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New machine-learning approach improves ability to predict long-term brain activity based on fMRI data FREE

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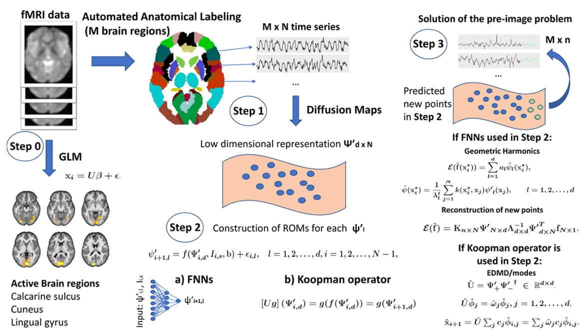
Model reduces the “curse of dimensionality” inherent in many brain-related machine learning models.



Discovering, understanding, and modeling the mechanisms that govern brain activity is one of the biggest challenges in cognitive neuroscience. Machine learning is useful for this task, but many models are afflicted with the “curse of dimensionality.” Brain imaging techniques, like fMRI, require the model to learn millions of spatiotemporal features.

Gallos et al. developed a machine learning methodology that relaxes the curse of dimensionality, enabling scientists to accurately predict long-term brain activity in specific brain regions with little or no a-priori information about the so-called regions of interest (ROI).

The team’s method combines physics, data, and numerical analysis to construct models of brain activity that require far fewer dimensions than traditional models. The new approach provides accurate long-term predictions and outperforms other traditional modeling approaches that often fail when processing high-dimensional data like fMRI outputs.

“Our methodology finds the dimension of the latent (low-dimensional) space of the emergent brain activity and constructs interpretable reduced-order models, thus predicting/discovering brain activity on specific brain regions,” author Constantinos Siettos said.

The team’s approach consists of three stages. Using a manifold learning technique called diffusion maps, the they identified low-dimensional spaces, or representations of brain activity data, which can be accurately described by a few observables. These coordinates are then used to construct machine-learning models with reduced dimensionality and then used to make predictions in a higher-dimensional fMRI space using advanced numerical analysis techniques.

Siettos believes the team’s methodology may trigger further developments in brain modeling that remove the computational limitations of deep-learning models.

Source: “Data-driven modelling of brain activity using neural networks, diffusion maps, and the koopman operator,” by Ioannis K. Gallos, Daniel Lehmberg, Felix Dietrich, and Constantinos Siettos, *Chaos* (2024). The article can be accessed at https://doi.org/10.1063/5.0157881.