IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321- 5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

NFTPCOS-18

National Conference on Future Technologies in Power Control and Communication Systems

College of Engineering Perumon, Kollam, Kerala

Vol. 1, Special Issue 2, March 2018

Illumination Correction in Medical Image Modalities

Santhosh B S[1], Anu S Nair[2], Aswathy A[3], Harilekshmi B[4], Manjima P Saju[5], Neethu N James[6]

Assistant Professor, Department of Electronics and Communication,

College of Engineering Perumon, Kollam, Kerala, India[1-2]

UG Scholar, Department of Electronics and Communication,

College of Engineering Perumon, Kollam, Kerala, India[3-6]

Abstract: An image is worth more than ten thousand words. The two principle application area of digital image processing methods (a) improvement of pictorial information for human interpretation and, (b) processing of image data for storage, transmission, and representation for autonomous machine perception. Here we propose a flexible method to enhance contrast of medical images by using modified adaptive gamma correction with a provision to correct the illumination. This proposed transformation technique may enhance the brightness of the darker areas of the image modality. The experimental results shows that the proposed image enhancement technique produces enhanced images of comparable or even higher quality than those produced via conventional methods.

Keywords: Contrast enhancement, medical image modalities, modified adaptive gamma correction, homomorphic filtering

I. INTRODUCTION

Contrast enhancement always plays a vital role in the refinement of visual quality of digital images, pattern recognition and for various digital image processing. In the case of medical image modalities insufficient contrast may reduce the capability of observer in analyzing the images and this may produce complexity in subsequent processing. Lack of operator expertise, inadequacy of the image capture device, lack of indoor lighting [1], and other condition results in low contrast and worst quality of images. When an image is processed for visual interpretation, the viewer is the ultimate judge of how well a particular method works.

Image enhancement is the process of manipulating an image so that the result is more suitable than the image before subjected to processing for a specific application. The word specific is important here because it brings into being at the outset that enhancement techniques are problem oriented. Despite of everything of the application or procedures used, however, image enhancement is one of the most visually appealing areas of image processing. Enhancement technique has been broadly classified into two classes: direct enhancement methods [2]-[4] and indirect enhancement methods [5]-[7]. By using direct enhancement techniques, the image contrast can be directly defined by a specific contrast term. Indirect enhancement techniques attempt to enhance image contrast by redistributing the probability density. Histograms are the basis for various spatial domain processing techniques. Histogram manipulation is one among the most popular indirect enhancement techniques used for image enhancement. It is a popular tool for real-time image processing for the reason that histograms are simple to determine in software and also lend themselves to economic hardware implementations. For a dark image the components of the histogram are concentered on the low side of the intensity scale similarly the components of the histogram of the light image are located towards the high side of the intensity scale. An image with low contrast has a narrow histogram located typically toward the middle of the intensity scale. The histogram processing techniques are easily adapted to local enhancement. Statistics obtained directly from an image histogram can be used for image enhancement. Gamma correction is the process used to correct the power-law response phenomena. This idea was incorporated with histogram modification techniques thus gives us a simple form of the transform based gamma correction given by,

$$T(h) = h_{max}\left(\frac{h}{h_{max}}\right)^{\gamma} \qquad (1)$$

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where, h_{max} is the maximum intensity of the input image. For every intensity value h of each pixel in the input image is transformed as T(h). γ is a varying adaptive parameter. The approximated probability density function (pdf) is given by,

$$\mathrm{pdf(h)} = \frac{i_1}{PQ} \tag{2}$$

where, i_1 is the number of pixels that have intensity h and PQ is the total no of pixels in the input image. The cumulative distribution function (cdf) based on pdf is given by,

$$\mathrm{cdf(h)} = \sum_{g=0}^{h} \mathrm{pdf(g)} \tag{3}$$

The normal histogram equalization uses the cdf directly as a transformation curve expressed by,

$$T(h) = \mathrm{cdf(h)} h_{max} \tag{4}$$

Here we propose an image enhancement technique that provides enhanced images of comparable or even higher quality images. The rest of the paper is organized as follows: brief description of conventional methods, proposed system and experimental results.

