Acceptance speech
21 de septiembre de 2021

Bernhard Schölkopf, awardee in the Information and Communication Technologies category (12th edition)

I am deeply grateful for receiving the BBVA Foundation Frontiers of Knowledge Award, and for sharing it with Isabelle Guyon and Vladimir Vapnik. I am humbled by the group of inventors, both artists and scientist, whose company I am joining.

The BBVA Foundation prize is very special to me for two reasons. It is awarded in Spain - I will come to that later - and it is unique in its breadth. It gives special prominence to fields crucial for our future: ecology, climate change, and - information technology.

Why is information technology crucial for our future?

The first industrial revolution was enabled by the steam engine and water power. The second one was driven by electrification. So both were about how to generate and convert forms of energy.

The current transformation has been called the digital revolution, but it really started already in the mid 20th century under the name of cybernetics. Its protagonist is not energy, but information. Like energy, information can be processed by people, but to do it at an industrial scale, we needed to invent computers. Like energy, information may be a conserved quantity, so we may not be able to truly generate it.

As in the two industrial revolutions, we can observe two phases in the current transformation: the first one was driven by the birth of computer science, the development of programming, and the beginnings of symbolic artificial intelligence - i.e., the hope that we can make computers truly intelligent by instructing them to manipulate symbols according to programs written by us. In this first phase, computers processed information that was specifically prepared for them; in other words, the symbols were provided by us.

The second phase, taking place now, unlocks a new information source by gleaning patterns in unstructured data such as real-world images. The enabling technology for this is machine learning, and today AI is almost a synonym for machine learning.

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A particularly elegant way to do machine learning uses a mathematical similarity measure called a kernel. Isabelle, Vladimir, I, and others applied those kernels to generalize a range of linear learning algorithms to nonlinear settings.

This can be done in a way to preserve the simplicity of the linear method, and thus allow mathematical analysis in terms of statistical learning theory as developed by Vapnik and Chervonenkis.

This way, we were able to apply mathematically well-founded methods to nonlinear real-world problems, provided that in some other space, possibly infinite-dimensional, they were linear.

We were also able to generalize linear algorithms to data that was non-vectorial, and structured in various ways.

Working on those topics with Vladimir, Isabelle, and others such as Alex Smola and Chris Burges was truly exciting. Once you have tasted how it feels to be part in discovering or creating something genuinely new, you are addicted to the big questions.

But the story does not end here. AI moved from a symbolic stage towards machine learning, and now it may be starting to move toward a causal stage. We recognize that an understanding of the world cannot be built on mere correlations, but it requires knowledge of what happens when we intervene in a system. This will lead to more robust methods that allow better transfer from one problem to the next, and that lead to more understandable solutions. It will take us one step closer to computers that 'think' in the sense of Konrad Lorenz, i.e., that can 'act in imagined space'. We have devoted the last decade to the problem of causality, including the basic problem of how to distinguish cause and effect from observations. Like machine learning, this is beginning to have impact in science and technology. As a hobby astronomer, I was happy when one of our causal learning algorithms helped discover a number of new exoplanets, one of them turning out to be the first exoplanet in the habitable zone where atmospheric water was discovered.

The first two industrial revolutions had major consequences for all our lives, and the ongoing one may be similar. In fact, it is our information processing abilities, and not our physical strength, that make us human. Machines that process information touch the human condition in more subtle ways than machines that are merely processing energy. We are beginning to see this in many ways - AI can diagnose diseases, manipulate information, influence elections, even help build weapons that take autonomous decisions without being accountable.

This is one reason why we should study and understand AI in Europe, in a broad sense. Machine learning is technology, and technology is built by people to serve purposes. Those purposes are bound to human culture, and ethics.

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If we do not want to become mere consumers of technology invented elsewhere, built on values we may or may not share, it is crucial for us to ensure that the state of the art of AI is researched and invented in Europe, embedded in our open societies.

We have no knowledge of the future, but we can influence it. This is one side of Shannon's duality between future and past.

Vice versa, we cannot influence the past, but we have knowledge of it, and I can thus try to give thanks to those who have helped along the way.

- The BBVA Foundation & the prize committee for the great honor of this award,

- the Max Planck Society, my students, postdocs and collaborators, for their support, insight, and trust,

- mi familia, que ha llevado la carga de compartir su vida con un científico; espero que también hayan sido recompensados en ocasiones.

(- my family, who have carried the burden of sharing their lives with a scientist - I hope they have also at times been rewarded.)