

DETECTION OF DIABETIC RETINOPATHY

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Abstract - Diabetes mellitus or simply known as diabetes is a blood glucose disorder which interferes with the body's ability to use blood glucose. Diabetes is characterized by production of excess glucose in the body. This sudden increase in glucose level results in the production of various symptoms. One such illness, Diabetic Retinopathy is a secondary illness that surfaces as a complication of diabetes mellitus. This complication affects eyes and causes weakness in blood vessels of retina. The illness manifests itself as slight blurriness of vision and over time causes blindness. From 2000 to 2010, 89% increase in diagnosis of Diabetic Retinopathy was observed in United States. Another such related complication is maculopathy. Also called as, macular degeneration, this disease is related to retina but concentrated at the central part of retina called as macula. The severity and vigorousness of both of these diseases require screening. The existing screening system burdens medical professionals and hence, this research proposes an automated screening system that accesses images, pre-processes it, extracts essential features and classifies the images accordingly.

Key Words: Diabetes, Retinopathy, maculopathy, fuzzy, grayscale, filtering, histogram,

1. INTRODUCTION

The underlying cause of the symptoms of Diabetes is serious health problems that are caused due to the increase in glucose levels. Glucose, commonly called as sugar, is body's prime source for energy. Nevertheless, its excess in body is fatal.

Diabetes is a chronic illness that affects almost 34.2 million Americans. This equates to almost 10.5% of the population. It is seventh most leading cause of death and affects diverse population of all age groups, ethnicity, race and culture (American Diabetes Association). In India, diabetes is referred to as "potential epidemic." As per statistics, in year 2014, 62 million people were diabetic in India. (Seema Abhijeet Kaveeshwar, et al.; 2014). These numbers are expected to rise to, as high as, 366 million globally by 2030 with the maximum rise and impact on Indian population. (Wild S, et al.; 2000). Diabetes is a multi-factor disease, factors ranging from genetic to environmental.

Diabetic Retinopathy is a secondary illness that surfaces as a complication of diabetes mellitus. This complication affects eyes and causes weakness in blood vessels of retina. The illness manifests itself as slight blurriness of vision and over time causes blindness. As mentioned above, the increase in glucose levels in blood causes major disturbances in the body. As a repercussion of increased sugar levels, the blood supplying vessels get blocked which cause major problems. The blockage of retinal blood vessels overtime triggers body's mechanism of production of new blood vessels. These new blood vessels are fragile due to poor development and can burst or leak, thus causing Diabetic Retinopathy (DR). It is of two types:

- Early Diabetic Retinopathy
- Advanced Diabetic Retinopathy

(Mayo Foundation for Medical Education and Research (MFMER)) Estimations suggest, almost all patients suffering from Type 1 diabetes are likely to develop Diabetes Retinopathy. In case of patients suffering from type 2 diabetes, 66.66 out of 100 are likely to develop DR at some point of time.

Timely screening of eyes is very essential for early detection. If detected early, the symptoms can be treated adequately and acute vision loss and blindness can be prevented. Regular screening determines whether and how the patients need to schedule their follow-ups. Various stages of DR, i.e. Mild, moderate, severe, proliferate and Advanced Diabetic Eye disease, are treated differently. For accurate treatment a robust screening system is required to aid professional health executives.

The severity and vigorousness of both of these diseases require screening to determine the time intervals at which the appointments have to be made. Hence, a model screening mechanism is required to accurately and efficiently screen and study the progression. Moreover, this will reduce the burden from medical professionals and aid them with the diagnosis. In this research, use of fuzzy image techniques is implied to extract necessary features of the accessed images. For grading of the processed and fuzzy imaging techniques modified images, classification system used by ophthalmologist for ranking the progression of Diabetic Retinopathy and Maculopathy. The images are graded into total of 10 orders.

2. LITERATURE SURVEY

As per statistics, in year 2014, 62 million people were diabetic in India. (Seema Abhijeet Kaveeshwar, et al.; 2014). These numbers are expected to rise to, as high as, 366 million globally by 2030 with the maximum rise and impact on Indian population. (Wild S, et al.; 2000). Diabetes is a multi-factor disease, factors ranging from genetic to environmental

Though, this disease does not lead to complete vision loss, yet, the severity of the disease cannot be undermined. It is concerned with the loss of central vision. Central vision usually defines the detailing power of the eye which is controlled by fovea, which lies at the Centre of macula. Furthermore, it also is responsible for the colored vision. Thus, loss in central vision can accurately be marked as "legal blindness" (S.S. Rahim, et al.; 2015). A number of reasons can cause maculopathy, yet, one of the most common underlying reasons is diabetes. Maculopathy is caused by micro aneurysms, exudates and/or hemorrhages in macular region of the retina.

