NeuroFutures 2014 Poster titles, authors & abstracts

Poster #1

Decoding articulate movements using micro-scale surface recordings in human motor cortex

Presenter: Bradley Greger, Associate Professor, Arizona State University

Coauthors: Hanrahan, Sara; Kellis, Spencer; Davis, Tyler; Smith, Elliot; House, Paul

Five epilepsy patients were implanted with micro-ECoG grids. Patients were asked to perform specific tasks depending on the placement of the micro-ECoG grid on the cerebral cortex. Tasks included repeating spoken words, flexing individual fingers, and reaching in two dimensions. Vocalized articulations of ten different words and silence were classified on a trial-by-trial basis with 82.4% accuracy. Three individual finger movements and rest were classified on a trial-by-trial basis with 62% accuracy. We were able to continuously decode the arm trajectory with a maximum correlation coefficient of 0.82 in the x-direction and 0.76 in the y-direction. These findings demonstrated that LFPs recorded by micro-ECoG grids from the surface of the cerebral cortex contain sufficient information to provide rapid and intuitive control a BCI communication or motor prosthesis.

Poster #2

Minimally invasive recording of high gamma with subdermal EEG

Presenter: Jared Olson, Physician, University of Washington, Rehabilitation Medicine

Coauthors: Darvas, Felix

High-Gamma (HG) band brain signals are important as control signals in brain-computer interfaces. Electrocorticography is generally used to acquire these signals, however there is a need for less invasive, long term recording methods. Previous scalp electroencephalography (EEG) studies have shown the presence of weak HG signals in post-hoc analysis, but insufficient for real-time HG brain-computer interface (BCI). Recording these signals from beneath the skin may be an option for a minimally invasive, long term BCI. We show that HG can be recorded in the subdermal tissue (at the skull-scalp interface) with 1.5x signal-to-noise ratio (SNR) compared scalp EEG due to closer proximity to the cortex and decreased potential spread from the skull scalp interface. HG can be reliably recorded without the use of an inverse model or head model. These findings could enable a real-time HG BCI.

Poster #3

Simulation and Synergies: Understanding altered neuromuscular control in cerebral palsy

Presenter: Kat Steele, Assistant Professor, University of Washington

Coauthors: Rozumalski, Adam; Schwartz, Michael

Cerebral palsy (CP) is caused by an injury to the brain near the time of birth and impacts 3 out of every 1000 individuals. Movement is impaired in CP, but how neuromuscular control is altered and implications for treatment remain unclear. One theory is that complexity of control is reduced in individuals with CP. We evaluated complexity of control using muscle synergies during walking for 549 children with CP and 84 typically-developing children. Complexity of control was significantly reduced in CP and related to severity of impairment, energy costs of walking, and outcomes after treatment. We are now using dynamic musculoskeletal simulation to evaluate the functional impacts of altered muscle synergies and guide development of patient-specific treatment plans.

Poster #4

Water permeability of the aging blood-brain barrier

Presenter: Valerie Anderson, Associate Scientist, Oregon Health & Science University (OHSU)
Coauthors: Lenar, David; Obayashi, James; Li, X.; Quinn, Joseph; Kaye, Jeffrey; Riccelli, Louis; Rooney, William

We measured the permeability-surface area product of water (PwS) in the deep white matter in 21 healthy adults (aged 59-82 years) using 7T dynamic contrast enhanced MRI and investigated the effects of age and sex on PwS. Intravascular water volume fraction (vb) and lifetime (τb) were determined by fitting changes in the longitudinal relaxation rate constant after contrast reagent administration to a pharmacokinetic model that incorporates the effects of transendothelial water exchange. PwS (= vb/τb) decreased significantly with age (p= 0.002). Although sex-related effects on PwS were not significant, τb was markedly higher in males (0.39 ± 0.10 s) than females (0.24 ± 0.12 s). Our results suggest that blood-brain barrier (BBB) water permeability declines with age and that the kinetics of processes that drive water exchange at the aging BBB may be different in men and women.

Poster #5

Modulation of brain networks with multi-coil stimulation

Presenter: Bret Schneider, Chief Medical Officer, Cervel Neurotech Inc.

