Computer Aided Approach for Detection of Age Related Macular Degeneration from Retinal Fundus Images

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***Abstract*-Age Related Macular Degeneration (ARMD) is a retinal disorder usually found in old people, which affects the central vision, but not the peripheral vision. The objective of this work is to develop an automated system for the classification of ARMD using digital fundus images, so that an intelligent computer aided system can be developed for the diagnosis of ARMD. from ARMD. Diagnosis and treatment of ARMD in the earlier stages helps to cure the disease and According to American Society of Retinal Specialists, about fifteen million people around the globe are suffering will save many from vision loss. ARMD may result from the ageing and thinning of macular tissues, depositing of pigment in the macula, growth of abnormal blood vessels or a combination of the these processes. So it is possible to detect and diagnosis the disease by analyzing such abnormalities present in the retinal images. The abnormalities should have significant difference with the neighboring tissues and by properly segmenting such regions, as a result macular degeneration is predicted whether it is present or not. Here the abnormalities are segmented from the fundus images after multi stage segmentation processes. Threshold based segmentation is used along with Canny edge detection algorithm to efficiently identify the abnormality region. Threshold based binary classification of the analyzed image is evaluated by finding the extent of abnormalities present in the image. The abnormal area are shown white pixels as a result the classifier the classifier checks whether the number of pixels in the result is more or less than the threshold value. If more it is considered as an ARMD affected image or else it is predicted as a normal one.**

I. INTRODUCTION

Age Related Macular Degeneration (ARMD) is an eye disease commonly occurring among people at age 50 and above, it leads to vision loss. It affects the macula, a small spot located at the centre of the retina and the part of the eye needed for sharp, central vision, they help to see objects that are straight ahead.There are methods proposed earlier to detect some of the diseases individually from the features of the retina.ARMD affects slowly that vision loss does not happen for a long time for some people. In some cases, the disease may progress faster and leads to a loss of vision in one or both eyes. A blurry area near the centre of vision is the common symptom. Over the course of time, the blurry area may get larger and may develop blank spots in the central vision. Objects do not appear to be as bright as they used to be.ARMD does not leads to complete blindness but they can affect the everyday task such as reading, recognizing faces, writing etc.The objective of the present work is an automated approach for the classification of the disease related to ARMD using fundus images, so that an intelligent system can be developed for the diagnosis of ARMD. This method of automatic detection of diseases can be used extensively used where mass screening of patients is required and is more helpful to medical experts. ARMD is a disease which takes out the central vision, but not the peripheral vision which occurs in older people. It affects both eyes simultaneously, although one eye may be worse for particular period of time. It mainly targets the macula, the central part of the retina which helps to read far and near objects. The retina helps us to identify these parts of the eye. With the help of Canny edge detection the amount of data in an image is significantly reduced, while preserving the structural properties of the image that is further used for image processing method.In order to get the final end result many processes such as image enhancement method, image segmentation, image restoration, thresholding, edge detection and morphological processing are used.

II. LITERATURE SURVEY

The retina is a light-sensitive tissue which lines the inner surface of the eye. The optics of the eye functions as the film in a camera which create an image of the visual world on the retina. The light strikes the retina which initiates a cascade of electrical and chemical events which eventually triggers the nerve impulses of the eye. The fibers sent various visual centers to the brain of the optic nerve which transmit various visual information from the retina to the brain. The retina comes under

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the Central Nervous System (CNS).The CNS is the part of the nervous system which coordinates the information that it receives from, and the activity of all parts of the body. It is the only part of the CNS that can be visualized from non-invasively manner [1].

The early detection of eye diseases such as glaucoma, central serous retinopathy and some of the systemic diseases like diabetes, hypertension and cardiovascular diseases can be seen in the pathological information contained in the retina of human eye.

The input fundus image may be of different sizes. So a standardization resolution is required to apply various operations in the subsequent steps. Here the input fundus image is set to a resolution of 768x1024.

