Neuron Field

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DSI 919 Capstone Project
12/14/2022

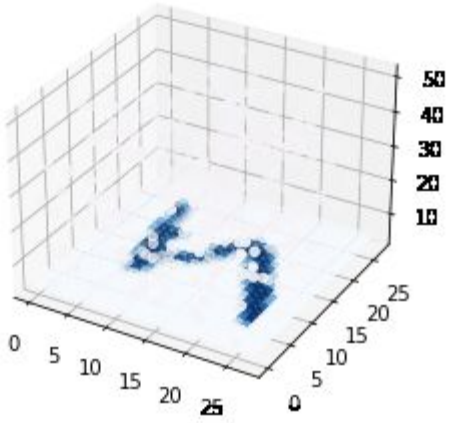
For working gifs, visit
https://docs.google.com/presentation/d/1UMoMW1hcWD1vrZGtmss5Q3VaPpiWBVHzFiyt2yJq2FI/edit?usp=sharing

Question:

Can we use a more brain-like 3D neuron structure to make predictions?

Agenda

1. Is it Possible?
2. Neuron Basics
3. Building a Neuron Field
4. Ultimate Outcome



Answer - Sort of!

People try.

- Tons of brain research being performed daily
- Equations about firing (models)
- Research on Integrating Tissue and Computers

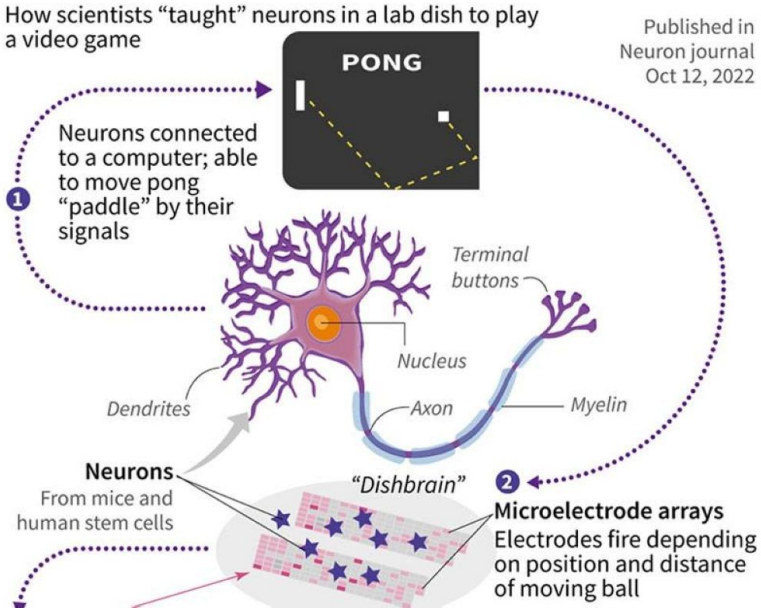
Dishbrain (pong!)

http://www.scholarpedia.org/article/Neural_fields

DishBrain by Cortical Labs

Successfully trained a pitri dish full of brain cells to play pong.

- Stimulated using electricity
- Rewarded with predictable electical stimulation
- Punished with random electrical stimulation



Important Concepts

Neurons!

- Nucleus
- Dendrite
- Axon

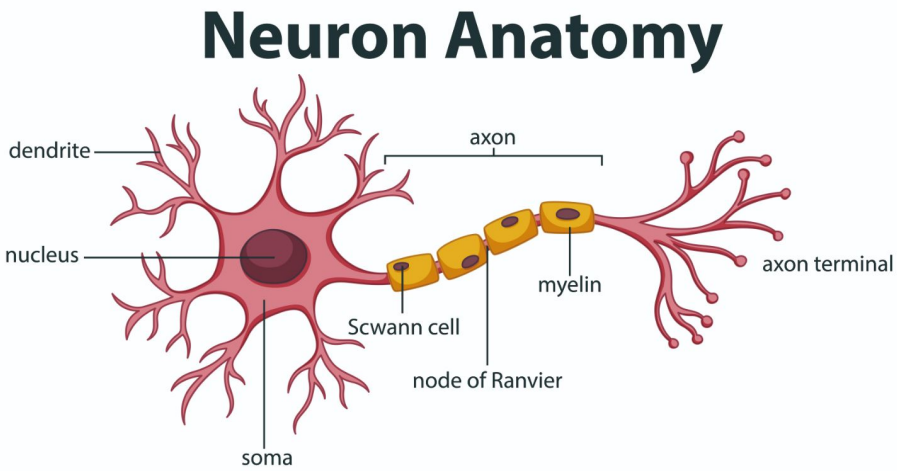
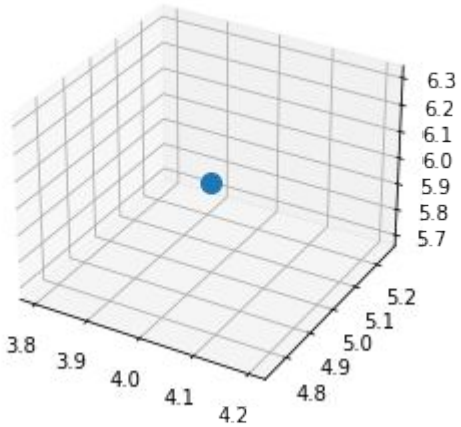


