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Image based motion assessment for magnetic resonance image guided adaptive radiotherapy

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In this work, methods for multi-modal feature-based detection of a localizer system and for marker-less real-time detection of respiratory-induced motion in cine MRI have been developed. Application of these methods enables assessment of inter- and intrafractional motion in MRgRT. With the increasing influence of MRI in IGRT, the presented developments are of particular importance as they implement key requirements for an adaptive radiotherapy workflow.

The proposed automated detection of position and orientation of the MR-guidance stereotactic body frame has shown to be of avail when it comes to comparison of considerable amounts of multi-modal image data sets. In the context of an offline shuttle-based MRgRT workflow, like the one currently investigated at DKFZ, the possibility for additional stereotactic registration is essential for a comprehensive analysis of the acquired image data.

For detection of intrafractional motion, the developed multiple-template tracking approach for lung tumors was used as a starting point for the second objective of this work. In the context of the investigations presented in this thesis, the tracking method was successfully enhanced to suit the requirements of tracking in abdominal cine MRI. The implemented optimization in template generation and handling as well as the adaptive approach for search area determination have improved both the effectivity and efficiency of the robust tumor tracking with multiple templates.

The challenge of estimating a 3D target coordinate while tracking on 2D image data was accomplished by development of two different methods for out-of-plane motion detection. The first approach was concerned with reduction of out-of-plane effects by rotating the acquisition plane in respect to the observed motion. However, this way out-of-plane motion can only be approximated in linear dependency of in-plane motion. To tackle this limitation, the second approach incorporated the use of a 4D template library. With the combined knowledge of target appearance in different breathing phases and in neighboring acquisition planes 3D motion was tracked while the strict requirements for computational efficiency were maintained.

In conclusion, the application of feature- and object-based algorithms for assessment of motion-induced anatomical changes in radiotherapy has shown to be well prepared for application in the novel context of MRgRT. Considering their effective and efficient implementation, these methods represent important building blocks in the process of providing streamlined motion adaptation in radiotherapeutic treatment for cancer patients.