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PHYSICALLY-GUIDED NEURAL NETWORKS WITH INTERNAL VARIABLES IN SOLID MECHANICS: FAST PREDICTIONS AND CONSTITUTIVE EQUATIONS DISCOVERY

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Complex nonlinear materials present some challenging issues when modelled using classical approaches such as the Finite Element Method. Although many nonlinear models have been proposed for modelling elastic and inelastic solids in the last decades, model selection and parameter identification and fitting are very expensive and time-consuming processes, which rely on data obtained under very specific and controlled lab tests.

Today, in the era of data and the Internet of Things, data is more characterized by its quantity than by its quality and structure. With the advent of machine learning tools, science has progressed to extract relevant information from available unstructured data, thus allowing to make predictions with incredible accuracy [1]. In particular, artificial neural networks have arisen as powerful tools to deal with nonlinear problems, when enough data is available, although they suffer from the inherent lack of explanatory capacity of "black-box" models.

Here, we exploit the recent concept of Physically-Guided Neural Networks with Internal Variables (PGNNIV) [2] in solid mechanics. PGNNIV enable the addition of physically meaningful constraints to deep neural networks from a model-free perspective, thus resulting in fast predictions of external and specially internal variables. Furthermore, due to their model-free character, there is no need for prescribing specific material models, in comparison to the Finite Element approaches. This way, we incorporate explanatory capacity, placing the method in what is known as Explainable Artificial Intelligence (XAI).

REFERENCES

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