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Damage detection using ANN supported FEM

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【Background】

Structural integrity of engineering structures such as bridges and buildings exposed to man-made and natural environments is constantly changing due to various factors. However, even with improvements in computing and sampling methods, updating the complicate FE model with higher degrees of freedom is time consuming. The large uncertainties can lead to large discrepancies between the measured physical response and the response from FEA, which can reduce the reliability of the predictions.

【Objective】

This study proposes a method aiming to avoid updating the FE model, reduce the amount of FE calculation, and increase the validity of the prediction. The artificial neural network (ANN) is adopted to solve the problem of inconsistency between results of FEA and observed data. The dynamic response of displacement is used to detect the damage on the bridge.

【Approach】

In this study, an ANN for damage detection is trained by FEA results. A scaling operator independent from FE model and ANN is developed to handle the discrepancy between the FEA and the observation. It consists of a kernel and a Hadamart operator. When the damage occurs, it will also be updated for the new damage state. A method of obtaining dynamic response of displacement by accelerometers is also discussed which is more practical in engineering.

【Publication plan】

- Engineering Structures
- ASCE

【Results】

The accuracy of damage detection is more than 90% when the training of ANN is stopped at the 23rd epoch. By updating the scaling operator, the ANN successfully detect the new damage on the bridge with an accuracy of over 95%.

Dynamic response of rotation angles is obtained from horizontal acceleration. Constrained least squares is used to generate the dynamic response of displacement. The result and the observed displacement are in high agreement. Using accelerometers to obtain dynamic response of shape is expected to be an option in displacement-based damage detection.