Center for Neural Systems Restoration

2024 Fall Symposium

NeuroSystems: From Circuits to Restoration

Sept. 17–18, 2024

Houston Methodist Research Institute
John F. Bookout Auditorium (R2-306)

HOUSTON Methodist LEADING MEDICINE | RICE

AGENDA

Tuesday, Sept. 17

8 a.m.	**Registration and Breakfast** (Registration open until 3 p.m.)
9 a.m.	**Opening Remarks from CNSR Directors** **Valentin Dragoi, PhD,** Houston Methodist/Rice University **Gavin Britz, MD,** Houston Methodist **Behnaam Aazhang, PhD,** Rice University
9:15 a.m.	**Session 1: Neural Circuits I** 1) **Cortical Circuits for Spatial Navigation** Christopher Harvey, PhD The Harvey lab studies the circuits that underlie computations for spatial navigation. This talk will present recent work that identifies an inhibitory cell type signaling error-related events during navigation. 2) **Closed-Loop Microstimulation Approach to Enhance Social Attention Dynamics** Steve Chang, PhD This talk will describe recent work that applied closed-loop microstimulation in prefrontal cortical areas when pairs of macaques interacted with gaze. Stimulations to the orbitofrontal cortex enhanced momentary spatial and temporal social attention, whereas stimulations to the dorsomedial prefrontal cortex modulated longer-term inter-individual gaze dynamics. This work has potential therapeutic implications for improving social attention. 3) **Information Processing and Coding in Cortical Circuits During Natural Behavior** Valentin Dragoi, PhD Summary: The presentation will focus on recent work from the Dragoi lab involving multi-electrode recordings of population activity in visual and prefrontal cortex in restrained and freely moving macaques to examine the neural network underpinnings of natural behavior. This includes information processing and coding principles in cortical networks underlying changes in behavioral performance after sleep and during complex behavior, such as foraging and social interactions.
10:55 a.m.	**Coffee Break**

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Tuesday, Sept. 17

11:15 a.m.	**Session 2: Neuroprosthetics/Physiology I** 1) **Miniaturized, Injectable and Distributed Brain Implants for Next Generation Neural Interfacing Applications** Baibhab Chatterjee, PhD Summary: Current state-of-the-art implantable technologies for the brain rely on intracortical or depth electrodes, and are either limited in the number of sites and spatial extent coverable or become too invasive when multiple of them are implanted together. This talk centers around designing the next generation of recording and stimulation devices for treating brain disorders. Chatterjee discuss his recent efforts on chronic, ultra-small brain implants which are minimally-invasive, individually addressable, wireless, battery-less and injectable. 2) **Artificial Tactile Feedback for Bidirectional Brain Computer Interfaces** Robert Gaunt, PhD Summary: Over the last decade it has become possible to use intracortical brain computer interfaces to restore artificial tactile sensations. Gaunt will briefly describe the abilities enabled by restoring somatosensory feedback and focus on recent advances in expanding the repertoire of artificial touch from simple detection through to edges and motion and discuss principles to more closely replicate our natural sense of touch using intracortical microstimulation. 3) **Unlocking Movement: Helping Paralyzed People Use Thought to Control Assistive Devices** Richard Andersen, PhD Summary: Andersen uses a novel approach to brain-machine interfaces: implanting electrodes in a variety of specialized cortical areas rather than in the motor cortex alone. This approach has enabled study participants to use their thoughts and intentions to control computers and robotics. These studies also provide a deeper understanding of the neurophysiology of different human cortical areas.
12:55 p.m.	**Lunch Break** Tour of CNSR (sign-up at registration desk)
2:05 p.m.	**Session 3: Innovative Technologies I** 1) **Functional Ultrasound Imaging of the Human Spinal Cord to Enable GU Neurorestoration** Charles Liu, MD, PhD Summary: Functional neuroimaging of the human spinal cord does not exist in practical reality, particularly outside the cervical segments. Thus, many of the processes inherent to critically relevant functions such as micturition remains poorly understood. Here, Liu describes the first application of functional ultrasound to image the human spinal cord in an epidural spinal cord stimulation model, followed by during bladder filling and emptying. This innovative technology will be a key enabler to GU neurorestoration. 2) **Empowered by Thought: A Vision for the Future of Brain Computer Interfaces** Florian S. Solzbacher, PhD Summary: Solzbacher will review the state of the art, major inflection points and breakthroughs as well as technical limitations, hurdles to adoption and access for implantable brain computer interfaces as well as ethical implications. What role can and may Artificial Intelligence play in conjunction with Brain Computer Interfaces. 3) **Toward Psychiatric Brain Computer Interfaces: Distributed Implants to Measure and Manipulate Brain States in Large Animals and Human Subjects** Jacob T. Robinson, PhD Summary: In this talk, Robinson will discuss recent developments in wireless networks of millimeter-sized bioelectronic implants to stimulate and record brain activity in large animals and efforts to translate this technology to the treatment of patients with drug-resistant mental health conditions.
3:45 p.m.	**Coffee Break**