We describe an advanced, next-generation magnetic system that modulates brain activity at multiple selected deep and superficial brain network locations. An array of multiple coils is used to induce steerable patterns of electrical currents in the brain via a reconfigurable custom-shaped magnetic field capable of producing a desired effect in deeper brain structures. Potential applications including chronic pain, depression and addiction are reviewed including a discussion of pertinent brain targets. We review brain imaging and clinical data demonstrating that deep shaped magnetic field pulses preferentially affect deep brain regions for inducing pain relief depends upon the shape of the magnetic field created. Multicoil brain stimulation provides means by which we may be able to achieve more effective neuromodulation treatments with fewer off-target effects.

Poster #6

Decreased Gray Matter High Energy Phosphate Levels in Multiple Sclerosis: 7 Tesla Phosphorus Spectroscopic Imaging Study

Presenter: Manoj Sammi, Assistant Scientist, Advanced Imaging Research Center, Oregon Health and Science University

Coauthors: Berlow, Yosef; Selzer, Audrey; Moloney, Breandan; Grinstead, John; Kim, Edward; Bourdette, Dennis; Rooney, William

Multiple Sclerosis is an immune mediated disease of the central nervous system with the primarily pathological finding of demyelinating white matter lesions. Gray matter involvement may also be substantial including lesions and volume loss observed by MRI. Neurodegenerative processes may be initiated as decreased tissue metabolism which can be detected by 31P MR spectroscopic imaging (MRSI). Cellular energetics of the human brain were assessed from phosphocreatine and adenosine triphosphate signals in 12 healthy control (HC) and 15 subjects with multiple sclerosis (MS). There was a 14% decrease in absolute phosphate metabolite signal in MS compared to HC subjects. A tissue dependence analysis indicates that most of this signal loss localizes to GM rather than WM.

Poster #7

Identification of Nicotinic Acetylcholine Receptor Subunits in Codling Moth

Presenter: Jessica Martin, Student, Heritage University and USDA-ARS

Coauthors: Garczynski, Stephen

Nicotinic acetylcholine receptors (nAChRs) mediate the fast actions of the neurotransmitter acetylcholine in synaptic transmissions in the nervous systems of vertebrates and invertebrates. The codling moth, Cydia pomonella, is a pome fruit pest that has been effectively controlled by neonicotinoid insecticides. This class of chemicals works by interfering with the function of insect nAChRs while having little to no effect on mammalian nAChRs. In this study, we identified the thirteen unique subunit classes of nAChRs in the codling moth, discovered splice variants in some of these receptors, and determined their variable temporal expression in the organism. The information from our completed study will be useful in monitoring target-site resistance mechanisms for codling moth, as well as in the design of insecticides that remain effective and safe to use in the presence of mammals.

Poster #8

MRI Biomarkers of Neuroinflammation in Japanese Macaque Encephalomyelitis

Presenter: Ian Tagge, Student, Advanced Imaging Research Center, Biomedical Engineering, Oregon Health & Science University

Coauthors: Kohama, Steve; Pollaro, Jim; Sherman, Larry; Bourdette, Dennis; Woltjer, Randy; Wong, Scott; Rooney, Bill

Japanese Macaque Encephalomyelitis (JME) is a spontaneously occurring neurodegenerative disease that closely resembles human multiple sclerosis (MS) and is the only known natural MS-like disease in non-human primates. MRI was performed on 13 animals during an acute attack of JME; all were humanely euthanized after MRI and brain and spinal cord tissues were collected for histology. Biomarkers associated with inflammatory response including blood volume, blood-brain-barrier permeability, and myelin water fraction can be calculated from MRI data and subsequently validated with histology. JME is a unique disease that, like human MS, is still not entirely understood. Investigation of JME and development of these non-invasive imaging biomarkers may contribute to the understanding and study of MS.

Poster #9

Optimizing Performance in a P300-Based Auditory Brain Computer Interface

Presenter: Karl Marrett, Student, University of Washington, CSNE

Coauthors: Wronkiewicz, Mark; Lee, Adrian

In order to communicate, patients with total loss of muscle control including eye movement can rely on brain computer interfaces (BCI) that utilize the P300 response, an evoked related potentials of the brain, recorded using EEG. Due to the auditory system's acute ability to selectively attend an auditory stream in what's known as the "cocktail effect", new speller paradigms that aid listeners' ability to selectively attend may increase the maximum bitrate of communication. In the proposed paradigm, users can use tone, spatial location, and informational cues to aid in auditory streaming. This project focuses on assessing users ability to discriminate different auditory cues used in an auditory BCI environment. This project offers future possibilities for auditory systems to help improve the ease of use and practicality for the community of individuals who rely on speller systems.

