Computer Aided Detection of Diabetes Retinopathy and Analysis through ANFIS and Optimtool

Thokala Nirosha[1], Kunjam Nageswara Rao[2], G Sita Ratnam[3]

[1]Department of Computer Science & Systems engineering,
Andhra University college of Engineering (A), Vishakhapatnam-530003, India.
nirosha.minni@gmail.com

[2] Department of Computer Science & Systems engineering,
Andhra University college of Engineering (A), Vishakhapatnam-530003,
India. kunjamnag@gmail.com

[3] Department of Computer Science & Systems engineering,
Andhra University college of Engineering (A), Vishakhapatnam-530003, India.
sitagokuruboyina@gmail.com

Abstract: *The entire human body can be controlled using a Computer aided diagnosis (CAD). One of such technology is CAD system for diabetic retinopathy detection. Damage or degeneration of the optic nerve, the brain or any part of the visual pathway between them, can impair vision. Diabetic Retinopathy (DR) does not exhibit any distinctive symptoms which the patient cannot easily perceive until a severe stage is reached. This is because lack of specialized ophthalmologists i.e., 1:1000 ratio availability of doctors to patients together with associated higher medical costs makes regular check up costly. We proposed to develop a low cost and versatile Computer Aided Diagnosis (CAD) systems. It can be achieved by Adaptive Neuro Fuzzy Inference System (ANFIS) assisted Diagnosis and by genetic algorithm through Fundus Image. So that we can estimate the damage of retina and the appropriate treatment to the patient can be recommended to save them from vision loss*.

Keywords*:* Diabetic Retinopathy, Computer Aided Diagnosis, ANFIS, Fundus Image.

1. INTRODUCTION

Bioinformatics is an interdisciplinary field that develops methods and software tools for understanding biological data. As an interdisciplinary field of science, bioinformatics combines computer science, statistics, mathematics, and engineering to study and process biological data. Computational technologies of bio-informatics are used to accelerate or fully automate the processing, quantification and analysis of large amounts of high-information-content biomedical images.

Modern image analysis systems augment an observer's ability to make measurements from a large or complex set of images, by improving accuracy, objectivity or speed. A fully developed analysis system may completely replace the observer. Although these systems are not unique to biomedical imagery, biomedical imaging is becoming more important for both diagnostics and research.

An Ophthalmologist needs to examine a large number of retinal images to diagnose each patient. It is the action done by human manually so there may be less accuracy. [2] Thus to achieve more accuracy we had implemented a computer aided detection of DR. In a diabetic eye we mainly see hard Exudates, hemorrhage of blood vessels are shown in fig1.

Fig1: Various features on a typical retinopathy image

2. MODULES

For our purpose system we collect images from different databases like HRF (High resolution fundus image), DIARETDB0(Diabetic Retinopathy DataBase0), DIARETDB1 (Diabetic Retinopathy DataBase1) etc. As the image contains noise it should be eliminated. Later by using automatic segmentation technique we can explore the presence of muscular edema in the fundus image. [1] Then by using ANFIS Tool and by Optimtool (by testing and training the input data) DR on human eye can be evaluated. The proposed system consists of two modules: Detection module and Analysis module shown in fig2.
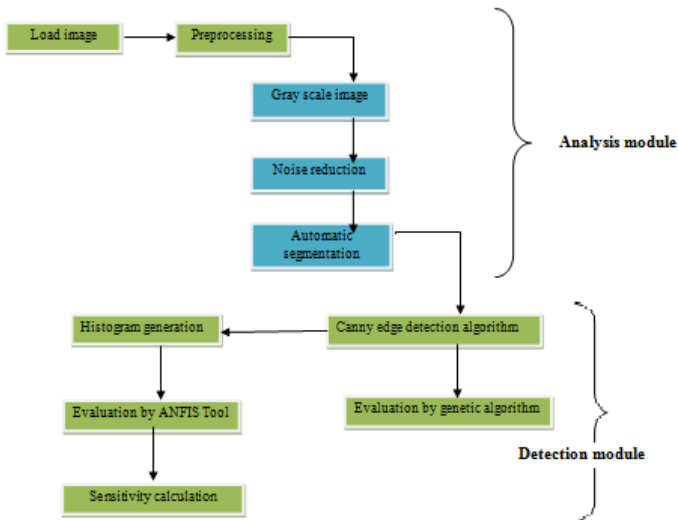
Fig2: CAD flow diagram with modules

3. ANALYSIS MODULE:
I. Load image:
The image input for Mat Lab GUI [3] is collected from different databases that are available on online like HRF, DIARETDB0 and DIARETDB1 etc.

