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Diabetic Retinopathy Detection Using Artificial Neural Network

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***Abstract*—** Diabetic retinopathy is a one type of eye disease which affect the people with diabetics. Diabetics mellitus commonly referred to as diabetics is a group of metabolic disorder in which there a high blood sugar level over prolonged period. It creates eye disease if left untreated. It causes many complications and one such complications is blindness. The high blood sugar level causes damage to blood vessels in retina that many are not aware of. There are three main phases namely preprocessing, segmentation, classification. The proposed model is implemented in MATLAB and the results are analyzed based on certain parameters. Preprocessing is done by median filter to remove unwanted noise and preserve the edges. From the input image the blood vessels are isolated and used in identifying the presence of microneurysms and exhudates. The blood vessels of the image are detected using morphological operation. Detecting the disease at an earlier stage can prevent the patients from vision loss. In this work ANN approach is used for better classification of diabetics and the classified images can be categorized under the stages of various abnormalities associated with eye.

***Keywords*—**Artificial Neural Network, Segmentation, Feature Extraction

I. INTRODUCTION

Diabetic retinopathy can be occurred when enough rate of insulin in the body is not produced properly by the pancreas. If a person has diabetes for more than 20 years he or she might have more probability to suffer from diabetic retinopathy. The National Eye Institute estimates that about 40 to 45 percent of Americans having diabetes are affected by diabetic retinopathy due to which around 24,000 people become blind every year. The early indications of DR are the appearance of microaneurysm, haemorrhages and exudates. DR starts when diabetes mellitus damage small retinal blood vessels causing microaneurysm (MA), the small swelling that form on the side of tiny blood vessels. As the damage increases it causes haemorrhages deep inside the retina. Retinal haemorrhages cause serious vision problem. As the disease advances, the retina reacts by growing abnormally weak, leaky, fragile and misdirected blood vessels.

There are different medical imaging techniques for capturing the internal structure of human eye including fundus photography and OCT.Fundus image are either indexed or RGB images of different intensities. The aim of pre-processing is to improve the image data which suppress unwanted image data distortion and enhance some images features that are important for further processing. To filter the unnecessary information from an image noise filter is used . Contrast enhancement is a process that makes image feature standout clearly by making optimal use of colour.

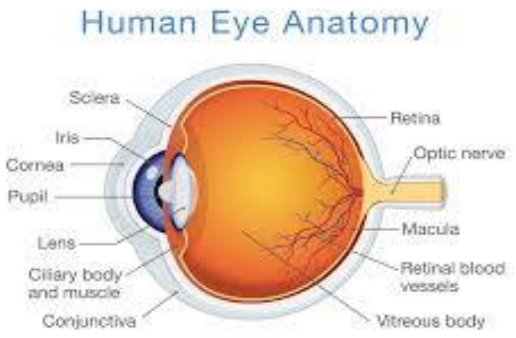

Fig-1: Anatomy of eye

Machine learning, a application of artificial intelligence, that provides the system the ability to learn automatically from data. To learn information directly from data as a model without relying on a predetermined equation by using computational method.

It deals with generalization and representation. Data instances representation and functions evaluated on these instances are part of all machine learning systems. . The training examples come from some generally unknown probability distribution and to produce sufficiently accurate predictions in new cases the learner has to build a general model about this space that enables it.
The different types of machine learning are:

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

SUPERVISED LEARNING:
Supervised learning is the machine learning task of inferring a function from supervised training data.For supervised learning the training data includes a set of examples with desired output and paired input subjects. To generalize from the training data in unseen situations that requires the learning algorithm. The two group problems of supervised learning

- Classification- In order to predict the outcome of a given sample The output variable should be in the form of categories (output in the form of a or b)
- Regression-It performs a task of regression. The target values based on independentvariablesSome of the supervised machine learning algorithms are as follows:

- Decision Trees

It is a one of the algorithm of supervised learning that is mostly used for classification problems. Surprisingly, it works for both categorical and continuous dependent variables.Here, we split the population into homogeneous sets.

- Random Forest

Random Forest is a classification algorithm that consists of decision trees. The collection of tress called forest. The attributes used to classify a new object, to create an uncorrelated forest of trees we should build a each individual tree by using bagging.

- Neural Networks

A neural networks are computing systems inspired by biological neurons. Similarly,a neural network is made up of cells that work together to produce a desired result, although each individual cell is only responsible for solving a small part of the problem. Neural networks are also called connectionist systems and neural networks consitute human brain.They interpret sensory data through a kind of machine perception, labelling or clustering raw input. A neural network is series of algorithms that helps to recognize patterns in your data. By detecting similar patterns in future data the predictions can be taken once the neural network has been trained on samples of your data .

