ASTUTE: Atomic Surface Transformation for Tumor Target Contour Quality Evaluation

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Introduction

Glioblastoma is one of the most commonly malignant and aggressive tumours of the brain and the central nervous system. The standard treatment involves surgery, adjuvant radiotherapy, and concomitant and adjuvant chemotherapy. Radiotherapy planning plays a vital role in achieving optimal tumour control and reducing normal tissue toxicity by conforming the dose to the target volume while minimizing the dose to organs at risk. This thesis proposes a new technique called Atomic Tumour Target Transformation for Contour Evaluation (ASTUTE). ASTUTE aims to evaluate the dose effect using a set of new metrics and enhanced visualization strategies.

Materials and Methods

The ASTUTE technique generates a deep learning-based dose prediction for a target volume reference contour and a modified contour. The modification consists of atomic surface transformations, each modelled by a sphere with a given radius, which is either added or subtracted. The two dose predictions are assessed based on a novel set of metrics for the target volume and the organs at risk, as visualized in Fig. 1. These surface transformations are carried out over the entire target volume surface, resulting in the ASTUTE sensitivity maps, representing enhanced visualization strategies showing the dosimetric impact on the target volume and the organs at risk.

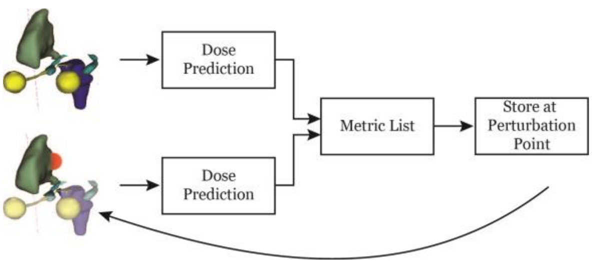

Fig. 1 Conceptual visualization of the ASTUTE technique, depicting the reference contour, an atomic surface transformation, and its evaluation.

Furthermore, a clinical evaluation was prepared to evaluate radio-oncologists' lack of dosimetric awareness and to quantify the clinical value of the ASTUTE technique.

Results

Based on the set of metrics, more than 100 maps result for a single patient case. For this reason, the information is compressed into so-called mega-maps. One method to compress is shown in Fig. 2, where the maxima of the organs at risk are quantified.

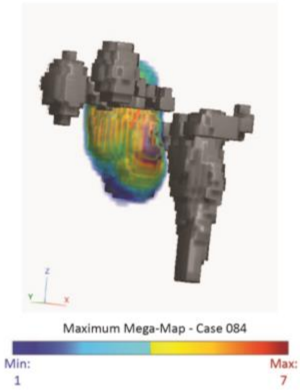

Fig. 2 Maximum mega-map: Displaying a medial region of interest on the target volume with organs at risk, namely the eyes, the brainstem, the optic nerves and the hippocampi for reference.

Discussion

The clinical evaluation suggests that additional dosimetric information is needed in the early stages of the radiotherapy workflow to improve patient outcomes. The ASTUTE technique has shown promising results in flagging problematic regions. The sensitivity maps strive to balance the amount of information and complexity. However, their usefulness still needs to be verified in a clinical setting.

References

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