Gates' interferometer configuration as a fringe projection unit

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ABSTRACT

In this paper we present the use of a Gates' interferometer configuration to the generation of a fringe pattern used as fringe projection profilometry system. The proposed interferometer consists of only a single beam splitter cube with one wedged entrance face and is insensitive to environmental vibration due to its common path configuration. The generated fringes are not localized which is one of advantages of this interferometer.

INTRODUCTION

Among the optical techniques used for the generating three-dimensional (3D) surfaces of complex objects, the use of fringe projection profilometry system have developed great interest in the metrology field [1], it is widely used in application such as medicine [2], 3D machine vision [3], industry[4], etc.

A typical fringe projection profilometry system consists of a camera as the image acquisition unit, an object to be measured and a fringes projection unit [5], commonly a digital projector. The used of the projector unit as a digital projector limited the resolution of the measurement, spatially in small object or surfaces details. In this work we substituted the use of a digital projector as a projector unit, instead, we used the Gates' interferometer configuration [6] that consist of a splitter cube 50/50 to generate a fringe pattern by means of interference of the light.

OPTICAL ARRAY

Based on a typical fringe projection profilometry system, the arrangement shown in Fig. 1 was mounted, with the modification of the conventional system on the use of the Gates' Interferometer configuration as subsystem/unit of fringes projection.

