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Information technology — Artificial intelligence — Artificial intelligence concepts and terminology

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The UK participation in its preparation was entrusted to Technical Committee ART/1, Artificial Intelligence.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO/IEC 22989

June 2023

ICS 01.040.35; 35.020

English version

Information technology - Artificial intelligence - Artificial intelligence concepts and terminology (ISO/IEC 22989:2022)

Technologies de l'information - Intelligence artificielle - Concepts et terminologie relatifs à l'intelligence artificielle (ISO/IEC 22989:2022)

Informationstechnik - Künstliche Intelligenz - Konzepte und Terminologie der Künstlichen Intelligenz (ISO/IEC 22989:2022)

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European foreword

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INTERNATIONAL STANDARD

ISO/IEC 22989

First edition
2022-07

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Technologies de l'information — Intelligence artificielle — Concepts et terminologie relatifs à l'intelligence artificielle

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Foreword

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Introduction

Advancements in computing capacity, reduction of costs of computation, availability of large amounts of data from many sources, inexpensive online learning curricula and algorithms capable of meeting or exceeding human level performance in particular tasks for speed and accuracy have enabled practical applications of AI, making it an increasingly important branch of information technology.

AI is a highly interdisciplinary field broadly based on computer science, data science, natural sciences, humanities, mathematics, social sciences and others. Terms such as “intelligent”, “intelligence”, “understanding”, “knowledge”, “learning”, “decisions”, “skills”, etc. are used throughout this document. However, it is not the intention to anthropomorphize AI systems, but to describe the fact that some AI systems can rudimentarily simulate such characteristics.

There are many areas of AI technology. These areas are intricately linked and developing rapidly so it is difficult to fit the relevance of all technical fields into a single map. Research of AI includes aspects such as aspects including “learning, recognition and prediction”, “inference, knowledge and language” and “discovery, search and creation”. Research also addresses interdependencies among these aspects[23].

The concept of AI as an input and output process flow is shared by many AI researchers, and research on each step of this process is ongoing. Standardized concepts and terminology are needed by stakeholders of the technology to be better understood and adopted by a broader audience. Furthermore, concepts and categories of AI allow for a comparison and classification of different solutions with respect to properties like trustworthiness, robustness, resilience, reliability, accuracy, safety, security and privacy. This enables stakeholders to select appropriate solutions for their applications and to compare the quality of available solutions on the market.

As this document does provide a definition for the term AI in the sense of a discipline only, the context for its usage can be described as follows: AI is a technical and scientific field devoted to the engineered system that generates outputs such as content, forecasts, recommendations or decisions for a given set of human-defined objectives.

This document provides standardized concepts and terminology to help AI technology to be better understood and used by a broader set of stakeholders. It is intended for a wide audience including experts and non-practitioners. The reading of some specific clauses can however be easier with a stronger background in computer science. These concerns are described primarily Clauses 5.10, 5.11 and 8, which are more technical than the rest of the document.

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Information technology — Artificial intelligence — Artificial intelligence concepts and terminology

1 Scope

This document establishes terminology for AI and describes concepts in the field of AI.

This document can be used in the development of other standards and in support of communications among diverse, interested parties or stakeholders.

This document is applicable to all types of organizations (e.g. commercial enterprises, government agencies, not-for-profit organizations).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 Terms related to AI

3.1.1
AI agent
automated (3.1.7) entity that senses and responds to its environment and takes actions to achieve its goals

3.1.2
AI component
functional element that constructs an *AI system* (3.1.4)

3.1.3
artificial intelligence
AI
<discipline> research and development of mechanisms and applications of *AI systems* (3.1.4)

Note 1 to entry: Research and development can take place across any number of fields such as computer science, data science, humanities, mathematics and natural sciences.

3.1.4
artificial intelligence system
AI system
engineered system that generates outputs such as content, forecasts, recommendations or decisions for a given set of human-defined objectives

Note 1 to entry: The engineered system can use various techniques and approaches related to *artificial intelligence* (3.1.3) to develop a *model* (3.1.23) to represent data, *knowledge* (3.1.21), processes, etc. which can be used to conduct *tasks* (3.1.35).

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Note 2 to entry: AI systems are designed to operate with varying levels of *automation* (3.1.7).

3.1.5
autonomy
autonomous
characteristic of a system that is capable of modifying its intended domain of use or goal without external intervention, control or oversight

3.1.6
application specific integrated circuit
ASIC
integrated circuit customized for a particular use

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.193, modified — Acronym has been moved to separate line.]

