A Deep Learning Method For Prediction of 3D Dose Distribution in Clinical Case

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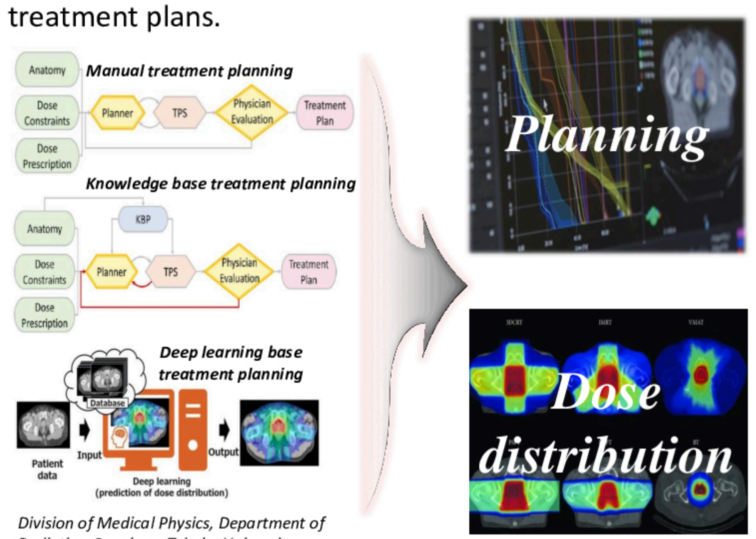
INTRODUCTION

■ To develop a method for predicting clinical cases (rectum and left breast cancer) of 3D dose distribution, given the radiation therapy (RT) planning and segmented anatomy image, by applying deep learning techniques to a database of previously optimized and approved treatment plans.



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METHOD

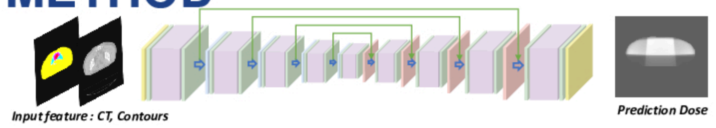

Figure 1, Schematic diagram of the U-net based dose prediction neural network (DpNet) Green block : Convolutional layer, Purple block: Residual with three-convolutional layers and one skip connection, Blue block : Max pooling layers, Red block : De-convolutional layers

■ We have modified a deep convolutional neural network (CNN) model, fusion-net (originally designed for cell structure segmentation purposes), for predicting dose from patient specific image contours of the planning target volume and organs at risk (OAR).

■ A database of volumetric modulated arc therapy (VMAT) plans for the fifty left breast cancer patients and 3D-conformal radiation therapy (CRT) plans for fifty rectum cancer patients used for training and validation data sets.

■ Dice similarity coefficient (DSC), and dose volume histogram (DVH) were used for the quantitative evaluation of 3D dose prediction.

RESULTS

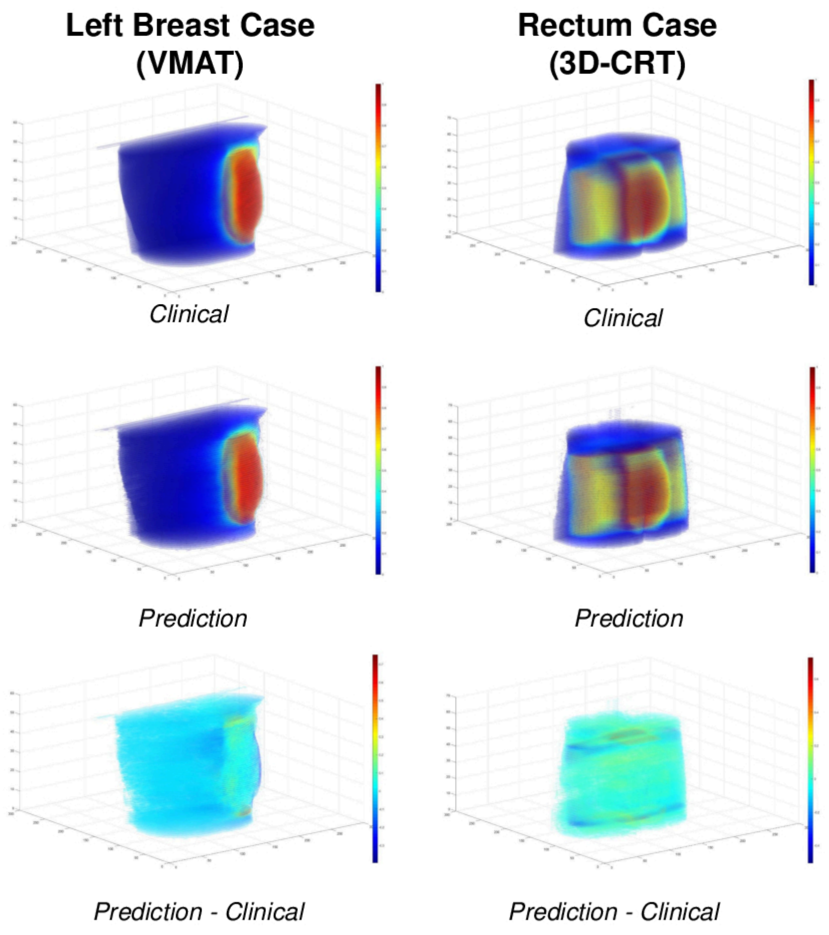

Figure 2, Difference in 3D dose distribution between clinical and prediction.

