CSCI 4850/5850 - Neural Nets

Course Introduction:
Makings of a Neural Network and Making a Neural Net Work

CSCI 4850/5850

What are Neural Networks?

Artificial neural networks (ANNs) are information processing mechanisms inspired by the operation of biological nervous systems.

Different from other information processing techniques in a number of ways:

- Computation is highly parallel
- Each "processor" performs an extremely simple function
- Operating in continuous domains is often preferred
- System behavior is often *learned* rather than *programmed*

The term ANN is often used synonymously with *deep learning* or *deep neural networks*, but they are *not* equivalent

May be implemented using specialized hardware, but are often implemented in software using standard computers.

What Is Learning?

- "Learning detects changes in a system … enables a system to do the same task more efficiently the next time" - Herbert Simon

- "Learning is constructing or modifying representation of what is being experienced" - Ryszard Michalski

- "Learning is making useful changes in our minds" - Marvin Minsky

What are ANNs used for?
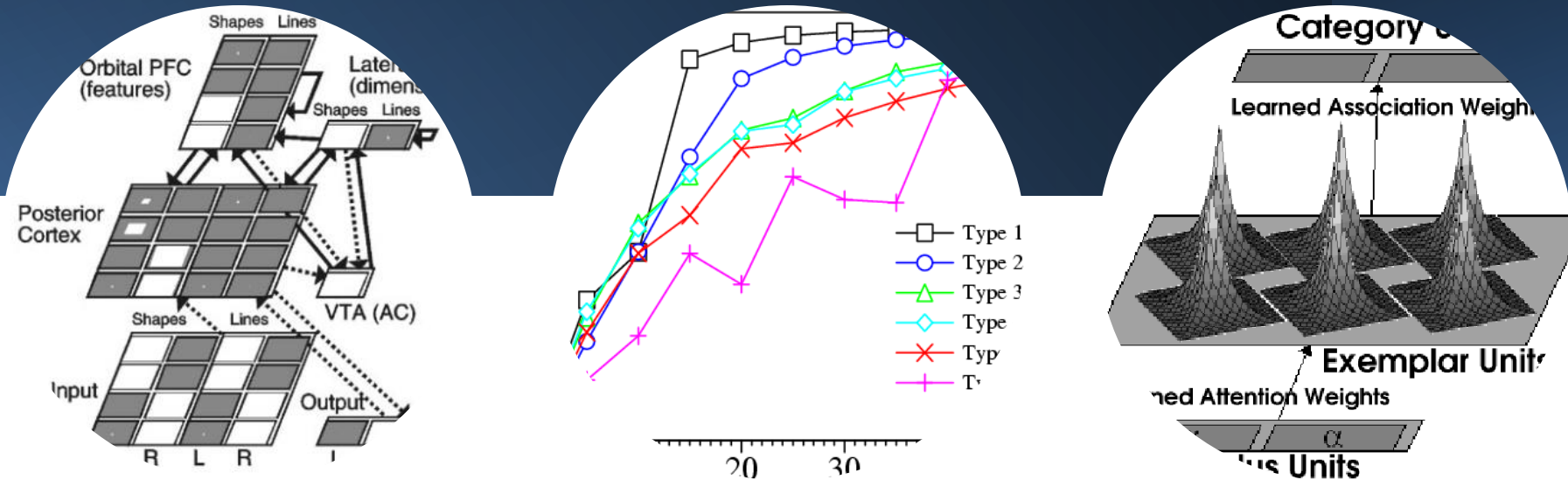
Difficult Engineering Problems

(Machine Learning)

P(fraud)

Computational Neuroscience

(Cognitive Modeling)

Cognitive Neuroscience

- Neural networks can also help us understand how the brain works
- By modeling constraints based on anatomical and physiological constraints, one can predict their mechanisms
- Results can be verified against human and/or animal performance data

Machine Learning

"A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks T, as measured by P, improves with experience E" – Mitchell, 1997

Tasks (T) – often comprise of tasks that are "difficult" to program or even develop concise algorithms to accomplish them
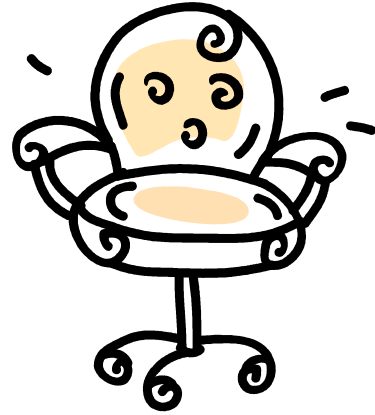
Performance Measure (P) – a quantitative measure of performance on T often in terms of accuracy, speed, or error rate but varies depending on the task

