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Optical Characterization of Materials for Precision Reference Spheres for Use with Structured Light Sensors

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Abstract: Traditionally, 3D digitizing sensors have been based on contact measurement. Given the disadvantages of this type of measurement, non-contact sensors such as structured light sensors have gained the attention of many sectors in recent years. The fact that their metrological performance is affected by the optical properties of the digitized material, together with the lack of standards, makes it necessary to develop characterization work to validate materials and calibration artifacts for the qualification and calibration of these sensors. This work compares and optically characterizes different materials and surface finishes of reference spheres used in the calibration of two structured light sensors with different fields of application, with the aim to determine the most suitable sphere material–sensor combination in each case. The contact measurement system of a CMM is used as a reference and, for the processing of the information from the sensors, the application of two different filters is analyzed. The results achieved point to sandblasted stainless steel spheres as the best choice for calibrating or qualifying these sensors, as well as for use as registration targets in digitizing. Tungsten carbide spheres and zirconium are unsuitable for this purpose.

Keywords: structured light; material optical characterization; non-contact digitizing; precision spheres; point cloud filtering

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1. Introduction

The development of scanning sensors capable of recording three-dimensional (3D) characteristics of the objects around us has become a key issue considering that the physical world in which we move is 3D. In the field of engineering, these sensors have changed the paradigm of product verification, replacing inspection processes based on the use of measuring instruments with processes consisting of digitizing for coordinate measurement.

Traditionally, digitizing has been carried out using contact measurement systems mounted on machines of various architecture called Coordinate Measuring Machines (CMM). These sensors, which are connected to a stylus usually ending in a small sphere, both with high rigidity and hardness, are responsible for detecting the instant at which the end of the stylus contacts the scanned surface. Thus, the 3D position of the contacted surface point can be recorded. Given their high performance when evaluated against metrological standards, these types of probes are often used as metrological reference systems for calibration, measurement, or characterization of other measurement sensors. However, they have a series of disadvantages: their point capture rates are low, they can show accessibility problems when digitizing objects with complex geometry, and they are difficult to integrate into the production chain. In addition, although they can be considered non-destructive inspection techniques, they must contact the surface of the object and their use is not advisable in flexible or soft materials, as well as in environments that require high levels of cleanliness.

Nowadays there are a multitude of sensors capable of non-contact 3D scanning, overcoming many of the drawbacks of contact measurement. Relevant advances in recent