ULB UNIVERSITÉ LIBRE DE BRUXELLES

Preparatory work for the Master Thesis

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Machine learning for analysis of EEG signals in neurosciences.

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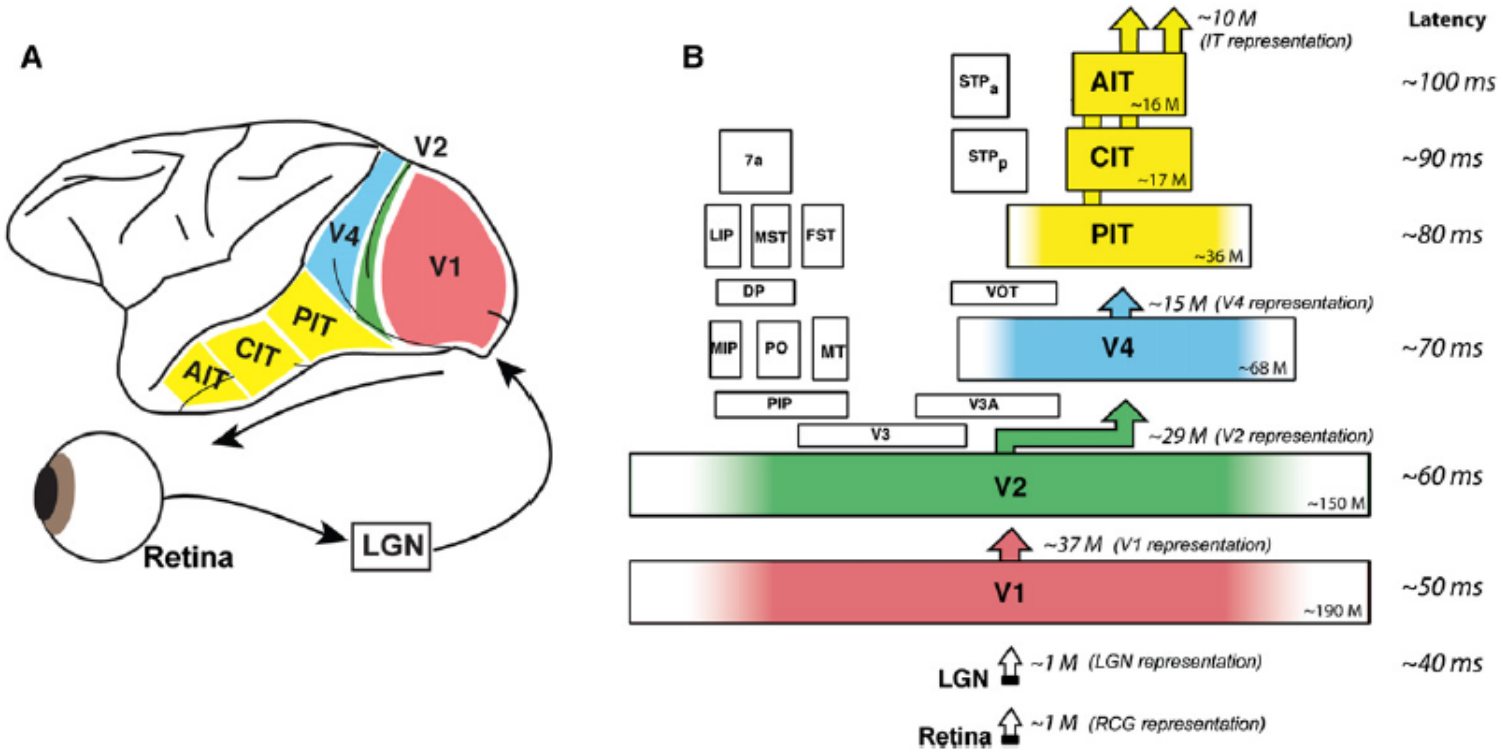
Advancement

What has been done (From 03/03 to 24/03) :

- Keep reading articles and gathering information about EEG and object recognition.
- Started looking into real EEG data and implementation (ThoughtViz)

