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JOINT AAPM | COMP MEETING

Rapid and Explainable DIBH Patient Selection Using Fully Automated, Planning-Free Deep Learning Framework in Left-Sided Whole-Breast Radiotherapy

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Innovation/Impact:

Not all the patients who can perform DIBH gain meaningful cardiac dose reduction, while others who might benefit the most are not readily identifiable. This work aims to leverage DL-based auto-contouring and automated radiotherapy planning to enable rapid, standardized evaluation of the dosimetric benefit of DIBH compared with FB. This automated framework can substantially reduce manual workload and inter-operator variability in treatment planning and evaluation, support efficient patient-specific dosimetric comparisons, and enable optimized selection of patients most likely to benefit from DIBH.

INTRODUCTION

Simple clinical criteria for deep inspiration breath-hold (DIBH) eligibility in left-sided whole-breast radiotherapy, such as the ability to sustain a 20 to 30 second breath-hold, are commonly used but do not reliably predict dosimetric benefit. Robust assessment requires acquisition of both free-breathing (FB) and DIBH computed tomography (CT) scans followed by manual target delineation and treatment planning, making the process labor-intensive and time-consuming. This study presents a fully automated, planning-free deep-learning (DL) framework to estimate dosimetric outcomes and support rapid, explainable DIBH patient selection.

METHODS AND MATERIALS

A DL framework was developed to optimize left-sided whole-breast radiotherapy planning workflow by predicting both 3D dose distributions and the corresponding tangential beam orientations. This approach utilized 3D CT images along with anatomical contours (left-breast, heart, and left-lung) generated via a commercial auto-segmentation tool. The model was trained on 36 treatment plans (19 DIBH and 17 FB) with data augmentation to enhance robustness and assessed on an independent test set of 8 treatment plans (4 DIBH and 4 FB). The predicted dose distributions and beam orientations were evaluated against clinical reference plans using dose-volume histogram (DVH) metrics ($V_{95\%}$ of planning target volume (PTV), D_{mean} of the heart, and V_{20Gy} of the left-lung) and mean absolute error (MAE). **Figure 1** outlines the proposed DL framework as integrated into the routine clinical workflow.

