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A software framework for the analysis of geometric and dosimetric interfractional variations in adaptive radiotherapy

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Analyzing the geometric and dosimetric variance over the treatment course of a single patient or whole patient collection was the named goal of this work. In the context of fractionated RT the complete workflow is not one trivial task but rather a set of different sub tasks. Analyzing and demounting the workflow, which is essential for a fractionated therapy, is the first step in identifying these sub tasks. Different analysis workflows may even differ in essential sub tasks, depending on the specific research question. This factor leads to some technical requirements like the modular design, which simplifies the adaption of the workflow depending on a specific research question.

Geometric Analysis: Finding an adequate registration algorithm for the respective problem statement is the first step in each workflow.

To quantitative evaluate a registration algorithm this work presented a new developed evaluation procedure based on a statistical method comparison approach, called the BA method. The evaluation process itself is defined as a functional goal of this work because it is an essential prerequisite for tracking anatomical changes over the treatment course.

The trained and quantitatively evaluated algorithm is used to analyse the geometric changes over the treatment course. The main functionality is provided by the, which works without human user interaction, to allow usage in an automatic working environment.

To enable the automatic processing of big amounts of analysis tasks the RegToolPy environment was developed and integrated into the AVID framework. This automatization scripts control the iterative execution of all analysis tasks defined, by utilizing the RegTool.

As mentioned, one functionality of the RegToolPy script environment is the iterative automatic processing of registration tasks, another functional aspect of the RegToolPy is the data analysis and visualization. Therefore the results of the RegTool are collected and processed to generate meta information and plots for visualization, which makes the information more accessible. The information presented can be specifically adapted to show the information concerning a specific time point of a single patient, the complete treatment course of a patient or a summarize of all the information of a complete patient collection.

Dosimetric Analysis: The information generated by the tools of the geometric analysis can be used as a basis to adapt the positioning of the patient and to evaluate the treatment course. To

evaluate the treatment course, the geometric analysis has to be used to calculate the dosimetric consequences accurately and.

Therefore a dose analysis workflow and toolchain was developed and integrated in the AVID framework to track dosimetric changes over the treatment course, based on recalculated dose information.

The dose analysis workflow was designed to support decision making processes. This is carried out by generating quantitative dose informations for specific time points of a treatment course. In addition a retrospective analysis of dosimetric effects can be done. Being able to generate dose information for arbitrary time points allows physicians to supervise the treatment course precisely. Whereas retrospective analysis can be used to analyse recurrences for specific tumor entities as demonstrated in a cooperative work. Furthermore information accumulated trough retrospective analysis of big patient collections could be used to verify or improve dosimetric guidelines in clinical routine.

Being able to generate different dose indices for specific structures allows not only the supervision of the currently applied dose of the GTV, but also specific supervision of ORs.

As illustrated, the AVID framework provides the basis for an automatic treatment analysis of a fractionated therapy, by providing and integrating tools for every necessary step. AVID includes tools for the optimization and evaluation of automatic registration algorithms. Furthermore it provides statistical tools for refining statistical descriptive information and for visualization the generated statistical information. For the dosimetric analysis it provides tools for dose accumulation, calculation and dose statistics. In addition prototypes for reference data acquisition, which is necessary for registration algorithm optimization and evaluation, as well as visualization tools for in-/output image and dose data were developed.