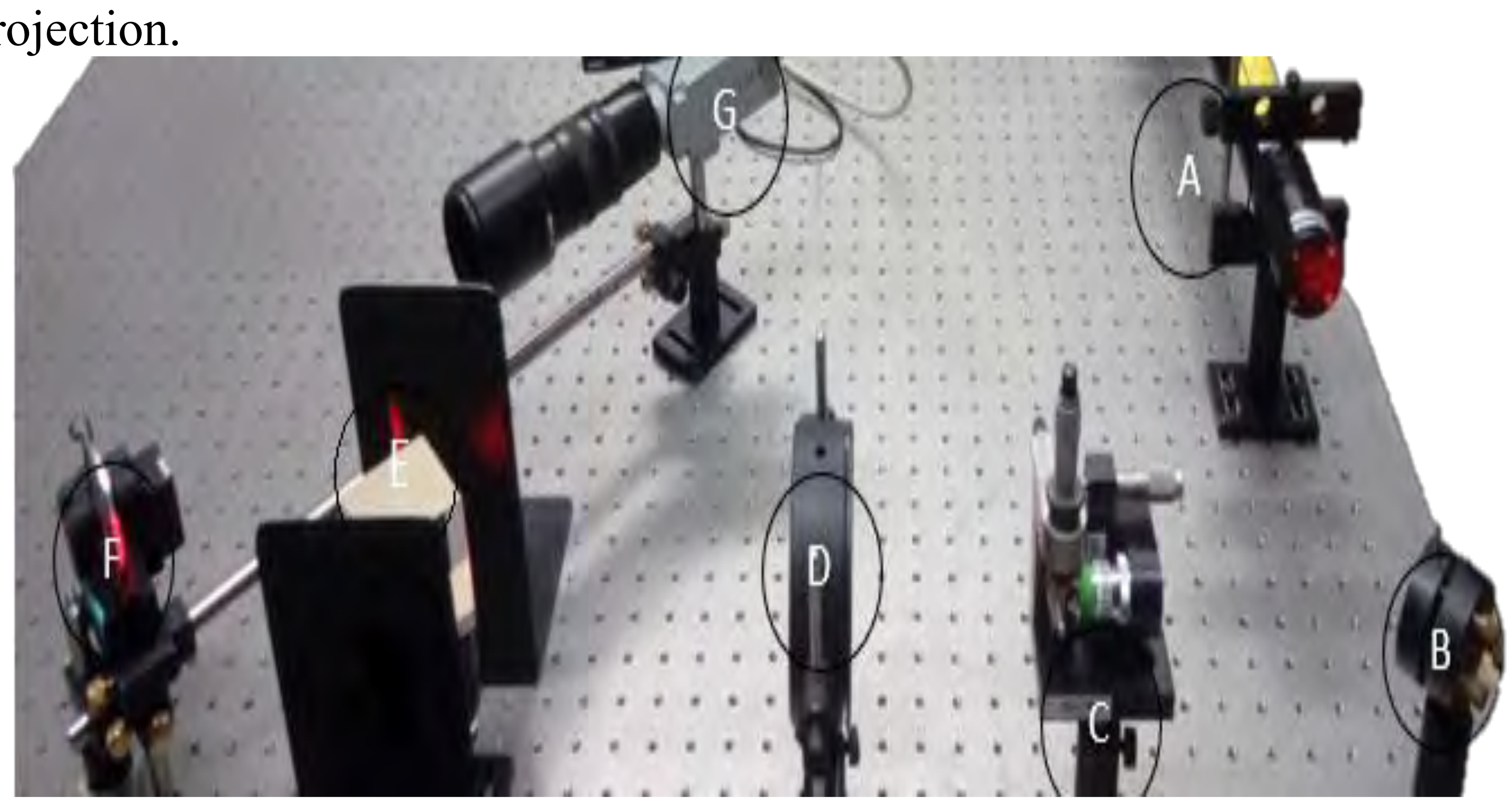

Fig. 1. Photo of the used optical array: A) He-Ne laser with $\lambda = 632\ nm$, B) mirror, C) spatial filter, D) collimator lens, E) beam splitter cube 50-50, F) sample G) CCD.

THE GATES' INTERFEROMETER

The Gates' Interferometer configuration consists of a laser beam and a nonpolarizing cube beam splitter 50T-50R, as shown in Fig. 2. The collimated laser beam hits on the edge of the cube, parallel to the prism's junction, with this configuration we produce fringe not localized with a period that depend on the tilt of the cube.

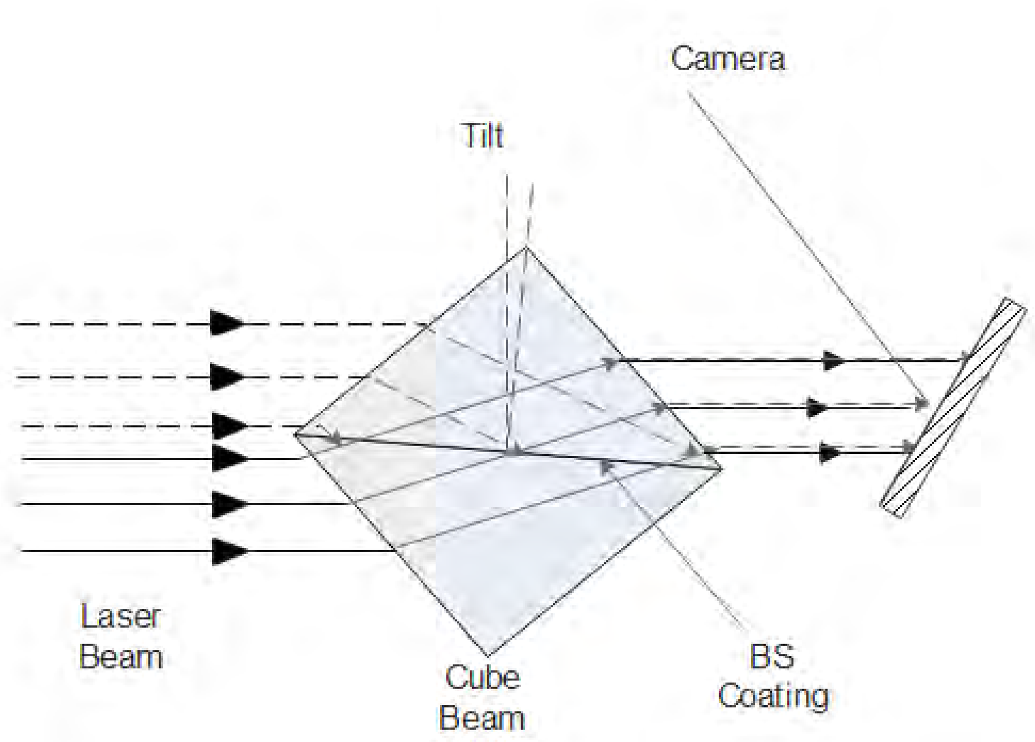

Fig. 2. The Gates' Interferometer configuration that consists in a cube beam splitter and a laser beam.

