Applied Mathematics & Information Sciences
An International Journal

http://dx.doi.org/10.18576/amis/130610

Investigation on Retinal Fundus Images for Detection of Diabetic Retinopathy and Classification Using ANFIS

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Received: 3 Apr. 2019, Revised: 12 May 2019, Accepted: 24 May 2019
Published online: 1 Nov. 2019

Abstract: In this paper, a novel method is developed to establish a framework for Investigation on Retinal Fundus Images for Detection of Diabetic Retinopathy and Classification. The preprocessing is done through green-channel enhancement followed by top-hat filtering method to enhance image details for subsequent segmentation and feature extraction. The extracted features are used to train the database images using Artificial Neuro Fuzzy Interference System. The optic disc and the blood vessels are found using a supervised segmentation algorithm, damaged area and hard and soft exudates using Kirsch operator to extract the features for the classification of healthy and abnormal images of Diabetic Retinopathy from the retinal images as Proliferal Diabetic Retinopathy (PDR) or Non-proliferal Diabetic Retinopathy (NPDR). The NPDR is further classified into mild, moderate and severe cases based on the calculation of microaneurysms count using Local Thresholding (LT), Local Shifted Thresholding (LST) and the count is compared to the Global Thresholding (GT) to provide the best classification results. Results are optimized, in terms of their sensitivity, specificity, accuracy and Q factors by calculating the True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) analysis of the test image. The images are trained with Artificial Neural Network (ANN) and Artificial Neuro Fuzzy Interference System (ANFIS). Analyzed results are compared and validation set is obtained for both methods.

Keywords: Diabetic Retinopathy, Retinal Fundus Image, ANN, ANFIS, PDR, NPDR

1 Introduction

The number of diabetic patients suffering from Diabetic Retinopathy (DR) has increased recently [1]. The number of diabetic patients suffering from Diabetic Retinopathy (DR) has increased recently [2, 3]. DR has grown as small variations in the retinal capillaries. The starting differentiable deviations are microaneurysms that are internaldisruptions of the retinal capillary. The deformed microaneurysms cause the creation of intraregional haemorrhage. This directs to the initial stage of DR which is generally named as minor non-proliferative diabetic retinopathy [4].

The sensitivity of eye fundus leads to few vascular diseases. Fundus imaging technique is highly appropriate for noninvasive category of screening. The effect of the screening method is directly associated with the quality and correctness of the fundus image extraction method combined with proficient image processing methodologies for recognizing the abnormalities.

Vision failure caused by diabetic retinopathy shows to be declining because of improved diabetes management and enhanced treatment options for Diabetic Macular Edema (DME) [5, 6]. Still, in absolute terms, the encumber of diabetic retinopathy seem to nurture as the number of people with diabetes increases [5, 7].

The Protein Kinase C (PKC) and Vascular Endothelial Growth Factor (VEGF) receptors are depicted in [8]. PKC isomer discerning inhibitors and VEGF trap are probably new therapeutics that might delay the onset or stop the succession of diabetic vascular disease. A novel promising therapy for diabetic retinopathy has undergone Phase III trials, in which they projected to targeted PKCβ II which has been involved in B cell activation, endothelial cell proliferation, and intestinal sugar absorption. Moreover, PKC beta II isomer is identified in superior concentration in spleen, brain, and so forth. Hence, oral targeting might be a questionable method since generalized inhibitors might prove toxic in diabetic

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retinopathy handling and ocular delivery could be a better alternative technique.

The evolving strategies in the treatment of diabetic retinopathy is described in [9]. Glycema and blood pressure control are important aspects in lowering the risk, controlling the growth and the treatment of DR. The two highest threatening hurdles of DR are Proliferative Diabetic Retinopathy (PDR) and Diabetic Macular Edema (DME).

Recent concepts and the function of the novel treatment techniques in the management of diabetic retinopathy are presented in [10]. Healthcare model for patients with DR involves strict metabolic control of hyperglycemia, blood pressure control, normalization of serum lipids, prompt retinal laser photocoagulation and vitrectomy. For patients who retort poorly and who increasingly lose vision in spite of the above model, intravitreal management of steroids or/and antivascular endothelial growth factor (anti-VEGF) drugs are a promising second-line of treatment. The growing DR rate in the developing world suggests that diabetic retinopathy might soon be a main problem in the clinical world [11]. A computerized screening system be capable of fully automated mass screening [12].