Diabetic Retinopathy is further categorized into classes that offer detailed analysis. The classes are as follows:

- Mild Diabetic Retinopathy with Maculopathy,
 - Mild Diabetic Retinopathy without Maculopathy,
 - Moderate Diabetic Retinopathy with Maculopathy,
 - Moderate Diabetic Retinopathy without Maculopathy,
 - Severe Diabetic Retinopathy with Maculopathy,
 - Severe Diabetic Retinopathy without Maculopathy,
 - Proliferate Diabetic Retinopathy with Maculopathy,
 - Proliferative Diabetic Retinopathy without Maculopathy and
 - Advanced Diabetic Eye Disease.
- (S.S. Rahim, et al.; 2015)

3. PREVIOUS WORKS

Akara Sopharak, et al.; proposed a system that uses certain morphological operators to produce low-contrasting images for detecting exudates. The images are verified by comparing it with the pre-existing images drawn by the ophthalmologists. Nathan Silberman, et al.; proposed a portable detection system working on Java to detect DR and myopathy using a single image. This system also works on detection of exudates by using a Support Vector Machine (SVM). M. Usman Akram, et al.; detects the progression of Diabetic Retinopathy by detection of micro aneurysms instead of exudates. Filter banks are used to detect DR by feature vectors that are formulated for each type of region in eye based on certain properties of colour, intensity and shape etc. it is a multi model approach that combines Gaussian mixture model and Support Vector Machine.

4. PROPOSED SYSTEM

In the proposed study, usage of Fuzzy Inference System (FIS) has overcome this issue. This system demands inputs in 2 dimensional planes with values from x-axis and y-axis. As mentioned above, the present system makes use of fuzzy imaging techniques to pre-process the data. A set of images were provided in JPEG format. Images are acquired and selected; the selected images are further processed using fuzzy imaging techniques. These techniques modify and alter image quality by increasing and enhancing the colour contrast. Other features like sharpness, image clarity etc are also enhanced. Subsequently, features are extracted. The area, the mean and the standard deviation of on pixels are the major focus. These features are extracted and at the end, classification of images is done using hand-drawn imaging by ophthalmologists. Total 10 orders of classifications are designated to divide the images and identification of stages of Diabetes Retinopathy and Maculopathy. Outlining, the whole process, the system process can be represented with the following flow chart.

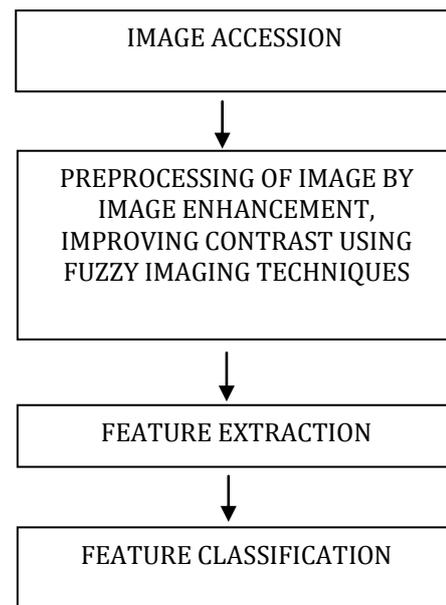


Chart -1: Outline of the Process

Classification of the images is done in two broad categories, viz., No Diabetic Retinopathy, Diabetic Retinopathy. Second category offers more detailed analysis and categorizes the images into Mild, Moderate, Severe, Proliferate and Advanced Diabetic Eye Disease, with or without Maculopathy.

4.1 Pre-processing

After selection of the images, data quality is improved using various parameters. In the present study, parameters used for data quality improvement are:

- Greyscale conversion
- Fuzzy Filtering
- Fuzzy Histogram Equalisation
- Fuzzy Edge Detection

4.2 Greyscale conversion-

The first processing technique used is the conversion of coloured images of the fundus to greyscale versions. This instates the luminance but decreases the saturations and tones. The rgb2gray feature of the software is used to perform the function.

