FONDAZIONE BRUNO KESSLER
MAGAZINE

What is artificial intelligence?

January 27, 2022

Oliviero Stock talks to Viviana Lupi on how AI has dramatically changed and will change human life.

Professor Stock, what is artificial intelligence?

A definition that is truly common to all does not exist. I always say that if we ask a hundred researchers, we will have (at least) a hundred definitions, or in any case different nuances. For me, AI is first of all having machines make the effort to understand us rather than vice versa. However, beyond personal views, the classic way of defining it is as engineering does: computer-based systems that perform functions that when performed by human beings are believed to denote intelligence.

As you can see, a definition that refers to another definition – that of intelligence – is not univocal. There are many different aspects of intelligence, from perception, to knowledge, to reasoning, to communication, including emotional intelligence, social intelligence, creativity and more. Behind the goal of attaining these functionalities lies the realization that the human being and the computer are both systems that process information. Basically, the field has always given space to various research sectors, often very different from a methodological point of view, while maintaining a common area of action.

Very little wotk has been done on what is often talked about in the popular press: the project of building an overall intelligence, integrated with all its multiple aspects in the same system. Instead, for various specific sectors, there was the ambition to be able to contribute to the understanding of human cognitive processes, in close cooperation with cognitive sciences. We have seen this a lot especially with regard to the “central” aspects of cognition, for example the underlying structure of our cognitive life – and the basis of our plans and actions – made up of beliefs, desires and intentions, or when it comes to understanding human language. At this particular time in the history of AI, sensitivity to cognitive psychology is being de-emphasized, but I personally believe it remains very important to the field.

How has the concept of artificial intelligence evolved?

To understand the methodological evolution of artificial intelligence, various aspects must be taken into account. The first is that from the very beginning, since the 1957 Dartmouth conference, there have been two ways of looking at the field. The first comes from the logical tradition, and is based on the construction of models, essentially knowledge from which further knowledge can be derived through logical processes. The second is instead linked to the cybernetic tradition, and proposes to

give value to the data and adjust the weight of their correlations, in this way possibly making new correlations appear, with substantially numerical procedures. In general it can be said that the second approach has always been important for perception processes (eg image recognition, speech recognition), the first for central cognition. Over time, there have been focus shifts from one approach to another.

Another important fact is that, especially thanks to the Internet (World Wide Web) and the spread of computers in various forms (for example smartphones), huge amounts of data have become available. Think of the huge image archives. Or to the case of language understanding: it can be said that copies of almost everything that has been written by man, since writing was invented, are now available in digital form and can be used by algorithms capable of “learning” how humans express themselves in writing. Another essential factor in combination with this is technological progress, basic hardware and software (as for parallel computing), which allows long-known learning algorithms to operate in a useful manner.

Has the definition changed in more recent times?

Very often there is a confusion between artificial intelligence and learning from large amounts of data. First of all, we should make clear that when we say learning, we do not mean anything similar to human learning, but basically statistical processes. A child does not learn to speak with huge quantities of sentences, quite the contrary. And in any case, this learning by machines is, as I said before, a non-general approach, albeit highly successful in many application sectors, including new ones. In some areas, for example visual recognition, artificial learning-based systems are even better than human vision, while in other fields that require the combination of multiple components, or for which there is little data, these approaches do not seem to be the ones that lead to a solution.

One effect of the propensity to mainly rely on the methodological approach based on learning in AI, which ensures robustness (i.e. the characteristic of providing some results, even if not optimal, in all circumstances) is that short term applications, and even scientific competitions, are favored. These do not necessarily bring us closer to more ambitious goals.

Another important critical aspect is that neural learning systems (which is the most popular approach), of one kind or another, are a sort of black box. They reach a solution but there is no explanation on how they do it. This is, of course, not only quite problematic for a scientific field, but it is also unacceptable for many application situations. It is quite different from the way knowledge-based systems worked: expert systems (of a few decades ago), for example, had the characteristic of explaining the lines of reasoning that led to the solution: a diagnosis also requires an explanation. It is somewhat paradoxical that now systems are being built that reach a solution in an opaque way, and that a research specialization is needed that tries to explain what they have done a posteriori.

At any rate, I think that in the future the ability to integrate knowledge-based reasoning based and data-based learning will become critical.

What are the tasks that artificial intelligence currently performs at the same level or better than human beings?

Many sectoral tasks. Tasks of perception recognition, but also of recognition and detection of correlations in many areas, including social ones. Prediction of future events, based on the past.

