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Damage detection using CVAE 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. Many studies have realized the mapping from structural parameters to damage conditions by training neural networks. However, in practical engineering, the inverse of the above process is equally important. The Conditional Variational Autoencoder (CVAE) is adopted to solve the problem.

【Approach】

In this study, an CVAE for damage detection is trained by FEA results. Through training the encoder, the mean and variance of the sample is obtained. Assuming this posterior distribution of them follows a normal distribution, the generator can reconstruct the sample itself from the distribution. If the damage situation is considered as the latent layer, we can then achieve targeted training of neural network.

【Publication plan】

- Engineering Structures
- MSSP

【Results】

This study investigates a method that estimates displacement using only acceleration data. The deformation could be used for damage detection, aiming to improve existing FEM model updating methods. This study solves the problem by establishing a mapping called scaling factor to map the real data set to the result generated by the FEA. In this way, CVAE can also be used for damage detection on real data.

CVAE is trained by minimizing the KL divergence, so that the targeted training of neural network could be achieved. The encoder could achieve the damage detection by showing different damage conditions occupy different spatial locations in the latent layer. The decoder could achieve displacement estimation under certain damage condition.