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Information technology — 3D Printing and scanning — Accuracy and precision evaluation process for modelling from 3D scanned data

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

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Introduction

This document was developed in response to the quality management needs of 3D printing and scanning technology, with the aim of taking full advantage of information and communication technology (ICT) in this context. 3D scanning is the process of scanning a real-world object or environment to collect data on its shape and possibly its style attributes. The main purpose of 3D scanning is for generating high-precision digital 3D models.

A 3D scanner can be based on many different technologies, each with its own purposes and targets, limitations, and advantages. There can be many limitations in each type of target object that will be digitized. For example, optical technology can encounter many difficulties with dark, shiny, reflective, or transparent objects. As a further example, when using computed tomography scanning, structured-light 3D scanners, and Light Detection And Ranging (LiDAR) technology, there is a need to use non-destructive internal scanning technology for generating digital 3D models.

Despite the rapid growth of 3D scanning applications, the accuracy, precision, and reproducibility of generated 3D models from 3D scanned data have not been thoroughly investigated. Inaccuracies can arise due to errors that occur during the imaging, segmentation, modelling, postprocessing, and 3D printing steps. The total accuracy, precision, and reproducibility of 3D printed models is affected by the sum of errors introduced in each step involved in the creation of the models.

For the expansion of 3D printing applications, it is necessary to review and evaluate the various factors in each step of the 3D model printing process that contribute to model inaccuracy, including the intrinsic limitations of each printing technology. Once identified, the initial error should be assessed and corrected, in order to minimize cumulative errors of 3D printing life cycles. In this context, evaluation of the overall process of data processing is critical.

This document proposes a standardized process for evaluating quality enhancement and error minimization in the generation of the 3D model from 3D scanned data. As a general concept, evaluation is the systematic determination of the extent to which an entity meets its specified criteria. The evaluation of product quality is vital to both the acquisition and development of any product. The relative importance of the various characteristics of product quality depends on the intended usage or objectives of the product. Due to the 3D printing process is the composition of various tasks, 3D printing products need to be evaluated in each task to decide whether relevant quality characteristics meet the requirements of the final product.

This document is divided into two main parts:

Clause 4: Evaluation model - This clause describes the underlying principles of evaluation. The use of 3D printing requires specific considerations with regard to some of these principles as described in Clause 5.

Clause 5: Evaluation process - This clause describes the process of evaluation. Evaluation processes involve the systematic application of policies, procedures, and practices to the activities of communicating, establishing the context, assessing, reviewing, and reporting evaluated results.

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Information technology — 3D Printing and scanning — Accuracy and precision evaluation process for modelling from 3D scanned data

1 Scope

This document defines a standardized accuracy and precision evaluation process for modelling from 3D scanned data. The set of processes, activities and tasks described in this document provides a common framework for evaluating quality factors such as accuracy and precision for modelling from 3D scanned data.

This document is not intended to evaluate the 3D printed product itself.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 25040, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality evaluation framework*

ISO/IEC 25041, *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Evaluation guide for developers, acquirers and independent evaluators*

ISO/IEC/IEEE 24765, *Systems and software engineering — Vocabulary*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO/IEC 25040, ISO/IEC 25041 and ISO/IEC/IEEE 24765:2017 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms and definitions

3.1.1
3D printing product
set of 3D printed thing, procedures, and 3D model, and possible associated documentation and data

Note 1 to entry: Products include intermediate products, and products intended for users such as developers, designers and maintainers.

Note 2 to entry: In the ISO/IEC 3532 series, 3D printing quality has the same meaning as 3D printing product quality.

3.1.2
3D replica
exact 3D printed clone of a real-world object

Note 1 to entry: A 3D replica is a copy closely resembling the original concerning its shape and appearance

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3.1.3
3D replication
process of making a 3D replica using 3D scanning and 3D printing

3.1.4
3D replica model
generated 3D model for 3D printing via 3D scanning

3.1.5
3D replica modelling
process for generating the 3D model for 3D printing via 3D scanning

3.1.6
quality evaluation
systematic examination of the extent to which an entity is capable of fulfilling specified requirements

Note 1 to entry: Annex C provides the comparison between 3D printing product evaluation process and SQuaRE evaluation process.

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.3267, modified — Note 1 to entry has been removed.]

3.2 Abbreviations

CT	computed tomography
DICOM	digital imaging and communications in medicine
LiDAR	light detection and ranging
SQuaRE	software product quality requirements and evaluation

4 Evaluation model

4.1 General

4.1.1 Background

3D scanning is the process of scanning a real-world object or environment to collect data on its shape and possibly its style attributes. The main purpose of 3D scanning is for generating high-precision digital 3D models, which is also a process for 3D replica modelling.

Generation of a 3D replica or 3D replica model with 3D replica modelling is an important initial step for moving between real world and virtual world. Remanufacturing or repairing of wearing parts or structures should begin the generation of 3D replica model from damaged parts using 3D scanning. Printing of the 3D replica part to replace a damaged one or repairing wearing portion of part in situ should begin with the generation of 3D replica model using 3D scanning.

As such, there remains a need to understand how model accuracy and quality can be affected by each activity within the whole 3D printing workflow.

4.1.2 Evaluation model

The evaluation process includes the inputs and outcomes, constraints and resources for the 3D printing product quality evaluation process, as shown in Figure 1.

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