Experience (E) – the kind of information the ML algorithm has access to in order to attempt to improve P with common tasks utilizing supervised, unsupervised, or reinforcement-based feedback
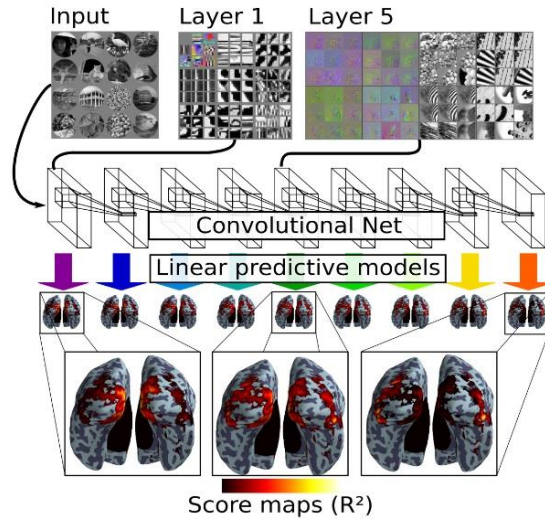
How do we represent a chair?
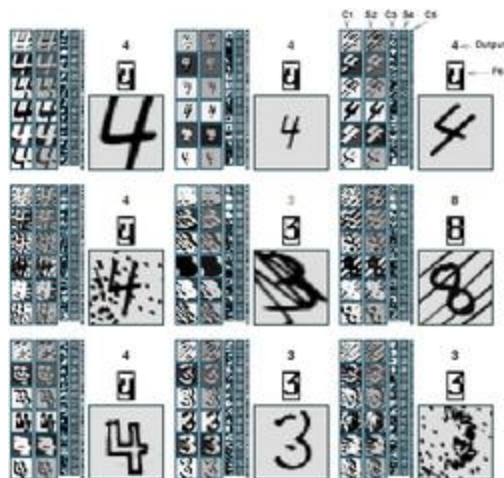
Could your algorithm be fooled?

Application: Computer Vision

Eickenberg, et al (2016)

LeCun (1989)

