24th SIAM Conference on Uncertainty Quantification (UQ24)
Trieste, Italy, 27 Februrary - 1 March 2024

A Gradient-Enhanced Neural Network as a Surrogate for Elastoplastic Finite Element Analysis

A.O.M. Kilicsoy, J. Liedmann, M.A. Valdebenito, F.-J. Barthold, M.G.R Faes

Key words: neural network, gradient-enhanced, uncertainty quantification, linear and non-linear elasticity, finite element analysis

ABSTRACT

When performing uncertainty quantification or optimization of an observed system, it is often necessary to evaluate the associated response repeatedly. This task can be solved by using complex numerical representations like finite element models, which can become time consuming and computationally expensive. Artificial neural networks show to be appropriate surrogate models for such repeated evaluations as well, thereby providing an alternative to the complex numerical models. In general, artificial neural networks are constructed using function values paired with input values during supervised training. When incorporating sensitivity information w.r.t. certain model parameters of these observed systems, additional gradient data is available. Thus, this contribution focuses on how to exploit the additional gradient information to train neural networks. The method of including gradient data into an artificial neural network follows by augmenting the inherent loss function used during training of the network model. Doing so, the supervised training process pairs function values and gradient values to input values. When taking advantage of this additional gradient data, the training and final performance of these gradient-enhanced artificial neural networks can be improved. The results show that gradient-enhanced artificial neural networks outperform the basic artificial neural networks during training, with better accuracy and quicker convergence of the training process.