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Nonlocal deep material network for material constitutive models with damage

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Abstract

The Deep Material Network (DMN) has emerged as an efficient surrogate model for replacing direct nonlinear finite element analyses of heterogeneous material volume elements. Its strong extrapolation capability in both loading range and constitutive behaviour broadens its applicability. However, existing DMN applications do not account for material damage. In a DMN, basic material phases are represented by the leaf nodes, while the effective heterogeneous response is obtained at the root or material node through a sequence of interaction operations across intermediate layers. When damage variables are introduced at the leaf nodes, damage tends to localize within a single node, leading to numerical instabilities. Moreover, the influence of this localized damage diminishes as it propagates through the network, resulting in an unreliable homogenized response. To address this limitation—analogous to the challenges faced in finite element analyses with local damage—we propose a discrete non-local damage formulation within the DMN framework. This approach enhances numerical stability when damage initiates at leaf nodes and enables the network to produce a more robust and reliable homogenized material response. This project has received funding from the European Union's Horizon Europe Framework Programme under grant agreement No. 101056682 for the project ''DIgital DEsign strategies to certify and mAnufacture Robust cOmposite sTructures (DIDEAROT)''. The contents of this publication are the sole responsibility of ULiege and do not

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