Traceability Assurance Method for Photogrammetric Measurements Performed Using RealityScan Application

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Abstract – **RealityScan is a free, powerful, photogrammetry-based mobile application that allows users to create high-quality 3D models from real-world objects using just a smartphone or tablet. By capturing multiple photos from different angles, the application processes the images into detailed 3D models that can be used in game development, virtual reality, and other creative projects. RealityScan simplifies the process of photogrammetry, making it accessible to professionals and hobbyists alike. In this paper, traceability assurance method for measurements performed using photogrammetric system built out of smartphone and RealityScan application is presented. It is based on measurements of material standards calibrated in accredited calibration laboratories or National Metrology Institutes, whose reference values are traceable to national measurement standards. The method allows also for assessing the task-specific maximum permissible errors of mentioned photogrammetric system. The paper shows procedures, example of measurements and result analysis. Limitations and possible fields of application of such metrologically traceable system, having in mind the values of maximum permissible errors that were determined, are also discussed.**

I. INTRODUCTION

Photogrammetry, a method that enables the extraction of information regarding the dimensions and shapes of spatial objects based on two-dimensional images in which they are represented, is a technique that has been known for several decades and is applied across numerous domains of human activity. Among these domains, various branches of engineering can be distinguished, including the field of precision measurement, in which photogrammetric techniques may be employed either directly for measurements [1,2], or as part of a larger system, for instance to assist in determining the spatial orientation of a measurement probe [3]. Photogrammetry is extensively utilized in geodetic surveying, where it serves, among other purposes, in the development of digital surface models [4] or orthomosaics, often generated using UAV platforms [5]. Another notable area of frequent photogrammetric application is the protection of cultural heritage, particularly in the context of monitoring and digitizing architectural objects [6]. Furthermore, photogrammetric solutions are of significant importance in biomedical engineering, where one of the key challenges is to ensure broad access to methods that facilitate treatment and therapy customization [7]. The broad spectrum of potential applications can also be extended to such diverse fields as public safety (e.g., the use of photogrammetry for accident site monitoring [8]) or the video game industry (e.g., the development of photorealistic models of environments and characters [9]).

Photogrammetry has been the subject of a substantial body of research focused on the assessment of dimensional accuracy and the reliability of the information obtained through its application. As noted in [10], photogrammetric measurements are influenced by numerous factors, including the camera used for digital image acquisition, the physical and optical properties of the measured object, the operator responsible for capturing or selecting the images, and the characteristics and operational principles of the software used to generate the model from digital imagery. Among the most significant sources of error in photogrammetric measurements is, undoubtedly, the digital camera itself. A number of studies have examined how specific camera parameters may impact the accuracy of results obtained via photogrammetric techniques. Remondino and Fraser in [11] presents various methods for camera calibration aimed at identifying and correcting fundamental sources of error. Similarly, Visockienė and Bručas in [12] discusses the calibration process of cameras employed in photogrammetry and evaluates its influence on measurement accuracy. The study presented in [13] highlights the role of focal distance and the choice of reference length, which is crucial for associating photogrammetric measurements with a physical unit of measurement. The impact of camera-induced errors is also

addressed in [14], where attention is additionally given to the importance of proper planning regarding camera position distribution for image acquisition, which directly affects the accuracy of the resulting models. This issue is further elaborated in [15], where the authors describe a strategy for camera placement, aiming to optimize both the number and positioning of image acquisition points. Other factors influencing photogrammetric measurements, as discussed in the literature, include the influence of processing software used [16], lighting conditions [17], and even the image file format [18]. General considerations regarding the methods for assessing the accuracy of photogrammetric scanners are presented in [3], whereas [19] offers a concrete example of a comparison between results obtained using photogrammetric measurements and results obtained from a total station.

The recent advancements in digital photography and computer science have significantly expanded the potential applications of mobile phones, including their use as tools for generating 3D models of objects in the surrounding environment. As a result, such devices can effectively be considered as 3D scanners. In recent years, a growing body of literature has emerged, demonstrating the feasibility of employing smartphones for 3D scanning across various domains of human activity. For instance, [20] describes the use of smartphone images to model transtibial sockets, achieving promising results in terms of both the scanned surface area and height measurements. The study presented in [21] provides an example of using smartphones for building measurements. Various smartphone models were tested, along with an evaluation of their camera error parameters and the accuracy of the resulting coordinate measurements. The findings suggest that smartphones can be effectively utilized in scenarios where high dimensional accuracy is not required. Another study illustrating the use of smartphones for generating spatial models of measured elements is described in [22]. This investigation compared results obtained using built-in smartphone cameras with those acquired via standalone digital cameras and a 3D scanner. The study highlighted the potential for unsatisfactory results if the smartphone camera lacks sufficient resolution (less than 12 MP).

