Image Processing of High Resolution Retinal Images

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Abstract-- **The processing of retinal images is an important part in the field of ophthalmology. The retinal image considered here will provide us cellular information and information regarding capillaries. The retinal images considered here undergo enhancement process using spatial enhancement technique; later these images are considered for detection and deletion of blur images and then the images are subjected to correction of uneven illumination. The detection of blur images is performed by peak value tracking algorithm and correction of uneven illumination in images is done using homomorphic filtering. The output image will show improvement in PSNR and MSE. . The method has been proven as one of the useful method in the retinal image processing.**

Keywords—retinal images, homomorphic filtering, peak value tracking, contrast stretching.

I. INTRODUCTION

This project will present a method for processing of high resolution retinal images. The retinal images used here are of different parts of retina which determine the distribution of the capillaries and nerves that are attached with the retinal surface. Here we consider a folder consisting of 40 images that are belonging to the same parts of the retina. Since retina is the major part of eye, processing of these images will provide more way to analysis of retinal surface. These images are captured by the CCD camera with infrared light as the source. Each folder consists of 40 images of each part of the retinal surface. This paper will deal with the image processing of one folder which includes different methods of processing the retinal images.

Many methods already exist for processing of retinal images. In spatial domain techniques [1], directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram In [2]-[3], Homomorphic filtering technique which is one of the important method used for digital image enhancement, especially when the input image suffers from poor illumination conditions. This filtering technique has been used in many different imaging applications, including biometric, medical, and robotic vision. Homomorphic filtering works in frequency domain, by applying a high-pass type filter to reduce the significance of low frequency components. In [4], Mean square error is a full-reference evaluation methods commonly used, which requires a reference to calculate sharpness of distortion image.

Image processing has been a very fast emerging field that has found its application in many different fields. Image processing techniques are present in today's era which can be implemented using both hardware and software. Diagnosis and treatment of several disorders affecting the retina and the choroid behind it require capturing a sequence of fundus images using the fundus camera. These images are to be processed for better diagnosis and planning of treatment [5].Moreover, the fundus camera can only provide an image for a portion of the retina but not the whole retina. The physician sometimes needs to have a complete image for the retina to be able to have a reliable diagnosis and hence plan for good treatment. This problem may be overcome by some image processing algorithms to build a complete map for retina. [7].

The paper discusses about image enhancement in the beginning and then with correction of uneven illumination and lastly with detection and deletion of blur images. The results and conclusion are discussed at the end of paper.

II. METHODOLOGY

The raw images obtained by High-resolution CCD camera are considered. The raw images obtained are completely dark in nature as the light source we use is infrared light while capturing. Hence, these images are not reliable for the analysis purpose. Here we discuss the various processing techniques that are applied on one folder consisting of 40 images of same part of retina. Since the raw images are completely dark, we need to increase the pixel value so as to recognize the information present. Hence we first multiply each pixel of one image by twice the pixel-depth. If the pixel image is represented by X_a , then by using spatial enhancement we multiply the pixels of the image by a constant value, then the pixels of enhanced image is given by,

$$x_{enhanced} = x_a *32 \qquad (1)$$

The enhanced image $X_{enhanced}$ is observed for all the folders manually, but we noticed that there were about five to six images that contained blurriness in them. Hence, we further deal with detection and deletion of blur images from the folders. For this we have used peak value tracking algorithm.

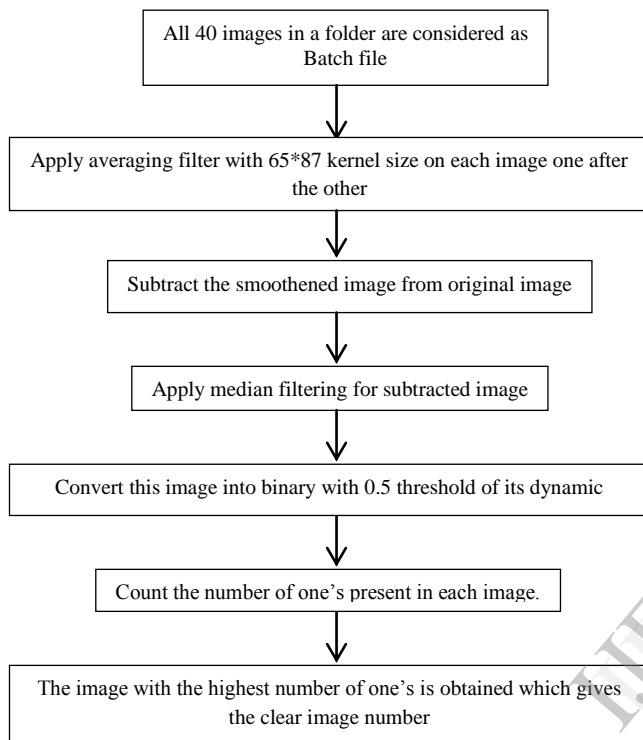The peak value tracking algorithm is shown in Figure 1.

