INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & MANAGEMENT

Review On: An Efficient Automated System for Detection of Vision loss caused due to Diabetic Retinopathy

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Abstract

Diabetes is a worldwide disease which is one of the main reason for blindness in the older age of any human community world-wide. Advanced level of diabetes leads to retinal problems called as diabetic retinopathy. Early detection of this disease is important. During pregnancy, diabetic retinopathy may also be problem for women with diabetes. This paper deals with detecting and classifying three diseases of diabetic retinopathy that are macula Ischemia, neovascularisation and vitreous haemorrhage using image processing methods. This paper mainly deals with automating detection of above three diseases in eye fundus images using digital image analysis methods which has huge potential benefits, allowing the examination of a large number of images in less time, with lower cost and reduced subjectivity than current observer-based techniques. Another advantage is the possibility to perform automated screening for pathological conditions, such as diabetic retinopathy, in order to reduce the workload required of trained manual graders.This method also uses support vector machine(svm) which is a supervised learning algorithm for both classification or regression challenges.

Keywords: Diabetic retinopathy(DR), Macula Ischemia(MI),Vitreous haemorrhage(VH),Support vector machine(SVM),Proliferative diabetic retinopathy(PDR), Non-proliferative diabetic retinopathy(NPDR), SUSAN (Smallest Unvalued Segment Assimilating Nucleus)

INTRODUCTION

Diabetic Retinopathy is a major disease which may occur to a patient who is having diabetic mellitus. DR is of two types.One is.PDR is the more advanced form of the disease. At this stage, circulation problems cause the retina to become oxygen deprived. As a result new fragile blood vessels can begin to grow in the retina and into the vitreous, the gel-like fluid that fills the back of the eye. The new blood vessel may leak blood into the vitreous. Another is NPDR is the early state of the disease in which symptoms will be mild or non-existent. In NPDR, the blood vessels in the retina are weakened causing tiny bulges called micro-anuerysms to protrude from their walls. The micro-anuerysms may leak fluid into the retina, which may lead to swelling of the macula. The proposed work focuses on three diseases that are MI, neovascularisation,VT Figure 1 shows difference between normal eye and diabetic eye. For automatic detection of three diseases following steps are important: Preprocessing of retinal images, Detection process, Feature extraction and SVM classification.

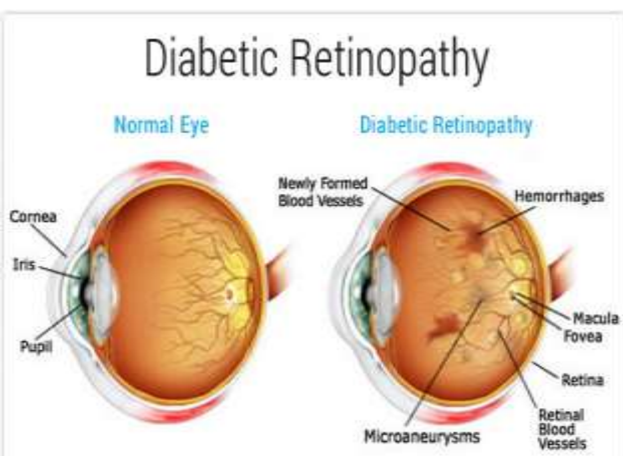

Figure 1:Difference between normal eye and affected eye.

LITERATURE REVIEW

In the paper written by [1] presents an overview of various methods used by other researchers in determining the retina vascular tortuosity and its association with DR. In this paper, several quantitative methods of retinal vascular tortuosity in Retinopathy of Premature (ROP) assessment are included as a benchmark of tortuosity measurement in DR. Initial finding suggests that there is a possible association between retinal vascular tortuosity and the development of DR. To confirm this, further research has to be conducted to see the frequency or rate of retinal vascular tortuosity. As such, this paper intends to report the preliminary work conducted which summarizes several developments in recent literature and discusses the various methods used for tortuosity measurement in DR.In the paper[2] A new algorithm is proposed to detect the presence of hemorrhage with maximum efficiency and accuracy. The algorithm works by partitioning the image into differentiated segments covering the entire retinal image. These segments are denoted by splats.Each splat here establishes a set of information which helps us to extract the appropriate boundary.

