Automatic Detection of Abnormalities in Retinal Blood Vessels Using DTCWT, GLCM Feature Extractor and CNN-RNN Classifier

Revathi priya Muthusamy, S. Vinod, Assistant Professor, M. Tholkapiyan,Professor

Abstract: In worldwide, retinal diseases are found to be frequent cause of blindness for working age population in western countries. So, early diagnosis can prevent the blindness. We develop a system for the early diagnosis of retinal disease. The images with different colour variation inside the eye is compared by using images taken laser camera with high definition. These images are termed as fundus images. Images processing technologies are employed as follows: The feature extraction of the fundus images can be obtained by using the software tool MATLAB. Automatic screening will help to quickly identify the condition of the patients in a more accurate way. The 4-level discrete wavelet transform is used to decompose the image into various sub-bands. The textural features had been calculated using GLCM features, and the classification is done by using CNN-RNN Neural networks. The processed output will be displayed using Matlab GUI. Experimental result proves that the abnormality in the blood vessels and exudates can be effectively detected by applying this method on the retinal images. 76% of test cases are correctly classified.

Keywords: Retinal, Funds image, MATLAB, DTCWT, GLCM, CNN-RNN.

I. INTRODUCTION TO RETINA AND BLOOD VESSELS

Fig 1. Undilated Pupil and Fundus image

Retina is the tissue which senses light, it lies in the backside of the eye.

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II. IMAGE PROCESSING USING DTCWT, GLCM AND RNN

Fig 2 Flowchart-Image processing of abnormalities in Retina

Image Pre-processing:

In this step, the retinal image is taken as an input and processed to RGB plane separation. Preprocessing consists of de-noising and enhancement steps. De-noising refers to the process employed for removing the noise that exists in the image; enhancement indicates a process used for increasing the image contrast. Here, the input image has speckle noise.(1) The speckle noises generally degrades segmentation process and decreases image quality. It will increase the difficulties of image segmentation. So the speckle noise should be removed to achieve the accurate segmentation. For removing the speckle noise, median filter is exploited for removing the speckle noise. The filter process is given below. Median filter is used to de-noising and smoothen the image without removing edges or sharp features in the images (3). After de-noising, the input image is re-sized to the particular dimension. The input image has separated into red, green and blue planes from this the green plane is taken as an input for next level processing.
The grey level co-occurrence matrix of all sub-band’s are calculated to arrive at resulting values which can be processed to arrive at the Final result of the feature vector.

In the above proposed method, DT-CWT dual tree - complex wavelet transform has to be first employed onto the raw image and we can obtain the sub-images at six different directions. After which the GLCM calculation is done for each sub image and thus the final resultant feature vector is constructed. This experimental results shows that this proposed method can achieve better accuracy with high texture classification than other conventional method and has the property of robustness.

**Classification**

The classification is done by using neural networks, here we will be using combination of convolutional neural networks with Recurrent Neural networks concepts (2). CNN detects patterns and makes sense out of them. CNN has Hidden layers called convolution layers, convolutional layers transforms the signal and passes on to the next layer. With each convolution layer, we specify the number of filters. Filters are used detect the patterns. The patern may be edges, corners, circles or squares. More sophisticated objects like ear, eyes can be detected. The output of the convolution layer is passed as input to the filters of the next layer.

The main use of Recurrent neural network is in the field of image recognition. The RNN is a network which has recurrent network connections. The traditional feed forward neural network does not provide good results for Times series/ sequential data such as Stock prices, video streams etc. They do not model memory. (6) RNN captures information from sequences and time series data. They can work with variable size input and work with variable size data. The concepts of Convolution neural network is also incorporated by adding recurrent connections to each convolutional network layer. This can also be called as recurrent convolution layers (RCL).

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**Feature extraction:** Dual Tree - Complex Wavelet Transform (DTCWT), enhanced directional selectivity and phase information properties of redundant CWT results in the super-resolved image. By using dual tree wavelet transform, the input image had been decomposed into sub-bands, these sub-bands is further fed as a input for GLCM (Grey level co-occurrence matrix) feature extraction which is a texture based feature descriptor.

**Fig 4 . Basic structure of a Recurrent Neuron**

RNN recursive formula

\[ S_t = F_w(S_{t-1}, X_t). \]

\[ X_t - Input \ at \ time \ step \ t \]

\[ S_t - State \ at \ time \ step \ t \]

\[ F_w - Recursive \ Function \]

RNN learns using Back propagation through time. RNN uses three to four layers maximum.

**Dataset:**

The dataset downloaded form the database of Indian Diabetic Retinopathy Image Dataset (IDRIID) and two public datasets STARE and DRIVE were used.

**III. EXPERIMENTS AND RESULTS**

100 images were used for training the tool using the training function TRAINSCG. We can evaluate our techniques by calculating three metrics: (i) Root- Mean Square Error (RMSE) (ii) Pearson Correlation Co-efficient (CC) and (iii) Concordance Correlation Co-efficient (CCC). The Concordance Correlation Coefficient calculates and measures the agreement between the two variables using the below expression:

\[ \rho_c = \frac{2\sigma_x \sigma_y}{\sigma_x^2 + \sigma_y^2 + (\mu_x - \mu_y)^2} \]

where \( \rho \) is Pearson correlation co-efficient, \( \sigma^2 x, \sigma^2 y \) variance of the predicted , ground truth value respectively , \( \mu_x, \mu_y \) – respective means. The highest CCC value can be used to select the strongest method

**Table 1. Comparison of Performance between:**

<table>
<thead>
<tr>
<th>Method</th>
<th>RMSE</th>
<th>CC</th>
<th>CCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline [13]</td>
<td>0.147</td>
<td>0.358</td>
<td>0.273</td>
</tr>
<tr>
<td>CNN</td>
<td>0.121</td>
<td>0.341</td>
<td>0.242</td>
</tr>
<tr>
<td>CNN+AD</td>
<td>0.113</td>
<td>0.426</td>
<td>0.326</td>
</tr>
<tr>
<td>CNN+AD</td>
<td>0.125</td>
<td>0.349</td>
<td>0.270</td>
</tr>
<tr>
<td>CNN+AD</td>
<td>0.118</td>
<td>0.405</td>
<td>0.309</td>
</tr>
<tr>
<td>CNN+RNN - tanh</td>
<td>0.111</td>
<td>0.518</td>
<td>0.492</td>
</tr>
<tr>
<td>CNN+RNN - RelU</td>
<td>0.108</td>
<td>0.554</td>
<td>0.506</td>
</tr>
</tbody>
</table>

**Table 2: CNN RNN performance with increasing no. of layers**

<table>
<thead>
<tr>
<th>Method</th>
<th>RMSE</th>
<th>CC</th>
<th>CCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNN+RNN - W=100 - 1 layer</td>
<td>0.107</td>
<td>0.553</td>
<td>0.481</td>
</tr>
<tr>
<td>CNN+RNN - W=100 - 2 layers</td>
<td>0.111</td>
<td>0.514</td>
<td>0.459</td>
</tr>
<tr>
<td>CNN+RNN - W=100 - 3 layers</td>
<td>0.106</td>
<td>0.565</td>
<td>0.489</td>
</tr>
</tbody>
</table>
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