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The Power of the Algorithms

Pedro Domingos on the Arms Race in Artificial Intelligence

Interview Conducted by Christoph Scheuermann and Bernhard Zand

In an interview, best-selling author and machine-learning expert Pedro Domingos discusses the global competition to take the lead in artificial intelligence, the advance of autocrats and the threats modern technology presents to Western democracies.

It's a quiet hallway in the computer science department at the University of Washington in Seattle. To the right, young software engineers sit in front of their laptops in the windowless, artificially lit rooms. To the left, computer science professor Pedro Domingos opens the door to his office, which has a view of the massive trees on campus.

Domingos' book "The Master Algorithm," about the technology of artificial intelligence (AI), made him famous and is also considered a standard reference work. The best-selling book, published in 2015, describes how machines that can learn are changing our everyday lives -- from the social networks and science to business and politics and right up to the way modern wars are waged. The book drew praise from Microsoft founder Bill Gates and Google CEO Eric Schmidt.

Recently, a third prominent figure noted that he'd read the book: Chinese President Xi Jinping. When state television broadcast his new year's speech this year, viewers discovered that next to Marx's "Capital" and "Selected Works" by Mao Zedong, he also has a copy of "The Master Algorithm" on his bookshelf.

"The book is much read in China," says Domingos. "That's probably why Xi and his people became aware of it. It's possible that it has now become even more popular." The book has also been published in Russian, Japanese, Korean and in many other languages, but not yet in German.

DER SPIEGEL recently sat down with Domingos in his Seattle office for an interview.

DER SPIEGEL: Mr. Domingos, Russian President Vladimir Putin says that he who leads in artificial intelligence will rule the world. Is that true?

Domingos: I agree with him, realistically. Artificial intelligence is a very powerful technology, and there is an arms race going on. Fast forward 20 years into the future and one of the players could have won the race. China is more likely to win than Russia is, although Russia has a lot going on. So, we could end up in a world that China may not formally control, but they effectively do because they rule the cyberworld.

DER SPIEGEL: Why is this tantamount to world domination?

Domingos: AI lowers the cost of knowledge by orders of magnitude. One good, effective machine learning system can do the work of a million people, whether it's for commercial

purposes or for cyberespionage. Imagine a country that produces a thousand times more knowledge than another. This is the challenge we are facing.

DER SPIEGEL: Chinese President Xi Jinping is very interested in artificial intelligence. Did you know before his new year's speech that your book was on his shelf?

Domingos: I didn't know before, but I found out pretty quickly. This is something that Xi Jinping regularly does. These books are on his shelf to send a message, and the message that I think he is sending by having my book is, "We really believe in artificial intelligence." So, when I found out about it I was not extremely surprised given that the Chinese government had announced before that it wants to dominate in AI.

DER SPIEGEL: Which sentiment prevailed when you saw your book there -- a sense of recognition or one of concern?

Domingos: It was both exciting and scary. Exciting because China is developing rapidly, and there are all sorts of ways the Chinese and the rest of the world can benefit from AI. Scary because this is an authoritarian government, going full tilt on using AI to control their population. In fact, what we are seeing now is just the beginning. Like any technology, AI gives you the power to do good and evil. So far, we have been focusing on the power to do good, and I think it is enormous. But the power to do evil is there, too.

DER SPIEGEL: Is it by coincidence that two autocrats like Xi and Putin take such an interest in AI?

Domingos: When I travel around America, Europe and Asia, it is interesting to see how differently people feel about this technology. The picture coming out of Silicon Valley is a very optimistic one, informed by libertarian ideas. The very opposite is true for Europe: I just came back from a conference in Berlin where I was struck by the sheer pessimism. Every other session was about: "Oh, we have to fear this. Who knows what may be going on here?" Until someone made a point that was really on the mark -- as the conference was called "Humanity disrupted." He asked: "Why don't we call the conference 'Humanity Enhanced'?" Sure, AI brings disruption -- but we are being much more enhanced than disrupted.

DER SPIEGEL: And China and Russia?

Domingos: They unfortunately see the authoritarian and less the libertarian potential. Xi Jinping and Vladimir Putin ask themselves: "What could we do with this technology?"

DER SPIEGEL: Are we Europeans losing out to the autocrats?

Domingos: There are many AI applications being used in the U.S. and China, be it on the local or the national level, in medical research or traffic management. Less so in Europe. So, yes, Europe is missing out to an extent, unfortunately.

DER SPIEGEL: Your book has been translated into Russian and Chinese, but not into German or French.

Domingos: My literary agent told me: "You are going to sell this book all over the world, but not in France and Germany." And that's what happened. "The Master Algorithm" was sold to Japan, China, Taiwan, South Korea. There are Polish and Russian translations. But my agent was right when he said: "The Germans and the French don't like these things."