The pixels are grouped by the similarity of the color, intensity and spatial location. Retinal ischemia and weak blood vessels are the main reasons for the occurrence of hemorrhage. The new algorithm is based on the segmentation which is grouped by the colour, intensity and the spatial of the entire image.In the paper[3].This study focuses on detecting and classifying neovascularization caused by proliferative diabetic retinopathy (PDR) in retinal fundus images. Image processing methods were applied to detect retinal vessels.

A fractal analysis approach based on the box-counting method was used to quantify vascular patterns in normal and abnormal cases showing neovascularization near the optic disk (NVD). Ten images including five normal cases and five neovascularization cases were analyzed. The mean fractal dimension obtained for the NVD cases was 1.66 compared to the mean value of 1.52 for the normal cases. The statistical significance of the difference was high, with a p-value of 0.0088. The results show promise for use in detecting neovascularization in retinal images caused by PDR.

In the paper [4] proposes methods to assess the image quality and to segment the image components for analyzing the disease severity level of a retinal image.Four major information constituting the image quality, namely color, contrast, focus,and illumination, are extracted in order to evaluate the overall image gradability. By classifying images according to their image quality factors, the Principal Component Analysis (PCA) technique is applied to reduce the data dimensionality and vividly project discriminant features over minor misleading details that could hamper the accuracy of the evaluation result.Then, the k-nearest neighbor is applied as a classification tool.

PROPOSED WORK

Diabetic Retinopathy is related to diabetes which is caused due to the lack of insulin secretion resulting in the visual illness.Screening of MI,NV,VH is manually done but it is very time consuming process because of large diabetic patients. Hence, there is a need to design automated system for detection of MI,NV,VH. Figure 2 shows proposed diagram.

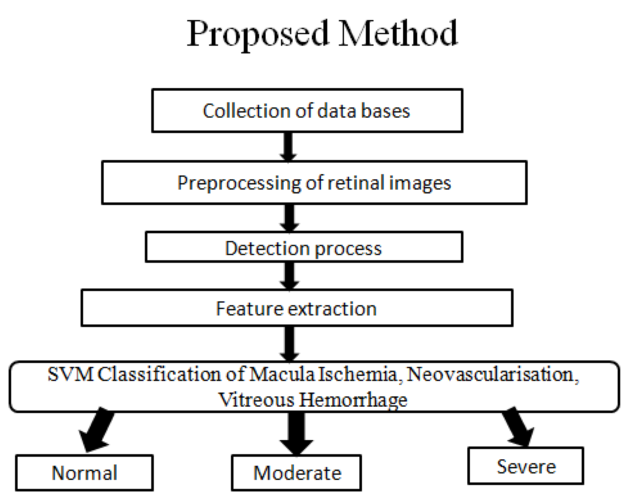

Figure 2: Proposed methodology

PREPROCESSING OF RETINAL IMAGES

The aim of preprocessing is to improve the retinal images by suppressing unwilling distortions and enhance some image features important for further processing.It includes following steps:1)converting retinal image into gray image.2)using laplacian of Gaussian filter.3)using unsharp masking.4)using high boost filtering. Laplacian filter highlights the region of rapid intensity changes.It is mainly used for egde detection. The Laplacian *L(x,y)* of an image with pixel intensity value *I(x,y)* is given by(1):

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

(1)

Combination of laplacian and Gaussian function is given by equation(2):

$$\mathrm{LoG}(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right]e^{-\frac{x^2+y^2}{2\sigma^2}}$$

(2)

Unsharp filtering is one of the sharpening technique.It creates an edge image by subtracting the unsharp image from the original image given by the equation(3):

$$g(x,y) = f(x,y) - f_{smooth}(x,y)$$

where $f_{smooth}(x,y)$ is a smoothed version of $f(x,y)$.

(3)

It creates sharp image by adding edge image and original image given by the equation(4):

$$f_{sharp}(x,y) = f(x,y) + k * g(x,y)$$

(4)

.

