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Buckling analysis of truss structures based on deep learning

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ABSTRACT

In this study, we propose a deep learning based truss finite element capable of representing buckling behavior. Under extreme loads, members of a truss structure experience buckling. However, conventional truss elements cannot represent buckling. To consider buckling, beam finite elements must be used, but this requires more degrees of freedom than when using truss elements. Additionally, nonlinear analysis of complex truss structures often faces convergence and efficiency challenges. To address this, we model individual truss members with beam elements and perform nonlinear buckling analysis. The resulting axial force-deformation data is used to train an artificial neural network. This enables the development of a deep learning based element that predicts truss behavior under various loading conditions. In finite element analysis, truss elements requiring nonlinear analysis are replaced with pre-trained machine learning elements, reducing degrees of freedom while improving computational efficiency. Since the proposed element directly generates stiffness and internal forces without iterative computations, it enhances both convergence stability and analysis speed compared to conventional nonlinear methods.

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