

# Real Time Periodic Assessment of Retina of Diabetic Patients for Early Detection of Diabetic Retinopathy



P. G. Prageeth, A. Sukesh Kumar and K. Mahadevan

## 1 Introduction

Increase of diabetic patients in INDIA is in an alarming proportion. Uncontrolled diabetes can lead to blindness. Normally this is due to diabetic retinopathy. If it is detected earlier and required treatments are taken, blindness can be avoided. It may affect both the eyes simultaneously. Diabetic retinopathy is affected to 50% of diabetic patients. Diabetic Maculopathy and Diabetic Neuropathy are the common affected diseases in diabetic patients. The possibility of blindness for these types of patients is 25% more. Diabetic retinopathy is of two types: Non-proliferated diabetic retinopathy and Proliferated diabetic retinopathy [1, 2]. Vitreous heamorrhage and retinal detachments are the immediate complications leading to blindness, if proper treatment is not provided at the correct time. If it reaches to the complicated level and loses vision, then it is not possible to revert. Hence diabetic patients who are affected with vision may be monitored periodically to assess the real status of retina. Hence apart from a multi powered disease control approach, it is highly essential to utilize the advance technology enabling the doctors to have regular real time assessment of retinopathy in diabetic patients through telemedicine [3].

Diabetic retinopathy is a condition occurring in persons with diabetes, which causes progressive damage to the retina, the light sensitive lining at the back of the

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eye. It is a serious sight-threatening complication of diabetes. Diabetes is a disease that interferes with the body's ability to use and store sugar, which can cause many health problems. Too much sugar in the blood can cause damage throughout the body, including the eyes. Over time, diabetes affects the circulatory system of the retina. Diabetic retinopathy is the result of damage to the tiny blood vessels that nourish the retina. They leak blood and other fluids that cause swelling of retinal tissue and clouding of vision. The condition usually affects both eyes. The longer a person has diabetes, the more likely they will develop diabetic retinopathy. If left untreated, diabetic retinopathy can cause blindness [4].

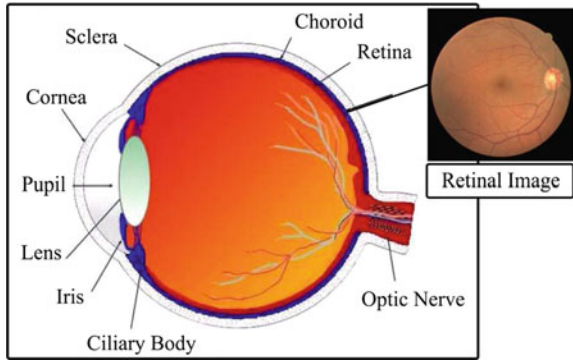
Symptoms of diabetic retinopathy include:

- Seeing spots or floaters in your field of vision
- Blurred vision
- Having a dark or empty spot in the center of your vision
- Difficulty seeing well at night

The ocular fundus is the only part of human body through which the vascular network can be observed directly and non-invasively. This can provide a lot of pathological information about eye diseases such as glaucoma, central serous retinopathy (CSR) and early signs of systemic diseases like diabetes, hypertension and cardiovascular diseases. All over the world, the patients having these diseases are increasing day by day. The medical imaging technology is developing in such a way that mass screening of patients is possible in ophthalmology. Nevertheless, the scarcity of medical experts in all landmarks of a country is limiting the mass screening of patients in developing countries. Hence, development of an automated system for analyzing digital fundus images and diagnosing the diseases is the greatest challenge, when mass screening of patients is needed [5]. The present work involves detection, quantification and analysis of retinal image parameters for various diseases and combined so that an intelligent system is developed for the diagnosis of glaucoma, diabetes, hypertension, stroke, heart attack and central serous retinopathy. Large numbers of retinal images of patients with necessary pathological data were taken from Regional Institute of Ophthalmology (Dept. of Ophthalmology), Medical College, Thiruvananthapuram for this work. The labelled diagram of a human eye and an image of the retina is shown in Fig. 1. Diabetes is detected from the presence of exudates and haemorrhages and changes in blood vessel parameters like arteriolar-to-venular diameter ratio (AVR). Images obtained from fundus camera are enhanced using filtering. Image segmentation is done to detect optic disc, fovea, exudates area and blood vessels. Connected component method along with concentric circle methods are used to determine the artery-vein width ratio. An algorithm is developed for the detection and quantification of the disease level from the parameters specified. The result is validated with the clinical data of the patient and achieved good results. A predictor system is developed to give the status of the patient from the analysis of the retinal image parameters using neural network techniques [6, 7].

