K-Means Cluster Analysis of Resting-State fMRI Time Series (10-10 EEG related seeds)

Carlos Montoya [1], Gonzalo M. Rojas [2],
Jaime Cisternas [1], Marcelo Gálvez [3]

[1] School of Engineering and Applied Sciences, Universidad de los Andes, Santiago, Chile
[2] Laboratory of Medical Image Processing, Department of Radiology, Clínica Las Condes, Santiago, Chile
[3] Department of Radiology, Clínica Las Condes, Santiago, Chile

Introduction

- The methods used to analyze Resting-State fMRI is mainly seed based, ICA, ALFF, fALFF. In Rojas et al., the authors shows a seed based analysis that used seeds positioned in 10-10 EEG electrodes (65) equivalent standard MNI coordinates.
- Generally, in the case of seed based analysis, a correlation coeficient is computed between different seed time series, and correlation matrices could be created.
- K-means (Hartigan & Wong, 1979) is an unsupervised and iterative clustering algorithm that partition the data in k disjoint clusters (k is defined by the user). With K-means method it is posible to find brain functional networks between proyected 10-10 EEG positioned seeds from resting state fMRI.
- Final results shows a high similarity brain network organization with Yeo`s fMRI 7 Networks.

Methods

We processed resting state fMRI scans for 45 right handed healthy volunteers (age 18-30, 3T MRI, Cambridge-Buckner dataset, 1000 Functional Connectomes Project; http://fcon_1000.projects.nitrc.org). The data was motion-corrected, despiked, detrended and spatially-normalized using AFNI and FSL. We used 6mm radius spherical seeds located in 65 EEG electrodes 10-10 system equivalent MNI coordinates (Rojas et al, 2012) to get resting state time series with each seed, and to calculate participant-level whole brain connectivity maps.

We build one big time series for each seed, to simulate the behaviour characteristic of all 45 volunteers.
The 65 resting state time series was clusterized using kmeans (Hartigan-Wong algorithm) in seven clusters (quantity of standard functional connectivity networks, Yeo et al 2011). To analyze the robustness, reliability and stability of the method and variability of connections, many replications of the method were used varying the initial conditions of the algorithm. This data was ordered in a matrix (named "K-Means based index matrix") in such a way that each value corresponds to the quantity of the same cluster that two seeds has in common in all replications.

