AI for Monte Carlo simulation

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Résumé

In this presentation, we will illustrate the potential interest of AI methods, based on deep neural networks, to accelerate the Monte Carlo simulations. Two examples will be described. The first example describe a method to speed-up Monte Carlo simulations of Single Photon Emission Computed Tomography (SPECT) imaging. It uses an artificial neural network (ANN) to learn the Angular Response Function (ARF) of a collimator-detector system. The ANN is trained once from a complete simulation including the complete detector head with collimator, crystal, and digitization process. During the simulation, particle tracking inside the SPECT head is replaced by a plane. Photons are stopped at the plane and the energy and direction are used as input to the ANN that provide detection probabilities in each energy windows. Compared to histogram-based ARF, the proposed method is less dependent on the statistics of the training data, provides similar simulation efficiency, and requires less training data.
The second example models large and inconvenient phase space files used in Monte Carlo simulations by a compact Generative Adversarial Network (GAN). The GAN is trained based on a phase space dataset to create a neural network, called Generator (G), allowing G to mimic the multidimensional data distribution of the phase space. At the end of the training process, G is stored with about 0.5 million weights, around 10 MB, instead of few GB of the initial file. Particles are then generated with G to replace the phase space dataset. This concept is applied to beam models from linear accelerators (linacs) and from brachytherapy seed models. Detailed statistical properties and limitations of the GAN-generated particles still require further investigation, but the proposed exploratory approach is already promising and paves the way for a wide range of applications.

Mots-Clés: Monte Carlo simulation, artificial intelligence

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