Poster #10

Open Source Tools for Data Visualization – Brian Cancer Pilot

Presenter: Rachel Galbraith, Research Program Coordinator, Fred Hutchinson Cancer Research Center

Coauthors: Fearn, Paul; Horse-Grant, Desert; McFerrin, Lisa; Holland, Eric

Currently, brain cancer patients are grouped based on clinical features. However, patients with similar clinical features can have widely varying responses to treatment over time. This variation may in part be associated with molecular differences in a patient's tumor. The purpose of this research is to develop methods and Open Source tools for visualizing and exploring both assay data (e.g. gene expression arrays, RNA-Seq data) and associated clinical and cost data brain tumor patients. Employing cutting-edge clustering and data visualization techniques from bioinformatics and computational biology for arrays of molecular data from tumor samples and patient clinical timelines will enable discovery of patterns that lead to more precise diagnosis and treatment and thereby lengthen survival for brain cancer patients.

Poster #11

Structure function relationships and network topology across species: Resting state connectivity in rodents and macaques

Presenter: Brian Mills, PhD Student, Oregon Health and Science University, Department of Behavioral Neuroscience

Coauthors: Jarrett, Ben; Miranda-Dominguez, Oscar; Kroenke, Christopher; Grant, Kathleen; Fair, Damien

A considerable obstacle to progress in psychiatry is the development of approaches that can bridge the gap between experimental animal models and human disease. Resting state functional connectivity MRI (rs-fcMRI) may provide a powerful and non-invasive "bridge" in this regard. Here, we develop this approach in two widely researched animal models, the mouse and macaque. First, we validate the approach by showing that functional connectivity has strong structural underpinnings across the whole mouse and macaque brain. We find that the strongest structural connections correspond most closely with the functional connectivity data. We also find that several large-scale topological properties that exist in human can be found to some degree in both macaque and rodent as well.

Poster #12

Structural and biological changes in traumatic brain injury (TBI)-related neurodegeneration

Presenter: C. Dirk Keene, Assistant Professor, University of Washington

Coauthors: Lein, Ed; Larson, Eric; Crane, Paul; Bongaarts, Angela; Cudabeck, Eron; Miller, Jeremy; Lee, William; Mukherjee, Shubhabrata; Sundkin, Susan; Kiel, Linda; Gibbons, Laura; Shen, Elaine; Balch, Steven; Schantz, Aimee; Montine, Thomas; Ellenbogen, Richard

This is a new collaboration between UW, Allen Brain Institute, & Group Health Research Institute. TBI causes extensive morbidity and mortality. Most prior human studies of late structural effects of TBI are limited to athletes or soldiers. Neuropathological sequelae of TBI experienced by the general population are largely unknown. We are analyzing TBI and control brains from the population-based Adult Changes in Thought (ACT) study. Evaluations will include standard neurohistologic analyses, detailed synaptic structural endpoints, protein and free radical changes, and gene expression studies. Results will be correlated with rich clinical, pharmacologic, and genetic information available from ACT. Results will illuminate neurodegenerative phenotypes of TBI, identify relationships of TBI with other neurodegenerative diseases, and foster future research. We will describe progress so far.

Poster #13

Multi-region goal inference improves performance in an invasive brain-computer interface task

Presenter: Jeremiah Wander, Student, Bioengineering, University of Washington

Coauthors: Rao, Rajesh PN; Ojemann, Jeffery G

Invasive BCIs have traditionally utilized signals from single cortical regions to grant users control of external devices. Recent work has shown that BCI skill acquisition and task execution involve multiple cortical and sub-cortical regions, and that facets of intent can be decoded from these networks. We present and validate a novel BCI framework that performs goal inference using distributed cortical activity patterns. This system correctly inferred intended movement direction in a one-dimensional BCI before control began up to 72% of the time, and during the task execution up to 100% of the time. Furthermore, by using goal inference to modulate task parameters, overall task performance was significantly improved ($p = 0.014$). Our findings demonstrate the feasibility of a multi-region, hierarchical approach to BCI design that could greatly improve on the current state of the art.

