Ultrasound-based Motion Modelling for the Lungs in Scanned Proton Therapy

Figure 1: Maximum intensity projection of a 3D MRI scan of the lungs (Picture: A. Giger).

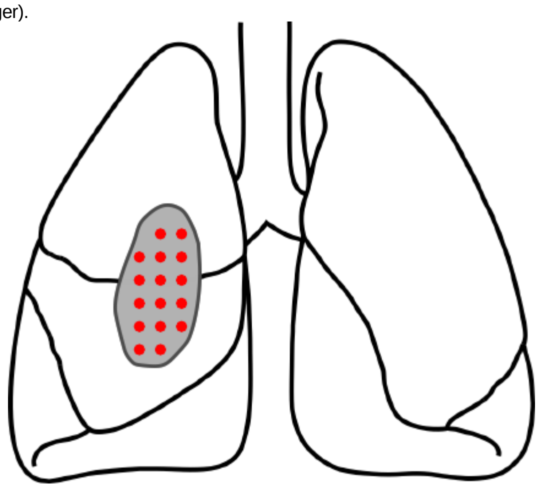

Figure 2: The priniciple of pencil beam scanning proton therapy: In spot scanning, the treatment beam is steered to scan the target volume spot by spot (Picture: A. Giger).

PhD Thesis by Alina Giger at the Center for medical Image Analysis & Navigation (CIAN).

According to the WHO's World Cancer Report 2020, lung cancer ranks first both in terms of incidence and mortality compared to other common sites of cancer. The aim of this project is to investigate the use of ultrasound-based respiratory motion models for their application in pencil beam scanned proton therapy.

Due to the physical properties of protons and the resulting high dose conformation, pencil beam scanned (PBS) proton therapy holds the potential to significantly improve cancer treatment when compared to conventional radiotherapy. However, respiratory organ motion hampers the clinical application of abdominal and thoracic proton therapy. For tumor tracking in the lung, the delivered beams are steered to follow the tumor in the presence of respiratory motion to ensure the best combination of target coverage and dose conformation. Precise tumor tracking requires accurate methods to determine in real time tumor position and shape of the lungs. Ultrasound (US) imaging offers an interesting surrogate signal as it provides internal organ motion information at a high temporal resolution while being non-invasive, relatively inexpensive and without providing additional radiation dose. Unfortunately, however, it is not possible to image lung tumors directly using US imaging due to physical constraints.

In this project we developed methods to use US imaging of the upper abdomen to predict three-dimensional motions in the lungs. With the indirect prediction scheme surrogate structures in the liver and on the diaphragm are used in combination with a patient-specific motion model of the lung to predict the respiratory motion and to allow accurate tumor tracking.

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References:

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