UNSUPERVISED LEARNING:
Unsupervised learning is machine learning algorithm to draw inferences from datasets including inputs without labelled responses. The method of unsupervised learning is cluster analysis is used for data analysis to find hidden patterns . Clustering and association are two groups of unsupervised learning.

- Clustering

It is a common technique for statistical data analysis used in many fields.cluster analysis used to gain some valuable insight from our data.

- Association

Association rule learning is a rule based machine learning method.Using some measures of interestingness intended to identify strong rules discovered in databases.Some popular examples of unsupervised learning algorithms are:

Expectation- Maximization for clustering problems:
The expectation-maximization algorithm is an approach for performing maximum likelihood estimation in the presence of latent variables. It is an effective and general approach and is most commonly used for density estimation with missing data, such as clustering algorithms like the Gaussian Mixture Model.There are two steps in Expectation Maximization algorithm,

- Expectation step (E – step): To estimate (guess) the values of the missing data the observed available data of the data set can be used.

- Maximization step (M – step): After the expectation complete data is generated .

REINFORCEMENT LEARNNING:
In order to maximize the notion of cumulative reward it concerns with sofware agents ought totakes actions in environment.It helps tolearn how to attain a maximize specific dimension over many steps. It increases strength and frequency of behaviour.

II. RELATED WORK

a) SVM AND NEURAL NETWORK BASED DIAGNOSIS OF DIABETIC RETINOPATHY

R.Priya, P.Aruna (2012) used SVM and Neural Network for Detection of Diabetic Retinopathy. Probabilistic Neural network (PNN) and Support Vector Machine (SVM) are two models to diagnose diabetic retinopathy are described in this method and their performances are compared. Performance is evaluated based on accuracy, sensitivity and specificity. The input retinal images were preprocessed using Grayscale conversion, Adaptive Histogram Equalization, Discrete Wavelet Transform, Matched filter and Fuzzy C-means segmentation.For classification process the features of pre-processed images were extracted. The classifier algorithm is used for classification of retinal images.

b) AUTOMATIC DETECTION OF RETINAL EXUDATES IN FUNDUS IMAGES OF DIABETIC RETINOPATHY PATIENTS

Mahsa Partovi1, Seyed Hossein Rasta and Alireza Javadzadeh (2016) proposed different image processing techniques such as noise removal image, resizing and contrast enhancement for diabetic retinopathy detection. On intensity components of Hue Saturation Intensity (HSI) space the morphological function is applied. . Thresholding was performed on all images to detect the exudates regions, and the segmentation is carried out in exudates region. The binary morphological functions were applied to optimize the detection efficiency. Finally, the

exudates regions were evaluated and quantified for further statistical purposes. Performance was measured based on sensitivity, specificity and accuracy.

c) DETECTION OF DIABETIC RETINOPATHY IN FUNDUS IMAGE.

A.Rajan (2015) proposed a new algorithm to detect the blood vessels effectively. Using preprocessing stage the initial enhancement of the image is carried out, followed by curvelet Transforms that are applied to the equalized image.For extraction of the blood vessels the enhanced image is used. The estimation of exudates is obtained from blood vessels and optic disc extracted images. The result shows the enhanced retinal images of blood vessels have a better PSNR and area shows the exudates severity.

d) RETINAL MICROANEURYSM DETECTION THROUGH LOCAL ROTATING CROSS-SECTIONPROFILE ANALYSIS.

Istvan Lazar and Andras Hajdu (2013) proposed local rotating cross-section profile analysis method for retinal microaneurysm detection. On each profile, and a set of attributes regarding the size,shape of the peak and height are calculated subsequently after peak detection is appliled. In Retinopathy Online Challenge the proposed method has been tested, where it proved to be competitive with the state-of-the-art approaches. Local maximum region method is used for feature extraction. FROC is used for performance evaluation. In future optic disc can be detected.

MICROANEURYSM DETECTION AND DIABETIC RETINOPATHY GRADING DONE BY ENSEMBLE-BASED SYSTEM

In medical image processing reliable microaneurysm detection in digital fundus images is still an open issue. B´alintAntal (2012) proposed an ensemblebased system for microaneurysm detection and grading. In this method a combination of internal components of microaneurysm detectors, namely preprocessing methods and candidate extractors have been used. In pre-processing method includes contrast enhancement is done using gray level transformation, contrast limited adaptive equalization, vessel extraction is done. Circular HoughTransform is used for candidate extraction. The evaluation metrices is based on sensitivity, specificity and accuracy.

