

# Computational Models of Neural Systems: 15-883

Fall 2021

Instructor:  
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# Course Info

Time: Mon/Wed 4:40 to 6:00 PM

Place: 4211 GHC (Gates Hillman Center)

Credit: 12 units

Current syllabus: on the class web site

Textbook: none

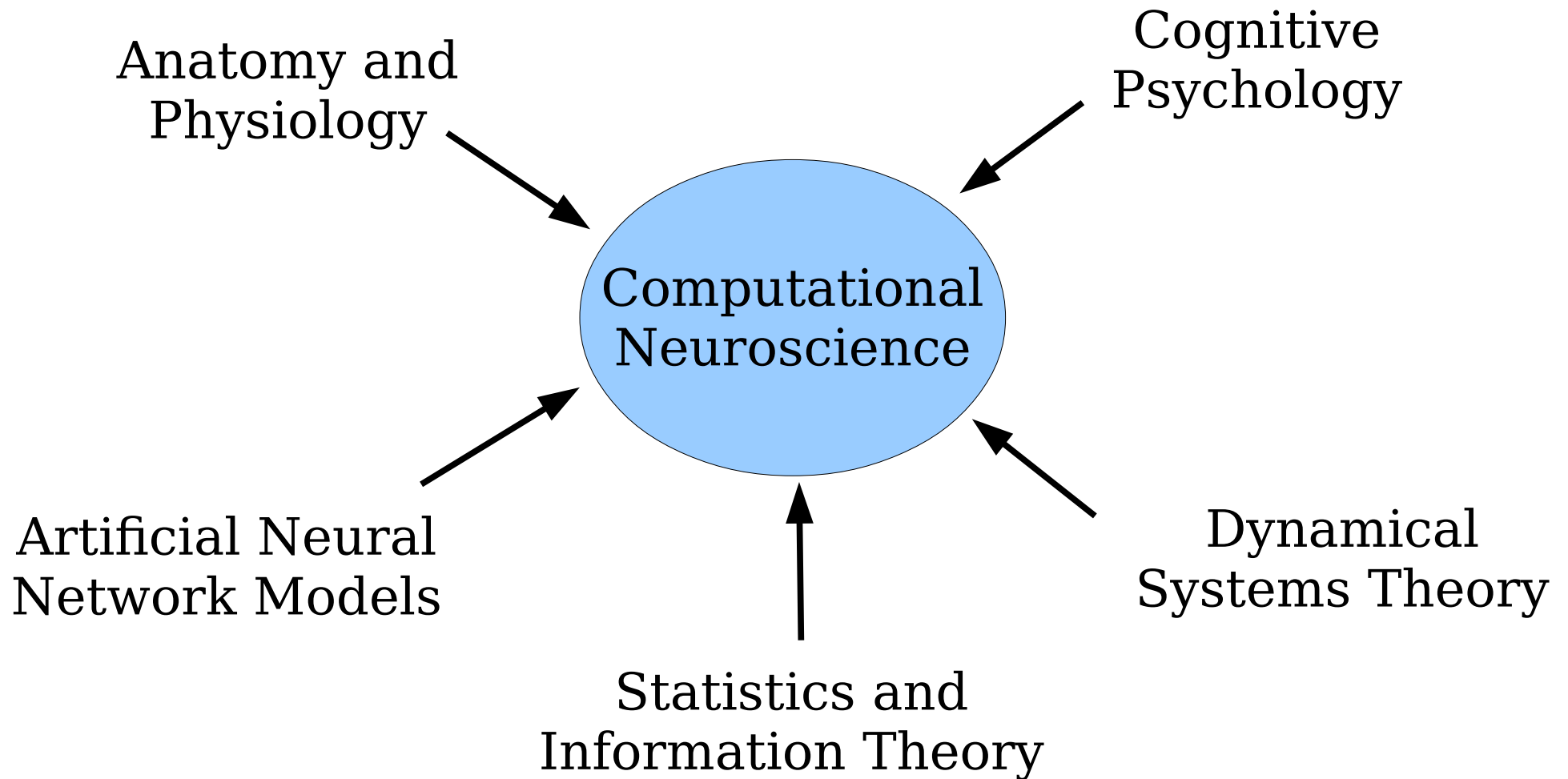
Readings:

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.

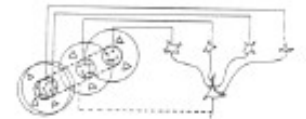
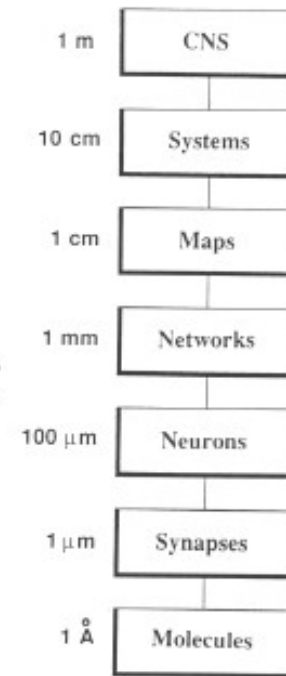
# 1: Neuronal Modeling

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.)