airplane

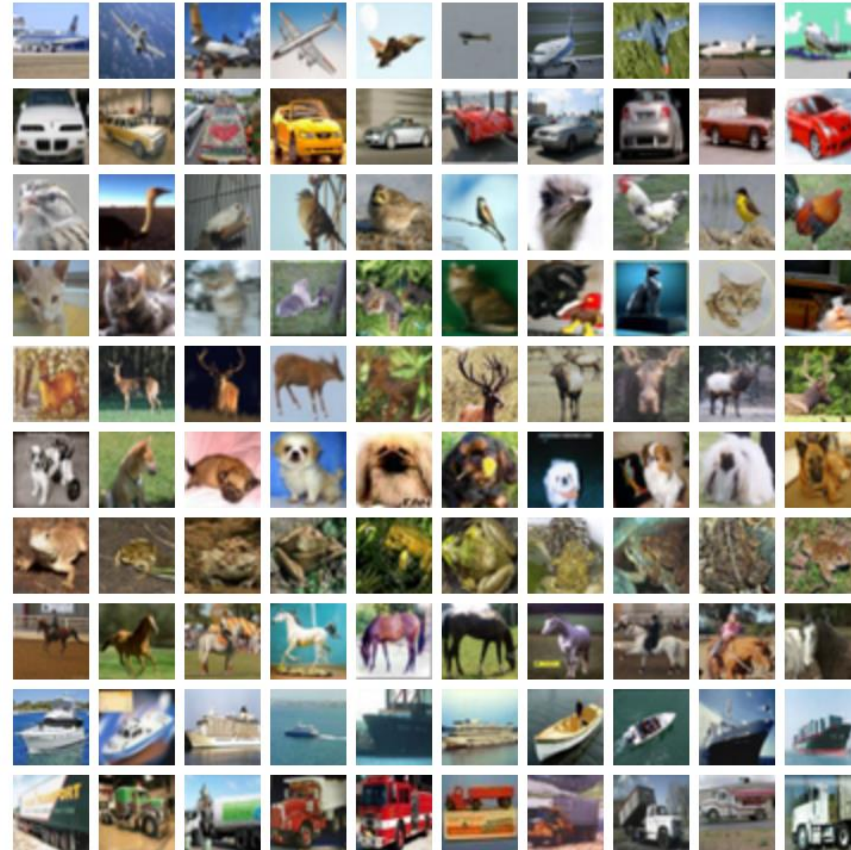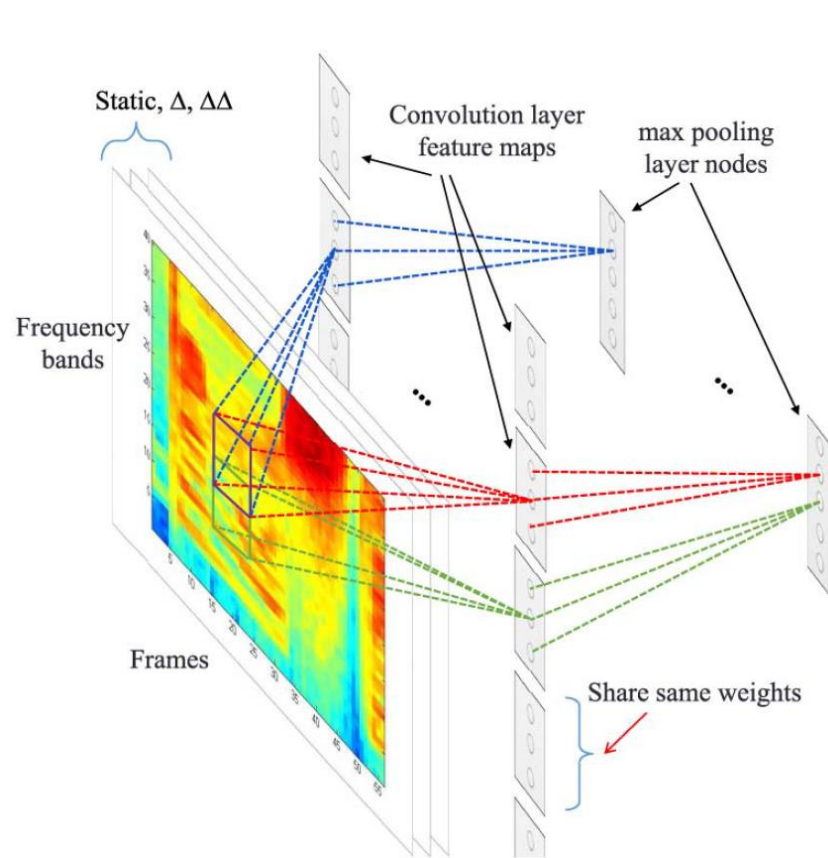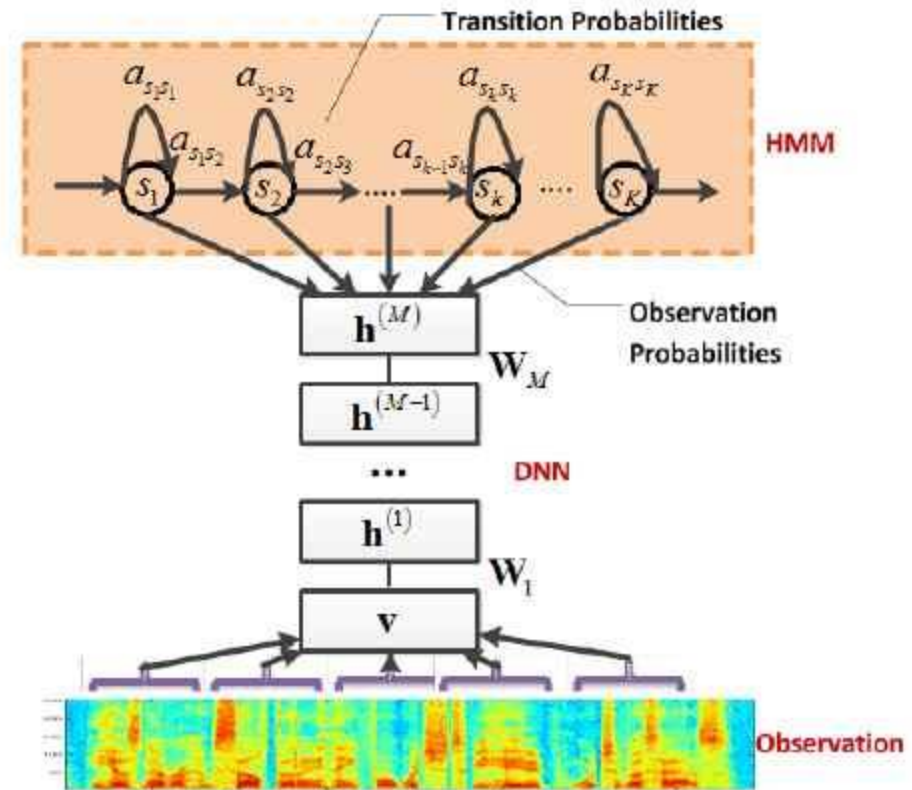automobile