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Tuesday, Sept. 17

4:05 p.m.	**Session 4: Neuroprosthetics /Physiology II** 1) **Mapping and Modulating Neural Circuits in Humans** Sarah Heilbronner, PhD Summary: Mental health disorders are largely understood to be connectionist disorders, but experts are limited in their understanding of human brain connectivity. Heilbronner will describe a potential pipeline for creating biologically validated maps of anatomical connectivity in humans, as well as show applications. 2) **Neuromodulation of Spinal Sensorimotor Networks Using Invasive and Non-Invasive Spinal Stimulation** Dimitry Sayenko, MD, PhD Summary: The purpose of this presentation is to articulate clinical and physiological perspectives on the use of transcutaneous (TSS) and epidural spinal stimulation (ESS) in combination with movement-specific training paradigms in individuals with chronic spinal cord injury (SCI) and in preclinical experimental animal models. 3) **Network-Minded Psychiatric Neuromodulation** Sameer Anil Sheth, MD, PhD Summary: The Sheth lab focuses on the study of higher cognitive function and psychiatric neuromodulation, topics that they view as flip sides of the same coin. On one side, they rely on opportunities derived from clinical neurosurgical procedures to study cognitive neurophysiology with intracerebral electrodes. On the other, they develop neuromodulatory procedures to engage dysfunctional circuits and steer them towards healthy states in the service of treating neurological and psychiatric disorders. Sheth will focus this presentation on the concept of network dysfunction in psychiatric disorders and the need for deeply understanding these dysfunctional circuits in order to optimize therapy.
5:45 p.m.	**Reception**

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Wednesday, Sept. 18

8 a.m.	**Registration and Breakfast** (Registration open until 3 p.m.)
9:15 a.m.	**Session 5: Neuroprosthetics/Physiology III** 1) **Epidural Electrical Stimulation Restores Upper Limb Motor Function After Cervical Spinal Cord Injury** Phil Horner, PhD Summary: The Horner lab applied a unique ventral approach to activate spinal motor circuitry from the ventral surface of the cervical spinal cord. Animals receiving a C4 spinal cord injury and electrical stimulation had significantly improved upper limb motor function. Electrical stimulation resulted in a gradient of gene expression near the electrode that indicates activity-dependent plasticity may involve immune modulation. 2) **Central Thalamic Deep Brain Stimulation in Moderate to Severe Traumatic Brain Injury** Nicholas Schiff, MD Summary: This talk will discuss recent results applying central brain stimulation to treat chronically impaired executive function following moderate to severe traumatic brain injury. The observations will be placed in the context of known anatomical and physiological specializations of the central lateral thalamic nucleus and the "mesocircuit" hypothesis for recovery of integrative brain function following coma. 3) **Towards an Artificial Retina: A Cellular-Resolution Bi-Directional Neural Interface** E. J. Chichilnisky, PhD Summary: Electronic retinal implants provide an opportunity to restore or even enhance vision. However, existing implants are not designed to reproduce the spatiotemporally precise and cell-type specific patterns of neural activity that mediate natural vision. Chichilnisky will argue that reproducing the neural code of the retina will require devices that both stimulate and record at single-cell, single-spike resolution. He will then describe his work using large-scale multi-electrode stimulation and recording from the macaque and human retina ex vivo. The results indicate that, in some cases, such resolution is possible, and these efforts to develop an implant can produce advanced vision restoration using this approach.
10:50 a.m.	**Neurorestoration-Related NIH Programs** **NINDS and Trans-NIH Programs Supporting Device Development and Translation to Restore Neural Function** Brooks A. Gross, PhD Summary: The National Institute of Neurological Disorders and Stroke (NINDS)'s Division of Translational Research (DTR) provides funding and resources to academic and industry researchers to advance early-stage neurological technologies, devices and therapeutics to industry adoption. Within DTR, the Translational Devices Team has created a variety of programs to support neurotechnology development and translation. These programs include all stages of neurotechnology translation from early-stage device development and optimization to preclinical evelopment and early feasibility clinical trials. An overview of funding opportunities in these NINDS and trans-NIH programs will be presented.
11:10 a.m.	**Coffee Break**

AGENDA

Wednesday, Sept. 18

11:30 a.m.

