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# Comparison of Image Preprocessing Techniques on Fundus Images for Early Diagnosis of Glaucoma

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**Abstract**— These Glaucoma is one of the major causes of blindness. Glaucoma is a group of conditions, in which high pressure inside the eye damages the optic nerve of the eye. Glaucoma usually affects both the eyes. It commonly occurs in adults above 40 years of age, but can even occur in newborn babies. The vision lost due to glaucoma is irreversible and can not be regained. Hence it is very important to detect this disease as early as possible and treat early to preserve vision. Preprocessing of eye fundus image is a crucial initial step before further analysis is performed. Many preprocessing techniques are available in the literature. In this paper, the performance of five preprocessing techniques are compared namely Contrast adjustment, Adaptive Histogram equalization,Median filtering, Average filtering and Homomorphic filtering. The performance of these techniques are evaluated using Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR).

**Index Terms**—*Glaucoma, image processing, , image enhancement, preprocessing,PSNR, MSE*



## I. INTRODUCTION

Eduard Jaeger (1854) described glaucoma as the silent thief of sight which is a specific optic nerve disease with the progressive break down of nerve fibers. Glaucoma is the second leading cause of vision loss in the whole world and its progression is expected to increase [2]. The eye is filled with a fluid (aqueous), which is there at a certain pressure called intraocular pressure (IOP). This fluid is continuously formed within the eye and is also simultaneously drained out to maintain a stable pressure. The blockage of the normal outflow mechanism generally leads to an increase in the pressure, which damage the optic nerve of the eye. The optic nerve connects the eye to the brain and relays the visual signal. This damage to the optic nerve results in loss of peripheral visual fields initially and later on affects the central vision as well .

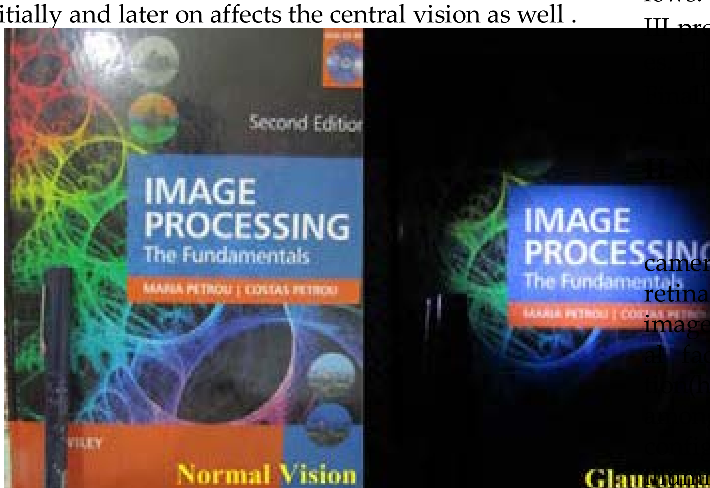


Figure 1. Normal vision vs. patient having glaucoma

Figure-1 shows how the objects are viewed by normal vision and patients having glaucoma.The different forms of glaucoma are Open-angle glaucoma (OAG) ,Angle-closure glaucoma (ACG), Normal tension glaucoma (also called low tension glaucoma), Secondary glaucoma and Congenital glaucoma . The reasons may be family history of glaucoma , aged above 40 years, short-sighted, diabetic, a serious eye injury, using steroid treatment over an extended period or having hypertension.

In this paper preprocessing algorithms are compared by the PSNR and MSE value. The paper is organized as follows: Section II discusses the need for preprocessing. Section III presents the preprocessing techniques for eye fundus imag- ... e experimental evaluation is presented in section IV. ... y conclusion is given in section V.

## ... EED FOR PREPROCESSING

Retinal images are acquired with a digital fundus camera[1] which captures the illumination reflected from the retinal surface. Despite controlled conditions, many retinal images suffer from non –uniform illumination given by sever- ... trors: the curved surface of the retina, pupil dila- ... ghly variable among patients), or presence of diseases ... others. The curved retinal surface and the geometrical ... uration of the light source and camera lead to a poorly ... nated peripheral part of the retina with respect to the central part. Preprocessing can dramatically improve the performance of image processing methods like Image transform, Segmentation, Feature extraction and disease detection. Sev-

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eral techniques have been used to enhance retinal images.

