Computational Models of Neural Systems: 15-883

Fall 2017

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CNBC
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Course Info

Time: Mon/Wed 4:30 to 5:50

Place: 4211 GHC (Gates Hillman Center)

Credit: 12 units

Current syllabus: on the class web site

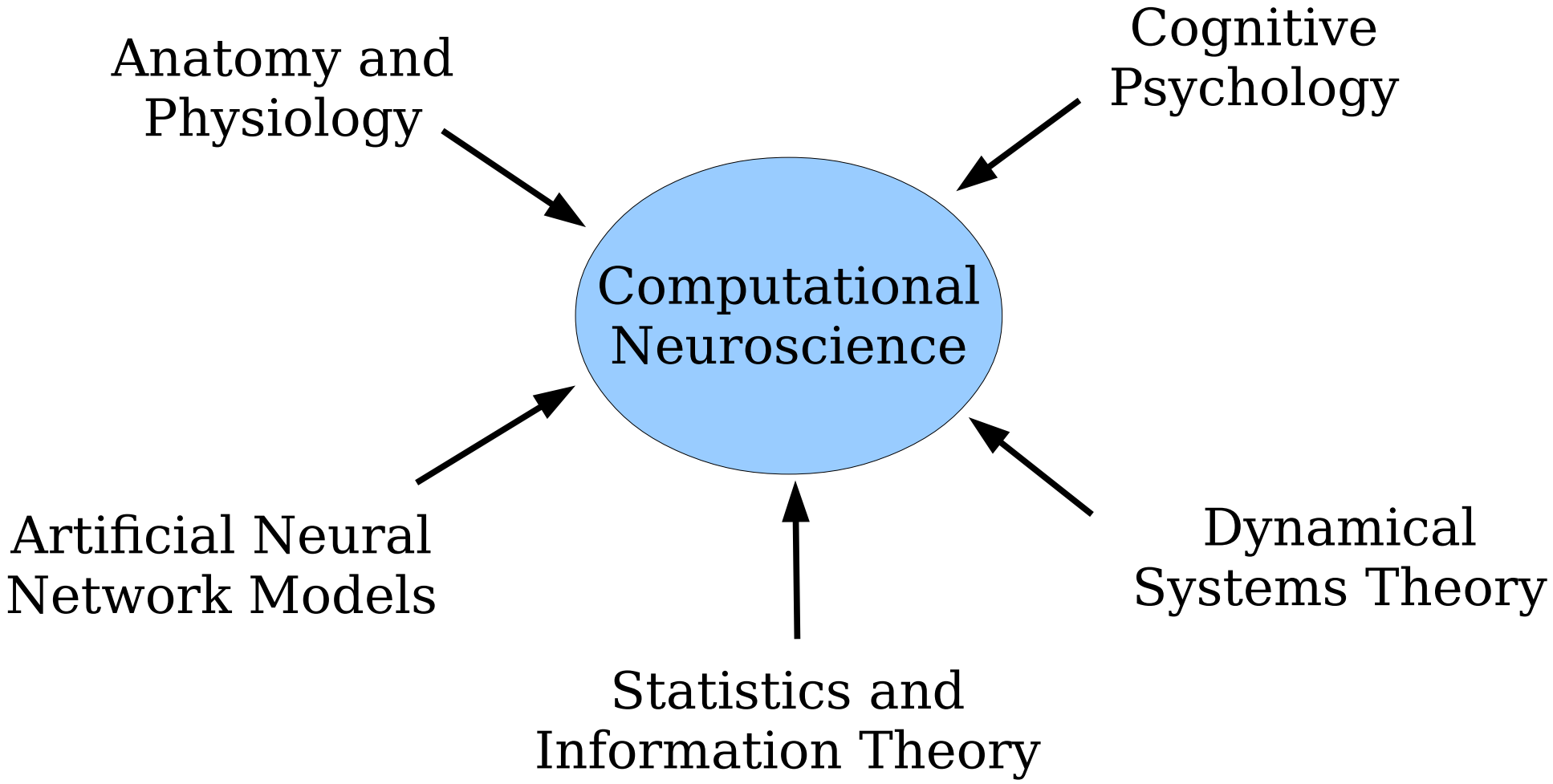
Textbook: none

Readings:
  Web repository (linked from syllabus)

Who Should Take This Course?

