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Novel Neuromorphic Computing based Monte Carlo Simulation of Alpha Particles Penetration into Tumor Cells in Targeted Alpha Therapy

Recent breakthrough of radiotherapy to cancers focuses on the high linear energy transfer (LET) radiation, e.g., the alpha particles. Targeted Alpha Therapy (TAT) is an important option of radiotherapeutic method for the treatment of cancers. TAT uses an alpha-immuno-conjugate (AIC) comprising a tumor selective molecule, which attaches to the surface of specific tumor cells selectively and then undergoes alpha decay to destroy the tumor cells. Monte Carlo (MC) calculations are a well-suited method to accurately simulate the energy deposited by ionizing radiation in very small biological structures such as DNA. Thus, MC simulation is the essential technology to estimate Alpha particles penetration into tumors and to accurately determine the optimum therapeutic dose of TAT. However, the computation complexity of MC in the TAT scenario is extremely expensive and then it is impractical to estimate the optimum therapeutic dose under the clinical setting. Consequently, it is very necessary to explore a highly effective computation solution to make alpha particle penetration simulation practical for TAT.

MC method is usually based on massive parallel computing, and neuromorphic computing-based solution is a promising solution to achieve large speed-up of computing effectiveness for the MC simulation. By simply mimicking computing mechanism of human brain, the neuromorphic computing architecture achieves optimal computing efficiency by integrating memory and processing units on a single chip and has been extensively applied in artificial intelligence (AI) application acceleration. In this work, our developed neuromorphic engine with employing novel nano-device (e.g. memristor) for highly enhanced computing parallelism is applied in the MC simulation. Basic computation models in the MC simulation such as Bayesian network is computed by the proposed neuromorphic engine. Improved neuromorphic design is further developed in algorithm and hardware to fit the computations in the MC simulation of the TAT. The simulation results of alpha particles penetration into tumor cells of TAT with highly improved computing speed and energy are presented.

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