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DETECTION OF DIABETIC RETINOPATHY USING DIGITAL IMAGE PROCESSING A SURVEY

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Abstract: - This survey paper primarily aims on the techniques used to identify the initial diabetic occurrence in human being using the digital image processing, which analyze the captured input image of an eye and obtain an understanding or make a decision to produce a balanced reliable bioinformatics details about the retina of an eye of human begin, whether he/she reflecting any symptoms of diabetes which helps early detection of disease, these process include the processing of image through various phases like eye image capturing, image enhancement, image restoration, morphological processing, segmentation , representation with description and finally object reorganization to find any changes in blood vessel patters in the retina to produce the high accuracy reliable results in the classification of images of diabetic retinopathy which occurs in patient of diabetic, helping in early detection of the diabetes and makes the best use of technology to take preventive measures towards healthy life.

Keywords*:* Diabetic retinopathy, medical image processing, retina, eye fundus image.

1. Introduction

The World Health organization estimates that 135 million people have diabetes mellitus worldwide and that the number of people with diabetes will increase to 300 million by the year 2025. Medical image analysis is one of the research areas that are currently attracting intensive interests of scientists and physicians. It consists of the study of digital images with the objective of providing computational tools that assist quantification and visualization of interesting pathology anatomical structures [1].

The continuous research and development in the field of computers to evaluate the different methods which help in medical field for treatment of patients which improving the quality of life of patients by identifying the disease in early stage, the technology is used to diagnose the human body and knows the current status and can suggest the better solution for the diagnosed disease.

A lot of approaches have been suggested and identified as means of reducing stress caused by this constant check-up and screening related activities among which is the medical digital image signal processing for diagnosis of diabetes related disease like diabetic retinopathy using image of the retina. This survey paper has listed different automated systems that distinguish normal and abnormal structure on the optic disc of an eye image. The focus is to highlight on technique used in automatic diabetic retinopathy and classifies the Exudates, Hemorrhages. In this survey an automated approach for classification of the disease diabetic retinopathy using fundus images is presented.

By digital image processing a better image is produced which further can be processed by appropriate methodology of automatic diabetic retinopathy system, the results will be examined by medical professional to understand the current health status with regard to diabetes of patients and helps the doctors to identify the disease at early stage, and further some preventive measures can be taken so as to minimize sever attack of disease.
Following are the area where we find application of Image Processing they are Medicine, Security, Transportation, Industrial, automation, Image/video databases, pattern reorganization and many more.

1.1 Image

Before introducing the image processing first we see what is image. “An image (from Latin imago) is an artifact, usually two dimensional (a picture), that has a similar appearance to some subject—usually a physical object or a person”.

An image defined in the "real world" is considered to be a function of two real variables, for example, a(x,y) with a as the amplitude (e.g. brightness) of the image at the real coordinate position (x,y).A digital image a[m,n] described in a 2D discrete space is derived from an analog image a(x,y) in a 2D continuous space through a sampling process that is frequently referred to as digitization. The 2D continuous image a(x,y) is divided into N rows and M columns. The intersection of a row and a column is termed a pixel. The value assigned to the integer coordinates [m,n] with {m=0,1,2,...,M1}and {n=0,1,2,...,N1} is a[m,n].

Common image formats include:

- 1 sample per point (B&W or Grayscale)
- 3 samples per point (Red, Green, and Blue)
- 4 samples per point (Red, Green, Blue, and “Alpha”, a.k.a. Opacity)

2. Image Processing

Image Processing is any form of signal processing for which the input is an image, such as photographs or frames of video; the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image processing techniques involve treating the image as a two dimensional signal and applying standard signal processing techniques to it.

An image processing operation typically defines a new image g in terms of an existing image f. The simplest operations are those that transform each pixel in isolation. These pixel to pixel operations can be written:

