Neuroscience Research and Brain-computer Interfaces in Real-World Environments

Swartz Center for Computational Neuroscience (SCCN), UCSD

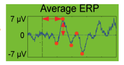
Director: Dr. Scott Makeig, Co-director: Dr. Tzyy-Ping Jung, POC: Shawn Hsu (shh078@ucsd.edu)

Challenges

- **Neuroscience:** Human brain, a spongy three-pound mass of tissue, is still a mystery
- **Engineering:** Lack of hardware and software tools to effectively record and accurately interpret brain activities
- **Research:** Laboratory-based research could not well translate to understanding naturalistic human cognitions and behaviors in the highly dynamic, real world
- **Translation:** How current knowledge of human functions could impact our daily lives?



Constrained Brain/Body Activities in a Well-Controlled Laboratory





Naturalistic Brain Activities in Real-world Environments

Goals

1. Advance basic neuroscience research in **real-world** environments using **mobile and multi-modal brain imaging**
2. Develop **advanced computational methods/tools** to study **attention, stress, emotions and learning**
3. Design **brain-computer interfaces** to enhance human performance
4. Improve prevention, diagnosis, and treatment of **neurological and psychiatric diseases**

Research Roadmap

WDSS (Wearable Daily Sampling System)

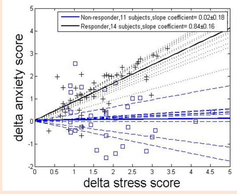


ReadiBand



Stress Scales



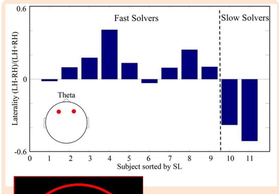


Real-world stress (exam, classroom)

Theta activity (under stress)



Stress, Anxiety

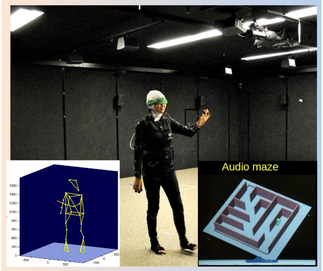




Insight (Math 24)

Learning, Insight

MoBI Lab: Spatial Navigation



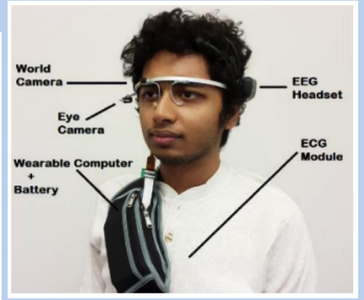
Mobile Body/ Brain Imaging (MoBI)

Everywear

NeuroGoggle

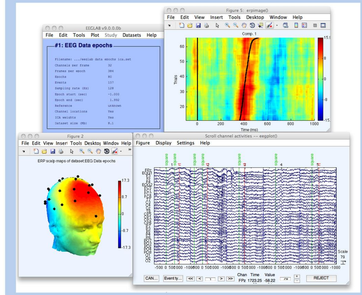


AR/VR-based EEG Goggle

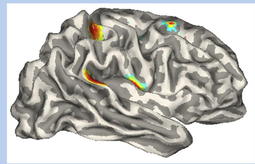


Multi-Modal Biosensing Platform

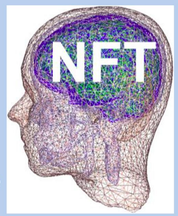
hardware



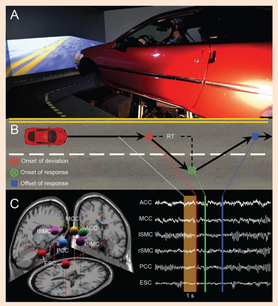
↗ **EEGLAB** (most popular toolbox for EEG analysis!)



