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TESI DI DOTTORATO / PH.D. THESIS

Building functional neuromarkers from resting state fMRI to describe physiopathological traits

Abstract

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Abstract

The overarching goal of this work has been that of devising novel methods for building functional neuromarkers from resting-state fMRI data to describe healthy and pathological human behaviour. Observing spontaneous fluctuations of the BOLD signal, resting-state fMRI allows to have an insight into the functional organisation of the brain and to detect functional networks that are consistent across subjects. Studying how patterns of functional connectivity vary both in healthy subjects and in subjects affected by a neurodegenerative disease is a way to shed light on the physiological and pathological mechanisms governing our nervous system.

The first part of this thesis is devoted to the description of fully data-driven feature extraction techniques based on clustering aimed at supporting the diagnosis of neurodegenerative diseases (e.g., amyotrophic lateral sclerosis and Parkinson's disease). The high-dimensional nature of resting state fMRI data implies the need of suitable feature selection techniques. Traditional univariate techniques are fast and straightforward to interpret, but are unable to unveil relationships among multiple features. For this reason, this work presents a methodology based on consensus clustering, a particular approach to the clustering problem that consists in combining different partitions of the same data set to produce more stable solutions. One of the objectives of fMRI data analysis is to determine regions that show an abnormal activity with respect to a healthy brain and this is often attained with comparative statistical models applied to single voxels or brain parcels within one or several functional networks. Here, stochastic rank aggregation is applied to identify brain regions that exhibit a coherent behaviour in groups of subjects affected by the same disorder. The proposed methodology was validated on real data and the results are consistent with previous literature, thus indicating that this approach might be suitable to support early diagnosis of neurodegenerative diseases.

The second part of the thesis is dedicated to the study of the link between brain functional connectivity and individual differences in intelligence and per-

sonality. Functional connectivity networks are built by parcelling the brain into regions according to some criterion, so that regions become the nodes of the network, and by adding a connection between two nodes if the time series of the involved brain regions are correlated. One of the challenge of functional connectivity estimation is that it can be greatly affected by motion artifacts and nowadays there is still no universal agreement on what is the best strategy for noise and motion artifact removal. For this reason, during this project a preprocessing pipeline was developed implementing the most used denoising steps found in literature, to study how different approaches affect the final outcome of the analysis. After preprocessing, starting from the connectivity network of each subject, regression models were built using the edges as features to predict IQ scores. The results have shown the presence of a correlation, although weak, between the strength of the connections and the intelligence score, but also how this value can be greatly affected by the presence of motion artefacts and experimental choices. The same framework was applied also to predict personality traits, to investigate the neural correlates of psychometric models currently adopted in personality psychology.