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Metrological evaluation of laser scanner integrated with measuring arm using optical feature-based gauge

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A R T I C L E I N F O

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A B S T R A C T

This work deals with the searching of metrological limits with which the laser scanners mounted on coordinate measuring arms (AACMMs or CMAs) are able to evaluate dimensional and geometric tolerances (GD&T). For this purpose, a novel feature-based gauge for optical sensors is used. This gauge incorporates different types of geometrical entities, perfectly adapted for several GD&T evaluations. In addition, these entities are optically functional so that they are captured from the laser sensors mounted in AACMM. The gauge is equipped with a set of "canonical" entities of ceramic type, manufactured with high dimensional accuracy to materialize a multitude of GD&T tolerances. Regarding the metrological evaluation, the measurements obtained with the laser scanner are compared with the previously calibrated measurements of the gauge, calibration that has been performed using contact probing in a CMM. Although in this research a rather obsolete model of laser scanner is used, the methodology is totally valid for any sensor mounted in AACMM, obtaining a high range of traceable values.

One issue that has received special attention is the control of variability produced by a manual scanning operation. To this end, research is approached from a twofold perspective: on one hand, an initial study to determine the best scanning strategy allowing a good coverage of each entity surface, and, on the other hand, a statistical analysis from a high number of repetitions of a complete measurement routine of the feature-based gauge. Thus, reliable dispersion values can be offered not only for different types of GD&T evaluations (form, dimensions, etc.) but also for the same GD&T evaluation over the same type of entity.

Although the work proposes precision values depending on the type of GD&T being analyzed, it also proposes a novel reliable method of calculation of the probing error for a laser scanner mounted on an AACMM.

1. Introduction

The use of laser triangulation sensors has initially been reserved for typical reverse engineering tasks. However, an increasing trend pursues to extend its field of application to the world of dimensional metrology. Unfortunately, the equipment and the software are not specifically designed to measure dimensional and geometric tolerances (GD&T), even though the equipment where they are mounted (AACMMs) are oriented for these GD&T inspection tasks, especially when using touch probing.

This work presents an experimentation aimed at analysing the measurement accuracy of Laser Triangulation Sensors mounted on Portable Coordinate Measuring Arms (CMAs). This measuring device is generally used to capture high-density point clouds over the surfaces of an object (in the present case the object will be a feature-based artefact) during short periods of time [1,2]. Nevertheless, the evaluation or quantification of the measurement accuracy is highly difficult due to a series of errors and factors involved. In fact, several researchers have studied this issue in recent years, for Laser sensors either mounted on Coordinate Measuring Machines (CMMs) where the trajectories and orientations of the sensor are automated [3–8] or mounted on Portable Coordinate Measuring Arms [9–12] where the sensor is handled manually. Some researchers have identified and studied factors of influence such as: the geometric parameters of the sensor, the qualification of the sensor [8], the relative orientation between the object, the laser beam and the CCD [11,13], the scanning strategy and point cloud density [11], or even factors related with the surface finish of the part (colour, roughness, brightness, reflectivity, etc.) [7,10,14,15]. All these factors are relevant for the quantification of the sensor accuracy, which is accomplished by means of the metrological evaluation of the dimensional and geometrical tolerances constraining a reference artefact, provided with spherical and planar features. The evaluation involves comparing the measurements obtained with the laser sensor and the reference values of those tolerances, previously obtained by means of a high accuracy contact sensor mounted on a CMM [12]. A common practice in the metrological assessment of the accuracy of this type of equipment is based on the application of standards, namely, IS0 10360-8:2013 and VDI/VDE 2617. In the application of these standards [15,16] the objective is to determine the probing and the volumetric error similarly to what is ac-

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