Poster #14

A high-fidelity robotic platform for the development of closed-loop invasive brain-computer interfaces for motor control

Presenter: James Wu, Graduate Student Researcher, University of Washington, Department of Bioengineering

Coauthors: Kumar, Vikash; Wu, James; Todorov, Emo; Ojemann, Jeffrey G.; Rao, Rajesh PN

A primary goal in the field of brain-computer interfaces (BCIs) has been the development of closed-loop prosthetics for replacement of lost motor function due to neuromuscular disease or injury. However, more powerful methods are required to develop BCIs for hand prosthetics that can replicate natural human control. Ideally, these BCIs must be able to exploit the brain's natural abilities, including its remarkable plasticity, to accomplish fine manipulation tasks. A promising approach involves uncovering cortical motor primitives through the application of machine learning techniques to electrocorticographic (ECoG) data. The Adroit robotic system coupled with ECoG BCIs provides a platform for testing strategies that will significantly advance our understanding of the computational basis of human manipulation capabilities and enhance the utility of ECoG for hand prosthetics.

Poster #15

Fully-Integrated, High-Voltage Compliant Neural Stimulation Electronics using Standard CMOS Technology

Presenter: Eric Pepin, Student, University of Washington, Dept. of Electrical Engineering

Coauthors: Micheletti, Daniel; Rudell, Jacques C.

Silicon CMOS technologies serve as the backbone of modern digital electronics and allow the low-cost realization of sophisticated systems incorporating both digital and analog functional blocks on a tiny, single silicon chip. Due to the resulting small form-factor and compatibility with low-power design, such single-chip CMOS solutions can be advantageous to the future development of implantable neural interfaces. However, the driving electronics for typical neural stimulation applications often require on-chip voltage-levels in-excess of ±10 volts, which presents a barrier for implementation in modern low-voltage CMOS technologies. Accordingly, we propose CMOS-compatible stimulator electronics which can safely attain practical driving voltage levels on-chip (effectively ~ ±12) while assuring safe/reliable operation and displaying the potential for a high-level of programmability.

Poster #16

Neural Computation of Cognitive Ability-Demand Gap in Adaptive Technology Design

Presenter: Gahangir Hossain, Graduate student, University of Memphis

Cognitive gap may occur from unbalanced cognitive demand imposed by technology devices and user's cognitive ability to perform the cognitive task. In the context of brain computer interaction, early identification of gaps promotes robust decision supports in adaptive and assistive technology tools. This study considers a neural approach of cognitive gap identification using synaptic theory of working memory (Mongillo et al. 2008). The study analyzed the multivariate pattern analysis (MVPA) of eye open/eye close interaction task, for modeling the subjective cognitive ability-demand gap effect using EEG data. Results suggest that, synaptic theory of working memory gives a mathematical formulation of cognitive gap identification and useful in future brain inspired assistive technology design.

keywords: BCI, cognitive ability-demand gap, Working memory, assistive technology.

Poster #17

Lipid nanoparticle delivery of RNA for loss- and gain-of-function studies in primary neurons in vitro and in vivo

Presenter: David Zwaenepoel, Application Scientist, Precision NanoSystems Inc.

Coauthors: Ansari, Aysha; Thomas, Anitha; Walsh, Colin; Leaver, Tim; Wild, Andre; Ou, Kevin; Taylor, James; Ramsay, Euan

A lipid nanoparticle (LNP) technology (SUB9KITS) was developed to deliver siRNA or mRNA in vitro and in vivo with high efficiency and low toxicity. LNPs mimic low-density-lipoprotein (LDL) which are taken up by cells through the LDL-receptor in presence of Apolipoprotein E4.

In vitro - Primary Cortical Neurons (PCN) incubated 72h with 100 ng/mL of siRNA-LNP showed 90% knockdown (qPCR, WB). Knockdown is sustained for 21 days after single treatment (qPCR). SUB9KITS showed significantly higher transfection of siRNA (qPCR) and no toxicity (LDH) compared to contemporary transfection kits. PCN incubated 72h with 500 ng/mL GFP mRNA-LNP showed 95% expression (Flow cytometry).

In vivo - Intracranial injection of siRNA-LNP (500 nL at 5 mg/mL) showed 85% knockdown 5 days post-injection (WB). SUB9KITS demonstrates rapid uptake by neurons which mediated effective and sustained silencing/expression.

