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Measurement of vibration distribution by use of a high-speed camera

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1. Introduction

Recent development of a high-speed vision system enables real-time image processing and high-frame-rate recording over 1kHz[1]. Modal analyses have been realized by utilizing such a high-speed vision system [2]. Such the measurement technique using the high-speed image processing technology is expected as new nondestructive inspection in place of the percussion.

Our goal is to realize vibration analysis with direct observation of interferometric fringes. Interferometric technique also enables visualization of a small amount of vibration distributions. Instead of recording multiple holograms [3], high-speed imaging visualizes temporal change of fringes. The purpose of this paper is to measure frequency distributions by use of a high-speed camera. Measurement of resonant frequencies of metal plates are conducted for demonstration of the proposed technique.

2. Measurement of frequency distribution

The optical configuration for vibration measurement is shown in Fig. 1. The optical configuration is based on Michelson interferometer. The light source is a He-Ne laser. The reference light and the object light that are composed through a beam splitter are focused on the imager of the high-speed camera. The interference fringes are recorded as consecutive images with a high-speed camera at a frame rate of 5000fps (frames per second). An observed interference fringe is shown at the top left in Fig. 1. The observed objects are two metal plates. They are located together within the field of view. An end of each plate is fixed on a fulcrum and the other end can be vibrated freely. It was confirmed that the resonance frequency varies according to length of the plate from the fulcrum to the free end by a preliminary experiment.

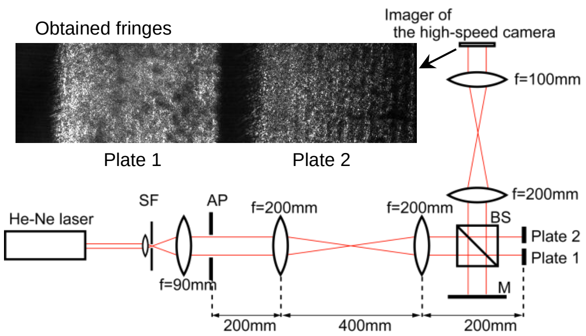

Fig. 1. Optical configuration for interferometric vibration analysis.

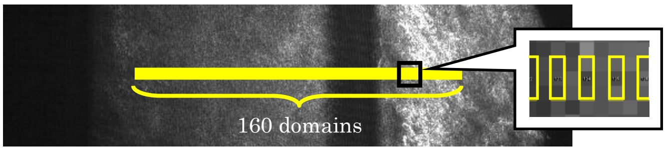

Fig. 2. Setting of the region of interest in a captured image.

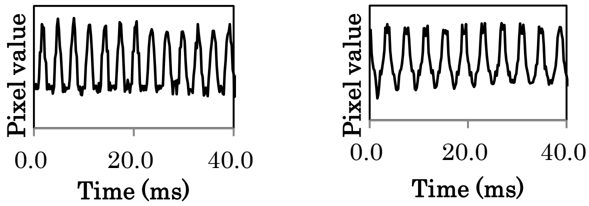

Fig. 3. Time variations of the pixel value at the position 35 and 140.

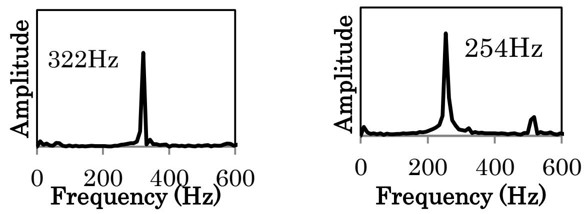

Fig. 4. Vibration frequency properties at the position 35 and 140.

In order to investigate resonance frequency distribution, we set the region of interest (ROI) as 160 domains with 1-pixel width and 3-pixels height that were located side by side in a straight line, as shown in Fig. 2. Within each domain, the average of the pixel values are calculated in every frame. Temporal change of the average value was used for Fourier analysis. We performed the Fourier transform of the temporal change and obtained frequency properties for each domain. Fig. 3 and Fig. 4 show typical results. Fig. 3 shows the temporal change of the averaged pixel value. Fig. 4 shows frequency distributions. The left and right graphs are results on the metal plate 1 and on the metal plate 2, respectively. The resonant frequencies of the plate 1 and the plate 2 were 322Hz and 254Hz, as they were manually tuned.

3. Conclusions

We have obtained vibration distributions by observation of interferometric fringes with a high-speed camera. Distribution of resonance frequencies are computed from the consecutive images.

References

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