Everything AI?

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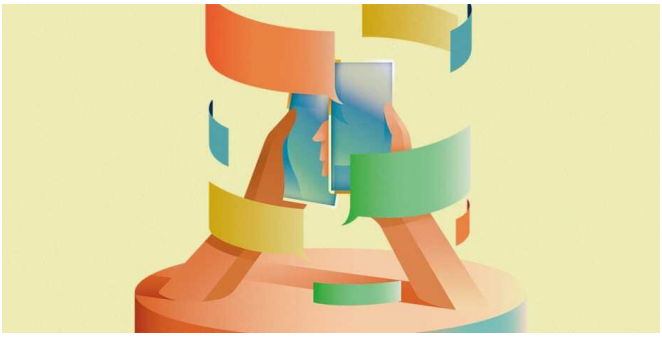

Credit: Ray Oranges

Artificial intelligence is having a growing impact on our daily lives and is also revolutionizing research. ETH Zurich recognizes its responsibility in this area and is striving to promote innovation and trust in this fast-evolving technology.

Sometimes a machine takes everyone by surprise. A recent example occurred at the opening event of Scientifica 2019, where ETH robotics specialists had trained a drone to welcome visitors by writing the word "enjoy."

At first everything seemed normal as the drone, known as Voliro, began to write. It started with the first letter, just as a human would. But when it got to the second letter, it did something nobody expected: it simply left out the vertical line of the "n" and went on to write all the other letters. Only then did it fly back to the "n" to add the missing line. The final result was perfectly correct, but the way in which it jumped back and forth while writing was very different to how humans write. Of course that wasn't how Voliro had been programmed! In fact its creator was just as surprised as everyone else. In all the rehearsals, Voliro had simply written the letters in their normal order. It wasn't until just before the final performance that the drone learned to do it in a way it considered to be more efficient.

When a machine like Voliro changes its behavior unexpectedly, we automatically think of intelligence. And in fact Voliro—an autonomous flying robot made by an ETH spin-off of the same name—is a good example of what artificial intelligence (AI) is capable of nowadays. What seems like human decision-making when viewed from the outside actually has its origins in statistical, data-driven processes that we call machine learning. These processes are a subset of AI.

Overhyped—and underrated

Machine learning is when computers learn by themselves to recognize patterns and regularities in data sets based on experience gained from training data. As they continue to learn from huge amounts of data, intelligent programs automatically improve their success rate. Machine learning methods can find valuable results that humans would fail to spot, especially when faced with very large, complex or heterogeneous data sets.

"Artificial intelligence, or AI, refers to technologies that enable computers to help humans with tasks that can only be solved by intelligence," says Andreas Krause, Professor of Computer Science and a specialist in machine learning. AI research has been around since the 1950s, and it is a tale of both unfulfilled expectations and unexpected success stories. What's changed more recently is that AI has become a far more tangible and visible presence in our day-to-day lives: automatically created photo albums and smartphone voice assistants are just two examples.

AI's increasing ubiquity stems from the convergence of three technological trends. Firstly, computer hardware has become incredibly powerful. A modern smartphone is as fast as a supercomputer from the mid-1990s, and a laptop has enough computing power to develop viable AI models. Secondly, software implementations for many AI learning methods are freely available online, which has boosted the number of developers and users. The third trend is the availability of large amounts of data—much of it on

the internet—that can be used to train AI systems. Scientists are making new advances on an almost daily basis and this, in turn, is greatly expanding our mathematical understanding of these learning methods.

"The result of these technological breakthroughs in AI is a multifaceted disruption to science, industry and society with far-reaching consequences that are both overhyped and underrated." This was the conclusion drawn by AI researchers at ETH Zurich when they took stock of how far AI had come in the summer of 2019.

New division of labor

In fact, AI and machine learning not only have an impact on individual users and industrial workflows, but also change the way in which work is divided between researchers and computers. Gisbert Schneider, Professor of Computer-Assisted Drug Design, Associate Vice President for ETH Global and founder of the ETH "think-and-do" tank RETHINK, uses AI to develop new drugs on the computer. "We have an AI model for virtual medicinal chemistry that automatically generates molecular structures possessing one or more desired properties," he says. This method allows the team to obtain new chemical entities and then synthesize and test these computer-designed compounds to see if they exhibit the calculated bioactivities. "AI methods enhance researchers' creativity, yielding surprising suggestions that they hadn't thought of themselves," says Schneider.

Many applications require a certain amount of decision-making autonomy. Lothar Thiele, a professor at the Computer Engineering and Networks Laboratory and Associate Vice President for Digital Transformation, develops technologies for sensor networks that collect data under extreme conditions. In collaboration with various partners, his group is studying the impact of climate change on permafrost in the Swiss Alps and the destructive processes it is triggering. Their results are also useful for early warning systems. "Huge amounts of data are collected on a continuous basis," explains Thiele. "So individual sensors have to make their own decision on whether an event is relevant or not. That's where we have found AI to be very successful."

