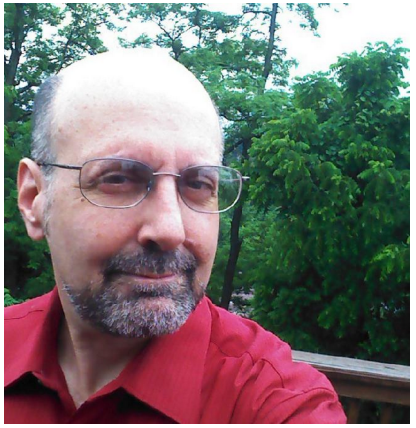
15-883: Computational Models of Neural Systems

Fall 2025



Professor:
Dave Touretzky
Office: GHC 9013
Office hours: Fridays 3-4 pm
dst@cs.cmu.edu

TA:
Max Ma
Office: GHC 9110
Office hours: Fridays 4-5 pm
xma3@andrew.cmu.edu

CNBC
Center for the Neural Basis of Cognition

Course Info

Time: Mon/Wed 3:30 to 4:50 PM

Place: 4303 GHC (Gates Hillman Center)

Credit: 12 units

Current syllabus: on the class web site

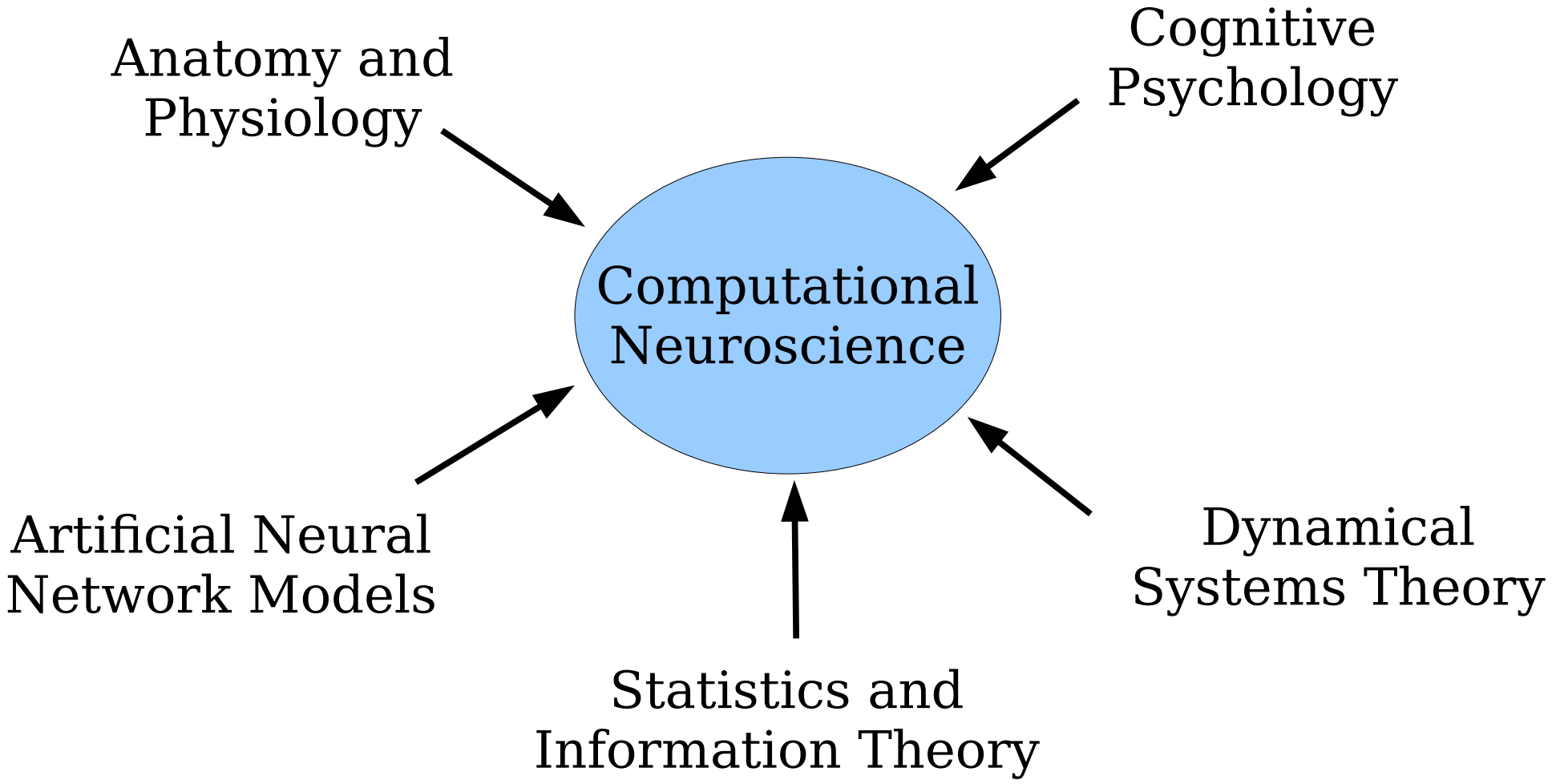
Textbook: none

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.

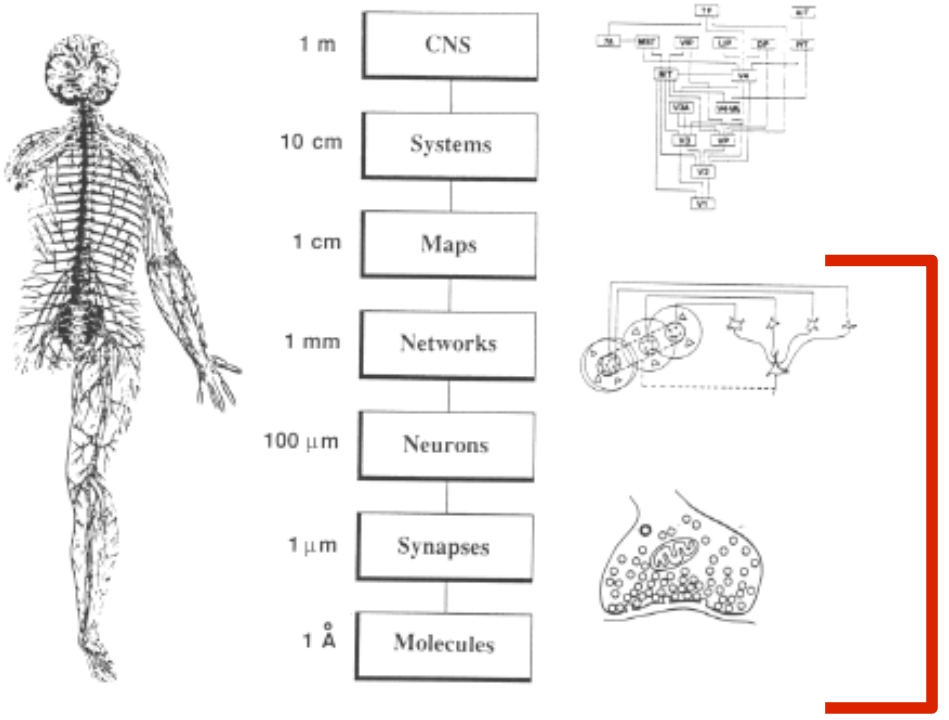
1: Neuronal Modeling

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
(Jon Rubin, Math Dept.)