$$g(x, y) = t(f(x, y))$$

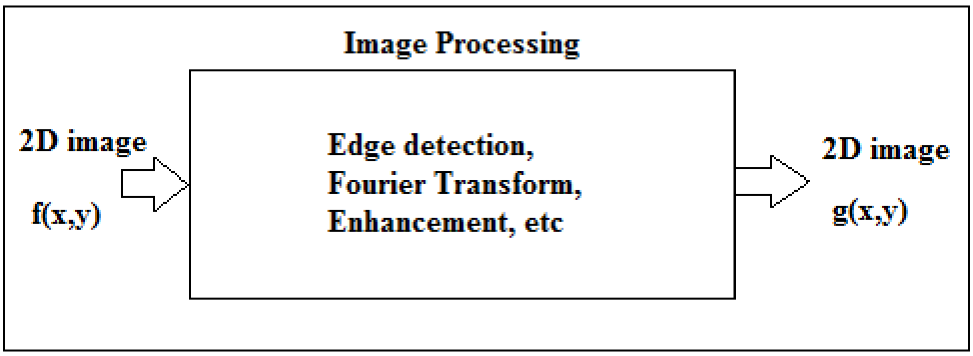

Figure 1: Image processing operation

2.1 Image Acquisitions:

Most of images are generated by the combination of an “illumination” sources and the reflection or absorption of energy from that source by the element of the “scene” being imaged.
For example the illumination may originated from a source of EM energy such as RADAR, X-ray system.
Image acquisition can be done with the help of single sensor or array of sensor.

2.2 Image Enhancement

It is the process of manipulating an image so that result is more suitable than the original for a specific application. Image enhancement improves the subjective quality of the image by working with the existing data
Image enhancement is achieved in the following two domains

- In the spatial domain
- In the Frequency domain

2.3 Image Restoration

It is an area that also deals with improving the appearance of an image. Image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic model of image degradation.

2.4 Morphological Processing

It deals with tools for extracting image components that are useful in the representation and description of shape.

2.5 Segmentation

Segmentation subdivides the image into its constituent region or objects. This simply means we endeavor to find out what is in image (picture).segmentation help for making decision in computer vision system. Description, interpretation, or understanding of the scene can be provided by computer vision system with the help of segmentation.

2.6 Object Reorganization

The process that assigns a label to an object based on its description.

2.7 Representation & Description

Image representation is concerned with characterization of the quality that each picture element (pixel) represents. Description also called feature selection, deals with extracting attributes that result in some quantitative information of interest.

2.8 Color Image Processing

The use of color image processing is motivated by two principal factors. They are as given below

- Color is a powerful descriptor that often simplifies object identification and extraction from scene.
- Human can discern thousand of shades and intensities, compared to about only two dozen shades of gray.

Color image processing is divided into two major areas.

(i) Full-color processing.
(ii) Pseudo color processing.

3. Diabetic Retinopathy

In the type 1 diabetes, the insulin production is permanently damaged, whereas in the type 2 diabetes, the person is suffering from increased resistance to insulin. The type 2 diabetes is a familial disease, but also related to limited physical activity and lifestyle [19]. The diabetes may cause abnormalities in the retina (diabetic retinopathy), kidneys (diabetic nefropathy), and nervous system (diabetic neuropathy) [11]. The diabetes is also a major risk factor in cardiovascular diseases [11].

The diabetic retinopathy is a complication of diabetes, causing abnormalities in the retina, and in the worst case, blindness. Typically there are no salient symptoms in the early stages of diabetes, but the number and severity predominantly increase during the time. The diabetic retinopathy typically begins as small changes in the retinal capillary. The first detectable abnormalities are mircroaneyrysms (Fig. 2(a)) which are local distensions of the retinal capillary and which cause intra-retinal haemorrhage (Fig. 2(b)) when ruptured [6]. In time, the retinal edema and hard exudates (Fig. 2(c)) are followed by the increased permeability of the capillary walls [6]. The hard exudates are lipid formations leaking from these weakened blood vessels. This state of the retinopathy is called non-proliferative diabetic retinopathy. However, if the above mentioned abnormalities appear in the central vision area (macula), it is called diabetic maculopathy [18]. As the retinopathy advances, the blood vessels become obstructed which causes microinfarcts in the retina. These microinfarcts are called soft exudates (Fig. 2(d)). When a significant number of soft exudates (> 6), or intraretinal microvascular abnormalities are encountered, the state of the retinopathy is defined as preproliferative diabetic retinopathy.

The preproliferative diabetic retinopathy can quickly turn into proliferative diabetic retinopathy when extensive lack of oxygen causes the development of new fragile vessels. This is called as neovascularization (Fig. 2(e)) which is a serious state threatening eye sight. The field of eye sight can be obstructed by a haemorrhage to the vitreous body which is a common cause of blindness for the type 1 diabetes. The neovascularization can tear retina, and when it is located near the center of macula, it can cause the loss of eye sight [18]. Due to the progressive nature of the retinopathy, regular monitoring is needed after diagnosis. However, broad screenings cannot be performed due to the fact that the fundus image examination requires attention of medical experts. For the screening, automatic image processing methods must be developed.