III. PROPOSED SYSTEM

In this paper an effective approach for detecting and classification of Diabetic Retinopathy in the retinal region using Artificial Neural Network has been introduced.To detect the affected region in the fundus image, techniques like pre-processing, segmentation, feature extraction and classification are proposed and the type is identified. Regular screenings are most effective treatment for early detection . To easily detect the patient's condition in more accurate way the automatic screening of these images would help the doctors. With this we can easily classify different types of retina images using ANN . this approach will reduce the number of reviews for the doctors.

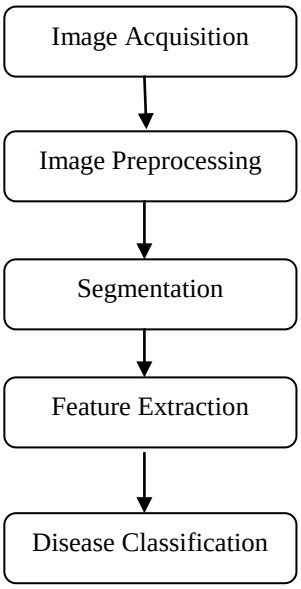

Fig-2: Flow Diagram of proposed system

The database is taken from the Standared Diabetic Retinopathy Database (DIARETDB1) which does not contain any unwanted data. Initially the datas are clustered using Expectation Maximization algorithm and then the statistical feature of the retina images are extracted and unwanted data is removed. The extracted features are given as input to the neural network classification model using testing and training process and finally, the tybe of Diabetic Retinopathy is predicted.

IV. METHEDOLOGY

The proposed methodology for detecting types of Diabetic Retinopathy contains techniques like Image Acquisition, Image Preprocessing, Segmentation, Feature Extraction and Classification.

A.IMAGE ACQUISITION

Image Acquisition is a process of getting an Input Image for the process of automatic detection of Diabetic retina system using Digital Image Processing. . A key advantage of a digital image, versus ananalog imag esuch as afilm photograph, is the ability make copies and copies of copies digitally indefinitely without any loss of image quality.

To perform some operations on an image, image processing is a method in order to get an enhanced image or to extract some useful information from it. Nowadays, image processing is among rapidly growing technologies. It makes computer science and engineering disciplines as core research area.

Image processing basically includes the following three steps:

- Importing the image via image acquisition tools.
- Analyzing and manipulating the image.

- Based on image analysis Output can be can be altered image or report.

Analogue and digital image processing are the two types of image processing methods. Hard copies like printouts and photographs are used analog image processing.While using visual techniques image analysts use various fundamentals of interpretation . To manipulate the digital images by using computers digital image processing tecniques are helped . When using digital technique like pre-processing, enhancement, and display, information extractionthe three general phases that all type of data undergo.

Image resizing is necessary when we need to increase or decrease the total number of pixels, whereas remapping can occur when you are correcting for lens distortion or rotating an image. Zooming refers to increase the quantity of pixels, so that when you zoom an image, we will see more detail.

To estimate values at unknown points interpolation works by using known data. To achieve a best approximation of a pixel's intensity based on the values at surrounding pixels and image interpolation works in two directions. Adaptive and non-adaptive are the two groups of common interpolation. Depending on interpolating adaptive methods changed, whereas non-adaptive methods treat all pixels equally.Nearest neighbour, bilinear, bicubic, spline, sinc, lanczos and others are included in non adaptive method. Adaptive algorithms include many proprietary algorithms in licensed software such as: Qimage, Photo Zoom Pro and Genuine Fractals.

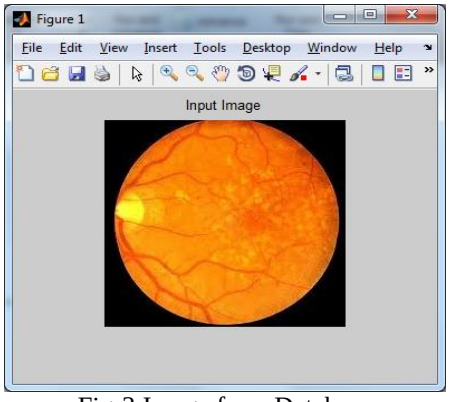

Fig-3:Image from Database

B.IMAGE PREPROCESSING

1) NOISE REMOVAL

The unwanted pixels in the images is called noise. Noise is the result of errors, the true intensities of the real scene in image acquisation that do not reflect in the result of pixel values because of noise.Depending on how the image is created noise can be introduced into an image,. For example:

- From a photograph made on film the image is scanned , source of noise is flim grain. Damage of the film is a result of noise, or also be introduced by the scanner itself.
- The noise is introduced by mechanism of gathering the data,if the image is acquired directly in a digital format.
- Electronic transmission of image data can introduce noise.Remove Noise Using an Averaging Filter and a Median Filter

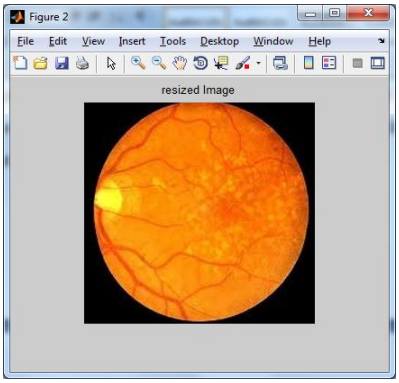

Fig-4: Resized Image

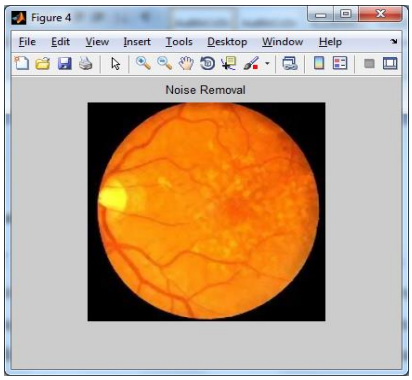

Fig-5: Noise Removal of the Image

2) CONTRAST ENHANCEMENT

Contrast enhancement is a process that by making optimal use of the colors available on the display or output device that makes the image features stand out more clearly. Contrast manipulations involves the increasing contrast by changing the range of values in an image . In this work image enhancement is done using adaptive histogram equalization.

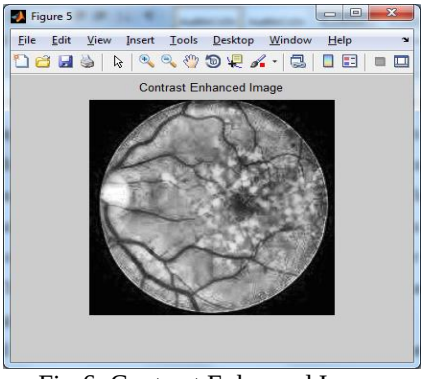

Fig-6: Contrast Enhanced Image

3) BLOOD VESSEL EXCTRACTION

The blood vessels of the image are detected using SIFT algorithm ,SIFT detects and uses a much larger number of features from the images, which reduces the errors contribution caused by these local variations in the moderate error of all feature matching errors.

The objects are identified even among clutter and under partial occlusion robustly when is SIFT is used, because the SIFT feature descriptor is partially invariant to affine distortion and invariant to uniform scaling, orientation, illumination changes.Here mentions a few competing techniques available for object recognition under partial occlusion and clutter and SIFT algorithm is summarized.The local scale selection established by SIFT descriptor based on image measurements in which reference frames are local scale invariant.

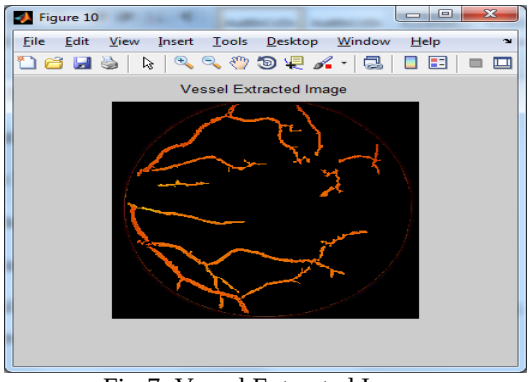

Fig-7: Vessel Extracted Image

C.IMAGE SEGMENTATION

It dividing a digital image into multiple parts callled segments (sets of pixels, also known as super-pixels) is a process of image segmentation.To simplify and/or change the representation of an image into something that is more meaningful and easier to analyze is a main goal of image segmentation.Typical method used to locate objects andboundaries(lines, curves, etc.)in a images is segmentation . More precisely, every pixel in an image have to be labeled in image segmentation and same label pixels are share certain characteristics.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set ofcontoursextracted from the image (seeedge detection). With respect to some characteristic or computed property, such as texture,color,or intensity ,the pixels in each region are similar. Adjacent regions are significantly different with respect to the same characteristics.

