Holographic interferometry is widely used to measure objects' deformations and displacements by observing fringe patterns. Intensity is proportional to \( \cos 2\pi(W' - W)/\lambda_0 \), where \( W \) and \( W' \) are two object wavefronts, and the phase difference between two consecutive fringes is proportional to half of \( \lambda \), the wavelength used. Because the fringe density is proportional to deformation magnitude, large deformations lead to high fringe densities that cannot be resolved easily by conventional detection systems (eye or CCD camera). One way to overcome this problem is to increase the wavelength by using IR laser lines, but holographic materials sensitive to these wavelengths are not common. Another way is to synthesize a longer equivalent wavelength from two visible wavelengths.

Earlier, Wyant developed two-wavelength holography, in which a hologram of a sample is taken at a wavelength \( \lambda_2 \) and read out with another \( \lambda_1 \), while keeping the test object in the same state. An interferogram is observed that is proportional to \( \cos 2\pi(W - W)/\lambda_0 \), where the equivalent wavelength \( \lambda_0 \) is equal to \( \lambda_1 \lambda_2/\lambda_1 - \lambda_2 \). The result shows the contour fringes of the test surface. The aim of our development is to mix the advantage of two-wavelength holography with classical holographic interferometry, in order to obtain an interferogram proportional to \( \cos 2\pi(W - W)/\lambda_0 \). The sensitivity of the interferometer can then be selected by choosing the correct pair of visible wavelengths.

Figure 1 illustrates the principle of measurement. Basically, two holograms are used in series in the set-up. The first object wavefront, \( W \), is recorded at both wavelengths \( \lambda_1 \) and \( \lambda_2 \) on the same holographic plate \( H_1 \), and so becomes the 'reference wavefront' (step a). Both laser beams propagate through the same path and can easily be switched into each other.

After processing, \( H_1 \) is correctly repositioned. It is illuminated, at \( \lambda_1 \), with the object wavefront that is now \( W' \) (the object wavefront after deformation), and not with the reference beam as usual in holography. \( H_2 \) diffracts at different orders. One has a phase given by \( 2\pi(W - W)/\lambda_2 + \alpha \), where \( \alpha \) — an angular term that depends on the recording geometry and wavelength — indicates that the order propagates in a certain direction. This order serves now as an object beam and is holographically recorded at \( \lambda_1 \) on the second holographic plate \( H_2 \) with the help of a second reference beam (step b).

After processing and repositioning of \( H_2 \), the beam at \( \lambda_1 \) is switched into \( \lambda_2 \) (step c). At that moment two processes occur. First, the hologram recorded at \( \lambda_1 \) on \( H_1 \) is read out with the \( H_2 \) reference beam but at the new wavelength \( \lambda_2 \). Its first diffraction order is a beam that reproduces the incident object, i.e., \( 2\pi(W - W)/\lambda_1 + \alpha \), providing a correction of the readout beam incidence angle due to the change in wavelength. At the same time, \( H_2 \) is still illuminated with deformed wavefront \( W' \) but now at \( \lambda_2 \), and diffracts among others one term with a phase equal to \( 2\pi(W - W)/\lambda_2 + \alpha \). This order propagates in the direction of hologram \( H_2 \) and, after passing through \( H_2 \), can interfere with the first order diffracted by \( H_2 \). This leads to an intensity distribution proportional to \( \cos 2\pi(W - W)/\lambda_2 \), which is recorded on \( H_2 \). Figure 2 shows interferograms at wavelengths \( \lambda_2 \) and \( \lambda_0 \). As expected, there were six times fewer fringes with two wavelengths than with one.

Presently the method does not work in pure real-time mode because it requires the recording and the readout of a second holographic plate, \( H_2 \), before producing the useful desensitized interferogram. The use of self-processable recording materials should improve this.

In conclusion, this method extends the applicability of classical holographic interferometry, enabling it to work with one wavelength if sensitive measurement with limited deformation range is required or with two wavelengths for extended range with lower sensitivity.

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