

## Artificial intelligence – How does machine learning work?

Artificial intelligence (AI) is a collective term for software that bundles a wide variety of different processes in order to solve complex tasks autonomously and to optimize the solution. An important subset of AI in this context is machine learning.

### AI requires algorithms

AI applications use algorithms to solve tasks. An algorithm is a clear procedure for solving a precisely defined problem. It describes how something is to be done so that you obtain a certain result. A cake recipe is also an example of an algorithm: It describes what you must do with certain ingredients so that you end up with the desired result, in this case, a cake. A mathematical formula can also be an algorithm.

### AI learns

The aspect that makes artificial intelligence so special is that the algorithms are not defined in advance. Instead, the various AI processes are designed to independently define the algorithms and dynamically improve them. This process is called machine learning and is a core area of AI. Accordingly, an AI application does not know at first how it can solve the assigned task and discovers the solution in the learning process.

### Pattern recognition

Pattern recognition is one of these processes that enable AI to define algorithms on its own. First, AI analyzes a large volume of data, looking for regularities. These “training data” help AI learn how it can solve its assigned task. For example, if AI has the task to teach itself mathematics, the developer would feed it numerous correctly solved calculation tasks as training data. AI analyzes the data and recognizes patterns, for example, what the plus sign means or how multiplication works. These training data must be complete and correct. Usually, people process the training data and provide it to the AI application.

### Reinforcement learning and neural networks

Another method that uses machine learning is reinforcement learning. In this process, AI tries out various ways of solving a problem, selects those that work particularly well, and continuously improves them.

The artificial neural networks method can also be applied in reinforcement learning. Here, AI is modeled on the functioning of the human brain: This means that it forms a network of artificial neurons. The different ways of problem-solving that are tested are mapped in this network through connections of varying strength between neurons. For instance, the artificial neurons determine which information is important and which is not. The neuron network is changed depending on the learning experience. In image recognition, each neuron would stand for certain information from the image. For example, in order for image recognition to identify a sun, the neurons for the information “color: yellow” and “shape: circle” would be assigned a particularly high weight, while “color: green” and “shape: square” would be disregarded. Based on the recognized patterns, AI develops its own algorithms. As in the math example involving algorithms, AI would learn the rules that it derived from the calculation tasks.

## **AI works**

The AI application is now trained and can be used. It receives the data for the task that it is actually supposed to solve – called the input data. In our example, these data would be unsolved calculation tasks. AI analyzes the input data and applies the patterns recognized and algorithms developed through machine learning. Ideally, AI can solve the tasks and calculate a result, which it provides as output data. Trained AI can then, for example, solve math problems or recognize whether a sun is depicted in an image.

Even when AI learns patterns itself and applies them to new data, it cannot work completely autonomously. It constantly needs the described training data or another form of comparison or orientation to know what is correct and what is incorrect and what it should learn. In addition, the goal of AI is specified by people. This means it should (and can) always solve only one specific problem or reach a defined goal and is trained toward this goal. Therefore, AI is always limited to this one learned problem-solving method. The math AI described above cannot write English essays, nor can it solve word problems.

## **AI makes mistakes**

At the same time, it is also possible for AI to make mistakes. If the training data contain errors – such as calculation tasks with incorrect results, or only addition calculation tasks and no multiplication tasks – AI learns these errors and applies them to new input data. Likewise, errors can occur if the objective is imprecise and the AI application misses the actual solution method. For this reason as well, AI is not independent of humans, but remains man-made despite a certain level of independence.