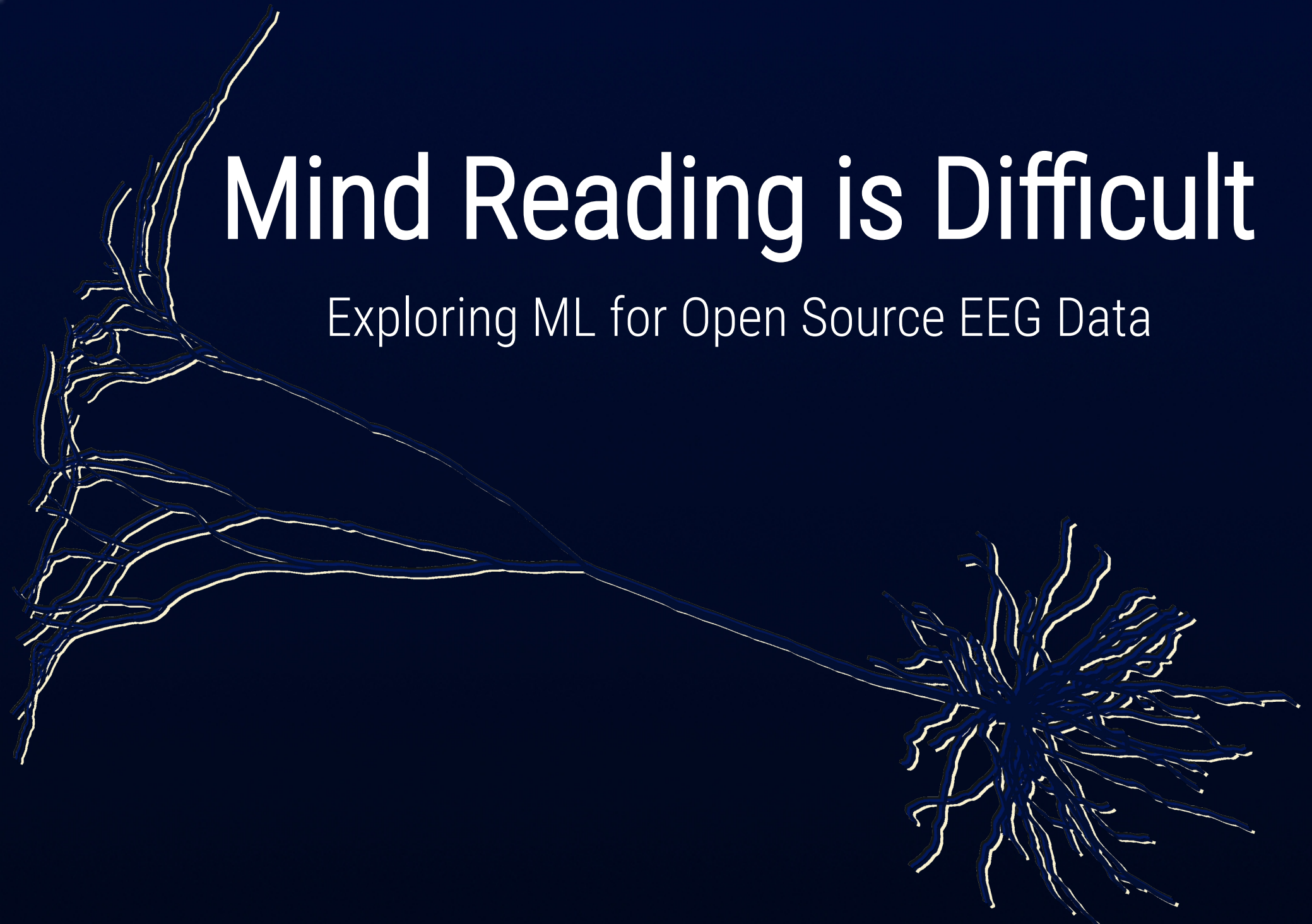
Mind Reading is Difficult

Exploring ML for Open Source EEG Data

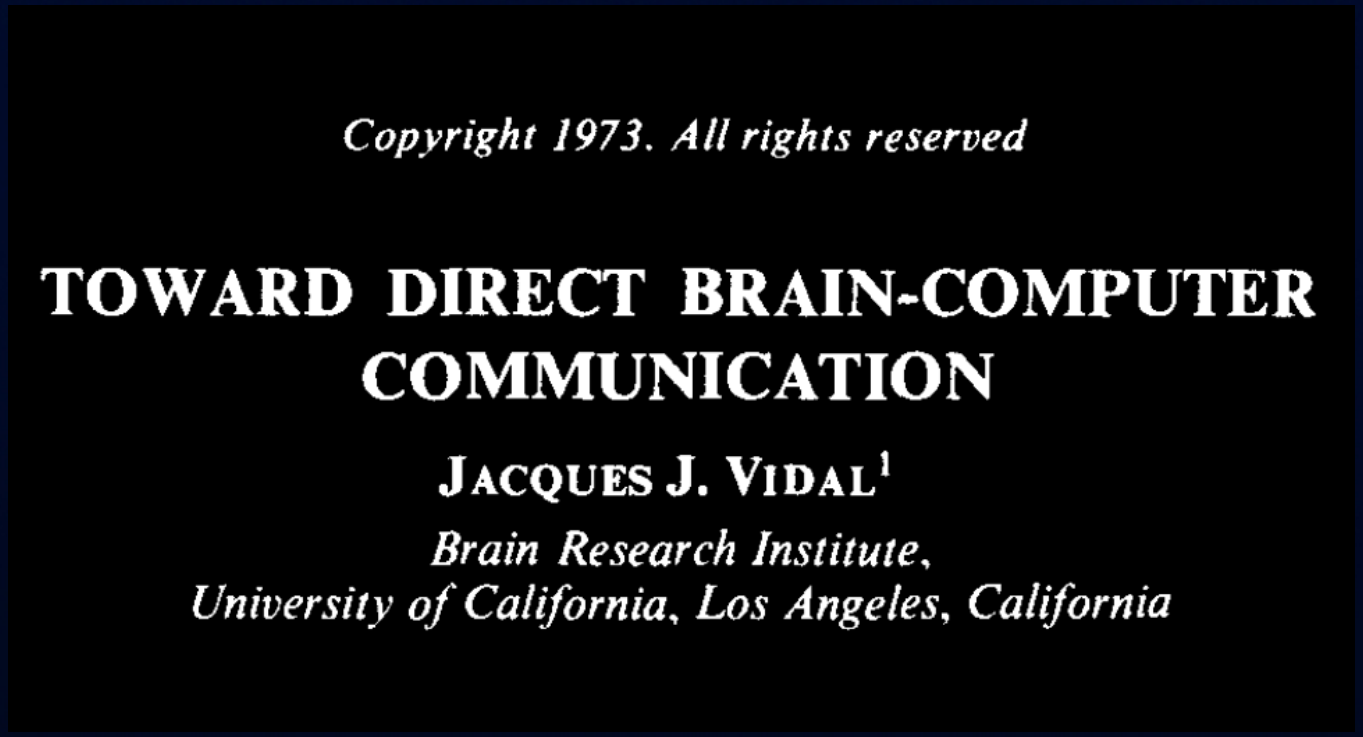


Outline

- Brain Computer Interfaces
- Neuro-Tech Access
- Commercial EEG systems
- Exploring a Public Dataset
- ML Classification
- Results (so far)

BCIs

"Can these observable electrical brain signals be put to work as carriers of information in man-computer communication or for the purpose of controlling such external apparatus as prosthetic devices or spaceships?"



