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A metrological approach for multispectral photogrammetry

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ABSTRACT
This paper presents the design and development of a three-dimensional reference object for the metrological quality assessment of photogrammetry-based techniques, for application in the cultural heritage field. The reference object was 3D printed, with nominal manufacturing uncertainty of the order of 0.01 mm. The object was realized as a dodecahedron, and in each face, a different pictorial preparation was inserted. The preparations include several pigments, binders, and varnishes, to be representative of the materials and techniques used historically by artists.
Since the reference object's shape, size and uncertainty are known, it is possible to use this object as a reference to evaluate the quality of a 3D model from the metric point of view. In particular, verification of dimensional precision and accuracy are performed using the standard deviation on measurements acquired on the reference object and the final 3D model. In addition, the object can be used as a reference for UV-induced Visible Luminescence (UVL) acquisition, being the materials employed UV-fluorescent. Results obtained with visible-reflected and UVL images are presented and discussed.

Section: RESEARCH PAPER

Keywords: Photogrammetry; multispectral imaging; reference object; metrology; cultural heritage

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1. INTRODUCTION

In the last few years, digitalization techniques and related 3D imaging systems have acquired major importance in several fields, like industry, medicine, civil engineering, architecture, and cultural heritage. For the last mentioned one, in particular, such technologies can provide multiple contributions, in terms of conservation, data archiving, enhancement, and web sharing [1]-[3].

The existing three-dimensional imaging systems, which acquire measurements through light waves, can be discriminated on the basis of the ranging principle employed [4]. Among the several techniques, photogrammetry is a remote image-based technique, that became widely diffused. In particular, this technique allows for the collection of reliable 3D data of an object, regarding its surface (color and texture) and its geometrical features without requiring any mechanical interaction with the object itself [5]. Indeed, a 3D model is constructed starting from digital images of the object, leading to the creation of its virtual replica.

With the increasing diffusion of digitalization techniques and the aims of many users to the creation of 3D models, several concerns have been raised about the results that can be achieved. Therefore, even though digitalization practices are widely diffused and they can provide realistic replicas of an object, the factors that impact the uncertainty of the final 3D models are several and they must be further investigated. Some authors have summarized the most important factors that affect the uncertainty in 3D imaging and modeling systems [4], [6]. Nevertheless, precision and accuracy evaluation of 3D models has not been supported by internationally recognized standards which are of major importance to avoid archiving and sharing wrong information [7]. Some publications have presented different test artifacts or new systems that could be used to test the performances of the photogrammetry approach [6],[8]. In some cases, the accuracy of a final model is determined by comparing the results with some reference data, acquired with active systems such as laser scanners [8]-[10]. Otherwise, the results are also evaluated on the basis of statistical parameters generated by the employed reconstruction software [11].