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Robotics — Collaborative applications — Test methods for measuring forces and pressures in human-robot contacts

Robotique — Applications collaboratives — Méthodes d'essai pour mesurer les forces et les pressions dans les contacts homme-robot

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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 document 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).

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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*.

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

All testing methods specified in this document represent the latest state-of-the-art in the research field of contact measurement and testing with robots made for biomechanically safe interactions with humans. The procedures described in this document have been developed with a focus on practical applicability and several examples have been included in the annexes to this effect. The intended users of the document include integrators, operators, and users of collaborative applications as well as manufacturers of pressure-force measurement devices (PFMD).

The purpose of this document is to facilitate the application of other standards such as ISO 10218-2:—[1)], Annex N, robot applications and robot cells integration (based on RIA TR R15.806:2018) or ISO/TS 15066.

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Robotics — Collaborative applications — Test methods for measuring forces and pressures in human-robot contacts

1 Scope

This document specifies methods of measuring forces and pressures in physical human-robot contacts. It also specifies methods for analyzing the measured forces and pressures. It further specifies the characteristics of pressure-force measurement devices (PFMD).

This document applies to collaborative applications deployed in an industrial or service environment for professional use.

This document does not apply to non-professional robots (i.e. consumer robots) or medical robots, although the measurement methods presented can be applied in these areas, if deemed appropriate. Additionally, this document does not apply to organizational aspects for performing contact measurements (e.g. responsibilities or data management), assessment of other mechanical contact types (e.g. friction or shearing), assessment of other contact-related hazards (e.g. falling, electrical or chemical hazards). Further, this document does not set requirements for specific PFMD-design or specify methods to identify contact hazards.

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 10218-2[2)], *Robotics — Safety requirements — Part 2: Industrial robot systems, robot applications and robot cells*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO/IEC Guide 50, *Safety aspects — Guidelines for child safety in standards and other specifications*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and ISO 10218-2 and the following 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
contact hazard
intended or unintended physical contact between human and robot or robot system in which the robot or robot system exerts forces and pressures on the human body

3.2
pressure-force measurement device
PFMD
measuring instrument with sensors to record forces and pressures of mechanical contacts

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3.3
biomechanical response
behaviour of a biological system when subjected to mechanical load that can be described by *biomechanical response curves* (3.4)

3.4
biomechanical response curve
curves that plot the contact force as a function of tissue deformation

4 Overview

4.1 General

The test methods presented in this document provide evidence through measurement whether a robot or robot system (hereinafter referred to as robot for simplicity) deployed in a collaborative application (hereinafter referred to as application for simplicity) complies with applicable force and pressure limits during physical contact with humans. Physical contact can result either from intended use or reasonably foreseeable misuse of the robot under test.

The testing procedure typically comprises several measurements of contact hazards (as identified by the risk assessment) that are replicated with the robot deployed in the target application environment. In such tests the forces and pressures, that the robot can exert on humans during physical contact, are measured. The robot passes the tests if the contact forces and pressures measured in the relevant contact situations do not exceed the applicable biomechanical limits.

If the applicable biomechanical limits also apply to children, the measurement procedures given in this document shall be executed in accordance with ISO/IEC Guide 50.

A pressure-force measurement device (PFMD) is used to measure forces and pressures, but also to replicate the biomechanical response of the human body. For replicating the biomechanical response, a PFMD can comprise various viscous and elastic materials.

The following list summarizes the steps of a proper test:

a) Preparation of the robot and the test conditions;

b) Replicating the contact situation by letting the robot under test collide with the PFMD;

c) Analyzing the forces and pressures measured;

d) Comparing the measurement values to the applicable biomechanical limits (if the measurement values do not exceed the biomechanical limits, the robot passes the test for the target application environment; otherwise, it does not pass the test);

e) Documentation of the test results;

f) If the robot does not pass the test for the target application environment, it will be possible to reduce force and/or pressure by modifying the robot. Repeat all the steps from a) to e) if the robot is modified and document the new test conditions.

4.2 Contact types

Human-robot contact situations can be categorized into intended or unintended contacts. Intended human-robot contacts are typically interactions between human and robot to complete a common task. Unintended human-robot contacts typically result from reasonably foreseeable misuse. Both contact categories shall be assessed through measurement if identified as relevant by the risk assessment. From here on, both contact categories will be referred to as *contact hazard*.

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