List of class projects for Introduction to Computational Neuroscience 2018-2019

- The idea is to work on a project that will allow you to study in some depth a phenomenon or question related to any aspect of neuroscience.

- A good option is to come with a project on your own on a question that interest you. However, you will need to explain the idea to any of the teachers who will have to check it before giving any approval and give you feedback to make the project feasible and interesting.

- Ideally, you should make teams of 3 or 4 people.

1) How circadian rhythms affect performance: x2

In this project you will measure how many of your cognitive abilities change depending on the time of the day. Your aim will be to design and execute an experiment to find out how much the reaction times, working memory, and other measurable brain outputs depend on the hour of the day. See https://www.humanbenchmark.com/ for a suite of tests than can be used for the project.

2) Day and night:

We live immersed in an environment which properties change in a predictable and rhythmic pattern. Just think how day-night cycles, tydes, or seasons influence our behavior and that of most animals on Earth.

Most animals have learnt to internalize or model these periodic patterns to their own advantage. Indeed, you have an internal circadian clock with a period around of 24 hours that determines when many of your bodily activities should achieve their peak, and that when it runs unadjusted to the external conditions gives you a bad jet-lag.

With this project you will explore how an artificial agent can learn to exploit the time-periodic regularities in its environment. The idea is to deploy a deep reinforcement learning artificial agent in an environment with a strong periodicity (day-night cycle) and test under which conditions it learns to internalize such a periodicity (develop its own internal circadian rhythm).

3) Body swap:

In the famous rubber hand illusion the real hand of a subject is keep out of sight while a rubber hand is visible. Then the experimenter simultaneously strokes with a pencil the real hand and the rubber hand. After some time the brain believes the rubber hand is actually the real hand.

In this project we will replicate the rubber hand illusion, but instead of a rubber hand we will use two test subjects. In this new experiment every subject will see the hand of the other subject. We will try to determine if it is possible or not that they perceive the hand of the other subject as their own hand, when we stroke it simultaneously. In future work we can study the exchange of the foot or the face of two persons.

4) Back to the future:

To understand causality organisms must determine the temporal order of their actions and sensations. However as seen in class different sensory pathways can present different delays, which the nervous system has to compensate. The aim of this project is to study how the brain compensates these delays and how this can affect causality.

We will try to replicate the results of Stetson et al. [1]. First we will inject a delay between pressing a key and the consequence, a light flash. Later on once the brain of the participants of this study has adapt, we will shorten the delay so participants will perceive the light flash happening before the key press.

1 Stetson, C., Cui, X., Montague, P. R., & Eagleman, D. M. (2006) .Motor-Sensory Recalibration Leads to an Illusory Reversal of Action and Sensation. *Neuron*, *51*(5), 651-659

5) Rise and shine:

Most people at some point needs to wake up at a concrete hour. Maybe some of you have experienced the phenomena of waking up exactly a few minutes before the appointed hour. In this project you will have to design and execute an experiment to corroborate or rule out the possibility that your brain is able to keep track of time with the precision of minutes to wake you up at the right time.

6) EEG measurements: x2

7) Kaggle Competition for Neuroscience: https://www.kaggle.com/datasets?tagids=7105

EEG data from basic sensory task in Schizophrenia

Circadian Rhythm in the Brain

Confused student EEG brainwave data

10) Learning time intervals with LSTM:

This project is only for people with some background in neural networks. Experiments in eyeblink conditioning show that the brain is able to learn time intervals between two stimulus. How well can neural networks learn time intervals compared to the brain? We will try to answer this question training a neural network with LSTM to learn different time intervals.

11) Biological motion using leap motion:

https://www.ncbi.nlm.nih.gov/pubmed/28378281
http://nwkpsych.rutgers.edu/roar/reprint%20pdfs/Prasad%20Shiffrar%2009.pdf