Topology optimization approach for dense sensor network distribution over large bridge structures

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ABSTRACT

Recent progress in microelectronics and measurement techniques allows a growing number of critical infrastructures to be equipped with Structural Health Monitoring (SHM) systems. Such SHM systems often consists of multiple measurement channels of different kinds of sensors, examples of which can be displacement transducers, strain gauges or accelerometers.

Sensors in such systems should be placed in a proper way to facilitate extracting valuable information from the structure under investigation. In the case of relatively simple spatial truss structures, sensors can be located with the aid of the Effective Independence (EI) method proposed by Kammer [1]. However, in the case of large structures, which are intended to be equipped with hundreds if not thousands of sensors, other sensor placement methods may be needed. Recently, a promising idea of utilizing a topology optimization approach for the purpose of sensor placement has been proposed by Mariani et al. [2]. The goal of this study is to extend their method, which has been verified on a plate structure, to the case of a FE model of a real arch bridge structure consisting a few thousands degrees of freedom.

A successful structural damage identification is determined by three inseparably coupled factors: damage locations and their intensities, sensor location and the applied force excitation (location and time variation). On the other hand, there are techniques that utilize modal parameters (e.g., the aforementioned EI method) and which are useful for unknown (or hard for measuring) excitation forces. In this work, both scenarios are numerically explored. The effectiveness and the results obtained by the topology based optimization are compared with an alternative technique.

The main goal of structural topology optimization is to find the optimum material distribution in order to minimize the mass of the structure while maintaining mechanical properties (load capacity, displacement in certain point, etc.). A similar concept can be used to determine the optimal placement of sensors in a structure to detect potential damage. It is difficult to place sensors in each element. Therefore, a subset of elements has to be determined for which the ability to detect the occurring damages is maximal. The search is based on the difference in the state of deformation for a damaged and undamaged structure. Several numerical examples will be presented in the paper.

REFERENCES

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