A Novel Approach for Detecting and Grading Diabetic Retinopathy using Wavelet Transform and Artificial Neural Network

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Abstract— Diabetic retinopathy (DR) is an eye disease that arises when fluid flow from blood vessels to retina. The initial recognition of DR is the best solution to limit the growth of this disease. In this paper we present an automated result finding system for early detection of diabetic retinopathy using artificial neural network (ANN) and discrete wavelet transform. A retrieval process will be developed by extracting features of query image using DWT and compare it with existing database of retina by using ANN. The presented system will reduces the professionals work to analyze every fundus image rather than diabetic affected image and develop a prototypical DR image management system to improve diagnostic performance.

Keywords— *Artificial neural network, DWT, Diabetic Retinopathy, retinal image.*

I. INTRODUCTION

Diabetes is a long term organ disorder that occurs when the level of blood sugar is huge as pancreas does not produce enough insulin in body or alternatively, cells do not react well to insulin [1]. Diabetic retinopathy is arises on diabetic patients which became major source of vision loss. After 10 years of diabetes about 20% of patients develop serious visual impairment. According to the study, the early finding of retinopathy stage can lower the danger of vision loss by 40% [2,3].

Normally diabetes is divided in two parts: Non Proliferate and Proliferate Diabetic Retinopathy. First phase of DR is NPDR in which blood vessels will start to damage and flow additional fluid into the eye. This phase includes microaneurysms (red dot), exudates (drop of fatty tissues), and hemorrhages (small spot of blood that flow in to retina) [4]. NPDR is again divided as mild, moderate or severe NPDR. Proliferate Diabetic Retinopathy is the situation in which retina's blood vessels is close & limiting the blood flow. PDR damage both vision peripheral and central which become the reason of serious vision loss [5-7].

The initial screening and up to date intervention is needed to control the growth of the disease. But the fact is the number of diabetic patients is very high as compared to the number of eye doctor, so there is a requirement of automated DR detection method so that only DR affected person refer to the doctor for treatment and analysis [8,9].

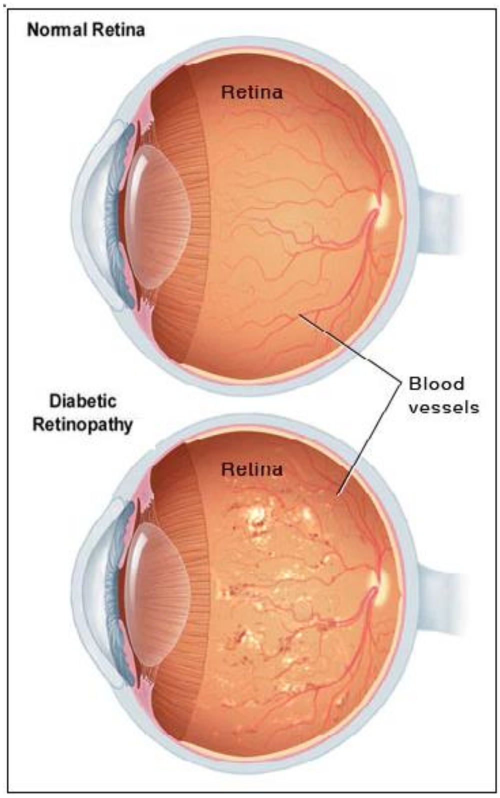

Fig.1. Retinal image

In this paper we propose an automated detection system to easily and effectively identify the stages of DR. For the detection process the artificial neural network is used that uses the identifier and wide number of training set for specific results.

II. PROPOSED SYSTEM

The objective of this research paper is to provide a method to perform a Diabetic retinopathy identification process using artificial neural network and discrete wavelet transform.

A. Artificial Neural Network

An Artificial Neural Networks (ANN) is the processing system which is modeled to simulate the way of human brain analyzing the information. ANN is the base of Artificial Intelligence and clarifies the issues that look impossible to solve by human or statistical measurements [10-12].

