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Automatic Detection of Diabetic Retinopathy from Color Fundus Retinal Images

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Abstract- The influence and impact of digital images on modern society is tremendous, and image processing is now a critical component in science and technology, in which Image segmentation plays a crucial role in many medical imaging applications. Medical image segmentation has a vital role in diagnosis, surgical planning, navigation, and various medical evaluations. Moreover it is suitable for segmenting the blood vessel of retinal images which is used for automated screening of early diabetic retinopathy (damage to the retina) detection caused by complications of diabetes mellitus, which can eventually lead to blindness. One of the main challenges in medical image processing is to segment the blood vessel with higher accuracy rate hence we propose a novel technique to increase the accuracy rate of segmenting the blood vessel.

Keywords *– Diabetic retinopathy (DR), Diabetes mellitus,Accuracy, Blood vessel segmentation*

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1. Introduction

One of the techniques in image processing is image segmentation.. It is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, It is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. It is a collection of methods allowing interpreting spatially close parts of the image as objects. The purpose of image segmentation is to partition an image into meaningful regions with respect to a particular application. It is based on measurements taken from the image and might be grey level, colour, texture, depth or motion. The inevitable need for image segmentation is to analyze the blood vessel images in retina. Blood vessel is one of the most important features in retina and it is also used as landmarks for registration of retinal images of a same patient gathered from different sources. Over the past decade, the retinal image analysis has been widely used in medical community for diagnosing and monitoring the progression of diseases. Examination of blood vessels in the eye allows detection of eye diseases such as diabetic retinopathy which leads to complication of diabetes and cause of blindness. It occurs when diabetes damages the tiny blood vessels inside the retina, the light-sensitive tissue at the back of the eye. Hence the blood vessel segmentation is the suitable tool for detecting the diabetic retinopathy in retinal images. Segmentation of blood vessels in retinal images is very important in early detection and diagnosis of many eye diseases. It is an important step in screening programs for early detection of diabetic retinopathy. Methods for blood vessels segmentation of retinal images, according to the classification method, can be divided into two groups - supervised and unsupervised methods. The supervised methods require a feature vector for each pixel and manually labeled images for training the algorithm. To classify the pixel as vessel or non-vessel the supervised method uses different classifiers. Finally, the accuracy rate is measured based on the pixel classification

The rest of the paper is organized as follows: Section 2 introduces the proposed method of blood vessel segmentation using supervised method. Section 3 presents related work on blood vessel segmentation. In Section 4 describes about result analysis and Section 5 describes the conclusion.

2. Proposed Vessel Classification Method

2.1 Preprocessing

This preprocessing approach is proposed to reduce the imperfections like lighting variations, poor contrast and noise and generate images more suitable for extracting the pixel features demanded in the classification step, a preprocessing comprising the following steps is applied: 1) vessel central light reflex removal, 2) background homogenization, and 3) vessel enhancement.

2.1.1 Vessel Central Light Reflex Removal

The first preprocessing step is the Vessel Central Light Removal. The high resolution fundus photographs often display a central light reflex. The light reflex of the retinal vessel is formed by the reflection from the interface between the blood column and vessel wall. Since retinal blood vessels have lower reflectance when compared to other retinal surfaces, they appear darker than the background. Some blood vessels include a light streak (known as a light reflex) which runs down the central length of the blood vessel. To remove

this brighter strip, the green plane of the image is filtered by applying a morphological opening using a three-pixel diameter disc, defined in a square grid by using eight-connexity, as structuring element.

2.1.2 Background Homogenization

The second pre processing step is the Background Homogenization. In this the fundus images often contain background intensity variation due to non uniform illumination .Hence background pixels may have different intensity for the same image and, their gray-levels are usually higher than those of vessel pixels .The intensity values of some background pixels is comparable to that of brighter vessel pixels. A background image is produced by applying a mean filter. Firstly, a 3x3 mean filter is applied to smooth occasional salt-and-pepper noise. Further noise smoothing is performed by convolving the resultant image with a Gaussian kernel of dimensions Here the shade-correction algorithm is proposed to reduce background intensity variations and enhance contrast in relation to the original green channel image.

2.1.3 Vessel Enhancement

The Vessel Enhancement is the final preprocessing step. It consists on generating a new vessel-enhanced image. This vessel-enhanced image is more suitable for further extraction of moment invariants-based features. Vessel enhancement is performed by estimating the complementary image of the homogenized image. Here the morphological Top-Hat transformation is used to enhance the vessels in retina of the eye, in which it uses morphological opening operation using a disc of eight pixels in radius.