TOWARD DIRECT BRAIN-COMPUTER COMMUNICATION

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BCIs

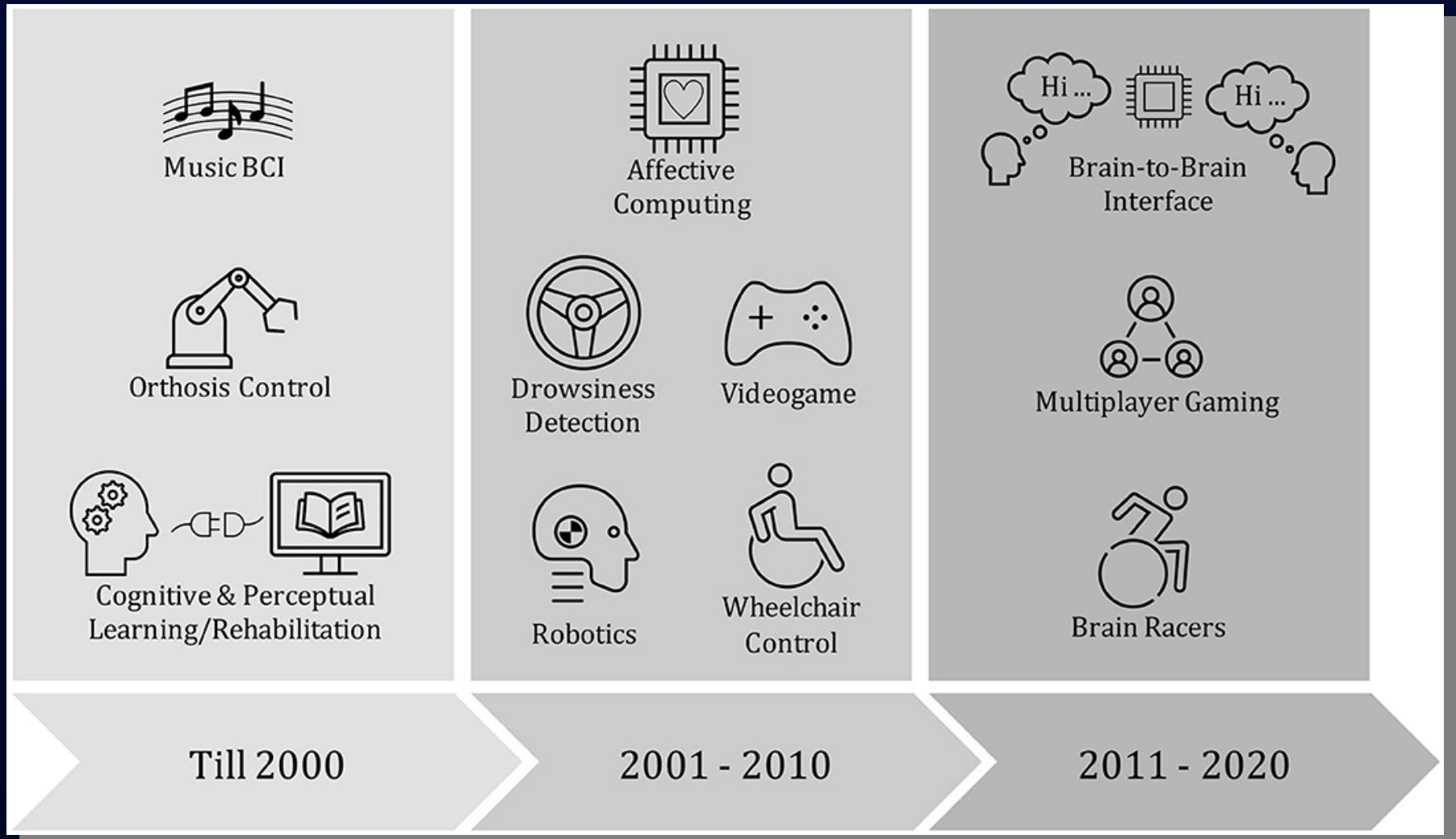
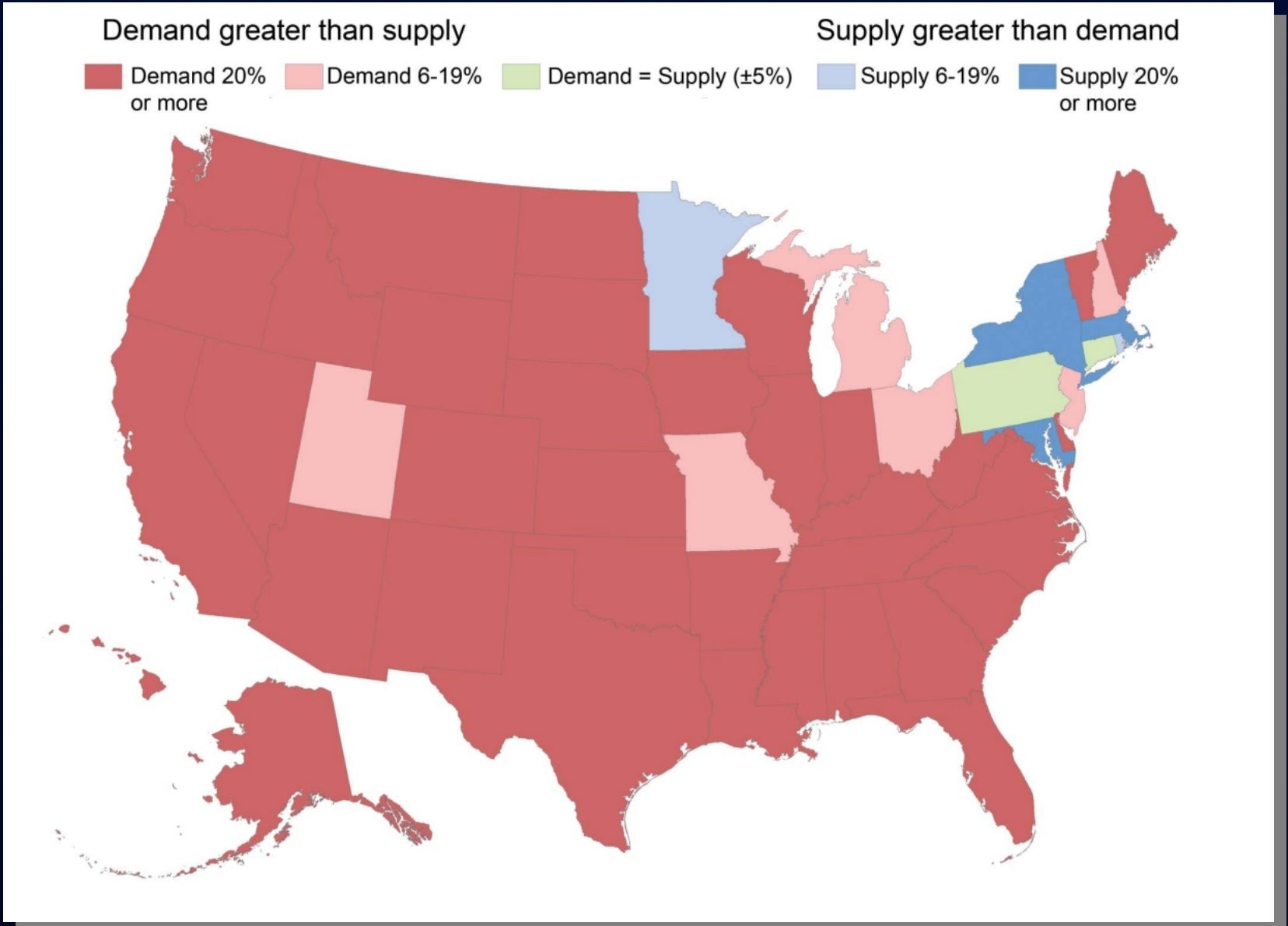