A Fundus Camera which is used to obtain fundus images of the human retina is shown in Fig. 2. In the camera the beams propagating from two light sources, and

**Fig. 1** Human eye cross-sectional view and a retinal image



**Fig. 2** A fundus camera and its accessories



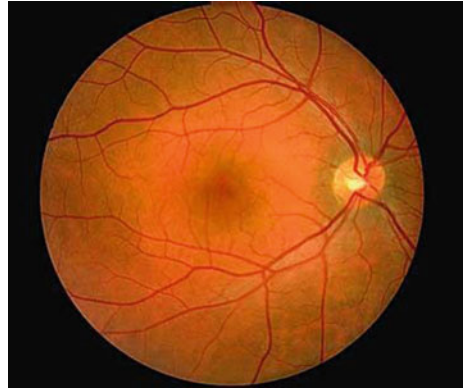
incandescent lamp used for viewing the fundus and ash lamp for photography, are optically combined by a beam splitter [8].

The fundus camera images of normal and diabetic patients are shown in Figs. 3 and 4. These images are used to detect and diagnosis the disease and the method of automatic detection systems are explained.

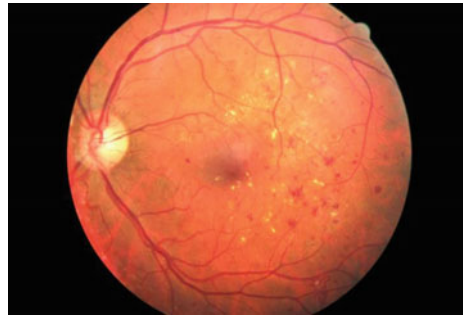
## 2 Proposed Method

The Graphical User Interface (GUI) window for the detection of diabetic retinopathy is designed as shown below in Fig. 5. This disease has dark red and yellow spots in it retinal fundus images. First input the image. Then resize to required size. Find

**Fig. 3** Fundus image of a normal eye



**Fig. 4** Fundus image of a diabetic patient's eye



the hue, saturation and intensity of the image [9]. Find contrast, homogeneity and correlation. Find threshold value for each. Use these values for disease detection.

In machine vision, colors of the pixels are composed from Red, Green and Blue, each measured in 8 bits (2 hexadecimal bits) [10]. The complete representation of a color would be of 6 hexadecimal bits. The problem is that a family of colors (like the orange and the combinations close to it) cannot be easily known from that 6 bits representation. Moreover, the changes in brightness will cause enormous changes in the RGB representation of a certain color. Therefore, in machine vision, the most used color representation is the HSI color space, which consists of Hue angle, Color saturation and Intensity [11]. To be independent of the intensity variance, we use the HS space. This will also help in making the processing and the computing faster.

The above describes histogram equalization on a gray scale image. However it can also be used on color images by applying the same method separately to the Red, Green and Blue components of the RGB color values of the image. However, applying the same method on the Red, Green, and Blue components of an RGB image may yield dramatic changes in the image's color balance since the relative distributions of the color channels change as a result of applying the algorithm [12]. However, if the image is first converted to another color space, then the algorithm can be applied to the luminance or value channel without resulting in changes to the