In this paper, we present the preprocessing and segmentation methods to detect blood vessels, optic disc, damaged area, exudates and microaneurysm for feature extraction and classification. Experimental setup has been done using Stare Database, Standard Diabetic Retinopathy Database and compared with Generic Database. This paper also includes a comparison between Artificial Neuro Fuzzzy Interference System and Artificial Neural Network classifiers in terms of normal/abnormal, hard/soft exudates and microaneurysm/non microaneurysm.

2 Materials and Methods

Fig. 1 shows the procedural flow of methodology followed to carry out the presented work. Subsequent subsections describe the proposed methodology.

To enhance the contrast of the fundus image, green channel enhancement method is used. The filtering applied in preprocessing is top-hat filtering. Complete blood vessels system and the optic disc are being removed to enhance the image so that MAs appearing near vessels become more easily detectable. One of the derivative masks applied for finding edges is Kirsch. Compass Mask is another derivative mask. This is similar to Robinson compass in identifying edges in all the eight directions. The only difference between the two masks is that we can change (adjust) the mask according to our own requirements in Kirsch. With the help of Kirsch Compass Masks we can find edges in the eight directions.

Features like correlation, energy, entropy, homogeneity, and so forth,are measured and the hard and soft exudates are found. Using these extracted features,

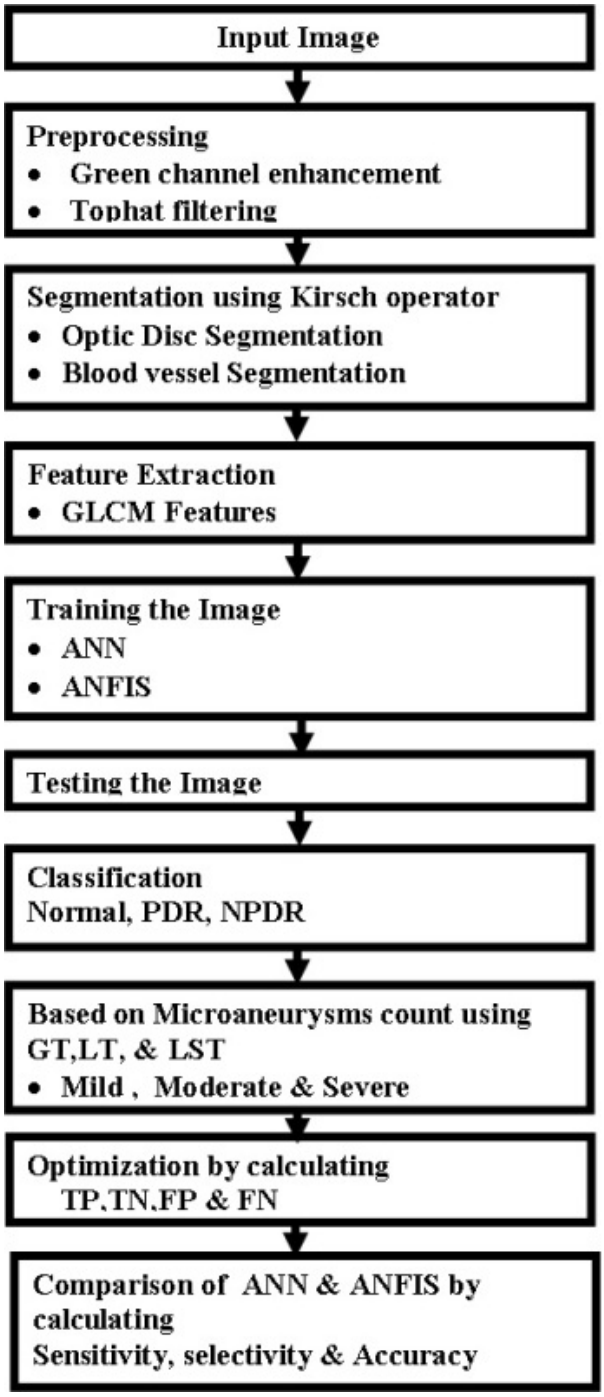

Fig. 1: Flow graph of proposed method

Images are trained using ANFIS and ANN.The test image is given to identify the classification of Normal, NPDR, and PDR categories.

Based on the Local Thresholding, Global Thresholding, Local Shifted Thresholding Microaneurysms counts is calculated and the NPDR cases are further divided into mild, moderate and severe cases.