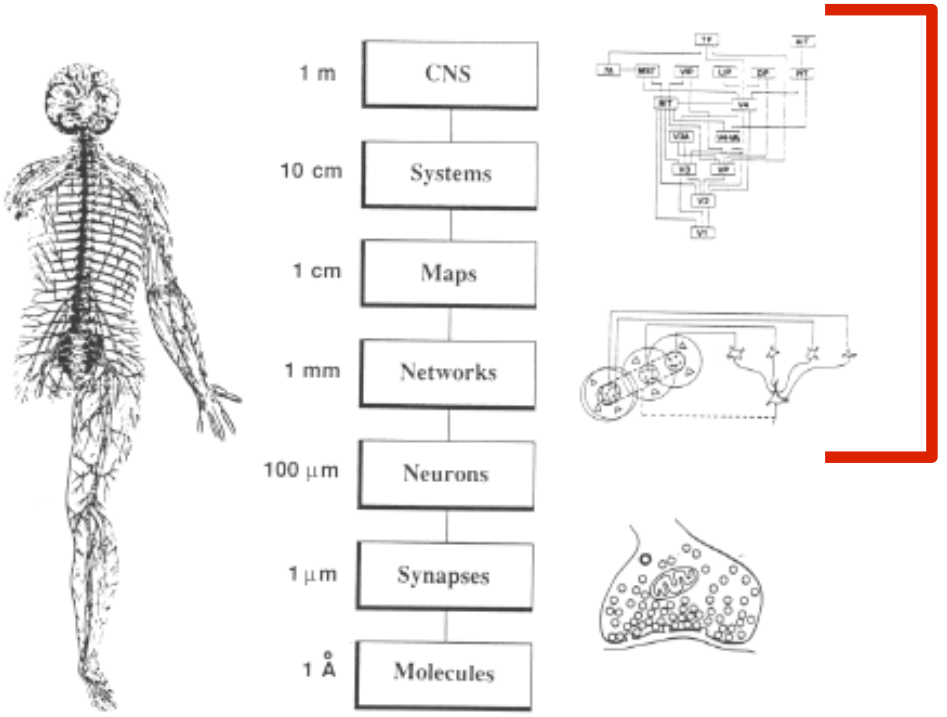
Churchland & Sejnowski 1988

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)

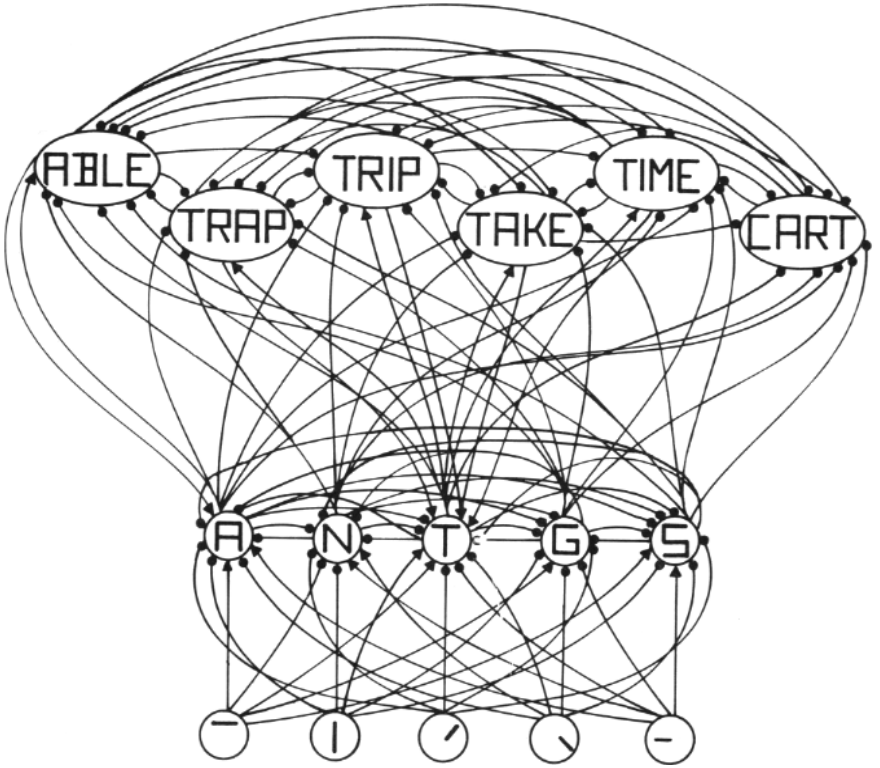
3: Connectionist (PDP) Modeling

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

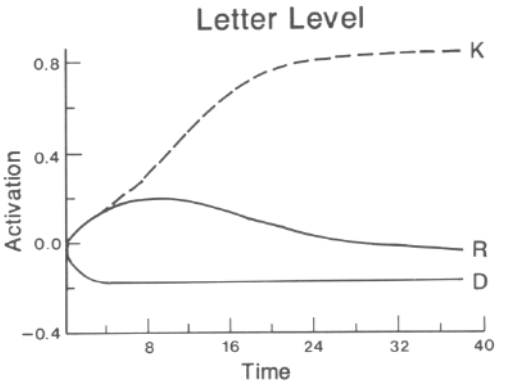
Models are fairly abstract.

How do priming effects act to influence reading?

