UNIVERSITA' DEGLI STUDI DI GENOVA
DIPARTIMENTO DI INFORMATICA, BIOINGEGNERIA, ROBOTICA E INGEGNERIA DEI SISTEMI
CORSO DI LAUREA MAGISTRALE IN BIOINGEGNERIA

Dibris

Scheda di Offerta Tesi

Titolo (provvisorio): Investigating the frequency properties of meso-scale structure using ultra-high field functional MRI (Magnetic Resonance Imaging)

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Descrizione

Motivazione e campo di applicazione

Functional connectivity (FC), that is the statistical association among neural signals of separate brain regions, has been widely recognized as a tool to investigate spatio-temporal properties of brain networks [1]. These networks have been characterized at various levels of the topological organization, ranging from local (single brain area or node) to global (whole-brain network), through the intermediate level, referred to as meso-scale. The single unit of the meso-scale architecture is a â€œcommunity,â€• which is composed by a set of nodes sharing similar connectivity patterns.

Obiettivi generali e principali attività

Several algorithms have been applied to brain networks [2] to reveal the properties of the meso-scale. However, how the meso-scale organizes across the frequency bands in functional MRI (fMRI) recordings is not fully addressed. The fMRI bands are usually defined as: Slow-5 0.01-0.027 Hz, Slow-4 0.0.27- 0.08 Hz, Slow-3 0.08 - 0.198 Hz, Slow-2 0.198 - 0.326 Hz), and the typical band 0.01-0.08 Hz. Moreover, Slow-5 and Slow-4 bands are associated with different brain areas [4] and they are sensitive to changes caused by diseases [5]. Altogether, these evidences suggest that the meso-scale structure and its frequency-specific organization can be exploited to i) better understand the physiological mechanisms underlying oscillatory brain activity and ii) investigate the pathophysiological mechanisms underlying altered brain activity in neurological disorders.
Finally, within this project, an MRI ultra-high field dataset (7T) will be available for both a population of stroke subjects and of age- and gender matched healthy subjects. 7T MRI has recently received clearance for use in clinical population [5], and hence the MSc student will have the chance to work with this unique and new dataset. In sum, the objectives of the project are:
1) the characterization of the frequency-specific meso-scale structure properties during both resting state and task fMRI.
2) to compare the meso-scale structure in a group of stroke subjects and of age- and gender-matched healthy subjects.

References:
[1] Reid, A. T., Headley, D. B., Mill, R. D., Sanchez-Romero, R., Uddin, L. Q., Marinazzo, D., ... & Cole, M. W. (2019). Advancing functional connectivity research from association to causation. Nature neuroscience, 22(11).
[2] Garcia, J. O., Ashourvan, A., Muldoon, S., Vettel, J. M., & Bassett, D. S. (2018). Applications of community detection techniques to brain graphs: Algorithmic considerations and implications for neural function. Proceedings of the IEEE, 106(5).
[3] Gohel, S. R., & Biswal, B. B. (2015). Functional integration between brain regions at rest occurs in multiple-frequency bands. Brain connectivity, 5(1).
[4] Zhao, Z., Tang, C., Yin, D., Wu, J., Gong, J., Sun, L., ... & Fan, M. (2018). Frequency?specific alterations of regional

homogeneity in subcortical stroke patients with different outcomes in hand function. Human brain mapping, 39(11).
[5] Cosottini, M., & Roccatagliata, L. (2021). Neuroimaging at 7 T: are we ready for clinical transition? European Radiology Experimental

Obiettivi di apprendimento (strumenti tecnici e analitici, metodologie sperimentali)

1)To learn how to use software packages for neuroimaging analysis.
2)To learn and apply community detection algorithms in the context brain network: e.g., Weighted Stochastic Block Model, Modularity Maximization, Spectral Clustering, among others.
3)To learn statistical tools for meso-scale structure comparison across frequency bands and between populations.
4)To improve knowledge in the field of human and network neuroscience.
Software tools: Python, MatLab, neuroimaging packages (FSL, FreeSurfer, SPM, AFNI), Unix-based operating systems, bash scripting.

Luogo/i in cui si svolgerà il lavoro: Norwegian University of Science and Technology

Informazioni aggiuntive

Numero massimo di studenti: 1