- Computer scientists who want to learn about the brain.
  - No prior neuroscience background required.
- Neuroscientists who want a computational perspective on brain function.
  - Focus is on representations and algorithms, rather than anatomy and physiology.
- Cognitive scientists who want to study brains as computing devices.
  - Taking the “brain as computer” metaphor seriously requires learning as much as possible about both.

Computational Neuroscience Intellectual Landscape



Varieties of "Neural Network" Research

1) Neuronal Modeling
2) Computational Neuroscience
3) Connectionist (PDP) Models
4) Artificial Neural Networks (ANNs)

Each area asks a different kind of question.

Some investigators work in more than one area.

Courses in all four areas are available at CMU or Pitt.

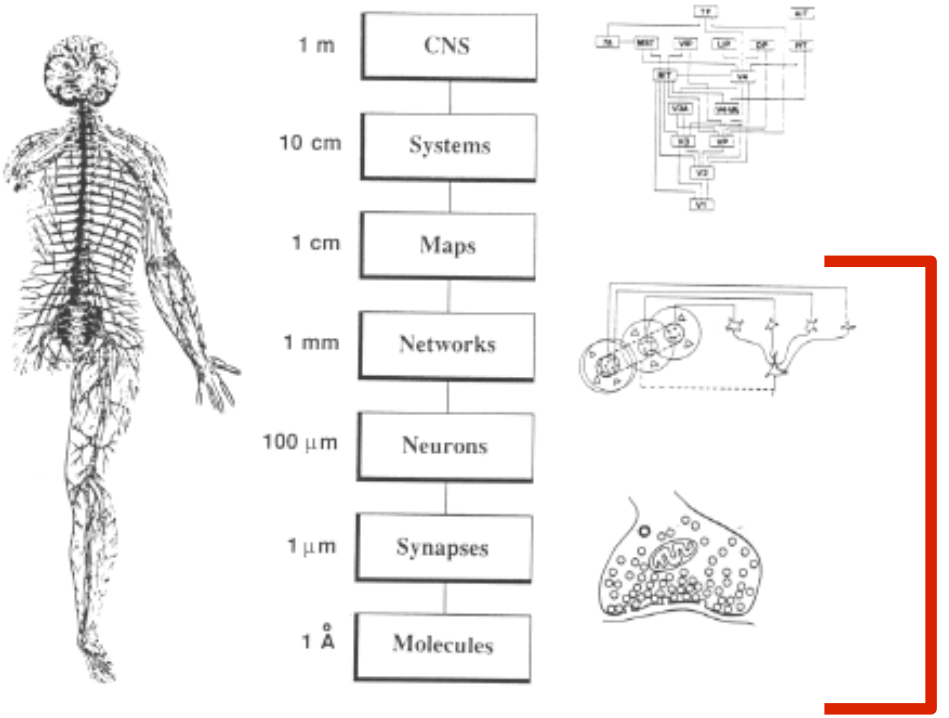
1: Neuronal Modeling

Understand the operation of single neurons or small neural circuits.

Detailed biophysical models of nerve cells, and collections of cells.

What makes a neuron spike?

Comp. neuro. course at Pitt (Brent Doiron, Jon Rubin, Math Dept.)