METHODOLOGY AND EXPERIMENTAL RESULTS

The fringes pattern was projected with a period of $0.1\ mm$ on the object, the splitter cube had a tilt of 2° and an angle of 40° between the CCD camera and the projection axis of the pattern.

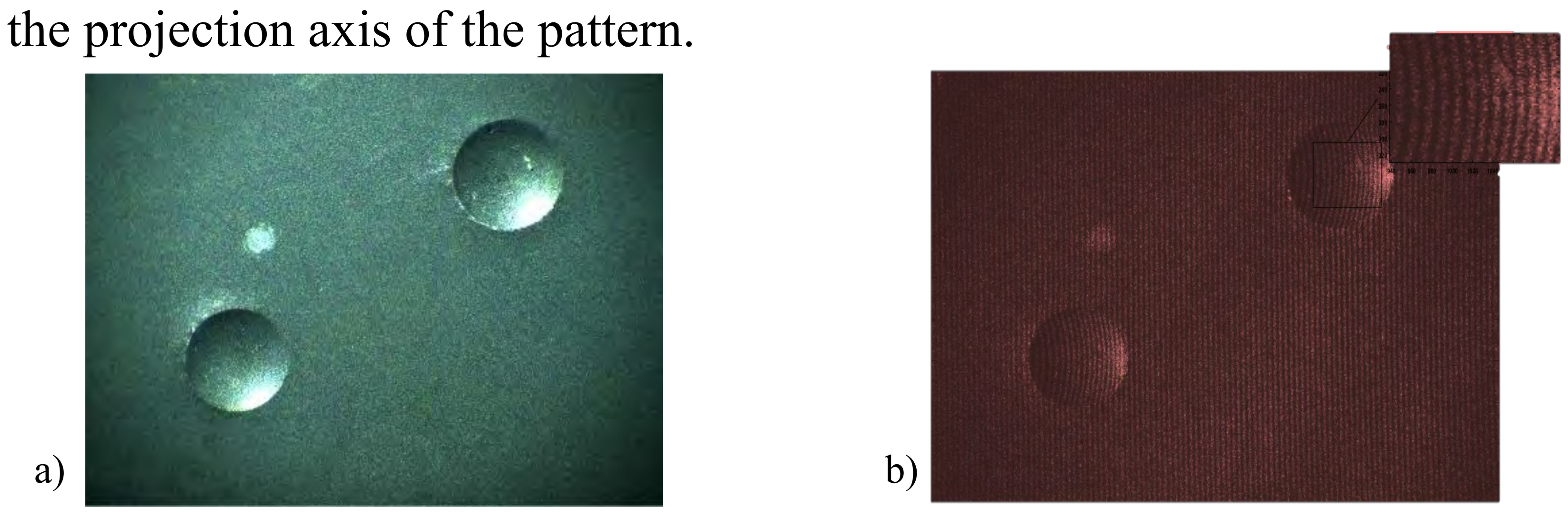

Fig. 3. a) Object. b) Pattern of fringes projected onto the object (camera view).

Through the technique of Fourier transform for demodulation of fringes proposed by Takeda [7] the phase wrapped was obtained and using an unwrapping algorithm [8] we obtained the unwrapped phase. Finally, by triangulation, we performed the conversion of phase map to height map [1].

