CSE 40171: Artificial Intelligence

Course Introduction / Introduction to AI
Course Info:

- CSE 40171: Artificial Intelligence
- Instructor: Walter Scheirer (wscheire@nd.edu; @wjscheirer)
- Office: 321C Stinson-Remick
- Lectures: MWF 3:30-4:20pm DeBartolo Hall 125
- Office Hours: Mon. & Weds. 1-3:15pm and by appointment.

Course Website:
Course Slack Channel

#cse-40171-fa19
nd-cse.slack.com
Grad TA:

• Sophia Abraham
• sabraha2@nd.edu
• Office Hours: Fri. 9-11am
  - Center for Digital Scholarship
    (Hesburgh Library)
Undergrad TAs:

Mike Eisemann (meiseman@nd.edu)

Fiona McCarter (fmccarte@nd.edu)
About me

• Joined Notre Dame Summer 2015
  - Ph.D. from the University of Colorado 2009
  - 2012 — 2015 Harvard University Center for Brain Science

• Research in Computer Vision and Machine Learning

Reverse engineering 
biological vision
Tools for Neuroscience
Statistical methods for visual recognition
Digital Humanities
How about you?

- Introduce yourself.
- Any experience with Neural Networks, Psychology, Neuroscience, or Statistics?
- What interests you about artificial intelligence?
Course Overview

• 33 lectures
• 1 documentary film screening (AlphaGo)
• 2 Invited Talks
• 8 homework assignments
• 2 quizzes (in-class)
• 1 group project
  - Project proposal
  - Project update
  - Final deliverable in lieu of final exam
Course Overview

*Full syllabus on course website

Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participation</td>
<td>100</td>
</tr>
<tr>
<td>Homework assignments.</td>
<td>8 x 100</td>
</tr>
<tr>
<td>Final group project.</td>
<td>700</td>
</tr>
<tr>
<td>In-class quizzes.</td>
<td>2 x 200</td>
</tr>
<tr>
<td>Total</td>
<td>2000</td>
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Important Dates

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Release Date</th>
<th>Due Date</th>
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</thead>
<tbody>
<tr>
<td>Homework #1 (Artificial Neural Networks)</td>
<td>Released: 9/9; Due: 9/16</td>
<td></td>
</tr>
<tr>
<td>Film Response</td>
<td>Released: 9/18; Due: 9/23</td>
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<tr>
<td>Homework #2 (Search Strategies)</td>
<td>Released: 9/23; Due: 9/30</td>
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<tr>
<td>Homework #3 (Search Strategies)</td>
<td>Released: 10/2; Due: 10/9</td>
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<tr>
<td>Homework #4 (Neural Network Search)</td>
<td>Released: 10/11; Due: 10/18</td>
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<tr>
<td>Quiz 1</td>
<td>10/30</td>
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<tr>
<td>Homework #5 (Segmentation for Connectomics)</td>
<td>Released: 11/6; Due: 11/13</td>
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<tr>
<td>Homework #6 (Neural Nets. with Anatomical Fidelity)</td>
<td>Released: 11/15; Due: 11/22</td>
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<tr>
<td>Homework #7 (Neural Nets. with Biological Dynamics)</td>
<td>Released: 11/25; Due 2/2</td>
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<tr>
<td>Homework #8 (Bayesian Read-outs)</td>
<td>Released 12/4; Due: 12/11</td>
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<td>Quiz 2</td>
<td>12/11</td>
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Course Overview

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The group (3-4 students) project will consist of several milestones, including a project proposal, interim project update, and a final deliverable including a full report and complete code and data.

**Important Dates**

<table>
<thead>
<tr>
<th>Project Proposal</th>
<th>Instructions Released: 10/28; Due: 11/4</th>
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<tbody>
<tr>
<td>Project Update</td>
<td>Instructions Released: 11/18; Due: 11/25</td>
</tr>
<tr>
<td>Final Deliverable</td>
<td>Released: 12/1; Due: 12/18</td>
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Prerequisites

Required prerequisite course: N/A

You need to be comfortable programming in Python
Other readings will be posted to the course website; keep an eye on the class schedule.
Course Objectives

• **Understand** the philosophical underpinnings of the field and motivations for pursuing the replication of certain competencies of the brain.