II. Preprocessing
Initially, the retinal images which have to be collected from Databases must undergo pre-processing. The few abnormalities present in the retinal fundus images are very small in size and hence their detection becomes quite confused because of the presence of noise. The important objective of image pre-processing is to remove noise and to seclude the dark abnormalities from the exudates regions, which appear as bright lesions in the retinal images. The colour fundus image in which each pixel has the three primary colour components red, green and blue was initially given as input to the system. In pre-processing, first the original fundus image that uses the red, green and blue (RGB) colour space was transformed into Lab colour space. This transformation prevents the problems associated with the application of grey scale methods to each of the components because of the high correlation between these components.

1. Gray scale Image:
Gray scale image is sometimes called "black and white," but technically this is a misnomer. [3] In true black and white, also known as halftone, the only possible shades are pure black and pure white. The illusion of gray shading in a halftone image is obtained by rendering the image as a grid of black dots on a white background (or vice-versa), with the sizes of the individual dots determining the apparent lightness of the gray in their vicinity. Gray scale is a range of shades of gray without apparent colour.

2. Noise reduction by simple filters:
Filtering is used to suppress the unwanted noise which gets added into the fundus image. As this images are collected in a supervised environment so it contain mainly two noises special radiation i.e., when the Ophthalmologist suggest to see a light spot while capturing image which is same as Gaussian noise, and noise generated by digital cameras. We can eliminate it by using simple low pass filters.

3. Automatic segmentation
The main objective of segmentation is to group the image into regions with same characteristics [5]. The goal of the segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is generally used to locate objects and boundaries (lines, curves etc.) in the images. The outcome of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. After performing all above operations on the fundus image blobs are detected which is the sign of severe diabetic retinopathy. The proposed CAD system uses Markov Random Field (MRF) to model the discrete field containing the classification of each singular pixel i.e. the segmentation field. In MRF, the value of a pixel is statically dependent only on the value of its neighbours. This strict dependency restricts considerably the model complexity. We used a Maximum Posterior Estimator (MAP) to estimate the realization of this hidden Markov field given the dependent observed data (the Fundus image). Moreover it considerably reduces the computation time. In MRS (multiple resolution segmentation algorithm), we first segment the image at coarse resolution n, then we use the segmented image as an initialization at the (n-1) resolution and so on until the finest resolution. For a fixed number M of classes, the MAP (Maximum Posterior Estimator) estimation of the segmentation field is computable using the multi scale ICM (Iterated Conditional Mode algorithm) segmentation. By this in further the process of evaluation complexity can be reduced.

4. DETECTION MODULE
III. Canny edge detection algorithm
The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in segmented images. [10] The Process of Canny edge detection algorithm can be broken down to 5 different steps:

1. Apply Gaussian filter to smooth the image in order to remove the noise
2. Find the intensity gradients of the image
3. Apply non-maximum suppression to get rid of spurious response to edge detection
4. Apply double threshold to determine potential edges
5. Track edge by hysteresis

1) Gaussian Filter:
Since all edge detection results are easily affected by image noise, it is essential to filter out the noise to prevent false detection caused by noise. To smooth the image, a Gaussian filter is applied to convolve with the image. This step will slightly smooth the image to reduce the effects of obvious noise on the edge detector.

$$H_{ij} = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{(i-k-1)^2 + (j-k-1)^2}{2\sigma^2}\right)$$

2) Finding the Intensity Gradient of the Image
An edge in an image may point in a variety of directions, so the canny algorithm uses four filters to detect horizontal, vertical and diagonal edges in the blurred image. The edge detection operator returns a value for the first derivative in the horizontal direction (G_x) and the vertical direction (G_y). From this the edge gradient and direction can be determined:

$$G = \sqrt{G_x^2 + G_y^2} \quad, \quad \theta = a\tan 2\left(G_y, G_x\right)$$

Where G can be computed using the hypot function and atan2 is the arctangent function with two arguments. [8] The edge direction angle is rounded to one of four angles representing vertical, horizontal and the two diagonals (0°, 45°, 90° and 135° for example). An edge direction falling in each color region will be set to a specific angle values, for example alpha lying in yellow region (0° to 22.5° and 157.5° to 180°) will be set to 0°.

3) Non-maximum Suppression:

It is an edge thinning technique applied to thin the edge. After applying gradient calculation, the edge extracted from the gradient value is still quite blurred. There should only be one accurate response to the edge. Thus non-maximum suppression can help to suppress all the gradient values to 0 except the local maximal, which indicates location with the sharpest change of intensity value. [7] The algorithm for each pixel in the gradient image is:

1. Compare the edge strength of the current pixel with the edge strength of the pixel in the positive and negative gradient directions.

