Four-dimensional Digital Tomosynthesis based on Visual Respiratory Guidance

Dong-Su Kim1,2, Siyong Kim3 and Tae Suk Suh1

1) Department of Biomedical Engineering & Research Institute of Biomedical Engineering
   College of Medicine, The Catholic University of Korea, Seoul, Korea
2) Korea Atomic Energy Research Institute (KAERI), Daejeon, Korea
3) Department of Radiation Oncology, Virginia Commonwealth University, VA, USA

INTRODUCTION

4D Digital Tomosynthesis (DTS) acquisition methods:

- Slow gantry rotation
- Constant frame rate & rotation speed → single scanning motion
- Shorter acquisition time
- Easier implementation

Step-and-shoot

- Acquiring projections at each of fixed locations
- Regular projection angle intervals in phase bins
- Difficult to implement

MATERIALS & METHODS

<Slow gantry rotation technique in 4D DTS>

Acquisition DTS images based on...

- Projection Acquisition Parameters
  - P: gantry rotation speed
  - M: maximum angular interval
  - G: gantry rotation speed
  - W: phase windows

- Signal Acquisition Parameters
  - SA: shorted respiratory cycle
  - LA: longest respiratory cycle
  - AT: acquisition time
  - NP: number of projection acquired

Guiding system:

- Virtual module for on-board DTS imaging
- Easy to implement
- Critical to anti-artifact phase bin correction
- Fundamental techniques
  - Virtual reconstruction
  - Proportion
  - Improve the regularity of breathing motion
  - Breathing control with visual guidance

RESULTS

Fig 2. An example of respiratory signals for one of volunteers. Blue, red and black lines indicate SuRB, SwG and SuRBI, respectively. Each marker indicates SI position at the time of each projection. Note that the minimum and maximum positions of guiding wave form (i.e., SuRBI) are -1 and +1 cm.

Tab 1. Projection acquisition parameters from respiratory signals for each volunteer

Fig 3. mSL image reconstruction at 0% (end-inhale), 20%, 50% (end-exhale), and 80% for one of volunteers. Note that the mSL consists of a moving part and a static part. Arrows indicate moving sphere according to respiratory signal acquired.

DISCUSSION & CONCLUSION

Fig 5. Reconstruction images of AP direction (i.e., coronal) using the 4D XCAT phantom. Yellow dash lines mean the apex of the diaphragm at its lowest and highest. Arrows indicate 2 cm lesion.

Fig 6. Reconstruction images of LR direction (i.e., sagittal) using the 4D XCAT phantom. Yellow dash lines mean the apex of the diaphragm at its lowest and highest. Arrows indicate 2 cm lesion.

Fig 7. Scatter plots of relationship between the number of projections in each phase with regard to SSIM (left side) and RMSE (right side) values. Note that (a) and (b) are to remind that the closer to the top left for SSIM and to the bottom left for NRMSE, the better the results, respectively. (c) and (d) are for mSL, (e) and (f) coronal XCAT, and (g) and (h) sagittal XCAT.

REFERENCES