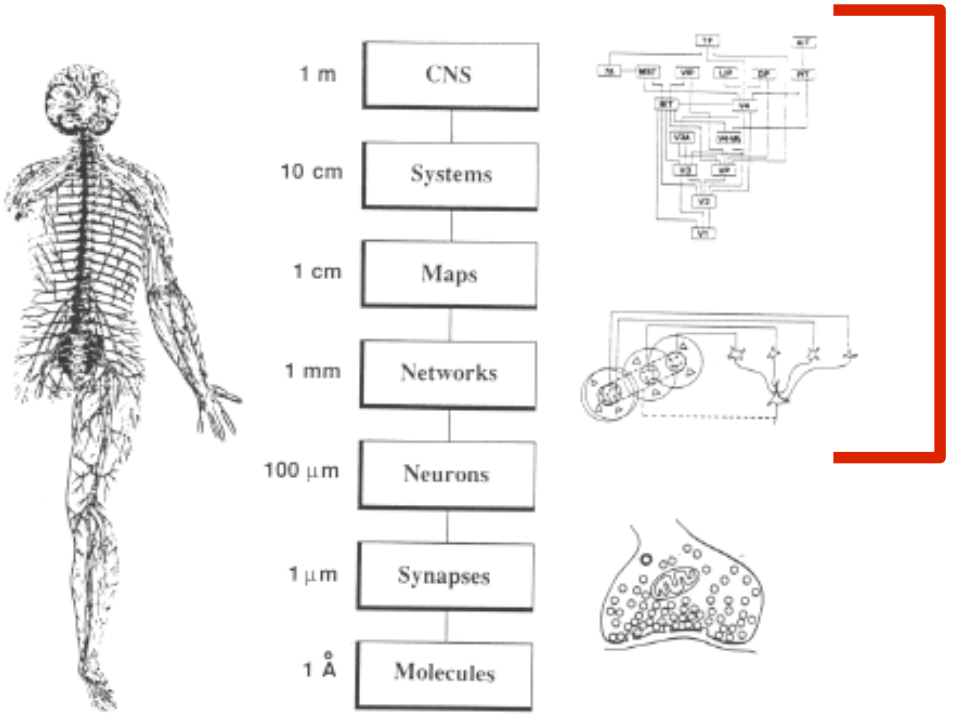
Churchland & Sejnowski 1988

2: Computational Neuroscience

Model information processing in actual brain systems.

The models refer to specific anatomical structures, but their operation may be abstract.

How does the hippocampus retrieve memories?



Churchland & Sejnowski 1988

15-883 Computational Models of Neural Systems course (Touretzky)

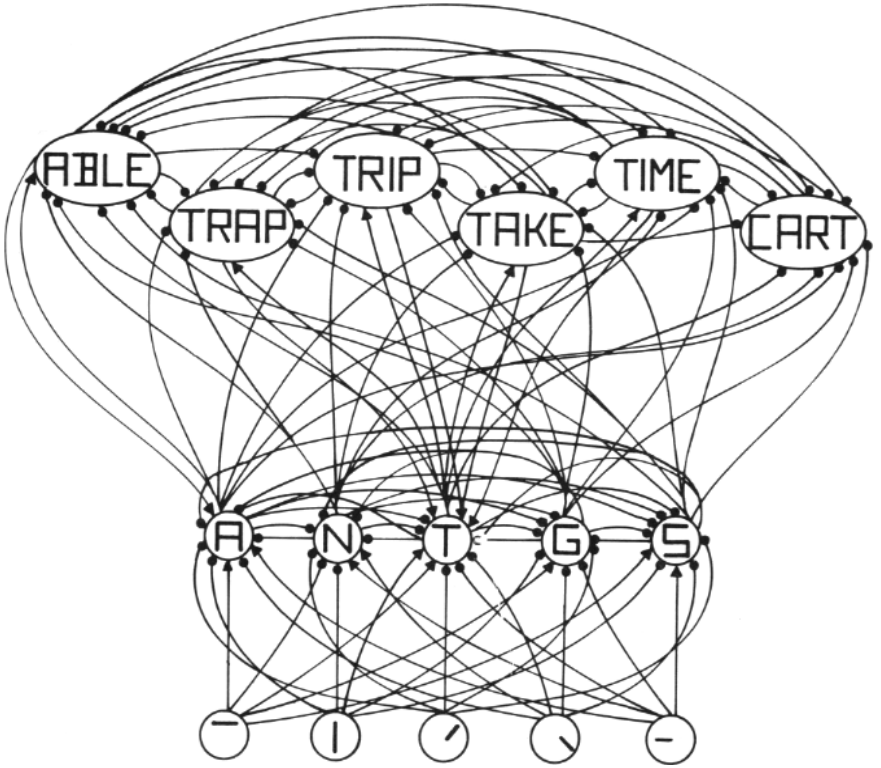
3: Connectionist (PDP) Modeling

Modeling human cognition in a brain-like way: parallel constraint satisfaction; distributed activity patterns instead of symbols.

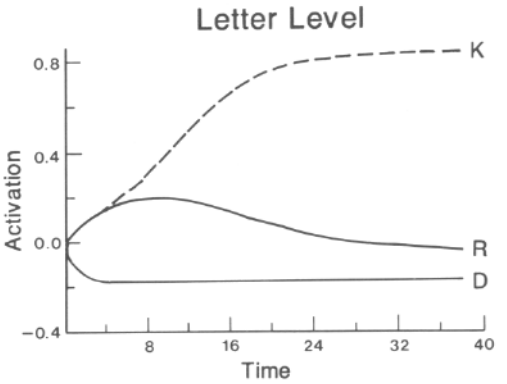
Models are fairly abstract.