↑ **NIST** (Neuroelectromagnetic Inverse Source Localization Toolbox)



↗ **NFT** (Neuroelectromagnetic Forward Modeling Toolbox)



Attention, Fatigue

Drowsiness detection (driving experiment)

Neuroscience

Swartz Center for Computational Neuroscience

Engineering

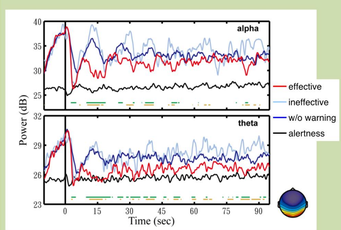
software

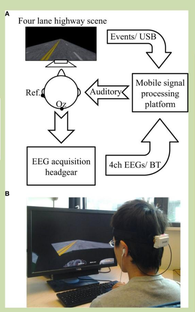
Translation

Sleep Staging

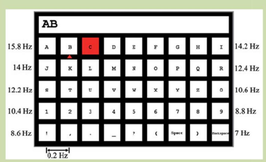
Real-time Cognitive State Monitoring

DMM (Drowsiness monitoring & mitigation) system





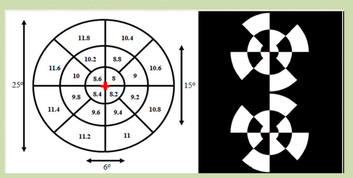
High speed **SSVEP speller**



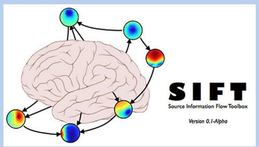
Brain-computer Interfaces (BCI)



Assessing visual function deficits in **Glaucoma**



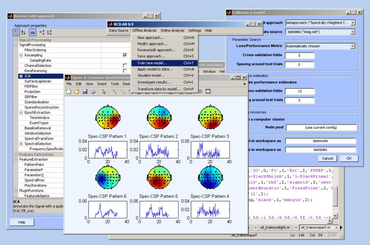
Advanced Computational Methods/Tools



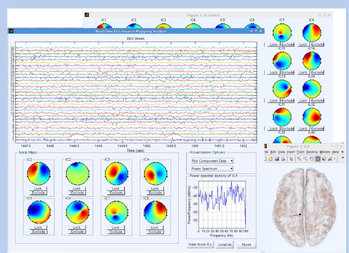


SIFT (Source Information Flow Toolbox)

BCILAB (Brain-computer Interfaces)

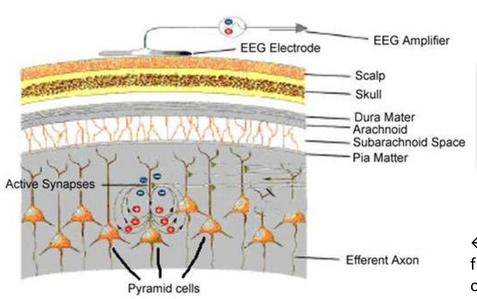


REST (Real-time EEG Source-mapping Toolbox)



Background

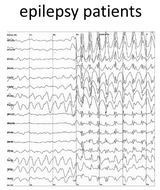
Electroencephalogram (EEG)



256-ch Biosemi

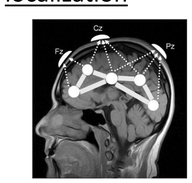


Raw EEG signals of epilepsy patients



← What does EEG measure? Voltage fluctuations resulting from ionic currents of synchronized activities of neurons

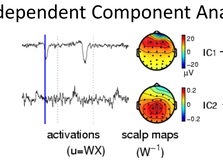
Source separation & localization



Scalp EEG signals are highly correlated because they each sum a mixture of signals generated in many brain areas.

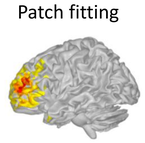
Independent Component Analysis (ICA)

separation

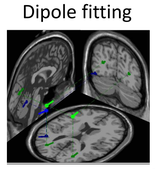


localization

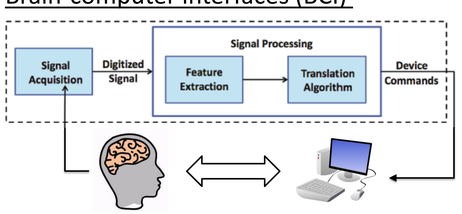
Patch fitting



Dipole fitting



Brain-computer interfaces (BCI)



A **BCI**, sometimes called a **direct neural interface** or a **brain–machine interface**, is a direct communication pathway between a brain and an external device

More Information

SCCN Website: https://sccn.ucsd.edu/
SCCN Wiki: https://sccn.ucsd.edu/wiki/

Welcome to our everyday Tea Time!

