INTERNATIONAL STANDARD

ISO 18646-2

First edition
2019-04

Robotics — Performance criteria and related test methods for service robots —

Part 2: Navigation

Robotique — Critères de performance et méthodes d'essai correspondantes pour robots de service — Partie 2: Navigation

Reference number
ISO 18646-2:2019(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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/TC 299, *Robotics*.

A list of all parts in the ISO 18646 series can be found on the ISO website.

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.

Introduction

This document is intended to specify performance criteria and test method for navigation of mobile service robots. It defines performance characteristics, describes how they are specified and recommends how to test them.

The characteristics for which test methods are given in this document are those considered to affect robot performance significantly. It is intended that the reader of this document selects which performance characteristics are to be tested, in accordance with the specific requirements.

The performance criteria specified in this document are not intended to be interpreted as the verification or validation of safety requirements.

Robotics — Performance criteria and related test methods for service robots —

Part 2: Navigation

1 Scope

This document describes methods of specifying and evaluating the navigation performance of mobile service robots. Navigation performance in this document is measured by pose accuracy and repeatability, as well as the ability to detect and avoid obstacles. Other measures of navigation performance are available but are not covered in this document.

The criteria and related test methods are applicable only to mobile platforms that are in contact with the travel surface. For evaluating the characteristics of manipulators, ISO 9283 applies.

This document deals with indoor environments only. However, the depicted tests can also be applicable for robots operating in outdoor environments, as described in Annex A.

This document is not applicable for the verification or validation of safety requirements. It does not deal with safety requirements for test personnel during testing.

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 7176-13, *Wheelchairs — Part 13: Determination of coefficient of friction of test surfaces*

ISO 8373:2012, *Robots and robotic devices — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8373 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 http://www.electropedia.org/

3.1
robot
programmed actuated mechanism with a degree of autonomy, moving within its environment, to perform intended tasks

Note 1 to entry: A robot includes the control system and interface of the control system.

Note 2 to entry: The classification of robot into industrial robot or *service robot* (3.4) is done according to its intended application.

[SOURCE: ISO 8373:2012, 2.6, modified — The words “actuated mechanism programmable in two or more axes” have been replaced with “programmed actuated mechanism”.]

3.2
mobile robot
robot (3.1) able to travel under its own control

Note 1 to entry: to entry: A mobile robot can be a *mobile platform* (3.3) with or without manipulators.

[SOURCE: ISO 8373:2012, 2.13]

3.3
mobile platform
assembly of all components of the *mobile robot* (3.2) which enables locomotion

Note 1 to entry: A mobile platform can include a chassis which can be used to support a *load* (3.6).

Note 2 to entry: Because of possible confusion with the term "base", it is advisable not to use the term "mobile base" to describe a mobile platform.

[SOURCE: ISO 8373:2012, 3.18]

3.4
service robot
robot (3.1) that performs useful tasks for humans or equipment excluding industrial automation applications

Note 1 to entry: Industrial automation applications include, but are not limited to, manufacturing, inspection, packaging, and assembly.

Note 2 to entry: While articulated robots used in production lines are industrial robots, similar articulated robots used for serving food are service robots.

[SOURCE: ISO 8373:2012, 2.10]

3.5
navigation
deciding on and controlling the direction of travel, derived from localization and the environment map

Note 1 to entry: Navigation can include *path* (3.14) planning for pose-to-pose travel and complete area coverage.

[SOURCE: ISO 8373:2012, 7.6]

3.6
load
force and/or torque at the mechanical interface or *mobile platform* (3.3) which can be exerted along the various directions of motion under specified conditions of velocity and acceleration

Note 1 to entry: The load is a function of mass, moment of inertia, and static and dynamic forces supported by the *robot* (3.1).

[SOURCE: ISO 8373:2012, 6.2.1]

3.7
rated load
maximum *load* (3.6) that can be applied to the mechanical interface or *mobile platform* (3.3) in *normal operating conditions* (3.9) without degradation of any performance specification

Note 1 to entry: The rated load includes the inertial effects of the end effector, accessories and workpiece, where applicable.

[SOURCE: ISO 8373:2012, 6.2.2]

3.8
rated speed
maximum speed of *mobile platform* (3.3) equipped with *rated load* (3.7) in *normal operating conditions* (3.9)

[SOURCE: ISO 18646-1:2016, 3.11]

3.9
normal operating conditions
range of environmental conditions and other parameters which can influence robot performance (such as electrical supply instability, electromagnetic fields) within which the performance of the *robot* (3.1) specified by the manufacturer is valid

Note 1 to entry: Environmental conditions include, for example, temperature and humidity.

[SOURCE: ISO 8373:2012, 6.1]

3.10
task program
set of instructions for motion and auxiliary functions that define the specific intended task of the *robot* (3.1) or robot system

Note 1 to entry: This type of program is usually generated after the installation of the robot and can be modified by a trained person under defined conditions.

Note 2 to entry: An application is a general area of work; a task is specific within the application.

[SOURCE: ISO 8373:2012, 5.1.1]

3.11
pose
combination of position and orientation in space

Note 1 to entry: Pose for the manipulator normally refers to the position and orientation of the end effector or the mechanical interface.

Note 2 to entry: Pose for a *mobile robot* (3.2) can include the set of poses of the *mobile platform* (3.3) and of any manipulator attached to the mobile platform, with respect to the world coordinate system.

Note 3 to entry: For mobile robots in contact with a flat surface, orientation is typically a scalar angle about the normal to the flat surface, with respect to a reference direction.

[SOURCE: ISO 8373:2012, 4.5, modified —Note 3 to entry has been added.]