## III. PREPROCESSING METHODS FOR EYE FUNDUS IMAGES

Preprocessing is the step taken before the major image processing task. The problem here is to perform some basic tasks in order to render the resulting image more suitable for the job to follow. In this case it may involve enhancing the contrast, removing noise.

Preprocessing is the important step that influences automated detection of disease like glaucoma. The following are the preprocessing methods under study

(a) Contrast adjustment
(b) Adaptive Histogram equalization
(c) Average filtering
(d) Median filtering
(e) Homomorphic filtering

### (a) Contrast adjustment

The contrast of an image is the distribution of its dark and light pixels. A low-contrast image exhibits small differences between its light and dark pixel values. The histogram of a low-contrast image is narrow. Since the human eye is sensitive to contrast rather than absolute pixel intensities, a perceptually better image could be obtained by stretching the histogram of an image so that the full dynamic range of the image is filled.Figure-2(a) shows the original and 2(b) the image after contrast adjustment.

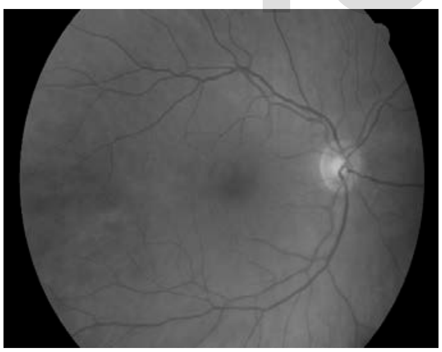

Figure 2(a). Original image

Figure 2(b). Contrast adjusted image

### (b)Adaptive Histotram Equalization

Adaptive histogram equalization (AHE) is a computer image processing technique used to improve contrast in images. It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. Figure-3(a) shows the original image and 3(b) image after adaptive histogram equalization.

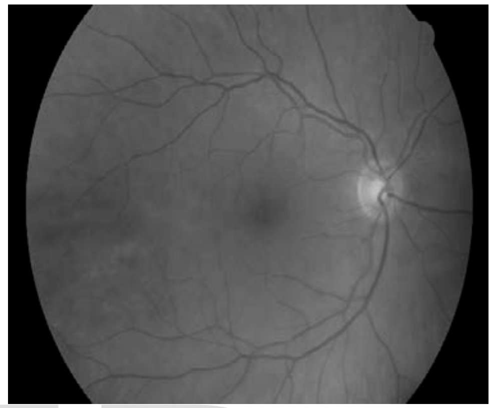

Figure 3(a). Original image

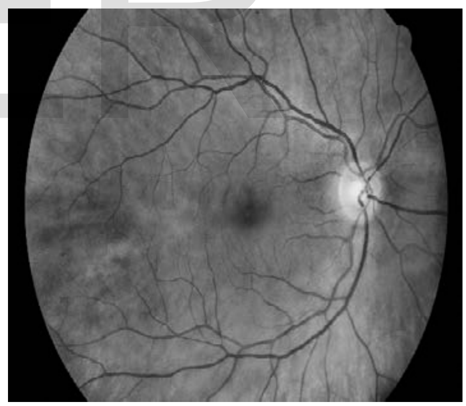

Figure 3(b). Adaptive histogram equalized image

### (c) Average filtering

The Average (mean) filter[3] smooths image data, thus eliminating noise. This filter performs spatial filtering on each individual pixel in an image using the grey level values in a square or rectangular window surrounding each pixel.

For example:
a1 a2 a3
a4 a5 a6 3x3 filter window
a7 a8 a9

The average filter computes the sum of all pixels in the filter window and then divides the sum by the number of pixels in the filter window:

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Filtered pixel = (a1 + a2 + a3 + a4 ... + a9) / 9

Figure-4(a) shows the original image and 4(b) image after Average filtering.

