Automatic Modal Operational Analysis of a Long-span Suspended Bridge using Pattern Recognition

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Abstract

The present paper addresses Structural Health Monitoring (SHM) of large bridges by presenting a strategy for automatic Operational Modal Analysis (OMA) based on Stochastic Subspace Identification (SSI) combined with the machine Clustering learning algorithm. Data acquired from a set of accelerometers installed on the 25 de Abril suspended Bridge, located in Lisbon, with over 1km central span, was used to test and validate the strategy. Natural mode information along with mode complexity and collinearity features were obtained and analysed for the purpose of automatic OMA, and allowed concluding that the combination of frequencies and mode shape components were the most effective. Additionally, it was concluded that both partitioning and hierarchical clustering associated with the SSI in its covariance version are effective in identifying natural modes and in distinguishing between these and spurious ones in a fully automated manner. It was also observed that imaginary and non-collinear mode shapes, such as those observed in the case study used, can be challenging to automatic OMA strategies, but were overcome by the strategy proposed herein.

Keywords: Suspended bridge, structural health monitoring, operational modal analysis, stochastic subspace identification, clustering methods.

1 Introduction

Structural health monitoring can be defined as the development of techniques capable of identifying changes in structural systems, from data acquired on site [1–3]. Ideally, these techniques should be capable of providing, without false detections and in real-time, information with physical meaning that can be directly related with the structural condition [1,4–6]. In this context, operational modal analysis assumes great importance since it allows obtaining, in real-time, frequencies, mode shapes and damping ratios, whose values are directly dependent on the stiffness, which in turn is directly influenced by damage occurrences [7].

Strategies for identifying structural changes based on operational modal analysis have recently been the subject of numerous research works and are

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