Challenges and opportunities in statistical neuroscience

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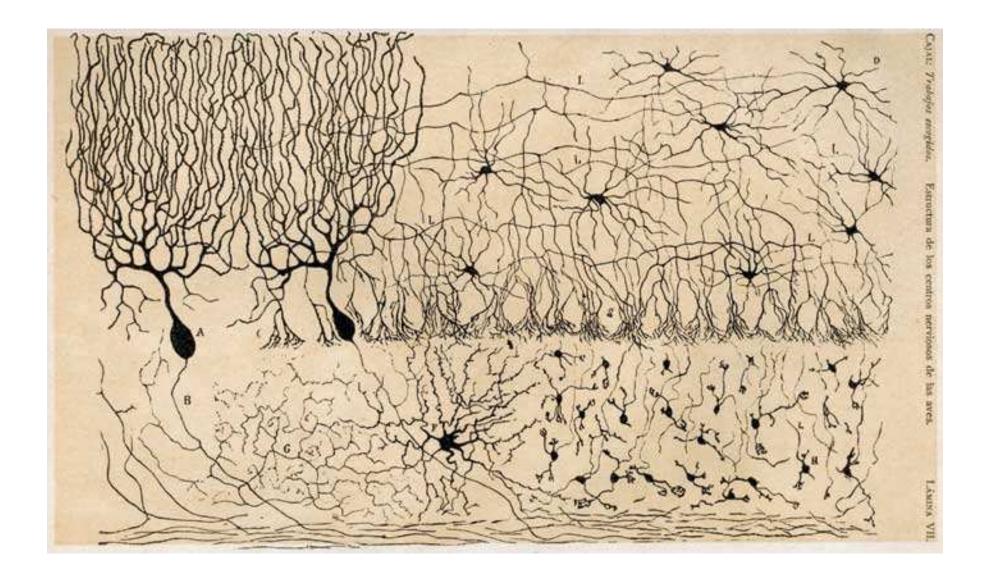
The coming statistical neuroscience decade

Remarkable recent developments in:

- machine learning / statistics methods for extracting information from high-dimensional data in a computationally-tractable, systematic fashion
- computing (Moore's law, massive parallel computing)
- novel neurophysiological methods for recording and stimulating many genetically-targeted neurons simultaneously

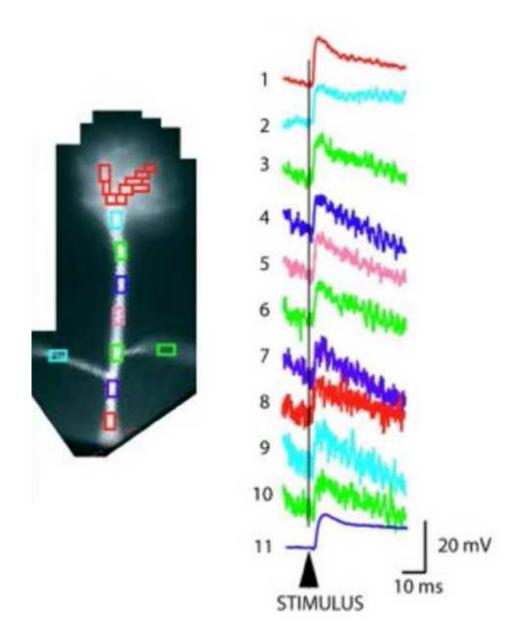
 \implies exciting new opportunities for understanding the brain.

