Detection of Diabetic Retinopathy

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Abstract- Diabetes is the common chronic disease that most people are facing nowadays. It also leads to various other health issues. Of them, blindness is the one major issue which could be permanent, if it is not detected and nursed at the early stages. Diabetic Retinopathy is a retina disease that affects diabetes mellitus patients, and is a significant cause of blindness. It is a condition where the blood vessels of the retinal gland swell. It affects the eye retina and could lead to blindness if the diabetes level is very high. So far, early detection by routine screening test is the most effective treatment. But such screenings need too much time, effort and cost. Hence in order to overcome these problems, we employ two image processing techniques that automatically detect the presence of abnormalities in the retinal images. They are: detection of a) Vessels through OD. b) Abnormal signs (such as exudates and lesions). In the first approach, the presence of vessels which is one of the major causes for diabetic retinopathy is detected by applying histogram equalisation algorithm to the digital retinal fundus images. In this, at the start the optic disc, which is the point of exit for ganglion cell axons or optical nerves leaving the eye is determined. Later, the damaged vessels are detected by using the blood vessels. Whereas in the second approach, there are three algorithms to be followed for accurate results, namely, statistical classification, brightness adjustment procedure and local window feature space algorithms. By using these algorithms the other leading cause for blindness i.e, presence of abnormal signs (exudates and lesions) is determined. In these algorithms the majorly considered factors are luminosity and contrast which are very helpful for the exact results, even though the screenings are done in different environments. In this method the results are also verified by the local window feature space algorithm. The dataset for the project is taken from STARE database and some are taken from DRIVE database.

Indexed Terms- Digital Retinal fundus images, Histogram equalization, statistical classification, local window feature space.

I. INTRODUCTION

Diabetic retinopathy (die-uh-BET-ik ret-ih-NOP-uh-thee) is a complication of diabetes that can impair sight. This is caused by obstruction of the blood vessels to the light-sensitive tissue (retina) at the back of the eye. Diabetic retinopathy may cause no symptoms at all, or just mild problems with vision. Ultimately, this can cause blindness. Whoever has type 1 or type 2 diabetes may develop the disorder. The longer one has diabetes, and the less the blood sugar is regulated, the greater the probability that one will develop this eye complication. Diabetic retinopathy happens when diabetes affects the tiny blood vessels inside the retina, a light- tissue at the back of the eye. One of the key characteristics of a retinal fundus image is the optic disk (OD), where methods are described for automated detection. In the first approach, we use this OD Detection step, which is a key pre-processing feature as same as in many algorithms designed for the automated removal of anatomical retinal structures and lesions, making it an associated module of most retinopathy screening systems. The OD is often used as a symbol for other fundus features; such as the fairly constant distance between the OD and the macula center (fovea). At first, the input fundus image is converted to gray scale images for the ease of detection. After the blood vessels and OD are highlighted using histogram equalisation and edge detection methods. Later, the OD is excluded so that the remaining highlighted parts indicate the presence of vessels. If there is no brightened part left means there are no vessels and so concludes the healthiness of the eye.

In the Second approach, we check the presence of abnormal symptoms. Abnormal symptoms are one that is usually expressed by exudates / lesions as irregular whitish / yellowish patches of different sizes, shapes and positions that can be used as advanced information to help determine the position of the macula. In general, a lesion is an area of an organ or tissue that has undergone damage or disease, such as burn, ulcer, abscess, or tumour. An exudate is any fluid that flows out into lesions or infection areas from the circulatory system. It can be a fluid similar to pus or transparent. When an injury occurs, it spills out of the blood vessels and into surrounding tissues, leaving skin exposed. The fluid is made up of blood cells that are red, fibrin, and white. As these leakages cause mild vision and severe leakage may also lead to blindness, we considered these as major factors in diabetic retinopathy. As mentioned, here three algorithms namely, statistical classification, brightness adjustment procedure and local window feature space algorithm are applied to the retinal fundus images. In the first step the appropriate feature space should be chosen according to the feature that is considered and then the Minimum Distance Discriminant (MDD) is calculated using the statistical classification. Afterwards, the brightness adjustment algorithm is applied for accurate results in non-uniform illumination. Later, the local window feature space algorithm is used for verification.

II. SOFTWARE USED

MATLAB (Matrix Laboratory) is a programming environment for algorithm development, data analysis, visualization, and numerical computation, developed by MathWorks. MATLAB is widely used for matrix-based computation designed for scientific and engineering use.

It helps to manipulate multiplications of matrices, to map functions and data, to apply algorithms, to interface with programs written in other languages etc. It is also a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include: Math and computation. Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPADsymbolic engine allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems.

III. EXISTING METHODS

Mostly daily screenings are needed for optical disk detection which leads to higher costs by examining OD's form, size and color. As it ranges from person to person there is a risk that OD will be identified incorrectly. To resolve this drawback the equalization of histograms is used. For another way, historically morphological procedure is used for irregular symptoms and it has 60 percent less accuracy. The cycle includes both dilation and erosion. To solve this highly efficient K-means clustering algorithm is used.

