8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

MODAL IDENTIFICATION OF STRUCTURES VIA VIDEO PROCESSING AND BLIND SOURCE SEPARATION

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Keywords: Modal identification, Video magnification, Structural health monitoring, Blind source separation, Output-only identification

Techniques of health monitoring and assessment of engineering structures by vibrational data are one of the most common methods for identifying structural damages, in which have surveyed since three decades till now.

The basic idea for damage detection based on structural dynamic among studies is variations in physical properties such as mass, damping, and stiffness due to damages that cause the modal properties, that is, natural frequencies, modal ratios and mode shapes would be detectable. Thus, variation in modal parameters of a structure implies the variation of structural health condition, i.e. damage. Therefore, experimental measurement and determination of dynamic behaviour of structure is important.

The central technique to describe the dynamic of structures is modal analysis, in which modal parameters controlling dynamic behaviour of the structure are identified.

Traditionally, wired sensors that physically attached to the structure are required in modal analysis. Employing such systems despite providing reliable measurements can cause mass loading on lightweight structures. On the other side, for structures with difficulties to access, this technique would be time-consuming and expensive as well as would require considerable repairs and maintenance. In addition, noise duo to the cables of data conveying should not be neglected. For upgrading and fixing problems about these sensors caused by cabling, some researchers have focused on wireless sensors. However, there are some problems about security and energy supply of networks. Also, these sensors are usually installed at a low number discrete location, so the spatial resolution would be low.

Therefore, researchers have recently focused on the possibility of non-contact monitoring and remote sensing techniques that can eliminate many problems of sensor networks which are sporadically distributed.

Non-contact techniques for measuring vibration, such as the measurements of displacement using laser vibrometer scan, supply the measurement ability with high spatial accuracy without sensor is directly installed on structures and mass loading is induced. Nonetheless, these measurement devices are relatively expensive and, on the other side, running successive measurements for measuring the big areas can be boring and time-consuming.

As an alternative non-contact method, using digital video cameras is relatively low-cost, fast and easy. In addition, they offer simultaneous measurements with a very high spatial resolution without exerting any extra mass on the structure. Measurements based on video camera along with image processing algorithms are successfully used for measuring vibration and modal analysis. However, despite the many benefits for these methods, there are challenges about large structures and inaccessibility duo to dependency to outward pattern and high contrast markers.

However, extensive accept of modal analysis techniques that are based on video camera, reveal the requirement to extend methods that use only video measurements without any extra preparation of surface.

Hence, phase-based algorithm is employed in this work. This algorithm does not require extra preparation of surface, and extract the resonance frequencies of structures by only measured full-field responses taken from high-speed video camera.

The process is as follows, the phase of pixels of each frame of video is extracted by a multi-scale image showing and decomposition technique. The time signal of extracted phases for each pixel code the structural vibration. In the next step, space-time data are acquired using principal component analysis (PCA) as a dimension reduction technique and modal responses are also estimated by applying blind source separation which is an output-only algorithm. In the last step, the resonance frequencies of the structure are calculated by applying Fourier transform on acquired responses.

So as to validate the presented algorithm, two examples were presented. In first example, vibration of a cantilever beam was reconstructed using MATLAB environments. In the next example, vibration of a laboratory-scale cantilever beam was recorded by a high-speed camera. Table 1 shows the consistency and accuracy of frequencies between acquired from the present algorithm and theoretical values. Experimental setup is shown in Figure 1.

(a)

(b)

Figure 1. Camera measurement, (a) experimental setup and (b) cantilever beam.

Table 1. Comparison results for modal frequencies.

Mode No.	Frequency (Hz)	
	Theoretical	Present Work
1	1.63	1.75
2	10.25	10.25
3	28.70	28.71

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