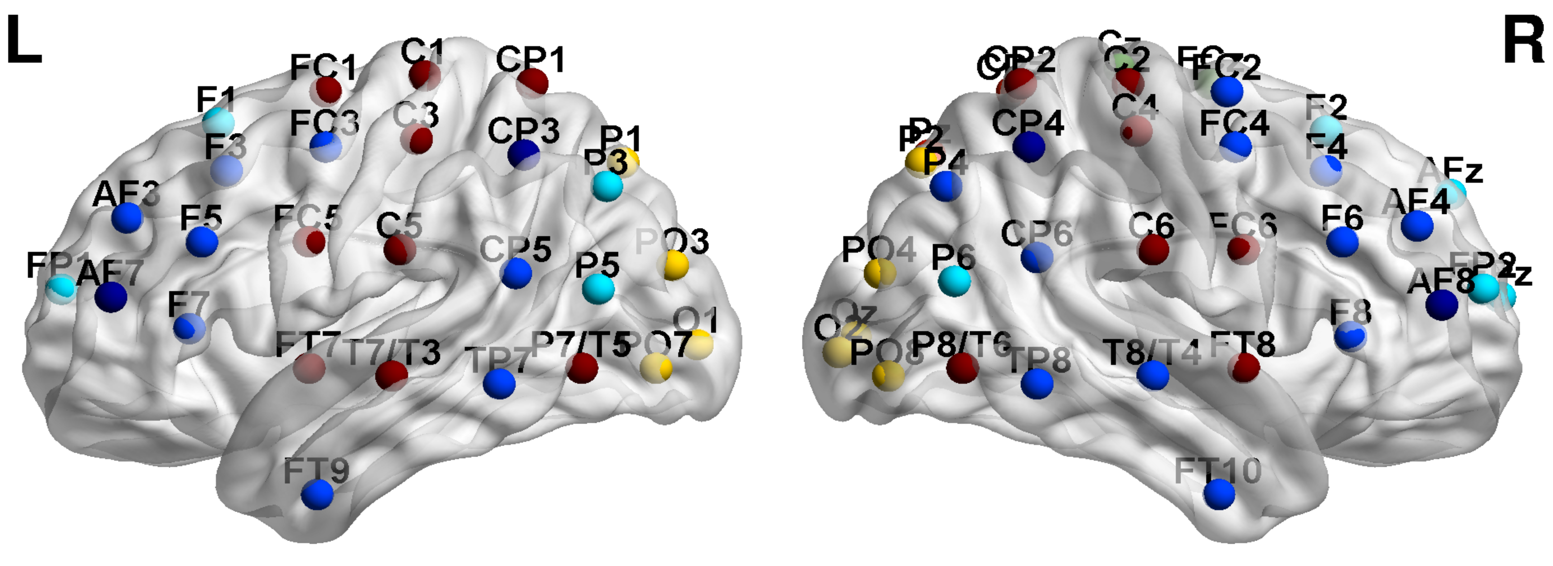

Fig. 1: 10-10 EEG seeds position. The standarrd brain used has not cerebellum.

Results

By visual inspection of Figs. 2-3, we could describe:

1) symmetrical seeds in contralateral hemisphere has an index greater than 10 (for example, FP1-FP2, F1-F2, F7-F8, AF3-AF4, AF7-AF8, C1-C3, C2-C4, C1-C2, O1-O2)

2) more than 30 (for example: C1-C3, C2-C4, O2-PO8 (same hemisphere), P9-FT10)

3) occipital electrodes has a kmeans index more than 30 (for example: O2-PO8 (same hemisphere), O1-O2).

81.5% of similarity in the comparison with Yeo's 7 Networks (Fig. 4) (Montoya, 2014). The results show that every cluster has symmetrical seeds in contralateral hemisphere (Fig. 5), the same shown in figures 2 and 3.

Using non linear regression econometric models (Montoya, 2014).K-Means method shown to be robust, reliable and stable for 7 Networks.

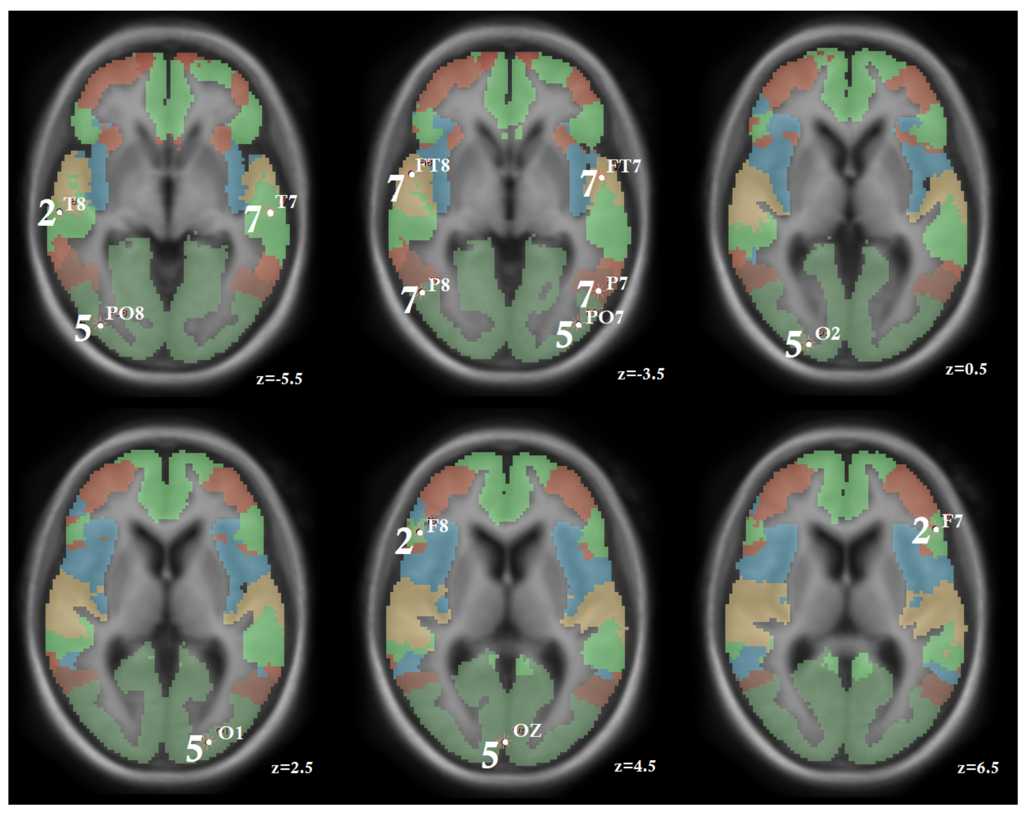

Fig. 4: Comparison between K-Means 7 Networks (Fig.5) and Yeo's 7 Netwotrks.

