

Computational Neuroscience 25 Years Later. And a modest proposal for the future.

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Outline

Definition of terms

Fallacies of Computational Neuroscience

The Four Nobel Truths of Computational Neuroscience

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 - ▶ Japanese Fifth Generation AI project was scaring the U.S.
 - ▶ The computer era was ready to begin

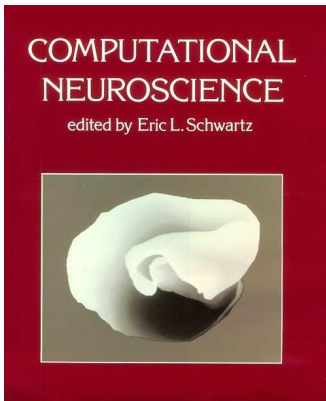
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- ▶ Fund three major areas of strategic interest
 - ▶ Neuroscience
 - ▶ Linguistics
 - ▶ Robotics

M.I.T. Press 1990

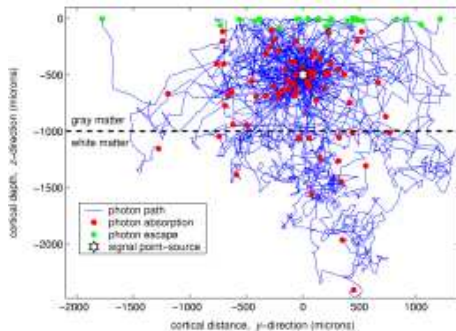


An attempt at definition

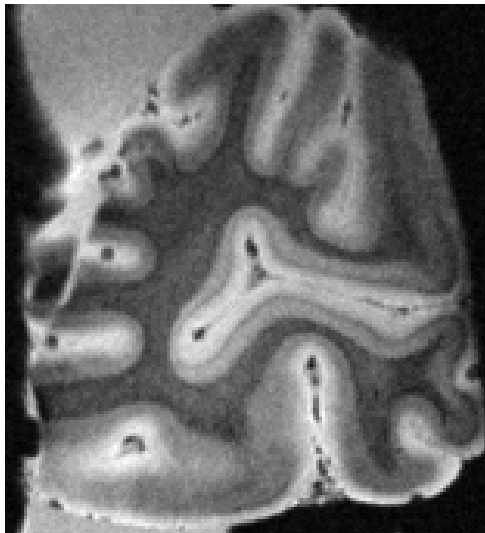
- ▶ "Computational Neuroscience" a non-trivial interaction of neuroscience, as a biological discipline, and mathematics and computer science methods as expositive approaches
- ▶ In subsequent years, the term has become very widely used, often not in the spirit of its original definition.
- ▶ As a partial means of dealing with the current terminological and scientific morass associated with this area, the interested reader may consult our guide to computational neuroscience, which provides valuable tips for working in this field.

Examples

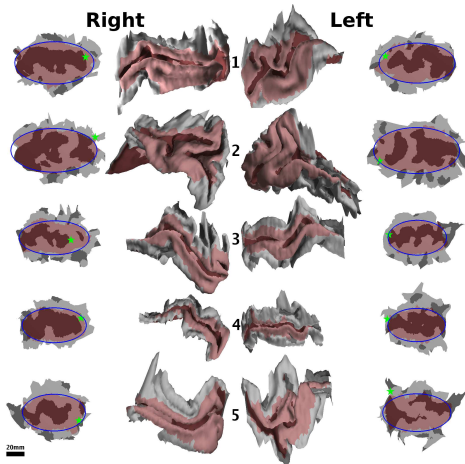
- ▶ Simulation: modeling photon scatter in brain tissue



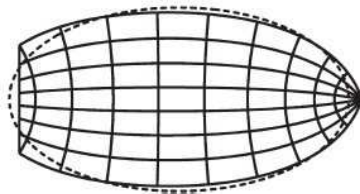
7T Ex-vivo 12 hour myelin scan: human coronal V1



Accurate cortical flattening



- ▶ Instrumentation: accurate surface modeling of cortex



- ▶ Theory: Science, e.g. Hodgkin-Huxley Theory

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Unity gain simulation You build an elaborate model of a simple phenomena, including many redundant mechanisms to get out the phenomena. If done well, you get the result that you wired in, but learn nothing, hence unity gain. If done poorly, reduces to G.I.G.O. True unity gain, although not interesting, is technically difficult, and requires some skill.