The main cause of the elderly blindness in developed countries is ARMD. A study [2]in the UK, revealed that, in between June 1987 and April 2002, approximately 17% of the participants were diagnosed with ARMD; more than 95% of these were aged above 65. Over the period of coming years ARMD is expected to increase significantly. Drusen, yellowish-white sub-retinal deposits which are located between the Retinal Pigment Epithelium (RPE) of the eye and Bruch's membrane, has been regarded as ARMD. Identifying and quantifying drusen, through examining of patients' retinal images is essential in diagnosing and staging ARMD. For instance, the detection of drusen at the early stage of ARMD is critical for effective treatment options but is a challenging task due to the variety of drusen in size and shape. Major works related to this research has been undertaken to identify the emergence of drusen through this process of image processing and analysis [3]-[5], as well as analysis of alphanumeric medical data [2], [6], which has given good end results. For aligning the pairs of retinal images an image registration method were reported in [7], however, expert interventions were needed during this process. In order to represent color distributions in images, histograms have been widely used. These are considered to be a simple way of representing the characteristics of an image in terms of color distribution within images, and an effective representation for identifying objects in images [8]. Many researches have been conducted on the use of histogram as a medium for image retrieval [9], [10].

An automated approach for classification of the disease ARMD using fundus images of the eye is studied in this paper [11].Number of features such as area, mean, standard deviation etc. of the preprocessed images are extracted to characterize the image content in order to diagnose the ARMD. A classifier technique is used to identify and classify the type of disease and diagnose the disease after the features are extracted. The main goal is to detect automatically and segment the disease ARMD in retina without any human supervision and interaction stored in the database.

III.SCHEMATIC DIAGRAM OF THE PROPOSED METHOD

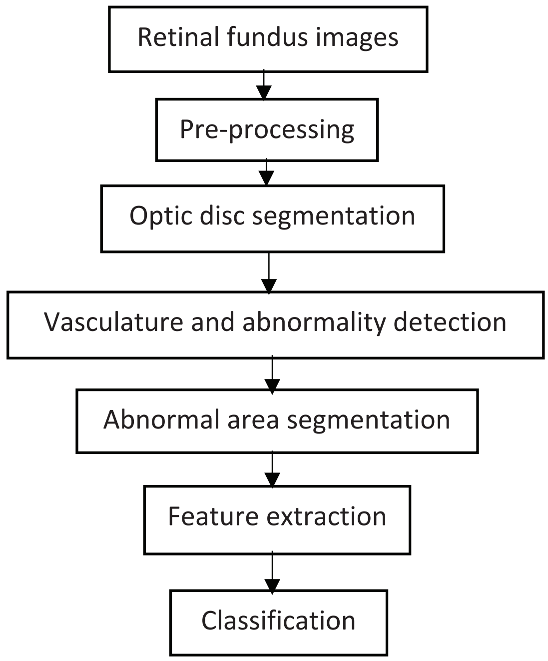

Fig.1 Block diagram of the proposed method in algorithm

A. Retinal fundus image

High resolution fundus images from the Pattern Recognition Lab (PRL) were used as the fundus image databases which were obtained from the department of ophthalmology, Friedrich-Alexander University Erlangen-Nuremberg (Germany). The first step of the program is to read the test image from the fundus database and save to variable for further image processing stages.

B. Conversion from color to gray.

The input fundus image is a 3 plane color image where each plane stands for red green and blue. For most operations just the illumination variations of the pixels are considered rather than color differences. So convert the RGB image to a single plane gray image by using the luminosity method, which uses a weighted average to account for human perception. The formula for luminosity is

$$0.21\ R + 0.72\ G + 0.07\ B. \qquad (3.1)$$

C. Illumination enhancement.

The gray level image needs contrast adjustments in order to make the edges more visible. Here spatial domain enhancement techniques are used. They are allowed to merge with the image plane itself and are built on direct manipulation of pixels in an image. These operations are formulated by

$$g(x,y)=T[(x,y) \quad (3.2)$$

g is the output image

f is the input image

T is an operation on f defined over some neighbourhood of (x,y)

They can be further divided into two categories according to the operations based on image pixels point operations and spatial operations. They enhance an image f(x,y) by arranging the image with a linear, position invariant operator. Frequency domain with DFT is performed by 2D convolution.