3.1.7
automatic
automation
automated
pertaining to a process or system that, under specified conditions, functions without human intervention

[SOURCE: ISO/IEC 2382:2015, 2121282, modified — In the definition, "a process or equipment" has been replaced by "a process or system" and preferred terms of "automated and automation" are added.]

3.1.8
cognitive computing
category of *AI systems* (3.1.4) that enables people and machines to interact more naturally

Note 1 to entry: Cognitive computing tasks are associated with *machine learning* (3.3.5), speech processing, *natural language processing* (3.6.9), *computer vision* (3.7.1) and human-machine interfaces.

3.1.9
continuous learning
continual learning
lifelong learning
incremental training of an *AI system* (3.1.4) that takes place on an ongoing basis during the operation phase of the AI system life cycle

3.1.10
connectionism
connectionist paradigm
connectionist model
connectionist approach
form of cognitive modelling that uses a network of interconnected units that generally are simple computational units

3.1.11
data mining
computational process that extracts patterns by analysing quantitative data from different perspectives and dimensions, categorizing them, and summarizing potential relationships and impacts

[SOURCE: ISO 16439:2014, 3.13, modified — replace "categorizing it" with "categorizing them" because data is plural.]

3.1.12
declarative knowledge
knowledge represented by facts, rules and theorems

Note 1 to entry: Usually, declarative knowledge cannot be processed without first being translated into *procedural knowledge* (3.1.28).

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[SOURCE: ISO/IEC 2382-28:1995, 28.02.22, modified — Remove comma after “rules” in the definition.]

3.1.13
expert system
AI system (3.1.4) that accumulates, combines and encapsulates *knowledge* (3.1.21) provided by a human expert or experts in a specific domain to infer solutions to problems

3.1.14
general AI
AGI
artificial general intelligence
type of *AI system* (3.1.4) that addresses a broad range of *tasks* (3.1.35) with a satisfactory level of performance

Note 1 to entry: Compared to *narrow AI* (3.1.24).

Note 2 to entry: AGI is often used in a stronger sense, meaning systems that not only can perform a wide variety of tasks, but all tasks that a human can perform.

3.1.15
genetic algorithm
GA
algorithm which simulates natural selection by creating and evolving a population of individuals (solutions) for optimization problems

3.1.16
heteronomy
heteronomous
characteristic of a system operating under the constraint of external intervention, control or oversight

3.1.17
inference
reasoning by which conclusions are derived from known premises

Note 1 to entry: In AI, a premise is either a fact, a rule, a model, a feature or raw data.

Note 2 to entry: The term "inference" refers both to the process and its result.

[SOURCE: ISO/IEC 2382:2015, 2123830, modified – Model, feature and raw data have been added. Remove “Note 4 to entry: 28.03.01 (2382)”. Remove “Note 3 to entry: inference: term and definition standardized by ISO/IEC 2382-28:1995”.]

3.1.18
internet of things
IoT
infrastructure of interconnected entities, people, systems and information resources together with services that process and react to information from the physical world and virtual world

[SOURCE: ISO/IEC 20924:2021, 3.2.4, modified – “…services which processes and reacts to…” has been replaced with “…services that process and react to…” and acronym has been moved to separate line.]

3.1.19
IoT device
entity of an *IoT system* (3.1.20) that interacts and communicates with the physical world through sensing or actuating

Note 1 to entry: An IoT device can be a sensor or an actuator.

[SOURCE: ISO/IEC 20924:2021, 3.2.6]

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3.1.20
IoT system
system providing functionalities of *IoT* (3.1.18)

Note 1 to entry: An IoT system can include, but not be limited to, IoT devices, IoT gateways, sensors and actuators.

[SOURCE: ISO/IEC 20924:2021, 3.2.9]

3.1.21
knowledge
<artificial intelligence> abstracted information about objects, events, concepts or rules, their relationships and properties, organized for goal-oriented systematic use

Note 1 to entry: Knowledge in the AI domain does not imply a cognitive capability, contrary to usage of the term in some other domains. In particular, knowledge does not imply the cognitive act of understanding.

Note 2 to entry: Information can exist in numeric or symbolic form.

Note 3 to entry: Information is data that has been contextualized, so that it is interpretable. Data is created through abstraction or measurement from the world.

3.1.22
life cycle
evolution of a system, product, service, project or other human-made entity, from conception through retirement

[SOURCE: ISO/IEC/IEEE 15288:2015, 4.1.23]

3.1.23
model
physical, mathematical or otherwise logical representation of a system, entity, phenomenon, process or data

[SOURCE: ISO/IEC 18023-1:2006, 3.1.11, modified – Remove comma after “mathematical” in the definition. "or data" is added at the end.]

