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Influence of the headrest on dose calculation in stereotactic radiosurgery

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Purpose

Dose calculation in RT Elements (Brainlab AG, Germany) relies on an accurate definition of the outer contour, defining the build-up regions for the radiation beams. So far, the 4Pi headrest system (Brainlab AH, Germany) is not automatically included in the outer contour. However, including the dosimetric effects of the patient headrest can lead to more precise dose distribution and reduced side effects such as increased skin dose. The thin, curved structure of the 4Pi system impedes its direct segmentation in the computed tomography (CT). This work aims to develop a method to automatically segment the 4Pi system based on point clouds and assess its influence through comparison to dose planning results of RT Elements 4.0 and 3.0.

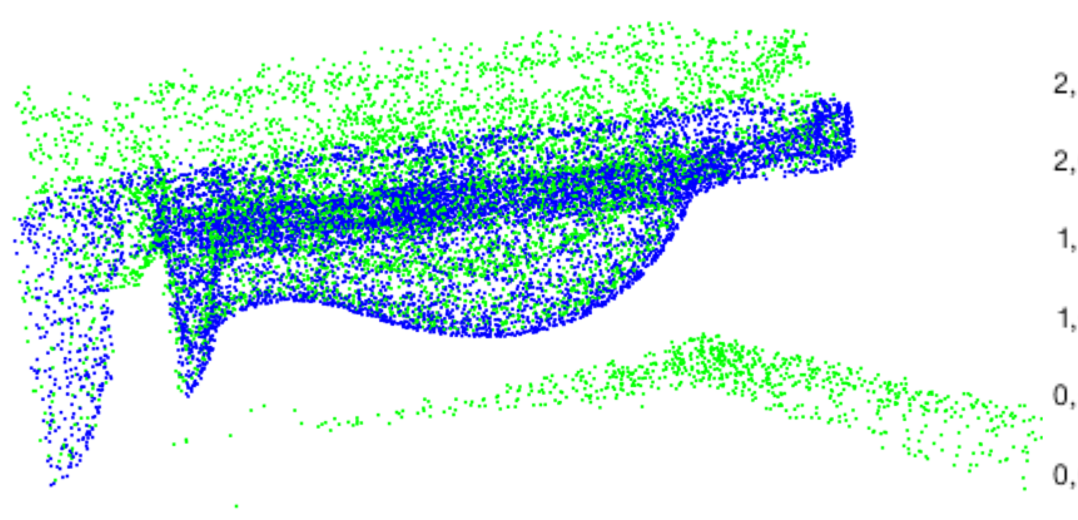

Figure 1: Result of the point cloud registration with the CPD algorithm; green: point cloud created from CT; blue: point cloud created from 4Pi CAD file

