

Suitability of HyperSight CBCT for Online Adaptive Radiotherapy of Locally-Advanced Lung Cancer

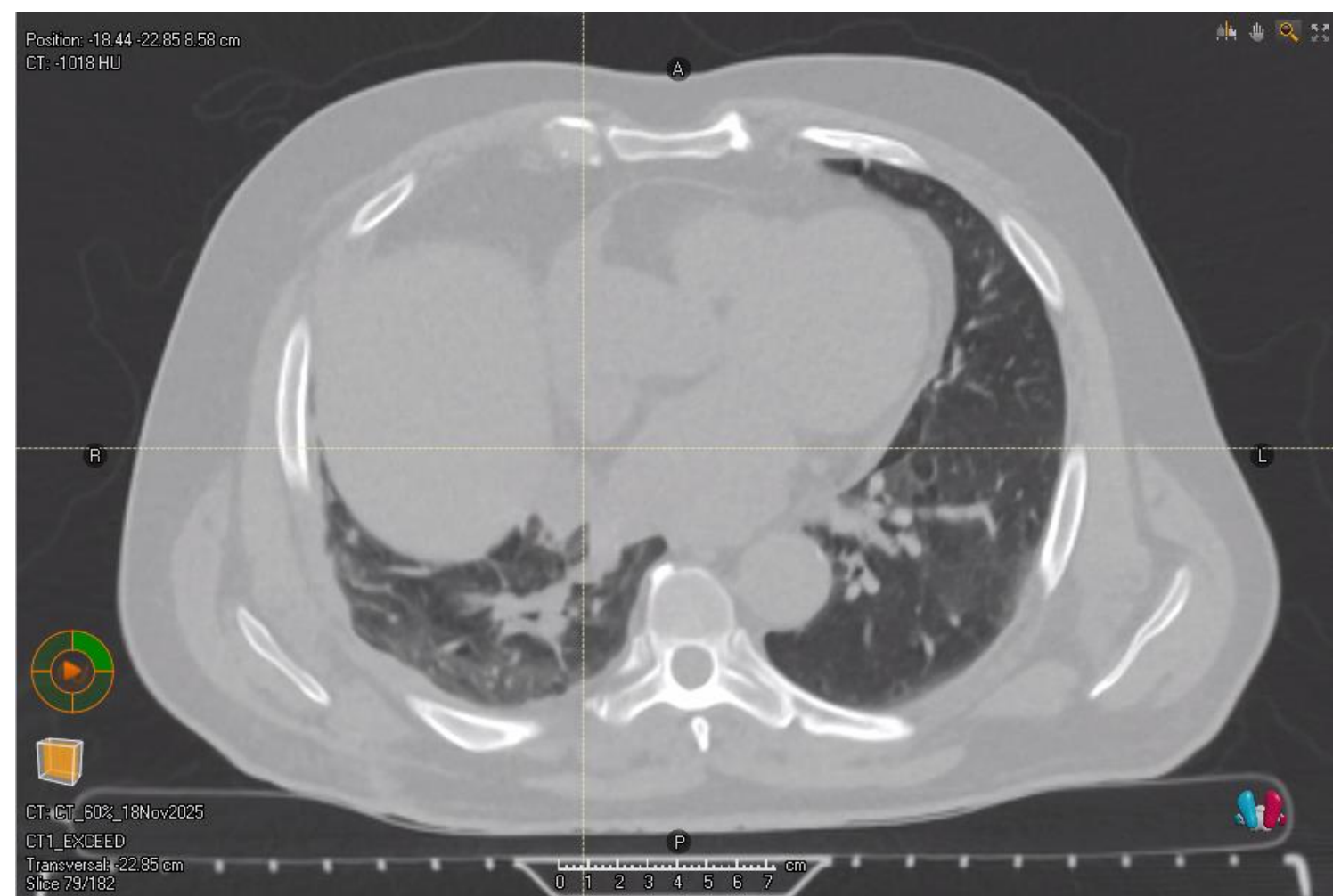
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Purpose

- Locally-advanced lung cancer patients may benefit from online adaptive radiotherapy
 - Tumours can change volume substantially
 - Grow between CT-simulation and first treatment fraction
 - Shrink on average 50% over course of treatment¹
 - May contribute to low treatment efficacy (5-year survival ~15%)
- Breathing motion introduces severe artifacts in Varian HyperSight Cone Beam CT (CBCT) images
 - Distorts Hounsfield Unit (HU) accuracy, especially in lungs, impacting dose calculation

