Center for Neurotechnology (CNT)

an NSF Engineering Research Center

Participating Laboratories

(additional labs may be added later)

University of Washington Labs (REU, REV, YSP, RET)

Laboratory of Dr. Chet Moritz

Research Mission: The Moritz lab is developing methods for bypassing damage to the brain or spinal cord and restoring conscious control of movement to paralyzed limbs. The team's goal is to record neural signals from intact areas of the brain and to use these signals to control stimulation delivered to paralyzed muscles or the spinal cord below the injury. Previous Research Experience for Undergraduate (REU) students demonstrated that stimulation within the cervical spinal cord is capable of evoking hand and arm movements both before and after injury. This intraspinal stimulation evokes functional and synergistic movements that may be the ideal means to awaken paralyzed limbs.

A Good Match for: Those who are interested in discovering new ways to help restore function for people suffering from paralysis. People interested in the intersection between rehabilitation medicine, physiology, biophysics, neurobiology, and electrical engineering.

UW Department: Rehabilitation Medicine
Website: http://depts.washington.edu/moritlab/

Laboratory of Dr. Steve Perlmutter

Research Mission: The Perlmutter lab is interested in understanding and manipulating neural plasticity in mammalian motor systems to develop new therapies that improve recovery after spinal cord injury and brain damage. Although the body's natural recovery processes after injury do not cause spared neural pathways to achieve their fullest potential for restoring function, substantial behavioral gains can be achieved with small but opportune changes in cortical and spinal organization. We are investigating strategies for inducing plasticity in normal and lesioned motor systems using activity-dependent, targeted, electrical and optical stimulation and delivery of neuromodulators and neurotrophins. Our lab uses neurophysiological, behavioral, anatomical, computational, and genetic techniques in studies in rodents and non-human primates. We have active collaborations with cell and gene biologists, neurosurgeons, and engineers designing devices for brain-computer interfaces.

A Good match for: People interested in developing new treatments for motor impairment after injury to the nervous system, motor behaviors of the arm and hand, and/or the combination of neuroscience and engineering for rehabilitation.

UW Department: Physiology & Biophysics, Neurobiology & Behavior
Websites: http://depts.washington.edu/pbiopage/faculty/sperlmutter
http://depts.washington.edu/behneuro/people/faculty/perlmutter.shtml

Laboratory of Dr. Jeffrey Ojemann

Research Mission: The Ojemann lab is interested in using electrocorticography (ECoG) to answer basic neuroscience questions as well as to develop tools for clinical and rehabilitative applications. ECoG, which is

used for long-term clinical monitoring of epilepsy patients, provides a unique opportunity to collect data directly from the surface of the brain in awake, active humans. The group represents researchers from a wide range of backgrounds including neurosurgery, neurology, rehabilitative medicine, engineering, neuroscience, and physics. A major focus of the group is brain-computer interfaces; current projects include learning mechanisms, tactile feedback, and recursive stimulation. Ojemann's team is also investigating more fundamental questions about cortical representation of simple and complex hand movements, the dynamics of cognition, language, and higher-order nonlinear interactions between brain areas. Other projects include integration of ECoG and fMRI (functional magnetic resonance imaging) and studies of temporal lobe epilepsy

A Good Match for: People interested in neurosurgery, epilepsy surgery, and brain research. People curious about the intersection between cognitive neuroscience, physics, applied math, and computer science.

UW Department: Neurological Surgery
Website: http://neurosurgery.washington.edu/research/labs/ojemann.asp

Laboratory of Dr. Jay Rubinstein

Research Mission: Dr. Rubinstein's lab explores cochlear implant signal processing to develop and improve implantable devices that combat the effects of hearing loss and disequilibrium. The Rubinstein Lab uses novel signal processing strategies to enhance function of current cochlear implant technology, and to understand the processing of auditory information in the brain. In addition, the group is developing novel instruments to evaluate auditory processing in patients.