Image Credit: Saha et al, 2021, DOI:10.3389/fnsys.2021.578875

Neurology Access



Projected Supply vs Demand for Neurology by 2025
Image Credit: Dall, et al, 2013, DOI: 10.1212/WNL.0b013e318294b1cf

Commercially Available Headsets

Open Source Tech → Greater Access?

Commercially Available Headsets

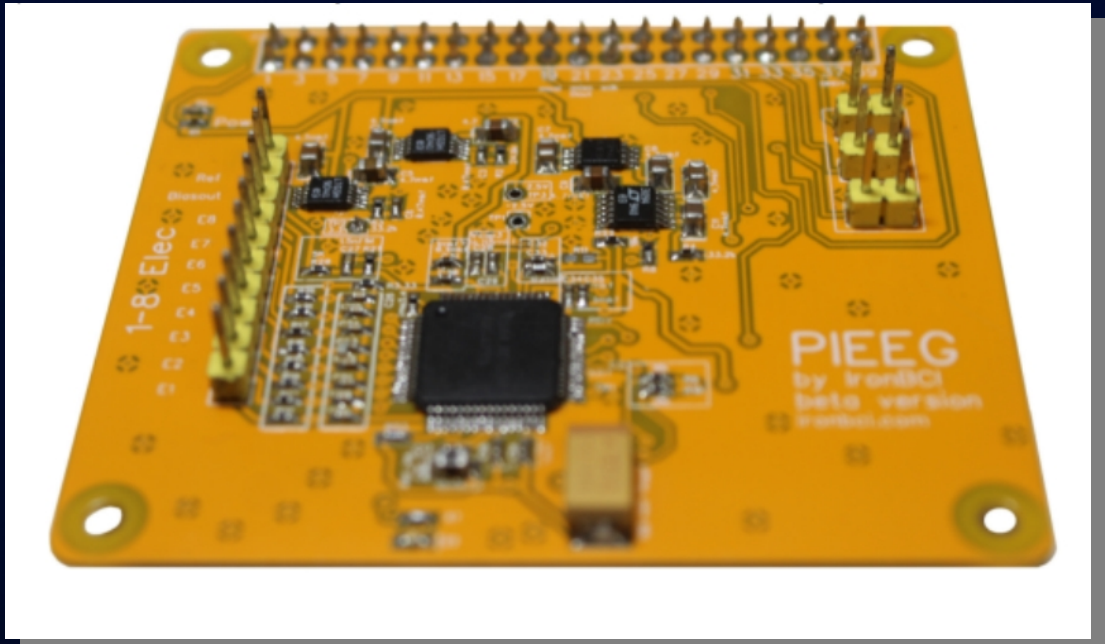
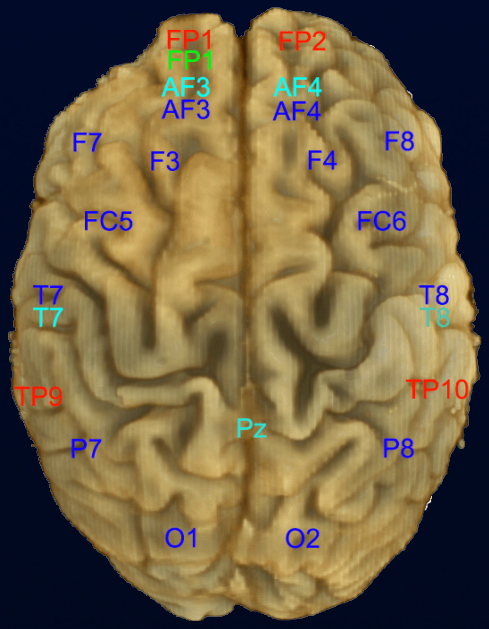


Image Credit: Rakhmatulin & Völkl, 2022, arxiv:2201.02228.pdf

MindBigData Digits Dataset

- ~ 2 Years of Recordings
- Emotiv EPOC
- Viewed & Imagined Digits
- 256 readings * 14 channels * 65,034 events