Spatial domain:

$$g(x,y)=f(x,y)*h(x,y) \quad (3.3)$$

Frequency domain:

$$G(w1,w\ 2)=F(w1,w\ 2)H(w1,w\ 2) \quad (3.4)$$

D. Segmentation of optic disc

Optic disc is the brightest part in the normal fundus images, which can be seen as a pale, round or vertically slightly oval disk. Optic disc is the entrance region of blood vessels and optic nerves to the retina, it often works as a landmark, and reference for the other features in the retinal fundus image [12] .The change in the shape, color or depth of optic disk is an indicator of various ophthalmic pathologies. It is indispensable for our approach to detection of exudates, because the optic disc has similar attributes in terms of brightness, color and contrast, and shall make use of these characteristics for the detection of exudates. In the gray level image as it see, the optic disc area is the most illuminated section. So the optic disc can be segmented by using a thresholding operation on the gray level version. Thresholding is a widely used technique in image segmentation. It is based on the assumption that the foreground (objects) can be separated from the background according to the gray-level values. In thresholding, pixels within a defined range are selected as belonging to the foreground whereas gray-levels outside the range are rejected to the background. Thresholding is an operation involving tests against function T.

$$T = T\,[x, y, p(x, y), f\,(x, y)] \quad (3.5)$$

Where f(x, y) is the gray-level of the pixel in location (x, y) and p(x, y) is some local property of the pixel, for example, the mean gray-level of the pixel neighbor-hood. The resultant image g(x, y) can be defined as

$$g(x,y) = \begin{cases} 1, & if \;\; f(x\,,y) \geq T \\ 0, & if \;\; f(x,y) < T \end{cases} \quad (3.6)$$

When T depends only on f(x, y), the threshold is called global. If T also depends on p(x, y), the threshold is called local. The threshold is called dynamic or adaptive if T depends also on spatial coordinates x and y.

As there might be other white small regions in the binary image due to the other illumination peaks in the gray image. This can be avoided by using morphological erosion in the image. Morphological dilation is also employed to fill up the small gaps in the optic disc area. The resulted imagecan be used as a mask to segment optic disc from the gray image. The gray image after removing the optic disc region is used in the next steps for segmenting the vasculature and abnormality region.

E. Segmentation of vasculature region

The retinal blood vessels constitute the major vascular network of a retina. Blood vessels appear as networks of either deep or orange-red filaments that originate within the optic-disc and are of progressively diminishing width [13]. The retinal vessels are usually termed arteries and veins. The central retinal artery and vein normally appear close to each other at the nasal side of the center of optic disk. Information about blood vessels in retinal images can be used in grading disease severity. The contrast enhanced version of resultant image from the last section is used here as the input and for detecting the vasculature region, Canny edge detection is employed to detect the high frequency areas from the image.

The image is first smoothed by applying a Gaussian filter and can be represented as

$$S=G_{\sigma}*I \quad (3.7)$$

Where I is the image and G is the Gaussian filter kernel

$$\bar{V}S = \left[\frac{\partial}{\partial X}S\;\frac{\partial}{\partial Y}S\right]^T=[S_x S_Y]^T \quad (3.8)$$

The magnitude and orientation of gradient are

$$|\nabla S|= \sqrt{S_x^2 + S_y^2} \quad (3.9)$$

And

$$\emptyset = \tan^{-1}\frac{S_y}{S_x} \quad (3.10)$$

Morphological operations are applied to eliminate small false detections. The detected area may contain both the vasculature region and the areas with abnormalities. The abnormalities alone will be filtered in a later stage.

F. Extraction of abnormalities

The presence of exudates or abnormal spots indicates retinal disorders and is associated with patches of vascular damage. Exudates usually show up as white patches in grey images and yellowish in colour images of varying sizes and shapes scattered randomly in vascular spaces. Exudates pathologies vary in size and are waxy in appearance with relatively distinct margins. The segment region includes both abnormalities and the vasculature region. So the next step is to segment the abnormalities alone. For this the contrast enhanced gray level mage is taken. The image is first converted to its binary version so it could extract the regions with high illumination values. Thus the extracted region will cover the abnormality areas and also other bright region. The abnormality area is shown in the red circle in which a radius is set where the abnormality area is located. The abnormality area is shown as white pixels where the threshold value is set to a value above eighty percentage. So for extracting that area morphological operation are used to preserve small regions while removing the large false blows. A final step is employed to ensure that the white region are of the required area. For this, consider the output of previous step and it only chose those areas which is common to both figures. Thus it is possible to extract the abnormality areas using the result image. Now the abnormality region is known and the vasculature region alone and it can be segmented out by using the three mask now obtained from optic disc, another one for vasculature region and the last one to detect abnormality regions.

G. Feature extraction and classification

Feature extraction method are employed here in order to capture the visual contents of images which are used for retrieval and indexing. The input data is transformed into the sets of features.Since the ARMD areas are segmented, if present any, it is possible to predict whether the image is affected by the disease or not by calculating the areas with ARMD spots. Here threshold based binary classification are used. Here the analyzed image is evaluated by finding the extend of abnormalities present in the image and also edge based extraction method is used. They are also known as unsupervised classification. In this case only the image characters are used in which there is less information in the area to be classified. They mainly use the population statics such as mean and variance.

