Pulmonary Airway Segmentation Framework: Application to CT Images

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Abstract. Pulmonary Airway Segmentation Framework: Application to CT Images

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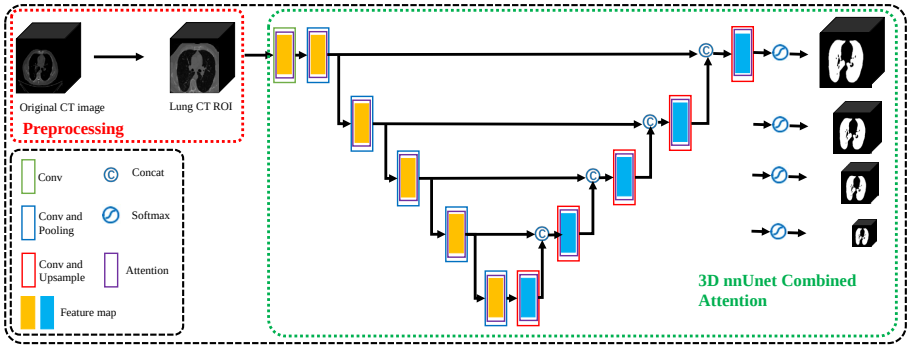

Fig. 1. Overview of the PASF framework. The framework contains two step, one for obtaining the ROI of lung, another for Pulmonary Airway segmentation based on nnUnet.

1 Method

An overview of the automatic Pulmonary Airway segmentation framework is shown in Figure 1. We first segment the lung region based on thresholding to obtain the region of interest for pulmonary airway. Then we crop the original CT image into an ROI of lung. After that, we could train a segmen- tation model using the lung ROI and corresponding labels. To achieve more accurate segmentation, we introduce an global context (GC) block inspired by [1], which has the

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benefits of both the simplified nonlocal(SNL) block with effective modeling on long-range dependency, and the squeeze-excitation (SE) block with lightweight computation.

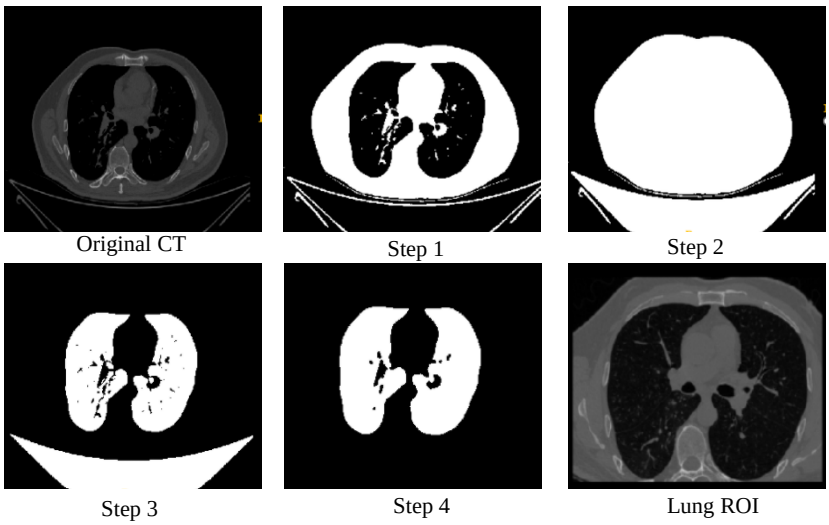

Fig. 2. Lung segmentation which contain 4 step.

1.1 Lung segmentation

It is necessary to segment the lung structure to assist subsequent operations, such as pulmonary airway segmentation. We introduce a traditional image processing method for this which contain 4 step as shown in Figure 2. In the first step, we use thresholding-based method to obtain coarse segmentation. In the second step, we segment the outer air and lung by seed filling algorithm. Considering that there are many fibers in the lungs that cause cavities. In order to fill these cavities, in the three step, we introduce to use morphology method. In the last step, we keep the largest connected domain which is the lung.

1.2 Pulmonary Airway segmentation network(PASF)

Once the lung ROIs are extracted, an pulmonary airway segmentation is performed for them using CNN. We proposed to utilizes 3D CNN which can extract a more powerful volume representation and spatical infromation on three dimension. We follow the nnUnet as our base model, which has been widely used in medical image task and achieved good performance. To solve the class imbalance problem in pulmonary airway segmentation, we propose to combine focal loss

with Dice loss and CE loss. The trained model would perform well on it. The segmentation loss is as follows,

$$\mathcal{L}_{seg} = \mathbb{E}_{x_i, y_i \sim P(X_i, Y_i)} \left[\mathcal{C}\left(y_i, \widehat{y}_i\right) + \alpha \cdot Dice\left(y_i, \widehat{y}_i\right) + \beta \cdot Focal\left(y_i, \widehat{y}_i\right) \right], \quad (1)$$

where $\widehat{y}_i$ is the segmentation prediction from x_i, $\mathcal{C}\left(y_i, \widehat{y}_i\right)$ is the cross-entropy loss, $Dice\left(y_{S_i}, \widehat{y}_{S_i}\right)$ is the Dice loss and $Focal\left(y_i, \widehat{y}_i\right)$ is focal loss. α and β is the hyper-parameter to balance them.

1.3 GCBlock

As the simplified nonlocal(SNL) block can effective model on long-range dependency, and the squeeze-excitation (SE) block can model global context with lightweight computation. Inspired by [1], we introduce the GCBlock to our PASF.

References

1. Cao, Y., Xu, J., Lin, S., Wei, F., Hu, H.: Gcnet: Non-local networks meet squeeze-excitation networks and beyond. In: Proceedings of the IEEE/CVF international conference on computer vision workshops. pp. 0–0 (2019)