Ventral Stream Pathway & Timings

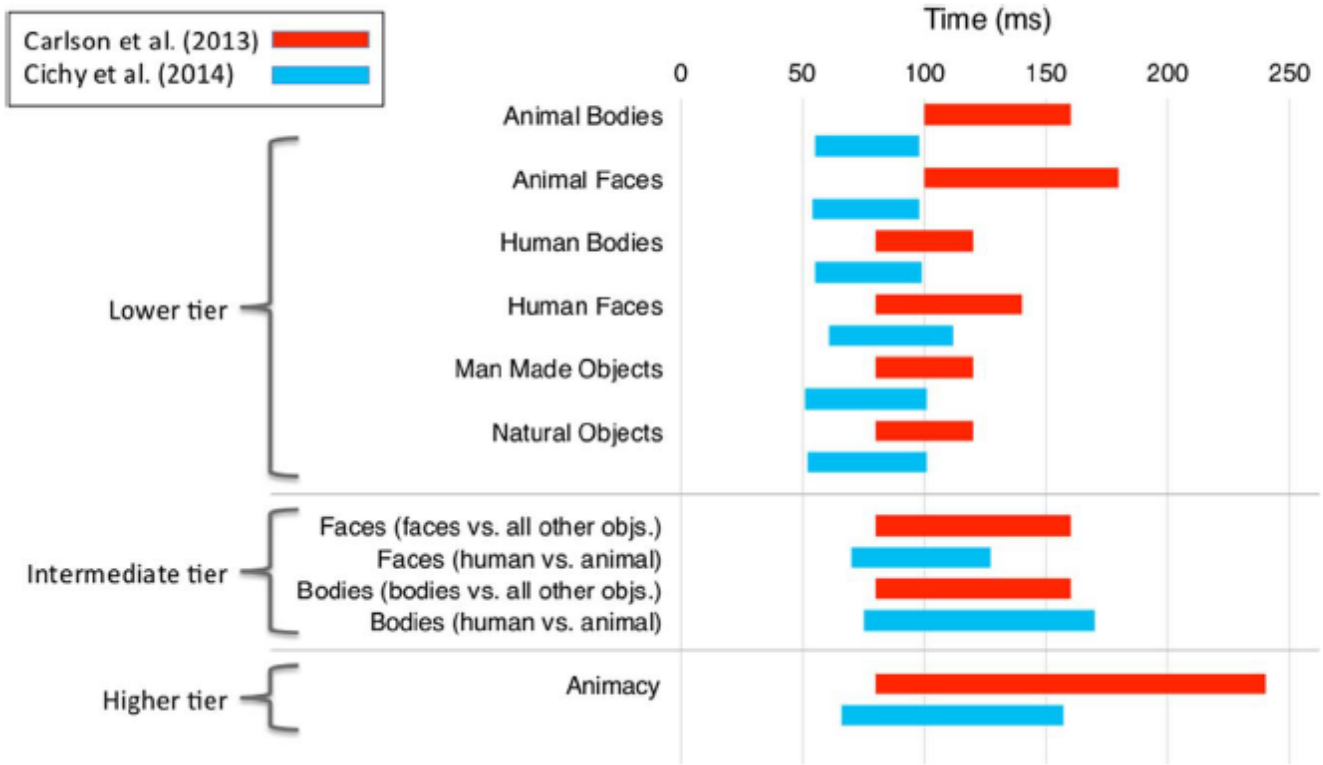
How does the brain perform object recognition ?



Ventral stream pathway [1]

Ventral Stream pathway & Timings

What are the timings for objects recognition ?



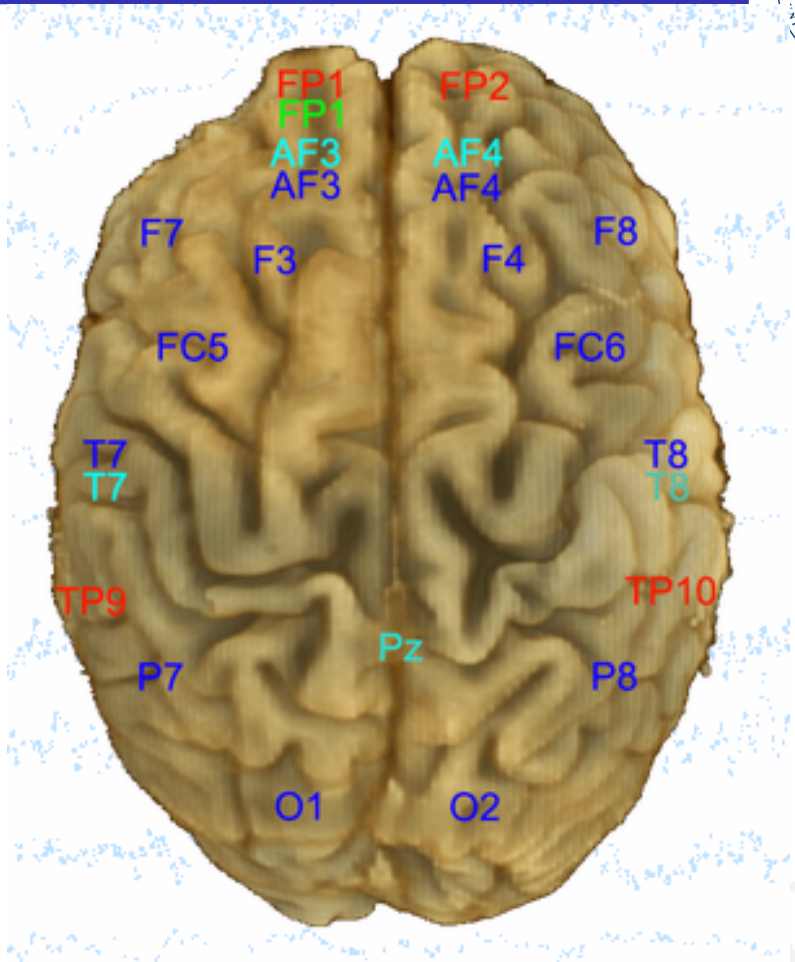
Onset and peak decoding times [2]

