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Diabetic Retinopathy Identification with Fuzzy C-Means Segmentation and Neural Network Classifier

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ABSTRACT

Diabetic Retinopathy is an eye disease that causes diabetic patients' vision to deteriorate. They are more affected as they get older. Exudates, the presence of microaneurysms, and haemorrhage are the first signs of DR. It has no early effects, and the medication becomes less effective as it progresses. As a result, early detection is more important in the prevention of this disease. To diagnose this disorder in the early stages, use machine vision technologies and image recognition. This is precisely what this paper does, assuming the Radial Basis Function Neural Network System, which provides high clarification in organizing this disease through spatial analysis. Pre-processing is done with a Notch filter, and segmentation is done with Fuzzy C means. To compare the proposed RBFNN classifier with the current CNN classifier, they use the Gabor Resonance-based Co-Variance Matrix with the Genetic algorithm for the feature extraction stage, and they use the Fuzzy C-means algorithm to increase the accuracy. This paper also makes use of the MATLAB program.

Keywords: *Vision problem, Fuzzy C-means segmentation, Genetic algorithm, Notch filter, BFRBFNN classifier, MATLAB system.*

1. Introduction

Diabetes is a long-term illness. Patients with diabetes are on the rise these days, and untreated diabetes can lead to serious illness and organ failure. Much of the patients' kidneys and hearts were affected, and they had serious eye problems [1]. Patients' blood glucose levels rise as a result of their bodies' failure to produce insulin, indicating that they have a metabolic disorder [2]. Diabetic Retinopathy is a form of retinal damage in which the patient's vision becomes blurred as the blood glucose level in the retina rises, and if not treated properly, it can lead to complete blindness (DR) [3]. Micro-aneurysms, rough exudates, and other tiny and intricate features of DR can be seen in the early stages.

Haemorrhages, neovascularization, and macular oedema are evident in the later stages (severe and proliferative) [4]. Diagnosing such small and complex features using fundus images takes a long time and involves an ophthalmologist with a lot of experience. This raises the need for automated diagnostic systems, which can minimize diagnosis time and relieve physicians of a lot of work [5].

1.1 Stages of Diabetic Retinopathy

Diabetic retinopathy is divided into four stages. Each stage has a distinguishing characteristic that aids the clinician in diagnosing it [6].

1) Diabetic Retinopathy (Mild) 2) Diabetic Retinopathy of Moderate Intensity 3) Diabetic Retinopathy with Severe Complications 4) Diabetic Proliferative Retinopathy.

(1) Mild DR

This is the first stage of DR, and the existence of microaneurysms indicates its presence. It's difficult to diagnose this stage because microaneurysms aren't easily visible.

(2) Moderate DR

At this point, the blood vessels that provide oxygen to the retina become blocked, resulting in a lack of oxygen in the retina. As vessels get clogged, they swell and leak fluid (lipoproteins). Microaneurysms, soft and hard exudates, and other signs of this stage confirm their existence.

(3) Severe DR

As more blood vessels become blocked, the retina's blood supply is cut off. When the retina runs out of oxygen, it sends a warning to the brain to create new blood vessels. The freshly formed blood vessels are easily broken, allowing blood to leak into the vitreous solution of the eye. The existence of this stage is confirmed by haemorrhage (blood vessel rupture).

(4) Proliferative DR

Blood vessels in the retina and the vitreous proliferate at this time, obstructing vision. The existence of proliferative features such as haemorrhage and neovascularization confirm the presence of the proliferative level.

2. Existing System

Diabetic Retinopathy is a serious retinal disease that is the major cause of disability throughout. Optical Coherence Tomography (OCT) and fundus photography are used by ophthalmologists to determine spinal reflexes and work, as well as to detect edoema, haemorrhage, and scars [7][8]. Deep learning models are used to describe Optical Coherence Tomography or Fundus Images, derive specific characteristics for each stage of Diabetic Retinopathy, and classify and stage the disorder. Convolutional Neural Network (CNN) has provided more accurate information in the classification of these diseases in spatial analysis than current deep learning methods, and it is more complex in architecture to infer more from visual prospects [9].

