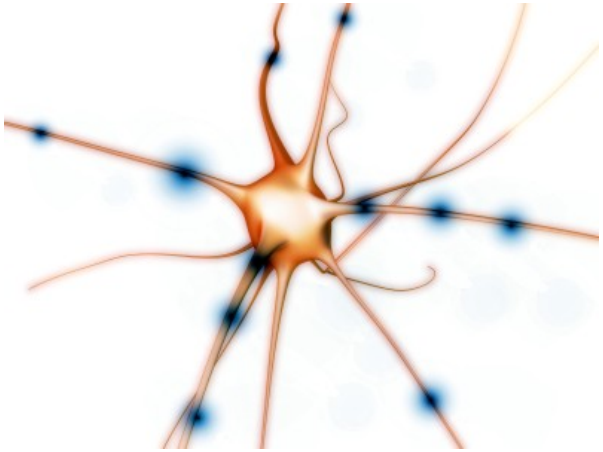
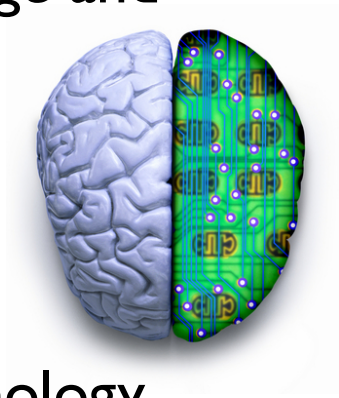


How to Model

CoSMo 2013
Gunnar Blohm

Computational neuroscience?

- It is the use of mathematical, engineering and computer science tools to attempt answering neuroscience questions.
- Builds mathematical models describing computations in the brain that give rise to mental abilities
- A way to put "word models" into mathematical language and to analyze the result
  - Identify hidden assumptions
  - Explain observations
  - Make predictions



- Interdisciplinary: neuroscience, cognitive science, psychology, electrical engineering, computer science, physics, mathematics, life science, health science, medicine, etc…

Goals

- Gain complete understanding of some experimental phenomenon
- Identify hypotheses, assumptions, unknowns
- Make quantitative predictions
- Build a theoretical brain as a model of the real brain (stroke lesions etc)
- Inspire new technologies
- Models of neurological diseases to help treatment, rehabilitation, quality of life
- Guidance in designing useful experiments (i.e. animal research)

Why model brain function?

- Models help answering three potential types of questions about the brain (Dayan & Abbott, 2001)
  - Descriptive = What?
    - Compact summary of large amounts of data
  - Mechanistic = How?
    - Show how neural circuits perform complex function
  - Interpretive = Why?
    - Computations in the brain are usually performed in an optimal or nearly optimal way
    - Understanding optimal algorithms and their implementation to explain why the brain is designed the way it is

How to start?

- Define a precise question/goal!
  - What exact aspect of data do you want to model?
  - Define the question/goal with as much precision as possible!
    - Try to identify data constraints, limitations in the data set, problems with data recording, etc. that affect your model
    - Also identify what you do NOT want to address
  - This is the most crucial step!!! Otherwise you'll get lost…
  - Write it all down!
- Review the literature!
  - Alternative models?
  - Complementary models?
  - Previous models as a starting point?

Then what?

- Decide on the approach!
  - Chose the appropriate tools
  - What level of detail do you need?
    - Normative model, systems approach, neural implementation, synaptic processing, etc…
- Keep the model as simple as possible, but as complex as needed!
  - Every element in the model must be a crucial component required to reproduce the phenomenon you try to model
    - Remove model components to see how the model is impacted
- Implement your model and make smart changes as you go…

Model evaluation?

- How do you know if this is a good model?
- Criteria?
  - Obviously, the model should meet your goals!
    - How do you evaluate this?
  - Can the model reproduce any other data sets?
    - How general is the model?
    - The more data it can describe, the better
  - Does the model make any TESTABLE predictions?
    - The more precise they are, the better!
  - Do you get any mechanistic insights into a phenomenon that you could not have gotten from the data alone?

Happy modelling @ CoSMo 2013!