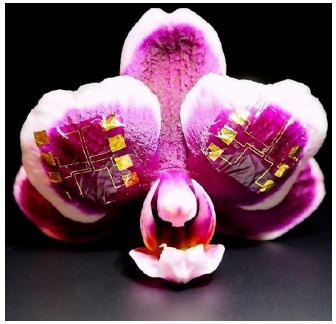
Systems Biology and Neuroengineering

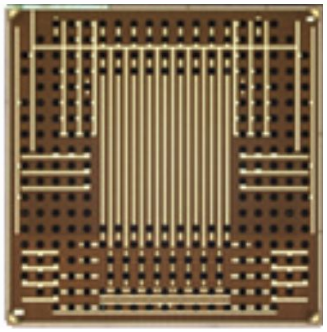
Dion Khodagholy
Translational NeuroElectronics
Columbia University

Systems Biology and Neuroengineering

Bioelectronic Devices

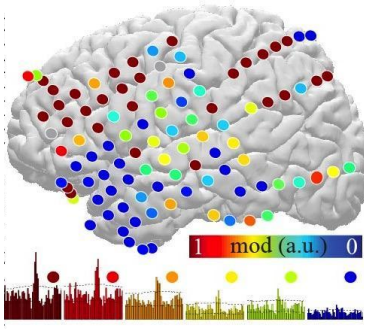
- New devices and architectures
- System integration
- Micro/nanofabrication

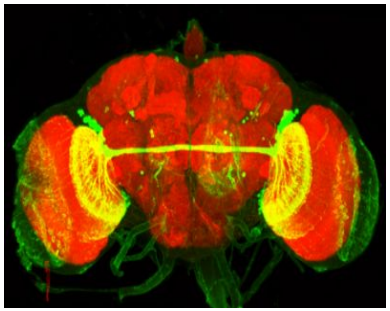




Large-scale data and systems

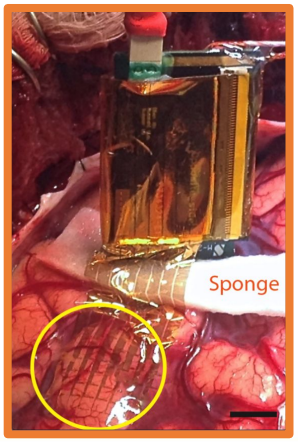
- Systems neuroscience
- Computational modeling
- Neuromorphic computations
- Genomics

