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Messages from the AI engine room

The Butterfly Effect

Artificial intelligence can strengthen our protection against extreme weather events and help us manage the impacts of climate change

Small thing, big effect. That could have been my headline for the year 1993. No, not because I had just got my secondary school-leaving certificate, but because paleontologists and chaos theorists were conquering the cinema screens! What a motivation for moving on to university.

In the blockbuster movie "Jurassic Park," U.S. actor Jeff Goldblum, alias Dr. Ian Malcolm, explained chaos theory as follows: "It simply deals with unpredictability in complex systems," he said. "The shorthand is 'butterfly effect.' A butterfly can flap its wings in Beijing, and there's rain instead of sunshine in Central Park."

The "butterfly effect" was popularized by the American meteorologist and mathematician Edward Lorenz (1917-2008) from MIT in Cambridge (Massachussetts), whose dream had been the perfect weather forecast. With sufficient computer power, he was convinced for a long time, a precise forecast should be feasible! But then his realization of the unpredictability and capriciousness of the weather had finally robbed him of all illusions. It was the birth of a new theory: Ed Lorenz gained insight into the principle of "deterministic chaos" — the starting point of chaos theory. He asked this question of memorable poetry, which, as you saw, even found its way to Hollywood: "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?"

Indeed, the air vortex induced by a butterfly wing can trigger a bigger one, and that in turn an even bigger one — with unpredictable consequences. Some ecologically-minded chaos theorists warned already as early as 1993 that every blast of a spray can could ignite a whirlwind. In short, Ed Lorenz recognized: The predictability of the world has its limits.

Lorenz had been working on long-term weather forecasts back then, and the statisticians he was working with presented him with a simple idea: if you can find a historical weather map that matches the weather of today, you should be able to make predictions by simply looking at subsequent maps from the historical one.

Unfortunately, it was (and still is) impossible to find two days in history with very similar or even identical weather conditions prevailed. Just for a single rain drop to fall down to the ground, countless and, above all, unpredictable conditions must be met: cloud formation, the amount of dust in the air, the size of the drop. If it is heavy enough, it might fall to the ground — but it might not. An updraft could hurl it upward, and heat could vaporize it before it hits the ground.

Because the atmosphere is so complex, Lorenz says, it is simply impossible to find a day in history when conditions are exactly the same as today's weather. But for weather forcasting they must be, according to his own research results. Lorenz tried to repeat a simple computer simulation of the weather, but due to a rounding error, he entered slightly different numbers. He went to get a cup of coffee, and when he returned, he saw that the simulation differed greatly from the previous run.

Today the most common way to predict the weather still involves atmospheric simulations, albeit much more complex ones than those carried out by Ed Lorenz at MIT. They require an enormous amount of computation, and the input data and in turn the predictions are a few hours old when the calculations are done — they are no longer up-to-date. This way, predictions in the range of a few minutes and hours are hardly possible.

A team led by Deep Mind, Google's London-based AI sister company, has now published an alternative in the renowned journal Nature. They presented an AI system that in almost nine out of ten cases can predict more accurately than conventional methods where, when, and how much it will rain within the next 90 minutes.

The underlying idea is quite compelling, because accuracy was increased by simply dispensing with time-consuming weather simulations: The AI system, trained with a lot of radar images of real rainfall areas, learned to derive the statistically most probable sequence of future radar images of rain. This is like finding a patch of gras, lying back and trying to predict how the clouds will go by.

I am very happy that such renowned colleagues as Markus Reichstein at the Max Planck Institute for Biogeochemistry in Jena have realized the potential of AI in many questions relating to weather, climate, and system earth. This is even more important because extreme weather events will become more frequent, with sometimes devastating consequences. Just think of the recent floods in Germany. We need to act now. As we have just seen, here AI is not a small thing, but it still will have big effects!

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