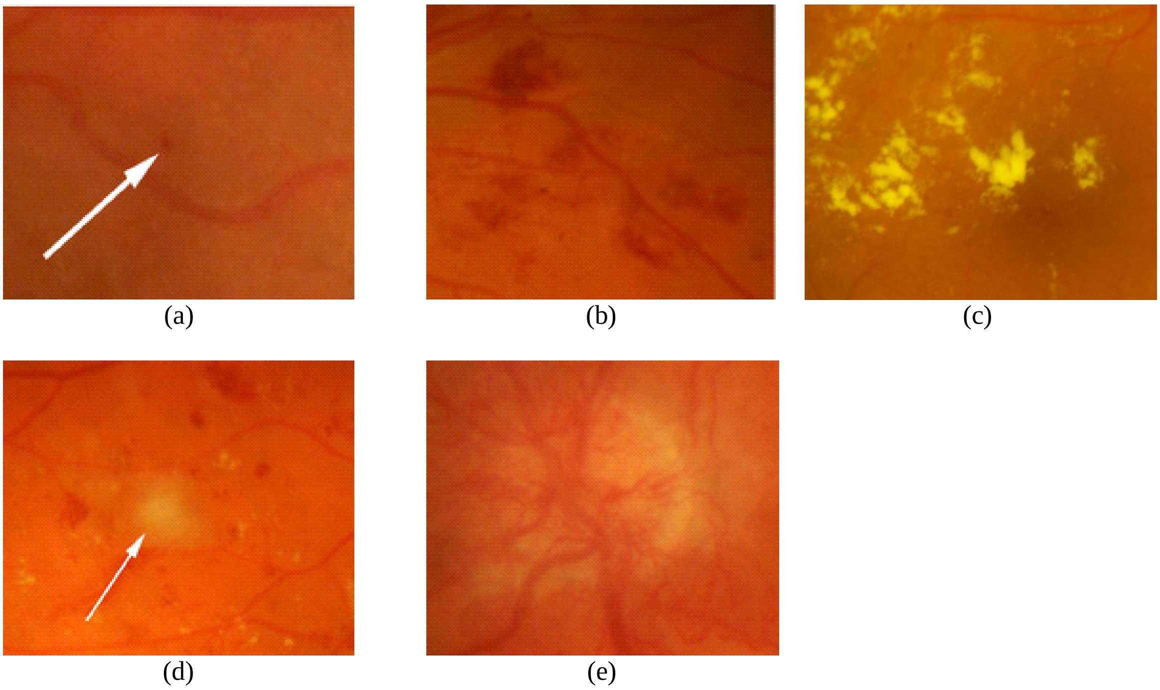

Figure 2: Abnormal findings in the eye fundus caused by the diabetic retinopathy.
(a) microaneyryms (marked with an arrow), (b) haemorrhages, (c) hard exudates, (d) soft exudate (marked with an arrow), (e) neovascularization

4. Comparison and Analysis

As mentioned previously, the diagnosis of diabetic retinopathy can be divided into the following two categories:

1. Screening of the diabetic retinopathy
2. Monitoring of the diabetic retinopathy

Most automatic systems approach the detection directly using shape, color, and domain knowledge of diabetic retinopathy findings, but the abnormalities can also be found indirectly by detecting changes between two fundus images taken from the same eye in different time moment [8, 14]. The direct approach contributes to screening of the disease, where indirect approach contributes to both screening and monitoring of the diabetic retinopathy.

Both approaches use roughly the following stages for finding abnormalities in fundus images:

1) Image enhancement
2) Candidate diabetic retinopathy finding detection
3) Classification to correct diabetic retinopathy category (or hypothesis rejection).

Some of the main features distinguishing between the different findings and normal fundus parts are the color and brightness. The same features have been verified also by ophthalmologists. Unsurprisingly these features dominate in the automatic methods.

4.1 Microaneurysms and hemorrhages

Image enhancement methods:
Niemeijer *et al.* [10] estimated non-uniform background intensity of fundus image by applying median filtering to the green channel of the fundus image. Shade correction was generated by subtracting the result from the original green channel.

Fleming *et al.* [3] had similar approach for microaneurysms, but the green channel of the original fundus image was divided with the background intensity image. In addition, the shade corrected image was normalized for global image contrast by dividing with its standard deviation. Multiple local contrast enhancement methods were tested to improve detection accuracy.

In hemorrhage detection, Zhang and Chutape [22] used histogram specification applied to each individual RGB color component to normalize the colors between different fundus images.

Sinthayothin *et al.* [16] used local contrast enhancement to equalize the intensity variation in fundus images. The fundus images were transformed from RGB color model to IHS color model and the local contrast enhancement was applied to the intensity component of the image.