bird

cat

deer

dog

frog

horse

ship

truck

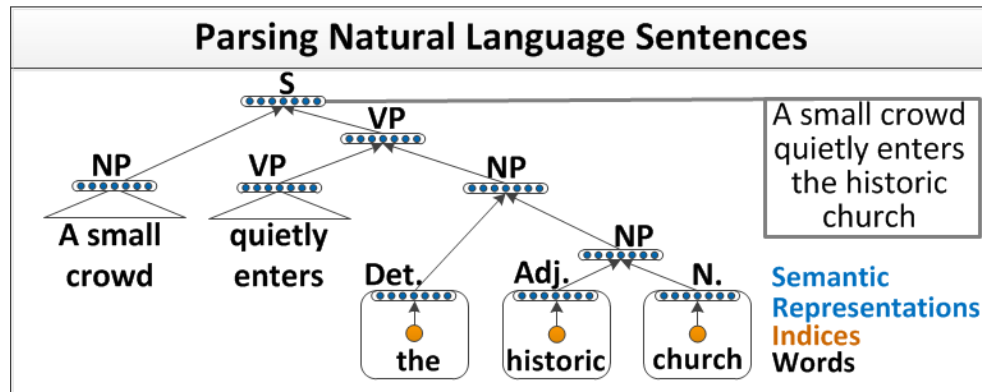Krizhevsky, Nair, and Hinton (2009)
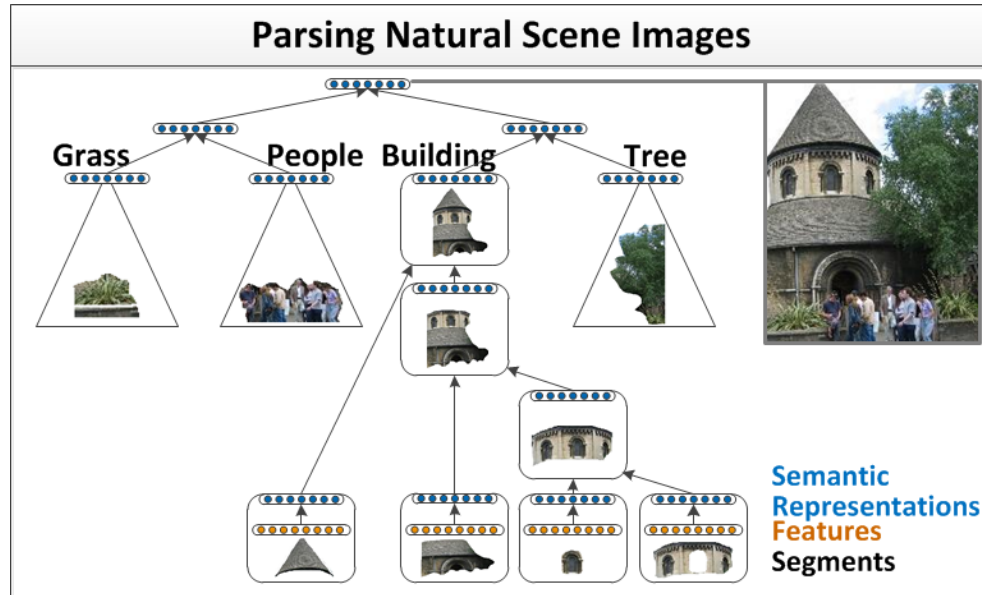
Application: Speech Recognition