Unsharp filtering preserves high pass components present in the image but low pass components are also necessary for accurate interpretation of image,so high boost filtering is used.It is given by equation(5) :

$$I_{highboost} = AI_{highboost} + I_{highpass}$$

(5)

TOP-HAT AND BOTTOM HAT FILTERING

Top hat filtering is mainly used here for the enhancement of images.It extracts small elements and details from given images.Top hat filter is used to enhance brightest points and bottom hat filter is used to enhance darkest points.

MEDIAN FILTERING

Median filter is a non-linear digital filter,often used to remove noise. A filtered image is generated as the center of the mask moves to every pixel in the input image.One kind of smoothing technique , this smoothing techniquesis effective at removing noise in smooth patches or smooth regions of a signal, but adversely affect edges. It provides good noise reduction for certain types of noise such as impulse noise. Significantly less noise as associated to weighted noise filter .Orders pixel within the area. Exchange value of center pixel with median filter.

DETECTION PROCESS

In this step segmentation techniques are used to detect that region of the image which is of our interest. Graph based method is used to segment blood vessels for macula ischemia.Susan edge detector is used for Neovascularisation. Linde-Buzo-Gray algorithm(LBG) is used for Vitreous haemorrhage.

ISSN 2277 – 5528
Impact Factor- 4.015

GRAPH BASED METHOD

An algorithm to measure the width of retinal vessels in fundus photographs using graph-based algorithm to segment both vessel edges simultaneously. Our proposed method aims to identify vessels and characterize them in the form of binary trees for subsequent vessel measurements. It has two main steps:1) identify crossovers 2) search for the optimal forest (set of vessel trees).

SUSAN EDGE DETECTOR

SUSAN stands for smallest unvalued segment assimilating nucleus was introduced in 1995.Its basic principle is based on the pixels similarity with its neighbour pixel gray value. Following figure 5 represent its basic principle in which circular templates carries information about image pixels around a given point. USAN area is shown by dark region and it is maximum at flat region, it becomes half at the edges and become very less at the corner of image. The weight or area of USAN region is calculated by following equation (6):

$$n(r_0) = \sum_r compare(r, r_0) \qquad \textbf{(6)}$$

$$C(r, r_0) = \begin{cases} 1 & |I(r) - I(r_0)| \le t \\ 0 & |I(r) - I(r_0)| > t \end{cases} \qquad \textbf{(7)}$$

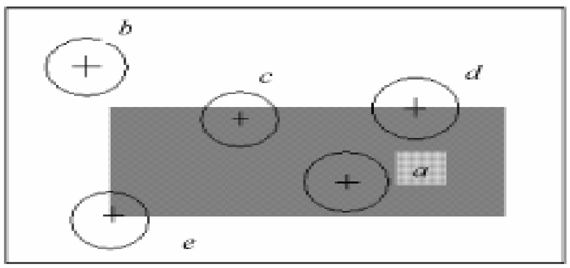

Figure 5: Testing principle of SUSAN

Where compare(r, r0) is function of pixel belongs to the USAN region within the template. *I(r0)are the* gray value of the nucleus within the mask. *I(r) as a* gray value for other random pixel in the mask, t is a threshold value of gray pixels. Then every pixels edge strength is computed using the mathematical formula[10]:

$$response(ro) = \begin{cases} g - n(ro) if\, n(ro) < g \\ 0\ otherwise \end{cases} \qquad (8)$$

Above formula shows the comparison between number of pixels in USAN region and geometric threshold value which is fixe at $3n_{max}/4$, where n_{max} is the highest value of number of pixels containing in USAN region. This edge response given by (8) will be larger as the SUSAN area is smaller. After edge response calculation the direction which is perpendicular to the edge is required for image to be suppressed. Direction of the edge which is being examined depends on its type either inter pixel or intra-pixel.

LINDE-BUZO-GRAY ALGORITHM(LBZ)

LINDE-BUZO-GRAY (LBG) is a technique of image segmentation which can be better used for segmentation and compression of images. Vector quantization is an efficient technique for image compression. The codebook is created from the clusters thus formed and this algorithm describes two dimensional vector space. The centroid is computed as the first code vector called C1. Two vectors V1 and V2 are generated are as the code vectors for constant errors. The Euclidean distances of the vectors are generated and then the code vectors are computed for the nearest code vector V1 and V2.This procedure is repeated for every new cluster until the required size of specified MSE(mean square error) is reached. Reconstruction of image is done to get the perfect output.

