Conoscopic Holography Systematic Error Processing by Means of Gaussian Filters

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ABSTRACT

This work analyses the directional effect shown by the point clouds when digitizing with a conoscopic holography (CH) sensor. The asymmetric shape of the laser spot for this sensor yields that directionality appears along the greatest spot length and it occurs repeatedly under different working conditions. To study this effect of the sensor, several tests were performed on a surface machined by EDM with a very uniform and isotropic finish, so that the directional effect should not appear actually. This ensures that the effect is a systematic factor related to the sensor and feasible to be compensated. A Gaussian filter is used with this purpose. The results found before and after applying the filter were compared with those obtained by a confocal microscope, which was used as reference due to its better metrological performance.

Keywords: Conoscopic holography, directionality, systematic error, Gaussian filtering

1. Introduction

Conoscopic holography (CH) is an interferometric technique based on the double refractive property of birefringent crystals. It was first described by Sirat and Psaltis [1] 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 [2].

The characteristics of the 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 to various depths of field. Moreover, being a collinear system allows for accessing to complex geometries such as holes or narrow cavities, by using simple devices for light redirection. All these characteristics demonstrate the feasibility of CH systems for being applied to different fields of industry, including 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 [3]. This concept is related to the minimum distance between such points and the size of the laser spot projected on them [4]. This way, as the distance between points to be digitized is smaller and the size of the laser spot greater, there is a higher probability of overlapping between the laser spots projected on them.

The effect of the *lateral resolution* could be resembled to a low pass filter that eliminates the high frequencies of the digitized surface [5]. 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.

Since the CH sensor used in this work has got an asymmetric laser spot (Figure 1), the effect of *lateral resolution* affects in a different way depending on the digitizing direction. Thus, the overlapping of the laser spots will be greater when digitizing along the largest direction of the laser spot instead of along the smallest one. Consequently, when digitizing points far each other a distance smaller than the lateral resolution, this type of sensor will not allow for measuring details of high frequency on the surface. Moreover, a directional behaviour can be observed in the texture of the point cloud obtained in the digitizing process (Figure 2). In addition, this directional effect occurs in the direction of the greatest spot length and appears repetitively under different working conditions, which ensures that it is a systematic effect of the sensor and, therefore, feasible to eliminate.