Abdel-Hamid, Deng and Yu (2013)

Seide, Li and Yu (2011)

Application: Natural Language Processing

Parsing Natural Scene Images

Grass   People   Building   Tree

Semantic
Representations
Features
Segments

Parsing Natural Language Sentences

S

VP

NP   VP   NP

A small   quietly   NP
crowd   enters   Det.   Adj.   N.

the   historic   church

A small crowd quietly enters the historic church

Semantic
Representations
Indices
Words

Stanford NLP Group - LINK

Some Text

Length
Feature

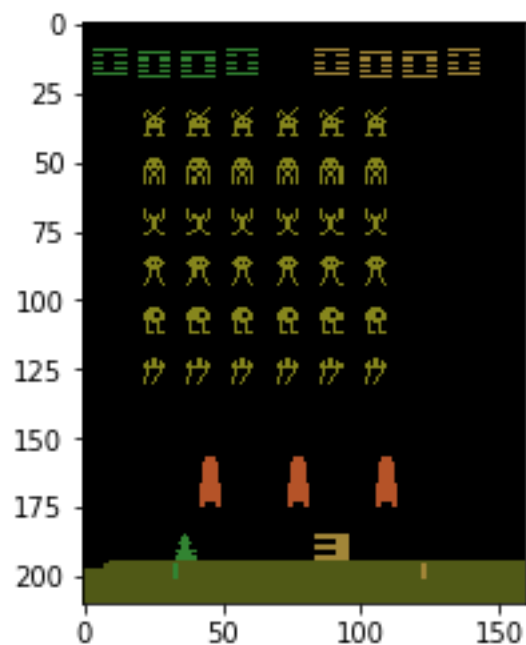Convolutions   Max-pooling   Conv. and Pool. layers   Fully-connected

