Researchers apply machine learning to condensed matter physics

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A machine learning algorithm designed to teach computers how to recognize photos, speech patterns, and hand-written digits has now been applied to a vastly different set of data: identifying phase transitions between states of matter.

This new research, published today in *Nature Physics* by two Perimeter Institute researchers, was built on a simple question: could industry-standard machine learning algorithms help fuel physics research? To find out, former Perimeter Institute postdoctoral fellow Juan Cassasquilla and Roger Melko, an Associate Faculty member at Perimeter and Associate Professor at the University of Waterloo, repurposed Google's TensorFlow, an open-source software library for machine learning, and applied it to a physical system.

Melko says they didn't know what to expect. "I thought it was a long shot," he admits.

Using gigabytes of data representing different state configurations created using simulation software on supercomputers, Carrasquilla and Melko created a large collection of "images" to introduce into the machine learning algorithm (also known as a neural network). The result: the neural network distinguished phases of a simple magnet, and could distinguish an ordered ferromagnetic phase from a disordered high-temperature phase. It could even find the boundary (or phase transition) between phases, says Carrasquilla, who now works at quantum computing company D-Wave Systems.

"Once we saw that they worked, then we knew they were going to be useful for many related problems. All of a sudden, the sky's the limit," Melko says. "Everyone like me who has access to massive amounts of data can try these standard neural networks."

This research, which was originally published as a preprint on the arXiv in May, 2016, shows that applying machine learning to condensed matter and statistical physics could open entirely new opportunities for research and, eventually, real-world application.

More information: Machine learning phases of matter, *Nature Physics*, nature.com/articles/doi:10.1038/nphys4035

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