ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND DEEP LEARNING: HOW THEY WORK

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Abstract: The article considers about artificial intelligence, machine learning and deep learning: how they work. Smart homes, self-driving cars, assistant robots… We are surrounded by innovative technologies based on algorithms that, in their specifics, resemble the work of the human brain. They are called differently: algorithms using machine learning, deep learning, and sometimes even artificial intelligence (AI).

Key words: artificial intelligence, machine learning, deep learning, innovative technologies, human brain, algorithms.

All tasks that can be solved by a person or a computer can be divided into two categories: routine and non-routine.

Routine tasks include those where it is quite easy to find a universal solution: for example, adding numbers or measuring air temperature.

Artificial intelligence is now called everything that is able to solve non-routine tasks at a level close to human, and sometimes even better. These challenges are all around us. Cameras above the road calculate the speed of the car, recognize its sign and send a fine, and security systems in the subway and airports find criminals in the crowd. All this is now considered to be artificial intelligence, although in reality the algorithms underlying each such technology are unique. And only a few use machine learning.

Artificial intelligence is not the name of a single algorithm, but rather a group of methods that are used to solve various kinds of problems. Algorithms that use learning approaches are just one subgroup of the whole set of algorithms that is commonly called artificial intelligence.

Machine learning is an approach in which an algorithm “learns” how to solve a problem. One of the simplest examples of a machine learning algorithm is classifying photos into those with cats and those with dogs:

Let's say there are several thousand photos of cats and several thousand of dogs. This data can be loaded into the algorithm and made to "learn" to distinguish cats from dogs, "scold" for errors in classification and "encourage" for the correct answers. Depending on the quantity and quality of the input data, as well as on the complexity of the algorithm used, after a certain number of iterations with “punishment” and “reward”, a trained algorithm is obtained, which can distinguish cats and dogs with different quality.

Using machine learning methods, these same algorithms can also be “trained” to perform more complex tasks, such as searching for people in a frame, determining a person’s gender and age, etc.

Can such algorithms be taught to solve problems of any complexity? In theory, yes. But in practice, we face a lot of problems, ranging from insufficient data for training to the inability to interpret human actions when solving the same problem. It turns out that it is impossible to build an algorithm that would perform these actions. A good example is a self-driving car. It is relatively easy to teach a car to keep a lane, enter turns and automatically reroute a route if there is a repair on the road, because there is an understanding of how a person would behave (and therefore how a car should behave) in such situations.

However, teaching a car to make decisions in emergency situations is much more difficult: the problem is that it is difficult for a person himself to understand exactly how to act in a particular emergency. Therefore, a person cannot show algorithms examples of good and bad behavior for such cases.

Just as machine learning is a subspecies of artificial intelligence, so deep learning is a subspecies of machine intelligence (see the picture at the beginning of the article). In deep learning, the same approaches are used: the algorithm is given a lot of data and "scolded" by it for errors. The difference here is that deep learning algorithms themselves are much more complex and often use more sophisticated mathematical models. Now, deep learning algorithms almost always mean neural networks.

Neural networks? Like the ones in the human brain?

This comparison is indeed often used. A neural network is a sequence of layers, each of which, in turn, consists of neurons, and each performs its own role. There are neurons (or structures of neurons) that learn to highlight important features in images, such as fur on a cat or dog; there are those who learn to draw conclusions based on the selected elements - for example, if an animal has long legs, then most likely it is a dog. These neurons are combined into groups (layers), and they turn into a single artificial neural network.

A number of ideas used in neural networks, the developers have learned from knowledge about the structure of the human brain. One of the most common tasks for neural networks is tasks related to working with images. For such tasks, a special type of neural networks is used, inside which there are so-called convolutional layers.

To put it simply, the meaning of this convolutional neural network is to evaluate each image element (pixel) not separately, but in a group with several neighboring ones, thanks to which you can find both basic shapes (lines, angles, etc.) and entire objects. Approximately the same process occurs in the human brain when processing visual information. After removing all possible visual signs in the neural network, as in the human brain, these signs are analyzed, and then a decision is made: we see, say, a cat or a dog.

The process of learning an algorithm is in many ways similar to the process of learning a person. Just as we make mistakes and learn from them (for example, not to put your hand in boiling water), algorithms that use machine learning make mistakes, for which they receive a penalty.

How does a neural network work? As an example, consider the process of training a neural network to recognize faces. To correctly train any neural network, you need to do two things: collect enough data and determine what we will penalize it for. In relation to this task, it is necessary to collect several dozen photographs of faces for each of the people to be identified, and penalize the neural network for the fact that the person predicted by it does not match the person in the photo.

From a mathematical point of view, a neural network is a function with a large number of parameters. Penalizing this function for incorrect face detection is when, in simple terms, we correct the work of the function in such a way that it makes less mistakes in the future. Accordingly, rewarding a neural network is when we simply do not penalize it.

In all examples, you talk about specific tasks. Is it possible to teach a neural network to think like a person?

This is more of a philosophical question. The thought process is directly related to the presence of consciousness. A neural network, like any other machine learning algorithm, is inherently just a mathematical function, and can only solve one specific problem. A neural network that has been taught to distinguish between cats and dogs will not be able to distinguish between a bear and an elephant, because it did not even know that such exist. The processes of data analysis that occur in a person's head are much more complicated than those that occur in a neural network, so even if there is data comparable in size to the array of information that a person receives in a lifetime, today it is possible to train a neural network to think like a person, impossible.

Reference

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