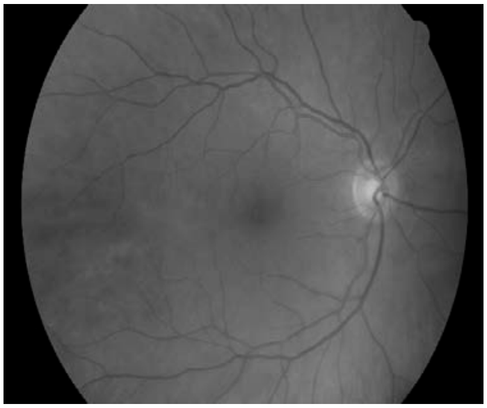

Figure 4(a). Original image

Figure 4(b). Average filtered image

**(d) Median filtering**

The Median Filter does somewhat the same, but instead of taking the mean or average, it takes the median. The median is gotten by sorting all the values from low to high, and then taking the value in the center. If there are two values in the center, the average of these two is taken. A median filter gives better results to remove salt and pepper noise, because it completely eliminates the the noise.To get the median of the current pixel and it's 8 neighbors, set filterWidth and filterHeight to 3, but we can also make it higher to remove larger noise particles. Figure-5(a) shows the original image and 5(b) image after median filtering.

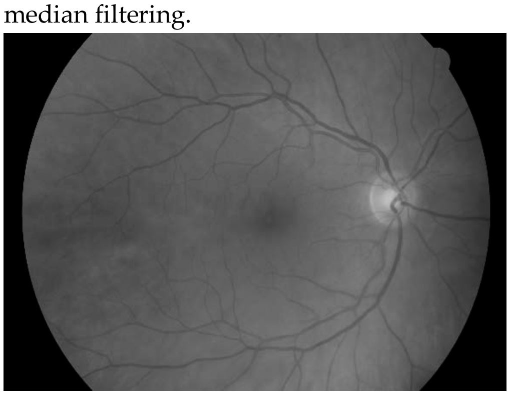

Figure 5(a). Original image

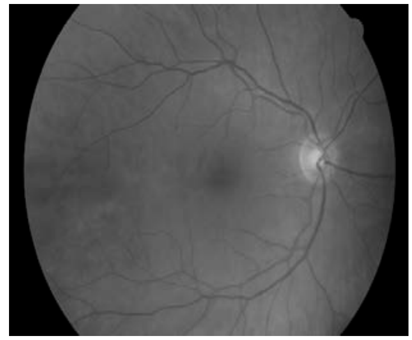

Figure 5(b). Median filtered image

**(e) Homomorphic filtering**

Homomorphic filter[6] is sometimes used for image enhancement. It simultaneously normalizes the brightness across an image and increases contrast. Here homomorphic filtering is used to remove multiplicative noise. Illumination and reflectance are not separable, but their approximate locations in the frequency domain may be located. Since illumination and reflectance combine multiplicatively, the components are made additive by taking the logarithm of the image intensity, so that these multiplicative components of the image can be separated linearly in the frequency domain. Illumination variations can be thought of as a multiplicative noise, and can be reduced by filtering in the log domain.

To make the illumination of an image more even, the high-frequency components are increased and low-frequency components are decreased, because the high-frequency components are assumed to represent mostly the reflectance in the scene (the amount of light reflected off the object in the scene), whereas the low-frequency components are assumed to represent mostly the illumination in the scene. That is, high-pass filtering is used to suppress low frequencies and amplify high frequencies, in the log-intensity domain[7]. Figure-6(a) shows the original image and 7(b) image after histogram equalization.

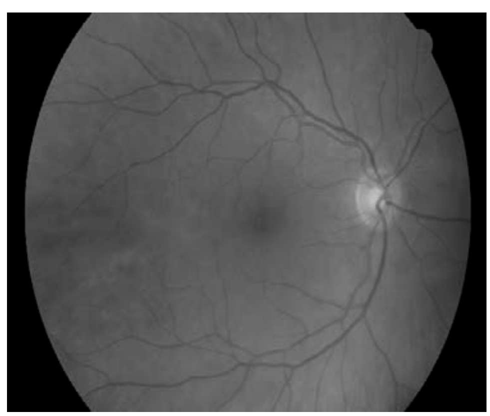

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Figure 6(a). Original image

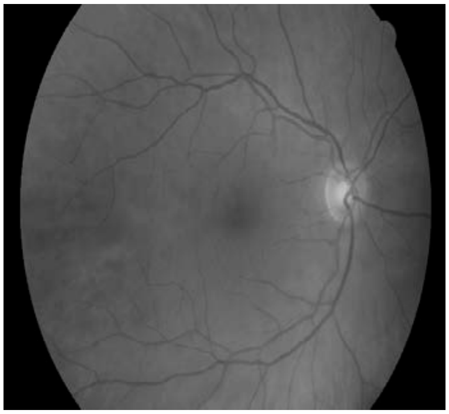

Figure 6(b). Homomorphic filtered image

## IV. EXPERIMENTAL EVALUATION

To test the accuracy of preprocessing techniques , the following three steps are used.

