Summer 2021
Summer School in Nonlinear Dynamics for Life Sciences

The project is designed with two parts and best done in groups of two or three students. One person can take the lead in each part and then results from both parts (model and brain RDMs) could be compared and discussed at the end within each team.

Preliminary
Data: The following data contains neural recordings from 296 neuronal sites across V4 and IT cortex of monkeys in response to 5760 images. The data is packaged in two .mat files. Download from https://tinyurl.com/y6gl5uga

1. **hvm_data.mat**: This file contains the data and is partitioned into several relevant fields described below:
    a. **data**: V4 and IT neural responses -- number neurons X number of images = (296 x 5760)
    b. **IT_idx**: indices of IT neurons.
    c. **V4_idx**: indices of V4 neurons.
    d. **obj_names**: name of the objects in each image (64 objects)
    e. **cat_names**: name of the category of object in each image (8 categories)
2. **hvm_images.mat**: Visual stimuli (i.e. images) which were shown to the animal are saved in this file.

Part 1

Goal: to examine the neural representation in IT cortex in response to viewing different objects.

Tasks:

1. Plot the average IT neural response to each category. For this, first sub-select the IT neurons from **data** using **IT_idx.** You need to make 8 plots (one per object category) with x-axis being the neuronal index and y-axis being the average responses with mean and standard deviation across images of each category.
2. Are the average neural responses to different categories easy to distinguish from each other? Explain why that is the case.
3. Use a logistic regression classifier to discriminate between different categories and objects given the neural data (refer to the slides). You can use the Matlab function **fitcdiscr** to classify different categories and objects. Report the 2-fold cross-validation error using the **cvpartition** function.
4. Compute the RDM matrix for IT responses and different objects and analyze the results. Compute the dissimilarity measure (1 – Pearson(x,y)) between responses to each pair of objects where "x" and "y" are the average response of neurons to all images of the same object. Dissimilarity scores should then be organized in a NxN matrix (N=number of objects) called a representational dissimilarity matrix and be sorted according to the semantic category of the objects in a way that objects belonging to the same semantic category are located beside each other. E.g. (fruits: rows 1-8; cars: rows 9-16; etc); see the slides for a visual description. Use Matlab **corrcoef** function to compute the Pearson correlation.
5. Discuss what the RDM tells us about the neural code in IT for objects and its relevance to object recognition behavior.

Part 2

Goal: to compare the internal representations of convolutional neural networks with those found in V4 and IT cortex.

Tasks:

1. Use the **alexnet** function to build an AlexNet convolutional neural network. List the layers in AlexNet architecture, with their names and types?
2. Get the internal activations of AlexNet model at the output of layers [relu3, relu4, relu5, fc6, fc7] in response to all the stimuli (from hvm_images.mat). You can use the **activations** function to compute and store these activations. Note that you have to resize the images to match the network's expected input size (227 x 227 x 3). You can use **imresize** function to resize and **repmat** function to copy the values along the last axis.
3. Compute the RDM matrix for activations computed in step-2 and plot them. For each layer, only use a random subsample of 5000 features to compute the RDM. Using all features might take a long time to complete.
4. Compare the similarity between IT cortex RDM and RDM for each of the layers in AlexNet. For this, you can use the **corrcoef** function to compute the correlation between each pair of RDMs.
5. Which layer has the most similar RDM to IT cortex?

6. Which other brain areas do you think the other layers in AlexNet best correspond to?
7. <u>(Bonus)</u> Compare the similarity between V4 RDM and RDM for each of the layers in AlexNet (similar to step-4). You can use the **V4_idx** to select the neurons from this area.