Course homepage: https://pages.ucsd.edu/~msereno/systneurosci

Systems Neuroscience

Professor:

Marty Sereno -- email: msereno@ucsd.edu
example time: MWF 9:00-9:50 AM, grad/adv: F 8:00-8:50 AM)
take hand-written notes for better memory consolidation!
take-home exams, final/paper based on lecture content

Course Content:

Sereno Lectures:
https://pages.ucsd.edu/~msereno/systneurosci/lectures.html
Sereno Lecture Notes PDF:
https://pages.ucsd.edu/~msereno/systneurosci/notes.pdf
Background reading (neuroscience reference texts):
Squire, Berg et al., eds. (2008/2013) *Fundamental Neuroscience*, 3rd/4th ed.
Kandel, Jessell, Schwartz, eds. (2008/2012) *Principles of Neural Science*, 5th/6th ed.
Nieuwenhuys, Voogd, van Huijzen (2008) *The Human Central Nervous System*, 4th ed.
Background reading (undergrad neuroscience textbooks):
Nicholls et al. (2012) *From Neuron to Brain*, 5th ed.
Bear, Connors, and Paradiso (2006/2015) *Neuroscience: Exploring the Brain*, 3rd/4th ed.
Additional reading/references:
https://pages.ucsd.edu/~msereno/systneurosci/readings.html

Exams:

multiple question short-answer, each question with subsections
2 midterms, final (midterms: 24% each, final: 32%), and short final paper (20%)
old pdf answer keys from my similar UCSD Systems Neuroscience course here and here

Learning Objectives:

Students will be able to do the following:
(1) describe neuronal electrochemistry, development, and relation to simple dendritic, Hebbian, and attractor models
(2) diagram neuroanatomical structures/connections from low to high levels in visual, somatosensory, auditory sensory systems
(3) diagram structures/connections involving superior colliculus, cerebellum, striatum, motor cortex, and limbic systems
(4) analyze sequential processing stages in visual, somatosens., and auditory systems from signals and systems perspective
(5) describe neural models of eye movement planning, hierarchical motor control, and body position and orientation

Lecture Topics: (e.g., Spring semester course)

Week 1 (WF) -- Introduction
[no class Mon]
introduction to course, folk theory of brain function
resting/Nernst/reversal potential

Week 2 (MWF) -- Cellular Physiology
action potential, voltage-gated channels
voltage-sensitive dendritic currents, bursting
neurotrans.-gated post-synaptic potentials, NMDA, LTP/STDP
grad lecture: Hodgkin-Huxley, integrate-and-fire models

Week 3 (MWF) -- Relation to Neural Models
current flow in dendrites, equivalent circuits
simple Hebbian network model of orientation selectivity
simple attractor network model, energy analysis
grad lecture: covariance/eigenvector analysis Hebbian learning

Week 4 (MWF) -- Neural Development
blastula, gastrula, neural plate, neural tube, optic cup
cylindrical coords, temporal lobe formation, 'rule of Sereno'
later development, cortical subplate, gyrification

Week 5 (MWF) -- Visual System I
retinal circuitry, origin of processing streams
retina to dLGN as a conformal map, layers
visual cortical maps: V1, V2, MT and the rest
grad lecture: achiasmatic sheepdog maps, backpropagation

Week 6 (MWF) -- Visual System II
cortical layer scheme, edges/brightness/motion in V1
V2 modules, simple/complex/hyper, 1st midterm review
Gabor filter model, aperture prob for color, pattern translation
1st Midterm Exam due

Week 7 (MWF) -- Visual System III
aperture prob complex motion, pos. invariance, contour analog
explicit V1-to-MT model, Horn and Schunck gradient model
grad lecture1: smoothness constraint, line processes, stereo
cortical-wide mechanisms of visual attention
grad lecture2: true color, stereo and motion, object recognition

Week 8 (MWF) -- Somatosensory System
somatosensory receptor types, spinal cord
muscle diagram, ascending paths: dorsal column, spinothalamic
somatosensory cortical areas, discontinuities, plasticity

Week 9 (MW) -- Auditory System I
hair cell receptors, lateral line, electric fish
cochlear structure/transduct., 1D vs. 2D, mammalian brainstem
[no class Fri]

Week 10 (MWF) -- Auditory System II
cochlear nuclei responses, auditory streams
nucleus laminaris coincidence detection
construction of the owl space map
grad lecture: auditory thalamus, cortex, freq vs. pitch

Week 11 (no class) -- SPRING BREAK
[Mon/Wed/Fri: no class]

Week 12 (MWF) -- Motor System I
bat echolocation and speech sound processing
gaze stabilization (VOR, OKN, pursuit)
superior colliculus retinal/motor maps, double-step remapping
grad lecture: bat FM, phonetics, auditory attention

Week 13 (MWF) -- Motor System II
multisensory map alignment: superior colliculus, VIP, LIP
motor system overview, spinal/brainstem pattern generators
motor cortex, 2nd midterm review
grad lecture: spatial->temp & temp->spatial, WTA, human VIP

Week 14 (MWF) -- Motor System III
2nd Midterm Exam due
cerebellum: connections, microanatomy, learning
striatum: connectional/funct overview, hierarchical sequencing
grad lecture: origin of language I: vocal learning

Week 15 (MWF)-- Limbic System
connectional overview limbic system
hippocampus: H.M./intermed. term memory vs. inertial guidance
head direction and grid cells, attractor models
grad lecture: origin of language II: language and scenes

Week 16 (MW) -- Neuroimaging EEG/MEG
source EEG/MEG, MRI, spin vs. precess, Bloch equation
Fourier transform, relation to MRI image formation

Week 17 -- Final Exam
Final paper due