Computer vision technique for blind identification of modal frequency of structures from video measurements.

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Objective:

To extract the modal frequencies of the structure from structure’s video, by estimating the time history data of the structure, using computer vision techniques like complex steerable pyramids, and separating the modal frequencies using principal component analysis (PCA) and analytical mode decomposition (AMD).
Methodology:

1. Phase extraction of each pixel
   - Input Video
   - Image Filtering
   - Multiscale decomposition
   - Phase Extraction

2. PCA+AMD
   - PCA on motion Matrix
   - Principal component extraction
   - AMD on Principal Components
   - Modal Frequency

*Figure 1- Flowchart of proposed method*
Validation:

The proposed method is validated on a 10 DOF numerical model.

Figure 2 - Schematic representation of a 10 DOF system

New 10 channel output with 4 modes dominant is generated by Newmark Beta Algorithm.

PCA for dimension reduction → AMD for signal decomposition.
Figure 3 – Eigen Value Decomposition of covariance of motion matrix

Figure 4 – Principal coordinates of numerical model
Results of Numerical model

Table 1 – Results comparison

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<th>Mode</th>
<th>Frequency (Hz)</th>
<th>Error %</th>
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<td>4</td>
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<td>20.00</td>
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Figure 5 – Extracted modes
Implementation:

Figure 6 – Actual frame of video of London Millennium bridge, used for analysis.

Figure 7 – Cropped frame

Figure 8 – Amplitude part

Figure 9 – Phase part
Results of Numerical model

Figure 10 – Modes extracted from video of London Millennium bridge

<table>
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<tr>
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<th>Estimated Frequency (Hz)</th>
<th>Error %</th>
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Table 2 – Results comparison
Conclusion:

• This study develops a hybrid output-only OMA algorithm that uses PCA and AMD to blindly extract the modal frequencies and modal coordinates from line-of-sight video measurement of the structures.

• The 10-DOF dynamic numerical model validation and implementation on London Millennium Bridge resulted in more than 99% accuracy in detecting the modal frequencies.

• Henceforth, the recommended algorithm can be utilized for an effective non-contact OMA using a computer vision monitoring system.
Thank You