Many tasks related to the verification of safety conditions in complex equipment, think of the operation of the railway network or the complexity of aircraft. These are all tasks in which we cannot do without artificial systems as they do better than us. Then there are many other specialized ones, and many new application sectors.

But here I take the opportunity to mention games that are considered arenas for the expression of intelligence. Even Go, the game from the far East, has recently seen a program dominate. It didn't look easy. But let's stick to a much better known game: chess. After the 1997 defeat with Deep Blue, IBM's special hardware-based program, Kasparov, arguably the greatest champion of all time, had complained of tricks; shortly after playing with the world champion program Deep Junior, based on a plain PC, he realized that the human domination was over and he played in order not to lose. When Deep Junior played with us at FBK against grand master Godena, chess commentators and the defeated grand master unanimously said that what had impressed them most was the creativity displayed by the program. Now, however, the challenges between humans go on and chess is more popular than ever, but we know that the programs are stronger.

What are the areas in which artificial intelligence fails to keep up with natural intelligence?

Perhaps the most difficult thing is the integration of the various aspects of intelligence into a single system. We are far away from it. Moreover, there are basic aspects that are debated between AI, cognitive sciences and philosophy, such as conscience, feeling emotions, the mind-body relationship. These aspects clearly tell apart, at this time, natural intelligence from artificial intelligence.

What are the areas of our lives that are already significantly influenced by artificial intelligence, of which we may not be aware?

Over time, there have been achievements in artificial intelligence that have come to be part of many products and processes. As they were adopted, they would lose the attribution of their origin. Basically, going back to definitions, it was as if the "real world" meant that artificial intelligence is all that computers are not yet able to do. But AI-based techniques were actually already embedded in a wide range of products and processes. Now the opposite is happening: the presence of artificial intelligence is emphasized for many products, even when defining it as AI is not accurate.

Anyway, to answer your question: we have AI in TV sets and in household appliances, of course in mobile phones, and in the program that guides us to reach our destination by car, for example. Not to mention AI managing our computers. Just to mention one visible aspect: the window system, now part of our lives on any PC, originated in one of the top AI centers, at Xerox Palo Alto Research Center.

In which fields will people notice a significant improvement in their quality of life thanks to the application of artificial intelligence in the near future?

I will just mention two obvious cases that will save countless lives. First of all AI in medicine. For example, there are already technologies available for the automatic recognition of possible disease indicators in radiography or in dermatology; but there are many other areas of application in medicine, both to help doctors with diagnostic work, and in surgery (think of the huge sector of precision robotics), and in facilitating the collaborative work of medical teams, or with helping find

new drugs. An additional chapter, which has only been glimpsed so far and which will grow in importance, is preventive medicine. This will mean in particular the development of intelligent interfaces and communication with people aimed at persuading individuals to adopt healthy behaviors.

A second obvious case is that of automatic, or at least semi-automatic, car driving. I think the number of car accident-related deaths we tolerate in our society is outrageous. Automated driving systems will first of all be much safer, they will save many lives. The biggest problem will be in the transition phase, when alongside self-driving cars there will still be a large number of reckless and unpredictable humans driving.

Are there dark sides of artificial intelligence?

Of course. In some cases they are linked to the method, as I mentioned earlier. Now, somewhat curiously, due to their inherent limitations, there is a need to make the behaviors of opaque learning-based AI systems explainable. But in addition to this particular aspect, linked to the currently most popular method, there are various general ethical aspects that it is important to keep in mind.

There are ethical aspects to AI in a similar way to how there are in other fields; think of biology, or even physics. These concern the applicative use of scientific results and sometimes of research itself. In the case of artificial intelligence, there is a lot of talk about the issue of privacy, AI can be used for example to control people, or even to predict their behavior. Another delicate aspect is that of biases: systems that learn from human behavior can assume the same biases, a negative thing that should be avoided. Or AI can be used to build weapons that can kill without human control.

In addition, social issues are being discussed, such as the divide between those who can make use of AI and those who are excluded, the huge profit of industry actors, the possible loss of jobs due to the introduction of intelligent systems that can replace human work. These are all important issues that deserve to be debated. There is a “digital humanism” movement, which deals with these issues in the area of information technology and, in particular, of artificial intelligence. The goal is to develop, first of all among employees, the awareness that the field must serve human development, individual and social progress.

But there is one aspect that is specific, unique to artificial intelligence: artificial intelligence systems will be able to make decisions on an ethical basis on their own. Tell good from evil. This is a new area of research, bound to grow over time, which intersects with philosophy and with the cognitive and social sciences. The constructivist perspective of artificial intelligence allows us, I would say forces us, to think about ourselves and about society.

