Docket #: S21-295

NeuMapper: a scalable computational framework for modeling brain dynamics

Stanford inventors have created a novel, interactive, highly scalable computational approach for representing dynamic brain activity as a network for use in clinical settings.

Neuroimaging is essential to understanding human brain function in health and disease. Clinicians and researchers generate large volumes of neuroimaging data from various modalities, including fMRI, that require extensive processing to be interpretable. Therefore, it is necessary to develop computational tools to create simple representations from complex, high-dimensional neuroimaging data. These simple representations can then be utilized in research and clinical settings. Previously, Stanford inventors developed an approach using the Mapper algorithm from topological data analysis (TDA) to generate these simple representations for neuroimaging data (Saggar et al. 2018; Geniesse et al. 2019; Saggar et al. 2022).

In this current method, Stanford inventors sought to extend the capabilities of their previous work and its applications to large-scale neuroimaging datasets (Geniesse, Chowdhury, and Saggar, 2022). They modified the underlying algorithm—improving its scalability and simplifying parameter selection—to accelerate and enable applications involving high-dimensional neuroimaging data. The new, scalable Mapper algorithm can create interactive network representations of dynamic brain activity data. It is also capable of operating on large repositories of high-dimensional neuroimaging data (i.e., thousands of individuals' full-length scans). They also developed new analytical tools for annotating and extracting neurobiological and behavioral insights from the generated representations, including a new way to compare different representations using techniques from optimal transport theory. Hence, they hope to facilitate the translation of precision neuroimaging to clinical settings—by enabling the fast construction of interpretable and interactive representations of individuals' data.

Stage of Development
Proof of concept

Applications

- Generates an interpretable report from a functional brain scan.
- Suggests features of clinical significance to the psychiatrist, along with a clear decision path leading to these features.

Advantages

- It is a scalable, nonlinear Mapper algorithm that can operate on large data repositories.
- It improves on an existing algorithm (from TDA) and a previous approach (using TDA) to neuroimaging data analysis.

Publications

- Geniesse, C., Chowdhury, S., & Saggar, M. (2022). NeuMapper: A scalable computational framework for multiscale exploration of the brain's dynamical organization. Network Neuroscience, 6(2), 467–498.
- Geniesse, C., Sporns, O., Petri, G., & Saggar, M. (2019). Generating dynamical neuroimaging spatiotemporal representations (DyNeuSR) using topological data analysis. Network Neuroscience, 3(3), 763–778.
- Saggar, M., Shine, J. M., Liégeois, R., Dosenbach, N. U., & Fair, D. (2022). Precision dynamical mapping using topological data analysis reveals a hub-like transition state at rest. Nature Communications, 13(1), 4791.
- Saggar, M., Sporns, O., Gonzalez-Castillo, J., Bandettini, P. A., Carlsson, G., Glover, G., & Reiss, A. L. (2018). Towards a new approach to reveal dynamical organization of the brain using topological data analysis. Nature Communications, 9(1), 1399.

Patents

- Published Application: 20230112375

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