Session 6: Neural Circuits II

1) **Prefrontal Astrocyte-Neuron Circuits Critically Mediate Reinforcement Learning**
Mriganka Sur, PhD
Summary: Recent work in the Sur laboratory demonstrates that astrocytes in the cerebral cortex are essential, instrumental mediators of reinforcement learning and learned behavior. Astrocytes respond selectively to norepinephrine (NE), which is released in the cortex by locus coeruleus neurons to signal reward prediction error during unexpected behavioral outcomes, and transform a brief phasic NE signal into a large prolonged calcium signal. Astrocyte calcium causes release of ATP/adenosine and alters the activity of neuronal populations in prefrontal cortex to enhance stimulus discriminability and improve subsequent behavioral performance. Astrocytes in prefrontal cortex are important novel targets for understanding and treating neuropsychiatric disorders.

2) **Characterizing How Neural Population Codes Transmit Information Downstream**
Stefano Panzeri, PhD
Summary: The last few decades have witnessed major progress in understanding how neural populations within a brain region encode information. However, less is known about the features of neural population activity that shape how this information is transmitted downstream. Part of the difficulties in understanding this has been due to the lack of suitable mathematical analysis methods to address this issue directly. In this talk, Panzeri will present computational work done in his lab to address these questions, and he will present what his team has begun to understand about how the structure of neural population activity shapes the transmission of this information to other areas.

3) **Chronic Neural Circuit Dynamics Revealed by Ultraflexible Electrodes: Exploring Representational Drift and Neuroplasticity**
Lan Luan, PhD
Summary: The recent advancement of ultraflexible electrode technology has enabled unprecedented longitudinal recordings of numerous neurons while minimizing tissue-electrode interface instability and allowing for simultaneous optical imaging in the same region. These capabilities have opened new avenues for investigating chronic neural circuit dynamics. In this presentation, Luan will discuss two studies. First, she will report day-to-day representational drift in the visual cortex under various visual stimuli, highlighting the role of temporal coding in stabilizing these representations. Second, she will discuss longitudinal tracking of neural activity in a single-barrel-targeted ischemic stroke model, demonstrating that stroke-induced plasticity manifests as selective potentiation within existing functional circuits, rather than functional remapping of new neurons. These findings highlight the crucial role of high-resolution, stable neural recordings in advancing our understanding of long-term neural adaptation.

1:10 p.m.

Lunch Break
Tour of CNSR (sign-up at registration desk)

2:10 p.m.

Session 7: Innovative Technologies II

1) **Cellular Voltage Imaging Analysis of Neural Circuit Mechanisms of Behavior and Clinical Neuromodulation**
Xue Han, PhD
Summary: In this talk, Han will describe her group's ongoing effort to develop cellular voltage imaging techniques, and the application of cellular imaging in probing the mechanisms of behavior, and electrical and ultrasonic neuromodulation.

2) **6,000 Channel Mice and 12,000 Channel Rats: Brain Wide Recording, A New Step in Electrophysiology Technology**
Tim Harris, PhD
Summary: The past decade has seen rapid growth in the capacity and fidelity of extracellular electrophysiology. Lead by Neuropixels, recordings with hundreds of units across the brain have become routine. Harris will show his most recent generations of probes, both with 1,536 channels. The most advanced of these is small enough to make a 6,000 channel implant in a freely moving, tethered mouse a straight forward experiment while 12,000 channels in a rat will be easier and 18,000 plausible. The very large data sets that result demand more automated analysis pipelines and consideration of system vs. single unit modeling of multi-region brain activity.

