Three dimensional medical image recognition of the lungs using artificial neural network

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Abstract

In this study, we propose a method of 3-dimentional medical image recognition of the lungs, pulmonary vessels and bronchial trees by using an artificial neural network. Two neural networks trained using the back propagation algorithm are applied to medical image recognition. First, the neural network recognizes the outline of the lungs and outputs the lung regions and 3-dimensional images of the lungs are displayed. Then, second neural network recognizes outline of the pulmonary vessels and bronchial trees and outputs the regions of them and 3-dimensional images are displayed accurately. These image processing proposed in this study can be easily applied to another medical image such as MRI image.

Keywords: Neural network, lungs, 3-dimensional image

1 Introduction

Neural network used in this study has a three layered neural network architecture that is constructed with the input layer, the hidden layer and the output layer. Weights of the neural network are estimated using the back propagation algorithm. Two neural networks are applied to 3-dimentional medical image recognition of the lungs, pulmonary vessels and bronchial trees. First, the neural network is organized in order to recognize the outline of the lungs and extract the lung regions. Then, the subtraction images of the lungs are extracted and are used to organize the second neural network. Second neural network is recognized and extracts the pulmonary vessels and bronchial trees regions. These image processing are carried out for all slices of multi detector row computed tomography (MDCT) images and 3-dimensional images of pulmonary vessels and bronchial trees are displayed with the volume rendering software.

2 Artificial neural network architecture

The neural network, which has 3-layered architecture with the input layer, the hidden layer and the output layer, is trained using back propagation algorithm. Architecture of the neural network is shown as follows:

(1) Input layer

$$u_i = x_i \qquad (i=1, 2,\ldots, p) \tag{1}$$

Here, x_j is input variables and p is the number of the input variables.

(2) Hidden layer

$$y_j = \sum_{i}^{P} w_i u_i - \theta, \ \left(j = 1,2,\cdots,g\right) \tag{2}$$

$$u_j = \frac{1}{1+\exp\left(-y_j\right)}, \ \left(j = 1,2,\cdots,g\right) \tag{3}$$

Here, w_i (i=1,2,…, p) is the weights between the input and the hidden layer and g is the number of neurons in the hidden layer.

(3) Output layer

$$y_k = \sum_{j}^{g} w_j u_j - \theta, \ \left(k = 1,2,\cdots r\right) \tag{4}$$

$$u_k = \frac{1}{1+\exp\left(-y_k\right)}, \ \left(k = 1,2,\cdots r\right) \tag{5}$$

Here, w_i (i=1,2,…, g) is the weights between the hidden and the output layer and r is the number of neurons in the output layer.

3 Application to medical image recognition of the lungs

The neural network trained using the back propagation algorithm was applied to the medical image recognition of the lungs. MDCT images of the lungs were used in this study.

3.1 Image recognition of the lung regions

An original image shown in Fig.1 was used for learning weights of the artificial neural network. The statistics of the image densities in the neighboring region, the N×N pixel regions, were used as the image features. Three parameters namely, mean, standard deviation and variance were used as the useful input variables [1]. The output value of the neural network was zero or one. When N×N pixel region was contained in the region of the lungs, the neural network set the pixel value at the center of the N×N pixel region to one and this pixel was shown as the white point. In this study, we set the value of N to 4. Figure 2 shows the output image of the neural network after the post-processing. In the post-processing, small isolated regions were eliminated by the image processing such as the dilatation and the erosion. Then, outlines of lung regions were expanded by N/2 pixels and outline of the lungs were extracted. In order to check matching between original and output image of the neural network. The output image was overlapped on original image after the post-processing. Overlapped image is shown in Fig.3. Gray scale image (Fig.4) of the lungs was subtracted from the original image (Fig.1) using the output image (Fig.2) of the neural network. These image processing were carried out for all slices of MDCT images and 3- dimensional images of the lungs are displayed with volume rendering software as shown in Fig.5.