A Good Match for: People concerned with or interested in the treatment of deafness and other communication disorders. People interested in the intersection of neurophysiology, otolaryngology, audiology, computer science, and neural engineering.

UW Department: Otolaryngology
Website: http://depts.washington.edu/coursejo/ESVN/rubinstein.html

Laboratory of Dr. Kat Steele

Research Mission: The Ability & Innovation Lab is focused on using engineering and design to improve movement for individuals with neurologic injuries such as cerebral palsy and stroke. Our team uses a variety of tools including musculoskeletal simulation (https://opensim. stanford.edu), motion analysis, 3D-printing, and electromyography to determine new ways to improve human movement. Previous students with the CNT have worked on projects using 3D-printing to improve the design of orthoses for individuals with impaired hand function and using electromyography to develop new systems to track and train muscle activity in daily life.

UW Department: Mechanical Engineering
Website: http://depts.washington.edu/uwsteele/

Laboratory of Dr. Fred Rieke

Research Mission: The research in the Rieke lab focuses on sensory signal processing, particularly in cases where sensory systems perform at or near the limits imposed by physics. The central goal of the work in the

Rieke lab is to relate biophysical mechanisms operating in the retina to defined roles in computation and ultimately behavior. The experimental basis for this work comes from several physiological preparations that allow researchers to track responses generated by the rod and cone photoreceptors across the retinal circuitry, and recently also from human behavioral work.

A Good Match for: People who want to research vision and visual processing. People interested in studying physiology and biophysics.

UW Department: Physiology and Biophysics
Website: http://rieke-server.physiol.washington.edu/index.html

Laboratory of Dr. Thomas Daniel

Research Mission: The Daniel lab is interested in sensorimotor control of animal locomotion. Projects in the lab include the study of flight control, implantable microelectronics to control behavior, and the dynamics of muscle contraction. The goals of these projects are to learn about neuronal dynamics and networks, synaptic interactions between neurons, and how neuronal signaling, behavior, and environmental stimuli are linked.

A Good Match for: People who want to work with insects, are fascinated by flight, or interested in building mathematical models and algorithms. People interested in the intersection between neurobiology, neural engineering, bioengineering, mechanical engineering, electrical engineering, and mathematics.

UW Department: Biology
Website: http://faculty.washington.edu/danielt/

Laboratory of Dr. Rajesh Rao

Research Mission: The Rao lab studies the computational principles underlying the brain's remarkable ability to learn, process, and store information. Using a combination of probabilistic techniques, computer simulations, and collaborative neurobiological experiments, researchers are investigating how the brain learns efficient representations of objects and events occurring in the natural environment, the algorithms that allow useful sensorimotor behaviors to be learned, and how the knowledge gained through computational studies of the brain may be used in biomedical applications such as brain-computer interfaces.

A Good Match for: People fascinated by brain-computer interfaces. People interested in the intersection between computer science, mathematics, and neural engineering.

UW Department: Computer Science & Engineering
Website: http://homes.cs.washington.edu/~rao/

Laboratory of Dr. Howard Chizeck

Research Mission: The University of Washington's BioRobotics Lab is home to a number of students and faculty dedicated to improving the lives of people through cyberphysical systems. The lab's mission is to develop science, technology, and human resources at the interface between robotics, control theory and the biological sciences. Their goal is to produce useful, innovative research and technology as well as trained

researchers capable of driving technological advancement in medical and biological systems. The lab has ongoing projects investigating privacy and security in brain-computer interfaces, brain-computer interface optimization, closed-loop deep brain stimulation, and lower-limb targeted muscle reinnervation.

A Good Match for: People interested in the intersection between electrical engineering, robotics, and electromechanical design.