Based on the examples discussed above, it can be anticipated that the trend of employing smartphones as 3D scanners will continue to intensify in the future, particularly given the increasing availability of free applications that enable the generation of 3D models from photographic data. One such application is *RealityScan*, developed by Epic Games, a company recognized for its work in the digital entertainment industry. This application is promoted as an intuitive tool capable of producing 3D models even of complex real-world objects. The present article aligns with current research directions in photogrammetric methods, as outlined in the cited literature review, in two main respects: it aims to evaluate the influence of the selected software on the accuracy of obtained measurements, and to assess the practical potential of modern smartphones in the context of geometric measurement tasks. The subsequent sections of this article present the experimental design, which includes the measurement of reference objects performed according to a defined measurement strategy. Thereafter, the results and conclusions of the study are discussed.

II. MATERIALS AND METHODS

RealityScan is a mobile photogrammetric application developed by Epic Games, designed to facilitate the creation of three-dimensional models of real-world objects using standard smartphone cameras. Technically, *RealityScan* operates by leveraging structure-from-motion (SfM) and multi-view stereo (MVS) algorithms to reconstruct 3D geometry from a series of overlapping two-dimensional photographs. Captured images are uploaded to Epic Games' cloud processing service, where the photogrammetric pipeline is executed. The SfM stage estimates camera poses and generates a sparse point cloud, while the MVS phase densifies the geometry to create a high-resolution mesh. Once the 3D model is computed, it is returned to the user's device and can be exported in standard formats such as FBX or OBJ. From a hardware perspective, *RealityScan* requires a smartphone with at least a 12-megapixel camera and support for relatively recent versions of iOS or Android. The application benefits from devices with optical image stabilization, as image blur and motion artifacts can significantly impair reconstruction quality. Lighting conditions and object surface characteristics (e.g., texture richness and reflectivity) also influence the final output.

The designed experiment involved multiple measurements of a measurement setup composed of geometric standards commonly used in conventional metrological applications and for assessing the accuracy of both contact and non-contact measurement systems, as well as elements used to establish the scale factor of the reconstructed model. Additionally, photogrammetric targets were placed at the boundaries of the working area to facilitate the model reconstruction process based on the images captured by the smartphone. Two calipers were employed as scale-setting elements (acting as reference length artifacts).

The experimental approach was based on established methodologies for verifying optical measurement systems, primarily drawing from ISO 10360 series standards and the VDI/VDE guidelines. Preliminary tests were conducted in accordance with these documents; however, the results proved unsatisfactory. The most significant issues arose during the measurement of spherical reference objects, which, due to their geometric regularity, posed challenges for the software in aligning sequential images and generating an accurate model.

Consequently, the measurement setup was modified to ensure that multiple reference elements would appear

within the camera frame during data acquisition, which was expected to enhance the performance of the matching algorithms utilized by the photogrammetric software. The reference standards used in the final phase of the study included: gauge blocks, spherical artifacts, and specially designed optical system verification targets composed of various geometric shapes and manufactured from materials with low reflectivity to minimize optical interference.

A summary of the reference objects used during the measurements, along with the 3D models generated using the evaluated application, is presented below (Fig.1a and Fig.1b)

Fig. 1a. Experimental setup consisting of reference elements and photogrammetry markers.
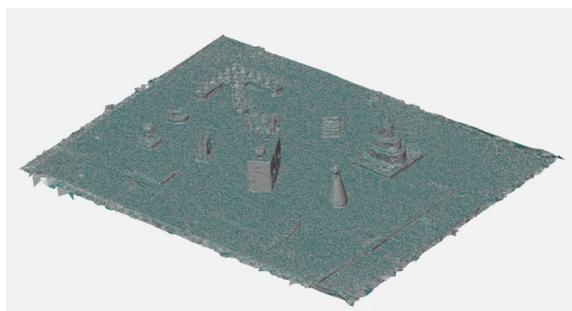

Fig. 1b. Model of measurement setup.

The measurements were conducted in series consisting of approximately 60 photographs, captured from four different angular positions relative to the measured objects and at varying distances from the measured objects, with the autofocus function enabled. After importing the images into the cloud-based processing environment, the computation settings for model generation were configured to their maximum accuracy level.

III. RESULTS

The measured features included: the distance represented by a selected gauge block (DIST_GB), the distance between the centers of two spheres on a ball-bar reference artifact (DIST_BB), the distance between two

holes on a dedicated optical calibration target (DIST_H), flatness (FLAT), as well as two angles 45° and 90°. The selected distance dimensions were chosen such that each measurement reflected a value within the range of 70 to 110 mm. An exemplary procedure for obtaining the tested dimensions is presented in the figure below (Fig.2), illustrating the measurement process on the optical calibration standard.
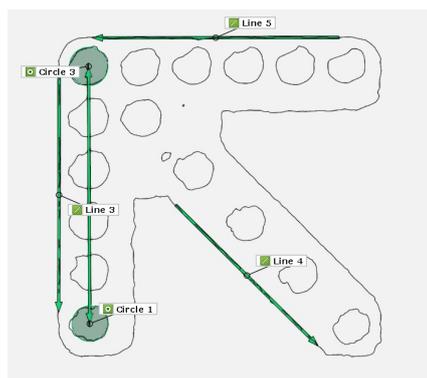

Fig. 2. Evaluation process of measurement data on the optical calibration standard.

