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AUTOMATED SYSTEM FOR DETECTION OF DIABETIC RETINOPATHY USING IMAGE PROCESSING

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Abstract - *Diabetes, referred to as Diabetes Mellitus, describes a group of metabolic diseases in which the person has high blood glucose. Possible complications that can be caused by badly controlled diabetes: Eye complications, Foot complications, Skin complications, Heart problems, Hypertension etc. Diabetic Retinopathy (DR), a common complication of diabetes, affects the blood vessels in the retina. It is due to retina not receiving enough oxygen. In this work, publicly available MESSIDOR database with 1200 fundus images are considered. By taking input as fundus image it goes through certain processes. These processes include "pre-processing"," segmentation", "feature extraction", "classification" and "result" stages. The project will display whether the provided image has hemorrhages or micro-aneurysms. Due to the textural changes in the retinal fundus images texture analysis methods like Statistical Moments and GLCM can be used for feature extraction. Classifiers such as Support Vector Machine (SVM), Random Forests, Gradient Boost, AdaBoost, Gaussian Naïve Bayes are used to detect DR.*

Key Words: Image Processing, Neural Network, MATLAB, Diabetic retinopathy, Automation, Machine Learning, Support Vector Machine

1. INTRODUCTION

1.1 Significance and relevance

Diabetic Retinopathy (DR) is leading cause of blindness. As per World Health Organization report more than 347 million people are having diabetic problems in 2030. Recent years maximum diabetes patients are getting malformation in retina which is called diabetic retinopathy (DR). People with age 30 or above have 78% chance of DR if they suffer with diabetes for more than 15 year. This rate increases to 97% if age is below 30 and suffers with diabetes for same period. Hence DR affects working age adult. This report motivates for early stage screening of DR. Diabetes mellitus have several systemic complications, like stroke, diabetic neuropathy, cardiovascular disease, diabetic nephropathy and DR. Retinopathy means damage to retina. DR appears due to longstanding of diabetes mellitus and because of that blood vessel becomes blocked, leaky and grows haphazardly. DR never shows any interference with sight till it reaches to advanced phase. Hence, eye screening for DR is essential at early stage. There are two stages of DR. Earlier one is known as non-proliferative diabetic retinopathy (NPDR) and latter one as proliferative diabetic retinopathy (PDR). The features in DR diagnosis are microaneurysms, haemorrhages, hard exudates, cotton-wool spot, abnormal new vessels, venous bending, dilations and segmentations. The microaneurysms are the small red dots on the retina, and they represent the earliest visible sign of the DR. So, detection of microaneurysms at an early stage is the first step in preventing DR. The conventional detection methods are Visual Acuity Test, pupil dilation,

Ophthalmoscopy or Fundus Photography, Fundus Fluorescein Angiography (FFA), Optical Coherence Tomography (OCT), digital retinal screening programs or services, computer vision approach, slit lamp bio-microscopy retinal screening programs. Preventive and early diagnosis of DR is very difficult particularly in rural and remote areas due to acute shortage of ophthalmologists and eye care infrastructure. This problem can be overcome by developing a automated system for detection of DR using fundus images. Mass screening of diabetic patients can be done using automated DR detection algorithms and suspected patients may be sent to eye experts for further diagnosis. For automated DR detection, digital image processing is used for diagnostic feature extraction from fundus images. There are other imaging techniques like FFA, OCT these techniques are costlier and have some side-effect too.

1.2 Problem statement

Diabetic retinopathy is a leading cause of blindness. Over 65.1 million people in India are diagnose with diabetes and this number will rise to 109 million by 2035. Therefore, it becomes need of the hour to build safe and reliable system that will work on early detection of this disease and will provide optimum and genuine results. Development of such project will lead to a social cause that will help to provide solution for diabetic retinopathy.

1.3 Platform used

For this project, image processing tools are required to recognize fundus images and to detect Region of Interest (ROI) in it. For this MATLAB(R2013a) is used which makes processing of any image, be it medical or color, easier. Its language is user- friendly which makes usage of its commands processable.

For medical fundus images required to be worked on in MATLAB, MESSIDOR database is used which is publicly available on the internet free of cost. It contains 1200 fundus images of retinas detected with Diabetic Retinopathy (DR). **MATLAB** (**mat**rix **lab**oratory) is a multi-paradigm numerical computing environment. A proprietary programming language developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

As of 2020, MATLAB has over 2 million users across industry and academia. MATLAB users come from various backgrounds of engineering, science, and economics.

