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A Gaussian filtering method to reduce directionality on high-density point clouds digitized by a conoscopic holography sensor

H. Patiño[a], P. Zapico[b], J.C. Rico[a], P. Fernández[a], G. Valiño[a,*]

[a] Department of Construction and Manufacturing Engineering, University of Oviedo, Campus de Gijón, 33203, Gijón, Spain
[b] Cybernetic Research Module, University of León, Campus de Vegazana, 24071, León, Spain

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ABSTRACT

This work analyses the directional effect shown by the high-density point clouds digitized with a conoscopic holography (CH) sensor. The asymmetric shape of the laser spot for this sensor yields directionality to appear along the largest spot dimension and to occur repeatedly under different working conditions. To study this effect, several digitizing tests were performed under different conditions on a surface machined by EDM with a uniform and isotropic finish, so that the directional effect should not appear. Nevertheless, the use of the 2D Fourier transform (2DFT) confirmed the existence of directionality in the point clouds along the largest spot direction and that it appeared repetitively under different working conditions. Thus, this effect could be considered as a systematic error associated to the CH sensor and then, feasible to be reduced. The use of an anisotropic 2D Gaussian filter is suggested for this purpose. The results found before and after applying the filter were compared to those obtained by a confocal microscope, which was used as reference due to the absence of directionality in the captured images. Results show that the filtered point clouds suitably fit the actual surface topography.

1. Introduction

The industrial application of non-contact digitizing systems has grown importantly in recent years [1–3]. To a large extend, this is due to their ability to digitize small and complex geometric shapes, the high rate for points acquisition and their portability, which allows for installing them in different machines and production equipment.

Among the different digitizing systems, conoscopic holography (CH) is an interferometric collinear technique based on the double refractive property of birefringent crystals. It was first described by Sirat and Psaltis [4] and patented by Optimet Optical Metrology LTD. The underlying physical principle of measurement of this type of sensor is included in the guideline VDI/VDE 2617–6.2 [5].

The characteristics of point-type CH sensors include high accuracy and repeatability, good behaviour for a wide variety of materials, ability to digitize steep slope surfaces and feasibility to combine the sensor with different lenses to adapt it to various depths of field. As a collinear system, it can access to holes or narrow cavities by using simple devices for light redirection. All these characteristics make CH systems very useful in different fields of industry, such as quality assessment, reverse engineering or in-process inspection.

Nevertheless, CH digitizing quality may be affected by a lot of factors similarly to other optical techniques. Among these factors, one that affects to the quality of the digitized surfaces is the *lateral resolution* of measurement or ability to recognize nearby points on a surface [6]. This concept is related to the minimum distance between these points and the size of the laser spot projected [7]. This way, as distance between points to be digitized is smaller and the size of the laser spot larger, higher overlapping between the spots appears.

The effect of *lateral resolution* could be resembled to a low pass filter that eliminates high frequencies of the digitized surface [8]. This is similar to the effect of digitizing a surface with a relatively large diameter contact probe, which is not able to access to the narrowest surface valleys, thus altering the measurement result.

Due to the asymmetry of the CH sensor laser spot used in this work (Fig. 1), the effect of *lateral resolution* is different depending on the digitizing direction. Thus, overlapping of laser spots will be higher when digitizing along the largest direction of the laser spot (Y_{CH}) than along the smallest one (X_{CH}). Consequently, when digitizing points separated from each other a distance shorter than the *lateral resolution*, this type of sensor will not allow for measuring high frequency details on the surface. Moreover, a directional behaviour can be perceived in the point cloud texture during the digitizing process (Fig. 2). In addition, the directional effect occurs along the largest spot direction and appears repeatedly under different working conditions, what reveals this effect as a sensor systematic factor feasible to be removed.

* Corresponding author.
E-mail address: gvr@uniovi.es (G. Valiño).

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