Towards AI-based dose prediction of daily delivered dose during lung cancer radiotherapy

Mathieu Chenier[1,2], Marcin Wierzbicki[1]

1 Juravinski Cancer Centre, Hamilton, ON
2 Department of Engineering Physics, McMaster University

McMaster University

Hamilton Health Sciences

Introduction

Radiation dose plans, developed using diagnostic-quality CT images obtained prior to therapy, are **not always optimal** for **patient anatomy** or **configuration** on the day of treatment.

It is **not practical or time-efficient** for treatment planners to develop new dose plans for every fraction of a patient's treatment course.

In this work, we describe the implementation of a **CNN** based on the U-Net architecture that **efficiently produces updated dose plans for every fraction of radiation therapy** using data already obtained in the current radiation therapy workflow [1].

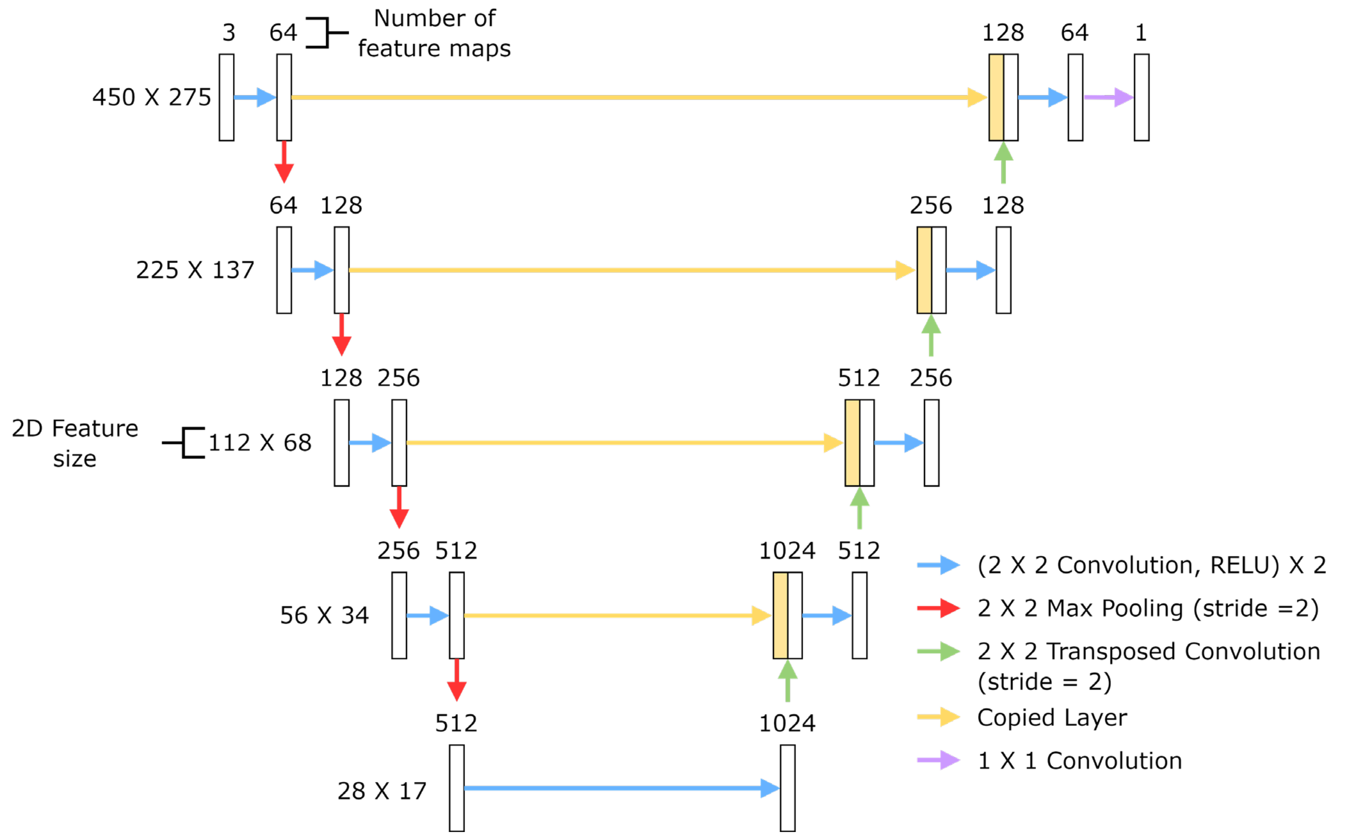

Figure 1: U-Net Architecture

Methods

1. Collect diagnostic CT, dose plan, and cone-beam CT (CBCT) images from 13 lung cancer patients receiving 6300 cGy over 30 fractions.
2. Co-register all 30 CBCT images with the diagnostic CT image using a previously described rigid transformation [2].
3. Recompute dose plan on all 30 co-registered CBCT images using a collapsed cone convolution to obtain "gold-standard" data for training.
4. Train U-Net model (Figure 1) using data from 12 of 13 patients and validate the model using the remaining patient data.

Results and Conclusion