1. Take R, G, B color (each in [0,1] range)
If they're in the range 0..255 instead, simply divide by 255.0
2. Compute $C_{linear} = 0.2126 R + 0.7152 G + 0.0722 B$
3. Compute C_{srgb} according to it's formula, based on C_{linear}

This is the nonlinear gamma correction

$$C_{srgb} = 12.92 C_{linear}$$

when $C_{linear} \leq 0.0031308$

$$C_{srgb} = 1.055 C_{linear}^{1/2.4} - 0.055$$

when $C_{linear} > 0.0031308$

4.3 Fuzzy Filtering

Image quality is improved using this feature by restoring the digital quality to the original quality. This is done using Fuzzy Switching Media (FSM) filter which cancels noise that was added in the transmission process.

As per the fuzzy theory, the belonging of element y to a set A is gradual and characterized by a membership function $\mu_A(y)$. Let Y be the universal set of elements y , then a fuzzy set A in Y is defined by:

$$A = \{(y, \mu_A(y)) \mid y \in Y\},$$

where $\mu_A(y)$ is called the membership function of the fuzzy set A . The filters used in the image processing that employs fuzzy logic model the characteristics of the image as a fuzzy set.

4.4 Fuzzy Histogram Equalisation

After noise filtration, contrast of images is enhanced by altering intensities. A standard histogram is kept for reference, the intensities are enhanced to match upto that the histogram readings. Using fuzzy techniques for equalization enhances the visualization and detection of images. Coloured fundus images, exceptionally, pose great

deal of problems and challenges. Various methods of these enhancements are being used by many researchers.

4.5 Fuzzy Edge Detection

This is an edge detection system that defines the edge of the pixels. Normally, a decent in intensity is observed when edge detection methods are used. This occurs due to misguidance of a shading effect as an edge. In the proposed study, usage of Fuzzy Inference System (FIS) has overcome this issue. This system demands inputs in 2 dimensional planes with values from x-axis and y-axis. Mechanism of this system includes assigning a "zero-mean Gaussian membership function." This function puts and defines the input to a membership function and degree based on the pixel value. For instance, if the gradient value of a certain pixel is inputted as 0, then the FIS assigns it to degree 1 and membership 0.

Intensity is a parameter of detection. This intensity, which is considered as "the output" of the edge detected image is assigned with a triangular membership function. Consequently, if one of the inputs is not zero a black pixel is presented, otherwise, if both of the inputs are 0 a white pixel is presented if it belongs to a uniform region. Hence, a black and white image is produced.

4.6 Extraction of features

After the early processing of the image, the next step is to extract the necessary features of the fundus image. As mentioned above, three parameters of feature extraction are done, namely:

- the area of pixels
- the mean
- the standard deviation

Feature extraction based on other parameters can also be done to further improve the quality of the given images. For the purpose of this study, we have only used these parameters.

4.7 Classification system

The grading and classification of the processed and feature extracted images are done. The parameters of grading are as follows:

- (i) diabetic retinopathy
- (ii) macular edema, and
- (iii) gradability

Scales have been predefined by international clinical diabetic retinopathy and macular edema disease severity scales. These scales were later donated as PIRC and PIMEC.

These two grading systems were used to extensively derive three more grading systems, namely:

- (i) nonreferable/referable diabetic retinopathy (NRDR/RDR)- binary system,
- (ii) nonreferable/referable diabetic macular edema (NRDME/RDME)- binary system, and,
- (iii) three-class system of ungradable/NRDR/RDR

(Jaakko Sahlsten, et al.; 2019)

RESULTS

The proposed system was tested and the results were validated. The results obtained were accurate and provided better visualization and detection of Diabetic Retinopathy and Maculopathy. The specificity and sensitivity of the system were up to the mark. The maculopathy can be clearly and optimally viewed in the fuzzy edge detected image. The contrast and sharpness of the image was greatly improved and the increase in area of "on pixels" for the images with retinopathy served as an optimum marker for detection.

CONCLUSION

The said system was developed to detect fundus images of Diabetic Retinopathy and Maculopathy. The concerned system can detect the images and the accuracy, sensitivity and specificity of existing systems have been improved several folds by fuzzy imaging techniques.

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