AI-Powered Precision: Revolutionizing CTV Contouring for SAVI® Brachytherapy in Breast Cancer

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AI-powered automatic contouring shows promise in improving radiotherapy planning for breast cancer, enhancing efficiency and accuracy.

INTRODUCTION

- Accurate contouring of the Clinical Target Volume (CTV) is crucial for effective radiotherapy planning in breast cancer treatment.
- Manual contouring by radiation oncologists is time-consuming and prone to variability.
- We explore the use of a Convolutional Neural Network (CNN)-based segmentation method for automatic CTV contouring in SAVI® brachytherapy, aiming to **improve efficiency** and **consistency** in radiotherapy planning.

MATERIAL & METHODS

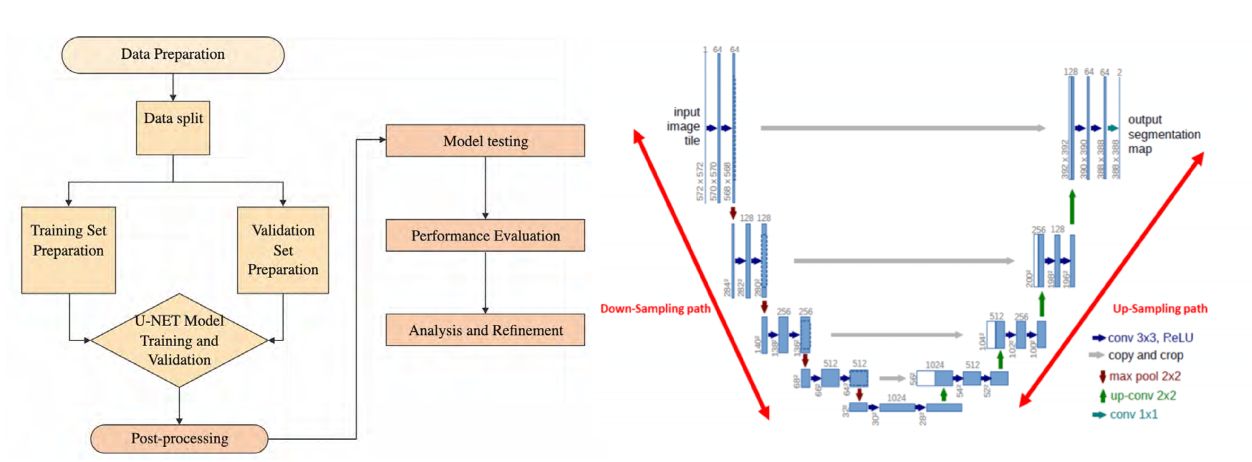

Figure 1: **Left:** Workflow diagram. **Right:** Classic U-NET architecture [1]

Data Collection:

- CT images from 200 breast cancer patients post-SAVI catheter implantation
- CTV manually contoured by radiation oncologist (ground truth)

Data Split:

- Both: 147 patients in the training set and 48 in the test set
- Left breast: 101 in training set, 10 in test set
- Right breast: 74 in training set, 8 in test set

- **Post-processing threshold**: Applied to reduce false positives

- **Performance Evaluation:** Dice Sorensen Coefficient (DSC) measures overlap between AI-generated and manual contours

- **CNN Architecture**: U-NET, a widely used CNN for medical image segmentation

MAIN FINDINGS

- **Observation 1:** U-NET training resulted in a combination of false and true positives.

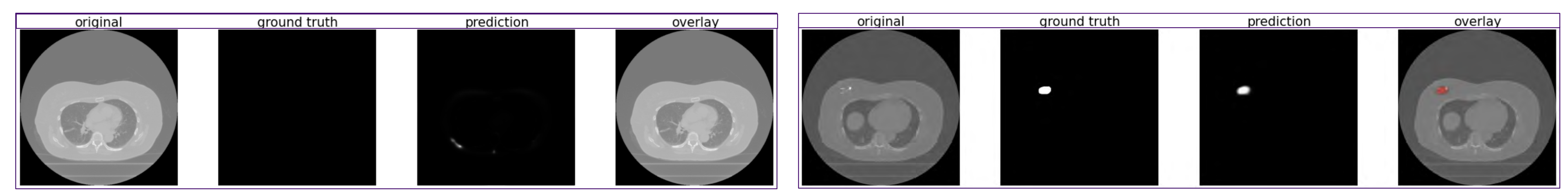

Figure 2: **Left**: False positive prediction using 0.7 validation set split with data set **not** divided by laterality. **Right**: True positive prediction with same validation set split.

