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Article

Metrology Benchmarking of 3D Scanning Sensors Using a Ceramic GD&T-Based Artefact

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Abstract: The use of non-contact scanning equipment in metrology and in dimensional and geometric inspection applications is increasing due to its ease of use, the speed and density of scans, and the current costs. In fact, these technologies are becoming increasingly dominant in the industrial environment, thus moving from reverse engineering applications to metrological applications. However, this planned transfer requires actions to ensure the achievable accuracy by providing traceability of measurements. In the present study, a comparison between the devices is carried out and a specific standard artefact is designed, equipped with multiple ceramic optically friendly entities, and allowing a wide variety of geometric dimensioning and tolerancing (GD&T). Four different 3D scanning sensors are used in the experimentation. Three of them are based on laser triangulation, and the fourth is a structured blue light sensor (fringe pattern projection). The standard artefact is calibrated with a high accuracy, using a coordinate measuring machine (CMM) and probing sensors. With this CMM, reference values of multiple predefined GD&T are obtained. The evaluation methodology maximises the accuracy of each device in measuring the dimensions of the artefact due to the good dimensional (milling and turning), surface (control of machining variables), and the dimensional and spatial distribution characteristics. The procedure also includes the same treatment of the captured point clouds (trimming, filtering, and best-fit algorithm, etc.) in each of the four 3D scanning sensors considered. From this process, very reliable measurements of the maximum achievable accuracy of each device (deviations from the CMM measurements) are finally obtained, and a multi-characteristic comparison between the four sensors is performed, also with high reliability.

Keywords: 3D optical scanner; benchmarking; metrological evaluation; GD&T-based artefact; reverse engineering

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1. Introduction

Currently, industries demand the procedures and artefacts that guarantee, in a simple way, the traceability of measurements performed in the field of dimensional inspection [1]. This is even more important in the Industry 4.0 context, where the aim is to digitise not only the manufactured products, but also the machines themselves, as well as the tools and fixtures, etc., and the processes in general.

For this reason, non-contact metrology inspection and reverse engineering equipment are essential. As evidence of this, these two aspects are undergoing an unprecedented industrial deployment that is not only due to their increasingly wide field of application, but also to the efforts of the manufacturers themselves in terms of performance enhancement and price containment. However, it is obvious that at present these two characteristics (performance and cost) are not incompatible, being not as far apart from each other as they were ten years ago. Today, 3D scanners and reverse engineering equipment are already available on the market with accuracies of less than 0.1 mm and at quite a reduced price (even below 3000 USD). Moreover, they have a high capacity, in terms of point cloud