(Keynote) Investigating neurodevelopmental disorders using innovative IGA, dynamic domain expansion, local refinement and deep learning

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Abstract

Neurodevelopmental disorders (NDDs) have arisen as one of the most prevailing chronic diseases. Often associated with severe adverse impacts on the formation of vital central and peripheral nervous systems during the neurodevelopmental process, NDDs are comprised of a broad spectrum of disorders such as autism spectrum disorder, attention deficit hyperactivity disorder, and epilepsy, characterized by progressive and pervasive detriments to cognitive, speech, memory, motor, and other neurological functions in patients. However, the heterogeneous nature of NDDs poses a significant roadblock to identifying the exact pathogenesis, impeding accurate diagnosis and the development of targeted treatment planning. To tackle this challenge, we introduce a novel neuron growth model utilizing the phase field method coupled with tubulin and synaptogenesis concentration to model intricate neurite outgrowth and disorders using isogeometric analysis. Our model leverages dynamic domain expansion to efficiently expand the domain based on outgrowth patterns to minimize degrees of freedom. Developing upon truncated T-splines, our model adeptly simulates complex neurite structures on coarse mesh while preserving accuracy by applying local refinements only to the cell boundary. Furthermore, we conduct thorough investigations into the functional role of various parameters affecting the neurodevelopmental processes with comparison to experimental results. This parameter study enhances our fundamental understanding of the mechanisms underlying these disorders, paving the way to more effective treatment planning. We also incorporate convolutional neural networks to expedite prediction efficiency for disorder studies.

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