2.2 Feature Extraction

Here the feature extraction is proposed for the reprocessed image. The aim of the feature extraction stage is pixel characterization by means of a feature vector, a pixel representation in terms of some quantifiable measurements which may be easily used in the classification stage to decide whether pixels belong to a real blood vessel or not. Here the following set of features are extracted namely gray-level based features and moment invariants based features.

2.2.1 Gray-level-based features

Gray level features are based on the differences between the gray-level in the candidate pixel and a statistical value representative of its surroundings. Here five gray-level features are extracted for pixel representation.

2.2.2 Moment invariants-based features

This feature is based on moment invariants for describing small image regions formed by the gray-scale values of a window centered on the represented pixels. Here two moment invariants-based features are extracted for pixel representation.

2.2.3 Texture Based feature

After extracting these two features the *AM-FM* method is proposed to extract the texture based features from the fundus image. These features are given as the input for classifying the blood vessels of retinal image.

2.3 Classification

Here the classification approach is based on the neural network approach as shown in Figure 1. A classification procedure assigns one of the classes (vessel) or (non vessel) to each candidate pixel when its representation is known. In order to select a suitable classifier, the distribution of the training set data in the feature space was analyzed. Two classification stages can be distinguished: a design stage and an application stage. The first stage is design stage in which the NN configuration is decided and the Neural Network is trained, and the second stage is application stage, in which the trained Neural Network is used to classify each pixel as vessel or non-vessel to obtain a vessel binary image, in which the binary value 1 which indicates vessel and binary value 0 which indicates non-vessel.

2.3.1 Neural Network Design

A feed forward neural network is a biologically inspired classification algorithm. It consists of a (possibly large) number of simple neuron-like processing units, organized in layers. Every unit in a layer is connected with all the units in the previous layer. These connections are not all equal; each connection may have a different strength or weight. The weights on these connections encode the knowledge of a network. Often the units in a neural network are also called nodes. A multilayer feed forward network, consisting of an input layer, three hidden layers and an output layer. The input layer is composed by a number of neurons equal to the dimension of the feature vector (seven neurons). Regarding the hidden layers, several topologies with different numbers of neurons were tested. A number of three hidden layers, each containing 15 neurons, provided optimal NN configuration. The output layer contains a single neuron and its output ranges between 0 and 1.

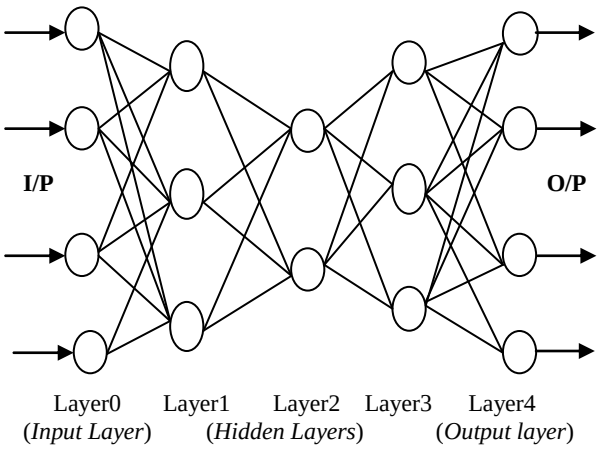

Figure 1. Feed Forward Network

2.4 Post Processing

The post processing step is used to improve the accuracy rate of classifying the retinal images. Classifier performance is enhanced by the inclusion of a two step post-processing stage: the first step is aimed at filling pixel gaps in detected blood vessels, while the second step is aimed at removing falsely detected isolated vessel pixels. From visual inspection of the NN output, vessels may have a few gaps (i.e., pixels completely surrounded by vessel points, but not labeled as vessel pixels). To overcome this problem, an iterative filling operation is performed by considering that pixels with at least six neighbors classified as vessel points must also be vessel pixels. Besides, small isolated regions misclassified as blood vessel pixels are also observed. In order to remove these artifacts, the pixel area in each connected region is measured.

3. Related Work

Most of the previous works on blood vessel segmentation and its accuracy rate is specified.

In [1],Mohammed al-rawi et al. proposed the an improved matched filter for blood vessel detection of digital retinal images, in which the blood vessels are detected in retina of the eye using an improved matched filter.

In[2],Subhasis Chaudhuri et al. proposed the Detection of Blood Vessels in Retinal Images Using Two-Dimensional Matched Filters, in which blood vessels in retinal images are detected using two dimensional filters.

In[3],G G Gardner, et al. proposed the automatic detection of diabetic retinopathy using an artificial neural network, in which the diabetic features are detected in fundus images with help of neural network.

