Physics augmented neural network model for simple isotropic damage in hyperelasticity

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Abstract

Neural networks in solid mechanics have come a long way from simple black-box models that fulfil a specific role. With the increasing number of different implementations, the knowledge of physics is brought into the modelling, either through the loss functions, keeping the properties of a classical neural network, or through the construction of new architectures and the implementation of new activation functions. The aim of this work is to develop a neural network model for simple isotropic damage that occurs in natural rubber and is known as the Mullins effect. In this work, a neural network architecture with a custom activation function was implemented in a specialised framework. The neural network architecture was adapted to satisfy some conditions such as the normalisation condition for energy, thermodynamic consistency, objectivity and polyconvexity. It was tested on several numerical examples with different variations of the architecture to find the best version. The result is a general approach to modelling damage in hyperelastic materials with a novel training framework for neural networks that is independent of the underlying neural network model.

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