Inverse Analysis investigation by Gaussian Processes optimisation of a historical concrete bridge relying on dynamic modal measurements

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Abstract

In the broad field of Inverse Analysis and Structural Identification, it is nowadays of a large interest the study of Gaussian Processes, as a reliable and efficient optimisation method, particularly helpful toward the identification of a global optimum point, under the conditions of complicated functions to be optimised (see, e.g., [1]-[2]). In the present contribution, a specific case study is considered, focusing on a historical road three-span reinforced concrete arch bridge, located in Northern Italy [3], employing dynamic modal properties, deciphered from in-situ measurements, previously acquired under operational traffic conditions, by a standard wired accelerometer system, placed just at the deck level. Aiming at identification and diagnosis of the bridge structure, three main methodological steps are herein considered: (a) the adoption of a FEM model of the structure, suitable to determine numerical counterparts of experimentally acquired data; (b) the definition of an appropriate scalar discrepancy function, as a norm vectorial difference between measured and numerically computed quantities; (c) the investigation of such a discrepancy function in order to assess its peculiar features, toward a consistent selection of an optimisation strategy for identification of sought parameters. Specifically, the FEM model of the structure is conceived, in the linear dynamic framework, to determine natural frequencies and mode shapes of the bridge, as functions of material parameters (Young's moduli and mass densities) of diverse elements of the structure. A consistent discrepancy function is formulated taking into account both mode frequencies and shapes, from experimental and numerical estimates, suitably normalised and combined; possible improvements regarding the discrepancy function implementation are provided, introducing penalty coefficients and/or mass weighting terms. The investigation on the discrepancy function, in diverse parameter spaces, with varying dimensionality, from two to nine sought parameters, highlights the specific features of the analysed function and the possible advantages of the proposed improvements, with reference to the specific bridge structure case study, toward the development of a general methodological optimisation approach by Gaussian Processes, particularly with the aim of a global optimum search. The presented developments and results display a rather efficient perspective, with reference to the case study, toward inverse analysis for structural diagnosis, in the context of strategic infrastructures.

References

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