Infrared digital holography using CO_2 laser

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Summary

This paper presents some wavefront amplitude reconstructions, achieved, by means of digital holography, using a CO_2 laser as source and a thermal camera as optical imaging system. This explorative work demonstrates the feasibility of such a method and investigates its characteristics.

Introduction

We aimed at performing Digital Holography (DH) in speckle mode, in the IR range, i.e. we intended to achieve a numerical amplitude reconstruction of the wavefront scattered by an object irradiated by a CO_2 laser using the interferograms recorded with a thermal camera. Such range has been only rarely explored, for DH, and we intended to further experiment the possibilities in this spectral region.

Experimental setup

An interferometer set up, as shown in fig.1, was used for off-axis Fresnel digital holography.

We used the coherent light source produced by a high power CW CO2 laser, emitting on the P(20) line at 10.59µm. The laser beam was set on the fundamental TEM00 mode at about 110W of emission power. In these conditions the laser beam is characterized by a waist of 10mm and a divergence of 2mrad. By adjusting the position of the lenses it was possible to obtain object and reference beams of comparable intensity and have the maximum fringe contrast in the interferogram. We managed to fix the angle between the object and the reference beam, thus obtaining an optimal fringe frequency. The interferogram was recorded by means of an ASi thermal imaging camera (Miricle Thermoteknix 110k) with 384x288pixels with 35µm pixel pitch, without the camera's objective.

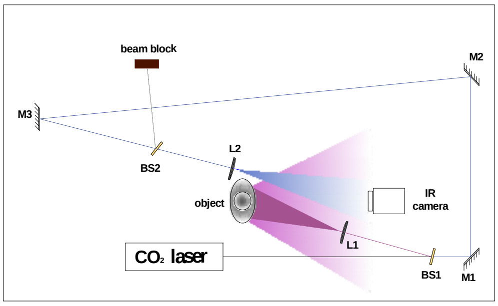

Fig. 1 Interferometric set-up. M2, M3: total reflective mirrors; BS1, BS2: ZnSe beam splitters; L1, L2: ZnSe lenses.

Results

Our goal was to obtain large objects interferograms (around 15cm of lateral dimension).

Using this long wavelength, we managed to image objects, of various materials, up to about 16cm x 12.5cm. With the same configuration, in terms of distances and detector pitch, using a laser beam in the visible range it is possible to reconstruct, at maximum, images of objects about 15 times smaller, as the dimension of the image area is directly proportional to the wavelength of the source used, according to [1].

As it is easily understood from fig. 1, once the object's dimensions are fixed, there are four principal parameters to tune in order to optimize the results. They are: the angular distance (*s*) between the object and the reference beam, the radius of curvature (*r*) of the reference beam and the distance (*l*) between the object and the object lens focus. We have chosen *s* such that we achieved a fringe period near the optimal value (0.07mm) for the given sensor's dimensions, according to the Whittaker-Shannon sampling theorem. The *r* parameter influences the reference beam intensity upon the camera and so the fringe contrast. On the *l* parameter depends the object beam intensity and also, which portion of the object is illuminated by the laser beam and therefore imagined by the camera.

Numerical reconstruction of object wavefront intensity was performed according to the discretization of the well known Fresnel approximation of Fresnel-Kirchhoff equation [2].

Fig. 2: Picture of one of the test objects.

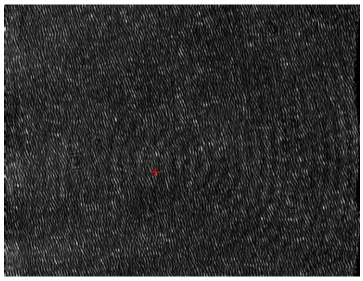

Fig. 3: Digital hologram recorded with the test object of Fig. 2.

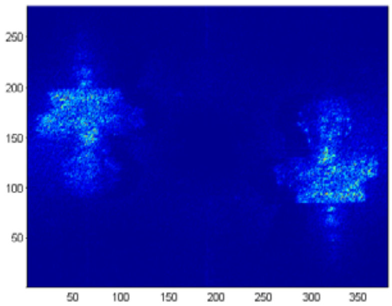

Fig. 4: Amplitude reconstruction of the hologram illustrated in Fig. 3.

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