DER SPIEGEL: Your book warns of the limitations, even dangers of this technology if it ends up in the wrong hands. Aren't we worried for good reasons?

Domingos: There are dangers, and in terms of regulating AI, Europe is ahead of the U.S. Unfortunately, there is too much regulation without understanding the technology that is being regulated.

DER SPIEGEL: What do you mean by that?

Domingos: The European Union's General Data Protection Regulation (GDPR) is putting too much value on the factor of explainability -- meaning why an algorithm decides this way rather than that way. Let's take the example of cancer research, where machine learning already plays an important role. Would I rather be diagnosed by a system that is 90 percent accurate but doesn't explain anything, or a system that is 80 percent accurate and explains things? I'd rather go for the 90 percent accurate system.

DER SPIEGEL: Why can't we have both -- accuracy and explainability?

Domingos: The best learning algorithms are these neural network-based ones inspired by what we find in humans and animals. These algorithms are very accurate as they can understand the world based on a lot of data at a much more complex level than we can. But they are completely opaque. Even we, the experts, don't understand exactly how they work. We only know that they do. So, we should not allow only algorithms which are fully explainable. It is hard to capture the whole complexity of reality and keep things at the same time accurate and simple.

DER SPIEGEL: How, then, should AI be regulated?

Domingos: There is no law detailed enough to compete with the complexity of things that algorithms can do. What can be regulated, though, are the dangers that come from overly crude objective functions such as Facebook's algorithms maximizing the time you spend on their site. These can be regulated by saying: OK, you have these business elements in your objective function because you need to make money. But you should also have these societal goals like, for example, the truth value of the things that are being said.

DER SPIEGEL: Which part should not be regulated?

Domingos: There is this notion predating the GDPR that data can only be used for the purpose it was collected for. This sounds plausible, but if we had been using that principle all along we would not have penicillin. We would have no X-ray. We wouldn't have all of the scientific discoveries that came unexpectedly. Serendipity, discovering new things in old data, is a huge driver in progress.

DER SPIEGEL: Have you explained this to European politicians?

Domingos: I have talked with some politicians, but again, less in Europe than in other places. The irony is that there are a lot of great AI researchers in Europe. Not as many as in the U.S., but in terms of the quality of research, Europe is better than China. But China is now coming up very fast ...

DER SPIEGEL: ... and may pull ahead of us in the end with its authoritarian model?

Domingos: Former Google CEO Eric Schmidt has said that, by 2025, China will be ahead because Beijing has a concerted strategy. This is entirely conceivable. But different areas have different advantages. The U.S. has a system that works very well from the basic research funded by the government to the VCs and startups which transfer knowledge from the universities. China's advantage is the huge data pool which fuels machine learning. Europe's advantage is the diversity of its people. If I had to choose between Europe or China as the pool of data to learn from I might choose Europe because in China, the data are often more homogeneous and redundant. Another aspect is that China is so cavalier about protecting the individual -- which can be both an advantage and a disadvantage.

DER SPIEGEL: Why?

Domingos: In cancer research, for example, it should be the ethical duty of the patients, in my view, to provide their data. But they will be hesitant to do so if they have to worry about privacy. So, the quality and security of data may be lower -- even if the volume is much bigger.

DER SPIEGEL: Will the AI arms race be mostly between countries or between big corporations?

Domingos: The world will change dramatically in this respect, the borders are already shifting. When I talk to people in the military -- a lot of my research is funded by the Department of Defense -- they have long given up the hope of keeping the enemy outside the walls. The enemy is already inside, as much as we try to patch up the walls. And this is why China becomes very good at building a surveillance state.

DER SPIEGEL: How does this concern the big internet corporations?

Domingos: It's between companies where the arms race is farthest along. So far, they have been working on AI and keeping it quiet, partly for competitive reasons. Today, the biggest tech companies owe allegiance to nobody -- five or six in the U.S., two or three in China. But sooner or later, there will be retrenchment, and the companies will become more nationally controlled. Again, this may be to China's advantage as the government and the companies there help each other with little compunction. This is very different in the U.S.

DER SPIEGEL: Which, would you say, are the leading companies in AI?

Domingos: The No. 1 company is Google, which has an extraordinary number of people in this field and units, like DeepMind and Google Brain, which are focused on AI. Then there is Microsoft, and, coming up from behind, Facebook and Amazon. Amazon has hundreds of thousands of people working in their warehouses who they probably would like to replace with robots.

DER SPIEGEL: And in China?

Domingos: The online retailer Alibaba and the conglomerate Tencent are the best ones, but the one that has made the biggest bet on AI is Baidu, the search engine.

DER SPIEGEL: Authoritarian regimes, the military, cyber espionage and now the data breach at Facebook -- how come you still view AI as a positive thing?