= 233,081,856 data points

Curse of Multidimensionality

Matrices like these are strange:

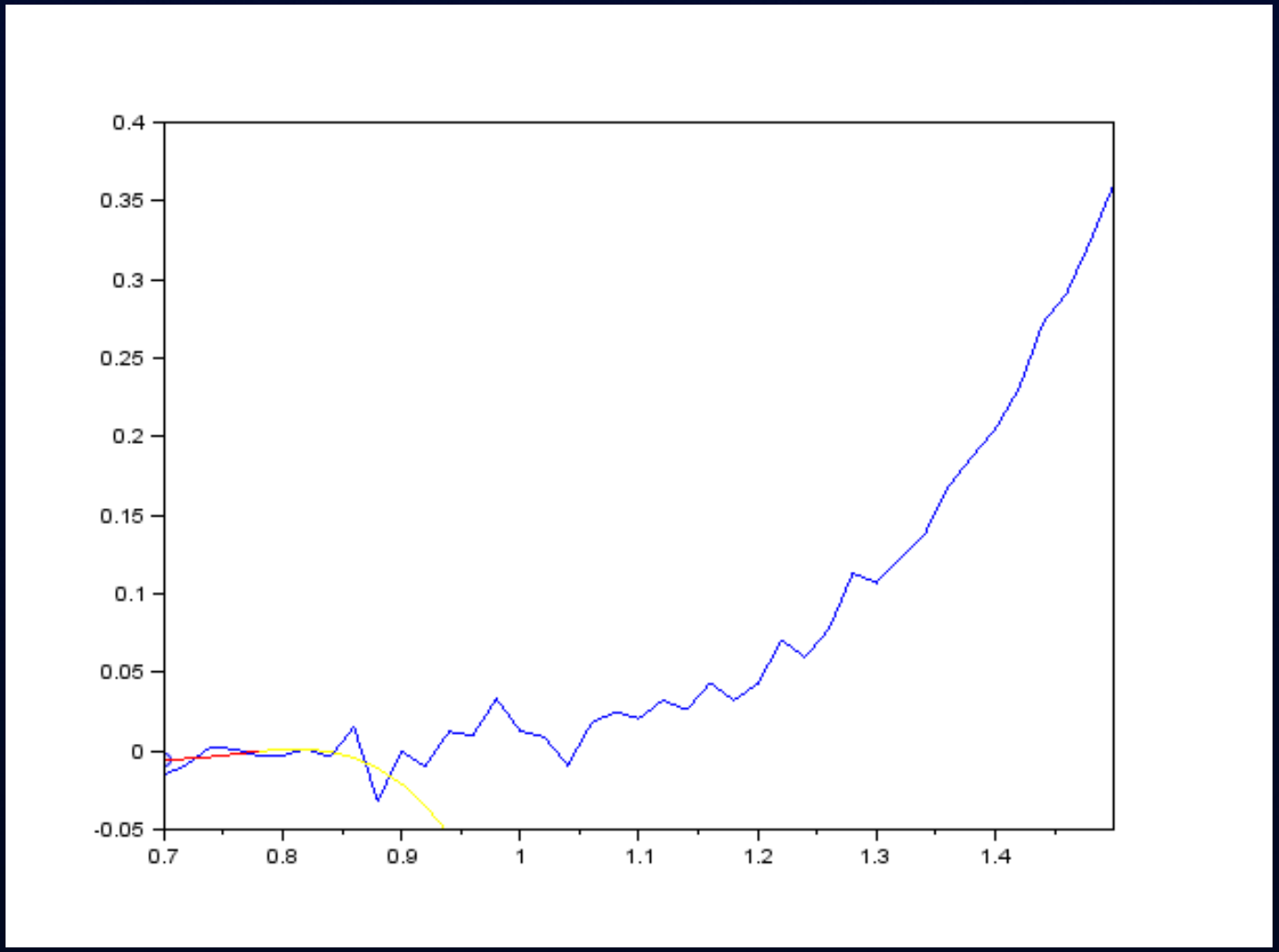
$$\begin{bmatrix} a & \vec{b} & \vec{c} \\ d & \vec{e} & \vec{f} \\ g & \vec{h} & \vec{i} \end{bmatrix}$$

