A Deep Learning Based Automatic Classification Algorithms Used for Pulmonary Veins and Arteries Separation in CT Images

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***Abstract*: Nowadays most of patients are suffering from pulmonary vascular diseases which can cause pulmonary emboli or pulmonary hypertension. Manual as well as automatic analysis of chest CT image of the sick personis carried out for diagnosing changes in vascular trees. Manual analysis of CT scan takes more time,is not standardized, and is also tiresome. So semi-automatic and automatic separation of vascular trees in CT images is nowadays used, which can help doctors to accurately detect abnormal conditions. Different methods for detection and classification of pulmonary vascular diseases using deep learning are discussed in this review paper.**

Index Terms: vascular disease, deep learning, automatic classification

I. INTRODUCTION

Computerized tomography based images are used for detection of vascular diseases[1].X-ray machines and computers are used in CT scan to produce images of cross-sections of the body and they give a lot of information than X-ray images. CT images project the soft tissues and arteries and veins in different regions of the body. Segmentation of vascular trees in CT images is used for accurate diagnose of pathological conditions like pulmonary emboli, pulmonary hypertension etc. Also ability of vascular tree separation opens opportunity for studying relation with different diseases ad genotypes. For diagnosing variations in vascular trees manual segmentation and classification was done earlier but its time consuming and not standardized. Semi-automatic and automatic separation of lung vascular trees from CT images is interesting field which help doctors to find disease conditions out and other discharges during thetreatment procedures. There are several methods used to intensify or segment arteries and veins from pulmonary CT images.

Revised Manuscript Received on May 30, 2019.

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II. IMAGE SEGMENTATION

Image segmentation refers to the method of dividing a picture to various groups of pixels. Purpose of segmentation is to reduce the projection of picture into a significant and simpler way to interpret image which discover borders and information in picture by allocating a name to each pixel of picture so that picture elements with alike labeling use almost similarcharacteristics. Segmentationproves to be difficult process and steps of segmentation include finding particular set of CT dataset, allocating values for possible parameters, running algorithms and validating results.

Different image segmentation algorithms are used for separating regions based on presence of edges or clusters[2][5].Threshold segmentation is simplest segmentation method in which an optimal threshold is automatically determined based on predefined criteria. Region growth segmentation mixes pixels with alike characteristics to form the area ie first select a simple prominent pixel at growth point and combine neighborhood area with alike properties of pixel in its region. Edgesegmentation usesdissimilar areas with color difference at edges to implement segmentation. Segmentation based on clustering segments picture elements in image space with similarproperties. Segmentation based on supervised learning is one in which training data which is known is taken and images are trained to do segmentation. Unsupervised learning algorithms does not involve supervision by critic

III. IMAGE CLASSIFICATION

The image classification follows preprocessing,segmentation and feature extraction. Image classification is used to classify artery and vein from vessel segmented images and is necessary step in pattern recognition. Various image classification algorithms are used for semi-automatic and automatic classification of images. In supervised ANN based image classification training takes place through known group of pixels. Unsupervised ANN based image classification uses properties of pixel to group and here trained pixels are not available. In SVM(Support Vector Machine)each unit is represented by a point in ‘n’ dimensional space and worth of every attribute is denoted by particular co-ordinate and then items are divided into classes by finding hyperplane. It is a good choice to segregate

two classes. Decision tree is used to split samples of datasets into homogenous sets.One of the recently used algorithms use a morphological multiscale opening operator[3].A newly developed fully automatic algorithm using energy minimization is also used nowadays[4].In[5]concept of graph cut minimization and local information is used. At present fully automatic algorithm using CNN[6]approach is used.CNN uses neurons that have learnable weights and biases.

IV. VASCULAR IMAGE SEPERATION

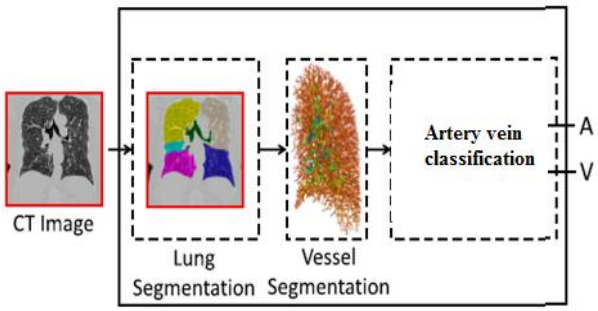

Fig1(a)Block diagram for vascular image segmentation and classification

First step is image acquisition in which CT scan image of the person is taken .Vascular image segmentation involves first lung segmentation from CT image followed by vessel segmentation.After vessel segmentation image classification is performed. It is done using deep learning based image classification algorithms in which the artery and veins are separated.Next image optimization is performed using optimization algorithms to get refined results.