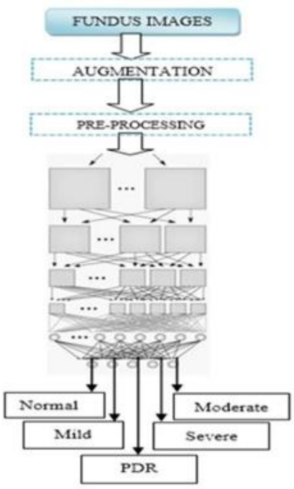

Fig.1. Block Diagram of the Existing System

The majority of image processing researchers have been concentrating on the development of machine learning in recent years. The MNIST dataset and image detection by IMAGENET are especially useful in this respect, as are deep learning strategies in the field of Hand-Written text detection.

The new therapies tend to be graded depending on the severity of the condition, based on the fundus images.

Several basic measures are used to achieve maximum accuracy from the image dataset in general, essentially a classification of diseases with current architecture a DCNN [add citation]. The multiple methods are Data Augmentation, Pre-processing, Network Initialization, Training, Activation Function Choices, Regularizations, and Ensemble.

In the existing, the framework is simplified in the DR classification model in fig 1, and the basic elements are:

Data augmentation

Pre-processing

DCNN Classification

A. Data Augmentation

The fundus image is obtained using various datasets taken with various cameras with varying fields of view, transparency, blurriness, contrast, and image sizes. Brightness changes, image flipping, and contrast adjustments are all done during data augmentation**.**

B. Pre-processing

It's for using a deep convolutional neural network to focus on fundus image spatial analysis. The first move is to resize the files. The image is then converted to grayscale before being fed into the architecture for classification. Finally, it'll be converted to an L model. A monochrome image will be produced, which will be used to highlight the vessels and microaneurysms in the fundus images.

It also flattens the image into a single dimension so that it can be processed further [11].

C. CNN Classification

The animal visual cortex, where fully automated systems are arranged in a way that responds to overlapping regions tiling the visual system, influenced the relational patterns among its neurons. CNN is a form of image recognition feed-forward artificial neural network whose connective patterns are influenced by the organisation of the animal visual cortex, in which individual neurons are organised in a way that responds to overlapping regions tiling the visual field [11].

The CNN used a dynamic architecture consisting of layered layers to characterize the images in deep learning. This architecture is especially well-adapted and for multi-class classification, adaptive to each function, and robust in the images.

Our network architecture is computationally intensive and complex, when the number of layers is large, high-level visuals are designed to process elevated images [12].

Drawbacks

- Less accuracy
- Slow in response

3. Proposed System

Using a Deep learning Bacterial Foraging Radial Basis Function Neural network classifier, this paper proposes Diabetic Retinopathy problems in the human eye. The notch filter is used to eliminate and reshape the input noises. The Fuzzy C segmentation algorithm is used to find the image pixels of the samples from the input reshaped image. The Deep Learning Neural Network Classifier is then used to categorize DR issues. MATLAB simulation is used to implement this article. The Deep learning Bacterial Foraging RBFNN classifier was used to classify diabetic retinopathy problems in the eyes. We use the Fuzzy C-means algorithm to improve accuracy. To compare the proposed RBFNN classifier's execution and segmentation analysis to that of an existing CNN classifier.

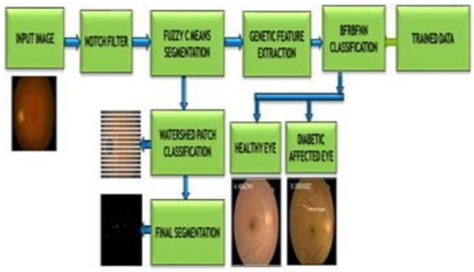

Fig.2. Block Diagram of the proposed system

A. Notch Filter

Band stop filter or Bad reject filter are other names for the notch filter. This filter attenuates/rejects signals in a particular frequency band called the stopband frequency range, thus passing signals above and below it. It can only block signals between 1500 and 1550 MHz This filter is used in pre-processing to eliminate spectral noise from the input image. This is referred to as a filtered picture. After that, the picture is transformed into a grayscale.