(Dismal) Results

Accuracy: 0.102

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 256, 14, 64)       128

 max_pooling2d (MaxPooling2D  (None, 256, 14, 64)      0
 )

 conv2d_1 (Conv2D)           (None, 256, 14, 64)       4160

 max_pooling2d_1 (MaxPooling  (None, 256, 14, 64)      0
 2D)

 conv2d_2 (Conv2D)           (None, 256, 14, 64)       4160

 max_pooling2d_2 (MaxPooling  (None, 256, 14, 64)      0
 2D)

 flatten (Flatten)           (None, 229376)            0

 dense (Dense)               (None, 32)                7340064

 dense_1 (Dense)             (None, 32)                1056

 dense_2 (Dense)             (None, 11)                363

=================================================================
Total params: 7,349,931
Trainable params: 7,349,931
Non-trainable params: 0
```

Savitsky-Golay Filter



& FastICA

Interpretation

- Time is Necessary For Neurons
- Rhythms & Waves
- Averaging Collapses Time

Another Try

- Data Vecs Expanded to Cols
- Shape → (48775 × 3584)
- Breaks CNN:

```
OOM when allocating tensor with
shape[799129600,32] and type float
```

Support Vector Classifier

- SVC Ran for ~6hrs
- Acc. Increased, but only To 0.112

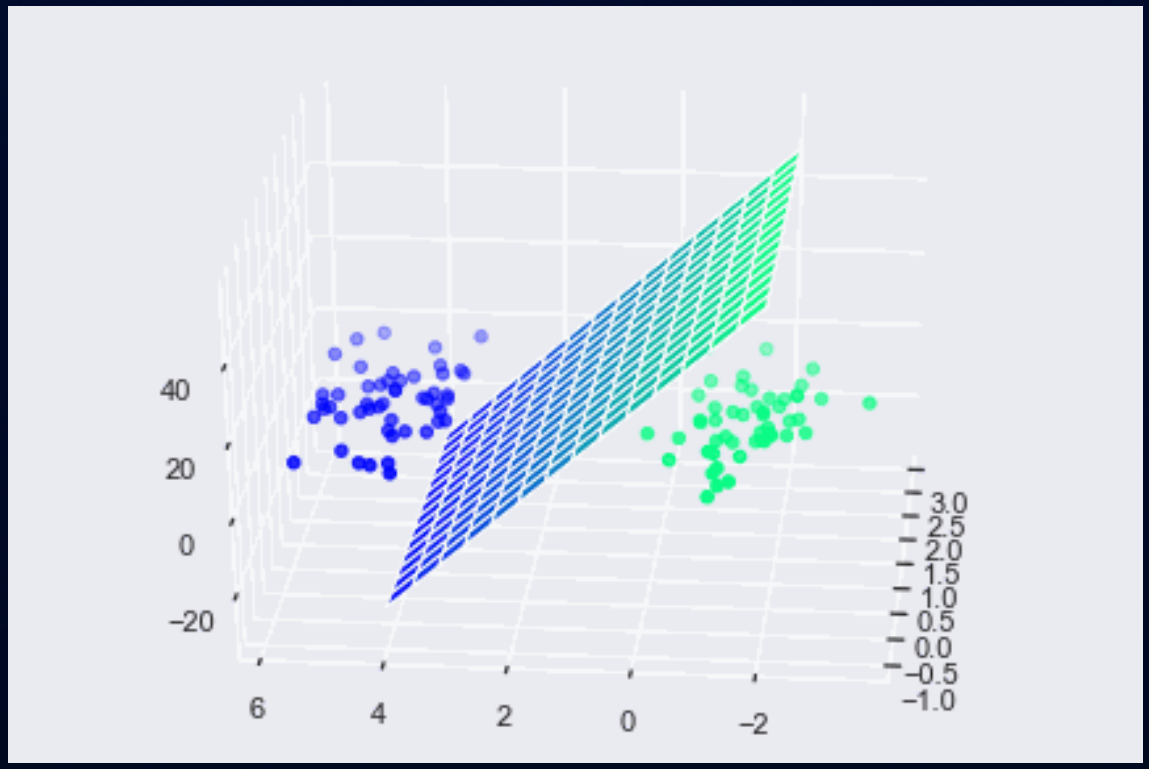
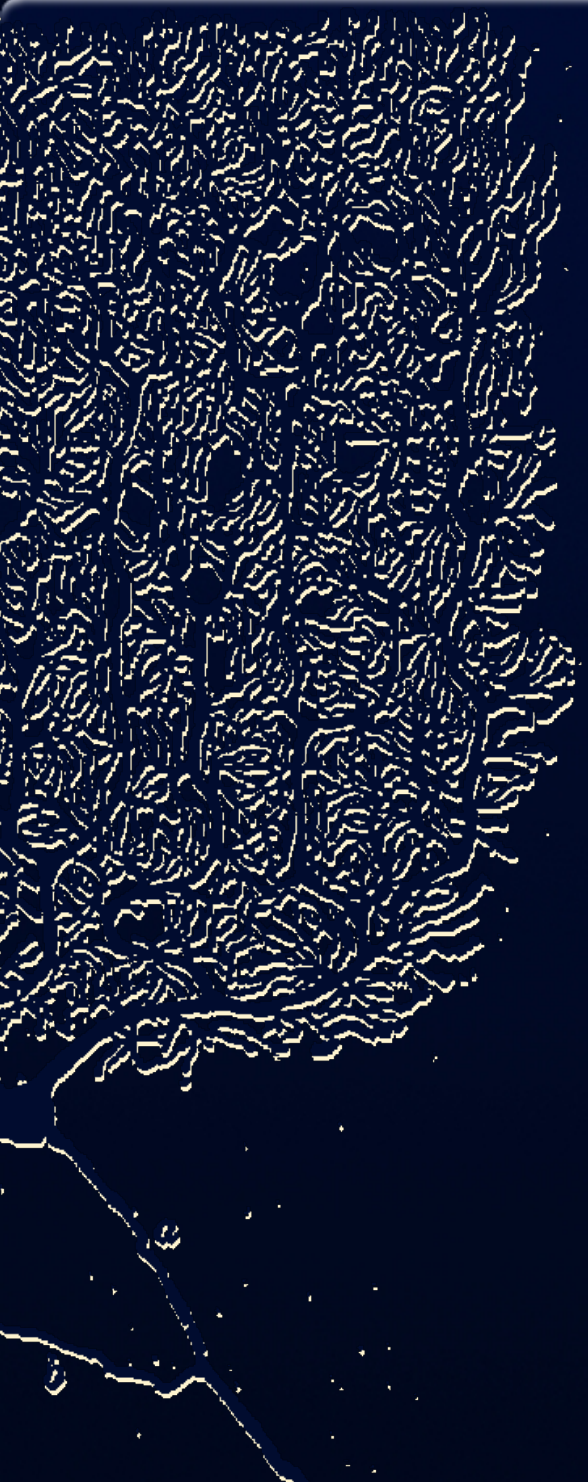


Image Credit:
https://machinelearningjourney.com/index.php/2020/03/09/support-vector-machines/

Next Steps

- Cloud Computing for More RAM
- ML Denoising & Source Separation
- Similar Project, Different Data
  - Around 100 EEG datasets: https://github.com/meagmohit/EEG-Datasets
  - NeuroData Without Borders, Kavli Foundation: https://www.nwb.org/
  - OpenNEURO, validated data https://openneuro.org/

Any Questions?



Code:
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