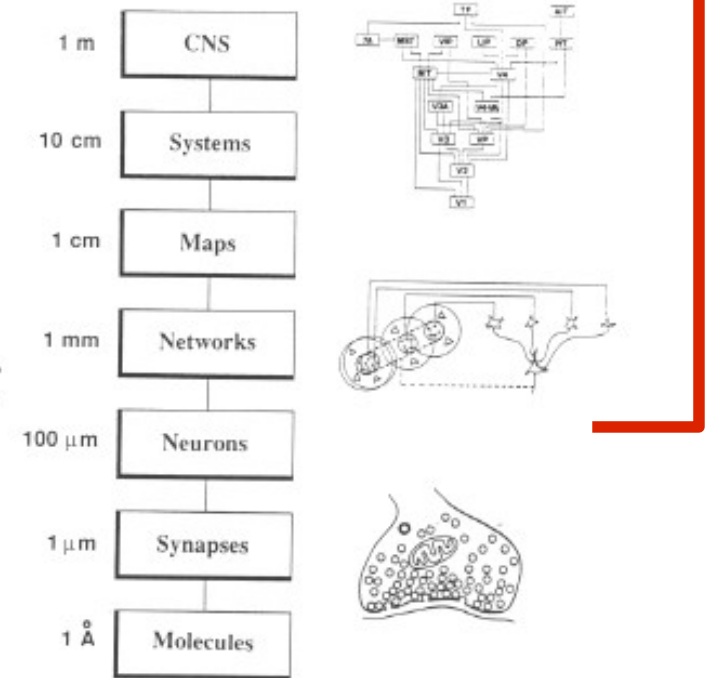
Churchland & Sejnowski 1988

# 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)

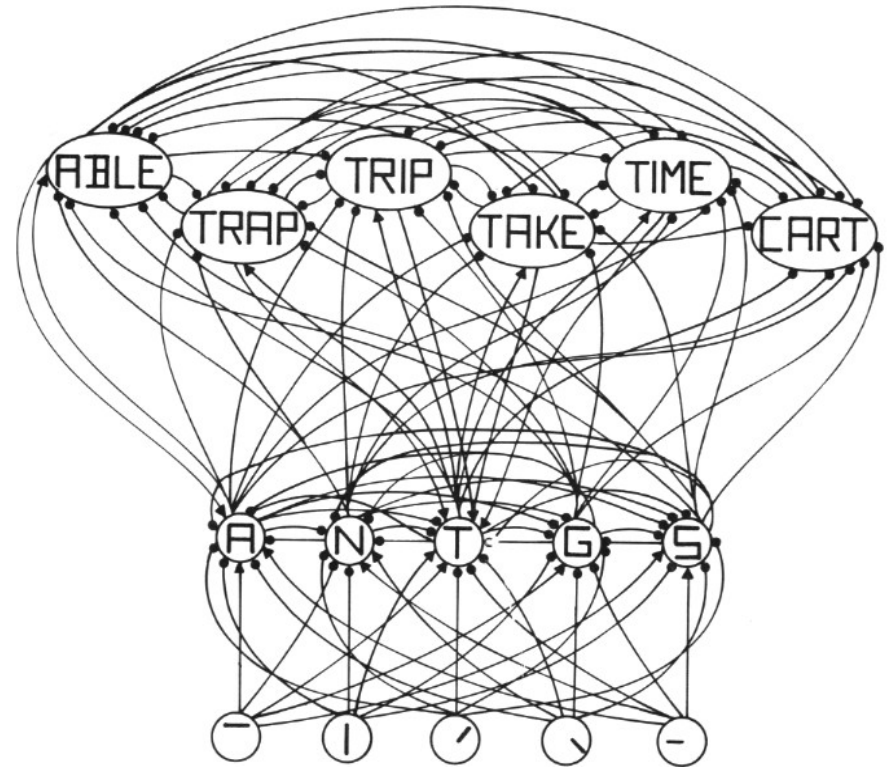
# 3: Connectionist (PDP) Modeling

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

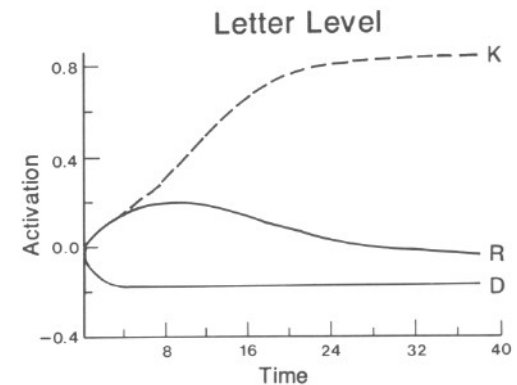
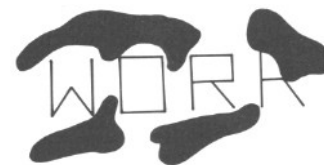
Models are fairly abstract.

