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Editorial

Computer method and modeling: Medical biophysics applications in cancer therapy, medical imaging and drug delivery

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Computational and modeling approaches have been used for a long time to study theranostics in medical biophysics. These approaches include using simulation to predict dosimetry in radiotherapy [1], determine internal organ motion based on various medical imaging modalities [2], and design advanced nanomaterials as radiosensitizers [3]. On the other hand, it is possible to use machine/deep learning to predict patient outcome from big data [4], create an accurate and precise radiation treatment plan [5], and identify various volume-of-interest such as tumour from medical imaging [6]. Artificial intelligence (AI) can assist human decision in theranostics, and enable staff/patient communication using human-like chatbot in healthcare [7].

Monte Carlo simulation is a good example in computer modeling for medical biophysics. Unlike other models focused on finding out the absolute solution of a problem, Monte Carlo simulation predicts the numerical result of a problem through repeated random sampling. The accuracy of result increases with the number of Monte Carlo experiments or histories. In the past, this method has time-consuming computer issue, because a huge number of histories is needed to run the simulation in order to acquire an accurate result. However, with recent advances of high-performance computing such as parallel, grid and cloud computing, simulation time has been reduced significantly, making many applications possible [8].

There are many examples of medical biophysics application using Monte Carlo modeling. For example, Monte Carlo method is used as a benchmark to predict dosimetry in radiotherapy [1]. The simulation can model the particle interactions in different heterogeneities with different irradiation geometries. To date, Monte Carlo method is used in dose calculation in a commercial treatment planning system for electron, photon and proton therapy [9]. In addition, Monte Carlo method is used to model the radiation dose delivery due to patient setup and internal organ motion uncertainties in cancer therapy [10]. Using simulation modeling, intensified measurements for patient can be avoided, because the model can handle hundreds to thousands of study cases easily to save human effort. The simulation can also be used to model the staff scheduling in emergency cancer therapy to produce an appropriate radiation staff schedule with a balanced workload [11,12].

Benefiting from the recent development of nanotheranostics, computer modeling plays a very important role in medical biophysics [13]. For nanodosimetry, various models in predicting DNA damages due to irradiations are studied for cancer therapy [14]. These include the double-strand break damage from the electron, photon or proton beams with and without magnetic field. Moreover, biophysical model can be used to design the next generation nanoparticle-based radiosensitizer with different sizes, morphologies, materials and surface chemistries [15]. Radiation dose enhancement and imaging dose are studied in nanoparticle-enhanced radiotherapy using simulations [16,17], and studies on nanoparticle transport to the cell in drug delivery are making good progress [18].

AI refers to the simulation of human intelligence in solving problem, and machine/deep learning is a branch of AI to get computer learning from the big data. Since AI can mimic human action, it can be used in a communication system such as chatbot to provide easy and comprehensive knowledge transfer. There are currently various chatbots developed in healthcare communication for cancer therapy and radiation safety education [7]. Another AI application is to use machine learning to identify specific volume-of-interest in medical imaging [6]. For example, after the machine is trained using the big data from patient imaging, the machine learning model can assist physician to locate the cancer tumour from the medical image. This can save a lot of human time and effort in clinical diagnosis. On the other hand, machine learning model can be used to predict dose-volume variables in radiation treatment planning for plan evaluation in radiotherapy [19]. It can also be used to predict dose distribution in a radiation treatment plan [20].

These are just some of the medical biophysics applications. In this special issue, various studies on this topic are welcome. The aim is to collect research works using computer approaches and modeling to investigate problems in cancer therapy, medical imaging, drug delivery, and other topics in medical biophysics.

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