Planning CT



Free-Breathing CBCT



- Goals:**
 - Develop a workflow to:
 - improve CBCT image quality
 - assess HU accuracy of daily CBCT images for online adaptive radiotherapy

¹Lim et al. 2011, *Journal of Thoracic Oncology*

Methods

- Sequential locally-advanced lung cancer patients were screened for voluntary breath-hold technique for fast CBCT acquisition
 - Varian Ethos/Halcyon units can acquire a full CBCT image in 6 seconds

Planning CT



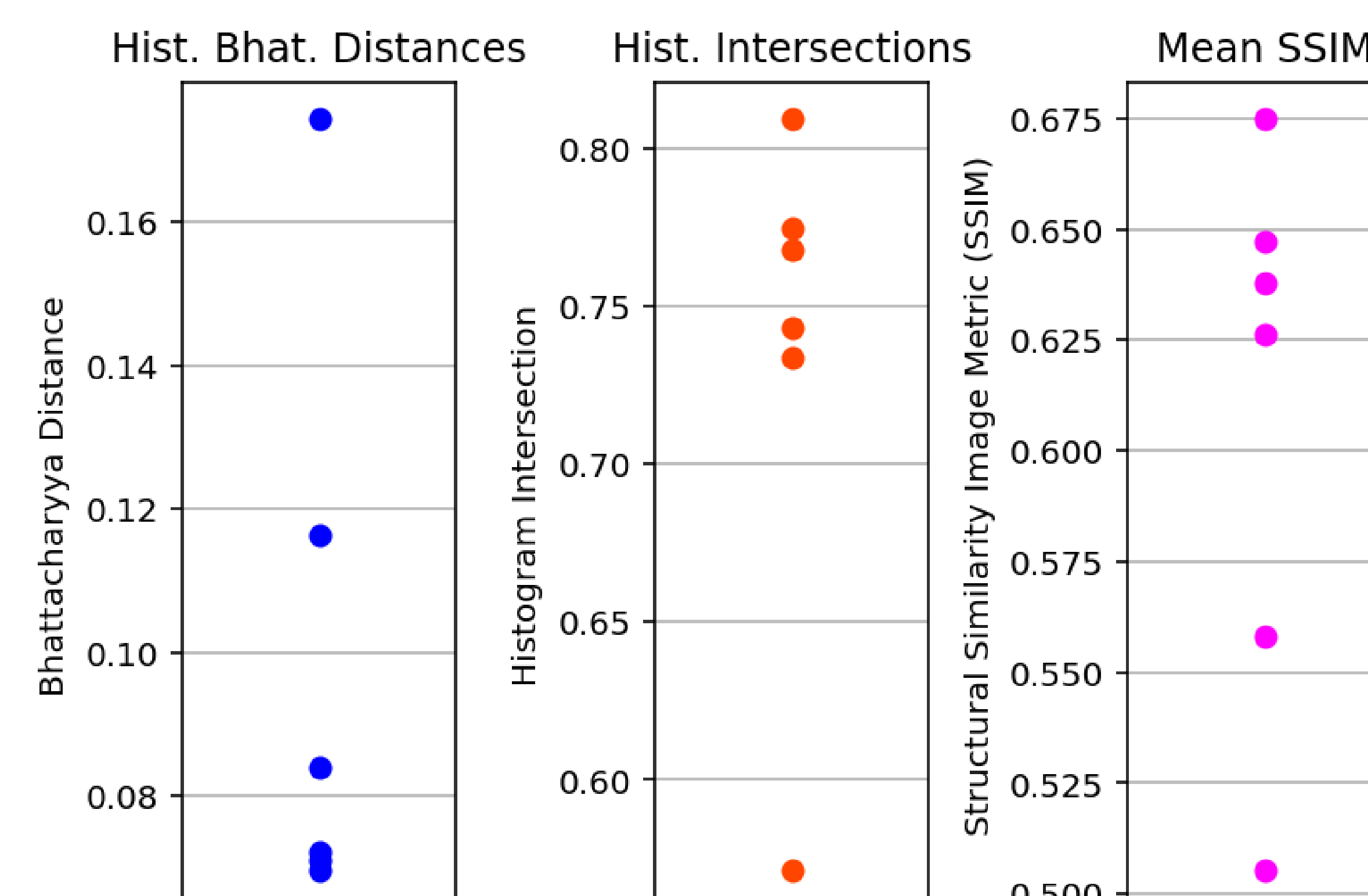
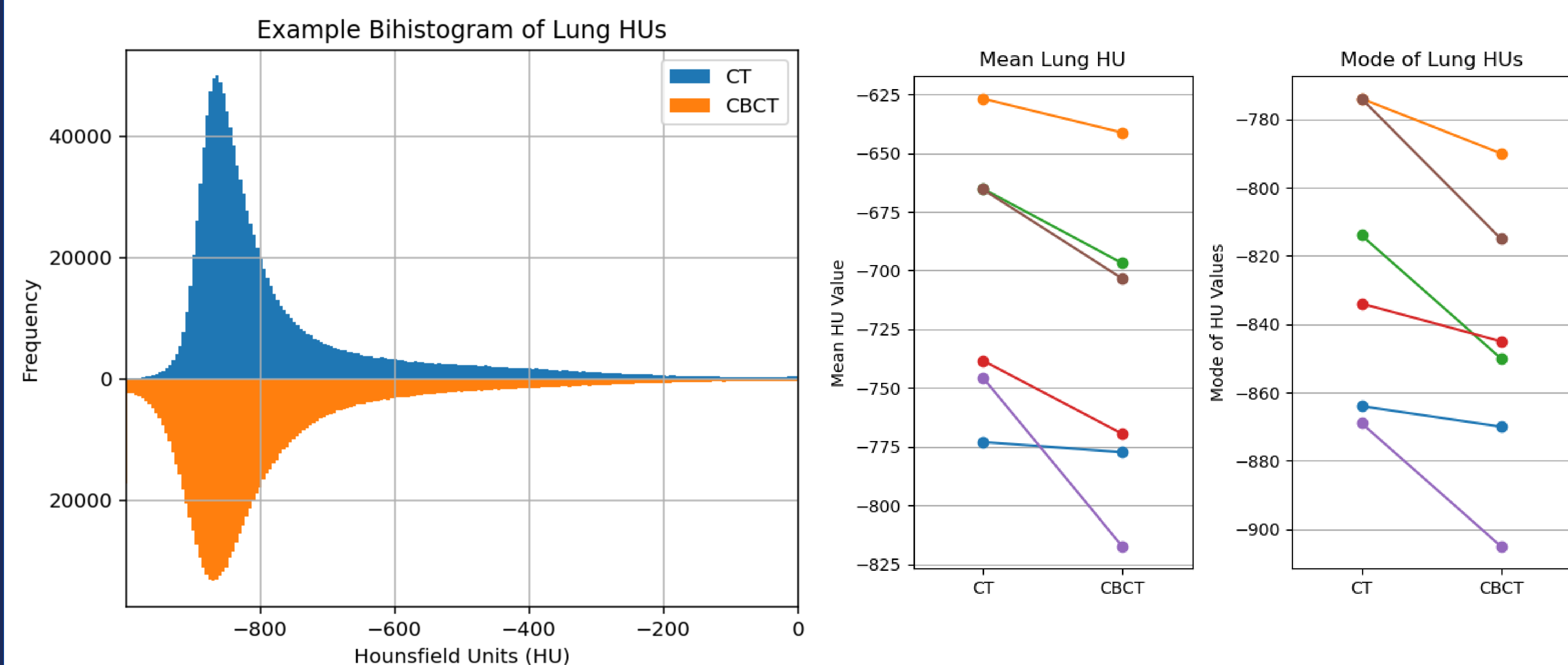
Breath-Hold CBCT