Based on Carlson et al. [3] and Cichy et al. [4]

Datasets and implementation

MindBigData,
"IMAGENET" of the brain.
Link
: `http://www.mindbigdata.com/opendb/imagenet.html`

Uses the "Emotiv Insight" headset.
Commercial and low-priced.
Covers 5 channels following the "10-20" system.
AF3, AF4, T7, T8 and Pz (cyan).

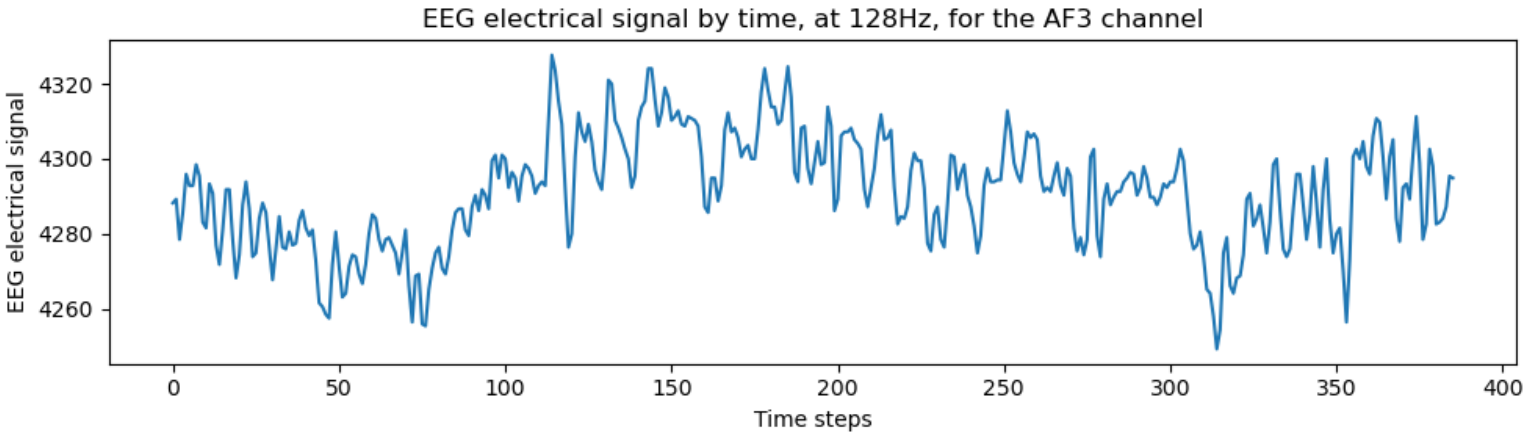


Electrodes placement

Datasets and implementation

EEG available for lots of different classes of images (more than 500), but a few EEG data for each class (around 20-25).

However, no articles using the dataset.