In[4], Xiaohong Gao et al. proposed the Vessel Diameter Measurement on Retinal Images, in which the diameter of the vessel at the cross section can be calculated using twin Gaussian functions.

In[5],Adam Hoover et al. proposed the Locating Blood Vessels in Retinal Images by Piecewise Threshold Probing of a Matched Filter Response, in which the novel method is proposed to locate the blood vessels in images of the ocular fundus.

In[6],Huiqi Li et al. proposed the Automated Feature Extraction in Color Retinal Images by a Model Based Approach, in which the features of blood vessels are extracted in color retinal images using Novel methods.

In[7],Ana Maria Mendonça, et al. proposed the Segmentation of Retinal Blood Vessels by Combining the Detection of Centerlines and Morphological Reconstruction, in which the vascular network in retinal images are segmented using novel method.

In[8],Meindert Niemeijer et al. proposed the Automatic Detection of Red Lesions in Digital Color Fundus Photographs which can detect images containing red lesions with a very high sensitivity

In[9], Joes Staal et al. proposed the blood vessel segmentation based on edges which is mainly used for the purpose of screening the diabetic retinopathy.

In[10],Yannis A. Tolias et al. proposed the Fuzzy Vessel Tracking Algorithm which is used for detecting the vessels in Retinal Images Based on Fuzzy Clustering.

4. Result Analysis

To validate our analysis, we have to implement blood vessel segmentation in retinal image by using MATLAB and by performing a serious of simulation based experiments to test its effectiveness.

In Figure 2, the input image is obtained from the Drive database. From the experimental result, we can see that the vessel central light reflex is removed from the fundus image by means of opening filtering operation is shown in Figure 3.

In Figure 4, the background lightening variations are removed by using 3x3 mean filter which is used to smooth salt-and-pepper noise and the noise smoothing is performed by convolving the resultant image with a Gaussian kernel

In Figure 5, the vessel is enhanced from homogenized image after the noise is removed

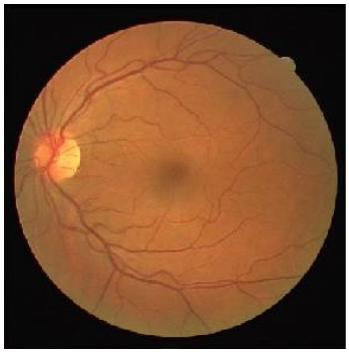

Figure 2.Input Image

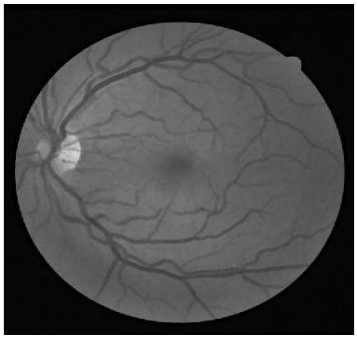

Figure 3. Vessel Central Light Reflex Removal

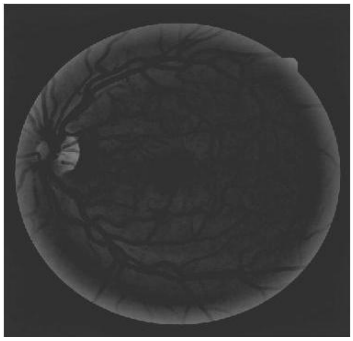

Figure 4. Homogenized Image

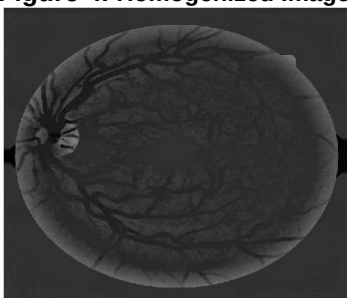

Figure 5. Vessel Enhanced image

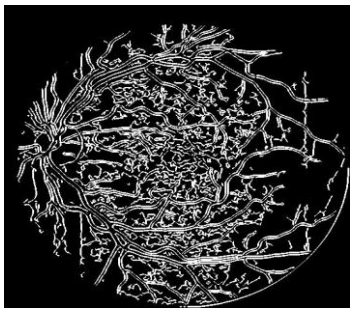

Figure 6. Segmented Blood Vessel

From the above experimental results, the proposed method effectively improved.

5. Conclusion

In the existing approach, the non-blood vessels in retinal image might be misclassified as vessel. Hence, the accuracy rate of the blood vessel segmentation is significantly reduced .In this paper we have analyzed the blood vessel segmentation and its accuracy rate in retinal images, therefore the AM-FM method is used in blood vessel segmentation to efficiently increase the accuracy rate, so it can be used for early diabetic Retinopathy detection.

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