1.4 Advantages

- This inter disciplinary project allows early detection of diabetic retinopathy and its severity.
- Any individual can use this system to detect his own severity of diabetic retinopathy.
- More digitized as compared to traditional detection systems.
- Elimination of hardware improves reliability of system.
- System can process on large number of fundus images.
- Cost effective solution for early detection of DR.

1.5 Applications

- This device can be used extensively in ophthalmology care centers, medical institutions.
- It can be used by individuals to detect their severity of Diabetes.
- Extended version of this project can diagnose all types of eye diseases.

1.6 Organization of project

The project consists of total five chapters. Out of five chapters first chapter consist of total introduction of the project including platform used, advantages and applications. Second chapter consist of research, understanding and development part mentioning block diagram. Third chapter includes literature review with study of system component. Result part will be covered in fourth chapter with testing of various parts of project. And last chapter is of conclusion, future scope and references.

2. RESEARCH DEVELOPMENT & IMPLEMENTATION

2.1 Understanding Diabetic Retinopathy

In any human eye, the different parts such the macula, OD, OC, fovea affect the veins which are in less comparison to the retinal dividers. The primary thing in distinguishing is the dividing of the veins which will help in recognition. The dividers of the blood veins in the retina has numerous boundaries, for example, dia, shading, width, length, branches, tortuosty, and so on.

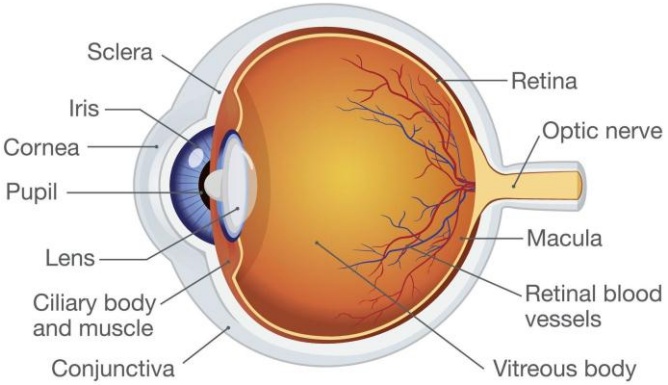

Fig -1: Structure of a Human Eye

Various eye ailments have unmistakable reactions that guides in their acknowledgment of maladies. The D R further can be recognized by the fragmenting of the OC OD w.r.t. blood vessels and by the division of veins/vessels in the fundus pictures. Retinal vein obstacle exhibits the sign of extended tangled veins, Retinal Conduit impediment have changed shades of courses that is copper or silver concealing. Diabetes is the disease which impacts the body parts like kidneys, eyes, tangible framework, heart thus forth. The natural eye which is the essential piece of the human body needs one of a kind thought as it has an impact on the vision. Patients who are having diabetes can experience the evil impacts of Glaucoma, DR, Waterfalls, Impediments in the retinal courses and Impediments in the veins of the retina. In the event that there is a high BP, this will have an impact on the eyes, prompting loss of vision.
Bigger piece of the eye ailments causes visual impairment in the natural eyes and if not reestablished honestly and taken consideration at earlier advances. DR is an eye affliction/disease that is a result because of the deferred and un-treated diabetes. The diabetic-retinopathy have the side effects which begins from miniaturized scale micro-aneurysms which exists because of debilitated blood vessels/veins/capillaries which are seen as red shading little specks (roundabout in nature). When these dividers of the retinal blood veins are broken, hemorrhages show up which are ruddy in shading platelets. Exactly when the reality of the DR increases, hard exudates appears in the retina which exists in light of spillage of proteins and lipids from the blood, which are yellowish in shading concealing. After more

noteworthy progress in reality of the ailment 'DR', there is a part of obstacle in the veins that prompts arrangement of sensitive exudates as cotton wool spots of white shadings in nature (whitish in shading exudates).A solid retina is appeared in the Fig. 2, while a retina influenced with diabetics (harmed retina) is appeared in the Figs. 3-5 separately.

