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Information technology — Computer graphics, image processing and environmental data representation — Benchmarking of integrated indoor localization and tracking methods using dead reckoning

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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

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Introduction

In the development of location-based service and application such as navigation, traffic line analysis, one of the most important parts is the localization and tracking method (LTM) used for estimating the position of the target people or objects. In contrast to the outdoor, global navigation satellite systems cannot be used in indoor environment because the signals from the satellite cannot be reached. In order to provide the solution for localization and tracking in indoor environment, the research and development on integrated indoor LTMs is flourishing and many new algorithms are proposed every year. Especially, dead reckoning technologies (xDR) such as pedestrian dead reckoning (PDR) can contribute integrated indoor localization, because of their capability of relative tracking without any infrastructure in the target environment.

Therefore, this document intends to foster objective evaluation and comparison of diverse LTMs, especially for targeting integrated LTMs using dead reckoning.

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 or closed competitions to be consistent with this document;

— by a technology developer or supplier who wishes to estimate and evaluate the performance of an indoor localization and tracking methods 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 indoor localization and tracking methods in terms of their performance.

The main targets of the benchmarking framework are integrated indoor LTMs using dead reckoning, which are assumed to be running on the mobile devices such as smartphones.

a) Master sets and test environments:

   The framework defines reference master sets and test environments, where integrated indoor localization methods using dead reckoning is assumed to be utilized. The reference master sets include dataset designed for evaluating individual contribution of dead reckoning method.

b) Benchmark metrics:

   The framework defines benchmark metrics consisting of indicators for dead reckoning and other indicators evaluation practical performance of indoor localization methods.

c) Benchmarking process:

   The framework defines benchmarking process which can evaluate each elemental performance of the contents of the integrated indoor localization methods and generalization performance.

d) Conformance.

   The framework defines conformance check list which can clarify how each benchmarking activity conforms to the benchmarking framework.

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Information technology — Computer graphics, image processing and environmental data representation — Benchmarking of integrated indoor localization and tracking methods using dead reckoning

1 Scope

This document specifies the reference framework for the benchmarking of integrated indoor localization and tracking methods (LTMs) using dead reckoning in areas of:

— master sets and test environments;

— benchmark metrics;

— benchmarking process;

— conformance.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology 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
localization and tracking method
method for estimating location of the target and continuously tracking the movement of the target over time

3.1.2
pedestrian dead reckoning
method for continuously estimating pedestrian's relative change of position and heading direction from a known position and heading direction by only using user mounted sensors such as inertial measurement unit, compass, barometer and other type of sensors which can be mounted on the user

3.1.3
error accumulation gradient
speed of error accumulation caused by the nature of relative tracking and includes variations such as position error accumulation gradient and orientation error accumulation gradient

3.1.4
position error accumulation gradient
speed of positional error accumulation caused by the nature of relative tracking

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3.1.5
orientation error accumulation gradient
speed of orientational error accumulation caused by the nature of relative tracking

3.1.6
absolute localization
localization method that estimates absolute position and posture of the target

3.1.7
relative localization
localization method that estimates relative change of position and posture of the target

3.1.8
absolute localization inapplicable period
period in dataset when data for the absolute localization such as records of Bluetooth®[1)] low energy (BLE) signals are deleted

3.1.9
absolute localization applicable period
period in dataset when data for the absolute localization are available (not deleted)

3.1.10
correction point
point whose ground-truth positions is provided by benchmark organizers for positional correction

3.1.11
evaluation point
point whose position is hidden from developers, and used for evaluation by competition organizers or benchmarking service providers

3.1.12
moving velocity check
negative check elements regarding moving velocity

3.1.13
obstacle avoidance check
negative check elements regarding objective avoidance

3.1.14
circular accuracy
accuracy evaluation elements evaluated by the deviation of the error distribution in 2D (xy) error space

3.1.15
un-walkable area
area defined in floor map as areas where tracking targets cannot walk into

3.1.16
velocity error
error of velocity compared with correct velocity

3.1.17
scoring dataset
dataset provided for actual benchmarking without ground-truth (GT) data

Note 1 to entry: Participants are asked to submit the result of LTMs by processing the scoring dataset.

1) Bluetooth is a tradename of a product supplied by Bluetooth Special Interest Group. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of the product named.

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3.2 Acronyms and abbreviated terms

AC-OEAG	angular change normalized orientation error accumulation gradient
AC-PEAG	angular change normalized position error accumulation gradient
AL	absolute localization
ALAP	absolute localization applicable period
ALIP	absolute localization inapplicable period
AP	access point
API	application programming interface
BLE	Bluetooth low energy
CA	circular accuracy
CE	circular error
DE	distance error
D-OEAG	distance normalized orientation error accumulation gradient
DOF	degree of freedom
D-PEAG	distance normalized position error accumulation gradient
EAG	error accumulation gradient
GT	ground truth
IMU	inertial measurement unit
IPIN	international conference on indoor positioning and indoor navigation
LiDAR	light detection and ranging (or laser imaging detection and ranging)
LTM	localization and tracking method
NTP	network time protocol
OEAG	orientation error accumulation gradient
PDR	pedestrian dead reckoning
PEAG	position error accumulation gradient
PIEM	path independent evaluation metric
RSSI	received signal strength indicator
T-OEAG	time normalized orientation error accumulation gradient
T-PEAG	time normalized position error accumulation gradient
VE	velocity error
vSRT	vision-based spatial registration and tracking

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WMS	warehouse management system
xDR	(generic expression of) dead reckoning

4 Overview of the framework

This clause outlines the reference framework of benchmarking of integrated indoor LTMs using dead reckoning, the details of which are described in Clauses 5, 6, and 7. As shown in Figure 1, the reference framework is composed of 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.

— Benchmark indicators, which quantify the performance of LTMs by taking into account not only positioning accuracy, but also various and practical performance required for LTMs in realistic situation.

— Master set, which is composed of datasets and physical testing fields to provide each benchmarking attempt with the same conditions.

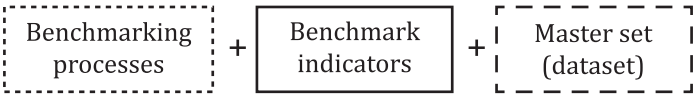


Figure 1 — Core components of the benchmarking framework

The above three components are identified and defined in accordance with grass-roots activities for standardizing benchmarking schemes and for conducting on-site and off-site comparison of LTMs which are often held as contests and are introduced in Annex A.

5 Benchmarking processes

5.1 Overview

This clause outlines benchmarking processes and related components necessary to produce and share benchmarking outcomes. Figure 2 illustrates the basic benchmarking process flow. The benchmarking process for indoor LTMs is a derivative of the benchmarking process for vSRT standardized in ISO/IEC 18520.

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