- An eye fundus image is taken as input.
- Preprocessing technique is applied for fundus image.
- The MSE and PSNR value is calculated for different preprocessing techniques.



The PSNR and MSE values exhibit the performance of preprocessing techniques. To estimate the quality of the reconstructed images, following parameters are used.

(a) Mean Square Error (MSE)

(b) Peak signal to Noise Ratio (PSNR)

**(a)Mean Square Error (MSE)**

Given a noise-free *m*×*n* monochrome image *I* and its noisy approximation *K*, the metric *MSE* is defined as:

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

Other metrics like Root Mean Square Deviation RMSE, Mean Absolute Error MAE and PSNR are defined using MSE.

**(b)Peak Signal to Noise Ratio (PSNR)**

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale. A higher PSNR would normally indicate that the reconstruction is of higher quality

The PSNR is defined as:

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

Here, $MAX_I$ is the maximum possible pixel value of the image.

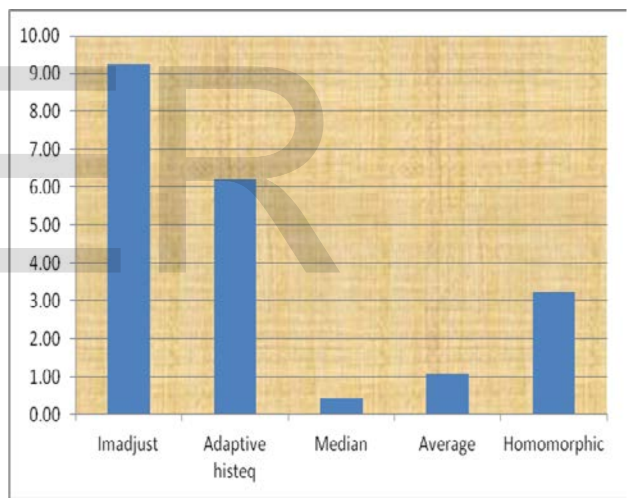


Figure 7.Comparison of different preprocessing algorithms by MSE

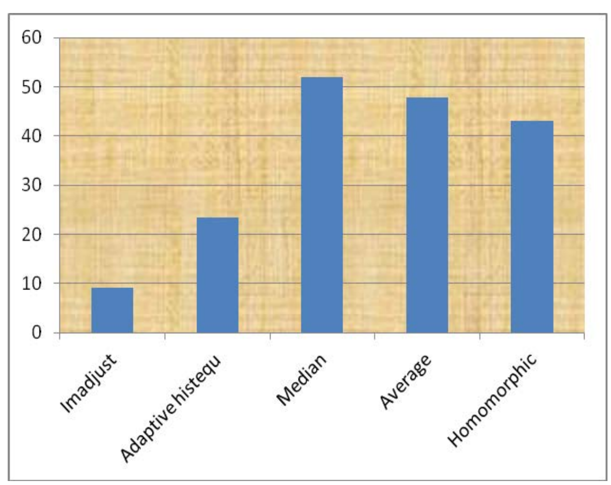

Figure8. Comparison of different preprocessing algorithms by PSNR

The figure-7 gives the MSE value for different image preprocessing algorithms and Figure-8 gives the PSNR ratio for different image preprocessing algorithms.From the figures it can be concluded that median filtering technique gives high PSNR value and low mean square rate. So the median filtering technique gives desirable results compared to other preprocessing techniques.

## V CONCLUSION

In the early detection of glaucoma the retinal image acquired using fundus camera is to be preprocessed before applying other image processing methods. The different preprocessing techniques like contrast adjustment, Adaptive histogram equalization, Average filtering, Median filtering and Homomorphic filtering are applied to the fundus images in the gold standard database. These algorithms are evaluated using Peak Signal to Noise Ratio and Mean Square Error. The Median filtering and Average filtering give suitable results and Median filter is found to be better with high PSNR and low MSE values.

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