefits of membership are:

-Networking with your 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.

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

THE BRAIN CENTER

The Building Reliable Advances and Innovation in Neurotechnology (BRAIN) Center is an Industry/University Collaborative Research Center at Arizona State University (ASU) and the University of Houston (UH). This partnership will allow rigorous testing of efficacy, safety and long-term reliability of neurotechnology that would not be otherwise possible within the traditional 'silos' of academic, industry, regulatory and clinical communities. The BRAIN Center will develop safe, effective and affordable personalized neurotechnologies for diagnostics, restoration, enhancement, and rehabilitation of sensory, motor, affective and cognitive functions. This mission will be pursued by supporting innovative interdisciplinary research across the multiple dimensions of brain function and behavior with the ultimate goal of improving quality of life.

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INDUSTRY PARTNERS

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.

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