Purpose: To develop a robust 3D lung tumor tracking method based on a single x-ray projection using maximum likelihood estimation.

Methods: 4DCT images at different phases are registered to yield motion vector fields and a PCA based lung motion model is built. An acquired CBCT projection is compared with the simulated projections under different metrics to yield the correct PCA coefficients and hence the corresponding motion vector fields, which can be used to derive the 3D tumor location at this projection. The metrics we considered include normalized cross correlation and normalized mutual information between the gradient images of the acquired CBCT and that of the simulated 4DCT projection, and the position of diaphragm. A maximum likelihood estimation method is developed to combine the tracking results from all the metrics and integrate the constraints regarding tumor motion smoothness and wave form, leading to robust tumor locations. The method is tested on real patient data.

Results: It is found that normalized cross correlation, normalized mutual information, and diaphragm location can be used to determine the PCA coefficients and the tumor position, although the efficacy of any single metric depends on the gantry angles and breathing phases. However, with the combination of different metrics, the tumor tracking accuracy is greatly improved. The resulting mean 3D error is found to be 1.3mm.

Conclusions: A robust 3D tumor tracking method is developed based on maximum likelihood estimation to derive tumor location corresponding to an x-ray projection for lung cancer patient.

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