Figure 1: Flowchart of Peak Value Tracking

Initially the peak value tracking method will consider the images after enhancement. To begin with the algorithm each image is smoothened using the averaging filter. The smoothening window size for the images is equal to the value which is lesser than the 16 times of its actual size. The original image is subtracted from the average smoothened image. The subtracted image is later intended for the second filtering which is comprised of median filtering. The median filtering uses the 3*3 matrix for smoothening.

Each of the images will thereby undergo double median filtering. The median filtered image is converted into binary image with threshold value of 0.5 times the dynamic range i.e. 65536. Now the binary image is consisting of 1's and 0's. To obtain the clear image of all the images present we need to calculate the number of pixels that are above the mentioned threshold value. Due to the blurriness caused by the motion of the eye, the energy present in each pixel in the blur image get distributed among the neighboring pixels hence the pixel values after the double median filtering will contain less number of pixels that are above the threshold value.

After applying the double median filtering and converting into the binary image, the count is made for the number of 1's present in the image. After the counts, the number of one's present is calculated for each image. Later these numbers of counts are arranged in the ascending order and the image with the highest count is considered as the best image in that folder.

After detecting the clear image number from the sequence of all the images, we observe that there exists an effect of uneven illumination in each image. Hence for removal of this effect, we incorporate the method of homomorphic filtering. Various methods of homomorphic filtering is obtained for the illumination correction purpose. In homomorphic filtering, we firstly consider all the images in the folder and these images are summed up one by one.

If each image in the folder is represented by I_i then the average summed image is given by,

$$I_{average} = \sum_{i=0}^{40} I_i \qquad (2)$$

This averaged image $I_{average}$ is smoothened using very large kernel size of 100*100. The clear-raw image $I_{clear,raw}$ is also considered side by side. Logarithmic function is carried out on both the smoothened average image and the clear image. Subtracting the Log of the average summed image from the log of the clear image we obtain the log of the illumination corrected image.

$$Log (I_{corrected}) = Log (I_{clear,raw}) - Log(I_{average}) \qquad (3)$$

The filtered image does not provide a good contrast which is required for the feature analysis purpose. Hence contrast stretching is performed. Initially the minimum pixel value of the image is calculated by scanning the rows and columns of the image. This value is used as the reference and each pixel I_{pixel} of the image is subtracted by this reference value.

$$Y_{minimal} = \sum_{p=1}^{1040 \cdot 1392} (Ipixel - minimal\ pixel\ value) \qquad (4)$$

Then the maximum pixel value of $Y_{minimal}$ is found and then the factor by which it is lesser compared to the dynamic range is calculated. This is obtained by dividing the dynamic range by the maximum pixel value.

$$Y_{multiplicative} = \frac{65536\ (dynamic\ range)}{maximum\ pixel\ value} \qquad (5)$$

All the pixels X_{pixel} of the image are multiplied by this value. The image that is obtained later will provide a good contrast of the image which can further be used for the feature analysis purpose.

III. RESULTS

The implementation of the project was performed using Matlab. The results obtained are discussed stepwise along with the figures. Figure 2 shows few images which are considered as the input images. Similarly about 40 images are considered for processing.

Figure 2: Raw images obtained from camera.