Example of EEG data of the MindBigData "IMAGENET" dataset

Datasets and implementation

Other datasets :

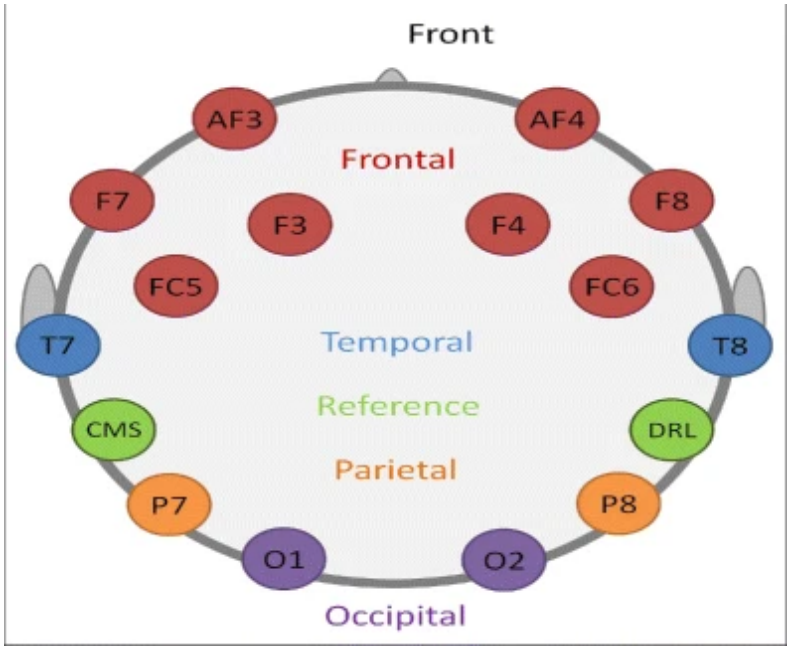
- MindBigData, "MNIST" of the brain. Link : `http://www.mindbigdata.com/opendb/index.html`
- ThoughtViz [5]

Advantages of "MNIST" of the brain, made with multiple headsets.
Largest dataset with the headset "Emotiv EPOC".
Around 90.000 EEG samples per digit.

The ThoughtViz uses another dataset [6], also made with "Emotiv EPOC".
The used dataset and the implementation are available.
Link : `https://github.com/ptirupat/ThoughtViz`

Datasets and implementation

The "Emotiv EPOC" headset has 14 channels (2 channels are references).



Electrodes placement on the "Emotiv EPOC" headset [6]

Datasets and implementation

The ThoughtViz article [5] is based on the article "Envisioned speech recognition using EEG sensors" [6] and does more than EEG classification.
The EEG classification uses CNN, LSTM and a combination of these architectures.
Biggest part is the generation of images from the EEG.

Datasets and implementation

Sample of 10 classes of objects generated. Columns 1-9 are generated images, last column is an random image from the training set.

Planning

- Keep reading articles and have as much information as possible.
- Try implementing the EEG classifier of [5] and [6].

References I

[1] James J. DiCarlo, Davide Zoccolan, and Nicole C. Rust. "How Does the Brain Solve Visual Object Recognition?" In: *Neuron* 73.3 (2012), pp. 415–434. ISSN: 0896-6273. DOI: https://doi.org/10.1016/j.neuron.2012.01.010.

[2] Erika W. Contini, Susan G. Wardle, and Thomas A. Carlson. "Decoding the time-course of object recognition in the human brain: From visual features to categorical decisions". In: *Neuropsychologia* 105 (2017). Special Issue: Concepts, Actions and Objects: Functional and Neural Perspectives, pp. 165–176. ISSN: 0028-3932. DOI: https://doi.org/10.1016/j.neuropsychologia.2017.02.013.

[3] Thomas Carlson et al. "Representational dynamics of object vision: The first 1000 ms". In: *Journal of Vision* 13.10 (Aug. 2013), pp. 1–1. ISSN: 1534-7362. DOI: 10.1167/13.10.1. eprint: https://arvojournals.org/arvo/content_public/journal/jov/932805/i1534-7362-13-10-1.pdf.

[4] Radoslaw Martin Cichy, Dimitrios Pantazis, and Aude Oliva. "Resolving human object recognition in space and time". In: *Nature Neuroscience* 17.3 (2014), pp. 455–462. DOI: 10.1038/nn.3635.

References II

[5] Praveen Tirupattur et al. "ThoughtViz: Visualizing Human Thoughts Using Generative Adversarial Network". In: *Proceedings of the 26th ACM International Conference on Multimedia*. MM '18. Seoul, Republic of Korea: Association for Computing Machinery, 2018, pp. 950–958. ISBN: 9781450356657. DOI: 10.1145/3240508.3240641.

[6] Pradeep Kumar et al. "Envisioned speech recognition using EEG sensors". In: *Personal and Ubiquitous Computing* 22.1 (Feb. 2018), pp. 185–199. ISSN: 1617-4917. DOI: 10.1007/s00779-017-1083-4.