B. Mathematical Description

If the bandwidth is large enough, notch filters can be described as a mixture of low-pass and high-pass filters that do not interfere with each other. The transfer role is as follows:

$$H(s) = \frac{s^2 + \omega_z^2}{s^2 + \frac{\omega_p}{Q} s + \omega_p^2}$$

The circular frequency is zero in this case, and the circular frequency is the pole circular frequency. The cut-off frequency is zero, and it is used to determine the form of a notch filter. When the Q-factor is denoted by the low-pass and high-pass notch, it is referred to as a regular notch. The formula for a regular notch filter is as follows:

$$H(s) = \frac{s^2 + \omega_0^2}{s^2 + \omega_c s + \omega_0^2}$$

Here the width of the rejected band is equal to the central rejected frequency.

C. Fuzzy C- Means Segmentation

Since fuzzy segmentation is a type of clustering, each data point may belong to multiple clusters. Cluster analysis, also known as clustering, involves grouping data points into clusters such that items in the same cluster are as close as possible, while items in different clusters are as dissimilar as possible. Similarity tests may be used to identify clusters. Connectivity, difference, and strength are examples of similarity measurements. Different similarity measures may be selected depending on the data or program. Especially in the case of image segmentation by pixel classification, FCM clustering is critical.

D. Genetic Algorithm

The Genetic Algorithm (GA) is a type of optimization algorithm that uses natural selection to solve problems. Its optimization approach is based on the Darwinian population evolution criterion.

Natural solutions are used to improve the efficiency of a set of potential solutions to achieve the best possible climate. For feature extraction, a genetic algorithm is used. It relies on biologically inspired operators like selection mutation and crossover to produce high-quality solutions for optimization and search problems. The next step is to use a mix of genetic operators including crossover and mutation to create a second-generation population of solutions. We begin by selecting the trained and test data. The train and test data are then compared, and if they are identical, the data is stored in mutation. If there is a difference in the data, it will be saved in a crossover. Recheck this crossover section; if the data is different, we can conclude that the picture is unrelated.

Optimization

The population of optimal solution for an optimization problem, also recognized as entities, species, or cell types, is designed toward effective alternatives in a genetic algorithm. Each solution has a set of attributes determined by chromosomes or genotype, and these properties can be modified and mutated. Generally, solutions are represented as strings of 0s and 1s in binary digits, but other solutes are also possible.

E. Feature Extraction

For feature extraction, a Gabor resonance-based covariance matrix with a genetic algorithm is used. We must compare the qualified and test data, which necessitates the use of some features. The Gray level Co-occurrence matrix is used to pick the best feature in this case. There are a total of 12 features

Entropy, RMS, Smoothness, Skewness, Energy, Contrast, Standard deviation, Correlation, Variance, Homogeneity, Kurtosis, Mean, These features are called texture features [3] [2].

F. Radial Basis Function of Neural Network

In mathematical modelling, an RBFNN is an artificial neural network that uses its features as kernel function. This network's output is a periodic function of the neuron parameters and the radial basis functions of the inputs. Regulation of the system. System regulation, series prediction, classification, and function approximation are only a few of the applications for function networks. The RBFNN method, which uses spatial examination to group these DR diseases, has a high degree of precision. The coverage of radial basis in Fourier series is 0 to 2, i.e., 360 degrees. As a result, it distinguishes between positive and negative pixel values. Internal and external memory is available to RBFNN. As a result, we can get a precise result. However, implementation takes longer. To improve classification speed, we combine the Bacterial foraging principle with RBFNN.

