INTRODUCTION TO SYSTEMS AND COMPUTATIONAL NEUROSCIENCE

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Part 1. Physiology and functions of the mammalian visual system (an introduction to systems/computational neuroscience)

Introduction to anatomy and physiology of the visual system

A systems/computational approach to the study of the visual system; Anatomy of the visual system

Classic findings about physiology of lower-level visual areas
Data analysis approaches in Systems Neuroscience
Classic findings about physiology of higher-level visual areas

Descriptive models of visual neurons
How to build models of visual neuronal responses (i.e., stimulus/response maps)
Mechanistic models of the visual system

Inferring the mechanisms underlying the response properties of visual neurons
Functional models of the visual system
Understanding neuronal population codes

Part 2. Sensory Systems: Tactile Perception

1. Introduction to the study of the cerebral cortex
2. Sensory maps in the cerebral cortex
3. Transduction
4. Somatosensory system and pain
5. Methods for computational neuroscience of perception
6. Encoding and decoding
7. Perceptual memory
8. Neuroscience of perceptual knowledge

Part 3. Evolution of Neural Computation

1: What are we after in the course?
2: Chemical computation – neuromodulators. Simple models of reinforcement learning,
3: Elements of information theory. Geometrical computation – early vision in flies, in fish and in mammals
4: Perceptrons and back-propagation. Creative geometry in the basal ganglia and in the cerebellum.

5: Pyramidal cells, distributed representations, associative plasticity – associative memory for faces with unlabeled data
6: From cortically plausible models to the Hopfield model. Simple associative nets in olfactory cortex, amygdala and orbitofrontal cortex.
7: Competitive nets, extended to the self-organization of cortical maps. Lamination and a realization in sensory cortex.
8: Pure memory in the mammalian hippocampus – David Marr. The statistical physics of flat and curved spatial maps.
9: Random number generators in the Dentate Gyrus, and neurogenesis – analyzing charts and their transitions
10: Memory from statics to dynamics, from semantics to grammar

Part 4: Language

What's a (human) language?
Arbitrariness and information
Form-to-meaning mapping
Language evolution and cognitive constraints
The brain as a statistical learner
A statistical learning view of word perception
The geometry of language: Lexical maps, semantic connections
Computational models of visual word identification