UW Department: Electrical Engineering
Website: https://brl.ee.washington.edu/

Laboratory of Dr. Jacque (Chris) Rudell

Research Mission: The Rudell lab studies a broad range of topics related to analog, mixed-signal, RF, and mm-wave circuits. The emphasis of the work is on novel architectures and circuits which overcome the challenges presented by future low cost, advanced silicon technologies, such as ultra-low voltage, low-intrinsic device gain, and poor matching characteristics. Typical projects in the lab focus on applications which are challenging to integrating as a single-chip. Some examples include devices for high-speed communication, imaging, and biological interfaces including neural stimulation. Students in our lab will focus both on system-level design issues as well as nuts and bolts implementation of an integrated circuit.

A Good Match for: People who want to design hardware for neural engineering applications, such as tiny implantable chips that stimulate neurons. People interested in electrical engineering.

UW Department: Electrical Engineering
Website: http://www.ee.washington.edu/research/fast/FAST.html

Laboratory of Dr. Joshua Smith

Research Mission: The Smith lab aims to improve the connection of information systems to the physical world. Researchers in the lab work to invent new sensor systems, devise innovative ways to power and communicate with them, and develop algorithms for using them. This research has applications for implanted devices, including those used for recording from and stimulating the nervous system.

A Good Match for: People curious about new sensor system technologies and their use in robotics and medical devices. People interested in the intersection of bioelectronics, robotics, ubiquitous computing, electrical engineering, and neural engineering.

UW Department: Electrical Engineering; Computer Science & Engineering
Websites: http://sensor.cs.washington.edu/jrs.html
http://sensor.cs.washington.edu/index.html

Laboratory of Dr. Andrea Stocco

Research Mission: Dr. Stocco's research concerns how human use abstract mental representations (like, rules, instructions, and plans) to perform complex tasks. He uses computational and mathematical models, neuroimaging techniques, and brain stimulation methods determine and predict how these mental representations are encoded in the brain, how they are transformed into behavior, and how this knowledge

can be used to improve learning and skill acquisition.

UW Department: Psychology
Website: http://ilabs.washington.edu/institute-faculty/bio/i-labs-andrea-stocco-phd

Laboratory of Dr. Visvesh Sathe

Research Mission: The VLSI systems lab led by Professor Sathe explores circuits and architectures for energy efficient digital and mixed-signal processing. The lab is focused on advancing the state-of-the-art in the area of neural signal recording, and power/energy-constrained neural signal processing by enabling hundreds of neural signal recording channels with extremely low power. Other areas of active research include clocking, supply voltage regulation, machine-learning, low-power cryptography, and ultra-low-power VLSI design.

A Good Match for: Students interested in circuits, computer architecture and hardware design in general. An interest in signal-processing and/or programming is a plus.

UW Department: Electrical Engineering
Website: http://vlsi.ee.washington.edu/

Laboratory of Dr. David Gire

Research Mission: Our brains utilize noisy, fluctuating sensory signals from the surrounding environment to guide valuable behaviors such as finding food or avoiding danger. Precise coding of relevant information in spatial and temporal patterns of neural activity is a key element of this function, with efficient coding adapted to both the statistical structure of sensory input as well as the changing behavioral demands of a given situation. This coding is achieved through complex circuits of synaptic interactions between populations of neurons and occurs as an animal explores and actively samples its environment. A mechanistic understanding of neural coding during active sensing and behavior is an important step towards the development of targeted therapeutics for psychiatric and neurodegenerative disorders. We seek to define the neural circuit operations that support complex and flexible behavioral responses to natural sensory stimuli. We study the olfactory system of rodents as a model for sensory information processing and connect neural activity to behavior by employing a variety of techniques including electrophysiology, multiphoton imaging, optogenetics, and automated behavioral analysis.

A Good Match for:

UW Department: Psychology
Website: http://www.psych.uw.edu/psych.php?p=358&type=1&PersonID=11750

Laboratory of Dr. Rajiv Saigal

Research Mission: The Saigal laboratory focuses on use of biomaterials and drug delivery systems for treatment of spinal cord injury and traumatic brain injury.

A Good Match for: Students interested in spinal cord injury and recovery.