Network Architecture

A RBFNN is made up of three layers: the input layer, the hidden layer with a non-linear RBF activation function, and the linear output layer. A real-numbers vector is used to represent the input. As seen in, the output of the network is a linear function of the input vector.

$$\varphi(\mathbf{x}) = \sum_{i=1}^{N} a_i \rho(||\mathbf{x} - \mathbf{c}_i||)$$

The weight of the neuron in the output linear neuron is the centre vector for a neuron, where N is the number of neurons in the hidden layer. The distance from the function is all that matters. The radial basis function is named for the fact that the centre of the vector is the same as the vector. In its most simple form, a secret neuron connects all inputs. The radial basis function is Gaussian, and the norm is Euclidean distance (even though the Mahala Nobis distance performs better recognition editorializing) [3].

$$\rho(\,\|\mathbf{x} - \mathbf{c}_i\|\,) = \exp\left[-\beta\|\mathbf{x} - \mathbf{c}_i\|^2\right].$$

In this case, the Gaussian basis functions are local to the centre vector, so the formula is,

$$\lim_{||x||\to\infty} \rho(\|\mathbf{x} - \mathbf{c}_i\|) = 0$$

Since the gap between them and the middle of that neuron is too great, changing the specification of one neuron has only a minor impact on input values. The activation function's form has a limited number of conditions, and RBF networks are universal and tightly packed groups. As a consequence, if the RBF network has sufficiently hidden neurons, it will approximate and close any continuous function on a bounded set with arbitrary precision. The parameter I am calculated to optimize the fit between the data .

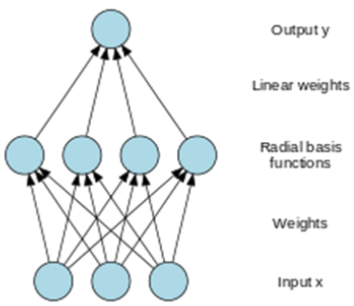

Fig.3. Architecture of RBFNN

Training

An RBFNN is a piece of software that is equivalent to a single neural network's hidden layer. Two-step algorithms are used to train these networks with pairs of input and target values. 1. Supervised Learning and 2.

Unsupervised Learning. The algorithm in a supervised learning model learns from a labelled data set and provides a response key so that it can evaluate its performance on training data. The unlabelled results of the unsupervised model, on the other hand, show that the algorithm for extracting features and patterns on its own makes sense.

The hidden layer of the RBF functions' centre vectors is chosen in the first step. In the second step, a linear model is used to fit the coefficients of the hidden layer outputs concerning some objective function [5] [2].

G. Grouping and Clustering

We group the pixels to separate them from one another, and we segment the image regions to group each set of pixels. As a result, segmentation is needed for grouping. There are three levels. 1. Slightly affected level, 2. Medium level, 3. Heavily affected level. The low level here reflects the early stages of DR. The acceptance stage of DR is represented by the medium level. The high level denotes the most advanced stage of the disease [6].

4. Results and Discussion

MATLAB is a high-performance programming language. Visualization, programming, and visualization are all organized in this software. It is easy to use and aids in the rapid discovery of solutions. MATLAB can be used in a variety of ways; since it is an interactive device, its basic data is an array, and it does not require dimensioning. This aids in the resolution of technical programming problems, mostly those involving matrices and vectors; writing a program in a scalar noninteractive language (C or Fortran) takes just a few minutes. The acronym MATLAB stands for matrix laboratory. It was written to make matrix software easier to use, particularly for ESIPACK and LINPACK papers, since matrix represents the art in both of them. It has seen a lot of development in recent years. In most universities, MATLAB is used as a basic instructional method for advanced courses in mathematics, engineering, and science, and in industries, it is used for study, industrial growth, and product research. MATLAB has a collection of application-specific and application-specific solutions. The MATLAB toolbox aids in the learning and application of advanced technology, which is important for many users. M-files, a compressed collection of MATLAB features, are responsible for the expansion. Toolboxes expand the capabilities of MATLAB to solve specific types of problems. Toolboxes are used in a variety of areas, including control systems, signal processing, fuzzy logic, neural networks, simulation, wavelets, and others. The feasibility of using fundus photos to diagnose and identify DR with a Deep Learning Bacterial Foraging RBFNN is demonstrated in this paper.