2. If the edge strength of the current pixel is the largest compared to the other pixels in the mask with the same direction (i.e., the pixel that is pointing in the y direction, it will be compared to the pixel above and below it in the vertical axis), the value will be preserved. Otherwise, the value will be suppressed.

4) Edge Tracking by Hysteresis:

So far, the strong edge pixels should certainly be involved in the final edge image, as they are extracted from the true edges in the image. However, there will be some debate on the weak image pixels, as these pixels can either be extracted from the true edge, or the noise/color variations. To achieve an accurate result, the weak edges caused from the latter reasons should be removed.[6] The criteria to determine which case does the weak edge belongs to is that, usually the weak edge pixel caused from true edges will be connected to the strong edge pixel. Finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

IV. Histogram generation

Histogram generation is the simple way to show the image results in graphical format. So after applying all algorithms on the image the final image is used to generate the histogram which shows the intensity of image at different positions.

V. Evaluation by ANFIS Tool

ANFIS Working

Adaptive Neuro-Fuzzy Inference System (ANFIS) is a very popular technique which includes benefits of both fuzzy and neural network. [9] Advantages of ANFIS are:

- ☐ Itrefine fuzzy if-then rules for segmenting image
- ☐ Provides more choices of membership function
- ☐ It does not require human expertise all time.
- ☐ It provides fast convergence time

VI. Optimization tool:

In optimization tool genetic algorithm (GA) is a method for solving both constrained and unconstrained optimization problems based on a natural selection process that mimics biological evolution. The algorithm repeatedly modifies a population of individual solutions. At each step, the genetic algorithm randomly selects individuals from the current population and uses them as parents to produce the children for the next generation. Over successive generations, an optimal solution will obtain.

5. RESULTS:

Computer aided detection for Diabetes retinopathy is done on fundus images collected from online data base repositories like HRF, DIARETDB0. And the gray scale image is generated which can be easily evaluated.
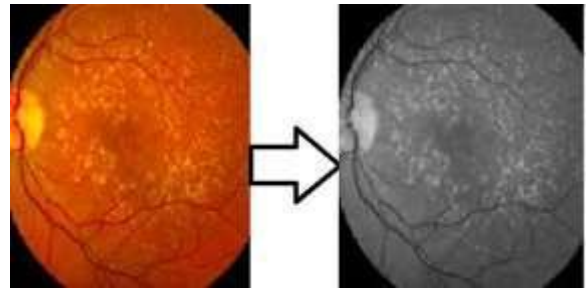

Fig3: Normal image to Gray scale image

By segmentation the affected area of DR is identified and an excel sheet of each pixel are generated as shown in fig4.
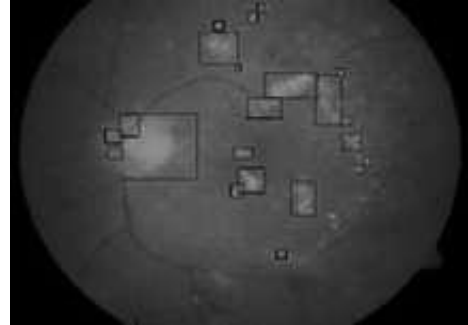

Fig4: Segmented fundus image

By using canny edge detection the segmented area edges and histogram are identified which are shown in fig5,fig6.
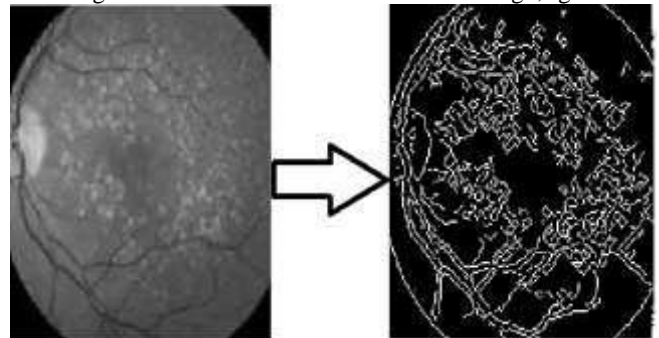

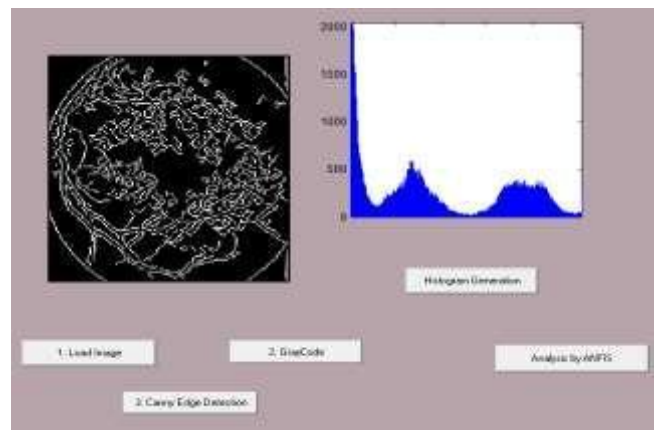Fig5: Edge detection using canny edge detection algorithm

