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Digitised point quality in relation with point exploitation

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Abstract

This paper deals with the quality of digitised points obtained with noncontact probes. The digitising system is analysed so that each source of inaccuracy can be isolated. In particular, for systems such as triangulation laser sensors, the use of the CCD camera is not influence free, and generates nonhomogeneous errors. All sources of inaccuracy of the digitising system lead to a point cloud, the quality of which is described through indicators. These indicators correspond to the digitising noise and the density of the data. In addition to those usual indicators, we suggest qualifying the point cloud through completeness and accuracy. The completeness identifies the dimension of the digitising gaps, while the accuracy is associated with the measurement uncertainty of a 3D point. For each indicator, an evaluation method is presented and then applied. However, the use of those quality indicators only makes sense if they are related to the point exploitation.

Keywords: Noncontact measurement; Quality indicators; CCD errors

1. Introduction

Nowadays, 3D digitising systems deliver a numerical representation of part shapes through large sets of 3D data. Most works have concentrated on the topic of automated digitising of part shapes; few of them propose an evaluation of the digitising quality. Indeed, as digitising points are generally exploited by applications such as reverse engineering, free form copying or part inspection, the quality of the delivered point cloud, as regards its exploitation becomes an important issue. Therefore the question is: is the point cloud quality suitable for its exploitation? The quality is defined by the standard as a set of characteristics that confers to an entity the ability to satisfy implicit and expressed requirements [1]. This definition implies that quality cannot be dissociated from user's requirements that are most often linked to point exploitation. Moreover, the expected quality levels are not equivalent for each point exploitation. However, there is no explicit definition available for characterising the quality of optical digitising data.

Most authors are interested in factors that influence the point cloud quality. A brief study of the digitising system brings out that the most significant causes of inaccuracy can obviously be linked to optical phenomena: speckle, use of a CCD camera, distortion, . . . [2–5]. Few of them propose to clearly identify digitising errors. Some authors suggest procedures to evaluate measurement accuracy of various digitising systems based on the measurement

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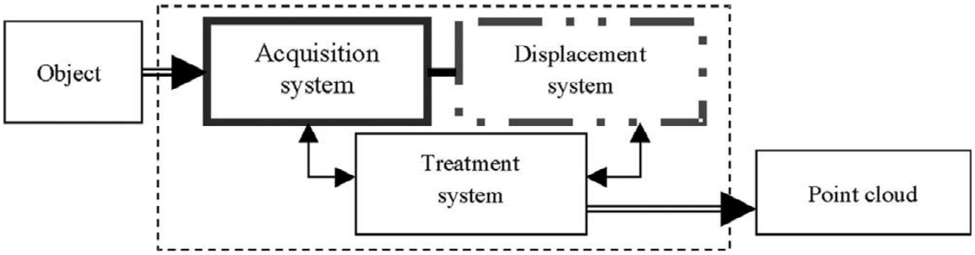

Fig. 1. Description of the 3D digitising system.

of specific shapes [6]. The digitising quality is evaluated in terms of accuracy, and special attention is given to how the object is recovered. Noncontact 3D devices can also be globally evaluated by the measurement of an artefact, including effects of both the scan depth and the view angle [7]. The influence of the scan planning can thus be highlighted.

However, integrating accuracy to the point exploitation is seldom carried out. Massios and Fisher integrate a quality criterion for selecting the best next view to scan an object, and show that the overall range data quality is thus improved [8]. Prieto suggests integrating digitising noise to define the most adapted scan planning for an application of part inspection. The digitising noise is previously correlated to scan depth and incidence angle [9]. In early works, Hoppe et al. show the difficulty to reconstructing surfaces from unorganised points. In particular, they suggest to qualify the data by indicators: δ—noisy and ρ—dense. The first indicator is more linked to the data sampling errors, and the second is directly linked to the sampling density. Both indicators are representative of the digitising point quality, and obviously influence the accuracy of surface reconstruction [10].

In this paper, we propose to evaluate the quality of digitising data in relation to the further point cloud exploitation. As suggested by Hoppe et al., the point quality is evaluated through quality indicators. However, considering that points can be exploited for surface reconstruction, but also for remanufacturing free form copying or inspection, specific indicators have to be defined. So, in addition to δ-noisy and ρ-dense, unorganised data points are also qualified through their completeness and accuracy. The next section is dedicated to the analysis of the various sources of digitising errors. Characteristics of the point cloud quality thus obtained are emphasised. Then, we suggest a definition for quality indicators and procedures in order to evaluate them. As they are defined, the user can link point cloud exploitation to its need.

2. Inaccuracies linked to the 3D digitising of a surface

3D digitising of an object consists in defining a numeric representation of the object surfaces through sets of 3D points. The 3D digitising system generally consists of various elements that can be classified into three main subsystems as described Fig. 1, the acquisition system, the displacement system, and the treatment system [11]. A short analysis of each subsystem can easily highlight the most significant causes of inaccuracies.

The acquisition system is the core of the digitising device. Its structure is strongly linked to the digitising technology employed: active triangulation, Moiré techniques, holographic interferometry, etc. [12]. Whatever the technology used, the acquisition is performed considering noncontact means. Therefore, the main sources of inaccuracies are essentially linked to optical problems. Among those, considering active triangulation technology, the most significant ones are linked to CCD camera imperfections, and speckle noise [2–5,13]. In some cases, optical problems such as distortions can to be corrected [2,13]. The influence of the CCD camera alone is more difficult to identify. Furthermore, considering the scan planning, accessibility and visibility problems must also be added [14,15].

The displacement system gives the degrees of freedom that allow the digitising of the part to be