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Influence of part material and sensor adjustment on the quality of digitised point-clouds using conoscopic holography

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A B S T R A C T

Conoscopic holography is an interferometric measurement technique commonly used for non-contact surfaces digitising in quality assessment, in-process inspection and reverse engineering. Among other factors, accuracy of measurements provided by this technology is influenced by the surface optical properties. Parameters such as laser power (P) or frequency of acquisition (F) are commonly used to adjust the sensor until a quality indicator of the signal acquired (*Signal-to-Noise-Ratio*) is maximised. Nevertheless, measurements taken under this adjusting criterion does not necessarily ensure the most accurate results from a metrological point of view. Taking this into account, the present work proposes two additional indicators to analyse the influence of sensor setting parameters on the quality of digitised point-clouds for different metals and polymers. Digitising tests have been performed on flat specimens of each material by means of a conoscopic holography sensor integrated on a Coordinate Measuring Machine. In order to meet an optimal scanning of each material, the study provides a series of recommendations about adjustment of the sensor as well as the most suitable indicator to be used in each case.

1. Introduction

Non-contact measuring methods can efficiently capture dense point-clouds in terms of acquisition speed. For this reason they are commonly used for industrial surface digitising although most of them are generally less precise than contact methods. Their accuracy strongly depends on the interaction between the sensors used, the workpiece geometry and the optical properties of the surface material [1,2]. Optical sensors using different principles may react, in fact, in different ways to the optical behaviour of the surface to be measured. The influence of surface material on the performance of some widely diffused techniques, such as triangulation systems, has been deeply analysed in literature. However, the performance of other technologies has not been fully described yet. This is the case of conoscopic holography (CH).

CH is an interferometric technique based on the double refractive property of birefringent crystals. It was first described by Sirat and Psaltis [3] and patented by Optimet Optical Metrology LTD. Malet and Sirat [4] stated that the performance of a conoscopic system can be described by the quartet of precision, depth of field, speed and transverse resolution. Furthermore, many advantages of CH in front of laser triangulation have been reported by Sirat et al. [5]: better accuracy and repeatability (up to 10 times for a given depth of field), good behaviour for a wide variety of materials (even for translucent ones) and steep slope surfaces up to 85°. Other practical characteristic is that a single conoscopic sensor can be combined with different lenses to be adapted to various depths of field (0.6 mm up to 120 mm) with accuracy from less than 1 μm up to 60 μm, respectively. Finally, being a collinear system allows for accessing to complex geometries such as holes or narrow cavities, by using simple devices for light redirection.

These characteristics have led CH to be incorporated in a wide variety of fields, including quality assessment, reverse engineering and in-process inspection. The importance of accuracy becomes an essential target in industrial applications, such as those reviewed by Álvarez et al. [6]. This group has successfully applied CH for multiple industrial on-line applications, including sub-micrometric roughness measurements, on-line measurement of high production rate products, surface defect detection in steel at high temperatures and simultaneous inspection of external and internal shape of hollow cylindrical parts.

Potential of CH as a valuable alternative to current well-established technologies (laser triangulation, range sensors or photogrammetry) has led researchers to work on analysing the performance of CH sensors under different scanning conditions.

The ability of CH for digitising highly sloped surfaces was highlighted by Ko and Park [7] when they compared the capabilities of triangulation, conoscopic holography and interferometry methods

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