How do priming effects act to influence reading?

85-719 PDP models course (Dave Plaut)



McClelland & Rumelhart 1981



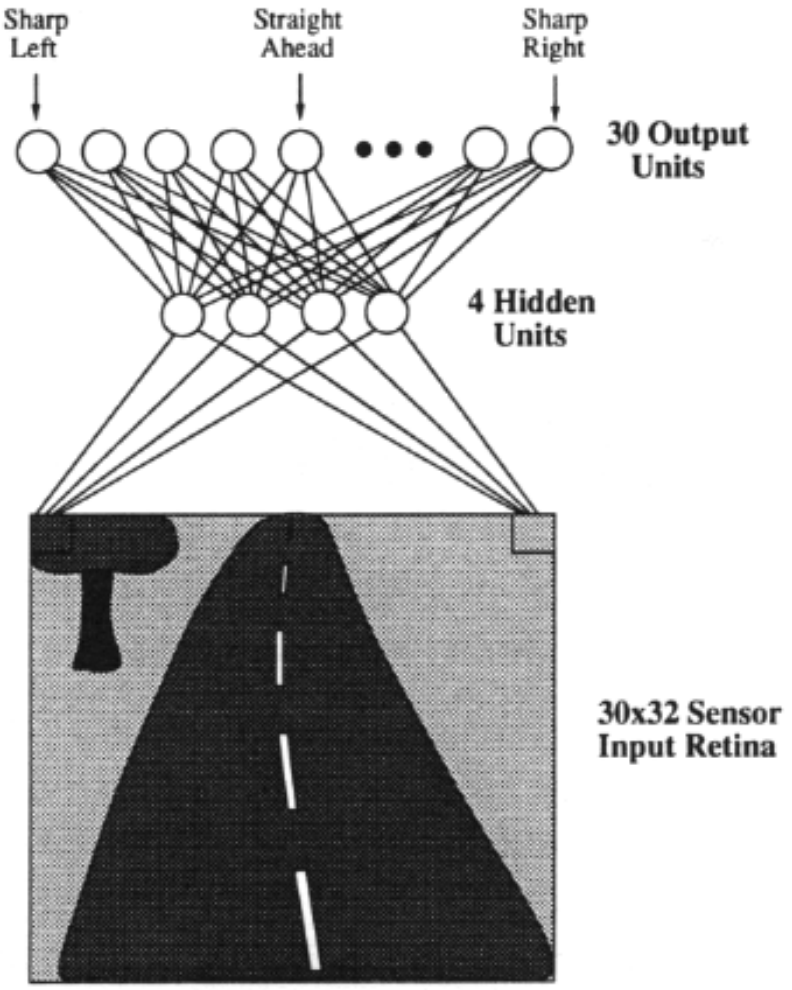
4: Artificial Neural Nets

Pattern recognition, adaptive control, time series prediction. (This is where the money gets made.)

Simple, “neuron-like” computing elements; local computation.

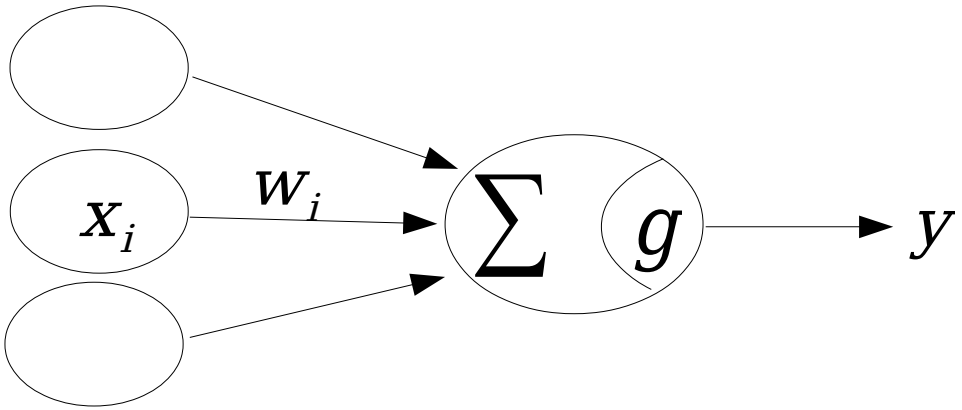
How can a machine learn to efficiently recognize patterns?

Covered in various courses in Machine Learning.