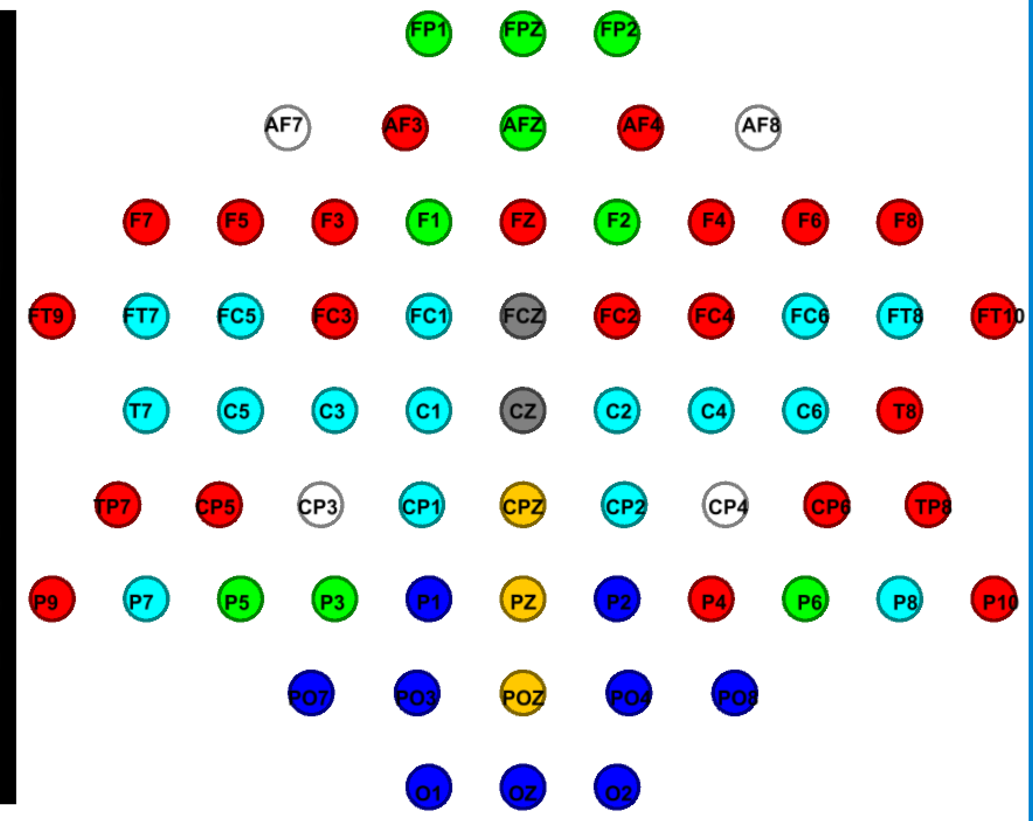

Fig. 5: K-means 7 networks.

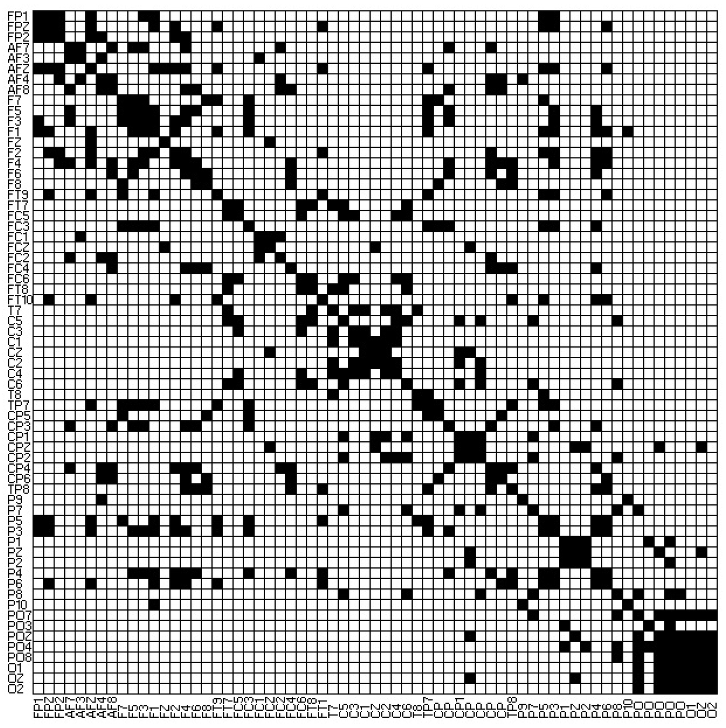

Fig. 2: kmeans index matrix (binary) with lower threshold of 20.