V. DEEP LEARNING FOR VASCULAR TREE CLASSIFICATION

Deep learning is an extension of machine learning concepts which focus on learning data denotations, compared to task-specific algorithms and is based on algorithms developed based on the arrangement of parts and purpose of the brain referred to as artificial neural networks. Deep learning is based on the concept of artificial intelligence (AI) which is concerned with using the learning approach that humans use to achieve certain levels of knowledge. The various learning approaches aresupervised, semi-supervised or unsupervised. Multilayer neural networks based algorithms are commonly used for deep learning.Multilayer network consists of several a number of hidden layers in addition to input and output layer. Hidden layer changes overall representation of system. Different types of neural networks used for deep learning are based on Artificial neural network, Convolutional Neural Network and Fully Convolutional Neural Network.

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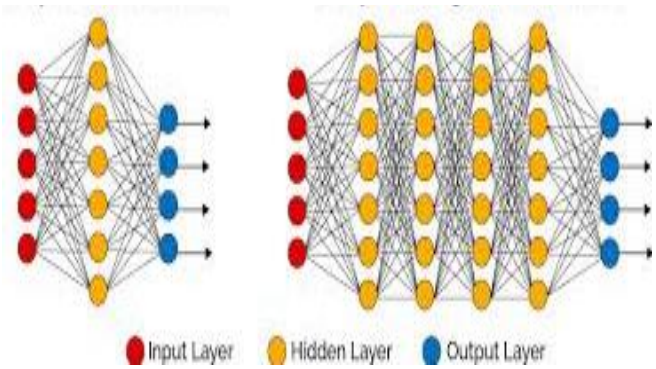
A. Artificial Neural Network

An **Artificial neural network** consists of basic input layer, hidden layer and output layer. The output from hidden layer is fed to hidden layer and from hidden layer to output layer.



(a) (b)

Fig 2(a)Simple Neural Network (b)Deep Learning Neural Network

B. Convolutional Neural Network

Convolutional neural network (CNN) refers to a class of neural networks, which is normally used to analyze images.CNNsrequire minimal preprocessing as they use a variation of multilayer perceptrons in design

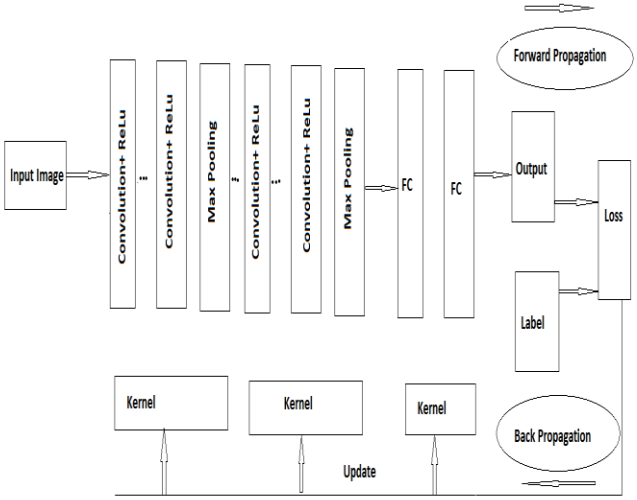


Fig3(a)Image classification using Convolutional Neural network

For pulmonary vascular image classification using CNN the layers used are input layer, convolutional layer, activationlayer, pooling layer and fully connected layer(FC).Information of the pixel values of the input image with any value [64x64x3](Pictureconsists of dimensions 64X 64, and Red,Green,Blue channels) is carried out by input layer into convolutional layer. Convolutional layer forms the foundation layer which follows input layer. It will calculate the outputbased on convolution of inputs and their weights .Based on the filter selected the volume is calculated. If we select 24filtersvolume is [64x64x24].The activation layer apply thresholding at zero. Ittherefore makes up no change in volume. ([64x64x24]).Maximum

Pooling layer follows the activation layer and performssampling operation which lower its volume size along the dimensions [32x32x24].

