Automatic detection and contouring nodules Based on Lung Computed Tomography Images using U-Net Segmentation Method for Treatment Planning System

Sadremomtaz A[1], Zadnorouzi M [1*]

[1]Department of Physics, University of Guilan, Rasht, Iran

[*] *Email: moh.phy73@gmail.com*

Abstract

Deep learning algorithms have recently been developed that utilize imaging information, as a means to increase treatment planning efficiency and improve radiotherapy plan quality. In this study lung nodule region segmented automatically using U-Net that is the popular segmentation network for biomedical images. 358 CT images from patients were used to train and test U-Net. In this research, lung cancer volume calculation process of target based on CT images was done. Calculation of target volume was done in purpose to treatment planning system in radiotherapy. The calculation of the target volume was done by adding the target area on each slices and then multiply the result with the slice thickness. The calculation of nodule region targets is 611 mm^2 for area target volume and 1527.5 mm^3 for GTV. In this study, the value of dice obtained 83% that confirms the usefulness of the proposed method in treatment planning systems.

Keywords: U-Net, segmentation, treatment planning

Introduction

Radiation therapy is a major clinical treatment for lung cancer. In radiotherapy, planning is required to determine the amount of radiation dose received by a tissue. Dose planning in radiotherapy is called treatment planning system (TPS).
The development of automated treatment planning technologies has accelerated in recent years [1].
The initial phase of the TPS is contouring the cancer or target volume. This process can be done quickly by using segmentation method which classifies the object pixels into a regions or parts [2].
Absorption dose will be increased significantly when volume of radiation is changed. therefore, it causes complications such as decreased bone marrow activity and skin disorders in patients [3].

Experimental

In this study, the design of automatic nodule detection and contour system was implemented in 4 stages:
1.Dataset Labeling: 358 Images and corresponding masks (nodule representing images) of people with lung cancer from LIDC-IDRI dataset using the Pylidc Python package (to select slices containing nodules) were used in this study.
2.Dataset preprocessing: In order to reduce the search space and processing volume of non-useful areas, we extracted only the areas of the lung lobes that contain pulmonary nodules. The steps to implement this are as follows:
2.1 Standardization of images by use of standard mean and standard deviation 2.2 Apply middle filter on images to de-noising them 2.3 Clustering of lung image with k-means algorithm to separate lung lobes from lung wall 2.4 Apply morphology operator to integrate lobes structure.

3.Lung nodule segmentation: We used U-Net model proposed by Ronneberger et al, shown in Figure 1, for nodule segmentation in lung CT imaging [4]. The architecture consists of a contracting path to capture context and a symmetric expanding path that enables precise localization. 286 images (CT) with corresponding actual masks were used as input and output respectively for training and the rest of the images were used for testing. The model was trained for 200 epochs with a batch size of 2. To evaluate the model, we used the Dice validation criterion, which indicates the degree of overlap of the correct and predicted results by the network.

4.Nodule contouring and calculating its volume: The isolated nodules in previous section were contoured in CT images and their volume values were calculated by the sum of the nodule areas in each image slice. In contouring process of this study, Gross tumor volume (GTV i.e. the main target volume of the primary and metastasis tumor) was determined in each slice image [2].

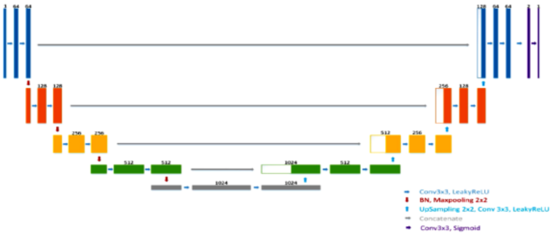

Figure1. Implemented U-Net architecture

Results

The result of lung image preprocessing and nodule separation by the U-Net is shown in Figure 2.

(a) (b) (c)

Figure 2. Original image (a), extracted lobes (b), nodule predicted by U-Net(c)

In this study, Dice similarity coefficient was used to evaluate the U-Net model implemented for nodule separation. Dice coefficient is defined as follows:

$$\mathrm{DSC} = \frac{2TP}{2TP+FP+FN}$$

In the present study, the model achieved 83% Dice values. Figure 3 shows the results of contour nodules of different CT slices of a patient as sample.

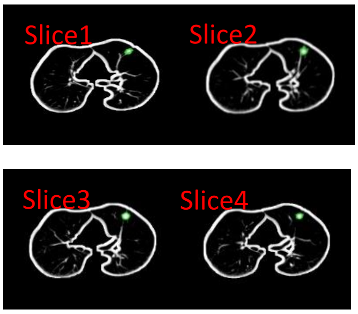

Figure3. contoured different nodule slices of a patient using masks produced by U-Net

Target area and volume values for different slices of this patient were calculated by multiplying the number of white pixels in the mask image by the area of each pixel (0.67 mm^2) and the slice thickness (2.5 mm), the results of which are shown in Table 1.

Table 1. results of evaluation metrics

	Target area(mm^2)	Target volume(mm^3)
Slice 1	181	452.5
Slice 2	119.2	298.1
Slice 3	123.9	309.7
Slice 4	186.9	467.2
Total	611	1527.5

Conclusion

By comparing the images obtained from U-Net method with clinical images using the Dice criterion, it is possible to provide an accurate assessment of the performance of the proposed system. In this study, the high value of dice confirms the usefulness of the proposed method in treatment planning systems.

References

[1] Vasant Kearney, Jason W. Chan, Tianqi Wang1, Alan Perry, Martina Descovich, Olivier Morin, Sue S. Yom & Timothy D. Solberg, *DoseGAN: a generative adversarial network for synthetic dose prediction using attention gated discrimination and generation*, J.nature, scientific reports(2020).

[2] Fiet Patra Yosandha, Kusworo Adi, and Catur Edi Widodo, *Calculation of Lung Cancer Volume of Target Based on Thorax Computed Tomography Images using Active Contour Segmentation Method for Treatment Planning System*, IOP Conf. Series: Journal of Physics: Conf. Series 855 (2017).

[3] Naderi H, Karimkhani Zandi S, Hasani M, Saadatmand S, Hamrahi D, *Evaluation of Effective Factors on Irradiated Volume of Lung, DuringThree-Dimensional Conformal Radiotherapy (3DCRT) for the Breast Cancer*, Iranian Quarterly Journal of Breast Disease 2018; 11(1):25.

[4] Ronneberger O, Fischer P and Brox T, *U-Net: convolutional networks for biomedical image segmentation.* https://arxiv.org/abs/1505.04597v1, 2015.