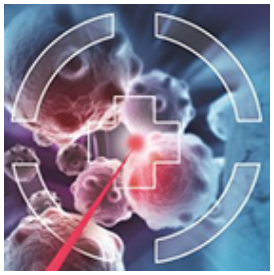

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Toward a novel treatment planning approach accounting for prompt gamma range verification

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Toward a novel treatment planning approach accounting for prompt gamma range verification

Introduction:

Prompt gamma (PG) monitoring is widely investigated to reduce range uncertainties in proton therapy. Our previous study proposed to re-optimize the treatment plan (TP) based on spot-by-spot conformities between the PG and the dose (so called PG-dose correlation). However, a good PG-dose correlation on the planning CT could still be affected by fractional anatomical changes, for which a new approach is proposed and investigated in this study.

Materials and Methods:

In this work, Monte Carlo (MC) TPs are created using an extension of a research computational platform, combining MC (Geant4) pre-calculated pencil beams with the TP system (TPS) engine CERR (A computational Environment for Radiotherapy Research). Other than the previously proposed PG-dose correlation indicator, which compares the laterally integrated PG and dose profiles, a new indicator is proposed to account for the sensitivity of individual pencil beams to heterogeneities in the 3D dose distribution. This is accomplished by using a 2D distal surface derived from 3D dose distributions of single pencil beams. Combining the indicators above, new TPs are created by boosting a few pencil beams (PBs) recommended for better PG imaging. TPs are MC-recalculated on three different fractional CT scans of a head and neck and a prostate cancer patient and then compared. Advantages over other proposed methods such as spot aggregation are also investigated.

Results:

Re-optimized and initial TPs are comparable in terms of dose distribution and dose-averaged linear energy transfer distribution on all CTs, while the PBs boosted in the new TP maintain good PG-dose correlation in the cases of fractional anatomical changes. Comparison to the performance of the spot aggregation will be also discussed.

Conclusion:

Based on our previous proposal to re-optimize treatment plans using the spot-by-spot conformities of PG and dose, an improved approach is put forward to ensure enhanced robustness of the PG-dose correlation of boosted PBs in presence of interfractional anatomical changes.

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