85-719 PDP models course (Dave Plaut)



McClelland & Rumelhart 1981



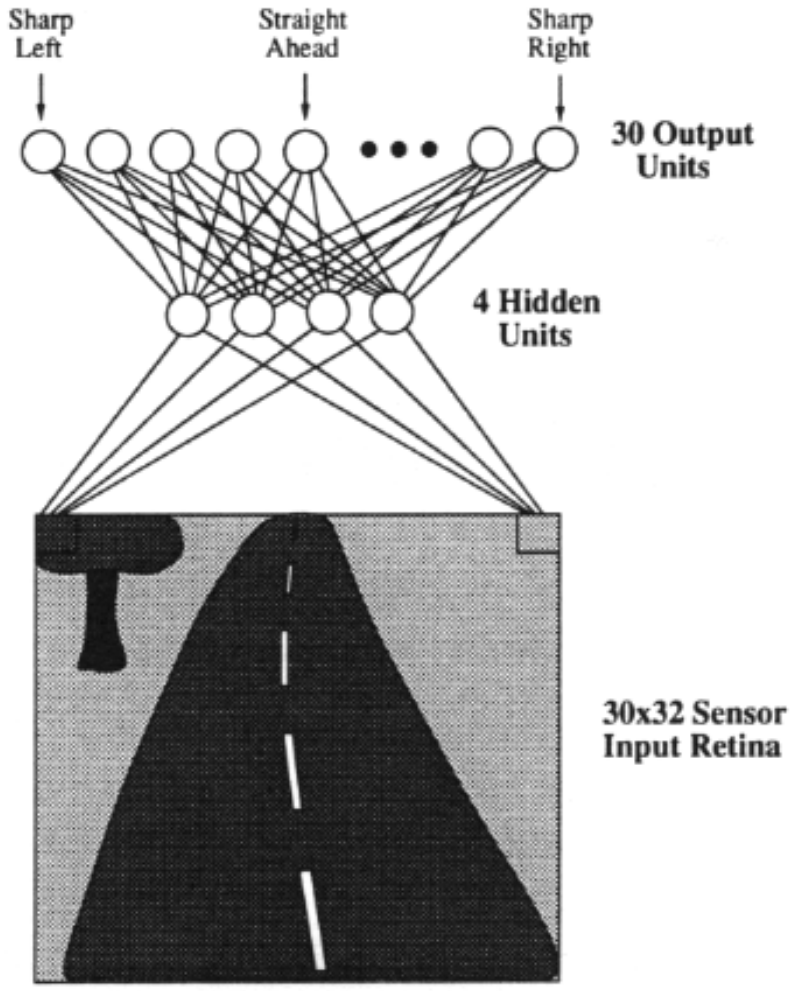
4: Artificial Neural Nets

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 cerebellum)
  - 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%	

An Experiment: LLM Tutor

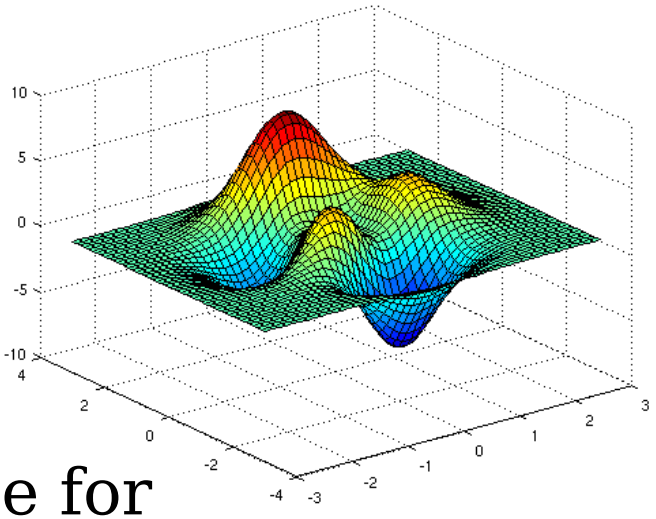
- We've created a custom LLM tutor to help you master the course material.

- It can support you by:
  - Answering questions about the slides or readings
  - Quizzing you on your understanding of key concepts
  - Working through examples of computations

- We need your feedback to make it better, and to judge its usefulness.

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 from the Andrew Software Center.

Pitt also provides MATLAB to its students.

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.