Poster #18

Established Brain Sample Bank for Fetal Death of Adverse Pregnancy Outcome

Presenter: Xiaoying Zheng, Professor and Director, Laboratory of Neuroscience and Mental Health, CCPHD, PKU

Background: We carried out pathological epidemiology for fetal death of adverse pregnancy outcome in North China.

Methods： A case-control study was performed to select the fetal death as cases and no-pathological termination of pregnancy as controls at any time during pregnancy. The fetal tissues samples of adverse pregnancy outcomes were collected, and whole brain specimen repository was constituted between 2010 and 2013. The study protocol was reviewed and approved by Institutional Review Board of Peking University Health Science Center.

Results： The whole brain specimens of 100 fetal death with adverse pregnancy outcome and 100 controls with no-pathological termination of pregnancy were collected.

Conclusions: The whole brain specimens repository for adverse pregnancy outcomes was established to make future research of cognitive dysfunction of children.

Poster #19

Extending the C. Elegans Connectome to Robotics

Presenter: Timothy Busbice, Independent Researcher, OPenWorm Project founder/contributor

Using the well mapped connectome of the nematode Caenorhabditis Elegans, I created a program that can be started three 302 times where each program inherits the attributes one of each of the worms 302 neurons and uses interprocess communications to connect the programs together in a manner similar to that of synaptic communication. Wrapping the entire connectome into a framework whereby sensory input can be derived from robotic sensors and directed to connectome sensory neurons, which in turn activates interneurons, which activate motor neurons, and muscle output can be accumulated to activate robotic motors, the simulated connectome and connectome framework allows for a biological simulation and study of the entire connectome from sensory input to muscular output. This, in part, answers the age old question of whether the connectome alone can have value in determining animal behavior.

Poster #20

Prototype Mobile Closed Loop Deep Brain Stimulation Demonstrations

Presenter: Jeffrey Herron, Graduate Student, Electrical Engineering, University of Washington

Coauthors: Chizeck, Howard

Neuromodulation systems such as deep brain stimulation (DBS) have become a key clinical tool for treating neurological movement disorders. One example of this is how constant open-loop stimulation is used to treat Essential Tremor. However, there may be room for improvement in the way this treatment is delivered by incorporating sensors to determine when and how this stimulation should be delivered. To investigate these closed-loop DBS systems, we have created a prototype system that uses a personal area Bluetooth network to connect an implantable neuromodulation device with sensors and a smartphone. By fusing data from wearable sensors we can demonstrate example closed-loop systems that can alter stimulation parameters in response to sensed movements or the intensity of the tremor.

Poster #21

Sensory feedback through vibrotactile actuators

Presenter: Iris Jiang, Graduate Student, University of Washington

Coauthors: Jiang, Iris; Hannaford, Blake

Limb loss not only removes the ability to control the limb, but also the sensations that were felt through the limb. Feedback is extremely important for robust, high performance control, yet current prostheses have no mechanism for feedback other than what can be felt inside the socket. We aim to provide low-cost, novel sensory feedback that could be useful for identifying and preventing dangerous situations like tripping and slipping. In order to design the system, we will first assess vibrotactile actuator placement, directionality, and response time for Below Knee Amputees (BKAs). This study determines how well people can differentiate between different vibrotactile signals and whether this is significantly affected while a person is walking. We also propose future work with BKAs who have undergone Targeted Muscle Reinnervation, to provide them with a more natural feedback sensation.

Poster #22

Morphological analysis of the layer 6 and layer 4 input to layer 4 in primary visual cortex (V1) of the mouse

Presenter: Agnes Bodor, Scientist, Allen Institute for Brain Science

Coauthors: M da Costa, Nuño; Takeno, Marc

One of the canonical features of cortical circuits is recurrent excitation, however we know little about how this architecture is implemented by different cell types. We address this question by investigating the pattern of excitatory inputs to layer 4 by two excitatory cell types.

Layer 6 and 4 neurons were labeled by immunohistochemistry in Ntsr1 and Nr5a1 mouse lines and prepared for electron microscopy. Afterwards synaptic terminals were reconstructed using serial sections micrographs.

In both groups the majority of targets were spines: 66% for L6 and 90% for L4 neurons, the rest were dendritic shafts of excitatory and inhibitory neurons. We conclude that both L4 and L6 terminals target mostly excitatory dendrites in L4 in a cell type specific way.