Domingos: Look at what technology has achieved over the past 200 years. Yes, bad things have happened, but the result has been overwhelmingly positive. There are good reasons to be

optimistic and pessimistic; in fact, reasons for both have become much bigger now. My basic frame of mind, however, is guardedly optimistic.

DER SPIEGEL: Isn't the Facebook scandal exactly the big "blow-up" in digitalization you warned about in your book?

Domingos: At Facebook, they have always been very cavalier about privacy, they have always done risky things which blew up in their face -- and only then did they step back. It is not by accident that they are less trusted than the other big tech companies. In some ways, this reckoning was due all along. Having said that, Facebook today is not what it was a few years ago. A data breach like the one with Cambridge Analytica would not happen today.

DER SPIEGEL: How would you regulate Facebook?

Domingos: Facebook does many things that are questionable. Their machine learning algorithms are set to maximize engagement. Of course, they're not the only ones to do that, every successful TV show, or sport or novel does that. But Facebook is using AI in order to maximize engagement and does some damage in the process. People are being misinformed by Fake News, then polarized. These are real things to be concerned about. Then maybe politics has to step in and say, "Look, these are the boundaries."

DER SPIEGEL: Can social media become a danger to democracy?

Domingos: They can be a danger and also an opportunity. If you think about it, democracy is still in the 19th century. Your communication with your representatives and ministers amounts to a few bits per year. It's ridiculous. One way to improve this would be a digital model of a citizen that politicians can consult in order to figure out what that citizen wants. Which would result in better decisions in cities and governments doing what people want versus what politicians think people want. Machine learning could help with this. So that's the opportunity.

DER SPIEGEL: And the danger?

Domingos: The danger is that this technology is used to manipulate people. But it's important to keep things in proportion. At the moment, social media companies are primarily interested in selling ads. The total value of a Facebook customer is something like $50 a year of someone who spends maybe $50,000. So, all of this machine learning, all of this data put together only influences 0.1 percent of what you do. The idea that you can sway elections with AI right now to me sounds a little bit far out. But I think going forward, as the technology becomes more powerful and social media companies have more data, the danger will be greater.

DER SPIEGEL: What is the bigger risk posted by AI -- data leaks like the one we saw at Facebook or the Orwellian surveillance state many autocrats dream of?

Domingos: If authoritarians are getting more out of AI than democratic countries, then we have a problem. Based on a famous quote by Trotsky, one could say, "You may not be interested in AI, but AI is interested in you." Just like Americans believe in lawyers, the Chinese believe in engineers. A lot of their top people are engineers. For them, society is just another engineering problem: We're going to engineer this machine to behave the way we want. For politicians like these, this is incredibly seductive.

DER SPIEGEL: Soviet leaders dreamed about ruling the world as well.

Domingos: Yes, and they lost to democracy and capitalism. But imagine what that regime could have accomplished with the algorithms of our time. Computers are like the ultimate bureaucrats. They can keep tabs on everybody and are incorruptible, but in the hands of a despot extremely corruptible. If in an open, democratic society, I tell my soldiers as the commander of an army to do something that they think is bad, they're actually free under the laws of most Western countries to refuse the command. If it's a computer, the computer doesn't say no. It just executes.

DER SPIEGEL: Are we sometimes overestimating progress in AI? Wherever we interact with it -- in voice or face recognition, for instance -- it disappoints.

Domingos: Technology always makes less progress than you expect in the short term and more progress in the long term, and AI is the ultimate example of this. The AI systems that we use in everyday life today are still incredibly stupid. There's no intelligence in Alexa or Siri.

DER SPIEGEL: Why not? Is it so hard to learn basic information about us from dozens of interactions and requests?

Domingos: It is extraordinarily difficult. We think intelligence is easy because we carry the whole history of evolution with us. Having said that, we have come a very long distance in the last 50 years in technology. We've come a thousand miles, and there are amazing things that we can do with what we have now. There's a million miles more to go, but we won't take as long as before.

DER SPIEGEL: In your book, you write that "any sufficiently advanced AI is indistinguishable from God." Could you explain this thought?

Domingos: It's a play on a quote by the science fiction writer Arthur C. Clarke that any sufficiently advanced technology is indistinguishable from magic. One of the broader points I wanted to make is that we're constantly afraid of the machines revolting. This is not going to happen. What could happen, though, is that we voluntarily relinquish control to the machines because they're so great. They are objective, they don't have all of these human failings. They have access to more data. Isn't a cellphone pure magic?

DER SPIEGEL: So, in the long run, it's about who controls the machines?

Domingos: Exactly. History shows how ready and willing we are to obey leaders and do what the gods say. We are psychologically totally prepared to put things in the hands of AI, even though we shouldn't. But in the end, it's not AI making the decisions, it is those who control AI. Who will be steering the major algorithms? Is it us -- or is it Xi Jinping? That's the question.

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