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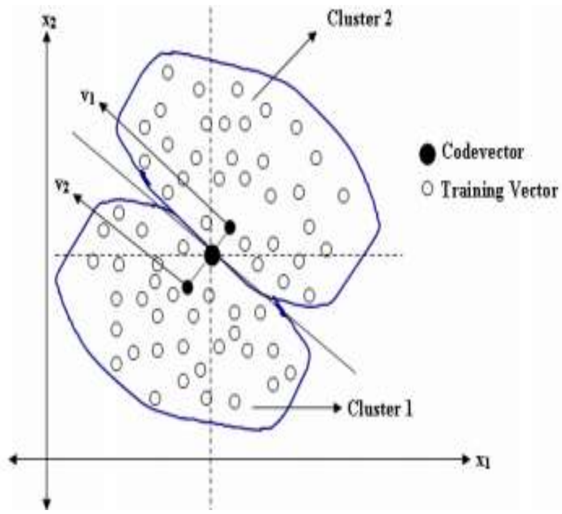

Figure 6: Clusters in LBZ algorithm

FEATURE EXTRACTION

Feature extraction is important to identify particular characteristic of the image. Three diseases that are Macula ischemia,Neovascularisation and Vitreous haemorrhage have different features,these features are identified using feature extraction techniques.In this paper graph based method is used as a extracting technique for Macula Ischemia.Line Tracking method is used for Neovascularisation and Vector quantization is used for Vitreous haemorrhage.

LINE TRACKING METHOD

Line Tracking Method used to trace a line on the image with a certain angular orientation and diameter. The pixel area boundaries will be determined to be tracked by the threshold value corresponding to the frequency of the intensity image.After getting the tracking area, for tracking pixel to pixel neighbours with direction and a predetermined diameter. By calculating the value of the weight of each pixel neighbours, it will be selected the pixels that have the greatest weight and the value exceeds a predetermined threshold weight.If it is not eligible, it will be re-initialization process early pixels. If there is one that meets the pixel, the pixel is marked as a line pixel by providing trust value of "1", while the other pixels set to "0".Furthermore, this process is repeated until all of the pixel area is completed tracking.

VECTOR QUANTIZATION

Vector Quantization is a proficient technique which employ the process of grouping of images into clusters in which the retinal images can be easily grouped into clusters. A codebook is generated with the help of vector quantization technique which can be easy to calculate the definite values of pixels. The training pattern is generated which divides the image into fixed number of blocks.

The clusters are formed with the help of the training pattern and these clustered images generated the codebook.Vector Quantization of an image leads to tracking of line in which the blood vessels are tracked for the leakage to be seen The unwanted region is then removed and various hemorrhages can be obtained with the removal of blood vessels.

SUPPORT VECTOR MACHINE

SVM is a supervised learning methodology. The basic idea of SVM is to find the hyper-plane that best separates vectors from both classes in feature space while maximizing the distance from each class to the hyper-plane. From this technique three parameters can be calculated that are Sensitivity, Specificity and accuracy. Sensitivity is known as the true positive rate in which the percentage of positively detected areas can be identified in the affected persons.

Sensitivity = TP/TP+FN.

Specificity is known as the true negative rate which defines the percentage of negatively detected areas in a healthy person who is not affected by the disease.

Specificity = TN/FP+TN.

Accuracy is defined as the degree or closeness to its true value.

Accuracy= (TP+TN) / (TP+TN+FP+FN)

True Positive refers to the correctly detected blood vessels pixels True Negative refers to the correctly detected background pixels. False Positive refers to the wrongly detected blood vessel pixels. False negative refers to the wrongly detected background pixels.

CONCLUSION

This paper describes about an automated system which can detect three diseases that are Macula Ischemia, Neovascularisation and Vitreous Haemorrhage efficiently It uses separate techniques. Filtering, segmentation and feature extraction techniques are important to correctly detect above three diseases with more accuracy. Support Vector Machine (SVM) is effective classification technique which classify image as normal, moderate or severe. This system can be very useful to doctors in proper decision making.

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