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Finite Element Model Updating for a Suspension Bridge Using Deep Neural Networks

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1 Abstract

The finite element model for the performance evaluation of an existing structure should be able to accurately reflect the current state of the structure. As one of popular methods, the dynamic finite element model update finds the optimal parameters for the finite element model closest to the measured modal frequencies and shapes by using error minimization procedures. In this study, we propose a new method to construct an inverse eigenvalue problem that can directly obtain the parameters of the finite element model from the measurement modal information by developing a deep neural network to solve the inverse eigenvalue problem quickly and accurately. The solution of the inverse eigenvalue problem is obtained by using the mode frequencies and shapes measured as the input of the network and using the corresponding model parameter as the output. As an application example of the developed method, the dynamic finite element model update of a suspension bridge for given response data is presented. Unlike the existing update method based on the optimization procedure, this method can be updated in real time, and various update solutions considering the measurement error can be easily obtained.

Keywords: finite element model updating; deep neural networks, inverse eigenvalue problem, suspension bridge.

2 Introduction

As the importance of maintenance and performance evaluation of large bridge structures grows, there is a growing need to develop accurate computational models for the structures. For this purpose, the finite element modelling is currently the most popular and effective way to express the geometrical, mechanical and physical properties of the structural system. In fact, almost all recent bridge structures are designed and constructed based on finite element analysis. However, in general, the design stage finite element analysis model does not accurately represent the bridge structure of the present state after the construction because it was developed mainly for design purposes assuming ideal or conservative conditions rather than actual conditions. For example, the stiffness of a design model is often underestimated by ignoring nonstructural elements, and the change of mass due to repair and maintenance works are

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