“TopoDINO: Self-Supervised Topological Representation Learning for Neuronal Morphologies”

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Abstract:

Neuronal cell types are categorized by transcriptomic identity, yet their morphological heterogeneity defies this classification. In response, researchers have turned to unsupervised graph representation learning to uncover this morphological variability. However, the complex geometry of neuronal morphology—especially long axons and dense dendrites—challenges graph neural networks, which struggle with message propagation across extended structures. To mitigate this, current approaches enforce sub-sampling on neuronal graphs and omit axons entirely, sacrificing critical biological features for computational efficiency. To overcome this trade-off, this thesis introduces TopoDINO, a self-supervised topological representation learning model that captures the full hierarchical structure of neuronal morphology. Rather than relying on simplified graph approximations, TopoDINO exploits a novel topology-lifting method to transform neurons from directed graphs to combinatorial complexes to capture the inherent hierarchical features of neurons. As a result, TopoDINO provides a biologically grounded embedding space, allowing researchers to explore neuronal structure with greater precision and interoperability.

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Time: 8:00 AM – 10:00 AM

Location: Zoom

Zoom Link: https://calpoly.zoom.us/my/fkurfess

Committee: Dr. Kurfess, Dr. Davidson, Dr. Pantoja