Schneider and Thiele are not the only ones using AI in their research: AI applications are now widespread across all fields of science at ETH. In principle, any area of research can benefit from AI-enhanced methods. Comparisons with other countries confirm how influential AI research has become at ETH and in Switzerland. According to Stanford University's AI Index 2019, Swiss researchers publish the second-largest number of AI articles per inhabitant after Singapore. What's more, citation rates show that Swiss publications are among the most influential.

The growing importance of AI can also be seen in ETH student numbers. While only a few hundred students attended a course in machine learning and AI methods in 2012–13, this figure has now risen to well over 3,000. "Introduction to Machine Learning" is attended by more students than any other lecture. Most students come from the core subjects of computer science, electrical engineering, mechanical engineering and mathematics. Equally striking is the fact that every academic department at ETH now has students taking courses in AI. To meet this demand, ETH launched both a Master's degree program and a continuing education program in data science in 2017.

"ETH Zurich's strengths in AI lie in its outstanding basic research in mathematics, computer science, information technology and data science, as well as the quality of its infrastructure," says Detlef Günther, Vice President for Research. "But we also have huge potential to develop innovative AI methods by combining our excellence in AI fundamentals with the top-class research we conduct in the variety of disciplines we offer."

A connected future

Governments, corporations and universities are implementing AI strategies to address AI's growing economic and social impact. The US and China are investing particularly heavily in AI. That raises the question of how Switzerland, and indeed Europe, can position themselves globally, and how ETH Zurich can continue to expand its status in the AI

field.

One strategy that was proposed recently in an interview with Thomas Hofmann—an AI researcher at ETH and co-director of the Max Planck ETH Center for Learning Systems—is to link up Europe's AI centers of excellence, which include Zurich, Lausanne and Lugano, in order to create a Europe-wide AI network that includes ETH researchers.

With this strategy in mind, ETH Zurich took the decision in May 2020 to extend its partnership with the Max Planck Society by another five years. Launched in 2015, this partnership in the field of learning systems connects ETH Zurich with the Max Planck Institutes in Tübingen and Stuttgart, two other European centers of excellence in AI. A new initiative that is linking up AI researchers across Europe is the European Laboratory for Learning and Intelligent Systems (ELLIS). Launched in December 2019, ELLIS comprises 17 European AI centers of excellence. ETH Zurich has been involved in the initiative right from the start through its ETH ELLIS Unit.

Reliable, ethical AI

A third new aspect concerns ETH itself, more specifically how it connects its AI researchers to the wider world and gives broader visibility to "AI@ETH." On 20 October 2020, the university will hold an opening ceremony to launch its new ETH AI Center. "The AI Center will set the stage for an interdisciplinary dialog with industry, government and society on how to continue developing artificial intelligence in a way that fosters innovation and inspires trust," says Günther.

In terms of its organizational structure, the center builds on the strengths of ETH and combines the fundamentals of AI theory and methodologies with expertise from the various disciplines. The core group comprises some 20 professors who conduct research in key AI fields such as machine learning, big data and statistics. Around this is a wider circle of researchers who develop AI methods for their particular subject area or who study the effects of AI. The center is also open to guests from other AI research institutes and from industry.

"The AI Center is not a virtual network," says Andreas Krause, the designated head of the center. "It is a real meeting point where AI scientists from research and industry can exchange ideas and embark on joint research projects." Due to the extremely rapid pace of development in the field of AI, the plan is to build up the AI Center gradually, with a focus on interdisciplinary projects and promoting talent.

The center's strategy is rooted in characteristic human traits that no intelligent machine can compete with, namely motivation, curiosity, creativity and flexibility in evolving situations. "Our aim is to get the center up and running by focusing firmly on talent, starting with a fellowship program," says Krause. "Doctoral students and postdocs will play a key role in interdisciplinary research partnerships. They will offer fresh perspectives on how to link up research topics and develop new AI tools." The new center had plenty of positive experiences to draw on, including the doctoral program run by the Max Planck ETH Center as well as the Master's degree program in data science, where computer science students develop AI solutions for other fields of research. "Both those programs are producing exciting results and have provided valuable inspiration," says Krause.

In terms of content, the ETH AI Center will deal with fundamental issues relating to AI. For example, there are a number of AI methods that are used in practice but are still short on theory. Plugging these gaps would mean not only seeing whether an AI method works, but actually getting to the root of why. "We want to fundamentally rethink how we develop AI models so that they work safely and reliably and produce results that are explainable, interpretable and fair," says Krause. "I see reliability and transparency as essential when it comes to the societal impact and ethics of AI." Safe, reliable and fair AI solutions can make a real difference, particularly in research areas that play to ETH Zurich's strengths, such as mobility, health, manufacturing, energy, climate and the environment. With some AI experts arguing that responsible and reliable AI could represent a major opportunity for Europe, the ETH AI Center is committed to making trustworthy AI a top priority.

Provided by ETH Zurich
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