Solving the three-body problem faster using a deep neural network

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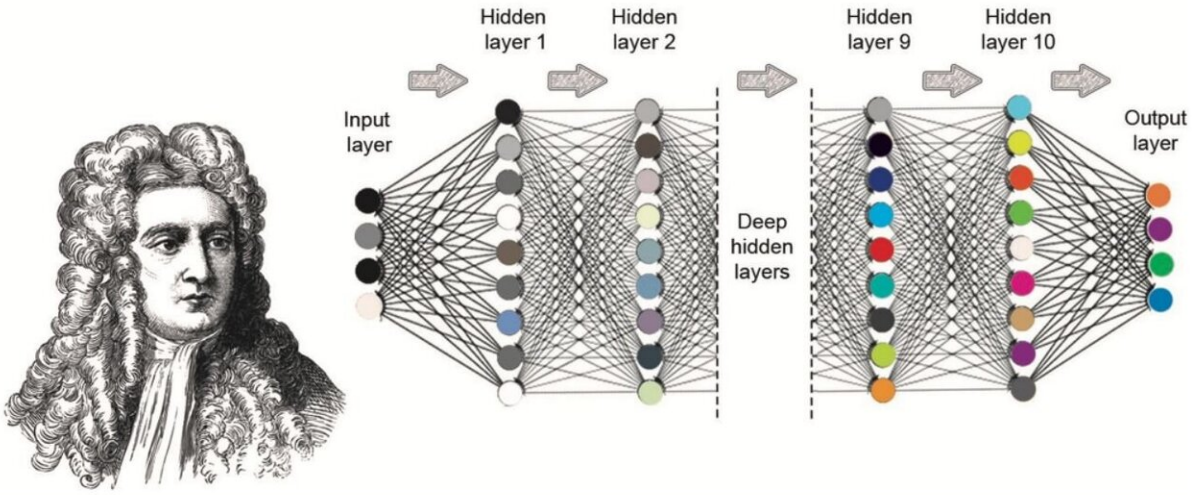

Newton and the machine. Image of sir Isaac Newton alongside a schematic of a 10-layer deep neural network. In each layer (apart from the input layer), a node takes the weighted input from the previous layer's nodes (plus a bias) and then applies an activation function before passing data to the next node. The weights (and bias) are free parameters which are updated during training. Credit: arXiv:1910.07291 [astro-ph.GA]

A small team of researchers from the University of Edinburgh, the University of Cambridge, Campus Universita´rio de Santiago and Leiden University has developed a way to use a deep neural network to solve the three-body problem. They have written a paper describing their efforts

and have uploaded it to the *arXiv* preprint server.

The three-body problem is simple to describe, but very difficult to solve. It involves calculating where three bodies (such as the sun, moon and Earth) will all be at a certain point in time, given their initial starting positions along with their mass, current direction and how fast they are moving. Early navigators were the first to try to solve three-body problems—it helped them to steer ships across large bodies of water such as the Atlantic Ocean. But such efforts were prone to errors due to the chaotic ways that gravity exerts its influence on all three bodies when they interact. Isaac Newton came up with some equations that involved describing the vector positions of the three bodies, assuming each had a certain mass. Solving the equations involved a long series of iterations, which is why the method was not used until computers were invented. But even now, with all the might and power of modern computers, the process is still long and laborious. Hoping to find a quicker way to get the job done, the researchers with this new effort wondered if neural networks might be up to the task. To find out, they used the results of a conventional system built to solve the problem—one named Brutus. They had Brutus solve 9,900 "easy" scenarios and fed the data and results to their neural network. Then, they gave the system its own "easy" scenarios to solve and compared how it did with Brutus working on the same scenarios.

The researchers report that the results given by the two systems were very close, suggesting the neural network was quite capable of solving three-body problems—and it did so much quicker. It took Brutus approximately two minutes to solve the "easy" problems—the neural network produced nearly identical results in less than one second. The researchers acknowledge that while very fast, their system is still limited by the crunching abilities of Brutus—without such data, the new system would have nothing to learn from. They suggest their work is still in the early stages but hope that one day neural networks will be able to solve

many-bodied problems, giving scientists who study the cosmos a very valuable tool.

More information: Newton vs the machine: solving the chaotic three-body problem using deep neural networks, arXiv:1910.07291 [astro-ph.GA] arxiv.org/abs/1910.07291