What can AI do for nuclear physics?

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Nowadays, artificial intelligence (AI) is participating more and more in people's daily life, even though some don't realize that. From speech recognition to graph classification, the algorithms of machine learning (ML) has reached a quite trustworthy level. However, if we apply the ML methods into research in nuclear physics, what will happen?

We all know that there is a dense and positive charged matter in the center of an atom called "nucleus". Inside the nucleus, nucleons (protons and neutrons) are arranged in respective levels. One of the most famous models to describe the nuclear structure and the motion of the nucleons is based on the Hartree-Fock-Bogoliubov (HFB) method, which is used in this project. Intuitively, one should unravel the field for the nucleons and solve the Schrödinger equation to get the information, in this case, the binding energies of the nucleons. Figure 1 shows how one can achieve the binding energy of nucleons in ^{2}H which only has one neutron and one proton. Then, the total binding energy can be the energy needed to separate the neutron and the proton.

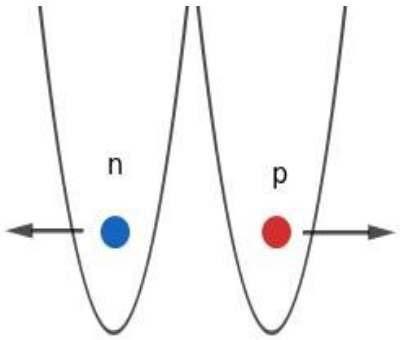

Figure 1: An illustration of the binding energy in ^{2}H.

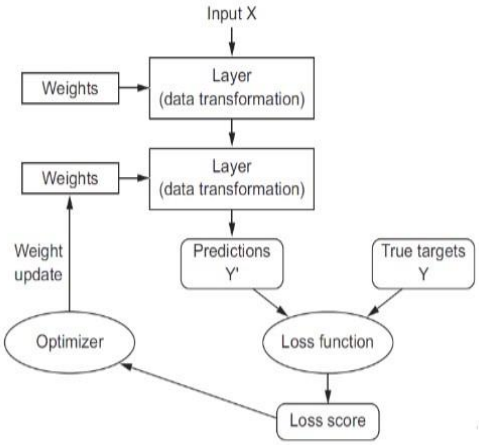

Figure 2: A typical neural network.

In other words, imagine yourself as a nucleon and that you are trapped in the nuclear potential. The energy you need to exceed the wall of the potential is just your binding energy.

A neural network can be a good tool to improve the theoretical calculations even further. Figure 2 shows how a typical neural network works. The true targets can be the experimental data of the nuclei and the predictions are given by the network. The whole project is like making a piece of breakfast bread. At the first step, you need to toast the bread and then, you dress the bread with some butter or jam. The HFB calculation is like the toasting process, which provides the foundation. After that, the dressing of the ML algorithm can improve the taste even better. The combination of the AI techniques and physics is not only a popular attempt in science, but also an optimization. The results can be useful for future experiments on unknown heavier nuclei as well.