Purpose: The purpose of this study is to use an Iterative Principal Component Analysis (PCA) methodology to enhance lung tumor motion relative to stationary surrounding anatomy in order to improve tumor localization and allow efficient lung tumor tracking.

Methods: A digital thorax phantom containing several ellipses of different sizes and densities was used to simulate tumor, lungs and vertebral column. The CBCT acquisition numerically generated 700 projections in 2min for 360deg. The projections were simulated using line-integrals of phantom density with parallel-beam geometry. The rigid anatomy perspective change remains minimal within 5-6deg while a typical tumor is moving approximately half breathing cycle. A set of 10-12 projection images is generated within 5-6deg arc and used for PCA analysis. PCA transformed the axes of the image set to extract uncorrelated dominant features. For a given set of 10-12 projections, the middle image was filtered using PCA where only a few principal components were considered; satisfying user defined cut-off threshold. The method is applied to all 700 projections based on a moving-angle window. The eigenvectors selection criterion allowed different number of components to reconstruct PCA-filtered images depending on variation among data set. Proposed methodology was evaluated using simple sin, sin6 and complex patient motion profiles.

Results: The PCA coefficient cut-off value of 10% and 20% recovered the amplitude, period and phase of phantom motion within 5% error. These cut-off values also enhanced lung tumor visibility of PCA-filtered images. The methodology was also implemented on prerecorded patient CBCT projections. The patient study was evaluated for 10% and 20% cut-off values. PCA coefficient with 20% cut-off value provided superior contrast.

Conclusion: The iterative principal component analysis is a robust method to emphasize variation among CBCT projection images when rigid anatomy remains relatively stationary. The proposed methodology has shown promising results on the patient data.