- For initial cohort of six patients:
 - Compared HU histograms of lung tissue between planning CT and CBCT taken with Varian HyperSight at first treatment fraction
 - Planning CT: single respiratory phase from 4D-CT taken at simulation
 - Lung tissue: contoured lung volume excluding contoured clinical target
- Compared rigidly registered CT and first-fraction CBCT images using standard image similarity metrics

Results

- Good agreement between histograms of lung HU values for CT and first-fraction CBCT under breath hold
 - Mean and mode of HU value slightly lower for all patients' CBCT images
 - paired t-test for mean: $t(6)=3.67$, $p=0.02$
 - paired t-test for mode: $t(6)=3.96$, $p=0.01$
 - No significant difference in standard deviation or skew
 - paired t-test $p>0.1$



- Small Bhattacharyya distances between CT and CBCT histograms
- Large histogram intersections
- Moderately large structural similarity image measures (SSIMs) for overlapping image regions
 - rigidly registered
 - averaged across all slices

Conclusions

- Breath-hold technique overcomes issue of HU degradation in Varian HyperSight CBCTs caused by respiratory motion
 - Produces images suitable for online adaptive radiotherapy
- Next steps:
 - Extend analysis to additional patients
 - Determine criteria for evaluating suitability of individual CBCT images for online adaptive radiotherapy
 - Extend analysis to liver cancer patients