Workshop on Experimental and Computational Fracture Mechanics
March 4-6, 2024, Baton Rouge, LA

INTEGRATED CONVOLUTIONAL AND GRAPH NEURAL NETWORKS TO ADVANCE COMPOSITES ANALYSIS

Maryam Shakiba, Marwa Yacouti

ABSTRACT

This paper introduces CompINet, an innovative approach that leverages two deep neural network architectures to predict stress distribution within microstructural representations of complex composites. Analyzing local mechanical fields such as stress in these composites is crucial for predicting performance, failure, or comprehending repair mechanisms. Our method combines a graph neural network and a convolutional network to predict both linear and nonlinear von Mises stress distributions within microstructural representations of fiber-reinforced composites. Inspired by the microstructural representation's intricacies, particularly the locations of the fibers and the distances separating them, CompINet exploits the power of graph neural networks. The critical role of the fiber's nearest neighbor distances in shaping linear and nonlinear stress responses within the composite's microstructure motivates our unique integration. The trained framework demonstrates exceptional predictive accuracy for mechanical fields at the microscale, while concurrently surpassing the computational efficiency of existing high and low-fidelity methods. Our approach is an unprecedented advancement in the field, promising to significantly enhance the analysis of complex composites, leading to more innovative and efficient designs for emerging applications.