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Foreword

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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

Advances in artificial intelligence (AI) have revolutionized various industries and transformed the way humans master technology. As AI continues to permeate our daily lives, it is crucial to establish standardized ways of describing AI systems that enable a shared understanding of these systems, including to better evaluate value and risk.

This document provides a framework for characterizing AI system methods (procedures, algorithms) and capabilities (abilities, functionalities). The framework can be used by stakeholders to characterize AI system methods and capabilities. The aim is to help relevant stakeholders to understand methods and capabilities used in an AI system. AI systems can consist of several components, each of which suggests one or more methods. In this context, the framework helps distinguish between different types of AI methods and AI system capabilities to create a common language for analysing, comparing and communicating about the diverse landscape of AI systems from a scientific perspective. According to this document, AI methods do not restrict to machine learning algorithms but also encompass a wide range of approaches, like heuristics, optimization algorithms, knowledge representation, reasoning and hybrid algorithms. Using these diverse methods, AI systems function not solely based on data-driven learning. By providing such a framework, this document aims to simplify the management of AI system's life cycle stages. By promoting the responsible and beneficial use of AI systems, this document aims to enhance transparency, foster trustworthiness of AI systems.

This document provides a common framework of descriptors that assist with communication about AI systems' technical characteristics among representatives from industry, science, public administration and civil society. The framework can be used descriptively and instructively by organizations, researchers, policymakers, practitioners involved in the development, deployment and regulation of AI systems as well as AI ecosystems. For example, the descriptors can help recipients draw inferences about matters such as what applications a system can be suitable for, what processes can be followed during system construction, what would be necessary in order to make changes to the system or what aspects of the system's behaviour can be easy or difficult for humans to form mental models of. Containing a matrix of methods and capabilities, this document demonstrates that AI systems can possess multiple AI methods and theoretically switch between them while executing an AI task. The matrix can be used to separate elements of complex systems into method and capability pairs, helping to understand the correct approach for conformity assessment as well as incident management and as a tool for communicating compliance-related issues among stakeholders.

The characterization can also be used to distinguish between AI methods in safety-related International Standards. In the course of using the framework, applicants of the framework can gain a deeper understanding of AI systems in order to standardize planning and decision processes related to stages of the AI system life cycle. For instance, the framework can help to better understand the AI system's methods and capabilities and to present various AI system characteristics in a more informative way, e.g. conformance, metrics, risks, technical performance, sustainability, autonomy, quality attributes as well as strengths and weaknesses. In addition, the framework can be used to identify opportunities for further advances in research of AI methods and capabilities.

This document does not cover AI systems that are intentionally designed or put in operation to perform avoidable harmful acts. For instance, harmful acts can include illegal or unethical nudging, surveillance, sorting, mental as well as psychological harm with regard to people, as well as malicious interference with data and finances.

In this document, the following structure depicts the methodology of AI system methods and capabilities:

— Clause 4 outlines the framework for characterizing AI system methods and capabilities;

— Clause 5 presents descriptors for AI system methods;

— Clause 6 presents descriptors for AI system capabilities;

— Clause 7 provides framework for characterization of AI system methods and capabilities;

— Informative annexes provide explanations and examples of how the framework can be applied.

Information technology — Artificial intelligence — Framework for characterizing AI system methods and capabilities

1 Scope

This document provides a framework of descriptors to support the consistent characterization of AI system methods and capabilities. The framework helps AI stakeholders to describe AI systems and have a common understanding of them.

This document applies to all types of organizations involved in any of the life cycle stages of AI systems as well as to any AI stakeholder roles.

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 22989:2022 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
algorithm
finite sequence of well-defined instructions for accomplishing a task or for solving a problem

[SOURCE: ISO 2382:2015(en), 2121376, modified]

3.2
AI system capabilities
AI capabilities of AI systems

3.3
capability
ability of an AI system to perform a task

3.4
conversational learning
hybrid AI method that improves the function of an AI system through interactive dialog-based feedback with users or other agents, actively incorporating new knowledge during conversations

3.5
emergent behaviour
observable system behaviour that arises when one or more AI systems dynamically coordinate multiple capabilities of their components across several knowledge processing domains

Note 1 to entry: Knowledge processing domains include the factual, conceptual, procedural and metacognitive domains.

3.6
matrix
two-dimensional concept depicting the methods and capabilities of AI systems

3.7
hybrid AI
merges the mechanisms of different AI methods, integrating paradigms such as learning strategies, representational forms, neural architectures, symbolic reasoning and statistical models

4 Principles of AI system characterization based on methods and capabilities

4.1 General

The framework categorizes AI component properties into the dimensions of AI methods and AI component capabilities.[1],[2],[3],[4] After providing a definition of the individual principles for describing AI systems using methods and capabilities, the intended implementation of those principles is described. Different perspectives on observing AI systems are represented in Annex A. Clause 7.4 and Annex B depict how the framework can be used to describe and understand AI systems.