• **Relate** real-life problems to perceptual and cognitive models that are able to solve aspects of them in an efficient manner.

• **Deploy** general search algorithms that can be applied to a wide variety of tasks.

• **Formulate** decision making processes that can be used for planning and classification purposes.
Course Objectives

• **Build** intelligent agents that perform simple tasks in an autonomous fashion.

• **Learn** task-specific models from large collections of labeled training data samples using algorithms that are optimized using numeric solvers.

• **Utilize** the Pytorch framework for building solutions to problems related to games, computer vision, natural language processing, and other general data science applications.

• **Identify** problems that are solvable with today's AI algorithms and others that require novel solutions.
Course Objectives

• **Grasp** the aspects of artificial intelligence where neuroscience and computer science come together to form the basis of a new class of learning algorithms.
Machine Learning Algorithms from Wet Lab Experimentation

- Neuroanatomy
- Neurophysiology

"shared metrics"

- graph motifs
- brain metrics
- model metrics

SAGE: Search for Architectures by Generation and Evaluation

- search over candidate space subject to constraints

Performance relative to human

Search those regions of model space that perform well and are neurally-consistent

- V1-like
- CV
- HMAX
- SAGE 1
- SAGE 2
Experimental workflow

A) Intracellular imaging of mouse brain with GPUs

B) Train animal
- 2p image to assess representation
- Tissue harvest
- Anatomical pipeline

C) Repeat as animal learns
- “class B”
- “class A”
- Morph continuum
- Trained curve
- Naive curve
- 100% report “A”
- 100% report “B”

D) 16-24 animals enter protocol
- ~ 6-10 successfully 2p imaged at full FoV / cell %
- 1-2 successfully SEM imaged at 1mm³ FoV

Failure to learn during imaging window of opportunity
- Fixation/cutting issues
- Unsuitable implant/insufficient expression
Course Roadmap

Introduction (week 1)

Neural Networks (week 3)

Brain Structure (weeks 12 - 13)

Decisions (week 16)

Bio. Intelligence (week 2)

Search Problems (weeks 4 - 9)

Brain Function (weeks 14 - 15)
A brief history of AI
Once a historical footnote...
...now big business
The early years
The 1950s…

Artificial Brain?

Theory of Computation

Cybernetics

Information Theory
Dartmouth Summer Program in Artificial Intelligence, June-August 1956

Photo Source: Achievement.org
The mid 50s to mid 70s: The (so-called) golden years
Reasoning as search

A example of greedy algorithm, searching the largest path in a tree. © Swfung8
The Blocks World

Photo Source: MIT Technology Review
SHRDLU

https://www.youtube.com/watch?v=bo4RvYJYOzI
I am the psychotherapist. Please, describe your problems.

Each time you are finished talking, type RET twice.

I have a terrible headache.

Maybe you should consult a doctor of medicine, I am a psychiatrist.

Okay, I'll do that then.

Can you elaborate on that?

What are you talking about? No I cannot elaborate. See you later.

Why do you say that?

Now you're just talking nonsense!

What makes you believe now I am just talking nonsense?

You are not making any sense.

Perhaps your plans have something to do with this.
Brash Optimism

“within ten years a digital computer will be the world’s chess champion" and "within ten years a digital computer will discover and prove an important new mathematical theorem.”

- H.A. Simon and Allen Newell

“machines will be capable, within twenty years, of doing any work a man can do.”

- H.A. Simon

“Within a generation... the problem of creating ‘artificial intelligence’ will substantially be solved.”

- Marvin Minsky

“In from three to eight years we will have a machine with the general intelligence of an average human being.”

- Marvin Minsky