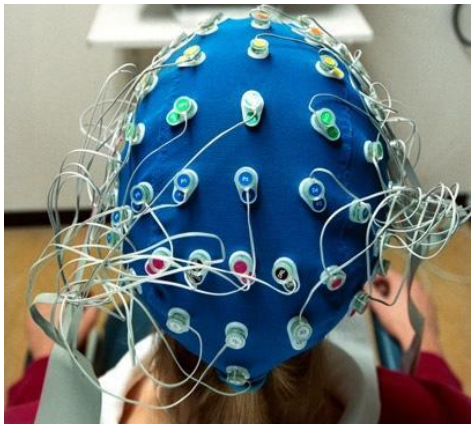




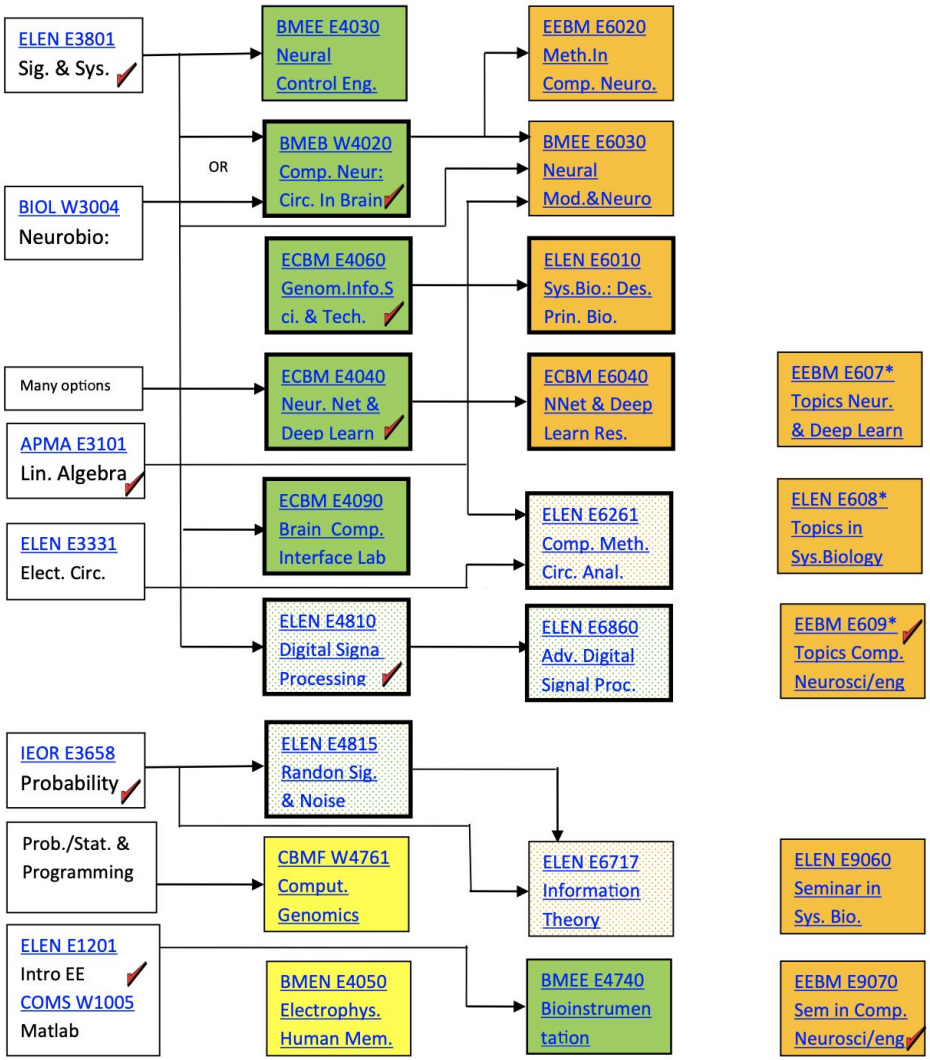
Translational devices and analysis

- Clinical electrophysiology and imaging
- Brain machine interfaces
- Drug discovery





Systems Biology and Neuroengineering Course Flow



Topical courses:

ELEN E608X

ELEN E6080: Methods of Signal Processing in Comp. Neuroscience
ELEN E6081: Compu. Methods for Biomolecular and Info Networks
ELEN E6082: Global Brain Modeling
ELEN E6083: The Origins & Implications for Large-scale Biological & Information Systems
ELEN E6084: Proteomic Biomarker Discovery from Analysis of Mass-spectroscopic Data

ELEN E609X

EEBM E6090 Topic: Global Brain Modeling
EEBM E6090 Topic: Brain Comp. Interfaces
EEBM E6091 Topic: Neuromorphic Engineering
EEBM E6091 Topic: Devices & Analysis for Neural Circuits
EEBM E6092 Topic: Big Data in Neuroscience Engineering
EEBM E6099 Topic: Brain Computer Interfaces

ELEN E4810

Digital Signal Processing
Prof. John Wright

- Prerequisites: (ELEN E3801)

- Digital filtering in time and frequency domain, including properties of discrete-time signals and systems, sampling theory, transform analysis, system structures, IIR and FIR filter design techniques, the discrete Fourier transform, fast Fourier transforms.

Neural Networks and Deep Learning

Prof. Zoran Kostic

- Developing features & internal representations of the world, artificial neural networks, classifying handwritten digits with logistics regression, feed-forward deep networks, back propagation in multilayer perceptrons, regularization of deep or distributed models, optimization for training deep models, convolutional neural networks, recurrent and recursive neural networks, deep learning in speech and object recognition.

- Analytical study and software design

- Team based projects

- Industry participation

Computational Neuroscience: Circuits in the Brain

Prof. Aurel Lazar

The Biophysics of Computation: Modeling Biological Neurons, The Hudgkin-Huxley Neuron, Modeling Channel Conductance and Synapses as Memresistive Systems, Bursting Neurons and Central Pattern Generators, I/O Equivalence and Spiking Neuron Models.

