Advance Parameter Optimization meets Electron Dose Distribution in Voxel-based Transport Simulations

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Abstract. Radiotherapy is crucial for treating tumors, but achieving effectiveness while minimizing damage to surrounding healthy tissue presents significant challenges. In this research, we present novel methods for automatically selecting a proper set of parameters to address these two opposing criteria: achieving maximum radiation homogeneity and minimizing exposure to organs-at-risk (OARs). Our research is based on the FOTELP-VOX program (author R.Ilić), a Monte Carlo technique that determines electron dose distribution in voxel-based transport simulations utilizing patient anatomy obtained from CT images.

Researchers utilize simulations to test various scenarios in radiation therapy to mitigate potential health consequences for patients. Finding the optimal scenario for each patient is crucial yet time-consuming, often relying on a manual trial-and-error approach with loose guidelines. This type of problem is well-recognized and falls within the class of optimization problems such as the traveling salesman and scheduling.

We enhance the current methodology using standard optimization techniques like random search, as well as advanced techniques including Bayesian optimization (BO) and genetic algorithms (GA). Our goal is to efficiently search the parameter space to find the closest solution to the existing AAA electron dose calculation model.

Keywords: Voxel-based simulations; evolutionary optimization; Bayesian optimization; Monte Carlo techniques

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