FE model updating: sensitivity, reliability and regularization issues

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Combining ambient vibration monitoring and finite element (FE) modelling through suitable model updating procedures allows for obtaining an estimate of the boundary conditions and mechanical material properties of engineering structures [1]. Application of FE model updating to historical buildings is relatively recent and involves the solution of a constrained minimum problem, whose objective function is generally expressed as the discrepancy between experimental and numerical quantities, such as natural frequencies and mode shapes [2], [3].
The paper presents an algorithm for FE model updating based on the construction of local parametric reduced-order models embedded in a trust-region scheme and implemented in NOSA-ITACA, a non-commercial FE code developed by the authors [4], [5], [6]. The algorithm exploits the structure of the stiffness and mass matrices and the fact that only a few of the smallest eigenvalues have to be calculated. This new procedure enables to compute eigenvalues and eigenvectors cheaply and thus to solve the minimum problem very efficiently. Besides reducing the overall computation time of the numerical process and enabling the accurate analysis of large scale models with little effort, the proposed algorithm allows for getting information on both the reliability of the solution and its sensitivity to noisy experimental data. Some case studies are presented and discussed and the adoption of regularization techniques to recover meaningful solutions investigated.

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