COGS 1

Week 1
Cognitive Science & Complex Networks
Announcements

• Sections happen Mondays, Wednesdays, and Fridays. Please try to go to your enrolled section, but it’s better to attend any section than none at all

• Quiz – first 15 minutes of section (be on time!)
This Week’s Questions

- What is Cognitive Science?
  - Disciplines of Cognitive Science?

- What are Complex Networks?
  - Physical/Biological/Social/...
  - Networks of the brain?
Disciplines of Cognitive Science

- Neuroscience
- Philosophy
- The Mind
- Computer science
- Linguistics
Philosophy (of Mind)

- Logic
  - Hallmark of the mind?
- Thought Experiments
- Theory of Mind
  - How do we perceive others’ minds?
- Mind vs. Body
Computer Science

- Computational Thinking
- Data Structures
  - How is knowledge represented?
- Artificial Intelligence
  - Simulation of mind
- The Turing test
Linguistics

- Language is key for human cognition
- Mental representations
- Rules/Concepts/Images
- How do we discern meaning?
Neuroscience

- **BRAIN!**
- Physical substrate of the mind
- Learning
- Memory
- Perception
- Disorders
Brain-Computer Interface

- “Mind reading”
- Intersection of neuroscience and computer science
- 3 Videos shown in class:
  - Music making
  - Bionic hand
  - Robot with rat brain
Networks

- Web of life
- Molecular analysis
- Hyperlinks
- Metabolic relationships
- Linguistic connections
- Social/behavioral relationships
Complex Behaviors

The New York Times
Slime Mold Proves to Be a Brainy Blob

Researchers in Japan have shown that a slime mold can design a network that is as efficient as one developed by humans over many years: the Tokyo rail system. Furthermore, the slime mold can build its network in a day.

A slime mold is what scientists refer to as a single-celled amoeboid organism. When foraging for food, it spreads out as an amorphous mass and then builds tubular connections between the food sources.

It may be just a blob, but it is a smart one. “We’ve found an unexpected high ability of information processing in this organism,” said Toshiyuki Nakagaki, a researcher at Hokkaido University who has long studied slime molds.

“I wanted to pose a complicated program to this slime mold, to design a large network,” Dr. Nakagaki said. “This kind of program is not so easy, even for humans.”
The human brain is complex!
- It has 100 billion neurons.
- One neuron has 10,000 synapses!
- At the cellular level: one thousand trillion components.
- Complexity is a characteristic of biological systems.
- Use mathematical tools and concepts to understand the system.
The brain is a complex network, out of which emerges the mind.
Modularity

“The entire brain system can be decomposed into subsystems or modules.”

Scaling

• Organization can be found on multiple spatial/temporal scales

• Not all nodes are created equal (central hub)

• Connectivity is key
The human connectome project

• “Navigate the brain in a way that was never before possible; fly through major brain pathways, compare essential circuits, zoom into a region to explore the cells that comprise it, and the functions that depend on it.”

• “The Human Connectome Project aims to provide an unparalleled compilation of neural data, an interface to graphically navigate this data and the opportunity to achieve never before realized conclusions about the living human brain.”
Emergence

**Emergence**

- Fundamental property of the brain
- Occurs between physical and functional levels of the brain.

**Reductionism**

- System phenomena
- Reducing the system down to smallest particle.

The mind emerges from the brain.
Results from the Reading

![Graphs showing proportion of contests won across different categories and degrees of asymmetry.]