IV. PROPOSED METHOD AND WORKING

Automatic scanning of the retinal images will help the doctors more accurately to detect the condition of the patient. It emphasizes that retinal images are calculated using correct image processing and data mining techniques. Using this we can quickly distinguish usual and abnormal retina images which will reduce the number of doctor comments.

The following are the two proposed method for the detection of diabetic retinopathy:

1. Vessels Detection using Optic disc (OD) method
2. Abnormal signs (exudates, lesions) detection

a) Vessels Detection:

Complex structures and their spatial variation low the rate of optical disc detection. Inspired by the fact that humans can locate optic disks in images by analyzing its histogram, we recommend using histogram equalisation algorithm to remove the effect of spatial position variability. The image is then reconstructed using a collection of matched filters with a threshold of 7.5 after eliminating the optic disc pixels in the histogram in the proposed method, and the frequencies of all local features are treated as a form of "spectrum" appropriate for the recognition tasks. We analysed the accuracy of the method by using the STARE database. The stepwise procedure of the entire approach is represented in the following flowchart.

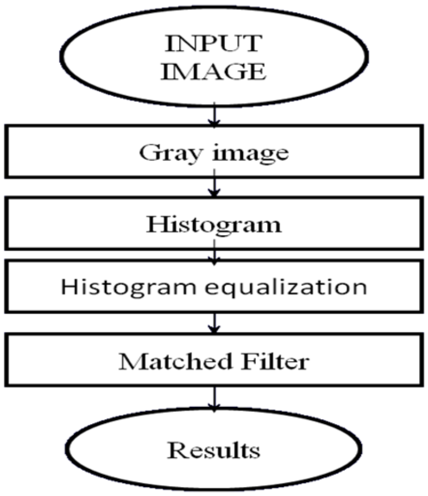

Fig: Flow Chart for the Vessels Detection.

The computer aided automatic detection and segmentation of blood vessels through the elimination of optic disc (OD) region in retina are proposed in this paper. The OD region is segmented using anisotropic diffusion filter and subsequently the retinal blood vessels are detected using mathematical binary morphological operations.

b) Abnormal Signs detection:

The abnormal symptoms are lesions and exudates. Lesions are areas which have been affected. Exudates mean fluid that flows out into lesions or areas of inflammation from the circulatory system. It can be either a puss, or a smooth fluid. When an injury occurs, it spills out of the blood vessels and into surrounding tissues leaving skin exposed. The fluid consists of blood cells, plasma, fibrin, and skin. The steps to be followed in the procedure is shown in the flowchart below. From the definition of exudates and lesions, it is clear that they have certain local features. Objects in an image may typically be defined in terms of certain features like f1, f2... fk such as colour, height, shape, texture and other more complex features. Such attributes, f1, f2... fk, form a function space k-dimensional, F. Ideally, we would like to find a space F such that in this function space, different objects map to separate, non-intersecting clusters. Using these features, we select a feature space with the help of K-map clustering algorithm. After selecting the appropriate feature space, we can calculate the Minimum Distance Discriminant (MDD) using the formula shown in fig. Though the minimum distance discriminant function method seems to work well for images under the same conditions of illumination, in practice we consider a significant variation among the images obtained. This variability is due to a number of factors, such as the intrinsic lesion attribute, decreasing color saturation at the lesion boundary, or variation in lighting over an image, etc. Consequently, in some regions of a picture the color of lesion patches can appear dimmer than the background color in another area.

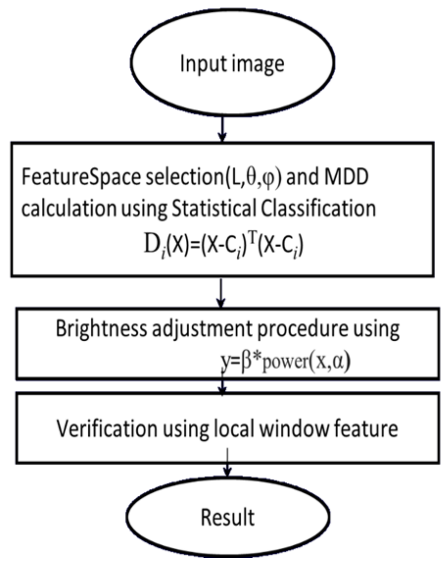

Fig: Flowchart for Abnormal Signs Detection

Under these conditions, MDD classifier will mistakenly identify such lesions as "background," rather than "lesion". Hence, the brightness adjustment algorithm is applied for non-uniform illumination. However, for exudates, there is often a distinct edge or border between the lesion pixels and their immediate surroundings, induced by visible color changes. By examining color variations within a small local area, we can check if the MDD classification map of the white pixel (lesion pixel) is actually a real or false lesion pixel. For this the local window feature space algorithm is used, in which we perform a second pass through the image using a MxM local window to distinguish whether there are true lesion points within this local window.