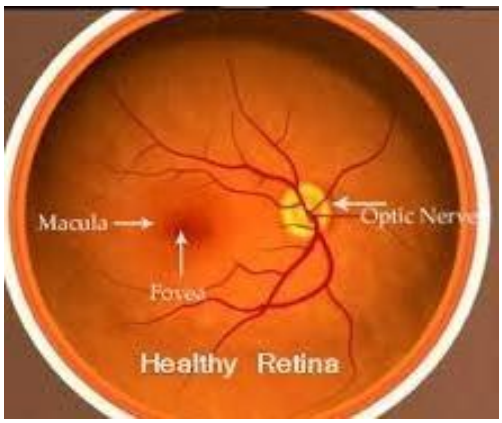

Fig -2: A healthy retina

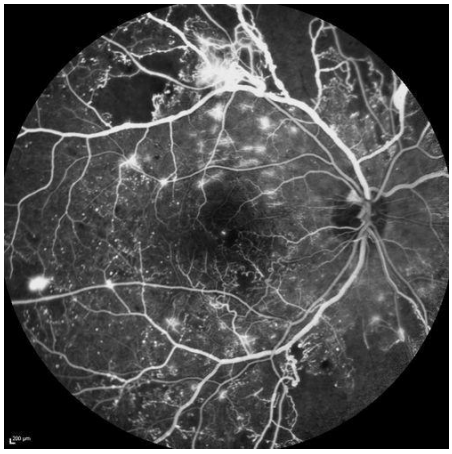

Fig -3: A human retina which is affected with Diabetes-1

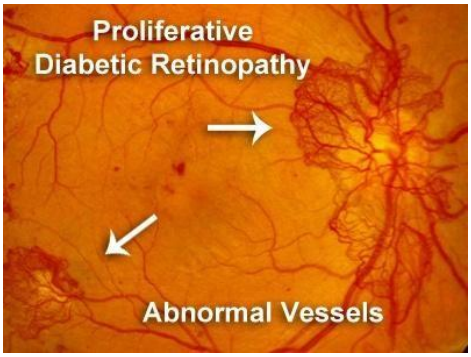

Fig -4: A human retina which is affected with Diabetes-2

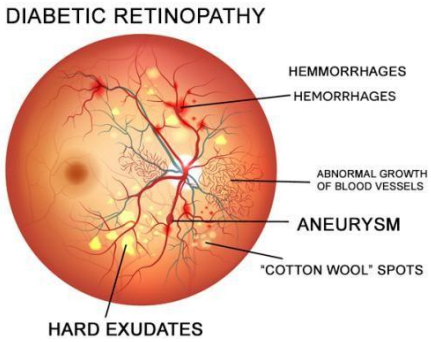

Fig -5: A human retina which is affected with Diabetes-3

So, diabetes is brought about by an adjustment in the structure of the veins of the human eye's hold. The retina structure will be a meager, internal covering at backside of natural eyes that is a lot of reliant on the light. The damage is brought about by an extension in blood's sugar level of the glucose substance which can hurt veins/vessels. At the point/crossroads when these veins-vessels thicken-become enormous, they can make spills, which at that point offers ascend to the natural eye's vision misfortune. The 4 periods of DR &is pictorially appeared as a slide in the Fig. 6, aside from which it is likewise clarified one after the different as follows. The 4 classifications of DR could be summed up as –

- Mild-Initial stage
- Moderate-Mid way stage
- Severe/non-proliferative pre-final stage
- Proliferative-final stage.

To think about the first one, the gentle or the non – multiply instance of DR, there will an expanding looking like a little expand w.r.t. a portion of the pieces of the veins or the blood vessels which are situated close to the retina. At that point the second stage, called as moderate/medium non-multiply retinopathy, not many retinal veins will get harmed because of the expansion in sugar level in this way giving ascent to the blockage. In the third stage, genuine or non-multiply DR conveys with it more blocked veins/vessels, which prompts numerous of the zones of the retina never again getting adequate blood stream, in this way offering ascend to more squares in retina. Along these lines, w/o proper circulation system stream, the human eye's retina can't grow more or fresh blood veins/vessels which can be utilized to supplant the harmed veins.

In the fourth and the last stage which is known as multiply retinopathy, this will be the propelled phase of DR illness. This is the moved period of the illness, where extra new veins will begin to create in the retina, i.e., begins developing, yet they will be sensitive and abnormal (little in structure). Thusly, they can spill blood (overflow out the blood) which will provoke weakening the vision loss& potentially bring about the visual deficiency.