How do priming effects act to influence reading?

85-719 PDP models course (Dave Plaut)



McClelland & Rumelhart 1981





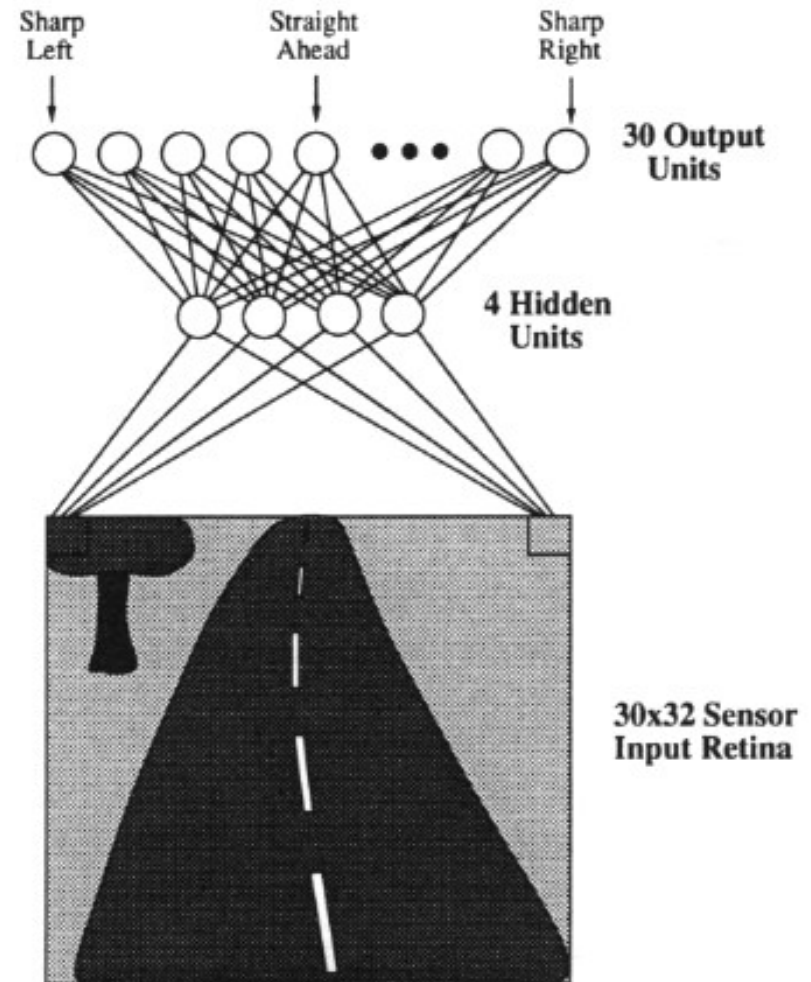
# 4: Artificial Neural Nets

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

# 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

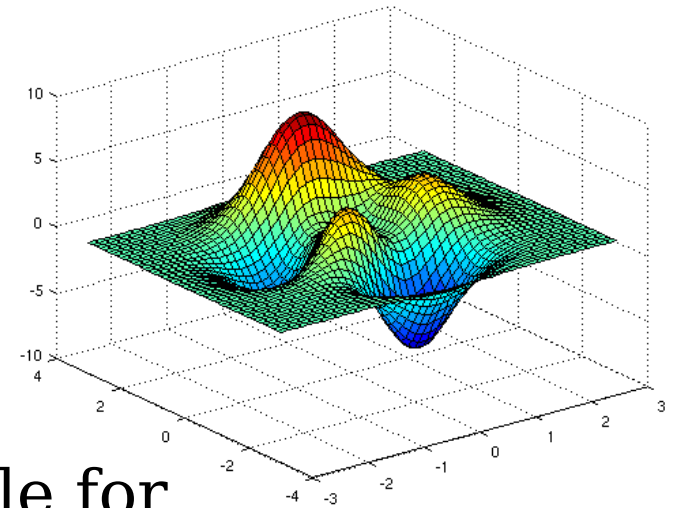
# Grading (Approximate Weightings)

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

# MATLAB

You need to learn MATLAB. It's fun!

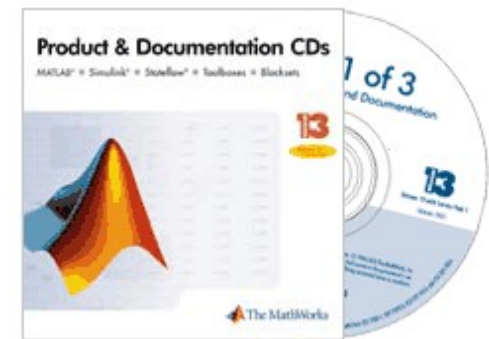
Type “matlab” on Andrew to run it.  
“peaks” will display this graph;  
“doc peaks” will tell you about it



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

- Watch today's videos; read today's papers.
- 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.