Structural observation of long-span suspension bridges for safety assessment: implementation of an optical displacement measurement system

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Abstract. This paper addresses the implementation of an optical displacement measurement system in the observation scenario of a long-span suspension bridge and its contribution for structural safety assessment. The metrological background required for quality assurance of the measurements is described, namely, the system's intrinsic parameterization and integration in the SI dimensional traceability chain by calibration, including its measurement uncertainty assessment.

1. Introduction

Observation is an important activity in safety assessment of large structures (such as bridges, viaducts, buildings, dams, among others), contributing for their structural condition monitoring and allowing a reliable analysis of its operational performance in accordance with safety requirements and historical records, thus providing relevant information for management entities.

In the long-span suspension bridge observation context, research efforts have been geared towards the development of non-contact measurement systems, capable of determining the 3D displacement of critical regions, namely, the bridge's main span central section. Optical systems are an attractive solution for the mentioned measurement problem, particularly, for the case of metallic bridges observation, where the accuracy of microwave interferometric radar systems [1] and global navigation satellite systems [2] can be compromised, namely, by the multi-path effect resulting from electromagnetic wave reflections in the bridge's structural components.

Recently, an optical methodology suitable for long-distance measurement of suspension bridges dynamic displacement has been studied and proposed by the authors [3]. This approach is supported by the use of a digital camera rigidly installed beneath the bridge's stiffness girder, oriented towards a set of four active targets placed at a tower foundation, materializing the world referential 3D system. Provided both the camera's intrinsic parameters and the targets relative coordinates are accurately known (by previous testing), non-linear optimization methods can be used to determine the position of the camera's projection center. The temporal evolution of this quantity is considered representative of the bridge's dynamic displacement at the location of the camera.

Following the design and development stages detailed in [3], this paper describes the implementation of the system in a real observation scenario: the 25th of April long-span suspension bridge (P25A) in Lisbon (Portugal). The experimental apparatus is described and displacement results