

Mini-Project 5: Correlation Tests & Brain fMRI

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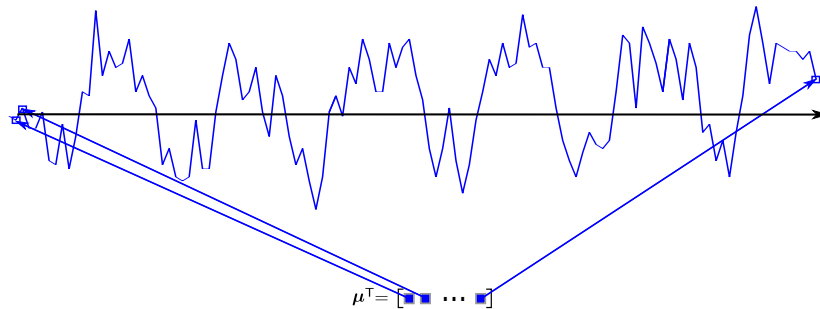
DUE 3/28/2018

In this mini-project you will use statistical learning in a brain mapping tool called *functional magnetic resonance imaging (fMRI)*. In *fMRI*, a series of MRI brain images are collected over time. Because oxygenated and deoxygenated hemoglobin have slightly different magnetic characteristics, variations in the MRI intensity indicate areas of the brain with increased blood flow and hence neural activity.

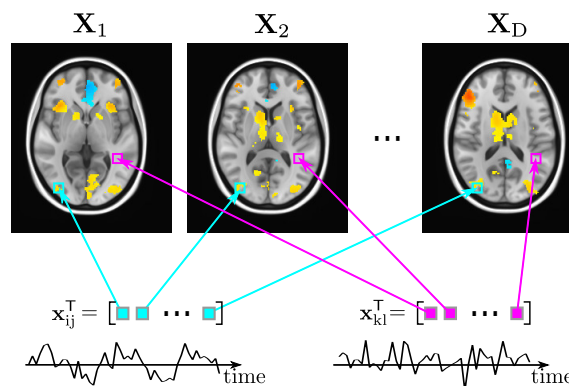
The central task in *fMRI* is to reliably detect neural activity at different spatial locations (pixels) in the brain to produce an *activation map*, i.e., a binary image of *active* and *non-active* brain regions. However, the data are noisy and the variation in intensity due to activation is very subtle, which often makes this problem challenging.

In this mini-project we will try to determine which region of the brain controls the thumb. To this end we will analyze *fMRI* data collected from an individual while she moves her thumb up and down. The file `thumb_data.mat` contains the following data:

- A reference vector $\mu \in \mathbb{R}^D$ with $D = 122$ oximetry measurements taken at the tendon of the thumb over time, as the thumb moves up and down.



- A sequence of 64×64 axial brain MRIs $\mathbf{X}_1, \dots, \mathbf{X}_D$ taken over time, as the thumb moves up and down. These are stored in a 3-dimensional data array \mathbf{x} . In Matlab code, $\mathbf{X}_t = \mathbf{x}(:, :, t)$, with $t = 1, \dots, D$. Equivalently, \mathbf{x} contains vectors $\mathbf{x}_{ij} \in \mathbb{R}^D$ with $i, j = 1, \dots, 64$ with the time-series of each pixel. In Matlab code, $\mathbf{x}_{ij} = \mathbf{x}(i, j, :)$.



Your goal is to create an activation map indicating the brain regions (pixels) correlated to the movement of the thumb.

- For each i, j , compute the correlation between \mathbf{x}_{ij} and $\boldsymbol{\mu}$. This should produce a 64×64 matrix \mathbf{C} indicating the correlation of each pixel of the brain with the thumb movement. Display \mathbf{C} as an image.
- We will say that a pixel \mathbf{x}_{ij} is *active* if its correlation with $\boldsymbol{\mu}$ (in absolute value) is larger than a threshold τ . Show activation maps for different values of τ .
- Which value of τ would you choose? Display the resulting activation map.
- Why should we use absolute value in step (b)?
- Submit your code.

I have created the following code to help you get started:

```

1 % © Daniel L. Pimentel-Alarcón, 2018, pimentel@gsu.edu
2 % ===== Code to generate a brain activation map using a simple
3 % ===== threshold and a correlation test.
4
5 - clear all; close all; clc;
6 - load thumb_data;
7
8 % ===== Plot reference vector =====
9 - figure(1);
10 - plot(mu);
11 - title('Reference vector \mu');
12
13 % ===== Compute correlation of all pixels with reference =====
14 - C = zeros(64,64);
15 %COMPLETE HERE: Write code to compute correlation matrix C.
16
17 % ===== Produce Activation Map =====
18 %COMPLETE HERE: Set a threshold tau to produce activation map.
19
20 % ===== Display correlation image and activation Map (in red) =====
21 - figure(2);
22 - imagesc(C);
23 - axis('square');
24 - colormap('gray');
25 - hold on;
26 - [j,i] = find(Act_Map);
27 - plot(i,j,'rs');
28 - title('Activation Map');
```