Artificial Intelligence for Monte Carlo Simulation in Medical Physics

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Background. Because of the nature of the Monte Carlo (MC) method, involving iterative and stochastic estimation of numerous probability density functions, the computation time is generally high. Despite the continuous and significant progress in Variance Reduction Techniques, in computer hardware and the (relative) easiness of using parallelisms, the computation time is still an issue for highly demanding and complex simulations. In this presentation, we will review the recent use of Deep Learning (DL) methods for MC simulation with their main associated challenges and potential interests.

Material and Methods. After a short literature review, we will focus on DL-based source modelling applied for 1) Linac beam phase-space, 2) SPECT imaging and 3) PET imaging. The challenges of the integration of DL models within Geant4 toolkit will also be addressed.

Conclusion: There may be a methodological change associated with the use of DL methods: instead of mathematically mastering the phenomenon under investigation, the modelling relies on a large amount of data to learn from heuristically. However, MC simulation which generates the training data needs to be skillfully setup and evaluated. For the moment, even if it is envisioned that deep learning can improve simulations, it does not seem certain that it can replace Monte Carlo. A mix of modelling based on large datasets and understanding of the underlying physics may become increasingly important.

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