Image credit to embibe.com
https://www.embibe.com/exams/neuron/

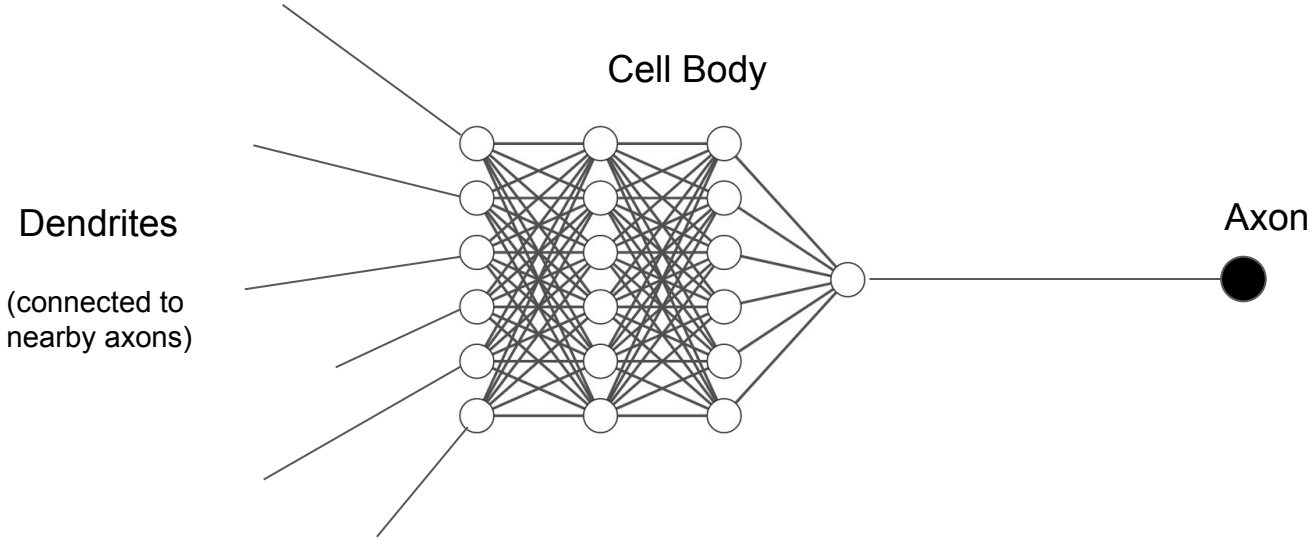
What is required?

Requirements:

- Neurons
  - Dendrites and a Cell Model in One Location
  - Axon in Another Location
  - Communicate with Neighbors
- Stimulus
  - Stimulate an Area with High Values
- Output
  - Read an Area