Encoding with Neural Circuits: Stimulus Representation with Time Encoding Machines, Geometry of Time Encoding, Encoding with Neural Circuits with Feedback, Spatio-Temporal Receptive Fields, Population Audio and Video Time Encoding Machines.

Functional Identification of Neural Circuits: Modeling Dendritic Stimulus Processors, Channel Identification Machines, A Fundamental Duality between Neural Decoding and Functional Identification, Identifying Spatio-Temporal Receptive Fields and Biophysical Spike Generators.

Projects in Matlab or Python

ECBM E4060

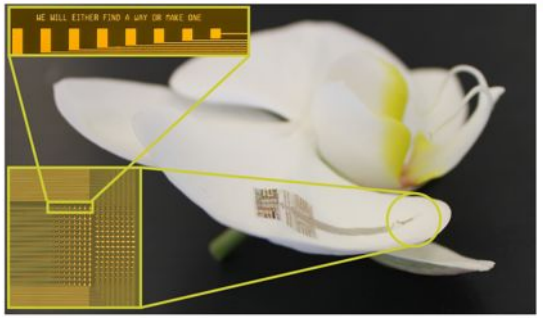
Introduction to Genomic Information Science and Technology

Prof. Dimitris Anastassiou, W. Cheng

- Introduction to the information system paradigm of molecular biology.
- Representation, organization, structure, function and manipulation of the biomolecular sequences of nucleic acids and proteins.
- The role of enzymes and gene regulatory elements in natural biological functions as well as in biotechnology and genetic engineering.

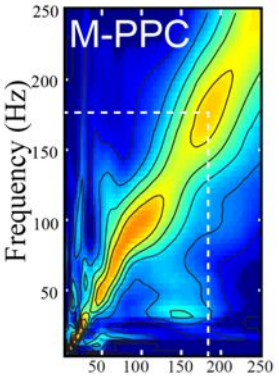
EEBM E6091

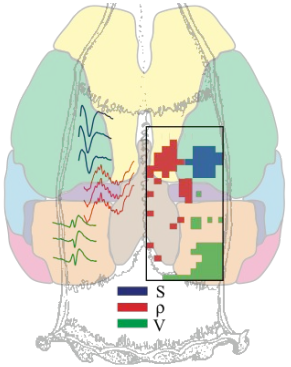
Tools and analysis for neural circuits
Prof. Dion Khodagholy

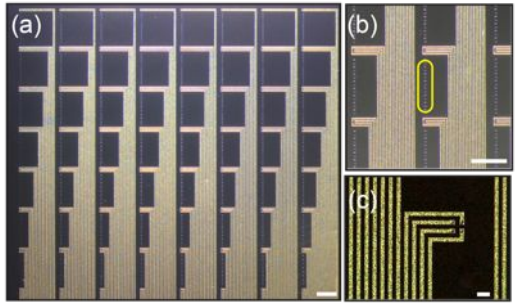


A comprehensive overview of devices and analytical techniques that enable investigation and decoding of neural circuits.

- Introduction to brain, brain states and neural networks
- Neural devices and their spatiotemporal resolution
- Time domain neural analysis
- Frequency domain neural representation
- Phase, traveling waves and wave propagation
- Closed-loop real time processing
- Template matching for event detection
- Clustering and sorting







Faculty

- **Dimitris Anastassiou** – Computational biology and genomics
- **Christine Hendon –** Optical imaging for cardiovascular and oncology applications
- **Predrag Jelenkovic** – Mathematical modeling of biological systems
- **Aurel Lazar** – computing with neural circuits
- **Nima Mesgarani** – Reverse-engineering the auditory system
- **Dion Khodagholy** – Neuroelectronics, bioelectronics, systems neuroscience
- **Ken Shepard –** Bioelectronics and neural interfaces
- **Paul Sajda –** Neural engineering, neuro-computation
- **Joshua Jacobs –** Electrophysiology of navigation and memory, brain stimulation, direct human brain recordings
- **Qi Wang –** Neural coding, brain machine interfaces

Thank You !