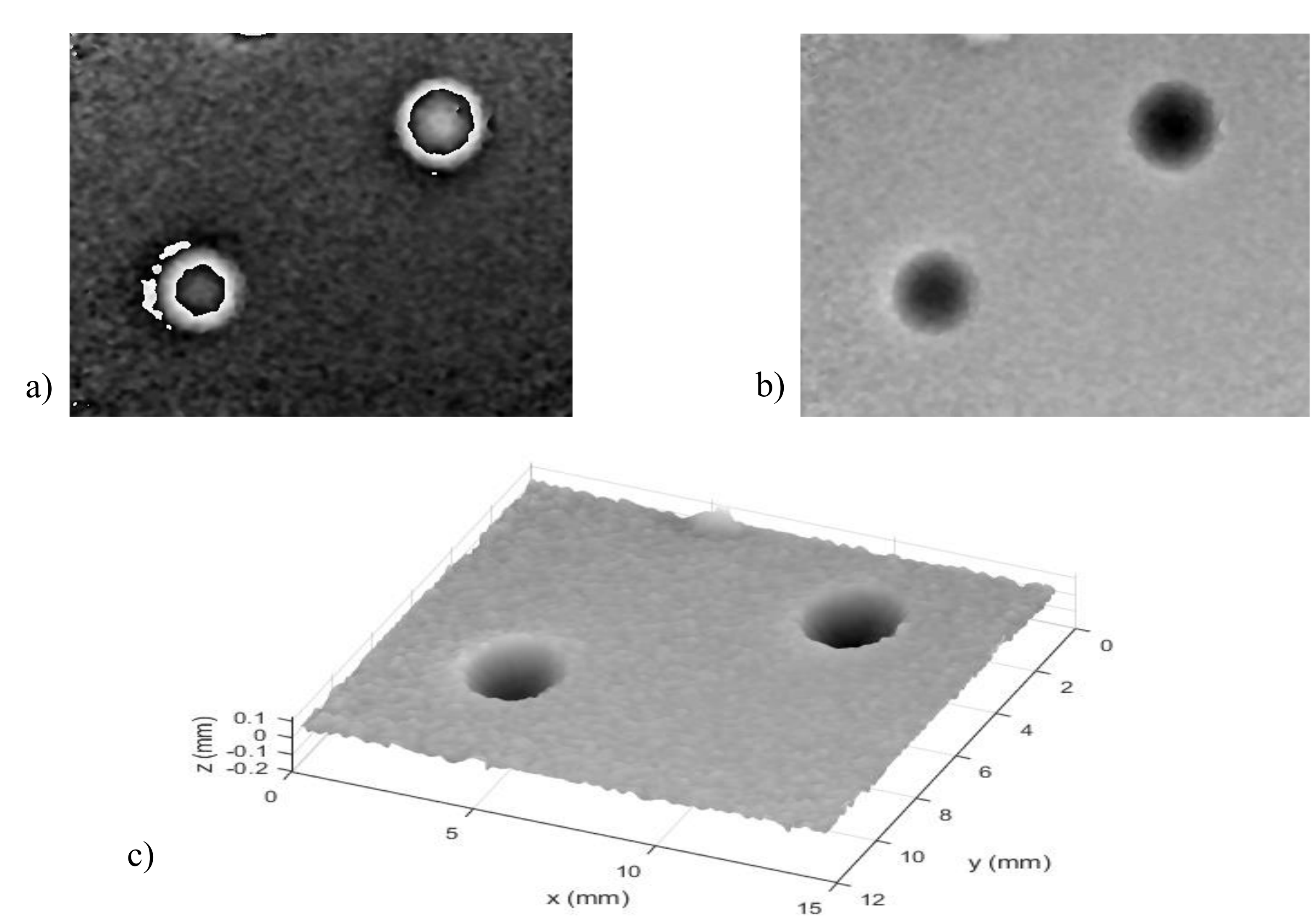

Fig. 4 a) Wrapped phase, b) Unwrapped phase, c) Height map.

CONCLUSIONS

In this work, the Gates' interferometer configuration was implemented as a subsystem of projection to generate non-localized fringes. Some advantages are: allow to have shorter period than the obtained with conventional projector, nonlocalized fringes exist everywhere within an extended (three-dimensional) region of space which allows to place the object without problem. One disadvantage of this configuration is that the period is limited mainly by the size of the speckle and the resolution of the camera.

As a future work, a low coherence laser will be used to reduce noise in the fringes.

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