Visualisation of network connectomes in fMRI data for characterisation of Autism Spectrum Disorder

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Introduction:

Autism spectrum disorder (ASD) is an umbrella for a group of developmental disorders, characterized by impaired social-communication and repetitive behaviors. Behaviorally, ASD includes a wide range, "a spectrum," of symptoms, skills, and levels of disability.

fMRI (functional magnetic resonance imaging) is a non-invasive imaging modality that allows us to assess brain activity and to localize critical functions by mapping them to the different areas of the brain. Unlike conventional experiments resting-state fMRI (rfMRI) is collected in the absence of any experimental paradigms. It is believed that temporal correlations within these low-frequency signals reflect the intrinsic functionality of the brain.

Effective identification and isolation of network connectomes provides a key link to understanding the social and behavioural characterisation of ASD.

Challenge:

Analysis of a multi-subject rfMRI imaging study often begins at the group level, for example, estimating group-averaged functional connectivity across all subjects. The limitation of group-based analysis lies in the treatment of heterogeneous patient group as a unified cohort. Essentially, valuable information about individual variation and key differences that may be linked to the disorder are lost. This is particularly true for ASD, and as a result, there are surprisingly few reproducible results within the fMRI literature.

Previous Work:

Historically, principal component analysis (PCA) has been developed as a statistical procedure in order to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables using orthogonal transformations. Essentially, it permits the capture of the maximum allowable variance in the data along a set of orthogonal components.

Popular approaches to dimensionality reduction in the context of fMRI include the application of some variant of Principal Component Analysis(PCA); as is illustrated in [1] which explains the use of group PCA on large fMRI datasets; while [2] employs kernel PCA for dimensionality reduction on the ADHD dataset. Besides these, [3] outlines a general approach based on Independent Component Analysis (ICA) on fMRI data for separation into spatial components.

In the past, the problem of identifying social communication networks in autism has been tackled by a Bayesian modeling approach. [4] , [5]

Dataset: Resting State fMRI (rfMRI) data is available for patients, some of which are controls while the others display Autism Spectrum Disorder. This includes the functional data along with the EPI (Echo Planar Imaging) template and the high resolution T1- weighted image providing structural and anatomical detail. ADOS (Autism Diagnostic Observation Schedule), SRS (Social Responsiveness Scale), SES (Socio Economic Scale) etc are some of the measures that will be employed in order to study the behavioural implications.

Objective: The project aims at identifying and isolating the network connections from the neuroimaging data available. Another key point is correlating the networks with behavioral symptoms and using the model to predict behavioral deficits in a new patient.

Scope: The scope of the project is defined keeping in mind the objective of network characterisation. The proposed *workflow* is as follows:

- Pre-processing the data
- Estimating the functional connectivity networks based on Pearson correlation coefficients
- Performing a dimensionality reduction by techniques like PCA/k-PCA/ICA for better data representation
- Correlating with and/or predicting behavioral symptoms

Future Work: Development of regression models for studying patients vs controls distinction

References:

[1] Smith SM, Hyvärinen A, Varoquaux G, Miller KL, Beckmann CF. Group-PCA for very large fMRI datasets. NeuroImage. 2014 Nov 1;101:738-49.

[2] Sidhu GS, Asgarian N, Greiner R, Brown MR. Kernel Principal Component Analysis for dimensionality reduction in fMRI-based diagnosis of ADHD. Frontiers in systems neuroscience. 2012 Nov 9;6:74.

[3] McKeown, Martin J., et al. Analysis of fMRI data by blind separation into independent spatial components. No. NHRC-REPT-97-42. NAVAL HEALTH RESEARCH CENTER SAN DIEGO CA, 1997.

[4] Venkataraman A, Yang D, Pelphrey K, Duncan J. Bayesian Community Detection in the Space of Group-Level Functional Differences.

[5] Venkataraman A, Duncan JS, Yang DY, Pelphrey KA. An unbiased Bayesian approach to functional connectomics implicates social-communication networks in autism. NeuroImage: Clinical. 2015 Dec 31;8:356-66.