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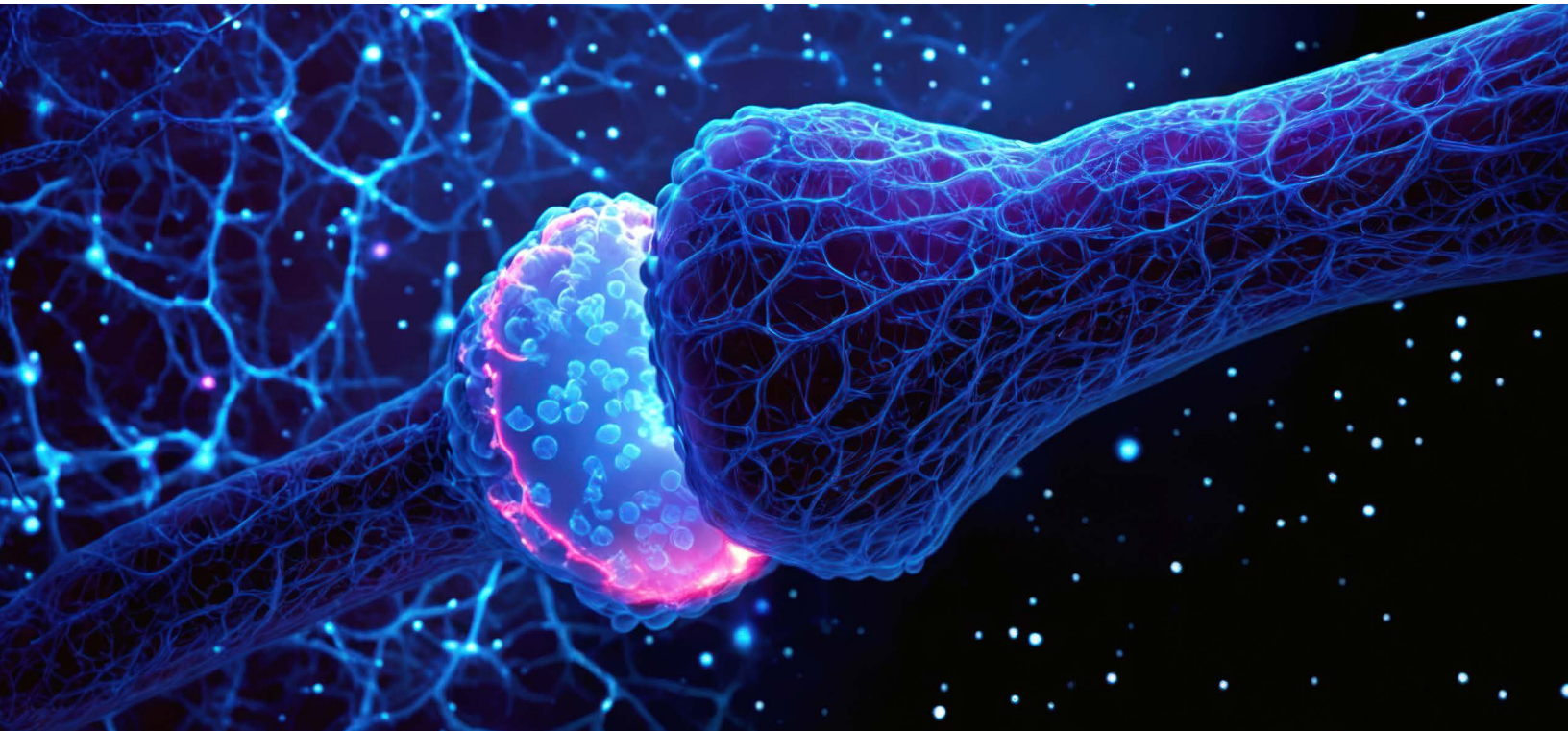
	Session 7: Innovative Technologies II 3) **Noninvasive Monitoring and Control of Specific Brain Regions With Molecular Engineering** Jerzy Szablowski, PhD Summary: Our laboratory focuses on developing tools that allow for interfacing with specific brain regions and cell-types through gene therapy, biologics, and small molecule drugs. Armed with these methods we aim to develop new therapies for psychiatric and neurological disorders. To that end, we developed multiple technologies, such as Acoustically Targeted Chemogenetics (ATAC) for noninvasive chemogenetic neuromodulation, or synthetic serum markers that allow for measurement of gene expression in the brain with blood tests.
3:55 p.m.	**Coffee Break**
4:10 p.m.	**Session 8: Innovative Technologies III** 1) **Ultraflexible Electrodes for High-Dimensional, Two-Way Neural Interface** Chong Xie, PhD Summary: Implanted electrodes are a primary tool in neuroscience and carry rising significance in clinical treatments. While being uniquely capable in time-resolved electrical detection and modulation of neural activity, neural electrodes have limits in tissue invasiveness, functional stability and scalability. In this talk, Xie will present his work on the development of ultraflexible neural electrodes and application of them in rodent brain and spinal cord models. He will present his recent efforts on massively scaling-up the channel count and density, and intracortical stimulation. 2) **When the Doctor Becomes the Patient** Hany Samir, MD Summary: Samir will discuss his personal journey as physician and patient, the innovations that were used for my recovery and adaptation, and their role in his daily life. He will also discuss the deployment of robotics vs AI technology using existing neuro pathways to bypass injured areas of the brain.
5:15 p.m.	**Final Remarks** **Valentin Dragoi, PhD**
5:30 p.m.	**Hors d'oeuvres**



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CONFIRMED SPEAKERS

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T&C Chen Brain-Machine Interface Center Leadership Chair
California Institute of technology

Steve Chang, PhD
Associate Professor, Psychology
Associate Professor, Neuroscience
Yale University

Baibhab Chatterjee, PhD
Assistant Professor, Electrical and Computer Engineering
University of Florida

E. J. Chichilnisky, PhD
Professor of Neurosurgery, Ophthalmology and
Electrical Engineering
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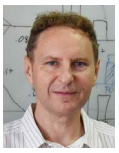

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CONFIRMED SPEAKERS

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Professor, Bioengineering
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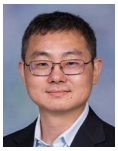

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