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A DEEP LEARNING-BASED CONSTITUTIVE MODEL FOR FINITE ELEMENT ANALYSIS

Fariborz Ghavamian[1], **Angelo Simone**[2,1]

[1] Faculty of Civil Engineering and Geosciences
Delft University of Technology, Delft, the Netherlands
f.ghavamian@tudelft.nl, a.simone@tudelft.nl

[2] Department of Industrial Engineering
University of Padova, Padua, Italy
angelo.simone@unipd.it

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A deep learning model is simply a function that maps a given input to a desired output. In spite of the simple nature of a deep learning model, over the past decade it has revolutionized natural language processing (NLP) and image understanding (IU). One can name three fundamental reasons to explain this astonishing accomplishment: 1) availability of large amount of data for NLP and IU over the past decade; 2) the fact that the performance of a deep learning model keeps increasing by increasing the training data (unlike other machine learning models); and 3) the recently available hardware and software infrastructures which are tailored for deep learning.

In this contribution we leverage the power of deep learning to construct a deep learning-based constitutive model. More specifically, we develop a novel neural network architecture which is tailored for simulations of history-dependent material behavior, and we discuss its implementation in a finite element model.

A possible application of this deep learning-based constitutive model is to serve as an efficient surrogate to a representative volume element (RVE) in a multi-scale finite element analysis. In this application large amount of training data can readily be generated from the RVE. As a proof of concept, we train our deep learning model on a set of data collected from a viscoplastic constitutive model and employ it a finite element model. Through numerical experiments we show that the structural level response of the finite element model is adequately approximated when using the deep learning-based constitutive model in place of the viscoplastic one.