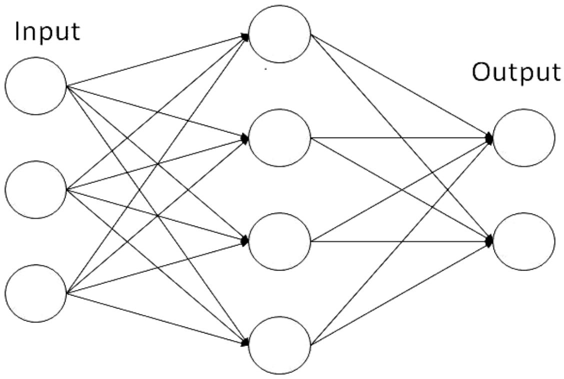

Fig 2. ANN dependency graph

Artificial Neural Networks are consisting of number of nodes that act like neurons of human brain. The neurons are joined and cooperate with each other by networks. Each node has the ability to take data input, process it and send it to next neuron. The result created at each node is known as node value. Data that move through the network can change the format of ANN as a neural network learn and develop on the basis of input & output [13,14].

B. Discrete Wavelet Transform

In our method DWT coefficients is used as feature vector. It is an analytical tool that is used to decompose and process an image [15,16]. In DWT transformation process is depend on number of small waves, known as wavelets, of shifted frequency and finite duration. It gives both frequency and spatial characterization of image.

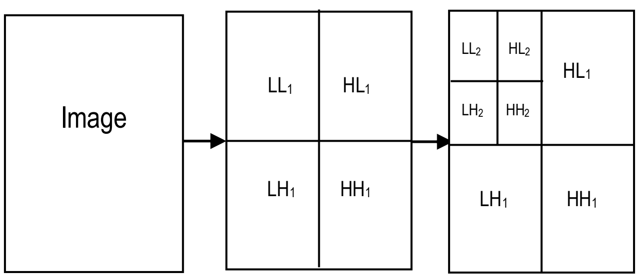

Fig. 3. Two-level discrete wavelet decompositions

DWT is the multi resolution characterization of an image that decode constantly from low to high resolution. It divides the image into low and high frequency element [17]. The high frequency has the information of corner elements and the low frequency is again divided into high and low frequency elements [19, 20]. A 2 level DWT operation is presented in the Fig 3.

C. Algorithm & Flow Chart

1) Input the query image.

2) Convert the RGB query image into Gray image.

3) Resize image to 256×256.

4) Decompose the image into four sub-images by applying Discrete Wavelet transform (DWT).

5) Calculate the energy, mean, Standard deviation and skewness of all decomposed images at the same scale [21], using:

Energy:

$$E = \frac{1}{N}\sum_{k,l}(P_{k,l})^2 \tag{1}$$

Mean:

$$M = \sum_{N}^{l=1}\frac{1}{N}P_{kl} \tag{2}$$

Standard deviation:

$$\sigma = \sqrt{\left(\frac{1}{N}\sum_{N}^{l=1}(P_{kl} - M)^2\right)} \tag{3}$$

Skewness:

$$S = \sqrt{\left(\frac{1}{N}\sum_{N}^{l=1}(P_{kl} - M)^3\right)} \tag{4}$$

Where P is the intensity of the pixel located at row k and column l and N is the total number pixel.

6) Create the retinal image database which contains images of various diabetic retinopathy signs.

7) Reading all the retinal images from database and repeat the step 3 to 6 for each and every database image.

8) Arranging them in a sorted order and on the basis of order label the relevant images

9) The labeled features and the feature database are used by the artificial neural network to retrieve the most relevant images.

10) Finally obtaining the most similar images as a result.

11) To measure performance of the system calculate precision and recall by following formulae [22]:

$$\text{Precision} = \frac{(\text{No.of retrieved images that are relevant})}{\text{Total no.of retrieved images}} \quad (5)$$

$$\text{Recall} = \frac{(\text{No.of retrieved images that are relevant})}{\text{Number of relevant images in the database}} \quad (6)$$

Fig.4 depicts the overall methodology in detection of diabetic retinopathy.