Table 1: Comparative study

Work	Sensitivity	Specificity
Proposed Method	98.69	86.24
Triad Network	75	85
Singalavanija	74.8	82.7
Dupas	83.9	72.7
Antal	90	91
Sinthanayothi et al.,	77.5	88.7
Jelinek et al.,	97	88
Fleming et al.,	85.4	83.1

With the trained image we can calculate the TP, TN, FP and FN.

TP: abnormal image correctly identified as abnormal
FP: Normal image incorrectly identified as normal
TN: Normal image correctly identified as normal.
FN: abnormal image incorrectly identified as normal.
In general,
Positive means identified and negative means rejected.
Therefore,
TP = correctly detected Microaneurysms count.
FP = incorrectly idetected Microaneurysms count.
TN = correctly rejected Microaneurysms count.
FN = incorrectly rejected Microaneurysms count.

Then, to optimize the results, sensitivity, selectivity, Accuracy and Q factors are measured.
Sensitivity, is calculated using:

$$\text{Sensitivity} = \frac{TP}{TP+FN} \tag{1}$$

Specificity, is calculated using:

$$\text{Specificity} = \frac{TN}{TN+FP} \tag{2}$$

Accuracy, is calculated using:

$$ACC = \frac{TP+TN}{TP+TN+FP+FN} \tag{3}$$

The comparison is made between ANN and ANFIS classifier.

3 Experimental Results

ANFIS and ANN algorithms are applied to compare all publically available databases and the generic database obtained from eye clinics.

From Table 1, the comparative study is made between the proposed method and sensitivity and specificity obtained by various researchers. It is clear that in our proposed method, good sensitivity and specificity are achieved.

Fig. 2 shows the performance analysis comparison for the proposed method with various previously analysed methods with parameters such as sensitivity and specificity.

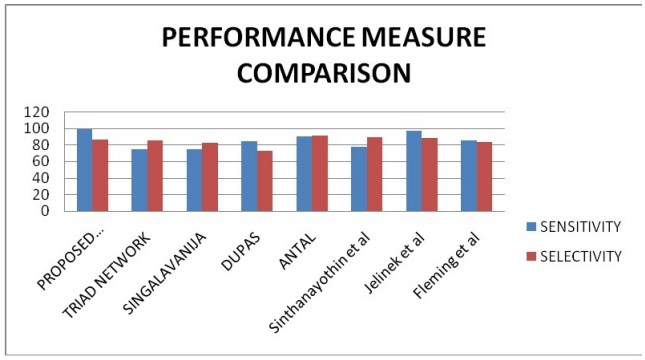

Fig. 2: Comparison of performance measures sensitivity and selectivity

Table 2: Performance analysis of DiaretDB0

	SE	SP	ACC	Q FACTOR
Image 1	97.18992	94.73204	94.81645	26.56674
Image 2	100	77.9661	97.16776	37.05606
Image 3	96.80697	96.01644	96.04357	23.22897
Image 4	97.23167	96.19301	96.22818	21.53226
Image 5	100	67.18266	95.43693	45.64604
Image 6	100	83.51254	97.98157	27.30863
Image 7	100	86.74699	98.53268	24.15483
Image 8	100	85.48387	98.39858	29.19679
Image 9	100	88.23529	98.66962	18.69503
Image 10	100	68.1388	95.64091	39.76266
Image 11	100	89.43089	98.84239	26.34821
Image 12	100	92.30769	99.15443	27.23028
Image 13	100	89.55823	98.84393	27.38344
Image 14	100	77.61194	97.35566	42.08996
Image 15	100	81.34328	97.79541	39.91071
Average	99.41524	84.96399	97.39387	30.40737

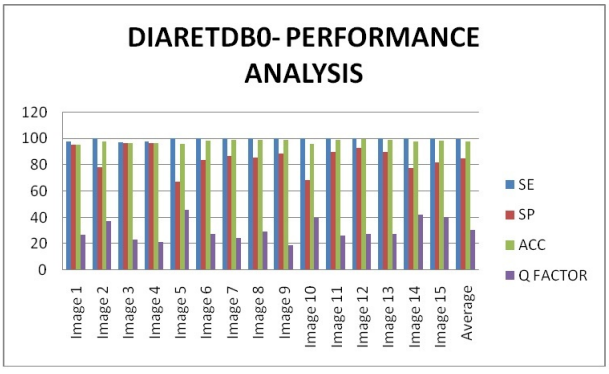

Fig. 3: Performance analysis of DiaretDB0

Table 2 is the calculation of sensitivity, specificity, accuracy and Q Factor for 15 images On the Average the Sensitivity obtained is 99.42, specificity is 84.96, Accuracy is 97.39 and Q Factor is 30.41.

