Identifying Predictive Features in Brain Connectome Data

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Brain Connectome Data

What is brain connectome data?

Brain networks can be described as graphs where edges are between regions that "fire together".

- fMRI measures activation of voxels over time
- Calculate time dependent activation correlations
- Pick threshold correlation to define "fire together"
- Create graph

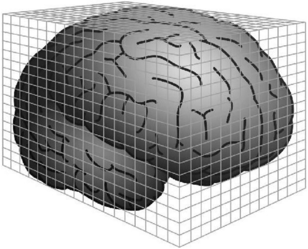


Figure 1-7: The human brain divided into voxels

(1)

Goals

Our goal is to find **novel features** of the connectome that can predict various behavioral, psychological, and demographic information.

E.g. Can we predict whether a participant is male or female from their connectome data?

Our analysis is partitioned into two themes:

- **local** connectome features (via motifs)
- **global** connectome features (via persistent homology)

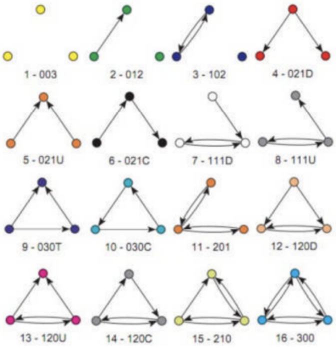
Motifs

Motifs: Sub-graphs that occur more often than would be expected in a random graph

- Triangle graph in social networks
- Triad motifs predict conscious state⁽²⁾

Motifs are going to be a proxy for local structure.

- Frequency of particular motifs
- Proportion of structural-function motifs



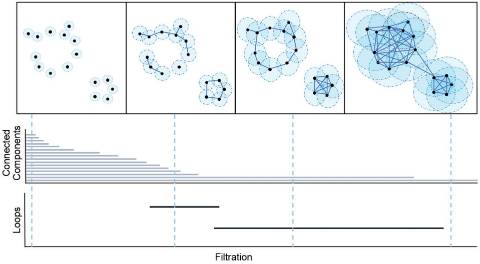
(3)

Persistent Homology

We want to learn how to abstract the global connectivity for graph learning

Process

- obtain time series data of fMRI scans
- construct graphs for each data set
- construct the node representation vectors
- identify a proper filtration
- apply persistent homology methods to obtain persistent bar codes → help expose significant features



(4)

References

(1) Barrett, L. F. (2017). How emotions are made: The secret life of the brain. Houghton Mifflin Harcourt.
(2) Duclos, C., Nadin, D., Mahdid, Y. et al. Brain network motifs are markers of loss and recovery of consciousness. Sci Rep 11, 3892 (2021). https://doi.org/10.1038/s41598-021-83482-9
(3) Braines, D., Felmlee, D., Towsley, D., Tu, K., Whitaker, R. M., & Turner, L. D. (2018). The role of motifs in understanding behavior in social and engineered networks. In J. Llinas, & T. P. Hanratty (Eds.), Next-Generation Analyst VI [106530W] (Proceedings of SPIE - The International Society for Optical Engineering; Vol. 10653). SPIE. https://doi.org/10.1117/12.2309471
(4) Ryu, N. L. and H. (n.d.). The shape of things: Topological Data Analysis. CHANCE. Retrieved June 5, 2022, from https://chance.amstat.org/2021/04/topological-data-analysis/

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