CENTER FOR SENSORIMOTOR NEURAL ENGINEERING

Center for Sensorimotor Neural Engineering (CSNE)

University of Washington (lead institution)

Improving lives by connecting brains and technology

A National Science Foundation Engineering Research Center since 2011

Partner Institutions:

- ***Massachusetts Institute of Technology***
- ***San Diego State University***

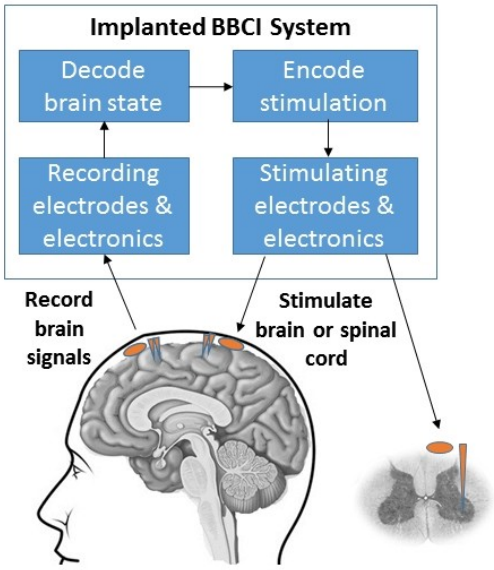
The Center for Sensorimotor Neural Engineering (CSNE) is pursuing a transformational approach to reanimating paralyzed limbs and inducing neuroplasticity for stroke and spinal cord injury patients using implantable *closed-loop, co-adaptive, bi-directional brain-computer interfaces* (BBCIs) that can both record from and stimulate the central nervous system.

The Center's mission is to develop principled ways of designing BBCIs that integrate state-of-the-art recording, stimulating, and wireless technologies with a deep computational understanding of sensorimotor processing and plasticity in the nervous system, guided by clinical needs and a responsible neuroethics framework.

The Center's neurally-engineered systems aim to significantly improve the quality of life of people with sensorimotor disabilities—specifically those with cervical spinal cord injury and ischemic stroke resulting in communication or motor impairments,with broader implications for designing neural interfaces for other conditions such as Parkinson's disease and essential tremor.

Goals:

- Promote the development of technologies that assist people with neurological disorders
- Promote global research in the domain of neural engineering through partnerships with international institutes
- Develop lesson plans, courses, and degree programs (K-12, undergraduate, graduate) that support advancements in the interdisciplinary domain of neural engineering
- Promote commercialization and small business start-up activities
- Increase diversity in research and industry in the U.S. with a focus on the emerging domain of neural engineering.



Research

The center's research mission is being accomplished with three core engineering thrusts:

1. The ***Communication & Interface*** thrust develops novel and robust technologies for neural recording and stimulation, wireless power, wireless data transmission, tactile sensing, and on-chip information processing for implantable BBCIs.
2. The ***Computational Neuroscience*** thrust explores the neural basis of computation in the brain through computational modeling to help develop new algorithms and paradigms for decoding brain signals and inducing plasticity.
3. The ***Neuroethics*** thrust studies how ethical issues such as identity, privacy, safety, authority, and moral or legal responsibility are intertwined with the development of new neural technologies.

The CSNE focuses on three testbeds which evaluate the applicability of Center-developed BBCI technologies for helping people with neurological conditions. These BBCIs are adaptive, closed-loop, and tailored specifically to the individual. Safety, security, autonomy, and ethical considerations are paramount.

1. ***Cortical & spinal plasticity testbed:*** focuses on inducing plasticity for targeted rehabilitation for people with neurological disorders. CSNE researchers are, for example, using BBCIs to promote recovery of neural connections between cortical regions using stimulation across a stroke-affected motor region. We are also developing BBCIs to restore cortico-spinal connections for recovery of hand function after spinal cord injury.

2. ***Cortico-spinal reanimation testbed:*** When plasticity and recovery are not possible, our researchers are also developing ways to bypass an injury to the spinal cord by using a BBCI. By recording the intention to move in motor areas of the brain, we can control stimulation of the spinal cord below the injury to produce hand and arm movements. The long-term goal of this testbed is to use our BBCI to reanimate the paralyzed hands of a person with complete cervical spinal cord injury.

3. ***Electrocorticographic bi-directional brain-computer interface testbed:*** This testbed explores the use of electrocorticography, or ECoG, which involves recording and stimulating the brain surface rather than penetrating the brain. ECoG can be used for both extracting a user's movement intentions and providing tactile feedback through brain surface stimulation. ECoG BBCIs will be applied to reanimate paralyzed arms and improve hand movement control for people with stroke, spinal cord injury, or other sensorimotor impairments.

Education

The CSNE develops courses, lab experiences, transdisciplinary degree programs, and partnerships to train the next generation of neural engineers to create cutting-edge neurotechnologies. For example, students in the Tech Sandbox course work through all stages of the device development process, from idea generation to the possibility of technology transfer and commercialization.

