Acceptance speech
September 21, 2021

Vladimir Vapnik, awardee in the Information and Communication Technologies category (12th edition)

It is a great honor to accept the BBVA Foundation Frontier of Knowledge Award in the Information and Communication Technologies category. I accept this Award with great pleasure and deep gratitude.

Scientists in information technology of my generation were lucky to be witnesses of the rapid development of this branch of science and technology.

In the 1950s, with the appearance of the first computers, Alan Turing formulated his test for "imitation by computer intelligent activities" and immediately Frank Rosenblatt suggested a model of imitation of a brain that could learn, suggesting a network of mathematical elements that he called neurons.

Now this brain-imitating model, which contains hundreds of mathematical neurons, called Deep Neural Networks, is one of the instruments for solving artificial intelligence problems.

Another instrument in the development of computer intelligence came from mathematical analysis of the concept of generalization. As pointed out by Eugene Wigner in his paper "The unreasonable effectiveness of mathematics in the natural sciences", it looks as if mathematics knows something about reality and, to understand physical reality, many scientists have tried to understand what is hidden in mathematical equations.

In the mid-1960s, my colleague Alexey Chervonenkis and me, pursuing pure mathematical ideas of generalization, constructed a theory of machine learning and introduced the corresponding approach to constructing learning algorithms, called Support Vector Machines.

Later my colleagues Isabelle Guyon, Bernhard Schölkopf and myself further developed this approach.

However, both approaches: Neural Networks, based on the idea of imitating the brain, and Support Vector Machines, based on mathematical principles of generalization, required many

more examples than human students need.

To understand why computers are less effective at generalization than humans, one must again look for the answer in mathematical analysis. As follows from the analysis, there exist not one but two mechanisms for generalization. One is based on the brute force approach: for better generalization one needs more examples. The second approach considers the intelligent part of the generalization method.

According to the intelligent learning approach, there exist several abstract ideas, the so-called predicates, which reflect our understanding of life. The predicates, applied to training examples, allow one to highlight some admissible means for generalization. Using brute force methods one chooses the specific means of generalization based on a small number of training examples.

This fact allowed the Support Vector Machine method to be reinforced by including an intelligent mechanism of generalization.

Also mathematical analysis tell us that there exist only two ways for generalization, and therefore one cannot speed up the learning process using only formal mathematical methods.

This means that the formal part of mathematical learning theory is complete, and the future development of intelligent learning methods will require understanding the informal choice of a collection of abstract ideas, the predicates.

The idea of the existence of abstract ideas that reflect an understanding of the elements of life exists in world literature. In 1928 Vladimir Propp published his "Morphology of Russian Folk Tales" where he described 31 abstract ideas (predicates) from which he composed all (known) Russian Folk Tales.

Later it was realized that most of situations described in literature, theater plays, films, television series, games, etc. can be represented by these abstract ideas. So Propp's 31 predicates reflect abstract understanding of a wide variety of life situations.

Another example of predicates was presented in an old Chinese book "The Art of War," attributed to Sum Tzu, which contain 36 strategic principles (predicates) for conducting wars.

These principles, however, have much wider applications than military action. They are studied in schools of business management to teach students how to act in different real-life conflict situations.

Now the challenge is how to select a small number of abstract ideas that are appropriate for understanding situations of interest.

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The philosophy behind modern SVM methods can be described in the style of Plato.

1. Reality contains two parts: The world of abstract ideas and the world of things. The world of ideas contains a (small) set of predicates that reflect a high-level understanding of reality.

2. We project ideas (universal predicates) into the real world, constructing a set of solutions for the problem of interest.

3. Using a small number of training examples, we select the desired solution.

The new idea in this Platonic model of Support Vector Machine is the interaction of the ideal world with the real world: the mechanism of transformation of predicates (abstract ideas) into a set of admissible solutions.

My scientific career has been spread over the time of the development of the intelligent computers concept: it started at a time when the main problem was to imitate intelligence, to find algorithms capable of generalization, and arrived at a time when the problem became to formulate the essence of intelligence and its philosophy.

I consider this prestigious award to be a recognition of the remarkable development in our industry, the understanding of the essence of intelligence, its philosophy, and its algorithmic methods.

I am proud that jointly with my colleges I took part in this development. Thank you again.