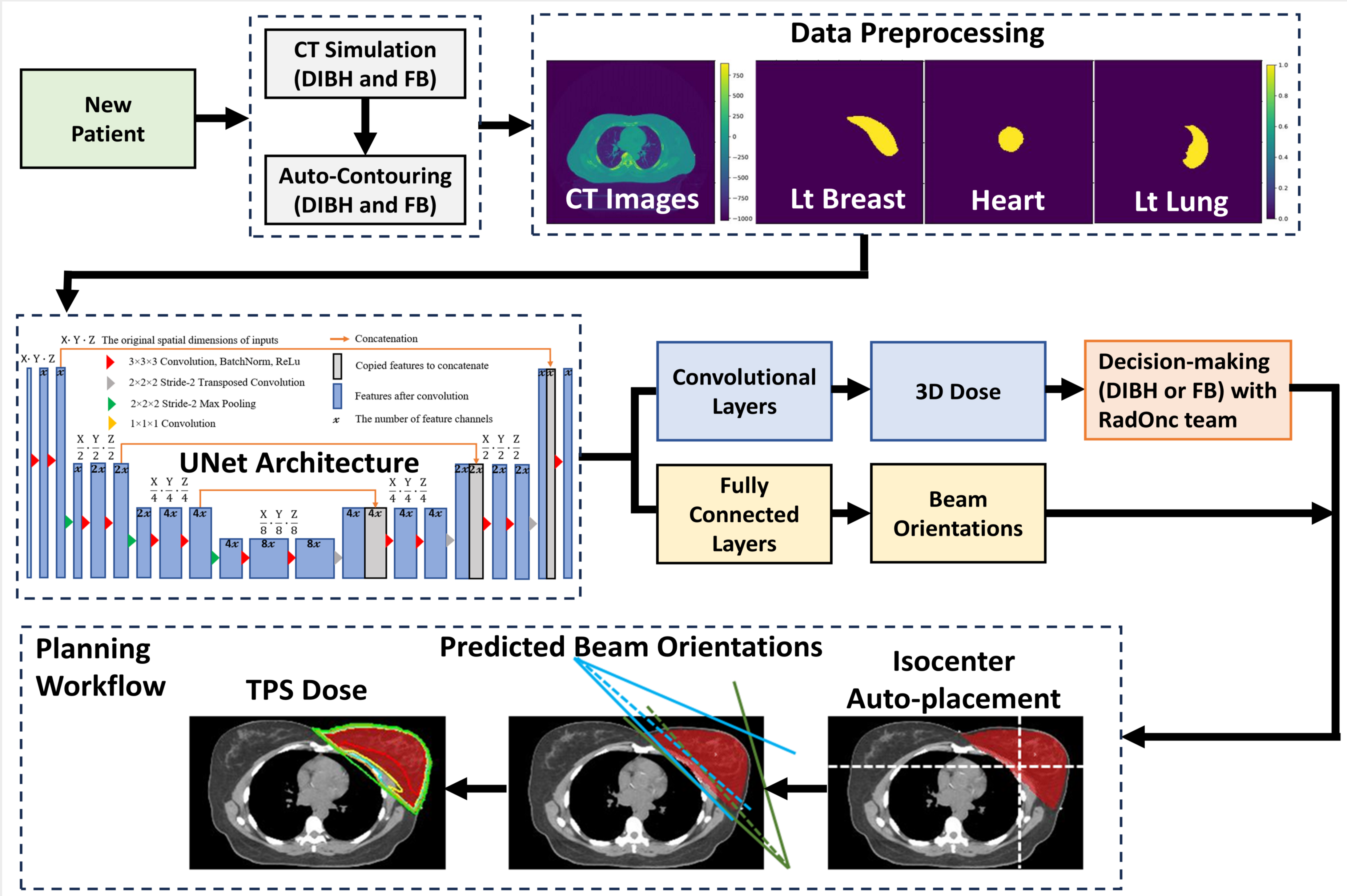

Figure 1: The proposed DL framework for left-sided whole breast radiotherapy. MVision, a commercial auto-segmentation tool, was used to perform auto-contouring.

RESULTS

Figure 2 presents the dosimetric comparisons between DL-predicted plan dose and clinical plan dose for a DIBH and a FB left-sided breast radiotherapy cases. The DL-predicted plans closely matched clinical reference plans in quality. The detailed dosimetric comparison results for both DIBH and FB test cases, are summarized in **Table 1.** The MAEs between the predicted and planned beam orientations for the DIBH and FB test cases are summarized in **Table 2**.

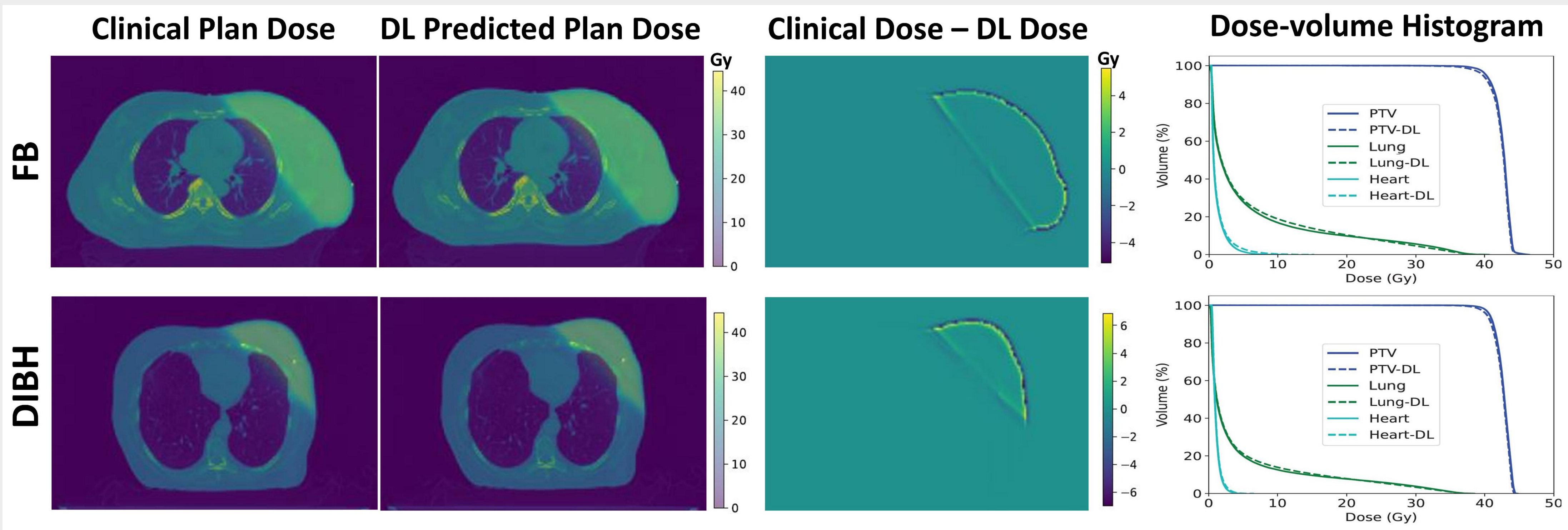

Figure 2: 3D dose comparisons and DVH curves comparisons for one FB and one DIBH cases. Solid lines represent DVH curves calculated from clinical plan dose. Dashed lines represent DVH curves calculated from the proposed DL framework.

Table 1: Dose prediction results analyzed using DVH metrics on the DIBH and FB test cases.

MAE	$V_{95\%}$ of PTV	D_{mean} of Heart	V_{20Gy} of Left-Lung
DIBH	0.49% ± 0.48%	0.23 Gy ± 0.34 Gy	0.36% ± 0.31%
FB	0.67% ± 0.58%	0.51 Gy ± 0.54 Gy	0.46% ± 0.35%
Average	0.58% ± 0.54%	0.37 Gy ± 0.47 Gy	0.41% ± 0.34%

Table 2: Beam angle prediction results on DIBH and FB test cases.

MAE	Beam Angle
DIBH	4.4°± 1.7°
FB	3.6°± 1.3°
Average	4.0°± 1.5°

CONCLUSIONS

The proposed fully automated, planning-free DL framework can be integrated into the clinical workflow for left-sided whole breast radiotherapy, providing transparent, patient-specific estimates of cardiac dose reduction to support rapid, explainable identification of patients most likely to benefit from DIBH. Moreover, the predicted tangential beam orientations can streamline the post decision-making planning process by minimizing the time dosimetrists spend adjusting and optimizing beam angles.

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