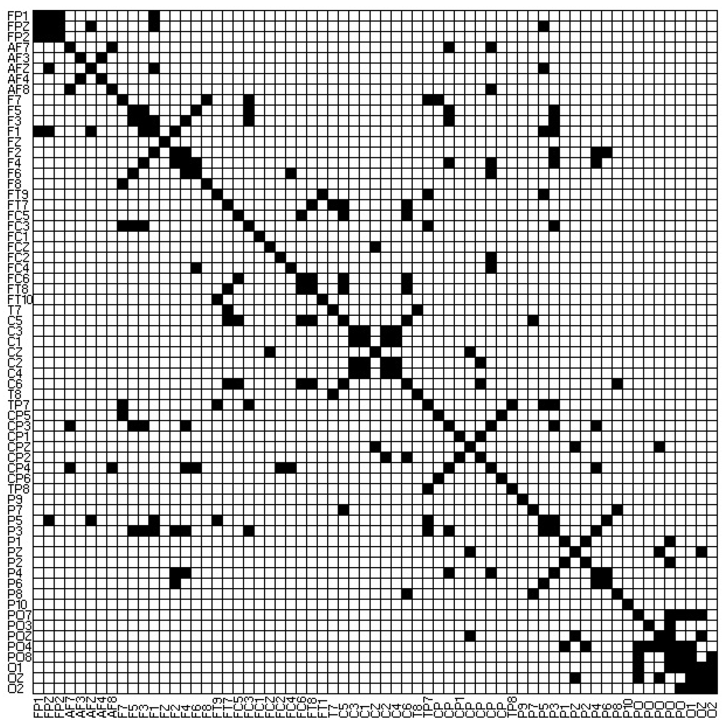

Fig. 3: kmeans index matrix (binary) with lower threshold of 30.