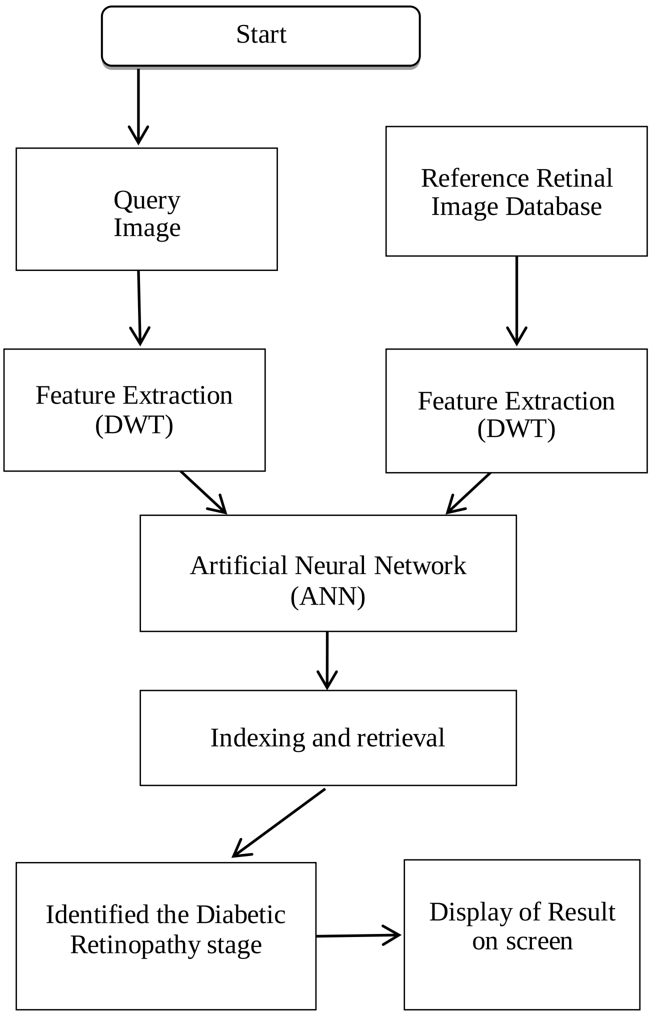

Fig.4. Flowchart of the proposed methodology

III. Experimental Results

The retinal image database which contains images of various diabetic retinopathy signs are collected from Aashirwad Laser & Phaco Eye Hospital Bilaspur. The patient's retina image (as shown in fig 5) and database images are applied on our detection program and their features are extracted by using DWT (as shown in fig.6).

Fig.5. Query Image

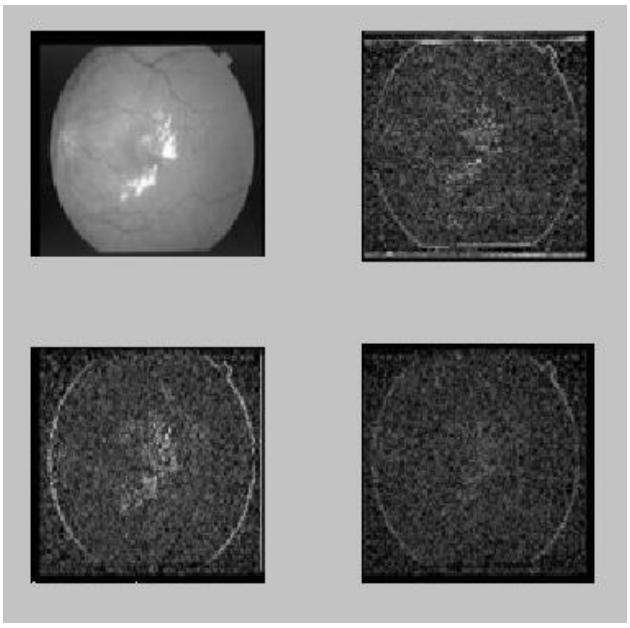

Fig.6. Wavelet Transform of Query Image

After that features point (energies, mean, standard deviation and skewness) of the query image and database images are calculated which is used by Artificial Neural Network to retrieve the most relevant images; we obtained the top 10 retrieval images (as shown in Fig. 7) which is all related to mild nonprolifrative diabetic retinopathy.

The table I shows the feature extracted value of retinal images.