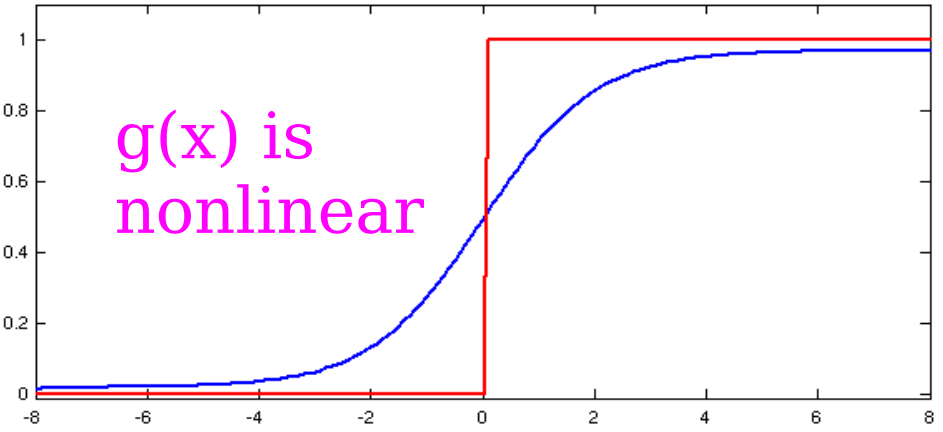
Pomerleau 1993: ALVINN

What's a “Neuron”?



$$netact = \sum_i w_i x_i = \vec{w} \cdot \vec{x}$$

$$y = g(netact)$$



Organization of this Course

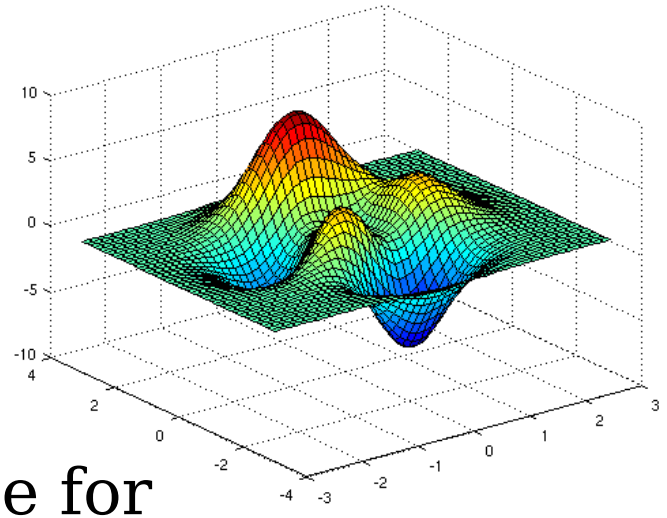
- Specific domain (e.g., the hippocampus)
  - Background lecture: anatomy and physiology
  - Family of models (e.g., associative memory models)
    - One or more papers in each family
    - Class discussion
    - Occasionally: experimentation in MATLAB
- Occasional problem sets
- Modeling project (or term paper)
- Mid-term exam
- Final exam

Grading (Approximate Weightings)

Problem sets	20%	
Modeling project	20%	(or term paper)
Midterm exam	30%	
Final exam	30%	

MATLAB

You need to learn MATLAB. It's fun!

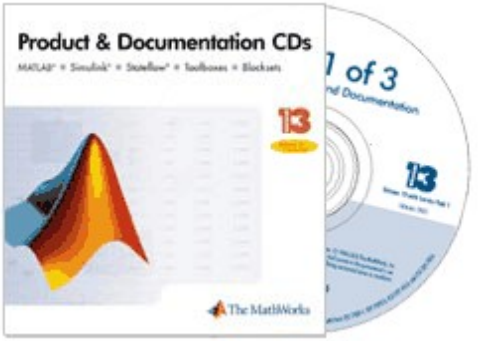


Type “matlab” on Andrew to run it.
“peaks” will display this graph;
“doc peaks” will tell you about it

Student Version of MATLAB: available for Windows/Linux/Mac for $99. Purchase from mathworks.com or CMU bookstore.

Pitt students can purchase a license for $10.

Tutorials are available online:
see the class homepage.



What You Should Do Today

- Read the Churchland chapter.
- Start learning MATLAB.
  - Type “demo” for a list of demos, and scroll down to the “Graphics” section. Play around a bit.
  - We'll have more formal MATLAB instruction later.
- Get started on Wednesday's reading.