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Information technology — Computer graphics, image processing and environmental data representation — Benchmarking of vision-based spatial registration and tracking methods for mixed and augmented reality (MAR)

Technologies de l'information — Infographie, traitement d'images et représentation des données environnementales — Étalonnage des méthodes d'enregistrement géométriques et de suivi basées sur la vision pour le MAR

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 24, *Computer graphics, image processing and environmental data representation*.

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.

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Introduction

In the development of mixed and augmented reality (MAR) applications, one of the most important technologies involves spatial registration and spatial tracking methods, especially vision-based methods. The research and development on registration and tracking based on computer vision technologies is flourishing and many new algorithms have been proposed every year.

Therefore, this document aims at fostering objective evaluation and comparison of diverse registration and tracking methods, in order to facilitate fairer competition among small and major companies/institutes involved in MAR technologies, applications and services.

Moreover, this document can be the baseline to standardize spatial registration and tracking methods which not only utilize a video camera but combine a video camera with other sensors such as another video camera, a depth camera, inertial sensors and infrastructure-based positioning technologies, and which utilize technologies such as IoT (Internet of Things) and GNSS (Global Navigation Satellite System).

The target audience of this document includes stakeholders of benchmarking activities. The following are examples of how this document can be used directly or indirectly:

— by a benchmarking service provider, a benchmark provider or a benchmarking competition organizer who wishes to align their benchmarking activities including self-benchmarking and open/closed competitions to be consistent with this document;

— by a technology developer/supplier who wishes to estimate and evaluate the performance of a vision-based spatial registration and tracking (vSRT) method for MAR appropriately with a benchmarking service provider, a benchmark provider or a benchmarking competition organizer who aligns their benchmarking activities to be consistent with this document; or

— by a technology user who wishes to obtain benchmarking results based on a benchmarking activity, which is consistent with this document, or to compare the existing vSRT methods for MAR in terms of their performance.

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Information technology — Computer graphics, image processing and environmental data representation — Benchmarking of vision-based spatial registration and tracking methods for mixed and augmented reality (MAR)

1 Scope

This document identifies the reference framework for the benchmarking of vision-based spatial registration and tracking (vSRT) methods for mixed and augmented reality (MAR).

The framework provides typical benchmarking processes, benchmark indicators and trial set elements that are necessary to successfully identify, define, design, select and apply benchmarking of vSRT methods for MAR. It also provides definitions for terms on benchmarking of vSRT methods for MAR.

In addition, this document provides a conformance checklist as a tool to clarify how each benchmarking activity conforms to this document in a compact form by declaring which benchmarking processes and benchmark indicators are included and what types of trial sets are used in each benchmarking activity.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, acronyms and abbreviated terms

For the purposes of this document, the following terms and definitions 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 http://www.electropedia.org/

3.1 Terms and definitions

3.1.1
benchmark
reference point against which comparisons can be made

Note 1 to entry: In the context of this document, the performance of vSRT methods for MAR is the object of comparison.

Note 2 to entry: See ISO/IEC 29155-1.

3.1.2
benchmark indicator
indicator that qualitatively shows a particular aspect of a *benchmark* (3.1.1) with appropriate metrics

3.1.3
benchmarking
activity of comparing objects of interest to each other or against *benchmarks* (3.1.1) to evaluate relevant characteristics

Note 1 to entry: In the context of this document, the object of interest is the performance of vSRT methods for MAR, and the characteristics are particular aspects of the performance such as reliability, temporal characteristic, etc.

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Note 2 to entry: See ISO/IEC 29155-1.

3.1.4
benchmarking instrument
tool, method or guide used to support every activity within the *benchmarking* (3.1.3) framework

3.1.5
benchmarking method
particular procedure for conducting *benchmarking* (3.1.3) and obtaining *benchmarking results* (3.1.7)

3.1.6
benchmarking repository
repository which is designated for retaining information necessary for *benchmarking* (3.1.3) such as *datasets* (3.1.9) for benchmarking and *benchmarking results* (3.1.7)

Note 1 to entry: Some benchmarking repositories might contain all information, and some might contain a subset.

Note 2 to entry: See ISO/IEC 29155-1.

3.1.7
benchmarking results
benchmarks (3.1.1) as primary results, and intermediate results and reports on *benchmarking* (3.1.3) including findings, issues and lessons learned as secondary results

Note 1 to entry: In the context of this document, a typical intermediate result is the output of vSRT methods such as the estimated position of a camera the accuracy of which is evaluated with a benchmark indicator.

3.1.8
competition organizer
person or organization that hosts an *on-site* (3.1.14) or *off-site* (3.1.13) benchmarking competition

3.1.9
dataset
collection of data that contains target images and the *ground truth* (3.1.11) regarding the target images for *benchmarking* (3.1.3)

3.1.10
extrinsic camera parameters
parameters that define the position and orientation of a camera reference frame with respect to a known world reference frame such as the translation vector and the rotation matrix

3.1.11
ground truth
collection of measurements that is much more accurate as a whole than measurements by technologies which are the targets of *benchmarking* (3.1.3)

3.1.12
intrinsic camera parameters
parameters that define the relationship between the pixel coordinates of an image point and the corresponding coordinates in the camera reference frame

Note 1 to entry: Intrinsic camera parameters contain the focal length, the scale factors, the skew, the principal point, the lens distortion, etc.

3.1.13
off-site benchmarking
benchmarking (3.1.3) that is conducted with target images in datasets which were prepared beforehand

3.1.14
on-site benchmarking
benchmarking (3.1.3) that is conducted by executing vSRT programs while capturing target images on the spot

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3.1.15
physical object
object, which exists in the real world, used as a target of *spatial registration* (3.1.16), *spatial tracking* (3.1.17) and/or augmentation

Note 1 to entry: Especially for off-site benchmarking with physical objects, the physical object instances shall be easily available or deliverable objects such as paper crafts and toy bricks, or they shall be made accessible by providing information on how to find them for capturing the images. The physical object instances in off-site benchmarking are utilized to gather and acquire information necessary for vSRT methods such as visual features and 3D models of the objects.

3.1.16
spatial registration
establishment of the spatial relationship or mapping between two models, typically between virtual objects and target *physical objects* (3.1.15)

[SOURCE: ISO/IEC 18039:2019, 3.1.20]

3.1.17
spatial tracking
update of the spatial relationship or mapping between two models, typically between virtual objects and target *physical objects* (3.1.15) over time

3.1.18
trial set
combination of a dataset and a collection of *physical object* (3.1.15) instances for *off-site* (3.1.13) and *on-site* (3.1.14) benchmarking of vSRT methods for MAR

3.1.19
vision-based spatial registration and tracking
spatial registration (3.1.16) and *spatial tracking* (3.1.17) based on image processing and computer vision technologies

Note 1 to entry: The term “spatial registration and tracking” is also called “geometric registration and tracking” in Annex A and in some of the bibliography references.

3.2 Acronyms and abbreviated terms

3DEVO	3D error of a virtual object
MAR	Mixed and augmented reality[1]
PEVO	Projection error of a virtual object
SLAM	Simultaneous localization and mapping[1]
vSRT	Vision-based spatial registration and tracking

4 Overview of the framework

This clause outlines the reference framework of benchmarking of vSRT methods for MAR, the details of which are described in Clauses 5, 6, and 7. As shown in Figure 1, the reference framework is composed of the following three core components.

— **Benchmarking processes**, which include how to produce benchmarking outcomes such as benchmarking results, benchmark surveys and benchmarking instruments with benchmark indicators and trial sets and how to share benchmarking outcomes.

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