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Proof of Concept of Interactive Treatment Planning in Mixed Reality for Spinal Stereotactic Radiosurgery

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Purpose

Real-Time Interactive Treatment Planning (RTIP) is a new approach that can overcome limitations of manual inverse treatment planning. The idea is to generate high quality plans quickly by controlling the planning process in real time via a graphical user interface. This allows, for example, real-time adjustment of the 3D dose distribution to the individual patient's anatomy and diagnosis. This work propose a method that can contribute to interactive treatment planning for spinal stereotactic Radiosurgery (SRS) using mixed reality (MR). It combines deliverability relevance (according to user's clinical goals), and reasonable distinctiveness of treatment plans.

Materials and Methods

The proposed method includes six steps:

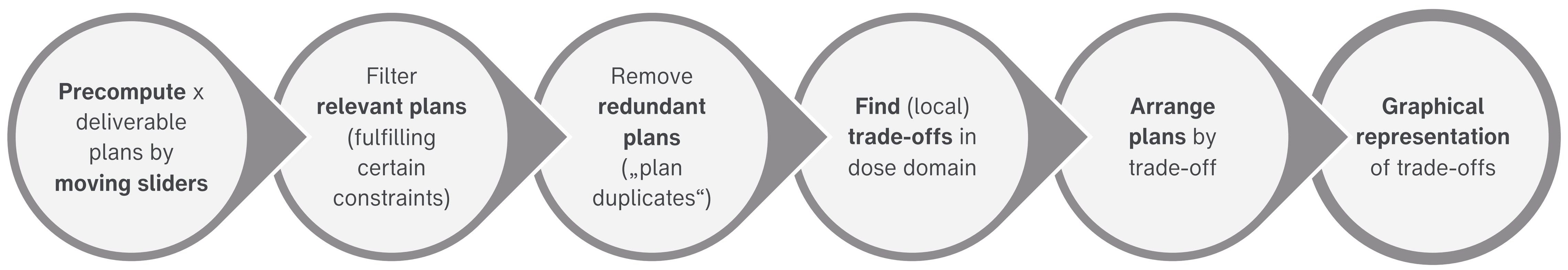

Fig. 1: Overview of the proposed method for calculating and representing deliverable, relevant and distinctive treatments plans for spinal SRS

The method is tested on a patient with a metastasis in a lumbar vertebra (gross tumor volume of 6.6 cm^3, planning target volume (PTV) of 42 cm^3, spinal canal as organ-at-risk (OAR) volume of 14.5 cm^3). The variable planning parameters are the weighting of OAR and targets, sparing of normal tissue and modulation, while the tolerated coverage volume and number of arcs are fixed values. The impact on the trade-off between the maximum dose in the OAR and the PTV coverage volume is analyzed.

Results

This work shows that for a limited set of planning parameters and constraints, a feasible set of plans can be found, all of which are deliverable, relevant, and reasonably distinguishable. For the test patient, 28 treatment plans were generated in step 1. Of these, 13 were identified as clinically relevant, with 9 of them being redundant. Finally, the method leads to 3 treatment plans (see Figure 2). The MR application provides an environment where multiple treatment plans can be quickly assessed (see QR code).

Conclusion

The results show that such a method for interactive treatment planning is feasible for this case of spinal SRS. The subset of plans found by the method defines a range of dose distributions that indicates how expansive a patient-specific dose distribution can be modified by a planner. This knowledge can be used for guiding strategies indicating the user which dose changes are feasible. Previous RTIP approaches were unable to produce feasible plans because the user could modify a dose distribution without any restrictions which was then too complex to be realized with a linear accelerator. It can be assumed that it will be possible to change the dose distribution in MR in real-time, as long as it is only allowed in a limited number of areas.