Mean

$$\mu ei = \frac{1}{n}\sum_{j=1}^{n} X_{ij}\ (i = 1,2 \ldots m) \quad (3.11)$$

Variance covariance matrix

$$\sum_{e} = \frac{1}{m}\sum_{i=1}^{m}(x_i - \mu_e)(X_i - \mu_e) \quad (3.12)$$

Where m- number of bands

n- Number of pixels

The number of band and number of pixels are likely to be used. It is clear to understand that the images with ARMD, will have more white regions when compared to a normal one. When compared to a normal the out of the abnormal pixels are very few while the white areas in ARMD affected images is more

IV. RESULTS AND DISCUSSION

Here high resolution fundus images were taken from the Pattern Recognition Lab (PRL) from the department of Ophthalmology, Friedrich-Alexander University Erlangen-Nuremberg (Germany). The proposed algorithm was found to be successful in classifying more than 90 percent of the images. Fifteen normal and five ARMD images were taken and thirteen out of fifteen normal images shows positive result while all the abnormal images shows desired result. Intensity based feature extraction techniques and a threshold based binary classifier were sufficient enough to classify ARMD images from normal ones. A more reliable classifier may be required to analyze more details like different types, stages, etc.

The color fundus image and its corresponding gray version is shown in the Fig.2 and Fig.3respectively. Raw fundus images are susceptible to speckle noise, so median filtering is applied to the input image prior to further steps. Processing over color images increase computation cost since the algorithms needs to work on three color planes.

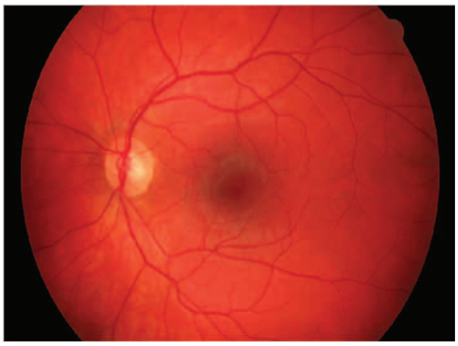

Fig.2 Color fundus image

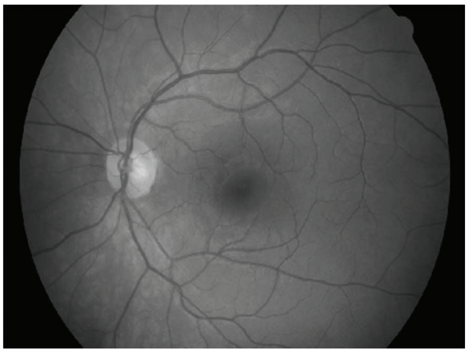

Fig.3 Gray level version of fundus image

The grayscale version of the median filtered fundus is shown in Fig.3. The enhanced version is used to boost the vessel and optic disc region is shown in Fig.4. In this image the contrast is enhanced by an edge detection method calledCanny algorithm which gives better results on this image. This method helps to locate the optic disk area more accurately.

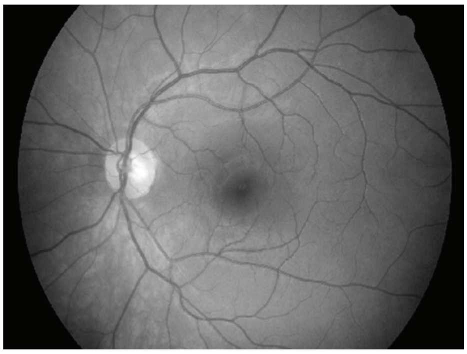

Fig.4 Enhanced image

The result of developing the mask of the optic disc from the fundus image is shown in the Fig.5. Threshold based segmentation is applied on to the enhanced image and to the image which consists of the optic disc. The masked optic disc from the gray version of the fundus image is illustrated in Fig.6

Fig. 5 Mask for optic disc segmentation.