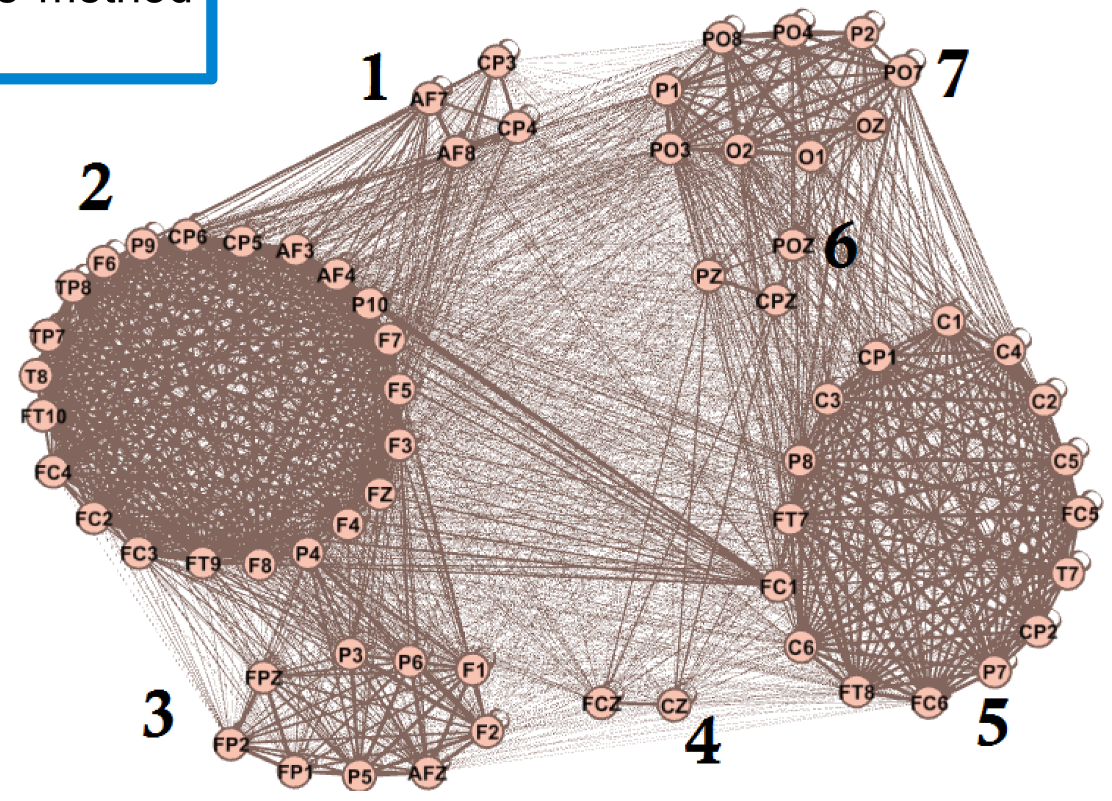

Fig. 6: Total network conection using K-Means based index matrix.

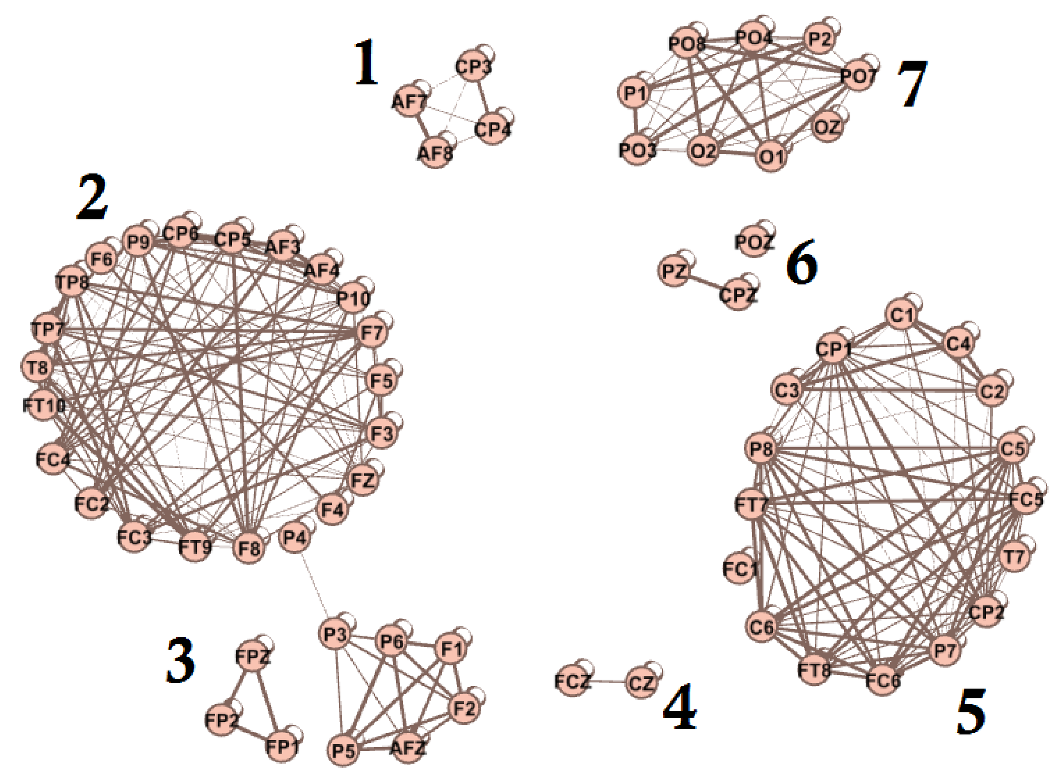

Fig. 7: Filtering lower match conections from Fig. 6.

Conclusions

Here we show another index to measure the dependence between seeds in resting state data.

·In comparison with correlation matrix of same 10-10 EEG related seeds (Rojas et al, 2012; Fig. 6), some ideas:
·i) with both approach many contralateral seeds has high correlation. (For example, FP1-FP2, O1-O2)
·ii) occipital seeds has high correlation (contralateral and ipsilateral seeds).

·Similar results of 7 networks connectivity are possible to obtain using 10-10 EEG projection from fMRI and comparing with Yeo's 7 networks.

·As same as K-Means index matrix, K-Means 7 Networks show in each cluster symmetrical seeds in contralateral hemisphere (Fig. 5).

·More research and studies should be done to understand better how these networks are formed and how the dynamics of connectivity of each node behaves.

References

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