Universität Basel

Research Project

Ultrasound guided motion mitigation of proton therapy in the lung

Third-party funded project

Project title Ultrasound guided motion mitigation of proton therapy in the lung
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In comparison to conventional therapy, Pencil Beam Scanned (PBS) proton therapy has the ability to significantly reduce doses to surrounding normal tissue. This is particularly important for treatments of lesions in the thorax, where it is necessary to keep the doses that the volumes of the lungs and heart receive as low as possible. Thus, PBS proton therapy could have significant advantages for the treatment of lung tumours. Indeed, it could eventually be the proton treatment of choice for mobile tumours, due to the relative ease with which it can be adapted for tumour tracking. With tracking, the delivered beams are 'steered' to follow tumour motion ensuring the best combination of target coverage and dose conformation in the presence of motion. Successful tracking, however, requires accurate methods for determining tumour position and motion in real-time. As such, ultrasound (US) and optical surface imaging are interesting modalities, as they are non-invasive and are associated with no additional radiation dose to the patient. Unfortunately, neither can be used to image lung tumours directly. However, US can be used to acquire real-time images of structures in the upper abdomen, such as the diaphragm and liver, whereas surface imaging can track chest and abdominal wall motions, all of which can act as surrogates of lung motion. It is the aim of this project to develop the methods by which ultrasound and/or surface imaging of the upper abdomen can be used to predict three-dimensional motions in the lung with an accuracy of 2-3mm. To achieve such accuracy, we propose to use both ultrasonic monitoring of the diaphragm/liver and surface motions as inputs to a patient specific, statistical model of lung motion. To build this model, simultaneous US and 3D-time resolved MRI (4DMRI) acquisitions will be acquired of volunteers and lung patients using MR compatible ultrasound probes and 4DMRI sequences. In contrast, as surface imaging devices are not MRI compatible, surface motions will be estimated by extracting these indirectly from the 4DMRI data sets. The accuracy of the developed models will be validated using a sophisticated 4D anthropomorphic phantom and through extensive simulations of PBS proton treatments using previously developed approaches based on 4D dose calculations. Should this approach prove successful, it could open the door to highly conformal proton treatments of lung tumours. Moreover, the proposed conceptual approach could be easily transferred to conventional radiotherapy.

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