Artificial intelligence learns to predict elementary particle signals

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AI will serve to develop a network control system that not only detects and reacts to problems but can also predict and avoid them. Credit: CC0 Public Domain

Scientists from the Higher School of Economics and Yandex have developed a method that accelerates the simulation of processes at the Large Hadron Collider (LHC). The research findings were published in *Nuclear Instruments and Physics Research Section A: Accelerators,* *Spectrometers, Detectors and Associated Equipment*.

Experiments in high-energy physics require work with big data. For example, at the LHC, millions of collisions occur every second, and detectors register these particles and determine their characteristics. But in order to receive a precise analysis of experimental data, it is necessary to know how the detector reacts to known particles. Typically, this is done using special software that is configured for the geometry and physics of a particular detector.

Such packages provide a fairly accurate description of the medium's response to the passage of charged particles, but the rate of generation of each event can be very slow. In particular, the simulation of the single LHC event may take up to several seconds. Given that millions of charged particles collide every second in the collider itself, an exact description becomes inaccessible.

Researchers from HSE and the Yandex Data Analysis School were able to speed up the simulation using Generative Adversarial Networks. These are comprised of two neural networks that compete with each other during competitive training. This training method is used, for example, to generate photos of people who don't exist. One network learns to create images similar to reality, and the other seeks to find differences between artificial and real representations.

"It's amazing how methods that were developed basically to generate realistic photos of cats, allow us to speed up physical calculations by several orders of magnitude," notes Nikita Kaseev, a Ph.D. student at HSE and coauthor of the study.

The researchers trained generative competitive networks to predict the behavior of charged elementary particles. The results showed that physical phenomena can be described using neural networks highly accurately.

"Using generative competitive networks to quickly simulate detector behavior will certainly help future experiments," says Denis Derkach, Assistant Professor in the Faculty of Computer Science and coauthor of the study. "Essentially, we used the most modern training methods available in data science and our knowledge of the physics of detectors. The diversity of our team, which consisted of data scientists and physicist, also made it possible."

More information: Denis Derkach et al, Cherenkov detectors fast simulation using neural networks, *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* (2019). DOI: 10.1016/j.nima.2019.01.031

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