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Real Time Adaptive Treatment Planning for Proton Therapy Radiation Patients

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Background: In radiation treatments for cancer patients, there is a type of treatment called proton therapy. For these treatments, the first step is to simulate the patient's treatment by acquiring computed tomography (CT) scans of the tumor in the position of treatment and converting those images into material and density maps for creating the best plan of treatment. All anatomical structures, including the tumor, are delineated in the 3D image. Based on the tumor type and normal structures near the tumor, the treatment plan is created. This treatment plan consists of, on average, 3 beam portals, each having approximately 25,000 proton beam spots. Each spot can have an energy between 70 and 230 MeV, any position between 40x40 cmˆ2 area, and a weight of 2x10ˆ6 to 5x10ˆ9 protons per spot. With this many degrees of freedom and the complexity of the human anatomy, it takes a substantial amount of computation time and human input. On average, the process of creating this plan requires 5 days. This treatment plan is used to treat the patient every day for 30 days. During this time, changes in the patient can take place that make the treatment plan suboptimal.

Purpose: We are developing a system to create, in near real time, a treatment plan of the day which can account for the variation in the patient and properly adapt the plan to give the optimal treatment for that day.

Methods: We have developed a GPU accelerated Monte Carlo simulation for the radiation dose calculation. This is key, as fast and accurate dose calculation is of great importance. We have also developed a fast, GPU accelerated optimization system to develop the treatment plan. We are currently developing a fast deformable registration system to adapt to the anatomical structural changes without human intervention.

Results: Currently we can optimize and calculate a plan in less than 20 minutes. Although fast, this calculation time can be improved, and the deformable registration needs to be included for the daily adaptive therapy to be realized for optimal treatment.

Conclusion: We are close to having a prototype system for daily adaptive proton radiation therapy. This system has the potential to impact the outcomes of cancer treatments.

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