Poster #23

Spectral shaping of V4 network activity regulates phase-dependent information biases in theta-gamma code

Presenter: Grant Mulliken, Postdoctoral Fellow, MIT, McGovern Institute for Brain Research

Coauthors: Desimone, Robert

When processing a visual stimulus, the local field potential (LFP) spectrum undergoes a simultaneous decrease in low frequency and increase in high frequency LFP power. We investigated the implications of spectral shaping on rhythm-dependent coding mechanisms in V4 during object tracking. In absence of a stimulus, spiking was highest during the depolarized phases of theta (3-9 Hz) and gamma (40-90 Hz) rhythms. When driven by a moving stimulus, spiking became desynchronized to the theta LFP and more strongly coupled to the gamma LFP. This led to a phase-dependent coding bias; spikes that occurred jointly at the peak of the theta LFP and the trough of the gamma LFP were the most informative about the time-varying stimulus. Pairwise correlations were also maximal at the peak of theta and trough of gamma LFPs. These data are consistent with a dynamic, phase-dependent theta-gamma code in V4.

Poster #24

Reliable Delivery of Complex Visual Information Through Transcranial Magnetic Stimulation

Presenter: Andrea Stocco, Research Assistant Professor, University of Washington

Coauthors: Abernethy, Justin; Youngquist, Tiffany; Rao, Rajesh; Prat, Chantel

Due to the perceived difficulty of carefully delivering focal stimulation limited to small cortical areas, non-invasive Transcranial Magnetic Stimulation (TMS) has been seldom used as a viable mechanism for Computer-Brain Interfaces. In contrast to the prevalent opinion, here we show that it is possible to precisely control the delivery of visual percepts using careful mapping techniques. Over the course of several sessions, we carefully recorded the effects of TMS pulses of varying intensity and orientation over multiple sites of a single subjects' occipital cortex. By altering the coil's position and orientation, we were able to induce replicable visual percepts in the form of perceived dark lines ("scothomes"). We conclude that it is possible to use TMS to deliver complex perceptual information non-invasively.

Poster #25

Experimental Analysis of 'Brain Malware' in Brian-Computer Interfaces

Presenter: Tamara Bonaci, Student (research assistant), University of Washington

Coauthors: Chizeck, Howard Jay

An increasing number of Brain-Computer Interfaces (BCIs) are being developed and used in medical, marketing, and entertainment applications. BCI-enabled technology carries a great potential to improve the quality of human lives. It provides people suffering from neuromuscular disorders with a way to interact with the environment. It also enables a more personalized experience in gaming and entertainment.

However, BCI applications are not without risk. Established engineering practices set guarantees on BCI performance and reliablity. But no standards are currently in place regarding users' privacy and security. In this work, we identify possible privacy-exposure attacks. We then experimentally analyze how non-invasive BCI platforms can be used to extract private information. This is an initial step towards making BCI-enabled technologies privacy preserving.

Poster #26

A closed-loop neurochip for rehabilitation of a cerebellar learning function

Presenter: Matti Mintz, Professor, School of Psychological Sciences, Tel Aviv University

Coauthors: Hogri Roni; Bamford Simeon; Taub Aryeh; Magal Ari; Del Giudice Paolo

Neuroprostheses are applied to compensate for neural damage. They typically consist of unidirectional interface to compensate for sensory or motor damage. In contrast, a closed-loop bidirectional interface can substitute malfunctioning brain structures. Previous closed-loops utilized a "black-box" approach, where system identification required extraction of input-output transformation in an intact brain, and its reproduction in the neuroprosthesis. We demonstrate a neuromimetic approach, in which a closed-loop interface mimics the cerebellar anatomy and physiology essential for classical motor conditioning. The chip was interfaced with cerebellar input and output nuclei in real time and successfully substituted cerebellar learning without pre-lesion system identification. This approach offers a novel paradigm for evaluating neuromimetic models embedded in a realistic biological context.

