# Biologically Informed/Plausible Networks

Chanh, Drew, Varun, Shaun

# What are bio-plausible/informed Networks?

Bio-plausible networks, for the purposes of our project are:

- Networks that perform their function (be it recognition, memory) in a way that could plausibly be done by the brain as well
  - Ex. backpropagation is NOT bio-plausible(?), since it is highly unlikely that information can rapidly be sent antidromically (conducting in a direction opposite to the usual one) from neuron synapses (https://www.nature.com/articles/337129a0.pdf)
  - Ex. Follow Hebbian plasticity rules (need to learn more about this)
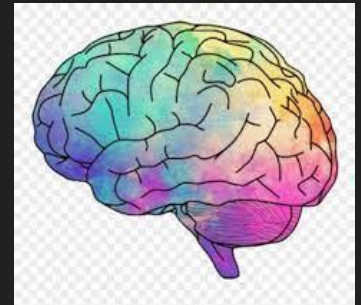
# Relation to Intelligence and other Spheres

Intelligence:

- Neural networks are a few abstractions away from the brain (not the best)… exploring bpnn can push ML boundaries
- Can help approximate behavior or outcome of modified "brains"
  - Mention of reconstruction of diseased state -> proper/improper behavior

Neuroscience:

- Probably the largest connection
  - ML engineers do not often care if their network is bio-plausible (not always the best for innovation)
  - Incredibly complex organ, attempting to simulate it is futile but we can work towards that
  - Models allow us to perform experiments otherwise deemed "unethical" and get some results (far off future unless i'm mistaken)

# Recent Papers/Projects

Unsupervised Learning by Competing Hidden Networks
- Describes a training algorithm that is both local and unsupervised
- Summary Article
- Published in 2019!

General Review paper published by Numenta on the need for a paradigm shift in AI Development
- Talks about need to consider biological basis for improving NN rather than mathematical
- Published 2021!

A Thousand Brains: A New Theory of Intelligence
- By Jeff Hawkins: Talks about him + his teams new theory of intelligence
- Published 2021!

A pattern I found: A lot of the work dealing with "plausifying" training algorithms is very recent: ~2017 onwards (or google is biased). The neuroscience at the level that these papers use though, I am not sure.

# Project Ideas!

- Memory Net
  - Through only feed-forward and local updates, can we efficiently encode information into a NN structured like a section of the brain?
  - Can we prove through this that the structure of the section of the brain responsible for memory is the most efficient at storing memory?

- Complex Behavior from Smaller Systems
  - The brain, while more complicated than any neural network by numbers, also operates on orders of magnitude higher levels of tasks
  - Is there a bio-informed paradigm of structure (and/or a method of training) we can use to create smaller networks that show significantly higher learning abilities than a traditional NN of that size?

# Project Ideas!

- Unlabeled Classifier
  - Is it possible to create a network that is bio-plausible and can differentiate images into separate categories without knowing what these categories are (i.e. knows the numbers 3 and 7 are different, but not that they are the numbers 3 and 7)
  - Look into autoencoders, can we make them follow local plasticity?
  - How well would these networks be able to generate new data? (autoencoders are generative)

# Possible Libraries to use

- Keras
- PyTorch

Probably the area that we don't know much about yet… Seeing what is used in research papers will help

# What do we need to better understand this?

- Basic neuroscience crash course! (Thanks neuro people :P)
- What can/can't the brain do?
  - Certain parts of the brain have different limitations due to their structure. Compare and contrast the following:
    - Function of brain section (what does it do and is that useful if isolated?
    - How are the neurons connected, are they special, and how so?
    - How does this specific section of the brain respond to information?
- How does the brain actually learn?
  - Very broad question, but we can decompose it into:
    - What CAN'T neurons do? What is their "scope" (i.e. what is the information available to each neuron?"
    - What CAN neurons do? How do they self-adjust? (Different for different brain sections)
    - What parameters does each neuron have, how do they affect its output, and are they mutable?

# Check out:

- Capsule networks
- Brain structure
- Neuron activation logic
- More nerdy stuff…

~FIN~