Who is holding the keys? What are the control mechanisms?

In general, society has lost its grip on IT giants. We did not perceive the great power they could achieve, the disproportionate and elusive profits, and in the end also the possibilities of further autonomous development of technologies, bound to strengthen them more and more. AI enters this scene, and now the buildup of data on individuals that are in the hands of companies is starting to be perceived as problematic. On top of this, we should add specific issues relating to the protection of the rights of individuals and the values of our society.

Today, especially in Europe, there is awareness about the importance of these aspects, and for example the European Commission has provided guidance and intends to set basic controls on the

indiscriminate adoption of AI technology, in an effort to ensure that development is for the good, that it does not affect the rights of individuals and democracy. In the United States these matters are addressed differently, and in China attention to them is at least very far from the general approach.

We should point out, though, that this does not have to do with limitations to basic research, for which, at least in words, they all agree in recommending that greater investments are needed.

What do citizens need to be aware of?

As I said, AI can be used in a manner that may harm democracy. But in Europe there is a strong focus on these aspects, we are more protected than in other places. But I think that we should not only introduce controls whose use does not transcend the interests of democracy, but push for a positive role, require AI to contribute to the development of democracy. For example: correct and accessible information is essential for democracy. Important research could be developed (for example funding it with a fraction of the profits of the companies) aimed at countering fake news and the fraudulent persuasion of people. It is a subject of the utmost importance today, as we know, and at the same time it is an intellectually delicate one. From a technology standpoint, it is a difficult challenge, but we can achieve results that, even if preliminary, will help us in those areas where up until now we have been poorly prepared and have let things go.

This is an example to indicate that citizens should require more AI aimed at exploiting its potential for the common good.

What were your dreams about the future as a child? When in your life did you decide that you would be doing research?

As a child my favorite toys were math, soccer and my scooter/bicycle. I didn’t manage to combine them. As a kid, I didn’t think I’d be doing research before I came across artificial intelligence. I had heard of it for the first time when I was working on my thesis (in mathematical linguistics) at the university. Later on, when working on my specialization thesis in computer science in Pisa (at that time there was no doctorate) I had the opportunity to develop a research project in artificial intelligence: it was the first automated sentence analyzer in Italy. Thanks to a splendid group of researchers from Pisa, who launched me in research, supported me and introduced me to an international environment, I found myself doing research right away. It was me who, later on, chose the uncertainty of public research on the topics I preferred over the certainties offered to me by industrial research in companies like Olivetti.

Why did you choose artificial intelligence?

It is a wonderful world that integrates human sciences such as studies on the mind, linguistics, philosophy, on a mathematical and engineering basis. The idea was to have a close conversation with them, and perhaps to contribute to our knowledge of the human being. A world where there is room for innovative ideas, where technology alone is not enough. It is also a field where you can move forward without being in the mainstream, there is room for originality. On the other hand, my generation, and I for sure, had the ambition to improve the world. For me, the development of research, and the consequent adoption of intelligent technologies, such as interfaces for people, would have served the purpose of giving the same opportunities for knowledge, learning and communication to everyone and not only to the privileged (for example those who have a secretary service or assistants) who can have them anyway.

What would you recommend to a youth who looks with interest to the world of research?

Research in artificial intelligence is fascinating, from various points of view. There is a world to discover, to improve and to build. But above all, artificial intelligence, if embraced with a broad vision, not just a technical one, forces us to think about human beings. With these perspectives comes also the possibility of having a leading role in the concrete applications of the future, not only in basic research.

Let me list some topics that I feel I can suggest for the future.

First of all, I would focus on the broad field of cooperation between human beings and systems, in the most diverse situations. Not an artificial intelligence that will replace human beings but one that will know how to fit in various social processes, including people and organizations, and will help people by enhancing their skills.

A second topic is the specific partnership for creativity, in various fields, from art to specific aspects of human communication – I will give a specific example that is close to my heart: humor, without which I am not sure our species would survive…

Another important topic is the understanding of persuasion, which concretely takes form both in the defense against its undesirable aspects and in the influence on individuals to improve themselves, for the collective good. Connected to this is the extremely difficult and delicate topic of the relationship with truth.

Finally, the issues of computational ethics: a new aspect that will become very important if we want the machines of the future to be good companions in our society, and, why not?, that they can also help us humans to behave with dignity and show respect for others.

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