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Source-Detector Trajectory Optimization for Target-Based C-Arm Cone Beam Computed Tomography

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Abstract : Nowadays, three dimensional Cone Beam CT (CBCT) has turned into a widespread clinical routine imaging modality for interventional radiology. In conventional CBCT, a circular sourcedetector trajectory is used to acquire a high number of 2D projections in order to reconstruct a 3D volume. However, the accumulated radiation dose due to the repetitive use of CBCT needed for the intraoperative procedure as well as daily pretreatment patient alignment for radiotherapy has become a concern. It is of great importance for both health care providers and patients to decrease the amount of radiation dose required for these interventional images. Thus, it is desirable to find some optimized source-detector trajectories with the reduced number of projections which could therefore lead to dose reduction. In this study we investigate some source-detector trajectories with the optimal arbitrary orientation in the way to maximize performance of the reconstructed image at particular regions of interest. To achieve this approach, we developed a box phantom consisting several small target polytetrafluoroethylene spheres at regular distances through the entire phantom. Each of these spheres serves as a target inside a particular region of interest. We use the 3D Point Spread Function (PSF) as a measure to evaluate the performance of the reconstructed image. We measured the spatial variance in terms of Full-Width-Half-Maximum (FWHM) of the local PSFs each related to a particular target. The lower value of FWHM shows the better spatial resolution of reconstruction results at the target area. One important feature of interventional radiology is that we have very well-known imaging targets as a prior knowledge of patient anatomy (e.g. preoperative CT) is usually available for interventional imaging. Therefore, we use a CT scan from the box phantom as the prior knowledge and consider that as the digital phantom in our simulations to find the optimal trajectory for a specific target. Based on the simulation phase we have the optimal trajectory which can be then applied on the device in real situation. We consider a Philips Allura FD20 Xper C-arm geometry to perform the simulations and real data acquisition. Our experimental results based on both simulation and real data show our proposed optimization scheme has the capacity to find optimized trajectories with minimal number of projections in order to localize the targets. Our results show the proposed optimized trajectories are able to localize the targets as good as a standard circular trajectory while using just 1/3 number of projections. Conclusion: We demonstrate that applying a minimal dedicated set of projections with optimized orientations is sufficient to localize targets, may minimize radiation.

Keywords : CBCT, C-arm, reconstruction, trajectory optimization
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