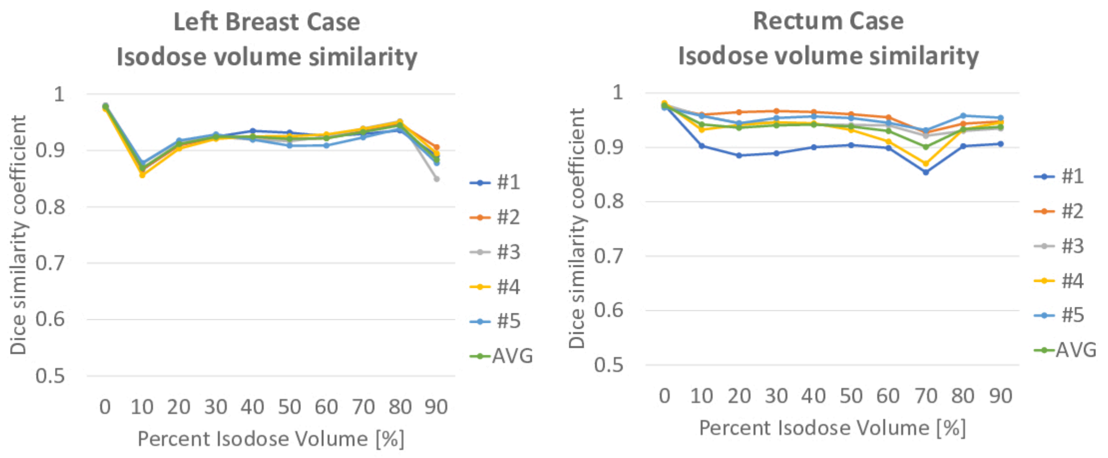

Figure 3, Dice similarity coefficient of Iso dose volume

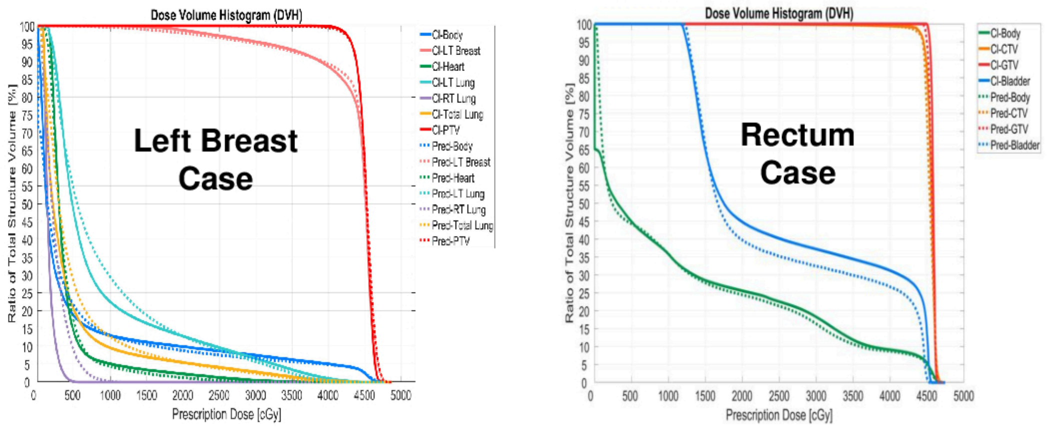

Figure 4, Dose volume histogram comparison between clinical(solid line) and predicted(dashed line) results.

Table 1, Result of the deep learning prediction average errors for left breast case clinical dose.

Structure *(Prediction - Clinical)*	*Difference of Max Dose [%]*	*Difference of Mean Dose [%]*
PTV	0.34	0.38
Lt Breast	0.52	0.24
Heart	-1.68	0.92
Lt Lung	1.60	2.86
Rt Rung	14.18	2.34
Body	0.34	-0.06

Table 2, Result of the deep learning prediction average errors for rectum case clinical dose.

Structure *(Prediction - Clinical)*	*Difference of Max Dose [%]*	*Difference of Mean Dose [%]*
GTV	0.14	0.18
CTV	0.14	0.22
Bladder	1.94	2.82
Body	-0.18	-0.60

DISCUSSION

■Although the current model considered different patients' geometrical structures when predicting dose distributions.

■ It can only predict one type dose distribution, which is unable to take any physician preferences into account. (versatile case dose prediction is currently impossible)

■ The current model focused on predicting 3D-dose distributions and did not convert it into an executable clinical plan. We developed a deep learning method for contour-based 3D dose prediction, and shown to be able to produce dose predictions in rectum and breast cancer.

■ Target structure (PTV, GTV, and CTV) showed no significant difference from clinical result in DVH. (Mean, Max dose difference : < 0.4 %)

■ The predicted 3D dose map can be useful for improving radiotherapy planning design, ensuring plan quality and consistency, which may play an important role for on-line adaptive radiation therapy.

CONCLUSIONS

■ We developed a deep learning method for contour-based 3D dose prediction, and shown to be able to produce dose predictions in rectum and breast cancer.

■ Target structure (PTV, GTV, and CTV) showed no significant difference from clinical result in DVH. (Mean, Max dose difference : < 0.4 %)

■ The predicted 3D dose map can be useful for improving radiotherapy planning design, ensuring plan quality and consistency, which may play an important role for on-line adaptive radiation therapy

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