Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

Case ID:M22-278P
Published: 3/8/2023

Inventors

Yongming Liu

Contact

Physical Sciences Team

Fracture Pattern Prediction with Random Microstructure using Deep Neural Network

Material fracture failure is a critical issue for many engineering structures and components. Accurate fracture prediction is necessary to ensure the safety of these structures and components. The finite element method (FEM) is a widely used approach for material mechanical modelling; however, FEM is known to have difficulties in solving problems involving spatial discontinuities, such as fracture and material interface. Recently, lattice particle method (LPM) is being used and is suitable for discontinuous problems.

Material fracture simulation intrinsically includes both a linear (elastic) stage and a nonlinear (crack propagation) stage. In order to solve the nonlinear stage, integration of incremental algorithms with LPM is needed, i.e., LPM tracks nonlinear deformation using many time steps and iterations. Thus, LPM demands a high computational cost and, considering the large number of particles required to obtain accurate fracture simulation, is time consuming. Deep learning is being used by material and mechanical scientists for material reconstruction and material property prediction. For material fracture problems, most researchers have applied deep learning to predict fracture parameters, such as fracture energy and stress intensity factor. However, very few works have been done to predict fracture patterns using deep learning.

A researcher at Arizona State University has developed a method for modeling material mechanics, particularly for predicting fracture patterns, using deep learning methods for applying lattice particle method (LPM). This method incorporates heterogeneous random microstructure information where previous works in this field focused solely on homogeneous materials. Random microstructure information promotes random crack initiation and crack patterns, which are more challenging to predict. Also, prior methods for predicating fracture patterns are purely data driven and require numerous training data to achieve predictions. This method can be tuned using less training data and less training epochs by leveraging physics knowledge from constraints and linear elastic responses of the system.

Related publication: Fracture pattern prediction with random microstructure using a physics-informed deep neural networks

Potential Applications:

- Material fracture prediction
- Material fracture simulation
- Material mechanical modeling

Benefits and Advantages:

- Reduction in computation time and in training time
- Utilizes strengths of lattice particle method (LPM) and deep learning methods for material fracture simulation by having:
- LPM determine linear (elastic) stage; and
- Deep learning method determine nonlinear (crack propagation) stage