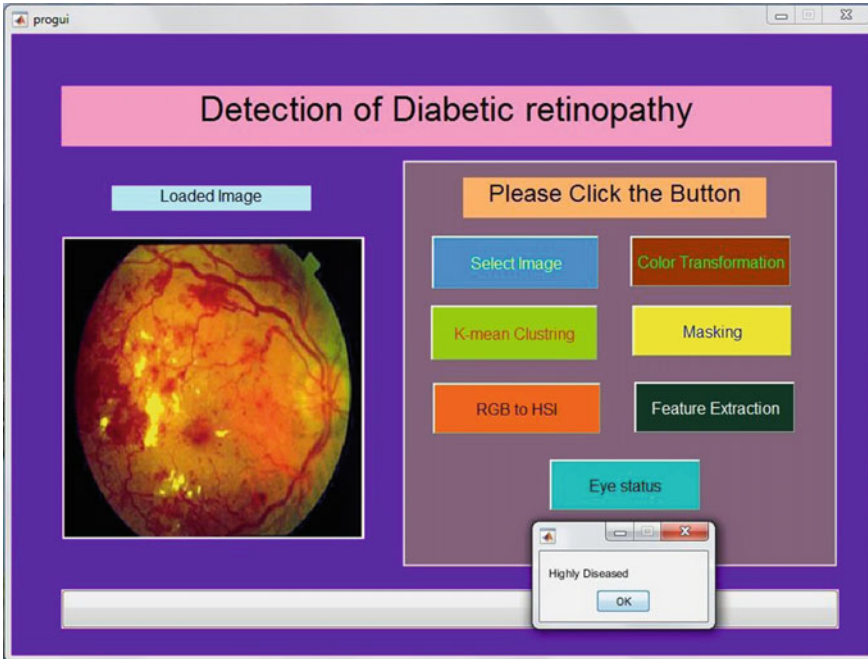
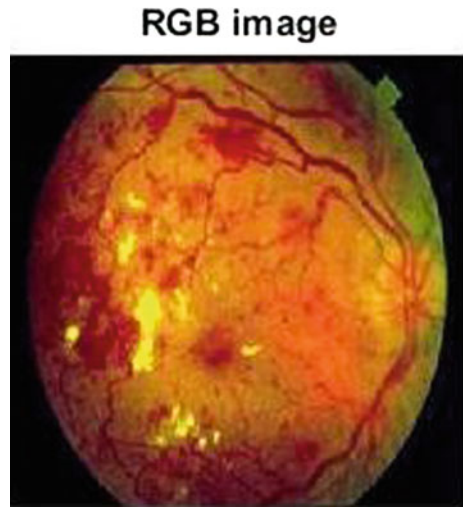


Fig. 5 Proposed GUI window for the detection of diabetic retinopathy

hue and saturation of the image. There are several histogram equalization methods in 2D and 3D space. However, it results in “whitening” where the probability of bright pixels is higher than that of dark ones [13].

With a large number of variables, K-Means may be computationally faster than hierarchical clustering (if K is small). K-Means may produce tighter clusters than hierarchical clustering, especially if the clusters are globular. Contrast is defined as the separation between the darkest and brightest areas of the image. Increase contrast and you increase the separation between dark and bright, making shadows darker and highlights brighter. Contrast enhancement plays a crucial role in image processing applications, such as digital photography, medical image analysis and scientific visualization. Image enhancement is a technique which reduces image noise, remove artifacts, and preserve details [14, 15]. Its purpose is to amplify certain image features for analysis, diagnosis and display. Contrast enhancement increases the total contrast of an image by making light colors lighter and dark colors darker at the same time. It does this by setting all color components below a specified lower bound to zero, and all color components above a specified upper bound to the maximum intensity (that is, 255). Color components between the upper and lower bounds are set to a linear ramp of values between 0 and 255. Because the upper bound must be greater than the lower bound, the lower bound must be between 0 and 254, and the upper bound must be between 1 and 255 [16, 17].