3.1.24
narrow AI
type of *AI system* (3.1.4) that is focused on defined *tasks* (3.1.35) to address a specific problem

Note 1 to entry: Compared to *general AI* (3.1.14).

3.1.25
performance
measurable result

Note 1 to entry: Performance can relate either to quantitative or qualitative findings.

Note 2 to entry: Performance can relate to managing activities, processes, products (including services), systems or organizations.

3.1.26
planning
<artificial intelligence> computational processes that compose a workflow out of a set of actions, aiming at reaching a specified goal

Note 1 to entry: The meaning of the “planning” used in AI life cycle or AI management standards can be also actions taken by human beings.

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3.1.27
prediction
primary output of an *AI system* (3.1.4) when provided with *input data* (3.2.9) or information

Note 1 to entry: Predictions can be followed by additional outputs, such as recommendations, decisions and actions.

Note 2 to entry: Prediction does not necessarily refer to predicting something in the future.

Note 3 to entry: Predictions can refer to various kinds of data analysis or production applied to new data or historical data (including translating text, creating synthetic images or diagnosing a previous power failure).

3.1.28
procedural knowledge
knowledge which explicitly indicates the steps to be taken in order to solve a problem or to reach a goal

[SOURCE: ISO/IEC 2382-28:1995, 28.02.23]

3.1.29
robot
automation system with actuators that performs intended *tasks* (3.1.35) in the physical world, by means of sensing its environment and a software control system

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

Note 2 to entry: The classification of a robot as industrial robot or service robot is done according to its intended application.

Note 3 to entry: In order to properly perform its *tasks* (3.1.35), a robot makes use of different kinds of sensors to confirm its current state and perceive the elements composing the environment in which it operates.

3.1.30
robotics
science and practice of designing, manufacturing and applying robots

[SOURCE: ISO 8373:2012, 2.16]

3.1.31
semantic computing
field of computing that aims to identify the meanings of computational content and user intentions and to express them in a machine-processable form

3.1.32
soft computing
field of computing that is tolerant of and exploits imprecision, uncertainty and partial truth to make problem-solving more tractable and robust

Note 1 to entry: Soft computing encompasses various techniques such as fuzzy logic, machine learning and probabilistic reasoning.

3.1.33
symbolic AI
AI (3.1.3) based on techniques and *models* (3.1.23) that manipulate symbols and structures according to explicitly defined rules to obtain inferences

Note 1 to entry: Compared to *subsymbolic AI* (3.1.34), symbolic AI produces declarative outputs, whereas subsymbolic AI is based on statistical approaches and produces outputs with a given probability of error.

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3.1.34
subsymbolic AI
AI (3.1.3) based on techniques and *models* (3.1.23) that use an implicit encoding of information, that can be derived from experience or raw data.

Note 1 to entry: Compared to *symbolic AI* (3.1.33). Whereas symbolic AI produces declarative outputs, subsymbolic AI is based on statistical approaches and produces outputs with a given probability of error.

3.1.35
task
<artificial intelligence>action required to achieve a specific goal

Note 1 to entry: Actions can be physical or cognitive. For instance, computing or creation of *predictions* (3.1.27), translations, synthetic data or artefacts or navigating through a physical space.

Note 2 to entry: Examples of tasks include classification, regression, ranking, clustering and dimensionality reduction.

3.2 Terms related to data

3.2.1
data annotation
process of attaching a set of descriptive information to data without any change to that data

Note 1 to entry: The descriptive information can take the form of metadata, labels and anchors.

3.2.2
data quality checking
process in which data is examined for completeness, bias and other factors which affect its usefulness for an *AI system* (3.1.4)

3.2.3
data augmentation
process of creating synthetic samples by modifying or utilizing the existing data

3.2.4
data sampling
process to select a subset of data samples intended to present patterns and trends similar to that of the larger *dataset* (3.2.5) being analysed

Note 1 to entry: Ideally, the subset of data samples will be representative of the larger *dataset* (3.2.5).

3.2.5
dataset
collection of data with a shared format

EXAMPLE 1 Micro-blogging posts from June 2020 associated with hashtags #rugby and #football.

EXAMPLE 2 Macro photographs of flowers in 256x256 pixels.

Note 1 to entry: Datasets can be used for validating or testing an AI *model* (3.1.23). In a *machine learning* (3.3.5) context, datasets can also be used to train a *machine learning algorithm* (3.3.6).

3.2.6
exploratory data analysis
EDA
initial examination of data to determine its salient characteristics and assess its quality

Note 1 to entry: EDA can include identification of missing values, outliers, representativeness for the task at hand – see *data quality checking* (3.2.2).

