
**Information technology — Artificial
intelligence — Assessment of machine
learning classification performance**

*Technologies de l'information — Intelligence artificielle — Evaluation
des performances de classification de l'apprentissage machine*



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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.

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 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 or www.iec.ch/members_experts/refdocs).

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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. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 42, *Artificial intelligence*.

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 and www.iec.ch/national-committees.

Introduction

As academic, commercial and governmental researchers continue to improve machine learning models, consistent approaches and methods should be applied to machine learning classification performance assessment.

Advances in machine learning are often reported in terms of improved performance relative to the state of the art or a reasonable baseline. The choice of an appropriate metric to assess machine learning model classification performance depends on the use case and domain constraints. Further, the chosen metric can differ from the metric used during training. Machine learning model classification performance can be represented through the following examples:

- A new model achieves 97,8 % classification accuracy on a dataset where the state-of-the-art model achieves just 96,2 % accuracy.
- A new model achieves classification accuracy equivalent to the state of the art but requires much less training data than state-of-the-art approaches.
- A new model generates inferences 100x faster than state-of-the-art models while maintaining equivalent accuracy.

To determine whether these assertions are meaningful, aspects of machine learning classification performance assessment including model implementation, dataset composition and results calculation are taken into consideration. This document describes approaches and methods to ensure the relevance, legitimacy and extensibility of machine learning classification performance assertions.

Various AI stakeholder roles as defined in ISO/IEC 22989:2022, 5.17 can take advantage of the approaches and methods described in this document. For example, AI developers can use the approaches and methods when evaluating ML models.

Methodological controls are put in place when assessing machine learning performance to ensure that results are fair and representative. Examples of these controls include establishing computational environments, selecting and preparing datasets, and limiting leakage that potentially leads to misleading classification results. [Clause 5](#) addresses this topic.

Merely reporting performance in terms of accuracy can be inappropriate depending on the characteristics of training data and input data. If a classifier is susceptible to majority class classification, grossly unbalanced training data can overstate accuracy by representing the prior probabilities of the majority class. Additional measurements that reflect more subtle aspects of machine learning classification performance, such as macro-averaged metrics, are at times more appropriate. Further, different types of machine learning classification, such as binary, multi-class and multi-label, are associated with specific performance metrics. In addition to these metrics, aspects of classification performance such as computational complexity, latency, throughput and efficiency can be relevant. [Clause 6](#) addresses these topics.

Complications can arise as a result of the distribution of training data. Statistical tests of significance are undertaken to establish the conditions under which machine learning classification performance differs meaningfully. Specific training, validation and test methodologies are used in machine learning model development to address the range of potential scenarios. [Clause 7](#) addresses these topics.

[Annex A](#) illustrates calculation of multi-class classification performance, using examples of positive and negative classifications. [Annex B](#) illustrates a receiver operating characteristic (ROC) curve derived from example data in [Annex A](#).

[Annex C](#) summarizes results from machine learning classification benchmark tests.

[Annex D](#) discusses a chance-corrected cause-specific mortality fraction, a machine learning classification use case. Apart from these, this document does not address any issues related to benchmarking, applications or use cases.

Information technology — Artificial intelligence — Assessment of machine learning classification performance

1 Scope

This document specifies methodologies for measuring classification performance of machine learning models, systems and algorithms.

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/IEC 22989:2022, *Information technology — Artificial intelligence — Artificial intelligence concepts and terminology*

ISO/IEC 23053:2022, *Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO/IEC 22989:2022, ISO/IEC 23053:2022, 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 Classification and related terms

3.1.1 classification

method of structuring a defined type of item (objects or documents) into classes and subclasses in accordance with their characteristics

[SOURCE: ISO 7200:2004, 3.1]

3.1.2 classifier

trained model and its associated mechanism used to perform *classification* ([3.1.1](#))

3.2 Metrics and related terms

3.2.1 evaluation

process of comparing the *classification* ([3.1.1](#)) predictions made by the model on data to the actual labels in the data