3.12
command pose
programmed pose
pose (3.11) specified by the *task program* (3.10)

[SOURCE: ISO 8373:2012, 4.5.1]

3.13
attained pose
pose (3.11) achieved by the *robot* (3.1) in response to the *command pose* (3.12)

[SOURCE: ISO 8373:2012, 4.5.2]

3.14
path
ordered set of *poses* (3.11)

[SOURCE: ISO 8373:2012, 4.5.4]

3.15
cluster
set of measured points used to calculate the accuracy and the repeatability characteristics

[SOURCE: ISO 9283:1998, 3.1, modified]

3.16
barycentre
point whose coordinates are the mean values of a *cluster* (3.15) of points

Note 1 to entry: For a cluster of n points defined by their coordinates (x_j — y_j — z_j), the barycentre of that cluster of points is calculated as follows:

$$\bar{x} = \frac{1}{n}\sum_{j=1}^{n} x_j \, , \bar{y} = \frac{1}{n}\sum_{j=1}^{n} y_j \, , \bar{z} = \frac{1}{n}\sum_{j=1}^{n} z_j$$

[SOURCE: ISO 9283:1998, 3.2, modified]

4 Test conditions

4.1 General

The robot shall be completely assembled, fully charged and operational, based on the manufacturer specification. All self-diagnostic tests shall be satisfactorily completed. Appropriate precautions should be taken to protect the personnel during the test.

The tests shall be preceded by the preparations for operation as specified by the manufacturer. These preparations shall be reported in the test report.

All conditions specified in Clause 4 should be satisfied for the tests described in this document, unless it is stated otherwise in the specific clauses.

Each test described in each clause of this document can have different test configurations which require separate test procedures. For each test configuration, multiple trials should be conducted if specified in the test procedure.

4.2 Environmental conditions

The following typical indoor environmental conditions should be maintained during all tests:

— ambient temperature: 10 °C to 30 °C;

— relative humidity: 0 % to 80 %;

— illumination: 100 lux to 1 000 lux.

The environmental conditions shall be declared in the test report. The manufacturer may specify environmental conditions outside these ranges (see Annex A).

NOTE Even though reflectivity can affect performance, it is not included in these environmental conditions.

4.3 Travel surface conditions

A hard, even and horizontal travel surface with a coefficient of friction between 0,6 and 1,0, measured in accordance with ISO 7176-13, shall be used.

4.4 Operating conditions

All performance shall be measured under normal operating conditions. When the performance is measured in other conditions, those conditions shall be declared in the test report.

For all tests, the robot shall be tested at the rated speed and equipped with the rated load, unless otherwise specified.

For the navigation of mobile platforms, external equipment, such as landmarks, shall be supplied according to the specifications of the manufacturer. Information on the external equipment, such as locations and types of landmarks, shall be provided in the test report.

4.5 Test paths

All test paths are parameterized with respect to the sizes of mobile platforms. Length unit LU is defined as the maximum of the width w and the length l of the mobile platform, as shown in Figure 1. The LU value used for the test shall be declared in the test report.

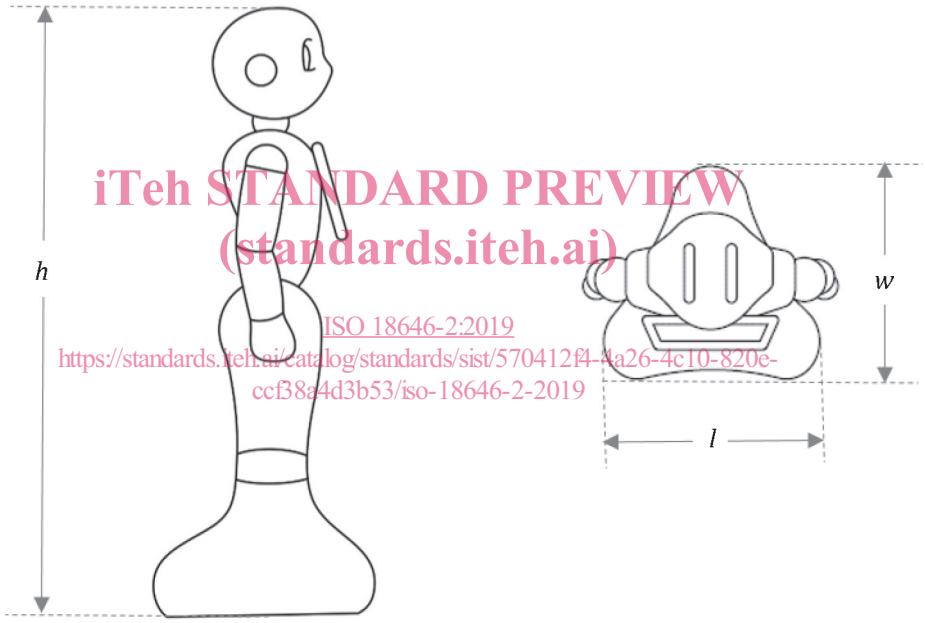

Figure 1 — Dimensions of mobile platform

Straight path, rectangular path and composite path are used in this document (see Figures 2, 3 and 4). The value of 5 LU is selected to normalize the travel distance of various sizes of robots when we measure the pose characteristics in Clause 5. Alternatively, the travel distance can be specified by the manufacturer considering specific applications. Straight path moves from the initial pose of P_0 until it reaches the goal pose of P_1. Rectangular path moves from the initial pose of P_0 to P_1, P_2, P_3, and finally to the goal pose of P_0. Composite path moves from the initial pose of P_0 until it reaches the goal pose of P_2 via P_1.

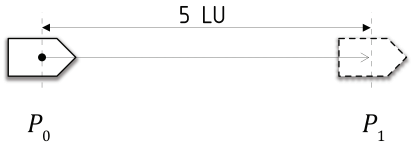

Figure 2 — Straight path