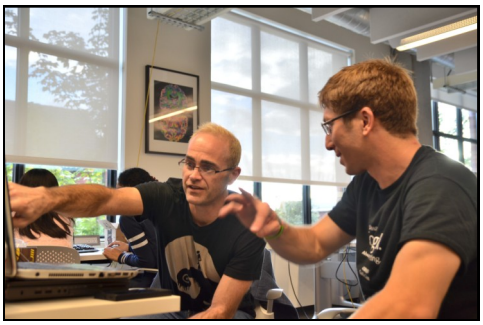
CSNE students host a neural engineering hackathon involving students from the University of Washington (UW), Massachusetts Institute of Technology (MIT), and San Diego State University (SDSU). The hackathon encourages camaraderie among the partner institutions and also allows students to be innovative and creative in

the neural engineering realm.

The Center is expanding and diversifying the pipeline of students prepared for college and advanced degrees in neural engineering by working with programs that serve students with disabilities and also by actively recruiting participants from historically underrepresented groups—including women, minorities, and individuals with disabilities—for Research Experiences for Undergraduates (REU), Teachers (RET), and Veterans (REV) programs. We have also launched a post-baccalaureate program to provide support for college graduates who are interested in neural engineering and pursuing graduate studies. The Center helps place post-bac students in a laboratory, so that they can gain more research experience, and also provides financial support for them in a transition year.

Our education partners include Morehouse College and Spelman College—historically black colleges in Atlanta—and Southwestern College in San Diego—the 11th highest associate degree producer in the nation for Hispanic students.

Our international partners in research and education are the Indian Institute of Science in Bangalore, University of British Columbia in Vancouver, B.C., and the BrainLinks-BrainTools program at the University of Freiburg in Germany.



Center staff and faculty develop new lesson plans and education programs to increase awareness about neural engineering from a research perspective and as a career option. Materials developed are shared among partner institutions and are posted on the CSNE website. At the UW, graduate students can receive a certificate in Neural Computation and Engineering and undergraduate students will soon have the option to minor in neural computation and engineering.

We have created a seminar series—featuring national and international leaders—to highlight neural engineering research. The Center also leads or is involved in formal and informal science education events and activities. We host school visits from precollege students at CSNE headquarters, and our staff, faculty and students visit classrooms and schools. We also participate in national and local science fairs and museum events.

Innovation Ecosystem

CSNE researchers work with large and small companies—and start-ups—to develop neural engineering technologies for medical devices and consumer electronics applications. We work with industry partners to ensure that technologies our researchers are developing are on-point with what people need. We foster the translation of promising innovations created by Center researchers and students into prototypes and products that will help people.

Through the Center's Industry Affiliate Program, we engage member companies to support technology transfer and commercialization efforts. We also provide industry-relevant training opportunities for faculty and graduate student researchers.

Facilities

The CSNE is headquartered in a 5,000 sq. ft. space on the UW Seattle campus, within reach of all key programs and departments. The Center has dedicated space for leadership and administrative staff and areas to host visiting faculty and students from core partner and affiliated institutions, industry members, and for student-faculty interactions.

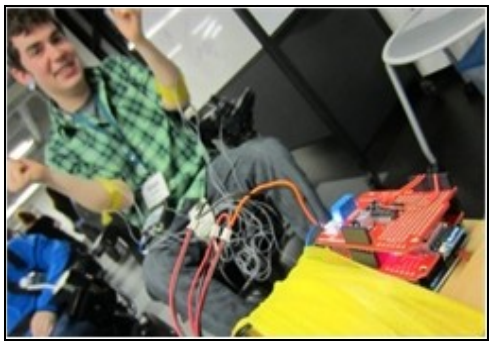
The headquarters includes a conference space that comfortably seats 60 people for seminars, advisory board meetings, Center research group meetings, and educational outreach. An additional 1,500 sq. ft. has

been created at the SDSU campus, which houses shared conference and administrative space. All three CSNE core institutions—UW, MIT, and SDSU—have an array of shared laboratories ranging from fabrication and machining facilities to motion capture systems.

Although the Center draws upon existing infrastructure in laboratories and facilities distributed across all partner institutions, our headquarters has significant open space for hands-on demonstration, exploration, and to accommodate start-ups. This space provides a physical portal between the Center's research activities and its educational and commercial interests. In addition, the open space serves as an exhibit space for visiting K–12 students and teachers. Almost all of the Center's equipment and furniture is on wheels, offering flexibility in the space. For example, the Center can reconfigure its open space to host annual meetings, poster presentations for research conferences, and school events. All central facilities were designed with the assistance of students with disabilities to ensure an open and accessible environment for all.

Center Configuration, Leadership, Team Structure

CSNE leaders develop and implement the Center's strategic plans and oversee research at all three institutions. This team includes the director, three deputy directors (one at each core institution), thrust leaders, executive director, administrative director, education directors, precollege and university education managers, industry liaison officer, diversity director, diversity manager, and communications manager. CSNE receives guidance from a Scientific Advisory Board, Practitioner and End Users Board, Industrial Advisory Board, Deans Council, and the Student Leadership Council.



This structure was strategically chosen for our multidisciplinary, multi-university environment, with diverse faculty who have years of experience leading other faculty, students, and industry. CSNE faculty members span a range of academic departments including Computer Science and Engineering, Electrical Engineering, Bioengineering, Biology, Physiology and Biophysics, Philosophy, Neuroscience, Rehabilitation Medicine, and Mechanical Engineering.

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