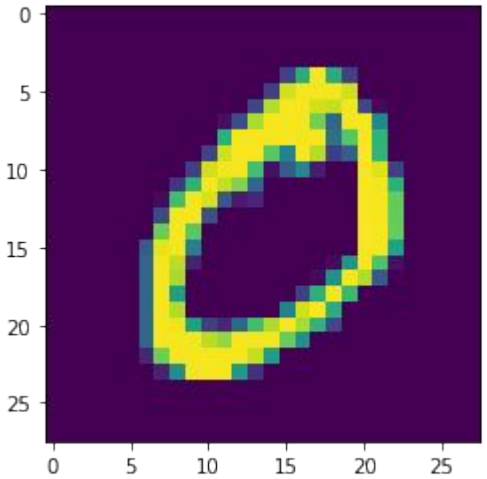
Cell Models, Dendrites, and Axons

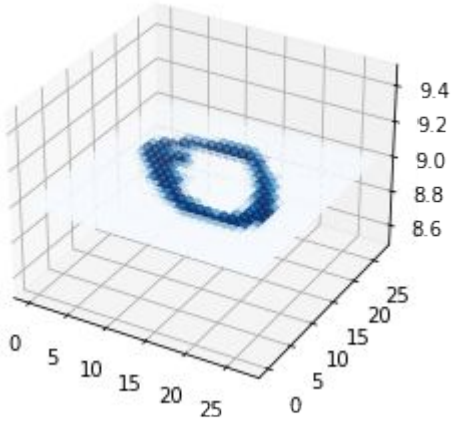


https://alexlenail.me/NN-SVG/

Input Neurons - Only Axons

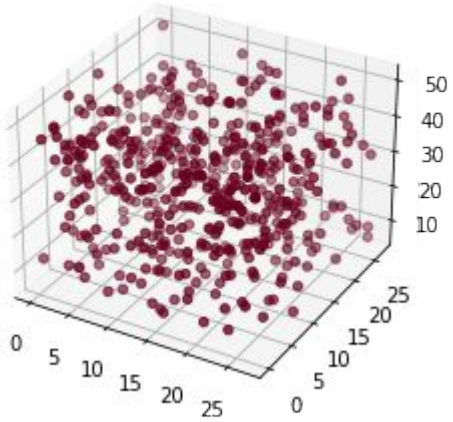
Place Images in the Field

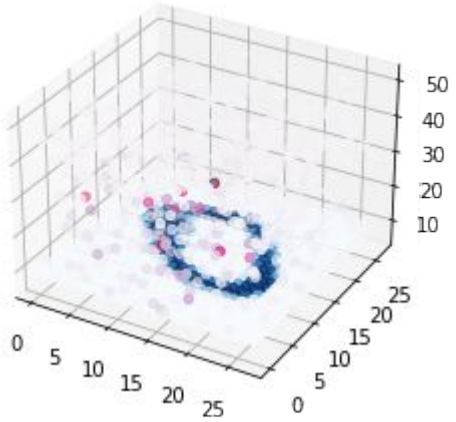




Field Neurons - Full Neurons

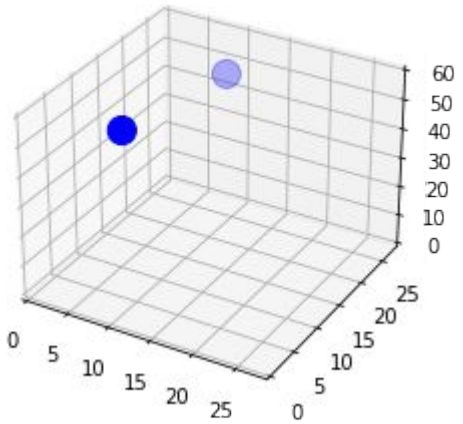
Connect to Neighbors and Send Signals

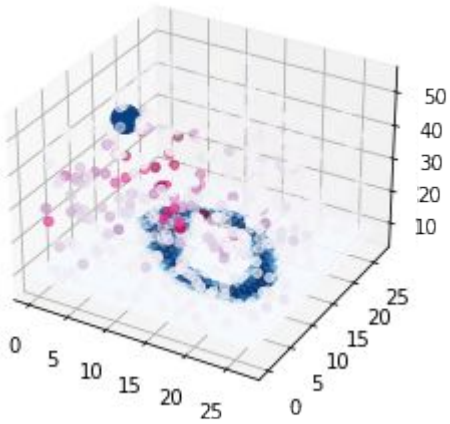




Output Neurons - Only Dendrites

Collect Information from an Area





Neuron Field - A Test Environment Full of Neurons

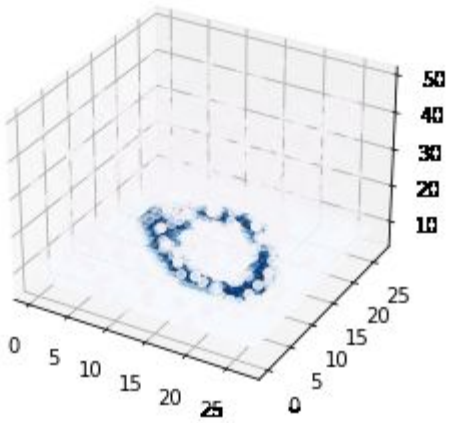
Methods:

- Instantiating Input, Field, and Output Neurons
- Placing an image at the bottom
- Performing Firing Cycles
  - Read, Fire
- Collect Data
  - Neuron Data, Output Data, Accuracy Scores

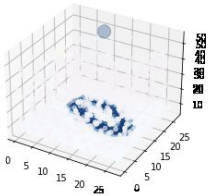
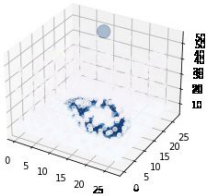
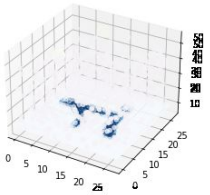
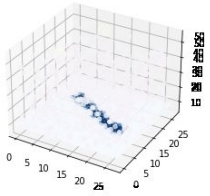
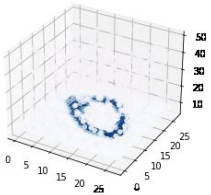
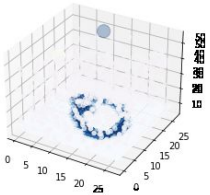
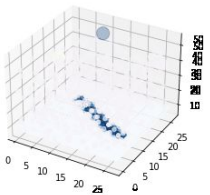
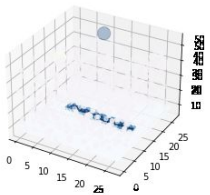
It’s this Easy

```
nf_test = NeuronField(input_size = 28,
                      field_size = 28,
                      output_size = 2,
                      k_neurons = 500,
                      min_dendrites = 4,
                      dendrite_radius = 5,
                      axon_length = 8
                     )

nf_test.initiate_field()
```



Classification Attempts

Results

- Training Attempts
  - Random changes to neuron model weights, switching to version with higher scores
- Known Issues
  - Input neurons touch too few field neurons
  - Output neurons touch too few field neurons
    - Or read one another’s neurons
  - Little coding bugs
- Speed
  - Switched from Tensorflow to numpy mathematics for cell models
    - 50-100x increase in speed
  - Finding neighbors
  - Loops

Further Experiments:

Adding / Subtracting neurons during training

- Based on activity - linking activity areas together? Memory?
- Axons pointing towards correct answers?

Image convolution before placement

Adding neurons where activity is high

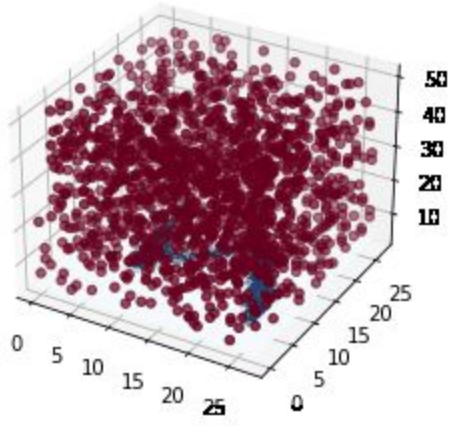
- High interactions with each other (or with outputs)
- Using that… to place the output neurons.

Stimulation, strengthening connections, and then measuring areas

Ensemble Models

- Reinforcement learning to extend axons
- Transfer Learning

Distributed Computing, Independent Neurons



Citations

Online Resources

- Cortical labs for their dishbrain image
- http://www.scholarpedia.org/article/Neural_fields
- https://www.embibe.com/exams/neuron/
- https://stackoverflow.com/questions/51527868/how-do-i-embed-a-gif-in-jupyter-notebook
- https://stackoverflow.com/questions/6046263/how-to-indent-a-few-lines-in-markdown-markup
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- https://alexlenail.me/NN-SVG/

Special thanks to:

- John Charles for some late-evening calculus headscratching
- Jonathan.charles9494@gmail.com, https://github.com/CharlesTheAnimator