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Neural Network-Based Constitutive Model for Solid Materials

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Constitutive models have been utilized to study the mechanical behaviors of solid material. The formulation of constitutive relations is difficult and could be associated with limiting hypothesis. In recent years, machine learning techniques have shown promising capabilities for capturing material behavior [1][2]. This work proposes novel neural network-based approaches to reproduce the complex nonlinear constitutive relations of solid materials including elastic behavior, plastic deformation and damage mechanism. A history-based strategy has been suggested using an artificial neural network for training path-dependent inelastic behavior. The network development is based on a general internal variable formalism. The number of selected internal variables is linked to the problem and degree of accuracy.

It is shown that the proposed methodology can represent exactly the von Mises elastoplastic material model in uni-axial stress state. The strategy was applied to sequences of training and validation data which were generated numerically for elastoplasticity with and without hardening as well as for elastoplastic damage. The results have been compared against established mathematical models and shown a potential of describing complex non-linear solid material behavior accurately in one-dimensional and multi-dimensional space.

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