To develop image segmentation several general-purpose algorithms and techniques are to be used.In order to effectively solve the domain's segmentation problems, domain's specific knowledge is combined with these techniques.

In this work Expectation Maximization algorithm is used for image segmentation.

Segmentation using Expectation Maximization:

To compute the Maximum Likelihood (ML) efficient iterative procedure EM algorithm is used with the estimate in the presence of missing or hidden data.For most likely observed data we wish to estimate model parameters in estimation of ML . The E-step, and the M-step are the two step process of each iteration. In the expectation, or E-step,To estimate (guess) the values of the missing data the observed available data of the data set can be used.

By explaining the choice of terminology and conditional expectation this method will be achieved. In the M-step, after the expectation complete data is generated. The estimate of the missing data from the E-step are used in lieu of the actual missing data. Convergence is assured at each iteration of algorithm is guaranteed to increase the likelihood .

D.FEATURE EXTRACTION

Feature extraction builds derived values intended to be non redundant and informative,it starts from initial set of measured data. When the input data to analgorithm is too large to be processed and it is suspected to be redundant then it can be transformed into a reduced set of features(also named afeature vector).

Feature extraction creates brand new ones when feature selection keeps a subset of original features.When performing analysis of complex data one of the major problem’s stems from the number of variables involved. Feature extraction methods are deformable templates,template matching,zoning,graph description.

Statistical feature of an image:

The study of the organization, , analysis,collection and interpretation of data is statistical analysis. It is probably the most used statistics concept in data science.

Statistical feature of image contains

- Mean
- Variance
- Skewness
- Standard deviation

E.CLASSIFICATION

Classification is a one of the application and most active research area of neural networks. It is fundamental feature to separate large data sets into classes. Assigning a given email to the"non-spam" or "-spam"class can be taken as a example,and assigning a diagnosis to a given patient based on observed characteristics of the patient (blood pressure, sex,presence or absence of certain symptoms,etc.). Classification is an example of pattern recognition.

Artificial neural networks are computing systems inspired by biological neurons. Similarly,a neural network is made up of cells that work together to produce a desired result, although each individual cell is only responsible for solving a small part of the problem. Neural networks are

also called connectionist systems and neural networks consitute human brain. The research is mostly on human body modelling parts and recognizing diseases from various scans (e.g.CAT scans,cardiograms,ultrasonic scans,etc.). Using scans neural networks are ideal in recognizing diseases there is no need to provide a specific algorithm on how to identify the disease.

V. EXPERIMENTAL RESULT

The proposed system classifies the fundus image using ANN. 12 fundus images are tested and classified. The classification performance is measured by sensitivity, specificity, accuracy and F-measure.

$$\text{Specificity} = \frac{TN}{\text{TN+FP}} \text{ ----------(4)}$$

$$\text{Sensitivity} = \frac{TP}{\text{TP+FN}} \text{ ----------(3)}$$

$$\text{Accuracy} = \frac{TP+TN}{\text{TP+FN+TN+FP}} \text{ ----------(5)}$$

$$\text{F} - \text{Measure} = \frac{2TP}{\text{2TP+FP+FN}} \text{ ----------(6)}$$

Here, TP (True Positive), TN (True Negative), FP (False Positive) and FN (False Negative) represents the result of the proposed system. Here, TP (True Positive), TN (True Negative), FP (False Positive) and FN (False Negative) represents the result of the proposed system. Sensitivity denotes true positive rate and specificity explores true negative rate. Accuracy represents proportion of true positive and negative rate. The results are calculated manually for 89 images by applying TP, TN, FP, FN values in Equation (3), (4), (5) and (6).

VI. CONCLUSION

In this work types of Diabetic Retinopathy is detected using machine learning techniques. The proposed system consists of pre-processing, segmentation, feature extraction and classification of lesions. In pre-processing, the background pixels of the images are eliminated, resized, unwanted noise in the images are removed using median filter and then contrast enhancement is done using adaptive histogram equalization algorithm.

The blood vessels of the image are detected using SIFT algorithm. In segmentation phase the images are partitioned using Expectation Maximization algorithm for efficient image analysis. Statistical analysis is used for extracting the feature of the fundus image. The fundus image can be then classified with the help of ANN . From this method screening of abnormalities are made easy. The disease can be easily identified and prevents people from vision loss. The performance result of ANN is about 95% .The true positive rate of the proposed system improved from 98% to 99%. In future other signs of diabetic retinopathy can be detected and classified. The performance will be evaluated by comparing different machine learning algorithms.

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