4.2 Definition of principles

The dimensions in this document have been elaborated upon based on the following principles:

a) Underpinning common communication needs: The dimensions and the descriptors within them are selected to reflect aspects of the workings of an AI system. AI actors, such as those who develop, purchase or oversee AI systems, can communicate about these dimensions and descriptors with each other (e.g. to facilitate inferences about possibilities and limitations).

b) Consistent coverage: The dimensions are meant to provide for description of a wide range of AI systems, including state-of-the-art systems. This includes allowing for accurate description of existing systems while still providing flexibility to appropriately classify novel methods or capabilities.

c) Clear distinctions between dimensions: The dimensions represent aspects of AI systems that can vary somewhat independently. Nonetheless, there can be strong correlations between dimensions. For example, modern systems that process image inputs using the capabilities dimension are usually trained using some form of unsupervised or self-supervised learning from the methods dimension. AI methods refer to the algorithms and procedures by which an AI system performs specific functions. These methods can be embedded at the system or component level and vary in architecture, ranging from single-method systems to those combining multiple methods.

d) High-level categories with room for multiple levels of detail: An AI system or AI component can be described along a given dimension at varying levels of detail. For example, in some communications about AI systems, it can suffice to specify that a model was built using machine learning. For others it can be necessary to specify that it was built using stochastic gradient descent. This document specifies only high-level descriptors within each dimension, but offers examples of more granular distinctions that can be drawn. It leaves room for adding such detail in glosses and for other documents to elaborate further on distinctions within a dimension or entirely different ways of systematically describing or categorizing AI systems.

4.3 Intended application of principles

4.3.1 General

Based on its principles, the framework provides a structured set of descriptors in terms of which AI systems can be partially described and makes it easier to differentiate between different types of AI systems. It encompasses AI methods, which represent the procedures and algorithms employed by AI systems and AI system capabilities, which describe the specific abilities and functionalities of AI systems. Within the framework, both AI system methods and AI system capabilities are grouped into subsets with varying levels of detail. The selection of specific subsets with a particular level of detail depends on the intended application scenario of the framework. The distinction between methods and capabilities assists in precise descriptions of AI systems, highlighting their strengths, limitations and implications.

4.3.2 Interweaving of methods with components, tasks, algorithms and models

The following statements reflect the relationships between AI methods, capabilities, models, tasks, systems and components:

— An AI system is composed of one or more components, at least one of which is an AI component. An AI component can be a standalone AI system;

— An AI system can contain multiple AI components that interact with each other or non-AI components of the overall system;

— An AI task is characterized by the input-to-output transformation that an AI system or component is expected to perform;

— An AI component is a functional component of an AI system. Typically, an AI component is built to execute one AI task, though the task can be a very general one, such as generating images from textual descriptions;

— An AI component takes data as input and produces data as output;

— The capabilities dimension is defined in terms of the task or tasks performed by an AI component;

— An AI model is a computational representation that enables an AI method to execute an AI task;

NOTE 1 An AI model is a computational representation that helps AI systems to execute one or more classes of AI tasks.

— An AI method or AI model method reflects a mathematical algorithm which computes input data to execute an AI task.

NOTE 2 An AI method is a class of AI models, a class of algorithms used by AI systems often to operate on AI models or a combination of the two.

NOTE 3 The terms classification, regression and clustering can be characterized within the concept of tasks as well as within the concept of methods. These terms are orthogonal both from the perspective of AI methods and AI tasks as AI methods refer to the algorithms, such as decision trees, neural networks and k-means used to solve problems. In contrast, AI tasks refer to the specific objectives or goals the system is trying to achieve, for example classifying data, predicting continuous values or grouping data points. This allows for executing the same task by different methods and using the same method for different tasks.

4.4 Understanding AI methods and AI system capabilities

An AI capability or AI component capability can be defined as the ability of an AI component to perform an AI task. AI tasks are for instance responses and actions. Inputs and outputs of the component are both data.

Descriptors for the AI methods and AI system capabilities dimensions can be used individually as well as in combination with each other. Distinguishing between the dimensions of AI methods and AI system capabilities simplifies effective communication and collaboration among AI stakeholders as well as civil society. In this context, using the dimensions enables a common language and a shared understanding

of AI systems for knowledge sharing, assessment and the development of best practices. Especially the simultaneous consideration of both dimensions helps identify synergies and potential gaps in AI research and development. The understanding about the choice of specific methods to realize certain capabilities lays the basis to assess the operational effort, use case-specific dependency of AI-relevant properties as well as the experience of stakeholders as well as representatives from civil society involved to achieve specific goals.

4.5 Application to AI systems

Applying the descriptors in this document to an AI system involves identifying and listing the methods used in the AI system and its resulting capabilities. Relevant stakeholders can then use the list of methods and capabilities to:

— communicate about the AI system with a common understanding;

— determine the suitability of the AI system for a given task;

— determine risks and mitigations;

— determine an appropriate test regime and metrics;

— determine whether the system is subject to any compliance requirements;

— determine an appropriate monitoring, update and incident reporting plan;

— determine opportunities for continuous improvement;

— describe the scope of AI systems in AI management systems and AI impact assessments.

5 AI system methods dimension

5.1 General

Considering the rapid pace of development in AI technology, this document describes a variety of methods but is not a comprehensive list of all possible AI methods. Table 1 organizes AI methods under the four non-exclusive descriptors traditional AI, symbolic AI, machine learning and hybrid AI, each encompassing similarly non-exclusive more specific descriptors, which can serve as orientation for the application or description of AI system methods.[5] Machine learning methods typically revolve around a model with parameters that are set via a training algorithm. Inference algorithms use the fully or partially trained model to generate outputs. Inference algorithms are sometimes used as part of training.

Table 1 provides an overview of the AI methods discussed in [6], [2], [1], [7].