Simultaneous 3D ESPI using a 3CCD Camera

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Introduction. ESPI is a non-contact, high-accuracy method for deformation measurement in many industrial fields. Due to the fact that its displacement sensitivity is closely related to the optical arrangement⁽¹⁾, it is difficult to measure the 3D deformation simultaneously. In this paper, an apparatus which enables displacement measurement for in-plane and out-of-plane components has been developed.

Principle. The optical arrangement is illustrated in the Fig. 1. The object surface is illuminated with 3 laser beams with multiple wavelengths which include 473 nm, 532 nm, and 671 nm. The red and green coherent lights are divided into two beams individually (denoted as RL and GL) to illuminate the surface of the stressed object, while the blue laser (denoted as BL) passes through a Michelson Interferometer (denoted as MI) to reach the object surface. A prism-based 3CCD camera, instead of a conventional monochrome CCD camera⁽²⁾, is adopted to acquire images before and after loading in the experimental setup. Inside a prism-based camera, since the incident light is re-directed to 3 independent sensor arrays by passing through a prism, the color coupling problem is solved and it is possible to acquire 3 images with specific wavelengths at one shot. In this paper, the real-time inspection has been achieved by combining the 4-step temporal phase-shift process⁽³⁾.

Fig. 1 Scheme of the apparatus

Verification. A rectangular constrained plate with diameter of 80 mm was used as the specimen. It was subjected to a normal concentrated load at the center as well as an in-plane rigid rotation. The coherent lights with wavelength of 473 nm, 532 nm, and 671 nm were scattered onto the specimen surface. Images before and after loading were captured with a 4-step phase shifting. The interference phase maps of the out-of-plane and in-plane are shown in Fig. 2.

Fig. 2 Experiment results (a) out-of-plane, (b) in-plane horizontal, (c) in-plane vertical

Conclusion. In this paper, an optical arrangement which enables phase measurement for in-plane and out-of-plane displacement components has been developed. Combining a prism-based 3CCD camera and multiple coherent lights with different wavelengths, the 3D displacement components have been measured simultaneously.

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