Table 3: Performance analysis of DRIVE database

	SE	SP	ACC	*Q* FACTOR
Image 1	97.33527	86.60003	86.96875	45.96367
Image 2	97.33914	87.76666	88.11605	47.64228
Image 3	97.14562	90.30672	90.54142	39.64071
Image 4	97.42593	90.16753	90.41337	40.76497
Image 5	96.62975	88.82471	89.10589	45.97924
Image 6	100	74.44089	96.54129	56.93442
Image 7	100	90	98.92857	51.81169
Image 8	100	66.76558	95.20753	49.71953
Image 9	100	82.82443	98.01061	54.41184
Image 10	100	72.60726	96.39601	43.98271
Image 11	100	90.11858	98.89037	26.34821
Image 12	100	91.77489	99.14836	27.23028
Image 13	100	89.55823	98.84393	27.38344
Image 14	100	79.31034	97.37991	42.08996
Image 15	100	80.69498	97.78663	39.91071
Average	99.05838	84.11739	94.81858	42.65424

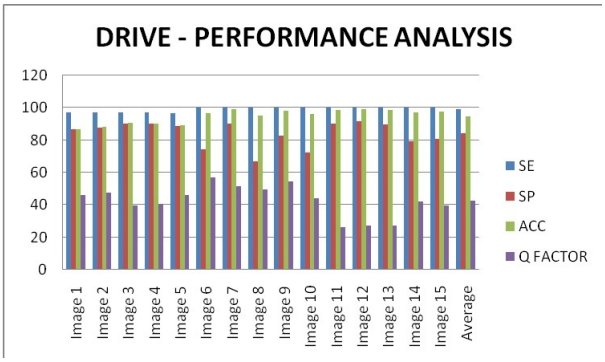

Fig. 4: Performance analysis of DRIVE dataset

Fig. 3 shows the performance analysis with sensitivity, specificity, accuracy and *Q* factor for DiaretDB0 database through our proposed method.

Table 3 is the calculation of sensitivity, specificity, accuracy and Q Factor for 15 images On average, the sensitivity obtained is 99.05, specificity is 84.12, accuracy is 94.82 and *Q* Factor is 42.65.

Fig. 4 shows the performance analysis with sensitivity, specificity, accuracy and *Q* factor for DiaretDB0 database through our proposed method.

Table 4 is the calculation of sensitivity, specificity, accuracy and Q Factor for 15 images On the Average the Sensitivity obtained is 99.18, specificity is 86.05, Accuracy is 96.47 and *Q* Factor is 34.14.

Fig. 5 shows the performance analysis with sensitivity, specificity, accuracy and *Q* Factor for MESSIDOR-Base 11 database through our proposed method.

From Table 5, the results obtained for Messidor Database shows that sensitivity is 98.36, specificity is 86.96, accuracy is 96.60 and *Q* Factor is 33.64. For the DiaretDB0 database, the sensitivity is 99.41, specificity is 84.96, accuracy is 97.39 and *Q* Factor is 30.41. For the Drive database the sensitivity is 99.05, specificity is 84.12, accuracy is 94.82 and *Q* Factor is 42.65.

Fig. 6 gives the comparison performance analysis for the databases Messidor, DiaretDB0 and Drive.

Table 4: Performance analysis of MESSIDOR–Base 11 dataset

	SE	SP	ACC	*Q* FACTOR
Image 1	96.55172	92.38491	92.53895	35.38374
Image 2	100	77.45455	97.27473	29.06703
Image 3	97.04886	91.53256	91.72187	36.61911
Image 4	97.4745	91.31678	91.52534	38.70692
Image 5	96.62975	91.94465	92.11343	36.73335
Image 6	100	86.6171	98.4134	33.00865
Image 7	100	84.70588	98.27051	28.0935
Image 8	100	76.19048	97.14034	43.16924
Image 9	100	82.18182	97.84615	36.52835
Image 10	100	77.03704	97.26872	31.82841
Image 11	100	91.37931	99.10394	26.34821
Image 12	100	91.77489	99.14836	27.23028
Image 13	100	93.39207	99.32645	27.38344
Image 14	100	79.31034	97.37991	42.08996
Image 15	100	83.63636	98.02285	39.91071
Average	99.18032	86.05725	96.473	34.14006