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3.2.7
ground truth
value of the target variable for a particular item of labelled input data

Note 1 to entry: The term ground truth does not imply that the labelled input data consistently corresponds to the real-world value of the target variables.

3.2.8
imputation
procedure where missing data are replaced by estimated or modelled data

[SOURCE: ISO 20252:2019, 3.45]

3.2.9
input data
data for which an *AI system* (3.1.4) calculates a predicted output or inference

3.2.10
label
target variable assigned to a sample

3.2.11
personally identifiable information
PII
personal data
any information that (a) can be used to establish a link between the information and the natural person to whom such information relates, or (b) is or can be directly or indirectly linked to a natural person

Note 1 to entry: The "natural person" in the definition is the PII principal. To determine whether a PII principal is identifiable, account should be taken of all the means which can reasonably be used by the privacy stakeholder holding the data, or by any other party, to establish the link between the set of PII and the natural person.

Note 2 to entry: This definition is included to define the term PII as used in this document. A public cloud PII processor is typically not in a position to know explicitly whether information it processes falls into any specified category unless this is made transparent by the cloud service customer.

[SOURCE: ISO/IEC 29100:2011/Amd1:2018, 2.9]

3.2.12
production data
data acquired during the operation phase of an *AI system* (3.1.4), for which a deployed *AI system* (3.1.4) calculates a predicted output or *inference* (3.1.17)

3.2.13
sample
atomic data element processed in quantities by a *machine learning algorithm* (3.3.6) or an *AI system* (3.1.4)

3.2.14
test data
evaluation data
data used to assess the performance of a final *model* (3.1.23)

Note 1 to entry: Test data is disjoint from *training data* (3.3.16) and *validation data* (3.2.15).

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3.2.15
validation data
development data
data used to compare the performance of different candidate *models* (3.1.23)

Note 1 to entry: Validation data is disjoint from *test data* (3.2.14) and generally also from *training data* (3.3.16). However, in cases where there is insufficient data for a three-way training, validation and test set split, the data is divided into only two sets – a test set and a training or validation set. Cross-validation or bootstrapping are common methods for then generating separate training and validation sets from the training or validation set.

Note 2 to entry: Validation data can be used to tune hyperparameters or to validate some algorithmic choices, up to the effect of including a given rule in an expert system.

3.3 Terms related to machine learning

3.3.1
Bayesian network
probabilistic *model* (3.1.23) that uses Bayesian *inference* (3.1.17) for probability computations using a directed acyclic graph

3.3.2
decision tree
model (3.1.23) for which *inference* (3.1.17) is encoded as paths from the root to a leaf node in a tree structure

3.3.3
human-machine teaming
integration of human interaction with machine intelligence capabilities

3.3.4
hyperparameter
characteristic of a *machine learning algorithm* (3.3.6) that affects its learning process

Note 1 to entry: Hyperparameters are selected prior to training and can be used in processes to help estimate model parameters.

Note 2 to entry: Examples of hyperparameters include the number of network layers, width of each layer, type of activation function, optimization method, learning rate for neural networks; the choice of kernel function in a support vector machine; number of leaves or depth of a tree; the K for K-means clustering; the maximum number of iterations of the expectation maximization algorithm; the number of Gaussians in a Gaussian mixture.

3.3.5
machine learning
ML
process of optimizing *model parameters* (3.3.8) through computational techniques, such that the *model's* (3.1.23) behaviour reflects the data or experience

3.3.6
machine learning algorithm
algorithm to determine *parameters* (3.3.8) of a *machine learning model* (3.3.7) from data according to given criteria

EXAMPLE Consider solving a univariate linear function $y = \theta_0 + \theta_1 x$ where y is an output or result, x is an input, θ_0 is an intercept (the value of y where x=0) and θ_1 is a weight. In *machine learning* (3.3.5), the process of determining the intercept and weights for a linear function is known as linear regression.

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3.3.7
machine learning model
mathematical construct that generates an *inference* (3.1.17) or *prediction* (3.1.27) based on input data or information

EXAMPLE If a univariate linear function ($y = \theta_0 + \theta_1 x$) has been trained using linear regression, the resulting model can be $y = 3 + 7x$.

Note 1 to entry: A machine learning model results from training based on a *machine learning algorithm* (3.3.6).

3.3.8
parameter
model parameter
internal variable of a *model* (3.1.23) that affects how it computes its outputs

Note 1 to entry: Examples of parameters include the weights in a neural network and the transition probabilities in a Markov model.

