Leveraging respiratory organ motion for non-invasive tumor treatment devices: a feasibility study

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In noninvasive abdominal tumor treatment, research has focused on minimizing organ motion either by gating, breath holding or tracking of the target. The paradigm shift proposed in this study takes advantage of the respiratory organ motion to passively scan the tumor. In the proposed self-scanning method, the focal point of the HIFU device is held fixed for a given time, while it passively scans the tumor due to breathing motion. The aim of this paper is to present a treatment planning method for such a system and show by simulation its feasibility. The presented planning method minimizes treatment time and ensures complete tumor ablation under free-breathing. We simulated our method on realistic motion patterns from a patient specific statistical respiratory model. With our method, we achieved a shorter treatment time than with the gold-standard motion-compensation approach. The main advantage of the proposed method is that electrically steering of the focal spot is no longer needed. As a consequence, it is much easier to find an optimal solution for both avoiding near field heating and covering the whole tumor. However, the reduced complexity on the beam forming comes at the price of an increased complexity on the planning side as well as a reduced efficiency in the energy distribution. Although we simulate the approach on HIFU, the idea of self-scanning passes over to other tumor treatment modalities such as proton therapy or classical radiation therapy.
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