Intrafraction motion correction by tracking of fiducial marker projections on sequential MV images in arc therapy

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Introduction

To correct for intrafraction tumor motion during adaptive radiotherapy of prostate cancer with volumetric modulated arc therapy (VMAT), we previously developed a method to detect implanted fiducial markers using MV images, with an accuracy of 0.52mm ± 0.46mm and a 97% detection rate (error < 4mm) [1]. In this work, we aim to use our detection method for prostate motion tracking.

Methods

Patients are implanted with fiducial gold markers and irradiated using VMAT. 3D marker locations are estimated by using their detected positions in sequential projection images with an adjusted reconstruction method from literature [2]. The reconstructed marker position is calculated solely based on previous projections to allow for real-time tracking. The moving window strategy [2] is only applied when the estimated motion between subsequent reconstructed marker positions is below a certain threshold. If not, the latest reconstructed position is used.

Our method was evaluated with simulated, realistic prostate motion patterns, an acquisition frame rate of 1 image per 5 degrees and projected marker positions as 2D detections with detection errors as added noise, statistically distributed as the detection errors in [1].

Results

Figure 1 shows accurate tracking results for marker movements visible in (= not orthogonal to) the projection image, while invisible movements were detected after a few projections. Additionally, RMS errors of the reconstruction components (Figure 1) were below 1mm for 1000 simulation runs.

Conclusion

We have developed a method that can accurately track the 3D position of a marker in real-time, based solely on MV images.

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Figure 1. 3D marker reconstruction components: lateral, vertical and longitudinal coordinates and their norm of simulated (blue) and reconstructed (red) marker locations for an EPID acquisition frame rate of 1 image per 5 degrees.