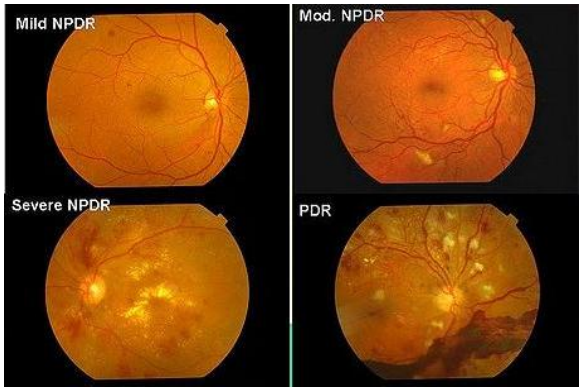

Fig -6: The four chronic stages of Diabetic Retinopathy

Care must be taken to see that if the sickness happens, it must be treated at a prior stage, else there would be misfortune of vision. The first guideline is gaining the picture of the retina of the ailing from a high-resolution camera. Next is to process the picture utilizing different kinds of pre-handling and division procedures, at last to separate the locale of intrigue, i.e., the ROI, when the nerve organize is acquired, at that point it tends to be chosen whether the patient is influenced with diabetes or not. In our work, we are going to focus on the pre-handling and segmentation gives that remove the return for capital invested effectively with no uncertainty and yield better results.

2.2 Procedure for Diabetic retinopathy detection in Human eyes

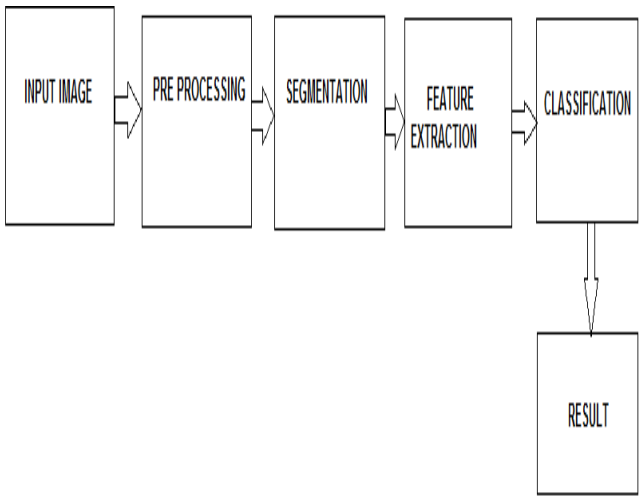

Fig -7: Block Diagram

1. Input Images: - The system's input is a Retinal Image from the MESSIDOR database available for research. This database contains Fundus eye images of various Diabetic patients (both left and right).

2. Pre-Processing: - The aim of preprocessing is to improvement of the image data that suppress unwanted distortion or enhances some image features important for future processing. In pre-processing, first we covert the color image (fundus image) into grayscale image and then histogram equalization of that image.

3. Segmentation:-It is a process of partitioning a digital image into multiple regions and extracting a meaning full region known as the region of interest(ROI).We are using Optimal Thresholding Method, it is used when boundary between foreground object and background object is not clear, then we have considerable overlapping of histogram. This method is optimal in our case. Under this method we have Otsu's Method, which selects the thresholding value optimally used on characteristics of the image data. Selects thresholding value based on the criteria [sigma(B)] ^2/[sigma(T)] ^2, where [sigma(T)] ^2 is total variance. Aim is to pick threshold such that the pixel on either side of threshold are close in value to the mean of pixels of that pixel, also the mean of one side is different from other side.

4. Feature Extracting: - Any characteristics or primitive of an object that helps to distinguish or discriminate an object from other objects is called an Image features. The purpose of an image feature extraction is to describe the object in a meaningful manner so as to aid the recognition process. This phase is critical because the quality of features influences the classification task. The extended set of features is stored as a vector called the feature vector. A feature vector or pattern vector is a vector that contains n measure values.
The classifier takes the feature vector as input and performs the classification. Any pattern recognition task such as classification or clustering can be performed to recognize the object.

5. Classification: -In this process we have Support Vector Machine.: Support Vector Machines (SVMs) are a relatively new supervised classification technique to the land cover mapping community. It has its roots in Statistical Learning Theory and have gained prominence because they are robust, accurate and are effective even when using a small training sample. By its nature SVMs are essentially binary classifiers, however, they can be adopted to handle the multiple classification tasks. The two approaches commonly used are the One-Against-One (1A1) and One Against-All (1AA) techniques.