- **Observation 2:** Greater DSC median when training data sets were divided into left and right operated breast.
  - Median DSC of validation set split at 0.7 and 0.8 were nearly identical (left)
  - Given marginal difference, 0.7 validation set split was used for training left and right breast data sets (right)

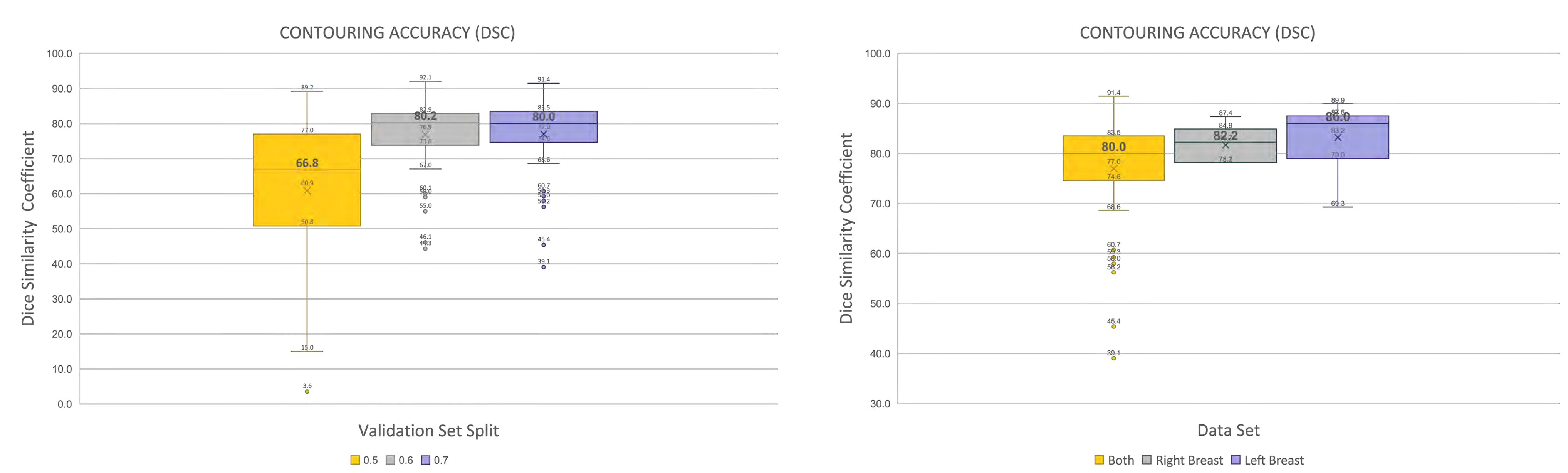

Figure 3: **Left**: Box plot of DSC for different validation set splits, **not** divided by laterality. **Right**: Box plot of DSC for data set not divided and divided by laterality with 0.7 validation set split

- **Observation 3:** Despite applying post-processing threshold, right breast had more false positives, resulting in better agreement in left breast data set with median DSC of 86.0 compared to right 82.2

