TECHNICAL REPORT

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Manipulating industrial robots — Informative guide on test equipment and metrology methods of operation for robot performance evaluation in accordance with ISO 9283

Robots manipulateurs industriels — Guide informatif sur l'appareillage d'essai et les méthodes métrologiques opératoires pour l'évaluation de la performance d'un robot conformément à l'ISO 9283

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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 in 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 main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee or sub-committee may propose the publication of Technical Report of one of following types:

-type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

-type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

-type 3, when a technical committee or sub-committee has collected data of a different kind from that which is normally published as an International Standard ("state-of-the-art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 13309, which is a Technical Report of type 3, was prepared by Working Group 2 - Performance criteria and related testing methods - of ISO/TC 184/SC 2 - Robots for manufacturing environment.

This document is being published in the form of a Technical Report because it is intended to provide an overview on technically feasible metrology methods and the current state-of-the-art of test equipment when evaluating robot motion performances in accordance with ISO 9283:1990 - Manipulating industrial robots - Performance criteria and related test methods.

Introduction

The International Standards ISO 9283 and ISO 9946 were published in 1990 and 1991 in order to meet the needs of industries. For the purpose of supplementing these standards some amendments are being investigated for real applications.

It is important to clarify the kind and performance level of existing measurement systems applicable to robots in relation to ISO 9283 and establishing additional standards or reports.

This Technical Report contains an attempt to classify the measurement techniques and methods applicable to the robot characteristics testing, and describes the principles of operation and accuracies of the current state-of-the-art, and as much as possible, currently available measurement systems.

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1. Scope

This report supplies information on the state-of-the-art of test equipment operating principles. Additional information is provided that describes the applications of current test equipment technology to ISO 9283.

2. Major categories of performance measuring methods

There are several methods which are used for characterizing robot performance in accordance with ISO 9283. These methods are classified as follows:

1. Positioning test probe methods
2. Path comparison methods
3. Trilateration methods
4. Polar coordinate measuring methods
5. Triangulation method
6. Inertial measuring method
7. Coordinate measuring methods
8. Path drawing method

Brief discussion of these methods is given in Section 4. Detailed description of these systems can be found in documents provided in Library list (Annex C).

3. Recommended robot performance measuring methods

Table 1 presents a list of the recommended methods for measuring the performance criteria in accordance with ISO 9283. The methods that are categorized into eight categories in Section 2 are itemized into a total of 16 individual methods. Each method's capabilities are also provided. Although some methods can be used to measure the characteristics of both the pose and the path, some of the methods have limitations. Some of the limitations are:

- (1) Only position (or orientation) can be measured in pose characteristics testing.
- (2) Path characteristics (linear or circular) can be measured only along restricted command paths.
- (3) Only robots with limited overshoot can be tested.
- (4) The performance of the test equipment may not provide sufficient accuracy or uncertainty of measurement for particular characteristics.

- (5) Measuring is limited to the number of freedom of the test equipment.
- (6) The test equipment may provide limited measurement volume compared to the test cube defined in ISO 9283.
- (7) The sampling frequency of the test equipment may not fit for the top frequency of the robot movement to be measured.

The tester should discuss the limitations with the test equipment manufacturer when planning performance measurement.

Table 2 is a summary of typical performance characteristics and capabilities of the recommended methods. It is advised that before testing a robot, the tester should understand the performance levels of the robot and select the appropriate testing methods.

4. Robot performance measuring methods

This section is a descriptive presentation and schematic configurations of the methods listed in Table 1.

4.1 Positioning test probe methods

The attained pose characteristics can be measured using a probe containing sufficient number of displacement or proximity sensors which are positioned by the robot to slowly touch a precision artifact located at a prescribed position or to stay in the air to measure possible overshoot. A typical set up is shown in Figure 1. Figure 2 shows some alternative applications of the method. Several types of test artifacts and probes can be combined, depending on the number of pose parameters required.

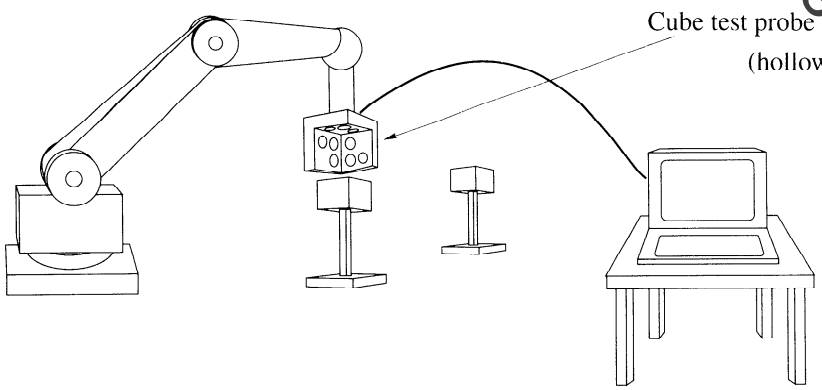

Figure 1 Positioning test probe method (cube artifact)