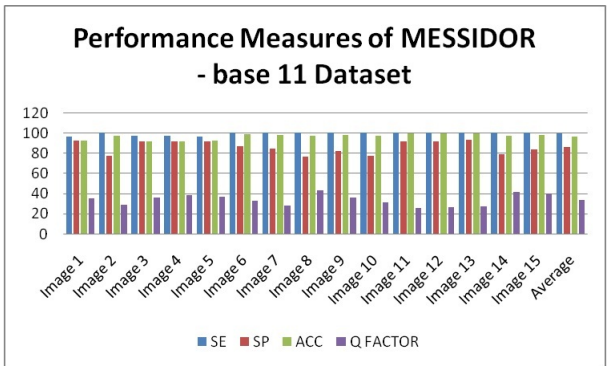

Fig. 5: Performance analysis of MESSIDOR-Base 11 dataset

Table 5: Comparison of various databases

DATABASE	SE	SP	ACC	*Q* Factor
MESSIDOR	98.36541	86.96116	96.60355	33.64219
DIARETDB0	99.41524	84.96399	97.39387	30.40737
DRIVE	99.05838	84.11739	94.81858	42.65424

Table 6: Comparison of ANN & ANFIS classifier

	ANFIS	AN
Se	80	60
Sp	100	50
Accuracy	93.33	53.33

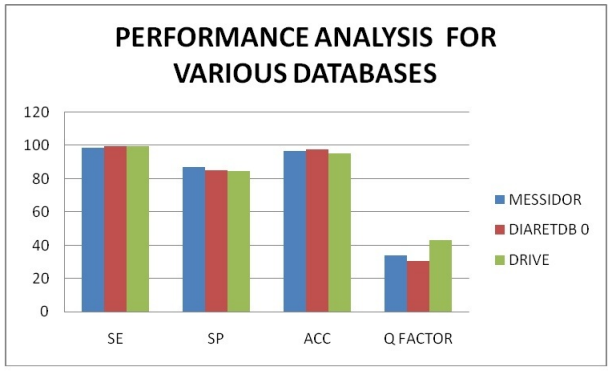

Fig. 6: Comparison of various databases

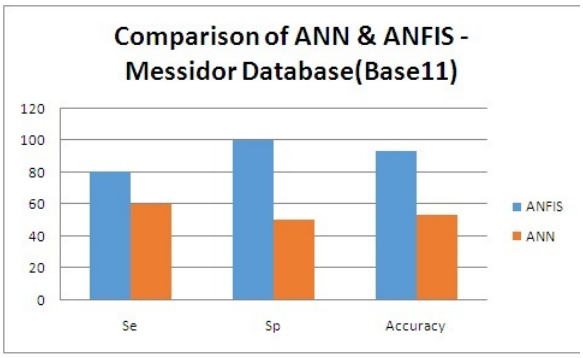

Fig. 7: Comparison of ANN & ANFIS Classifier

From Table 6, the results obtained for Messidor Database shows that Sensitivity is 80 with the classifier ANFIS & 60 using ANN, specificity is 100 for ANFIS and 50 using ANN, accuracy is 93.33 using ANFIS and 53.33 using ANN. It is noted from the attained results that, the ANFIS classifier is best suited for Diabetic Retinopathy classification.

Figure 7 gives the Performance Analysis using ANN and ANFIS classifiers based on the calculation of selectivity, sensitivity and accuracy for the Messidor-Base 11 database.

4 Conclusion

Diabetic Retinopathy, an overwhelming retinal complication of diabetes mellitus, is a severe global public health issue that diminishes the quality of life. number of people worldwide who are in danger of developing vision loss from diabetes is expected to double over the next 25 years. As DR can progress despite the lack of symptoms, developing irreversible damage to the retina. Regular screening assessments play a vital role in reducing the magnitude of DR-related visual impairment in the population.

While DR gets recognized, the evidence-based therapies which create the standard of care for DR.

Present techniques of enhanced laser photocoagulation and Vitrectomy techniques will get emerged in preventing the visual failure caused by Diabetic Retinopathy.

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