Understanding dendritic complexity



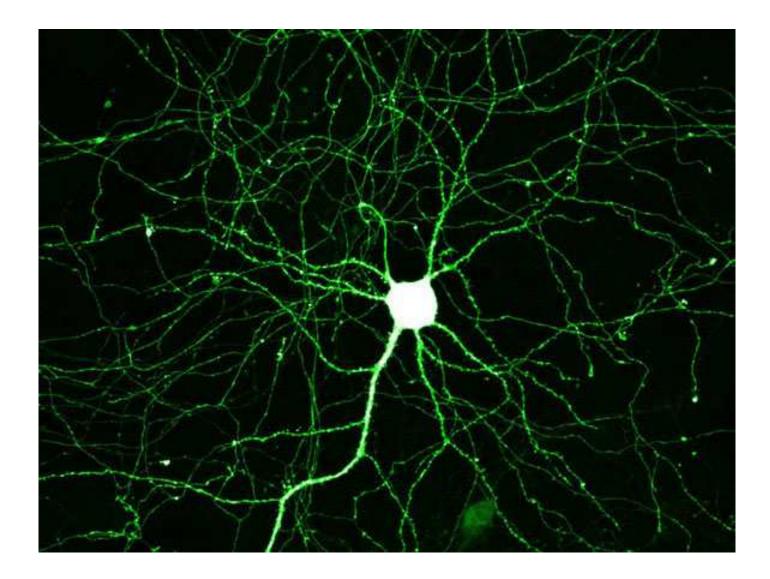
Ramon y Cajal, 1888.

Imaging dendritic electrical activity



Problem: observations are still noisy and undersampled; must filter signal appropriately.

Problem: scale



Optimal filtering in a complex dynamical system with $\sim 10^4$ dimensions? (Standard methods require $\sim (10^4)^3$ operations per time step...)

Fast, scalable optimal filtering

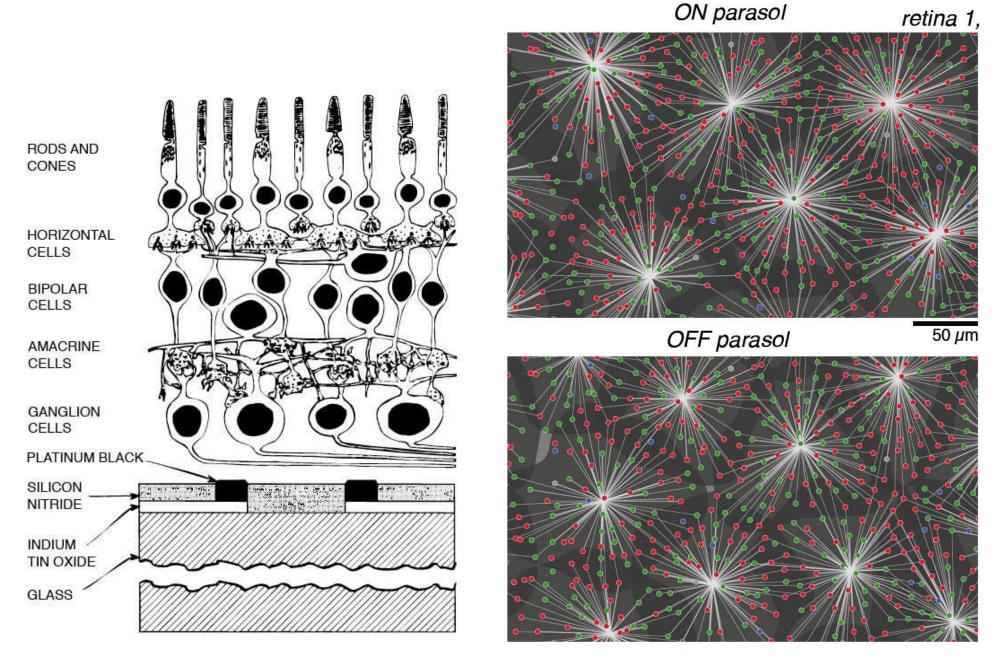
(Loading low-rank-speckle.mp4)

Closed-loop neural circuit inference

Record large-scale calcium movie Aim 1: Extract spike times Aim 2: Estimate network model probabilistic linear filter nonlinearity spiking fluorescence post-spike current Cell 1 parameters coupling currents spikes 0 2 3 4 5 1 time (sec) Cell 2 parameters Inferred network model Aim 3: Check results via photostimulation Vm Two-photon uncaging pulse 11/111 *Recording IV Va 40x Vb Objective VI **Recording Electrode**

w/ R. Yuste, CU Bio

Retinal connectivity: the neural representation of color



 ≈ 1 TB of data per experiment (Field et al, Nature '10).

example calcium movie:

http://gaya.jp/data/CA3_movie.gif