Physics-informed neural network for structural engineering

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Kyoto University, Dept. of Civil and Earth Resources Eng., Chul-Woo Kim, kim.chulwoo.5u@kyoto-u.ac.jp

Purpose

Develop physics-informed machine learning platform to solve partial differential equations of solid mechanics without labeled dataset, import three-dimensional object to simulate complicated shapes

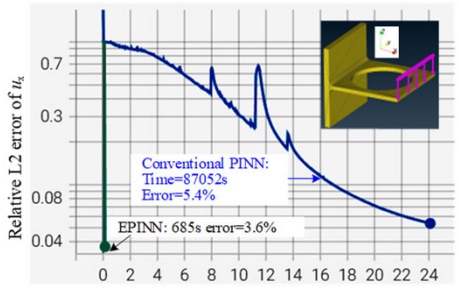
Outline

Proposed Exact Dirichlet boundary Physics-informed Neural Network (EPINN) platform for solving partial differential equations in solid mechanics based on Principle of Least Work

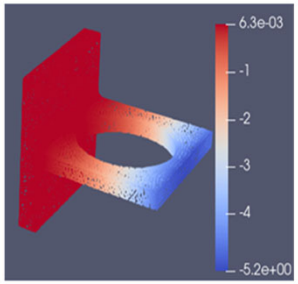
Result

Developed EPINN with more than 100 times speedup compared to conventional physics-informed neural network (PINN) in solid mechanics problems and reaching the simulation speed of conventional finite element solver. Developed Auto Machine Learning for EPINN algorithm to reduce error.

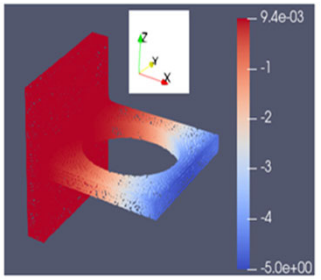
Computing system:	SQUID GPU nodes
node-hour	1200 node hours
memory used	320 GB (GPU memory)
parallelize	1 node with 8 GPUs



(a) Learning curves of 3D solid mechanics problem



(b) Finite element vertical deform (time=1140s, benchmark)



(c) EPINN vertical deform (time=685s, error=3.6%)

Comparison between Finite Element solution and EPINN model