Fig6: Histogram generation for image

A note of results obtained after applying neural rules by ANFIS and later by Optimtool through Genetic algorithm:

An ANFIS tune parameters and structure of FIS (fuzzy inference system) by applying neural Learning rules. Inputs represent the different textural features calculated from each image. We Load a previously saved FIS structure of fundus image from a file or the MATLAB workspace.

Generate the initial FIS model by choosing Grid partition generates a single-output FIS by using grid partitioning on the data.

Training the FIS:

After loading the training data and generating the initial FIS structure, we can start training FIS.

☐ In Optim. Method, choose hybrid or back propagation as the optimization method.

☐ The optimization methods train the membership function parameters to emulate the training data.

☐ Enter the number of training Epochs and the training Error Tolerance to set the stopping criteria for training.

☐ The training process stops whenever the maximum epoch number is reached or the training error goal is achieved. Click Train Now to train the FIS. This action adjusts the membership function parameters and displays the error plots. Sensitivity of the eye at Each input was given two bell curve membership functions and the output was represented by two linear membership functions.[4] Outputs of the fuzzy rules comprised one single output, which represent output for that particular input image are noted in the table.

In the below table1 we observe that when a Non-diabetic eye is given as input the error tolerance in negligible. Whereas the diabetic eye had given a considerable tolerance error by which we can say that eye is affected with diabetic retinopathy

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Table1: Results obtained for fundus image for tolerance of diabetes retinopathy

Images	Epoch	Method	Error tolerance
NDR1	20	Hybrid	0.0001
NDR1	20	backprop	0.00003
NDR2	100	Hybrid	0.0011
NDR2	100	Hybrid	0.0011
DR1	20	Hybrid	3.8167
DR1	10	backpro	3.5167
DR2	20	Hybrid	5.7862
DR3	100	backpro	4.8722

Proposed Algorithm

GENETIC ALGORITHM

Birth: if the current cell is off and the count of pixel is exactly 3, the current cell is switched on.

Survival: if (a) the count of pixel is exactly 2, or (b) the count of pixel is exactly 3 and the current cell is on, the current cell is left unchanged and go to Birth else go to Death.

Death: if the count of pixel is less than 2 the current cell is switched off. Go to next pixel.

By this the presence of micro aneurys in the input image is evaluated as presence of exudates and non-exudates and noted in the below table2.

Table2: Results obtained after the verification of the pixels as exudates and non-exudates

IMAGES	CPU TIME(IN SEC)	PROBABILITY OF EFFECT OF DR
DRIMAGE1	0.52	0.814
DRIMAGE2	0.38	0.702
IMAGE3	2.11	0.010
IMAGE4	1.47	0.000

In our proposed system we include optical disk which may detect exudates occurring in the optic disk which might be left undetected because of its elimination in previous papers. By this in our proposed system we can estimate the effect of exudates **99%** accurately.

6. CONCLUSION

As seen from the top of discussion, if a person suffers from DR, micro aneurysms may occur in patient's retina image as tiny reddish dots which are generated due to hemorrhagic of blood vessels. In our proposed system first we had collected the data form available sources and then it is preprocessed to eliminate the noise in the fundus image and then canny edge detection is imposed which can clearly show the each pixel edges, and then excel sheet had been generated which ANFIS tool takes as input and the tolerance of error has been obtained and optimization tool is used which loads the proposed genetic algorithm and evaluates the presences of diabetes and display the probability of effect on eye then appropriate treatment is suggested, so that DR can be controlled before the person loses the vision. And also by analyzing six months continues treatment fundus images we can also say the vision de-blurring is by soft Dustan or by DR.

As a future work, the algorithm can be extended to work on more sensitive images with necessary modifications. Processing time in identification of the next pixel affected can be reduced. In future cause of blindness in non-diabetic person due to soft drusen is also evaluated and bionic eye is the one way to eliminate DR, which is one of the current research and future enhancement.

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Author Profile

Thokala Nirosha received B. Tech degree in Computer Science and Engineering from Naarasaraopeta Engineering collage during 2009-2013, Pursuing M.Tech in Bio-informatics (CST) in Andhra University, presented many papers at various colleges on Artificial intelligence Robotics, Cloud Computing, and attended many conferences like IBCB, WICON'12 an IEEE R10 congress.