Zhang, Zhao and LeCun (2015)
93% accuracy on positive/negative
Amazon reviews

Google Translate

Google Neural Machine Translation (GNMT)
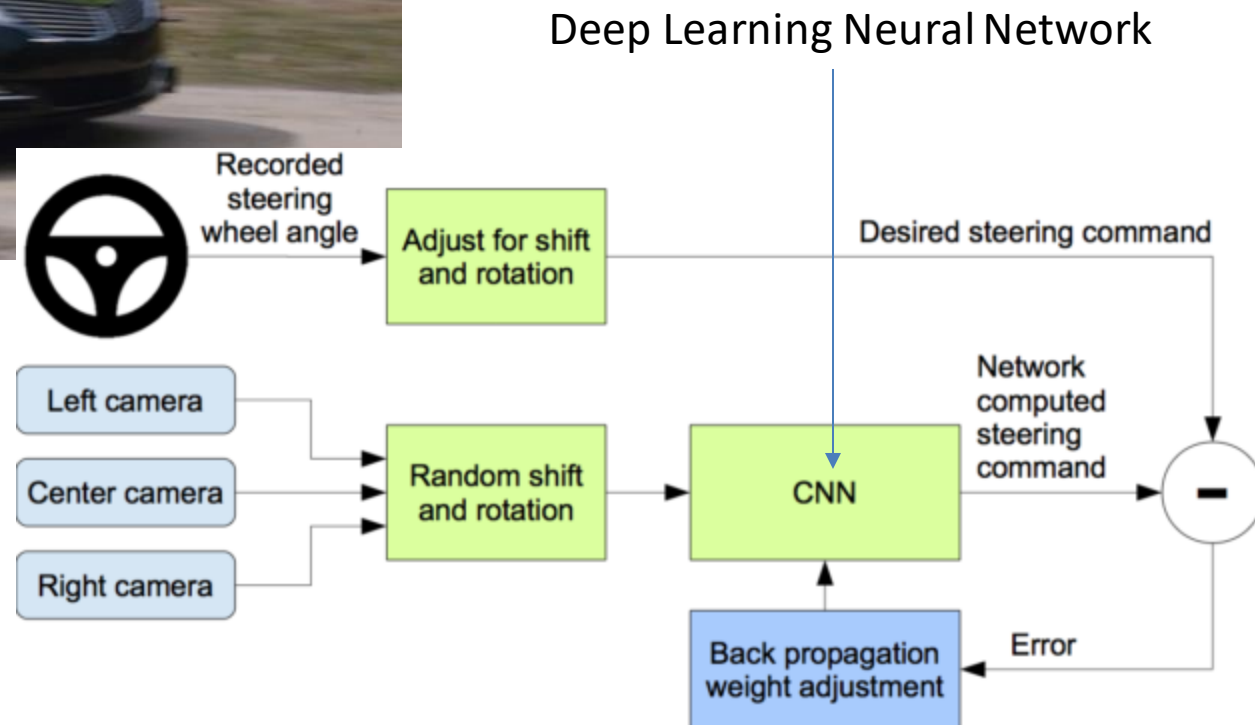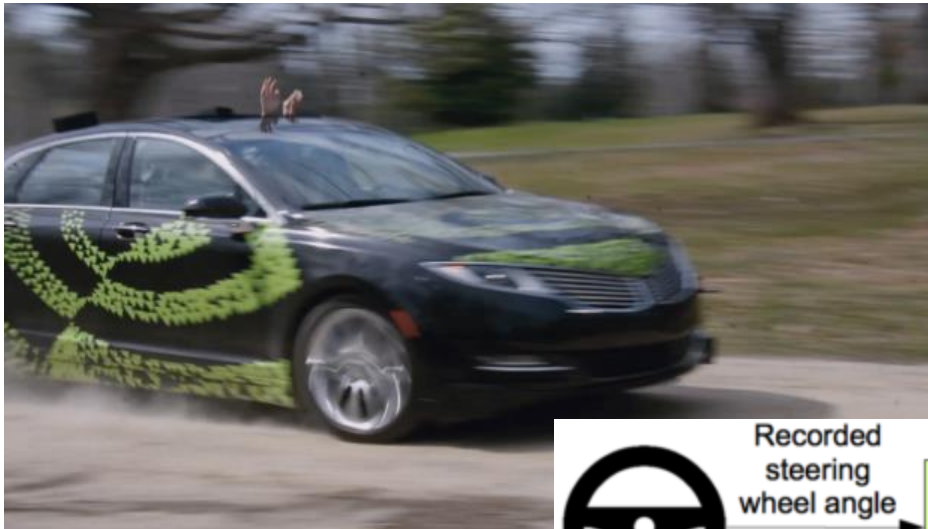(2016)

Application: Playing Games!

Mnih, et al. (2013)

AlphaGo

Google, 2015

Application: Automated Driving

Deep Learning Neural Network

https://devblogs.nvidia.com/parallelforall/deep-learning-self-driving-cars/

Application: Generative Modeling

"An astronaut riding a horse in a photorealistic style"

Ramesh et al. 2022 - https://arxiv.org/abs/2204.06125

https://openai.com/dall-e-2/

Prompt:
Tell me a joke about neural networks and college students

Response:
Why did the college student struggle with neural networks? Because they couldn't find the X and Y in their GPA!

Prompt:
What if the joke was more about the professor?

Response:
Why did the professor struggle to teach neural networks? Because the students kept asking him to backpropagate their grades!

Radford et al. 2018 - [link]
Ouyang et al. 2022 - https://arxiv.org/abs/2203.02155
https://chat.openai.com/

Computational Tools

JupyterLab
- Jupyter Notebooks
- Markdown + LaTeX Math Mode
- Python 3.11
- MS VS Code (codeserver)
- Apptainer

Python Packages
- Numpy/Scipy/Sympy/Sklearn
- PyTorch/Lightning
- Matplotlib/Plotly

Auxiliary Development
- Github
- LaTeX
- Weights and Biases
- HuggingFace

Quick Feedback Session

WHAT WOULD YOU LIKE TO GET OUT OF THIS COURSE?

WHAT ARE SOME APPLICATIONS THAT SOUND MOST INTERESTING?

Next: Historical and Biological Foundations

perceptron

Action Potential

Refractory Period

Synapse

Axon

Synapse

Cell Body   APs travel along the axon

Dendrite

Communicate chemically at the synapse

Dendrite

Spine

Receptors

mGlu AMPA NMDA

Postsynaptic

Neuro-transmitter (glutamate)   Na+

Ca++   Cleft

Ca++   Presynaptic

Vesicles

Terminal Button

Axon

Microtubule