These images will undergo increase in pixel values by multiplying each of the pixel value by 32% of dynamic range. The figure 3 shows one of the image which has been increased in its pixel values.
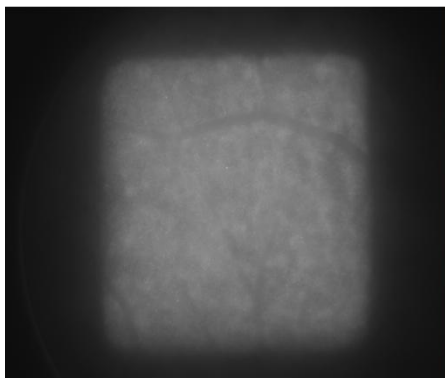

Figure 3: Image after manipulating pixel values.

These enhanced images are later considered for automatic detection and deletion of blur images from the folder. The peak value tracking method is proved as the method which gives us a clear image of the rest of the images. As explained, each of the images is processed using double median filtering. Figure 4 shows result of median filtering on one of the image.
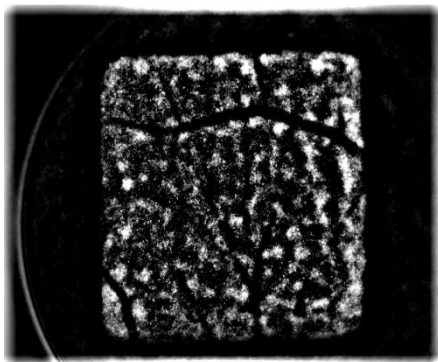

Figure 4: Median Filtered output.

By counting the number of one's in the image and arranging the image number in descending order we obtain the image number of the clear image. The snapshot of the matlab determining the clear image number is as shown in Figure 5.

Figure 5: Clear images list Obtained form MATLAB

Here the image number 22 in the sequence has the highest number of one's present hence the image number is determined using peak value tracking algorithm. The peak value algorithm will help in determining clear image out of all the images. After obtaining the clear image, it is later processed for correction of uneven illumination effect. Homomorphic filtering is a well-known process for eliminating effect of uneven illumination. In the final filtered image, each pixels of the image is in its exponential form. Hence, we obtain a complete white image as all pixels will reach a value that is more than the dynamic range. Therefore we are supposed to take the antilog of this image. The output filtered image is as shown in Figure 6.
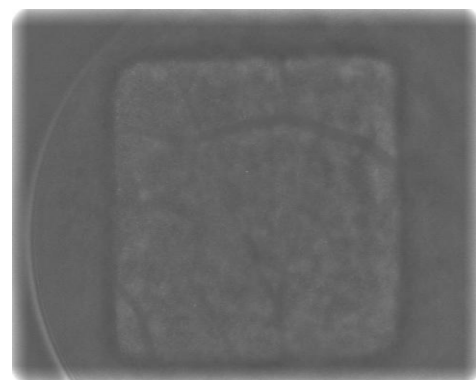

Figure 6: Homomorphic Filtered Output.

It can be noticed that the figure 6 suffers from the contrast and as a result the image does not provide the features of the retina. After the filtered image is subjected to contrast stretching, the final image after improving the contrast and cropped accordingly to show only the area which contained the features is as shown in figure 7.
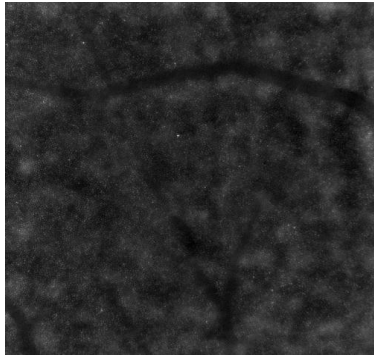
Figure 7: Image after Contrasting Stretching.

Later comparison between an input image and output processed image is performed with consideration of MSE and PSNR individually. The MSE and PSNR obtained is 11.220 and 0.43 respectively.

As the result depict improvement in the processed image and this method has experimentally proven the improvement in the processed image.

IV. CONCLUSION

This method is proved as one of the best method that can be used for processing of retinal images. MSE and PSNR of the processed image are obtained as 11.220 and 0.43 respectively which is an improvement in the image quality. But the value by which each image is multiplied by a constant can be improved by further methods. Instead of using just one image for analysis, further methods can be used where percentage of best images can be used which would increase the depth of the image in its features.

V. REFERENCES

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