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Damage detection in isotropic cracked rod via fusion of genetic algorithm with deep learning-based wave propagation simulators

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Structural damage and deterioration of structures forms a primary engineering problem as such process can often cause catastrophic failures. The objective of structural health monitoring (SHM) is to identify anomalies or damages such as cracks, delaminations, etc. in structures. A number of SHM techniques exist for damage detection, such as vibration-based SHM, electromechanical impedance-based SHM, guided wave (GW)-based SHM, etc. The GW-based technique offers a number of advantages because of its high sensitivity to small defects and large area scanning. Damage detection is an inverse problem, in which the damage needs to be detected using the measured input and output signals. The conventional calculus-based search techniques use gradients, which can not handle problems having a finite number of discontinuities or functions with many local maxima or minima. But, genetic algorithms (GAs) can handle such problems without getting locked into a local optimum configuration. Damage detection in the form of an inverse problem can be performed using stochastic and evolutionary optimization methods, such as the GA, which is based on the principles of natural selection and genetic evolution.

In this research, elastic wave propagation emulated by a deep learning-based model is used as a tool for damage detection.The GA employs the deep learning-based simulator for multiple solutions of the forward problem. Our deep learning-based model is found to outperform traditional numerical solvers. Thus allowing low computational cost of damage detection, using GA as an optimization, with good accuracy.