Formulas for feature space:

$L = (R^2 + G^2 + B^2)^{1/2}$

$\theta = \text{Arctan}(G/R)$

$\varphi = \text{Arccos}(B/L)$

Where L represents an image's exposure or brightness, while θ, φ shows variations or color changes. When L is held constant, θ and φ indicates the chromaticity in an isoluminant surface.

Formulas for MDD calculation and brightness adjustment:

$Di(X) = P(Ci/X) = P(Ci)\, P(X/Ci)/P(X)$

$$P(\mathbf{X}/C_i) = \frac{1}{|\Sigma_i|^{1/2}\sqrt{2\pi}} \exp\left(-\frac{(\mathbf{X}-\mathbf{C}_i)^T \Sigma_i^{-1}(\mathbf{X}-\mathbf{C}_i)}{2}\right)$$

$Di(X) = T[(X-Ci)]\,(X-Ci)$

Where P (Ci) is the priori probability of class i in the image to be classified. P(X/Ci) is the conditional probability of X given class C and P (Ci/X) be the posterior probability. It denotes the probability of measurement vector X belonging to event or class i. Σi means variation of i is from 1 to N and j=1, 2...N, j≠i. Di(X) is the required MDD.

V. RESULTS AND DISCUSSIONS

The results for the first approach of vessels detection are

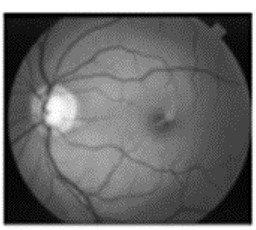

Fig 1. Input image

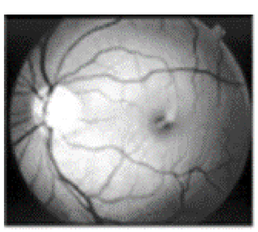

Fig 2. Histogram equalised image

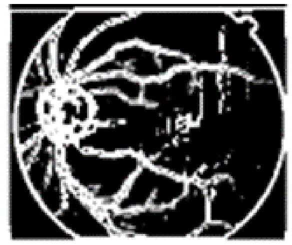

Fig 3. Detected Vessels

As mentioned in the working, at first the input image is converted to rgb colour space which is shown in the figure a. Then histogram equalisation algorithm is applied for this image and is represented in fig 2. Later this image is passed through the matched filters, finally detecting the presence of vessels as shown in the fig 3. Here the OD is also represented for better understanding but these pixels are eliminated and the final figure contains vessels only. A clear advantage of using the 2-D matched filter for vessel segmentation is the ability to obtain the VDM implicitly while segmentation, without any additional algorithm as proposed as shown in the result.

Now coming to the second approach, in this we use K-map clustering algorithm for the processing of the input retinal fundus image. In this approach the main focus is on damages areas and leakages, which are the leading causes for blindness in diabetic people. These damages are different in color compared to the rest of the eye. Taking this as base, we proceed to the approach and the following are corresponding results.

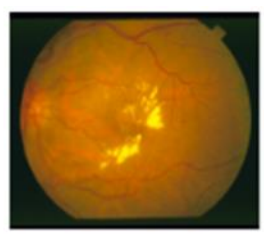

Fig 1. Input image

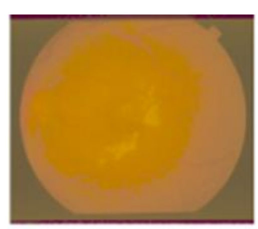

Fig 2. Processed Image

Fig 3. Lesions Detection after processing

Unlike in the first approach, in this there is no need of conversion for image to rgb space. The major factors of this approach are brightness or exposure and variations in color. The input colored image is processed through brightness adjustment procedure after the selection of appropriate feature space thereby calculating the Minimum Distance Discriminant. The input and processed images are shown in the fig 1, 2 respectively. Even for non-uniform illumination images in which background is also taken into consideration and any variation in this affects the entire results. Hence, the output is verified by using a local window algorithm and the result with the lesions detected is shown in fig c.

CONCLUSION

The algorithms of the detection of optic disk, blood vessels and exudates are investigated in this paper. More than thirty images have been tested and the algorithms can extract most features of the fundus image successfully. Future work will include improving the presented algorithms and the extraction of other futures such as hemorrhages. On the bases of color information, presence of lesions can be preliminarily detected by using MDD classifier based on statistical pattern recognition techniques. To deal with the problem of non-uniform illumination in the retinal images, an effective pre-processing step, the brightness adjustment procedure, is proposed to ensure dim lesion patches that are scattered in background would not be regarded as background finally in abnormal signs a local window feature D is used to verify the classification result. With this, we are able to achieve 100% accuracy.

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