Deep-learning dose prediction as first step toward real-time adaptive replanning

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INTRODUCTION

Real-time adaptive radiotherapy therapy (RT-ART), introduced to account for severe intrafraction variations based on real-time images during radiation therapy delivery, is difficult with the current treatment planning technology. As a first step toward RT-ART, we are developing a machine learning model that rapidly predicts dose based on a segmented image set. It is our end goal to incorporate deep-learning dose prediction into a larger planning scheme to facilitate an automatic end-to-end replanning workflow.

AIM

This work aims to develop a machine learning model that can rapidly predict dose based on a segmented image set and be generalized to any tumor site thereby facilitating the first step towards real-time adaptive replanning.

METHOD

- Training dataset consists of segmented CT image slices from pancreatic cancer patients (46) paired with ground truth dose distributions obtained from clinical plans
- 128 2D transverse slices per patient for total of 5,888 training data
- Prescription of 50.4 Gy to the PTV
- PTV, liver, stomach, large bowel, small bowel, duodenum, and spinal cord were segmented by trained dosimetrists and physicians
- The network architecture is a 2D conditional generative adversarial network (Pix2pix) and consists of a U-Net generator followed by a binary discriminator.
- Model was tested on 1 held-out patient with 128 slices

RESULTS

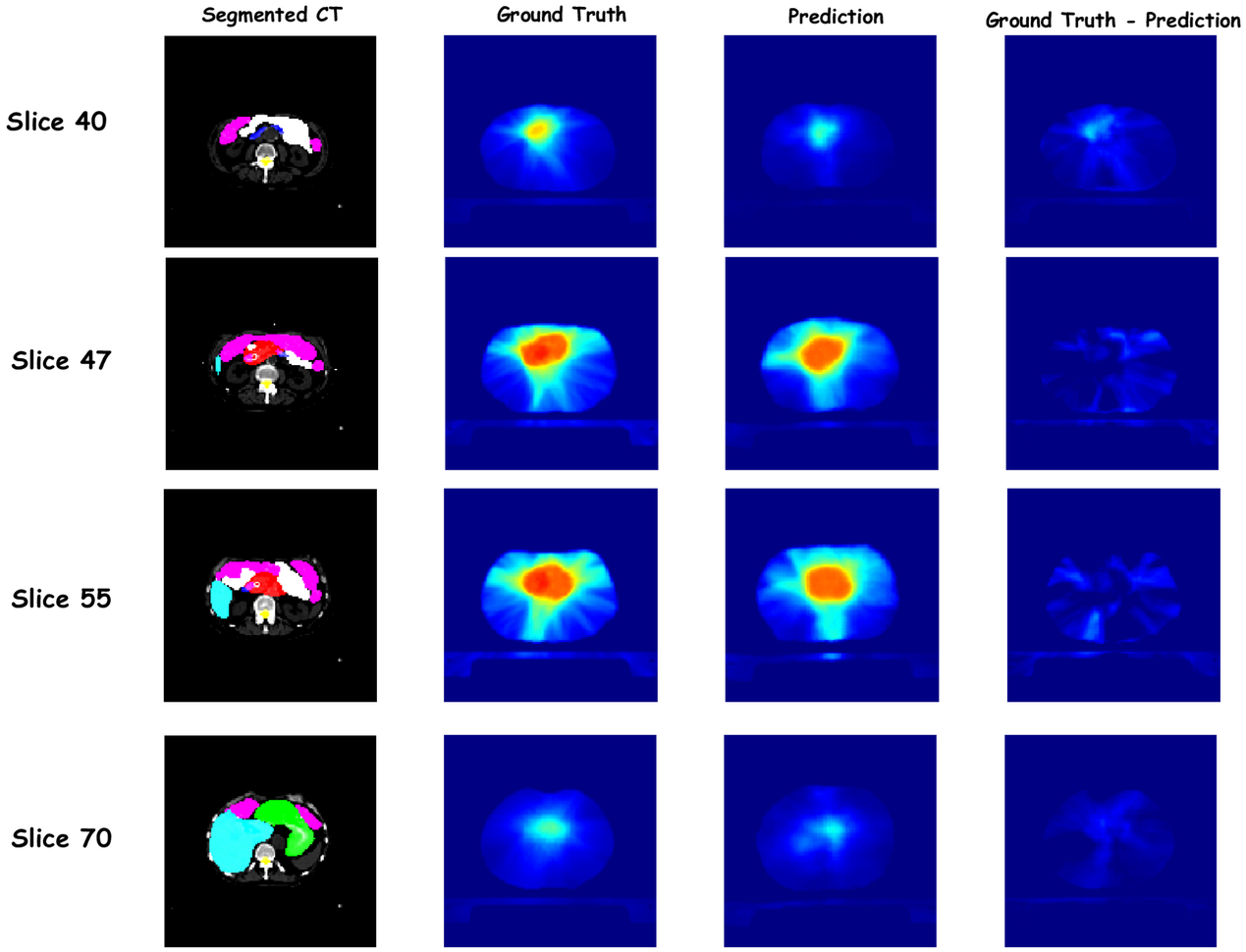

Figure 1: Representative slice by slice comparison of dose prediction results for test cases.

CONCLUSIONS

- The maximum percent difference between ground truth and predicted dose is 41% (slice 40), 8% (slices 47 and 55), and 17% (slice 70)
- Dose difference between ground truth and prediction varies from slice to slice and is greatest at the "top" and "bottom" slices
- Slice by slice variation is likely a result of training pixel-by- pixel instead voxel-by-voxel
- Future work includes extending the model to 3D and testing the network architecture on multiple different cancer sites

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