The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

A machine learning based approach to predict the stress intensity factors in 2D linear elastic fracture mechanics

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Key Words: *Machine learning, neural network, fracture mechanics, stress intensity factors, Physics-informed neural network*

Within the framework of linear elastic fracture mechanics, the stress intensity factors (SIFs) are the mostly applied crack-tip characterizing parameters. To obtain the SIFs, approximate formulae are widely used because exact analytical solutions are available only for very simple geometrical and loading configurations [1]. However, even approximate solutions for SIFs are also rather limited to very simple geometrical and loading conditions. In this work, an accurate and efficient SIF prediction model based on Physics-informed neural network (PINN) [4] is developed, where we incorporate the equilibrium equations and constitutive relations into the PINN. In order to capture the singular behavior of the stress and displacement fields around the crack-tip, we extend the standard PINN structure by including the crack-tip asymptotic functions such that the singular solutions at the crack-tip region can be modeled accurately. Then the enhanced Physics-informed neural networks are trained to satisfy the governing equations and the corresponding boundary conditions.

REFERENCES

[1] Gross, D.; Seelig, T. Fracture Mechanics: With an Introduction to Micromechanics, *Springer Verlag*, 2. Edition, 2011.
[2] Liu, X.; Athanasiou, C. E.; Sheldon, B. W.; Gao, H. A machine learning approach to fracture mechanics problems. *Acta Materialia*, Vol **190**, 2020, pp. 105-112.
[3] Zhu, N.; Oterkus, E. Calculation of stress intensity factor using displacement *Ltd,* extrapolation method in peridynamic framework, *Cambridge University Press*, 2020.
[4] Raissi, M., Perdikaris, P. & Karniadakis, G. E. Physics-informed neural networks: a deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. *J. Comput. Phys*. 378, 2019, pp. 686–707.