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Extended Abstract

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High resolution phase shifting methods in multiple beam holographic interferometry

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This talk reviews high resolution phase shifting methods which have the capability of accommodating the requirements inherent in multiple beam holographic interferometry. These methods facilitate the use of multiple PZTs in an optical setup, offer the flexibility of using arbitrary phase steps and spherical beams, and provide the ability of making simultaneous multidimensional deformation measurements. The main sources of errors in implementing phase stepping are caused by the miscalibration of the piezo electric device (PZT) and by the presence of non-sinusoidal waveforms (consequence of CCD nonlinearity or multiple reflections inside the laser cavity). The proposed phase stepping methods render the holography related interferometry techniques insensitive to the error sources mentioned above. Experimental results show the feasibility of the proposed methods.

NDT Techniques: Laser-based P.M. Boone, in Encyclopedia of Materials: Science and Technology, 2001 2 Holographic Interferometry Holographic interferometry (HI), which provides interferometric comparison of real objects or events separated in time and space, is a technique of unparalleled applications. Various kinds of HI have been developed, e.g., real-time, double-exposure, and time-averaged HI. Furthermore, HI can be performed with one, two, or more reference waves, which can be of the same or different wavelengths. The reference wave can come from the same side of the hologram as the object wave, or from the other side of the hologram. HI can be performed with a continuous wave laser, or a pulsed laser. The possibilities are endless, and so are the applications. The detection of an internal defect of polythene pipe.

Practically, HI achieves the comparison of two wavefronts from the real object. These two waves are usually from the initial (unstressed) state and the final (stressed) state of the object. However, it is assumed that the microstructure of the surface does not change as a result of loading: the two waves differ because of path difference changes rather than microstructural changes.

Probably the most fundamental technique is double-exposure HI. Here the two states of the same object are recorded on the same medium: the subsequent object waves are reconstructed simultaneously and interfere, giving a reconstructed image on which a fringe pattern is superimposed as a function of the displacement. For real-time HI, a hologram of the object is made, processed, and placed back exactly at the same location it occupied during recording. Reconstruction of the hologram by the reference wave generates a replica of the original object wave, which propagates in the direction of the original wave. If the object wave is also present, these two waves thus interfere when the object is loaded. The object wave carries the deformation phase information, and an interference pattern is observed which changes in real time with the load. The response of the object to the external loading agent can therefore be monitored continuously until the fringes become too fine to be resolved. This technique is also known as single-exposure or live-fringe HI. In time-average HI, the hologram is recorded when the object is moving or vibrating. If the vibration is sinusoidal, the object stays longer in the two extreme positions than in the intermediate ones—the fringe patterns are directly related to the amplitude of displacement.

Holographic interferometry is used in the field of non-destructive testing, e.g. in vibrational analysis. Real-time interferometry, in particular, is of technical interest. Generally, it is performed in a two-step process. First, a hologram of the non-vibrating object is recorded and developed. After exact repositioning or processing *in situ*, it is illuminated with the original reference beam. Simultaneously the object is irradiated, with the result that the observer receives two wavefronts, one originating from the hologram illuminated with the reference beam, representing the original wavefront of the object, and another reflected directly from the object. If the reflecting object (or parts of it) is now slightly displaced from its primary position, the observer sees an image of the object covered with an interference pattern. This pattern results from constructive and destructive interference of the two wavefronts (holographic diffraction and direct reflection) which reach the observer at the same time.

Holography is a photographic principle that produces 3D images that are so real that it is possible to take measurements inside this image with a precision of a fraction of a thousandth of a millimeter. Contours are formed within the holographic image that, like the relief lines of a map, indicate the displacements of every point on the object surface. The method is named holographic interferometry (see Holography, Techniques: Holographic Interferometry) and it can be used to measure deformation, vibration and also, with slightly lower resolution, dimension.

In real time holography the deformed object is directly compared to the holographic image of its undeformed state. In double exposure holography the comparison is made between two holographic recordings on the same plate, while in sandwich holography the two states are recorded on two different plates that are sandwiched together for comparison.

Sandwich holography is useful in industrial environments, because it can measure much larger deformations and also compensate for unwanted movement of the object or the setup between the two exposures. Further on in the process it will produce any sign of deformation and comparison can be made at any time without referring back to original setup. However, processing of the two plates is needed before the comparison can be made and the plates have to be positioned with high accuracy.

Bottom Note: *This work is partly presented at International Conference and Trade fair on Laser Technology, July 20-22, 2015, Orlando, Florida, USA*