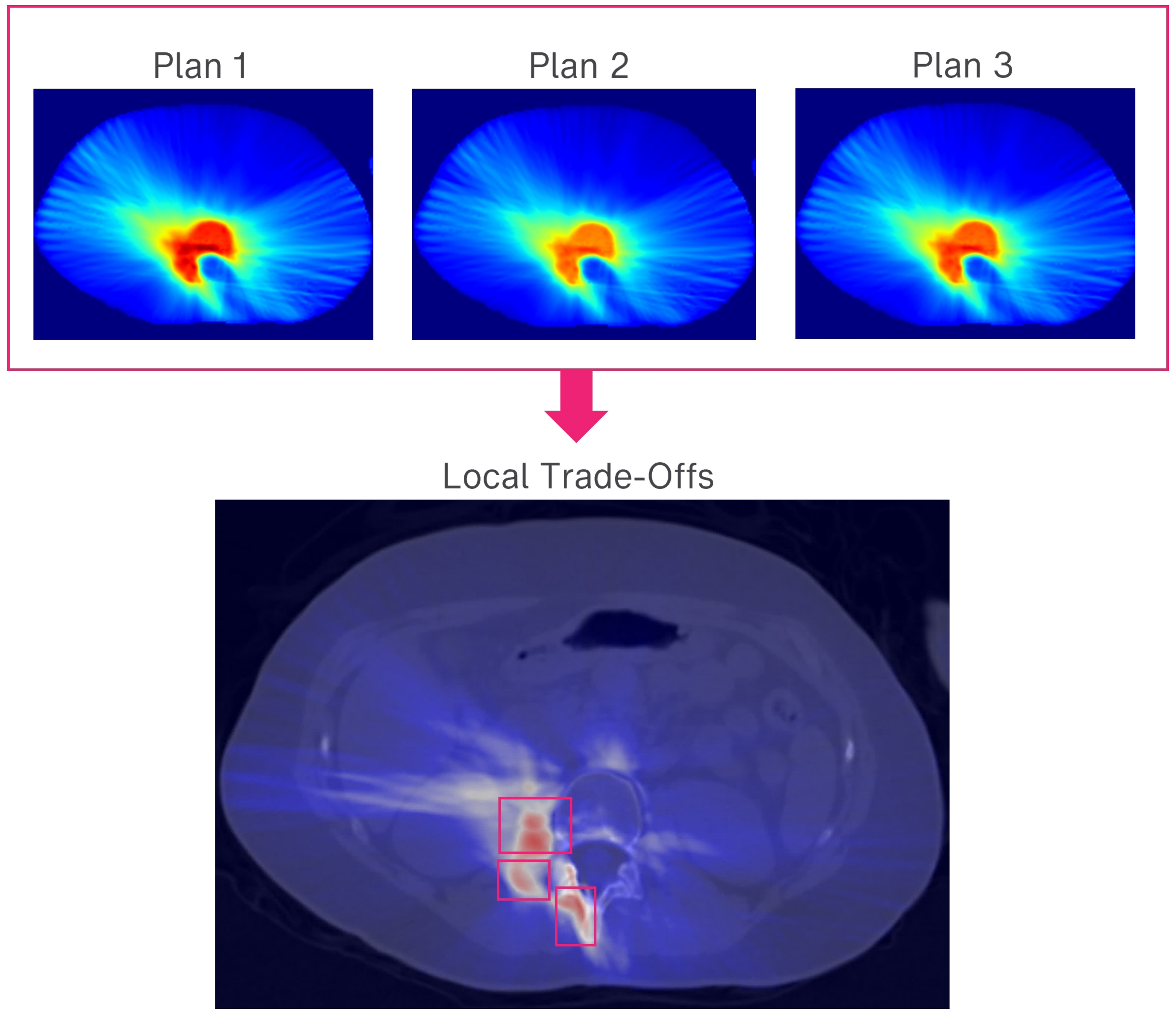

Fig. 2: The 3 remaining treatment plans from step 3 are distinct, but it is unclear where they differ dosimetrically. Step 4 identifies the regions where these plans differ most (local dose trade-offs).

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