Lung Segmentation Using Proposed Deep Learning Architecture

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Abstract—The Prediction and detection disease in human lungs are a very critical operation. It depends on an efficient view of the CT images to the doctors. It depends on an efficient view of the CT images to the doctors. The clear view of the images to clearly identify the disease depends on the segmentation that may save people lives. Therefore, an accurate lung segmentation system from CT image based on proposed CNN architecture is proposed. The system used weighted Softmax function the improved the segmentation accuracy. By experiments, the system achieved a high segmentation accuracy 98.9% using LIDC-IDRI CT lung images database.

Keywords—CT images, lung segmentation, DNN, CNN, Softmax

1 Introduction

Lung Segmentation in CT images is a very important and useful technique in medical field [1]. An efficient and accurate segmentation results lead for better disease prediction and detection. Now days with the pandemic of COVID-19 the needs of reliable and accurate system of segmenting the lung became more importance.

DNN is successfully applied in segmentation of the medical images [2, 3] and other recognition and detection systems [4, 5, 6]. Several deep networks with various activation functions are obtained a satisfied-results in different researches and existing systems [7], [8]. Therefore, we will use the CNN in our proposed work for better segmentation results.

The most recent researches related to the lung segmentation system Qinhua Hu et al. [9] used the Convolutional Neural Network (CNN) Mask R-CNN with the K-means kernel for segmenting the lung from CT images. The authors mentioned that their system achieved a high segmentation accuracy 97.68% and low runtime 11.2 seconds.

Sarah E. et al. [10] present deep learning framework for lung segmentation with Acute Respiratory Distress Syndrome (ARDS) using novel multi-resolution convolutional neural network (ConvNet). The authors used Transfer learning to accommodate the limited number of training datasets. The obtained results were 91 – 96% using multi-resolution model.

Brahim A. et al. [11] employ the U-net architecture of deep learning for segmenting the lung. The architecture extract high-level information and a symmetric expanding path which is recover the needed information based on the contracting path. Based on end-to-end training, the used architecture gives 95% accuracy using only very few images.

Yuchong Gu. Et al. [12] investigated deep convolutional neural network (DCNN) for lung area segmentation based on U-Net and V-Net. The both networks are used as a baseline networks and a new multi-scale prediction network (MPN) is designed for better dice coefficient results. The system results were 87-98% using MPM, 93-98% using U-Net and 52-97% using V-Net.

Tao P. et al. [13] present a system for lung Region of Interest (ROI) boundaries detection. Hull-Closed Polygonal Line Method (Hull-CPLM) is used for detecting the ROI in chest radiographs based on two steps which are preprocessing and refinement. Besides, the system performance was 97.08% using Dice Similarity Coefficient (DSC) evaluation and public lungs database.

2 Proposed System

A proposed CNN architecture is employed for segmenting the input lung from CT image. First the system used a standard CT lung images database called LIDC-IDRI [14]. The proposed CNNs architecture is illustrated in figure 1.
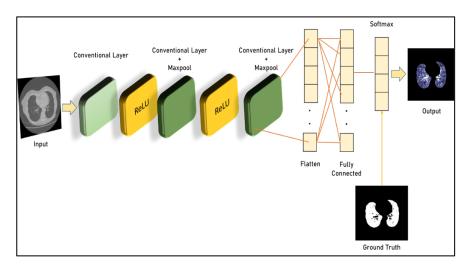

Fig. 1. Proposed CNN architecture

Proposed CNN architecture is first trained by the input CT images and their corresponding masks. However, corresponding mask is generated for the input image as an output during the testing stage. After that, the generated mask is used to segment the required are of the input CT image. The last step of the proposed system is the use of Softmax function. In our system a weighted Softmax function is used to match the output segmented image within the ground truth image for accurate segmentation result. Softmax could be interpreted using equation 1:

$$Sp = \frac{1}{M}\sum_{j=0}^{n}\sum_{i=0}^{n} -logPr(A = a_{i,j}/ \text{B=}b_{i,j}) \tag{1}$$

Where,

Sp = The Probability of Softmax function
$a_{i,j}$ = The average of weight
$b_{i,j}$ = The pixel of the input image
i,j = The iteration of the value
Pr = A and B probability function

The probability function under the Softmax function is the main focus of the proposed system. In equation 1 a bias probability is included, in order to push the strong biases in the input data away. The data could be normalized by adding a positive weight to a high negative bias and adding a negative weight to a high positive bias.