**Fig. 6** Fundus image of a diabetic patient in RGB to input to the GUI window



There are several reasons for an image/video to have poor contrast:

- || the poor quality of the used imaging device, |
- || lack of expertise of the operator and |
- || the adverse external conditions at the time of acquisition. |

These effects result in under-utilization of the offered dynamic range. As a result, such images and videos may not reveal all the details in the captured scene, and may have a washed-out and unnatural look. In graphics and imaging, color saturation is used to describe the intensity of color in the image [18]. A saturated image has overly bright colors. Using a graphics editing program we can increase saturation on under-exposed images, or vice versa. Digital Image Correlation (DIC) is a full-field image analysis method, based on grey value digital images that can determine the contour and the displacements of an object under load in three dimensions. Due to rapid new developments in high resolution digital cameras for static as well as dynamic applications, and computer technology, the applications for this measurement method has broadened and DIC techniques have proven to be a flexible and useful tool for deformation analysis.

The image shown in Fig. 6 is that of an acute diabetic patient. Likewise we can give normal, mild, moderate, severe levels of images as the inputs to the GUI window and can get the corresponding output parameters and predictions [19, 20]. For the sample input image given above, the output images of the parameters helpful for all men to detect the disorders and the clinicians for the diagnosis, are shown in Fig. 7.

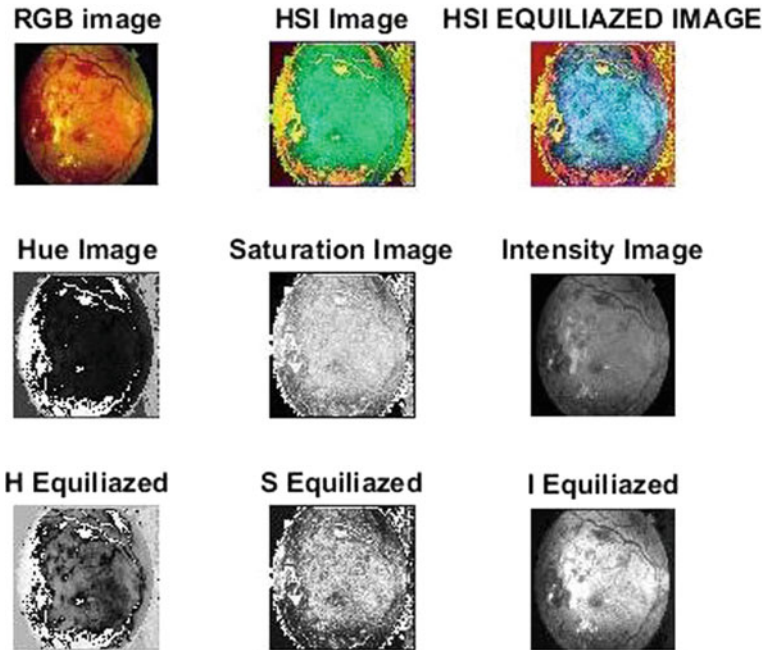


Fig. 7 Output images for evaluating the parameters of eye of a diabetic patient

### 3 Conclusion

According to the above images and values, we can send all the parameters to the highly qualified ophthalmologists. Final decisions and all other curing methods, preventive medicines and the consultation if needed should be done by the clinicians. The above developed system can be used by the biomedical engineers to help the doctors and the remotely resident patients. If this system is developed to work in online way, then the doctors can identify the eye conditions of the patients who are very far away from hospitals. The system can be developed to work as a *kiosk* in remote areas like ATM machines, X-ray labs, Clinical labs to test the blood and all etc. Then it will be very useful and will get a maximum coverage of the patients around the globe. The doctors need not run to all patients here and there. The patients can go to the very nearby labs and if needed only they can go the service of the doctors.

We now designed only a prototype of the system in software model only. If this system is to be developed in a hardware model, sufficient fund is needed just to make a sample. Then only we can make arrangements for the commercialization of the product.

This is going to be a great boon and boom for the common man (actual beneficiaries of this project) to get into the prevention of diabetes rather than cure as a result of periodic review using this project. Unfortunately if any person gets into the diabetic

disorder, then this project will help in the periodic assessment of the various levels of the disease, thereby avoiding the progression of the disorder cent percentage.

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