Fourier Neural Operator for Mode Shape-Based Damage Identification

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【Background】

Structural Health Monitoring (SHM) is vital for ensuring the safety and longevity of civil infrastructures. Among different methods, modal parameter-based methods have been a heated topic for a long time. However, they often face challenges due to low-resolution modal data, sparse sensor networks, and measurement noise, which impede accurate localization and quantification of structural damage.

【Objective】

- Applying Fourier Neural Operator to extract the hidden damage information from mode shape changes.
- Designing data enhancement algorithms to super-resolve mode shape data and enhance feature extraction ability.

【Approach】

To address these issues, this research proposes an integrated, data-driven framework that combines a Multi-Branch Convolutional Neural Network Super-Resolution (MB-CNNSR) module with a Modal-Stiffness Fourier Neural Operator (MS-FNO). The MB-CNNSR module reconstructs high-resolution mode shape data from coarse measurements, while the MS-FNO learns the mapping from the modal response field to the stiffness field, enabling precise damage identification

【Publication plan】

- IABSE 2025
- R7 JSCE Annual Conference
- CACIE or MSSP

【Results】

The MS-FNO achieves high accuracy for damage identification in different tasks. The MB-CNNSR module can upscales coarse sensor data, and the resulting high-resolution data is used to validate the MS-FNO model. Results demonstrate that the method accurately reconstructs stiffness loss distributions even under complex damage patterns.