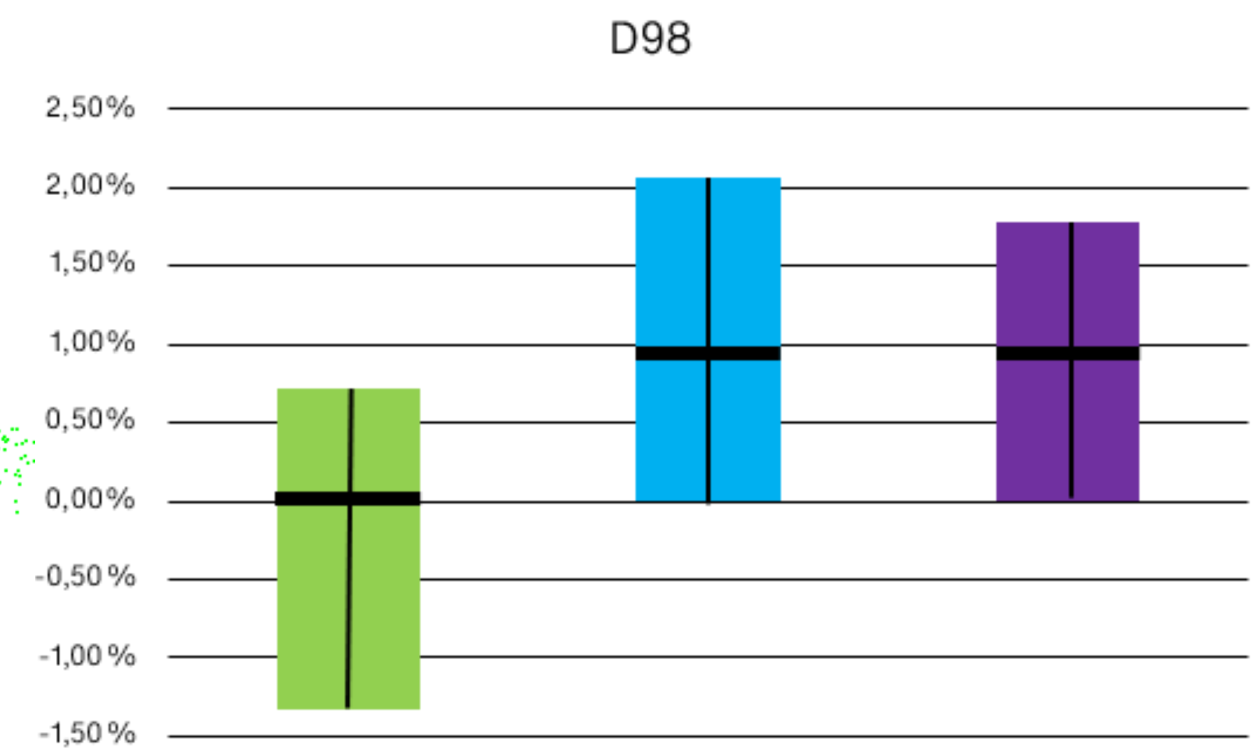

Figure 2: D_{98} comparison over all patients in %
Green bar: Dose difference between 4.0 phantoms and the modified phantoms;
Blue bar: Dose difference between 3.0 phantoms and the modified phantoms;
Purple bar: Dose difference between 4.0 phantoms and 3.0 phantoms

Materials and Methods

The workflow for creating a point cloud from a patient CT is shown in Figure 3. A second point cloud is created from a CAD file representing the 4Pi system. With the Coherent Point Drift (CPD) algorithm, the 4Pi system is registered to the patient CT. Then the couch top is inserted with its correct electron density values. Ten clinical, Monte Carlo calculated treatment plans were recalculated to compare the created approach with a user-defined threshold of -800 HU in RT Elements 4.0 and the pre-defined threshold of -200 HU in RT Elements 3.0. Relevant dosimetric parameters, such as D_{Mean}, D_{98} and D_{95} were compared for all 10 calculated treatment plans.

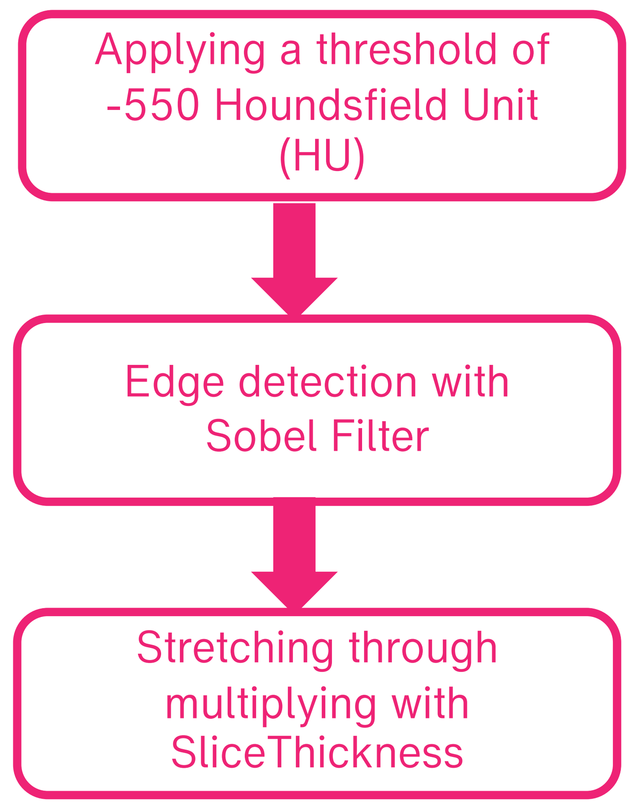

Figure 3: Workflow for creating point cloud from a patient CT

Results

The dose results of the modified approach compared to RT Elements 4.0 are less dissimilar from each other. The difference between them over all planning target volumes (PTVs) at D_{Mean}, D_{98} and D_{95} on average is low. Over all metastases D_{98} differs on average 0,00% (<0,01%) between RT Elements 4.0 and the modified approach. However, there are relevant dissimilarities when comparing individual metastases. The dose difference of D_{98} for single metastases are between 0,72% and -1,33%. RT Elements 4.0 and the modified approach have over all considered objects larger differences to RT Elements 3.0. Comparing these two approaches to RT Elements 3.0 the average dose differences of D_{98} is at 0,93% resp. 0,94%.

Conclusion

This work has shown that the consideration of the 4Pi system with its associated electron density values has an influence on dose calculation. The 4Pi system in a CT can be registered by using the CPD algorithm. Dose differences were perceived when comparing the user-defined threshold, where the 4Pi system is considered as part of the outer contour.