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

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***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

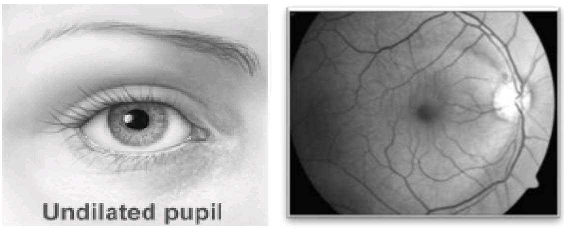


Fig 1. Undilated Pupil and Fundus image

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

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Retinal relays the images to the brain A healthy retina helps us to read, drive and see finer details around us. (7). A disease in retina affects this tissue and may even cause blindness. The most common retinal disease are Glaucoma, diabetic retinopathy, floaters and the retinitis pigmentosa. **Fundus Imaging-** Fundus Image is captured using a camera which is attached with a specialized low-power microscope. Ophthalmologists can use these retinal images for diagnosis and treatment of eye diseases.

## 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 a 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 a input for next level processing.

**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 an texture based feature descriptor. 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.

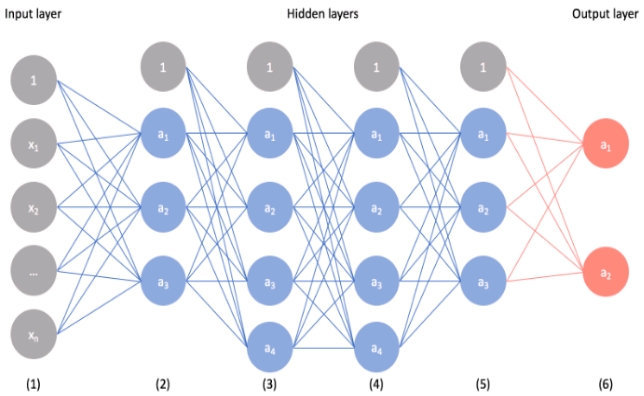


**Fig 3. Convolutional neural network**

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).

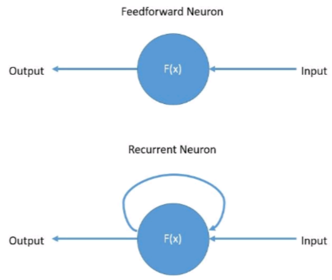


**Fig 4 . Basic structure of a Recurrent Neuron**

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 (IDRiD) 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:

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

where ρ is Pearson correlation co-efficient, σ 2 x , σ 2 y variance of the predicted , ground truth value respectively , μx, μy –respective means. The highest CCC value can be used to select the strongest method

| Method | RMSE | CC | CCC |
|---|---|---|---|
| Baseline [13] | 0.117 | 0.358 | 0.273 |
| CNN | 0.121 | 0.341 | 0.242 |
| CNN+D | 0.113 | 0.426 | 0.326 |
| CNN+A | 0.125 | 0.349 | 0.270 |
| CNN+AD | 0.118 | 0.405 | 0.309 |
| CNN+RNN - tanh | 0.111 | 0.518 | 0.492 |
| **CNN+RNN - ReLU** | **0.108** | **0.544** | **0.506** |

Table 1. Comparision of Performance between: (i) Baseline method (ii) CNN having Single frame with different regularization levels (iii) CNN having Single frame with RNN A = Data Augmentation and D = Dropout.

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

| Method | RMSE | CC | CCC |
|---|---|---|---|
| CNN+RNN - W=100 - 1 layer | 0.107 | 0.553 | 0.481 |
| CNN+RNN - W=100 - 2 layers | 0.111 | 0.514 | 0.459 |
| **CNN+RNN - W=100 - 3 layers** | **0.106** | **0.565** | **0.489** |

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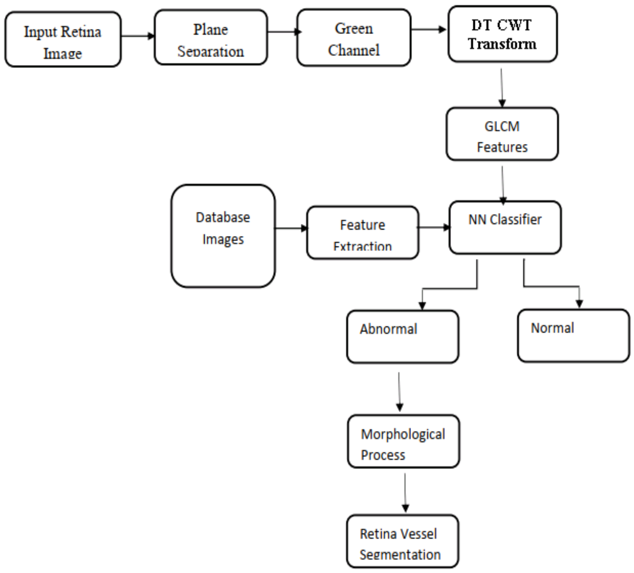


**Fig 5. Process flow diagram of Image processor with Pre-processing, feature extraction and Classifier.**

## IV. DEEP LEARNING USING MATLAB SOFTWARE

Requirement Specification:
(i). Retinal Images for Training and Quality testing.
(ii). Software Requirement

- MATLAB 7.5 and above versions
- Deep Learning Toolbox

MATLAB software can be used to in Image processing such as to remove the noise in image, produce high resolution image from low quality image using Convolution nueral network.

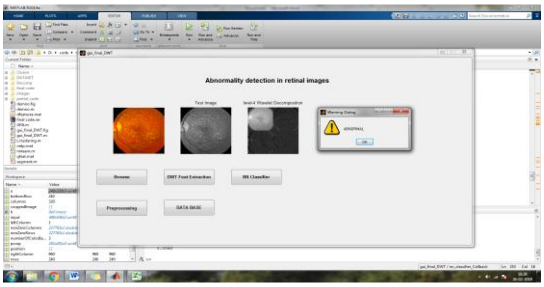

**Fig 6. MATLAB GUI of the proposed system.**

## V. CONCLUSION

In this work, we have pre-processed the image to separate the Green plane of the image, de-noised and fed the signals to DTCWT and GLCM feature extraction process followed by the CNN-RNN neural network for classification. The Network is prior trained with the dataset using Deep learning techniques of MATLAB functions for the detection of normal and abnormal images. The output is displayed in MATLAB GUI. Our model has achieved better performance compared to other state-of-the-art image processing systems.

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**Revathi priya Muthusamy** was born in Coimbatore, Tamilnadu, India in 1982. She received her Bachelors degree in Electronics and Communication Engineering from Bharathiar University, India in 2003. In 2003 she joined as Software Engineer in Information technology field and she has around 8 years of experience in SAP ABAP Programming. She is currently studying Master of Engineering in Computer Science and Engineering at VelTech Multi Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai, Tamilnadu, India. She has also presented a Seminar in University of Freiburg, Switzerland in Image processing and Human Computer Interface and did courses on Web Engineering, Human Computer Interface and Pervasive Computing. Her areas of interests includes Image processing, Human Computer Interface, Pervasive Computing, DBMS and Enterprise resource planning.

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