13 models were made, each using a different patient's data as the validation set. Gamma analysis was performed to compare the "gold-standard" co-registered CBCT plans and the U-Net predicted plans for each model. A dose percent threshold of 3%, a distance threshold of 3 mm, and a low dose threshold of 20% were used. Sample data for a single fraction is shown in Figure 2.

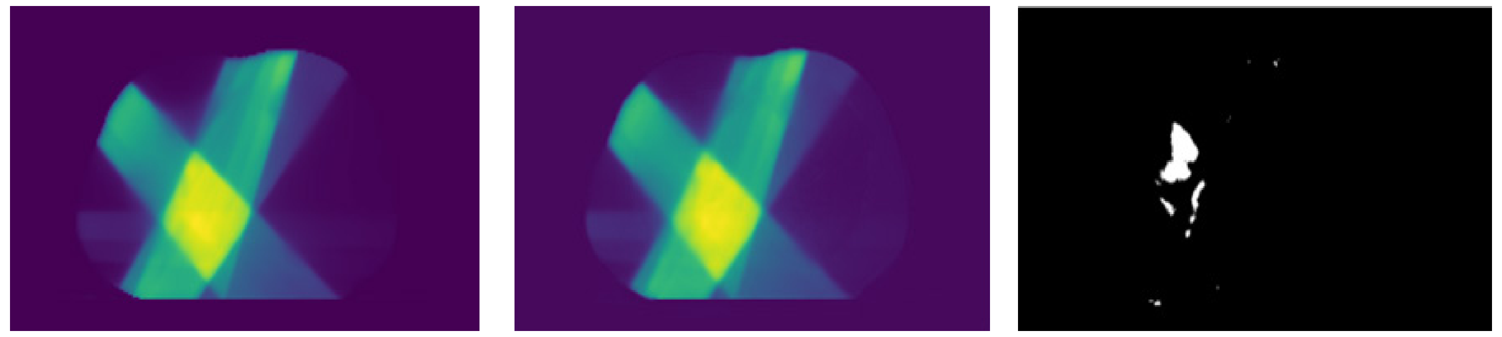

Figure 2: Example data from a single patient, including the "gold-standard" co-registered CBCT plan (left), the U-Net predicted plan (middle), and a gamma map (right). White areas in the gamma map indicate regions where the gamma index is greater than 1.

Mean Gamma Index for all Fractions and Models: 86.9 ± 13.8 % (values between 22.05 % and 100 %)

Conclusion: This method shows promise in improving the accuracy of radiation therapy across fractions but more work is needed to expand the dataset for model training and to make the quality of predicted doses more consistent. Future work should also compare the quality of the U-Net predicted doses with the original planned dose.

References

[1] O. Ronneberger, P. Fischer, and T. Brox, "U-Net: Convolutional networks for biomedical image segmentation," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 9351, pp. 234–241, 2015.

[2] M. Wierzbicki, M. Drangova, G. Guiraudon, and T. Peters, "Validation of dynamic heart models obtained using non-linear registration for virtual reality training, planning, and guidance of minimally invasive cardiac surgeries," Med. Image Anal., vol. 8, no. 3, pp. 387–401, Sep. 2004.