Poster #27

Non-invasive detection of high gamma band activity during motor imagery

Presenter: Melissa Smith, University of Washington, Departments of Neurobiology and Behavior and Computer Science and Engineering

Coauthors: Weaver, Kurt; Grabowski, Tom; Rao, Rajesh; Darvas, Felix

The high gamma (HG) frequency band has been characterized from invasive electrophysiological approaches as a rapidly evolving, spatially localized neurophysiological signal that is believed to be the best representative signature of engaged neural populations. Because of these properties, the ability to derive HG signals from electroencephalography (EEG) could significantly enhance the performance of non-invasive brain-computer interface devices. Additionally, the ability to study the HG band non-invasively with a relatively inexpensive and simple modality such as EEG opens this part of the human brain spectrum to a wider research community within human neuroscience. In this study, we show that by using an individual subject's head anatomy and inverse modeling methods, HG activity can be recovered from EEG during motor imagery.

Poster #28

A Brain-Controlled Spinal Interface (BCSI) for reanimation of paralyzed limbs after spinal cord injury

Presenter: Aiva Ievins, Graduate student, University of Washington

Coauthors: Sunshine, Michael; Dighe, Aalap; Ranganathan, Vaishnavi; Bosma-Moody, Alice; Carlson, Ryan; Fairhall, Adrienne; Smith, Josh; Voldman, Joel; Moritz, Chet

Brain and spinal cord injuries often lead to severe motor impairments that limit individuals' daily activities. Incomplete injury to the cervical spinal cord is the most common spinal cord injury (SCI) diagnosis, and restoration of hand and arm function is the highest treatment priority for individuals with cervical SCIs. Recent advances in brain-machine interface and microstimulation technologies provide opportunities for the development of new devices that could restore motor function after central nervous system injury. We are developing a closed-loop Brain-Controlled Spinal Interface (BCSI) that records movement intention from the brain and delivers task-specific real-time stimulation to the spinal cord using neural recording and intraspinal microstimulation technologies. The primary goal of this BCSI is to re-animate and restore function to the paralyzed hand and arm.

Poster #29

In vivo neural circuit engineering: reprogramming neural circuits by genetic manipulation of synaptic connections

Presenter: Ithai Rabinowitch, Postdoctoral Fellow, Fred Hutchinson Cancer Research Center

Coauthors: Chatzigeorgiou, Marios; Zhao, Buyun; Treinin, Millet; Bai, Jihong; Schafer, William

We have developed a novel technique for manipulating specific synaptic connections. This engineering approach can complement current methods for investigating neural circuits based on monitoring neuronal activity (e.g. electrophysiology), manipulating it (e.g. optogenetics) and mapping the synaptic connections between neurons (e.g. connectomics). In order to modify the transmission between distinct neuron pairs we genetically inserted heterologous electrical synapses in the nervous system of the nematode C. elegans using neuron-specific promoters. This method enabled us to re-engineer circuit function through rationally designing new neural connections and thus reprogramming whole animal behavior. We present several applications for neural circuit engineering including the switching of olfactory attraction to aversion and the study of a circuit-level mechanosensory coincidence detector.

Poster #30

Correlating tissue responses with recording performance of implanted and brain-surface electrodes

Presenter: Ian Dryg, Graduate Student, University of Washington

Coauthors: Vomero, Maria; Ozyilmaz, Emre; Jia, Xiaoting; Shain, William

Microfabricated neuroprosthetic devices have made possible important observations on neuron activity; however, long-term high fidelity recording performance of these devices has yet to be realized. Tissue-device interactions appear to be a primary source of lost recording performance. Devices from collaborating groups are designed to avoid, control, and investigate the tissue response. We will test these devices in vivo and evaluate recording quality and electrode-tissue interactions. Collaborators include Dr. Sam Kassegne (SDSU), Dr. Polina Anikeeva (MIT), and Dr. Ulrich Hofmann (Freiburg). Additionally, we are implementing driven recordings. Many studies of electrode performance simply record from neurons which may or may not be active, skewing results. We will drive neuronal activity, so we can be confident that signals are not lost due to an incidental decrease in neuronal activity.

Poster #31

Anatomical and functional mapping of the thalamocortical pathways

Presenter: Tianyi Mao, Assistant Scientist, Oregon Health and Science University, Vollum Institute

Coauthors: Hunnicutt, Barbara; Long, Brian; Kusefoglu, Deniz; Gertz; Zhong, Haining

The thalamus and the cortex are two essential brain regions for sensory processing, motor control and executive functions. More importantly, their functions are distributed through their subdivisions.However, the precise subdivision connectivity Between thalamus and the cortex is poorly characterized, particularly in mouse. We employed a systematic, high-throughput viral approach to visualize thalamocortical axons with high sensitivity. We then developed algorithms to directly compare injection and projection information across animals and constructed the comprehensive map of thalamocortical projections. We determined the projection origins of specific cortical subdivions, and verified that the characterized projections formed functional synapses using optogenetic approaches. This dataset will serve as a foundation for functional investigations of thalamocortical circuits.