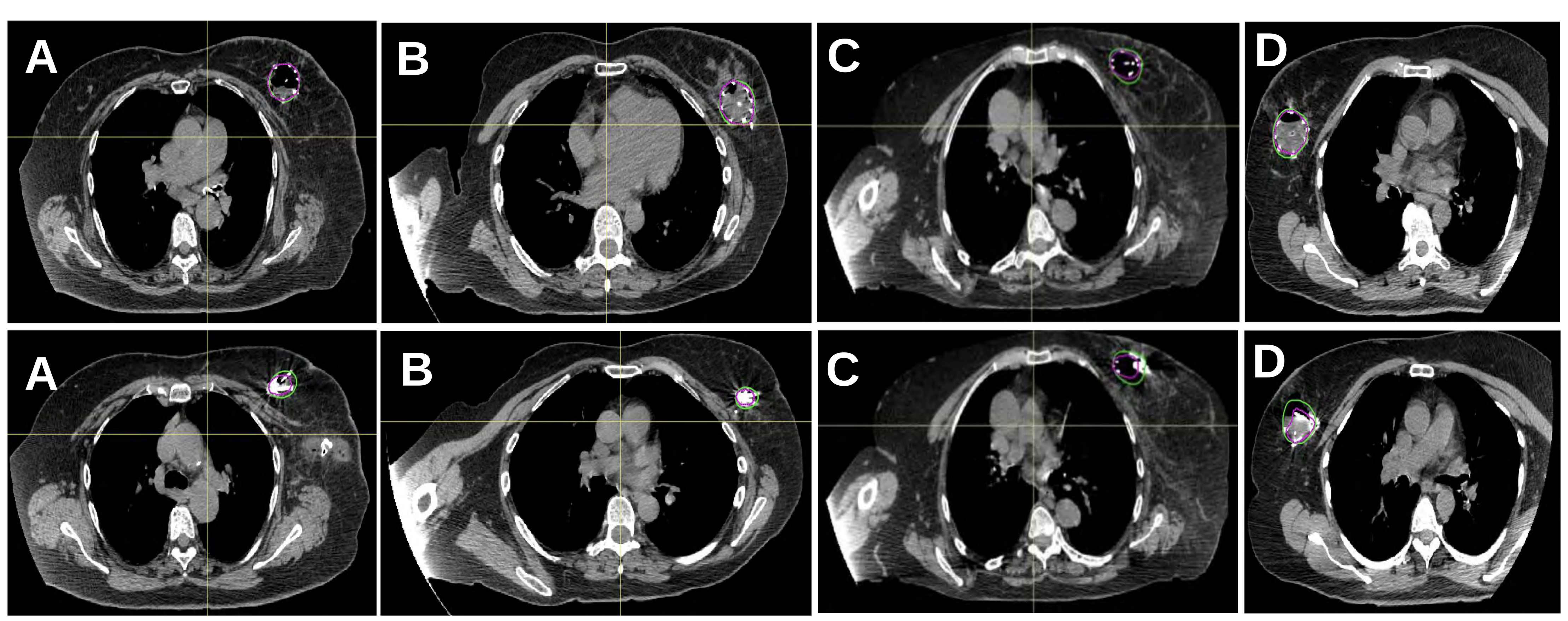

Figure 4: Green: CTV; Pink: AI CTV. **A**: CTV contours for left breast with **highest** DSC of 91.4 using combined data set. **B:** For left breast with DSC of 89.9 using left breast data. **C**: For left breast with **lowest** DSC of 69.3 using left breast data. **D**: For right breast with DSC of 82.4 using right breast data.

DISCUSSION

- **Best Performance**: Achieved when training data was split by breast side, **left** > right breast
- With 50 epochs, training took <7 hours
  - Predictions can potentially improve with more complete cycles (epoch)

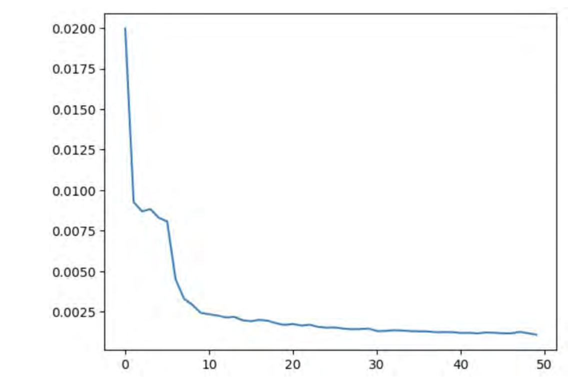

Figure 5: Loss vs. epoch graph of U-NET training of data set with both left and right breast

- **Limitations**: Unclear cause for difference in # of false positives due to **poor interpretability** and **explainability** of CNNs
  - Significant barrier for adoption of AI in clinical space
  - Variability in contouring practices among radiation oncologists → challenge in obtaining ground truth for AI training

CONCLUSION

Promising application of AI in streamlining and enhancing the radiotherapy planning process for SAVI® brachytherapy in breast cancer patients. AI can potentially:

- Reduce contouring time
- Improve consistency and accuracy
- Assist physicians by capturing errors and improving workflow

REFERENCES

[1] Ronneberger, O., Fischer, P., & Brox, T. (2015). U-Net: Convolutional Networks for Biomedical Image Segmentation. In Medical Image Computing and Computer-Assisted Intervention (MICCAI), Springer, LNCS, Vol. 9351, 234-241

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