# WHAT IS INTELLIGENCE?

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## HOW TO DISTINGUISH ARTIFICIAL INTELLIGENCE SYSTEM FROM OTHERS

Wikipedia tells us that intelligence is the "***ability to perceive or infer information, and to retain it as knowledge to be applied towards adaptive behaviors within an environment or context.***" This is an unconditionally correct definition in which every aspect mentioned is essential. However, for practical use, the definition requires a more detailed analysis.

## BEHAVIOR

The term "***behavior***" suggests the presence of some ***purposeful activity*** that ***depends on the situation***. In the literal sense, "***behavior***" means, for example, that a hungry predator starts hunting at the sight of potential prey, and a well-fed predator acts according to the principle "*you've eaten, now you can sleep*," ignoring the opportunity. The word "***behavior***" in objects that demonstrate the same dynamics regardless of the situation (for example, the expansion of bodies when heated) is possible only figuratively.

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Thus, an object that exhibits some behavior must have a ***control system*** that ***collects information about the situation*** and generates a particular ***intention***, which is then implemented.

Note that improving ***behavior*** is not about tweaking ***parameters*** for particular behavior/activity; such ***parameters adaptation*** does not require intelligence and is implemented in many devices. Examples: automatic brightness adjustment in a video camera (electronic system), car brake clearance adjustment (mechanical system).

## INTENTION

Do not confuse ***intention*** with ***need***; the ***intention is a way to satisfy a need*** (or several needs at once). For example, depending on the situation, a cat's ***need for food*** can generate ***two different intentions***: to ask for food from the owner or to get food (a mouse or a bird) on its own.

## CONTROL SYSTEM

Technologically, a ***control system*** can be an element of a ***holistic system***: elements of the system that are involved in the control process are not separated from the other component. Plants are such in nature; an example of an ***artificial holistic system is a weather vane***.

The holistic system, due to the interdependence of components, makes it challenging to improve control algorithms, so natural selection has led to the ***structuring*** of organisms in animals with the allocation of the ***nervous system, which is a natural version of the control system***, into a separate component (along with ***sensors***, ***muscles/actuators***, ***glands***, energy subsystem, etc.). This made it possible to radically increase the speed of response to a change in the situation and ***allow behavior modification without modifying the rest of the components***. In particular, the isolation of the nervous system made it possible to organize the ***memorization of personal experiences***. Such a possibility is a necessary condition for autonomous learning.

Another ("orthogonal") aspect is the ***complexity*** of the principles implemented by the control system. The most primitive version:

- A rigid activity algorithm is set from the outside.
- Only events/objects/situations from a fixed set of expected (predefined) ones are recognized.
- Decisions are made based only on the current situation.

Despite their relative simplicity, such systems can demonstrate rather complex behavior. For example, car electronics, depending on the situation, turn on/off the light, lock/unlock the doors, etc. These include many industrial control systems, aircraft autopilots, automatic weather stations, etc.

Complex control systems are ***hierarchical systems of components***, each of which, in turn, is a control system endowed with one ***degree or another of autonomy***. The top-level component provides planning "in general," deep (but slow) analysis of the accumulated data, and the formation of a set of routine operations on the child level. Lower-level components

provide fast simultaneous processing of various information streams and routine operations without requiring intervention from the upper level.

The most advanced control systems are represented by options that combine computer systems and human intelligence: people play the role of a control subsystem.

The concept of ***consciousness*** is connected with the hierarchy of the control system; this aspect deserves a separate discussion.

Aspects orthogonal to both the complexity of the control system and the degree of "holisticity" are the presence or absence of two followed abilities:

- The ability to ***actively collect information about the situation***, determining the ***source*** and ***amount*** of information (*look to the left - look to the right*). Since we are talking about the ***activity of collecting*** information, then there is a corresponding component of the ***system behavior***.
- The ability to ***memorize*** the collected information and use it for generating ***intentions***, planning ***actions*** to implement intentions, and ensuring the ***improvement of the behavior using personal experience***.

An essential and non-obvious aspect is that ***immutable algorithms can improve behavior*** for collecting and accumulating information, generating intentions, generating plans, etc.

## ENVIRONMENT

AI systems can be designed to function in various ***environment***s.

The complexity of the target environment may vary in a wide range. The simplest one:

- At any time, the ***entire environment is available for observation*** and analysis
- The ***set of possible objects is finite and does not change***
- ***Discrete time and space***

Examples of such (artificial) environments are ***chess, Go***, and many computer games used as test environments in AI development.

The most complex is a ***natural environment***:

- Only ***part of the environment*** is available for observation
- The ***number of objects and object types is infinite***

- The ***set of objects in the observed part of the environment is constantly changing***
- ***Continual time and space***

Accordingly, the complexity of describing the current situation is also different; the ***continuality of time and space radically complicates all operations***.

The most significant difference, however, is the ***unlimited number of types of objects*** in the natural environment. This ***eliminates the possibility of supplying the AI system with descriptions of all possible kinds of objects in advance***.

An AI system capable of operating effectively in a natural environment ***should be able to discover unknown objects in the environment and generate their internal descriptions***, allowing them to be identified in the future, to ***find the causal relationships in which they are involved***, to take into account their presence when choosing actions, and so on. In other words, an ***intelligent system capable of operating effectively in a natural environment cannot be made using only predetermined knowledge***. It must be capable of autonomously ***acquiring knowledge***, as is the case with humans and (non-primitive) animals.

The systems currently in use, positioned as AI, cannot operate effectively in the natural environment precisely because of the lack of the ability to detect unknown objects in the environment.

## INTELLIGENCE

The human intellect, the model/reproduction of which is the developing artificial intelligence systems, is adapted for functioning in the natural environment, the most complex of those described above. AI systems applying for the AGI level (strong AI, human-level AI) must be able to do everything that people do in their daily activities (full-scale intelligence):

- ***searching for information about observable part of the environment***
- ***detecting objects that become observable or disappear***
- ***known objects identification***
- ***making the description of the previously unknown object***
- ***permanent updating inner structured description of the situation***
- ***organization of communication with detected objects when it is possible and desirable***

- ***memorization of information received in the process of communication***
- ***filtering and storing important information from the stream of collected data, expanding individual knowledge***
- ***discovering causal relationships between situations and events***
- ***forecasting nearest future of situation using extrapolation and causal relationships***
- ***situation analysis, intention generation, planning, current actions selection***
- ***experimentation to find new knowledge and solutions***

An essential aspect is that not only humans but also animals possess the abilities listed above. The ***difference lies in the perfection*** (productivity, speed) of the execution of the corresponding functions (for example, the limit of the complexity of the revealed cause-and-effect relationships, the amount of memory, etc.), and ***not in the set of possibilities.***

AGI, in its idea, should implement all these abilities with a human-like perfection level.

Systems capable of modifying behavior but not implementing all listed abilities can be classified as artificial sub-intelligence.

In accordance with the original definition, ***systems incapable of modifying behavior cannot be classified as intelligent***. Systems classified today as "***narrow AI***" obviously do not fit the original definition; how to deal with this circumstance, the reader must decide for himself.

A vital circumstance influencing the development of AI is the possibility of ***separate development/testing/modification of components*** that implement the listed features. A common "hub" for functional components is ***data describing the current situation and a repository of accumulated knowledge***. "Holistic" architecture, in which many functionalities are implemented as one indivisible component, does not have such an opportunity.

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