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Deep Learning for 3D Automated Delineation of Primary Gross Tumor Volume for Nasopharyngeal Carcinoma by CT Combining Contrast-enhanced CT

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INTRODUCTION

Automatic delineation of primary Gross Tumor Volume(GTVp) for nasopharyngeal carcinoma is significant in clinical practice because it increases efficiency and reduces the inter-observer variability. CT and other modality images may-be not obtained at the same time, and thus the tumor volume is not identical. It is meaningful to improve the accuracy of target delineation in CT images because the radiotherapy plan is designed based on CT images.

AIM

The objective is to develop an automated delineation method of GTVp of nasopharyngeal carcinoma (NPC) in computed tomography (CT) image for radiotherapy applications.

METHOD

We proposed a modified version of the 3-dimensional(3D) U-Net model with Res-blocks and SE-block for delineation of GTVp. Besides, an automatic pre-processing method was proposed to crop the 3D region of interest(ROI). Radiotherapy simulation CT images and corresponding manually delineated target of 205 NPC patients diagnosed with stage T1-T4 were used as datasets for training. Automated delineation models were generated based on plain CT(CT) combining contrast-enhanced CT(CE-CT) and CT alone, respectively. We compared the automatic delineation results against the manually delineated contours by radiation oncologists with 5-fold cross-validation to evaluate the performance of the proposed model. We also compared with the framework using 3D convolutional neural network(CNN) and 2-dimensional(2D) deep deconvolutional neural network(DDNN), respectively. Besides, the model generated by one medical group was assessed against the other two separate medical groups. Precision (PR), Sensitivity (SE), Dice Similarity Coefficient (DSC), Average Symmetric Surface Distance (ASSD), and 95% Hausdorff Distance (HD95) are calculated for quantitative evaluation.

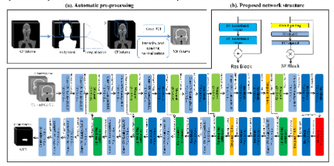


FIGURE 1. Network architecture of the proposed 3D U-Net. (a) framework of the pre-processing stage; (b) the structure of the proposed network.

RESULTS

Experimental results show that the proposed method outperforms other methods on the CT images. Automated delineation models based on CT combining CE-CT is superior to that base on CT alone.

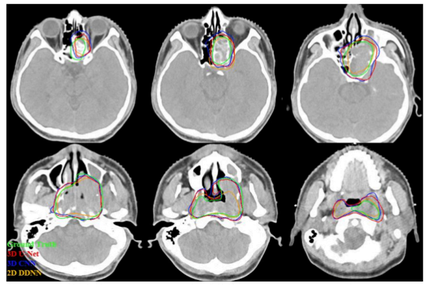


FIGURE 2. Delineation results for different methods, Green lines denote ground truth, red lines denote the contours of automatic delineation with our method, blue lines denote the contours of automatic delineation with Lin's method, orange lines denote the contours of automatic delineation with Men's method.

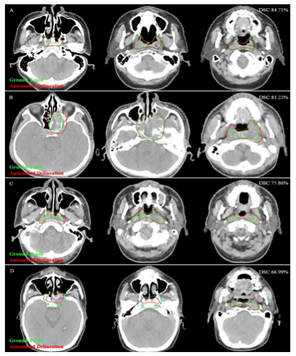


FIGURE 3. Example CT images show the level of consistency for GTVp between the automatic delineation with our method and ground truth. Green lines denote the human experts delineated ground truth, and red lines denote the contours of automatic delineation.

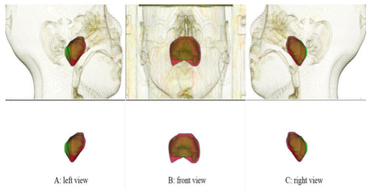


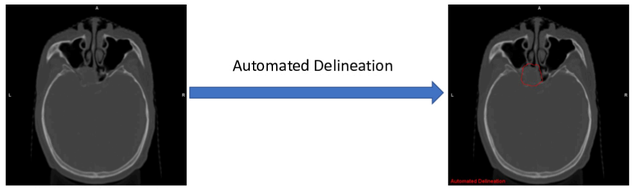
FIGURE 4. Example of consistency for GTVp between the automatic delineation with our method and ground truth in 3D space. Green volumes denote the human experts delineated ground truth, and red volumes denote the contours of automatic delineation.

Image	Study	Algorithm	PR (%)	SE (%)	DSC (%)	ASSD (mm)	HD95 (mm)
CT	Our study	3D U-Net	75.38	76.34	73.72	1.47	4.96
	Lin et al. [1]	3D CNN	74.78	74.29	72.05	1.57	5.41
	Men et al. [4]	2D DDNN	75.88	65.16	67.35	1.92	7.36

TABLE . Comparison of the performance among our network model and other models based on CT alone

CONCLUSIONS

The modified version 3D U-Net model based on Res-block and SE-block is robust and accurate. It could be useful for the 3D delineation of GTVp for NPC during the planning of radiotherapy.



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