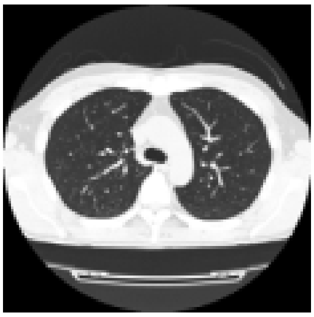

Fig.1 Original image

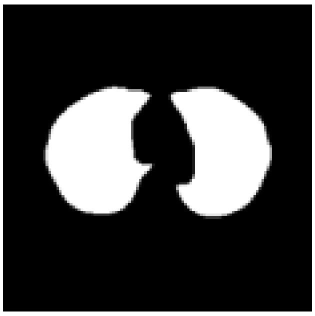

Fig.2 Output image(1)

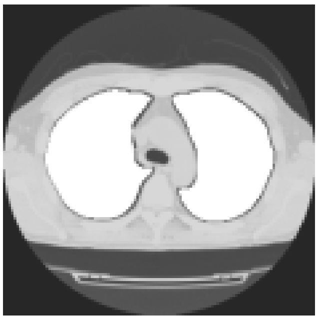

Fig. 3 Overlapped image

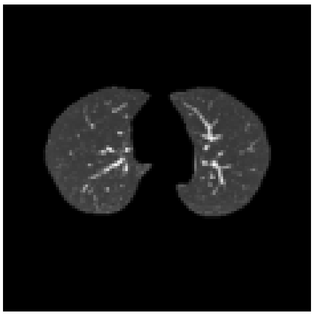

Fig.4 Subtraction image(1)

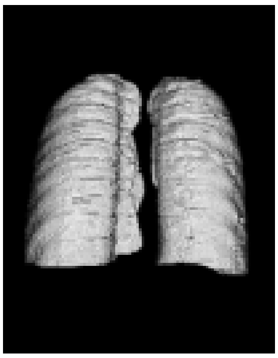

Fig.5 3-dimensional image of the lungs

3.2 Image recognition of the pulmonary vessel and bronchial tree regions

Gray scale image shown in Fig.4 was used as a new original image to organize second neural network. The organized neural network recognizes the outlines of pulmonary vessels and bronchial trees and outputs the regions of them. Figure 6 shows the output image of second neural network. Then, the gray scale images (Fig.7) of the pulmonary vessels and bronchial trees are extracted from the new original image (Fig.4) using the output image (Fig.6) of the neural network. These image processing were carry out again to all slice images of the MDCT. Then, 3-dimensional images were displayed by the volume rendering software using these gray scale images of the pulmonary vessels and bronchial trees. By these procedures, the regions of pulmonary vessels and bronchial trees were recognized and extracted accurately by the neural network.

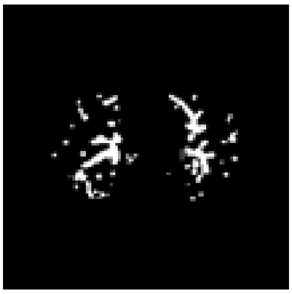

Fig.6 Output image(2)

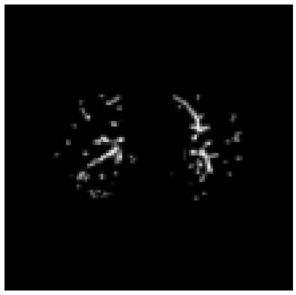

Fig.7 Subtraction image(2)

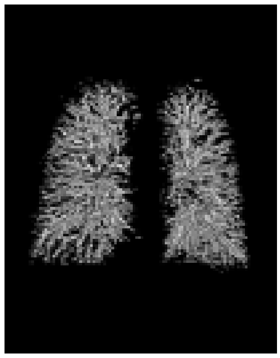

Fig.8 3-dimensional image of the pulmonary vessels and bronchial trees

4 Conclusion

In this study, the neural networks trained using the back propagation algorithm were applied to the 3-dimensional medical image recognition of the lungs, the pulmonary vessels and bronchial trees and 3-dimensional images were displayed accurately. These image recognition procedures using the artificial neural networks can be applied easily to another medical image such as the MRI.

References

[1] T.Kondo, J.Ueno and K.kondo, "Revised GMDH-type neural networks using AIC or PSS criterion and their application to the medical image recognition", *Journal of advanced computational intelligence and intelligent informatics*, Vol.9, No.3, pp.257-267,2005.