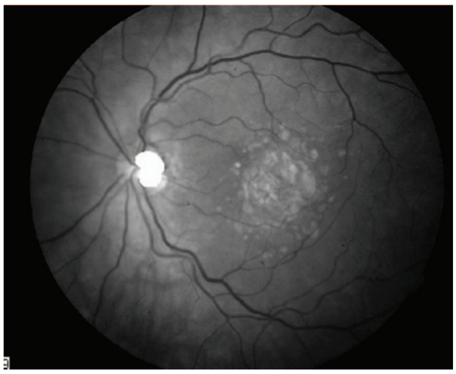

Fig.6 Optic disc removed gray level image

In Fig.6 the optic disc area is segmented out and the next step is to extract the vasculature region, here representing the segmented blood vessel cum abnormality area is shown in Fig.7. The high frequency pixels are segmented using Cannyedge detection. As a result the output has both the blood vessels and abnormality areas.

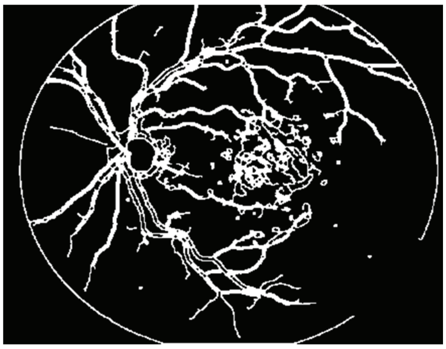

Fig.7Segmented vasculature region and abnormalities

The next step is to segment the abnormality region alone from the image. Next step is to find the regions with high illumination values and the thresholded image is shown in Fig.8. The abnormality region is common to edge detected image and to the thresholded image.

Fig.8Thresholded fundus image

The segmented abnormality area in an ARMD affected person is given in Fig.9 while the result of the normal fundus is given in Fig.10. The abnormal pixels are very few in the output of normal images while the white areas is much more in the ARMD affected images. So the classification can be based on the extent of white pixels in the output image. Based on the evaluation of 20 fundus images, the threshold can be fixed to 1/200th of the total pixels in the image. So the classifier checks whether the number of pixels in the result is more or less the threshold value. If it is more then it will be considered as an ARMD affected image and else it will be predicted as a normal one.

Fig. 9 Output of an ARMD image

Fig.10 Output of a normal image

V. CONCLUSION AND FUTURE WORKS

The ocular fundus is the only part in the human body in which the vascular network can be detected directly and noninvasively. A lot of pathological information about eye diseases such as Glaucoma, Central Serous Retinopathy (CSR) and early signs of systemic diseases like ARMD, diabetes diseases can be found and diagnosed. In the present work concentrated for the diagnosis of ARMD.

Automatic computer aided diagnosis of diseases plays an important part in our present world where the conventional of diagnosis system have several disadvantages like high cost, time lag,lack of sufficient medical practitioners etc. The detection of retinal disorders like ARMD, diabetic retinopathy, glaucoma etc. from digital fundus image will be much helpful in the medical field which can reduce the time and cost required for diagnosis and detection. The present work concentrates on the diagnosis of ARMD and the proposed system can be used to detect several factors from a digital fundus images like optic disc, vasculature map, lesions etc. The system can also be modified to implement an efficient system which can be used to study various features of retinal objects. Digital image processing techniques will be helpful to detect even the small disorders when compared to human eyes. The computer aided detection can be used to study, diagnosis, and for curing of retinal disorders in a better way.

The fundus camera is used to diagnose these diseases. This automated system can be extensively used in mass screening of patients, which helps ophthalmologists with or without any expertise in diagnosis of the above diseases. The patients can be proceeded to further clinical tests and the diagnosis depending on the severity of the particular disease. Further studies are required to find out whether any characteristics of the retinal image parameters are directly or indirectly related to various retinal disorders and earlier detection and diagnosing can save many from being visually impaired. Studies are required to find the retinal parameters relation with other human diseases, so that these diseases can also be detected in the same approach as used in this work. It is feasible that in the near future an integrated system like an Automatic Telling Machine (ATM) consists of camera, computer with printing facility may be developed so that the hard copy of the result is available on the spot. This will be useful to have kiosks like ATM facility in rural areas where there is limited medical services. Here the common man can use the facility without the help of medical experts, get the print out of the risk level of the diseases and can decide for further detailed clinical investigation and treatment. This kind of facility is more suitable where mass screening of patients is required and the places where hospital facility is less.

This system can also be incorporated with telemetry system so that the result of the patient can be sent directly to the hospital database. This data can be retrieved by the doctors in the hospital and the doctors can give advice to the patient for further treatment. This is more helpful to the patients who require periodic diagnosis of diseases.

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