Poster #32

Predicting Temporal Progression of Alzheimer's Disease using Hippocampus Surface-based Morphometric Features

Presenter: Sinchai Tsao, Postdoctoral Fellow, University of Washington

Coauthors: Gajawelli, Niharika; Zhou, Jiayu; Shi, Jieping; Wang, Yalin; Lepore, Natasha

Previous work by Zhou et al. has shown that a multi-task learning framework can be used to encode both sparsity as well as temporal smoothness in predicting cognitive outcomes of ADNI subjects based on MRI baseline features as well as other subject information. We will show that when we apply a set of novel hippocampus-based multivariate tensor-based morphometry (mTBM) features to this learning framework, it outperforms just using standard volumetric features when used for disease classification. In short, this study combines a multi-task framework with mTBM applied on to hippocampus surface to improve prediction performance of cognitive scores 6-48 months from baseline. We assess the predictive power of these novel features relative to existing imaging-based features provided by FreeSurfer as well as non-imaging features such as age, sex, baseline test scores and genetic information.

Poster #33

3D structure tensor analysis of light microscopy data for validating diffusion MRI

Presenter: Khan, Ahmad; Postdoctoral Fellow, Oregon Health & Science University

Coauthors: Leigland, Lindsey; Kohama, Steven; Cornea, Anda; Jespersen, Sune; Kroenke, Christopher

Diffusion MRI (d-MRI) is a powerful non-invasive technique for characterizing tissue microstructure. However, validation of d-MRI poses an obstacle to accurate interpretation of d-MRI measurements. Recently, 2D structure tensor (ST) analysis of light microscopy images has been described. These analyses are promising but limited for comparisons to 3D d-MRI measurements. Here we describe the analytical framework for extending ST analyses to 3D, and utilize the results to analyze 3D confocal microscopy images of rhesus macaque hippocampal tissue. We implement image transformations to remove the effects of anisotropic tissue shrinkage, and the microscope's anisotropic point spread function. We demonstrated that the 3D ST analysis successfully identifies structure tensor orientations diffusion tensor that are parallel to diffusion tensor orientations measured with d-MRI.

Poster #34

Adaptation for Brain-Computer Interfaces

Presenter: Charlie Matlack, PhD Graduate Student, University of Washington Dept. of Electrical Engineering

Moritz, Chet; Chizeck, Howard J.

Neural coding models used in brain-computer interfaces do not explicitly account for feedback control strategies. However, optimization of closed-loop BCI performance is an instance of the dual control problem, wherein control and estimation are not separable into independent design problems. We identify and characterize the strategies used by a non-human primate during a cursor control task driven by either an isometric manipulandum or an intracortical brain-computer interface.

We find that a simple linear feedback model provides good explanatory power in both cases, but that time-delayed and anticipatory feedback terms are required. Additionally, we make the counter-intuitive finding that the brain does not appear to adjust delay and prediction intervals in its controller when switching from manual to direct brain control of the task.

Poster #35

Subdural Surface Spinal Stimulation and Recording as a Robust Paradigm for Cortico-Spinal Plasticity

Presenter: Brian Mogen, Graduate Student, University of Washington, Department of Bioengineering

Coauthors: Perlmutter, Steve; Fetz, Eberhard

It has previously been shown that neural connections between the brain and spinal cord can be strengthened by triggering intraspinal stimuli from the action potentials of corticospinal neurons during free behavior. Engaging this plasticity mechanism may offer a way of strengthening remaining connections after spinal cord injury. We show a proof of concept study in two sedated macaques that expands the scale of previous cortico-spinal plasticity mechanisms to neural populations recorded from the surface of the spinal cord. Using a novel surgical procedure and array design we show that surface arrays are capable of recording stimulation-evoked potentials and eliciting motor outputs from stimulation. Combining surface spinal stimulation and minimally-invasive cortical implants will be a robust platform for long term investigations of cortico-spinal plasticity.