Detection and classification methods:
Niemeijer *et al.* [10] extracted the candidate finding areas by assigning posterior probability of being red finding for every pixel using Gaussian filter and its derivates as features for k-nearest neighbor clustering. Shape and intensity properties of the candidate areas were used for more accurate abnormal red finding and normal red finding classification.

Fleming *et al.* [3] segmented candidate microaneurysm areas by applying region growing to image enhanced with morphological top-hat operation and thresholding. The result candidate areas were classified with k-nearest neighbor clustering using the shape and intensity information.

Zhang and Chutape [22, 23] used hemorrhage areas restricted by finite window in training images as input for support vector machine. To detect different sized hemorrhages a pyramid of images was generated by changing the resolution of fundus image. The local minima of the support vector machine provided evidence map were selected as hemorrhage locations. The principal component analysis was used to reduce the complexity of feature space.

Sinthanayothin *et al.* [16] sharpened the edges of red finding regions by applying moat operator to green channel of the contrast enhanced image. From the result image, red findings were extracted with recursive region growing and thresholding.

4.2 Hard and soft exudates

Image enhancement methods:
Narasimha-iyer *et al.* [8] used normal retinal findings (vasculature, optic disk, fovea, and abnormal findings) to estimate the illumination component using iterative robust homographic surface fitting to compensate the nonuniform illumination in fundus images.
In detection of bright diabetic retinopathy areas from fundus images, Zhang and Chutape [24] applied adaptive local contrast enhancement to sub-image areas using the local mean and standard deviation of intensities. The same approach was used by Osareh *et al.* [12] after color normalization between fundus images using histogram specification.

Wang *et al.* [21] adjusted the image brightness using brightness transform function similar to gamma correction.

Detection and classification methods:
Hsu *et al.* [4] determined abnormal and normal finding areas using intensity properties for dynamic clustering. From the result abnormal areas, hard exudates were separated from soft exudates and drusen using intensity

contrast information between abnormal areas and immediate background. The domain knowledge of retinal blood vessels were used to remove false artifacts.

Walter *et al.* [20] eliminated the vessels by applying morphological closing to the luminance component of the fundus image. From the result, within a sliding window local standard variation image was calculated and thresholded into coarse exudate areas. More accurate countours were acquired by thresholding difference between original image and morphologically reconstructed image.

S`anchez *et al.* [15] used yellowish color and sharp edges to distinguish hard exudates from the fundus images. The image pixels were classified into background and yellowish objects using minimum distance discrimination, where the countour pixels of extracted optic disk were used as background color reference and pixels inside the contour were used as yellowish object color reference. The segmented yellowish areas and 5 their edge information extracted with Kirsch's mask were combined to hard exudate areas using boolean operator.

Zhang and Chutape [24] located the bright abnormal regions in fundus images by applying fuzzy c-means clustering in LUV color space. The result areas were classified to hard exudates, soft exudates, and normal findings using support vector machine.

Osareh *et al.* [12] searched the coarse hard exudate areas using fuzzy c-means clustering with Gaussian smoothed histograms of each color band of the fundus image. The segmented areas were classified to exudate and non-exudate regions using neural networks. Color, region size, mean and standard deviation of intensity, and edge strength were used as features.

Li and Chutape [7] segmented exudates with combination of Canny edge detection and region growing in LUV color space. Gradient, mean pixel value, and seed pixel value were used as criteria in region growing.

Niemeijer *et al.* [9] used a similar approach for bright abnormal region detection as they used for finding abnormal red regions in [10]. In addition to the previous work, the prior knowledge of optic disk and vascular arch were used to improve detection accuracy.

Sinthanayothin *et al.* [16] clustered similar pixels using intensity difference as criteria for recursive region growing. The regions with the most pixels were considered as background and defined the threshold value for hard exudate areas.

Wang *et al.* [21] used spherical color coordinates as features for the classification of fundus image pixels to background and bright abnormal findings using minimum distance discriminant. The abnormal findings were verified using local-window-based method.

5. Conclusion

The digital image processing technology can be used in detection of diabetic retinopathy and the classification such as exudates, micro aneurysms and hemorrhages using fundus images helps in detecting the initial stage of diabetes. The diagnostic methods, evaluation and comparison methods, fact, and the procedure are proposed for automatic detection of diabetic retinopathy; the results of automatic diabetic retinopathy methods helps in finding the disease in its initial stage further can take preventive measure to minimize the loss to diabetic patient. This field needs more research on detecting the initial stages of diabetic symptoms accurately in human beings, the continues research will definitely gives us more reliable methods of finding initial stage of diabetic, which will be helpful in life saving for human being.

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