3.3.9
reinforcement learning
RL
learning of an optimal sequence of actions to maximize a reward through interaction with an environment

3.3.10
retraining
updating a *trained model* (3.3.14) by *training* (3.3.15) with different *training data* (3.3.16)

3.3.11
semi-supervised machine learning
machine learning (3.3.5) that makes use of both labelled and unlabelled data during *training* (3.3.15)

3.3.12
supervised machine learning
machine learning (3.3.5) that makes only use of labelled data during *training* (3.3.15)

3.3.13
support vector machine
SVM
machine learning algorithm (3.3.6) that finds decision boundaries with maximal margins

Note 1 to entry: Support vectors are sets of data points that define the positioning of the decision boundaries (hyper-planes).

3.3.14
trained model
result of *model training* (3.3.15)

3.3.15
training
model training
process to determine or to improve the parameters of a *machine learning model* (3.3.7), based on a *machine learning algorithm* (3.2.10), by using *training data* (3.3.16)

3.3.16
training data
data used to train a *machine learning model* (3.3.7)

3.3.17
unsupervised machine learning
machine learning (3.3.5) that makes only use of unlabelled data during *training* (3.3.15)

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3.4 Terms related to neural networks

3.4.1
activation function
function applied to the weighted combination of all inputs to a *neuron* (3.4.9)

Note 1 to entry: Activation functions allow neural networks to learn complicated features in the data. They are typically non-linear.

3.4.2
convolutional neural network
CNN
deep convolutional neural network
DCNN
feed forward neural network (3.4.6) using *convolution* (3.4.3) in at least one of its layers

3.4.3
convolution
mathematical operation involving a sliding dot product or cross-correlation of the input data

3.4.4
deep learning
deep neural network learning
<artificial intelligence> approach to creating rich hierarchical representations through the *training* (3.3.15) of *neural networks* (3.4.8) with many hidden layers

Note 1 to entry: Deep learning is a subset of *ML* (3.3.5).

3.4.5
exploding gradient
phenomenon of backpropagation *training* (3.3.15) in a neural network where large error gradients accumulate and result in very large updates to the weights, making the *model* (3.1.23) unstable

3.4.6
feed forward neural network
FFNN
neural network (3.4.8) where information is fed from the input layer to the output layer in one direction only

3.4.7
long short-term memory
LSTM
type of *recurrent neural network* (3.4.10) that processes sequential data with a satisfactory performance for both long and short span dependencies

3.4.8
neural network
NN
neural net
artificial neural network
<artificial intelligence> network of one or more layers of *neurons* (3.4.9) connected by weighted links with adjustable weights, which takes input data and produces an output

Note 1 to entry: Neural networks are a prominent example of the *connectionist approach* (3.1.10).

Note 2 to entry: Although the design of neural networks was initially inspired by the functioning of biological neurons, most works on neural networks do not follow that inspiration anymore.

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3.4.9
neuron
<artificial intelligence> primitive processing element which takes one or more input values and produces an output value by combining the input values and applying an *activation function* (3.4.1) on the result

Note 1 to entry: Examples of nonlinear activation functions are a threshold function, a sigmoid function and a polynomial function.

3.4.10
recurrent neural network
RNN
neural network (3.4.8) in which outputs from both the previous layer and the previous processing step are fed into the current layer

3.5 Terms related to trustworthiness

3.5.1
accountable
answerable for actions, decisions and performance

[SOURCE: ISO/IEC 38500:2015, 2.2]

3.5.2
accountability
state of being *accountable* (3.5.1)

Note 1 to entry: Accountability relates to an allocated responsibility. The responsibility can be based on regulation or agreement or through assignment as part of delegation.

Note 2 to entry: Accountability involves a person or entity being accountable for something to another person or entity, through particular means and according to particular criteria.

[SOURCE: ISO/IEC 38500:2015, 2.3, modified — Note 2 to entry is added.]

3.5.3
availability
property of being accessible and usable on demand by an authorized entity

[SOURCE: ISO/IEC 27000:2018, 3.7]

3.5.4
bias
systematic difference in treatment of certain objects, people or groups in comparison to others

Note 1 to entry: Treatment is any kind of action, including perception, observation, representation, *prediction* (3.1.27) or decision.

[SOURCE: ISO/IEC TR 24027:2021, 3.3.2, modified – remove oxford comma in definition and note to entry]

3.5.5
control
purposeful action on or in a process to meet specified objectives

[SOURCE: IEC 61800-7-1:2015, 3.2.6]

3.5.6
controllability
controllable
property of an *AI system* (3.1.4) that allows a human or another external agent to intervene in the system's functioning

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