Fig.4. Input Image

Fig 4 shows the input eyes image. The eye image noise has reduced using a notch filter. Fig 5 shows the notch filter output result. The notch filter is the special hysteresis type of band-reject filter. Fig 6 shows the notch filtered result. Fig 7 shows the Enhanced image result. Fig 8 shows the Histogram result. Fig 9 shows the image grouping result. Fig 10 shows the Clustering Image. Fig 11 shows the Segmented Image result.

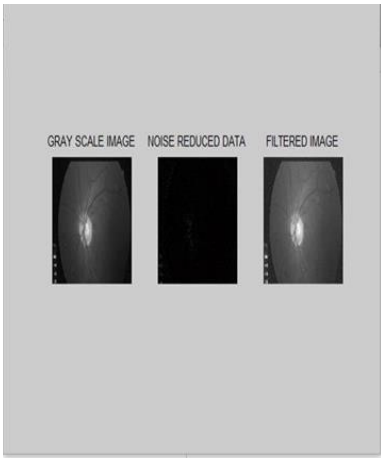

Fig.5. Grayscale image

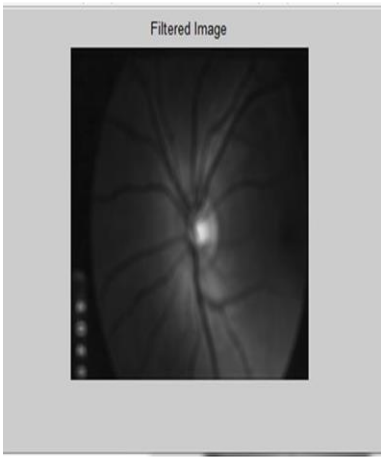

Fig.6. Filtered Image

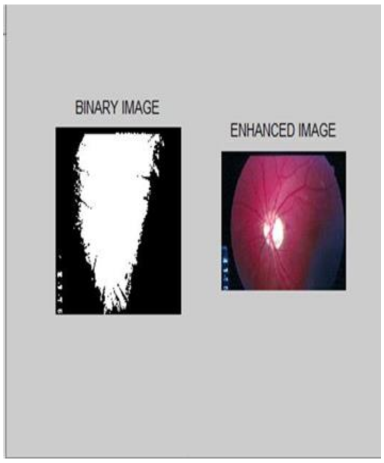

Fig.7. Enhanced image

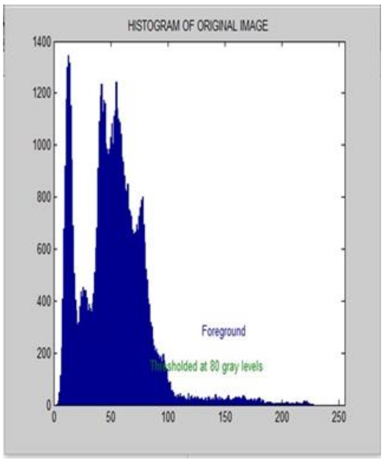

Fig.8. Histogram Result

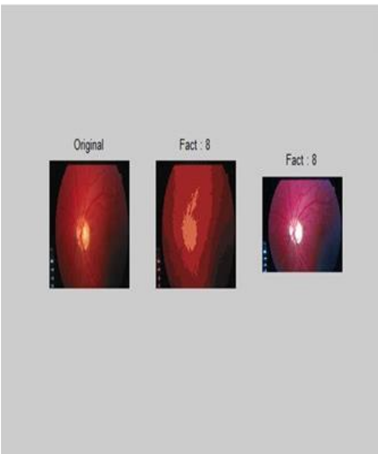

Fig.9. Image Grouping

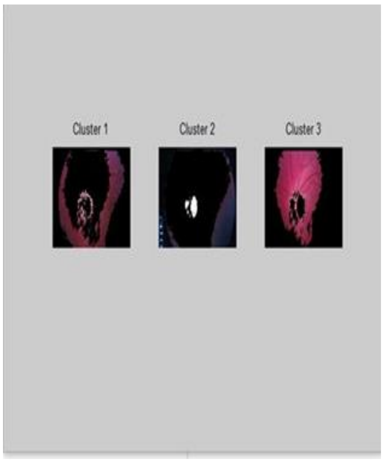

Fig.10. Clustering Image

Fig.11. Segmented Image

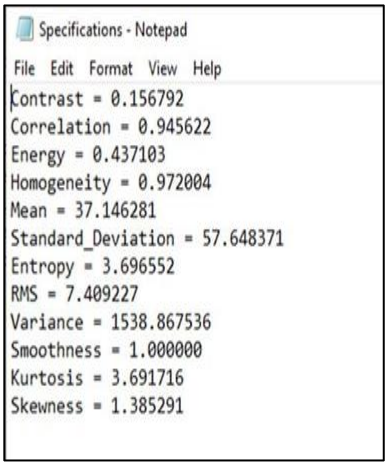

Fig.12. Feature Extraction Result

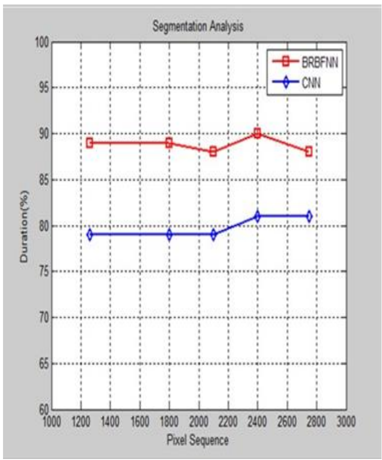

Fig.13. Segmented Result

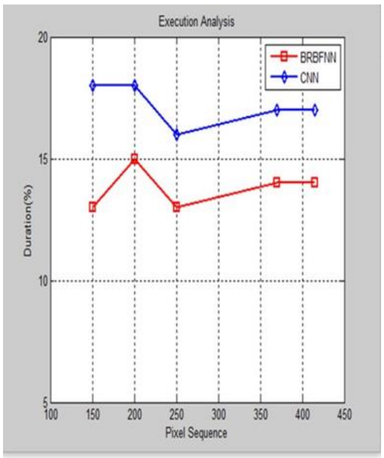

Fig.14. Execution Analysis

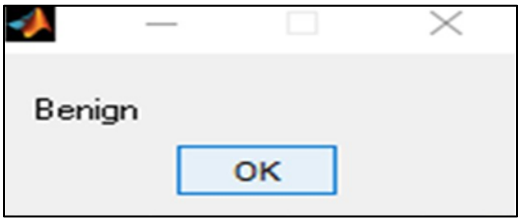

Fig.15. Final Result

5. Conclusion

A strong solution is provided by our proposed algorithm for automatic feature extraction and detection of Diabetic Retinopathy.

Our paper can provide a low-cost, high-consistency approach for diagnosing DR. Our study demonstrates the utility of deep learning in more precisely diagnosing DR from fundus videos. Physicians' reliance on this form of an automated system is reduced.

Future possibilities involve gathering a vast amount of data with enough images at each point and from a variety of demographic areas, as well as reducing doctors' confidence in automated systems. Finally, because of its important features, this algorithm is not a suitable substitute for an eye test for eye replacement.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Consent to participate

Not Applicable

Consent for publication

We declare that we consented for the publication of this research work.

Availability of data and material

Authors are willing to share data and material according to the relevant needs.

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