6. Results: - After classification, final results will be shown with the help of GUI window (Graphical User Interface). The result will display whether the input image is affected with Micro aneurysms or

hemorrhages. Therefore, the consultant will be able to diagnose the patient correctly.

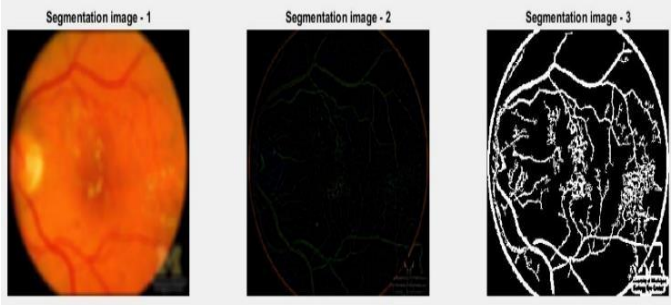

Fig -8: Original colored retinal image

Fig -9: Screenshot of captured preprocessed image

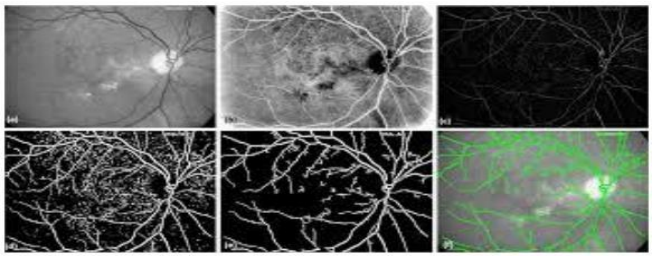

Fig -10: Segmented retinal images

3. LITERATURE REVIEW

Various analysts across the world have taken a shot at the point of diabetic retinopathy& its detection from the retinal nerve fibers. Their brief insight into the works done till date is presented in the following points.

3.1 Literature survey

[1] Proposed methodology provides comparative analysis of preprocessing techniques for detecting diabetic retinopathy. Four methods like HE, ADHE, CLAHE and ESIHE were stated. Out of these HE is easy to implement but ESIHE has lowest noise ratio.

[2] Provides information on different classifiers and their accuracy levels. With this comparative study it can be safely stated that SVM provides better results than any other method.

[3] This paper provides a different approach altogether to this topic. Different feature extraction methods and post processing algorithms is added.

[4] Tested paper provides information on high level accuracy and was implemented on 189 images. The threshold method is adaptive but provides vary low number of falls diagnosis.

[5] Mentioned paper provides detection of hemorrhages using three main modules preprocessing, segmentation and filter-based reduction. Method has highest sensitivity of 94.62%.

[6] This paper provides machine learning based classification and has future scope to detect NVE (Neovascularization Elsewhere).

3.2 Existing system

- Ketaki S. Arcade et al. proposed "Automatic Detection of Diabetic Retinopathy using Image Processing and Data Mining Techniques" [2015].
- Ravitej Singh Rekhi et al. proposed "Automated classification of exudates from Digital Fundus Images" [2017].
- Vijay Mane et al. proposed "An Automatic approach to Haemorrhage Detection" [2015].
- Shuang Yu et al. proposed "Machine Learning based Automatic Neovascularization Detection Optic Disc Region" [2016].
- Wei Zhou et al. "A Novel approach for red lesions detection using super-pixel multi-feature classification in colour fundus image" [2017].

4. RESULT AND DISCUSSION

4.1 Problems faced during setup

- Understanding the mechanisms of Image processing and its implementations using MATLAB.
- MESSIDOR database having fundus images of retinas affected with diabetic retinopathy.
- Working with medical images and performing operations on it was tricky.

- Various parameters of fundus images needed to be considered.

5. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

- This project takes input as fundus image and processes it to detect diabetic retinopathy.
- Project can run on any MATLAB installed- platform and can manage well with stack of fundus images, given one at a time.
- The result stage will diagnose the type of damage caused to retina, whether Hemorrhage or Microaneurysms.

5.2 Future scope

- Modified version can help detect and diagnose any eye related problem.
- Cost effective solution can be provided for a social cause of blindness in people.

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