TABLE I. EXTRACTED FEATURE POINTS OF RETINAL IMAGES

Img	Sub-band	Energy (E)	Mean (M)	Std (σ)	Variance (S)
Query	LL	39749.053	0.601	0.621	0.386
	LH	39.248	0.006	0.023	0.003
	HL	62.128	0.008	0.034	0.001
	HH	4.188	0.002	0.008	7.819e-05
DR_1	LL	39103.171	0.752	0.528	0.279
	LH	32.195	0.009	0.023	0.002
	HL	42.534	0.010	0.027	0.001
	HH	4.951	0.003	0.007	5.010e-05
DR_2	LL	39033.923	0.528	0.557	0.311
	LH	33.766	0.005	0.021	0.005
	HL	45.399	0.007	0.029	0.003
	HH	3.165	0.002	0.007	5.871e-05
DR_3	LL	38990.090	0.768	0.579	0.336
	LH	43.261	0.008	0.025	0.003
	HL	38.400	0.009	0.028	0.004
	HH	2.756	0.003	0.007	5.821e-05
DR_4	LL	38537.090	0.688	0.556	0.309
	LH	43.261	0.011	0.023	0.004
	HL	38.400	0.013	0.024	0.001
	HH	2.756	0.003	0.006	4.168e-05
DR_5	LL	37922.469	0.777	0.556	0.309
	LH	42.879	0.012	0.026	0.006
	HL	44.532	0.013	0.026	0.003
	HH	3.287	0.004	0.007	5.044e-05
DR_6	LL	37074.601	0.693	0.671	0.450
	LH	34.872	0.007	0.025	0.006
	HL	58.392	0.009	0.033	0.003
	HH	4.378	0.003	0.008	7.630e-05
DR_7	LL	36068.634	0.665	0.558	0.311
	LH	40.317	0.009	0.026	0.004
	HL	48.379	0.010	0.029	0.003
	HH	3.520	0.003	0.007	5.913e-05
DR_8	LL	36002.761	0.837	0.603	0.363
	LH	40.901	0.011	0.030	0.005
	HL	56.500	0.013	0.034	0.001
	HH	4.921	0.004	0.008	8.015e-05
DR_9	LL	35726.819	0.379	0.419	0.176
	LH	38.435	0.006	0.016	0.003
	HL	41.302	0.008	0.018	0.004
	HH	3.049	0.003	0.006	4.895e-05
DR_10	LL	35060.277	0.603	0.590	0.348
	LH	35.900	0.007	0.021	0.004
	HL	34.253	0.008	0.025	0.006
	HH	2.391	0.002	0.006	4.121e-05

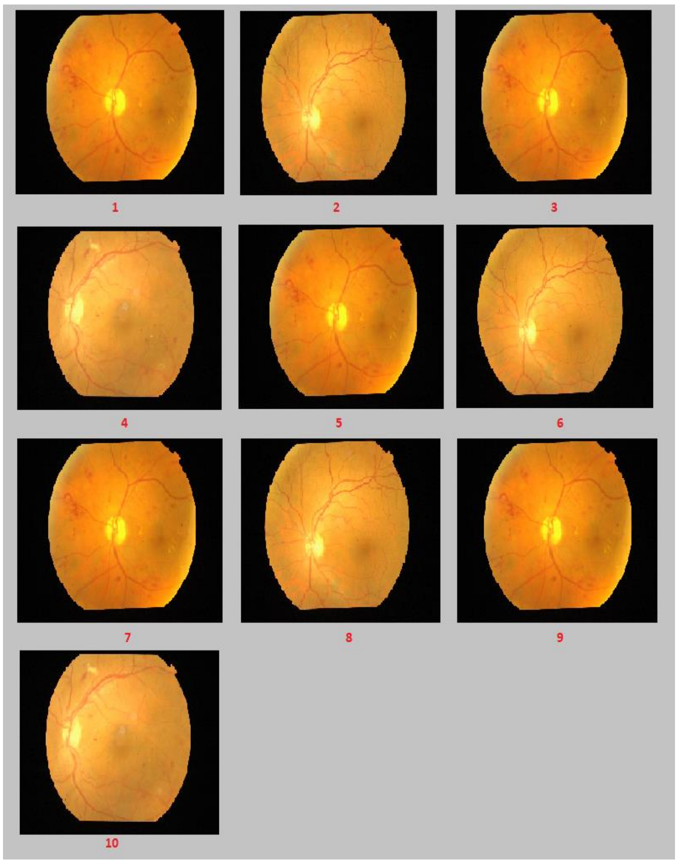

Fig.7. The Retrieve retinal images

The precision and recall is calculated as:

- Precision: 66%
- Recall: 59%

Displayed result: "Patient has Mild nonproliferative Diabetic retinopathy".

IV. CONCLUSION

We have presented automated DR examination system based on DWT and artificial neural network. The neural network provides the good and clear classification between the different levels of DR and DWT reduce the complex computational work to provide fast result. The experiment result shows that the finite numbers of retina image is retrieved with 66% precision and 59% recall rate to cut down the analysis time.

V. Acknowledgment

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