The bias probability element is increased, when the value of the weight is very small, due to a very small denominator. Proposing a new weight called Extra Weight (w1) can enhance the equation 2:

$$\boldsymbol{My}_{i,j} = \sum_{j=0}^{j=m}\sum_{i=0}^{m} \boldsymbol{MW}_{i,j}\boldsymbol{x}_{i,j} + \frac{e^{MW_{i,j}}}{\sum_{i,j}e^{EW1+MW_{i,j}}} \tag{2}$$

Where,

$My_{i,j}$ = The improved function of evidence
$MW_{i,j}$ = The main weight
EW_1 = Extra Weight
$\boldsymbol{e^{EW_{i,j}}}$ = The Weighted Exponential
i,j = The iteration of the value

By applying the equation 1 will normalize the evidence function will make the system obtain a better segmentation accuracy.

3 Results and Dissection

In the proposed system Python 3.8.3 programing language is used with Tensor Flow 2.2 library based on Keras for implementing the proposed system. Besides, NVIDIA GeForce with 640 CUDA Cores and 8 GB of memory in order to exploit its computational speed for better and authenticate results. The used network parameters were:

- Batch size: 64.
- Number of epochs: 70.

In the proposed work the configurations of the CNN shown in table 1. The depth of the configurations increases from the left (A1) to the right (A4), as more number of layers are added. The convolutional layer parameters are denoted as conv with its number in the table.

Table 1. Configurations of the proposed CNN architecture

A1	A2	A3	A4
10 weighted layers	10 weighted layers	15 weighted layers	15 weighted layers
Input CT Lung image			
Conv64	Conv64 ReLU	Conv64	Conv64
Maxpool1			
Conv128	Conv128	Conv128	Conv128
Maxpool2			
Conv256	Conv256	Conv256	Conv256
Maxpool3			
Conv512	Conv512	Conv512	Conv512
Maxpool4			
FC1			
FC2			
Softmax			

Furthermore, 512 CT images of LIDC-IDRI database are used to evaluate the proposed system. Figure 2 shows a samples images of the used database.
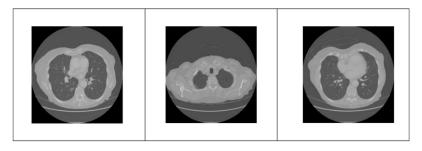

Fig. 2. The LIDC-IDRI CT lung sample images

A result of applying the proposed CNN architecture on three different images is illustrated in figure 3.
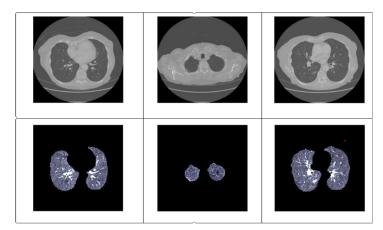
Fig. 3. The Segmentation results of the proposed CNN architecture

In addition, dice coefficient index DSC is used for evaluating the proposed network performance. DSC is obtained using the equation 3 below:

$$DSC = 2 * \frac{\|S \cap T\|}{\|S \oplus T\|} \tag{3}$$

The obtained lung area presented by S, in the proposed approach, and the ground truth image presented by T. By applying the equation 6 the system achieved 98.9%.

In another hand, using ReLU activation function and the modified Softmax function leads the proposed system accurate result. Table 2 shows the effect of use the standard Softmax function and the modified one.

Table 2. Comparison result of proposed method and standard Softmax function

Method	Accuracy%
Softmax	96.2
Proposed	98.9

4 Conclusion

An accurate lung segmentation system is presented in this paper. The system used proposed deep learning architecture based on CNN, ReLU activation function, and modified Softmax function. The system achieved a high segmentation result which is 98.9% using LIDC-IDRI database. In the future work, the proposed system could be employed for detecting the COVID-19 in the CT lung images of the infected patients. Several DNN could be used for achieving high detection accuracy with lowest detection errors.

5   References

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