UW Department: Neurological Surgery

Website: http://www.uwmedicine.org/bios/rajiv-saigal

Laboratory of Dr. Anat Caspi

Research Mission: The Taskar Center for Accessible Technology (TCAT) at the University of Washington Department of Computer Science & Engineering develops and deploys technologies that increase independence and improve quality of life for individuals with motor and speech impairments. We aim to enhance access to everyday technologies through the development of user-focused novel interfaces, the addition of sensors and input devices to existing technologies, and promotion of accessible design best practices in engineering. TCAT engages in research collaborations, community outreach, and technology design, translation, and prototyping. Our goal is to develop innovations that empower individuals living with disabilities in a variety of ways, including:

1. Supporting access and integration of individuals in community settings, including educational settings.
2. Improving functional capacity of individuals through enhanced sensory and motor function.
3. Enabling community living and participation by individuals through accessible information technology, including software, systems, and devices.

A Good Match for: Students interested in computer science and assistive technologies.

UW Department: Computer Science and Engineering
Website: https://tcat.cs.washington.edu/

Laboratory of Dr. John Tuthill

Research Mission: The goal of the lab is to understand the fundamental computations that underlie the neural coding of sensory information, and to figure out how sensory signals are used to guide movement and behavior. The ability of animals to navigate complex environments depends critically on the integration of mechanosensory information with motor commands. For example, human patients who lack mechanosensory feedback can generate coarse limb movements, but are unable to execute fine motor tasks. To understand the neural computations that occur at the interface of mechanosensation and movement, we study the circuits of the Drosophila ventral nerve cord (VNC), which functions like the vertebrate spinal cord to control the sensation and movement of the limbs. The distinct advantage of the fruit fly as a model system is the existence of specific genetic driver lines that allow us to identify and label specific neurons for targeted recordings. We use electrophysiology and optical imaging to measure neural activity, and genetic tools to label and manipulate specific circuit elements in behaving flies. Although there are obvious differences between flies and humans, many of the basic building blocks of the nervous system are remarkably similar. These similarities suggest that the principles discovered in circuits of the fruit fly will be highly relevant to sensorimotor processing in other animals.

A Good Match for: Students interested in how the nervous system senses and controls the body, and who want to learn functional imaging, genetics, behavior, and computational research techniques.

UW Department: Physiology and Biophysics
Website: http://faculty.washington.edu/tuthill/

Laboratory of Dr. Sam Burden

Research Mission: Our research in the AMP and BioRobotics labs focuses on sensorimotor control theory -- the science and engineering of dynamic closed-loop interaction between humans and machines. We focus on applications in dynamic and dexterous robotics, neuromechanical motor control, and human-cyber-physical systems using a variety of mathematical, computational, and experimental tools including data-driven modeling, machine learning and optimization, virtual / augmented reality, motion capture, haptics, and brain-machine interfaces. Our ultimate goal is to amplify the ability of all people to interact with and control the physical world.

A good match for: Students who are excited about robotics, human-robot interaction, neuromechanical interfaces, data-driven modeling, optimization, virtual / augmented reality.

UW Department: Electrical and Computer Engineering
Website: http://faculty.washington.edu/sburden/

Laboratory of Sara Goering

Research Mission: The neuroethics group (Goering "lab") studies ethical issues arising from emerging neural engineering technologies. Issues include questions of privacy, security, moral and legal responsibility, changes in our understanding of agency, shifts in personal identity, and social justice. We have a commitment to the inclusion of disability perspectives in the design of devices intended to benefit people with disabilities. Our group does both normative theoretical research and writing, and empirical studies such as focus groups with intended end-users.

A good match for: Students interested in neural engineering and particularly drawn to the ethical and policy implications of new technologies. Interest in philosophy, disability studies, and social justice. Engineering, neuroscience, social science and humanities majors welcome.

UW Department: Philosophy
Websites: https://www.phil.washington.edu/users/goering-sara