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Tibetan prayer wheel Building merit by turning cycles (on your computer). Your model is conceptually simple, and/or of little interest, but it required a supercomputer to run it. Legitimizing your model by emphasizing that it required the “world’s largest computer” to run.

Two card monte The street card game (shell game) played in academia: you sell the computer scientists that your model is an important contribution to biology, and you sell the biologists that your model is an important contribution to computer science. But it is neither. Works even better with more than two disciplines involved. The more remote they are, the better.

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- Pseudo biological detail** Related to two card monte. Overload your model with irrelevant biological parameters and metaphors, in an attempt to direct attention away from conceptual weakness.
- Proof by sales receipt** I'm a neuroscientist. I bought ten MACS (Suns, PC's, etc.) on my grant. Therefore, I'm a computational neuroscientist.

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Totemism The totem is believed to (magically) take on properties of the object. The model is legitimized based on superficial and/or trivial resemblance to the system being modeled. pause

Hail Mary You have a fragment of an idea, but don't know how to state, develop, or support it. But, if true, you will be famous. So, embed it in a ridiculous "model" and publish it, in the hope that your "model"; will be proven "correct", somehow, someday.

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Neuro-bagging You assert that an area of physics or mathematics familiar to few neuroscientists solves a fundamental problem in their field. Example: "The cerebellum is a tensor of rank 10^{12} ; sensory and motor activity are contravariant and covariant vectors". Related to 2-card monte (above), but distinguished by more extreme bodaciousness.

Scientific pointillism Your "humanoid robot" is really a pair of active vision camera's and robot arms bolted together, with a flashy plastic body. The rhetoric describing it is laden with terms indicating its humanoid abilities: it "interacts" with humans (and even graduate students); it has emotions. However, when looked at more closely, the thing is supported by simple software that appears to be ten or fifteen years behind the state of the art. If done well, you can enjoy the feeling of metaphorically, as well as literally, being the "star of your own movie".

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Bruno's Lemma When it is pointed out that the fundamental idea of your model strongly violates basic facts, you claim that your model can be fixed, since it is a model of the brain, and the "brain can do it".

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Treatment Mandatory publishing of source code

Symptoms

- ▶ Estimate the fraction of papers published in IEEE PAMI that involve computational procedures that don't work as advertised.
- ▶ Which fraction of these are accompanied by source code?
- ▶ In computational science, the paper is the advertising, the code is the work. (John Claerbault).
- ▶ What is the corresponding estimate in Computational Neuroscience or neural modeling?

Causes: neuroscience is low context

Five disciplines of neuroscience and their units

- ▶ Biology/Physiology (liters and moles)
- ▶ Psychology (lamberts)x
- ▶ Philosophy-Theology
- ▶ EngineeringExperimental Physics (mks-SI)
- ▶ MathematicsTheoretical PhysicsCS (1)

Prognosis

- ▶ Computational science is fundamentally different than experimental science
- ▶ Computations can be checked by anyone, at anytime, for almost no cost
- ▶ Experiments are increasingly difficult and expensive to check
- ▶ We evolved in an environment where ones “word” HAD to be taken
- ▶ But this is not true in computational science

The Cure: a modest proposal

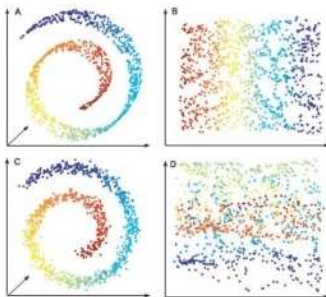
- ▶ No more papers published without access to source code
- ▶ Referees responsible for running code at least
- ▶ Readers have the chance to run code and change parameters and inputs
- ▶ Effected by lobbying NIH, NSF and journals.
- ▶ Easy top-down solution

Treatments can be painful

- ▶ Much more work—code has to be professional looking (!)
- ▶ Exposure to work being stolen
- ▶ Exposure to embarrassment and humiliation
- ▶ Far fewer acceptable published papers
- ▶ Technical difficulty of ensuring portability

No Pain, No Gain

My personal experience in both directions.



- ▶ The upside
 - ▶ More than 50% of the CNS literature will “work”
 - ▶ There will be far less papers published
- ▶ The downside
 - ▶ There will be far less papers published
 - ▶ There will be far more work to do: software engineering
 - ▶ There will be theft and embarrassment