Convolutional Neural Network [6] consists of neural network which is having convolutional layers with FC layers seen at the output. The disadvantage of CNN is that it is not adaptive.It cannot be applied to the network to images of virtually any size. Higher computational cost and representation power is also needed.Another disadvantage of CNN is that loss of spatial information due to presence of fully connected layers.

Supervised learning algorithm using CNN for training multi-layer neuralnetworks uses forward and back propagation methods.Back propagation algorithm inputsthe values andmeasure the error and sends it back . Actuallyforward-propagation forms a portion of the algorithm which comes before back-propagation.Feedback output obtained from back propagation is applied to kernel after being updated

C. Fully Convolutional Network

A fully convolutional neural network (FCN)[7] is one where all the learnable layers are convolutional, so it doesn't have anyfully connected layer. If Fully connected layer in present in network,the network can be applied to images ofvirtually any size. Lower calculation rate and denotation power are the other advantages of FCN. In FCN loss is minimum as it is not fully connected. A fully convolutional network tries to get knowledge representations and arrive at conclusion basedon local input as its adaptiveand has learning filters.

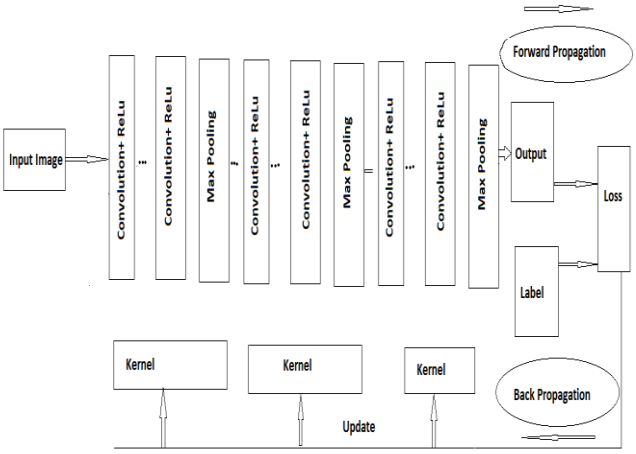


Fig4(a)Image classification using Fully Convolutional Neural network

For pulmonary vascular image classification using CNN the layers used are input layer, convolutional layer, activation layer,pooling layer .Information of the pixel values of the input image with any value [64x64x3](Pictureconsists of dimensions 64X 64, and Red,Green,Blue channels) is carried out by input layer into convolutional layer.Convolutional layer forms the foundation layer which follows input layer. It will calculate the output based on convolution of inputs and their weights .Based on the filter selected the volume is calculated .Based on the filter selected the volume is calculated.If we select 24filtersvolume is [64x64x24] .The activation layer which apply thresholding at zero. Ittherefore leaves the size of the volume unchanged ([64x64x24]).Maximum Pooling layer follows the activation layer and performssampling operation which lower its volume size along the dimensions[32x32x24].

Supervised learning algorithm using CNN for training multi-layer neuralnetworks uses forward and back propagation methods.Back propagation algorithm inputsthe values andmeasure the error and sends it back . Actuallyforward-propagation forms a portion of the algorithm which comes before back-propagation.Feedback output obtained from back propagation is applied to kernel after being updated

VI. IMAGE OPTIMIZATION

After classifying artery and veins next step is image optimization. Types of optimization techniques used are Graph cut optimization algorithm which calculate local minimum value even when very large changes are allowed[8].Also optimization based Random forest algorithmalso is used. Optimization algorithm reduces size and storage space of image without sacrificing quality.Moreover the advantage of optimization isless bandwidth is used by small file sizes image.

VII. CONCLUSION

Manual analyses of CT images are time consuming and tedious and so semi-automatic and automatic analysis is done for vascular tree separation. Most of Automatic analysis algorithms cannot be used for varying image conditions. Moreover automatic classification algorithm using CNN fails to segment isolated vessels and it also fails in large vessels compared to vessels of medium size. So FCN based algorithms are CNN based algorithms are compared and reviewed here.

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