The following figures present the reconstruction of successive measured reference standards on the model: gauge blocks (Fig. 3a and 3b), the ball-bar artifact (Fig. 4a and 4b), and the special optical calibration standard (Fig. 5a and 5b).
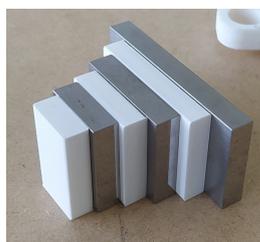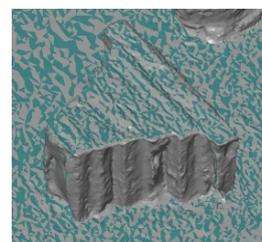

Fig. 3a. Measured gauge blocks.

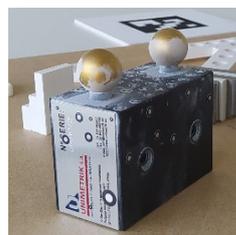*Fig. 3b Reproduced model with gauge blocks*

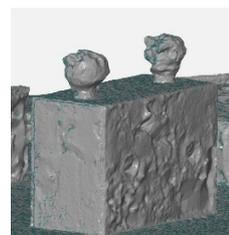*Fig. 4a Measured ball-bar*

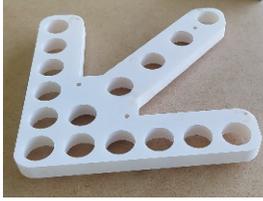*Fig. 4b Reproduced model with ball-bar*

Fig. 5a Measured special optical standard

Fig. 5b Reproduced model with special optical standard

The results of the conducted measurements are presented in Table 1 and Table 2, which show the mean deviations from nominal dimensions for the inspected features, as well as the maximum observed deviations and the corresponding standard deviations.

Table 1. Results of performed measurements of distance and flatness evaluation for all reference elements. All values given in mm.

Feature	Average	Max. Deviation	Std. Deviation
DIST_GB	-0,760	-0,893	0,119
DIST_BB	-0,171	-0,504	0,405
DIST_H	-0,829	-1,008	0,155
FLAT	0,251	0,317	0,066

Table 2. Results of performed angle measurements. All values given in °.

Feature	Average	Max. Deviation	Std. Deviation
45°	0,206	0,360	0,240
90°	-0,163	-0,25	0,117

IV. DISCUSSION AND CONCLUSION

The study confirms that the RealityScan application, when used in conjunction with a standard smartphone, enables the generation of 3D models suitable for basic dimensional measurements. However, the results also reveal several limitations in the system's accuracy and repeatability, which must be taken into account when considering potential applications.

The analysis of linear measurements shows that the deviations from nominal values varied significantly depending on the reference object. The average deviations ranged from -0.171 mm (for the ball-bar distance) to -0.829 mm (for the optical calibration target), with the maximum deviations reaching nearly 1 mm in some cases.

The variability of results, reflected in relatively high standard deviations, particularly for the DIST_BB feature, suggests that model reconstruction is sensitive to specific geometric characteristics and image acquisition conditions.

Flatness deviation and angular measurements performed on reconstructed models yielded smaller errors. The flatness deviation remained below 0.32 mm, while angular deviations did not exceed 0.36° for the 45° angle and 0.25° for the 90° angle. These outcomes indicate that RealityScan may be more reliable in reconstructing planar or simple angular features compared to complex geometric distances, especially spherical and cylindrical shapes, what was also conclusion coming out of measurements performed according to guidelines of ISO 10360-8 and VDI/VDE 2634 documents (form deviations for material standards shaped in this way was usually in the range of 2 to 4 mm).

Measurement uncertainty estimation was also done preliminarily for measurements presented in this paper. Uncertainty estimation was based on uncertainty budget and ISO guidelines. Expanded uncertainty values do not exceeded 0.2 mm for distance measurements and 0.15 degree for angle measurements. More details on uncertainty determination will be given in next publications of authors of this paper.

Despite the identified limitations, the proposed method enables a task-specific estimation of maximum permissible errors, which is essential for determining the suitability of this photogrammetric system in metrologically relevant contexts. While RealityScan and smartphones are not currently suitable for high-precision measurements, they can be effectively applied in scenarios requiring moderate accuracy, such as preliminary assessments, educational purposes, or cultural heritage documentation.

In conclusion, RealityScan represents a valuable tool for democratizing access to 3D modeling through photogrammetry. The proposed methodology allows users to quantify its accuracy and evaluate traceability, thus supporting informed application in both professional and hobbyist contexts. Future work should focus on reducing sources of error through improved calibration procedures, image acquisition strategies, and potentially integrating additional software tools for post-processing and validation.

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