A. Conventional methods

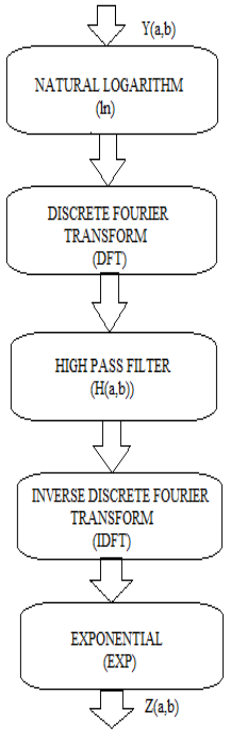
Few methods are available in literature for the correction of illumination in medical image modalities. They are homomorphic filtering [8]-[11] and adaptive gamma correction (AGC) [12]-[14].

Homomorphic filtering is a technique of image processing concerned with a non-linear mapping to a different domain in which linear filter technique are applied , followed by mapping back to the original domain. This is mainly used to detach multiplicative noise. Uneven illumination is considered as a multiplicative noise and can be decreased by filtering in logarithmic domain. It will overthrow low frequency illumination variations between pixels nearer to each other and cannot correct uneven illumination between pixels lying apart. For images having very poor contrast and complex structured background such as medical imaging modalities, sometimes this may lead to the enhancement of noise components in the image in some important areas which can be perceive with eyes. To reduce the presence of noise in enhanced images we are assigning new technique that is homomorphic filtering. Homomorphic filtering is a generally known method used to enhance or restore disgraced images having uneven illumination.The homomorphic filtering technique describes about illumination-reflectance model in its working. The image is divided into two primary components.

The first component is the amount of light incident on the image which can be viewed I(a ,b). The second component is reflectance on the image R(a , b). Thus the image Y(a , b) is given by

$$Y(a\,,b) = I(a\,,b) \times R(a\,,b) \tag{5}$$

The intensity of I(a , b) changes in such way that I(a , b) is crawling R(a , b). So I(a , b) have more amount of low frequency components than R(a , b). Based on this reality homomorphic filtering techniques desire is to reduce the low frequency component I(a ,b) of the image. It can be obtained by the filtering process in frequency domain, so the image is firstly converted to frequency domain from spatial domain. This can be achieved by transforming it using fourier transform. Before transformation we will take the logarithm of the function for separating I(a, b) and R(a, b) from the multiplication form as shown in equation (5) into addition form. The figure (1) shows the blocks that demonstrate the homomorphic filtering actions.



The adaptive gamma correction (AGC) method firstly enhances global contrast of the medical image modality. This is a systematic method for contrast enhancement of all type of images [16]. The adaptive gamma correction technique can progressively increase the low intensity and can eliminate eloquent abatement of the high intensity. This can be done by increasing the brightness and contrast without changing any visual artifacts.

$$S = c * R^{\gamma} \tag{6}$$

where S and R are the input and output image intensities and c and ϒ are the 2 parameters that decide the shape of the transformation curve.

II.PROPOSED METHOD

The proposed method is able to reimburse the frontier of the existing methods. This paper proposes a technique which can create stability between high levels of visual quality and low computational costs. Modified adaptive gamma correction technique proposed by this paper can fulfil this objective.
In Modified adaptive gamma correction, the enhanced intensity is computed from the modified Cumulative Probability Distribution (cpd) which is given by,

$$T(h) = h_{max}\left(\frac{h}{h_{max}}\right)^{1-M_{we}(h)} \tag{7}$$

The cpd is calculated from the normalized weighted histogram as,

$$M_{we}(h) = \sum_{x=0}^{h-1} \frac{d_{we}(k)}{\sum_{k=0}^{h_{max}} d_{we}(k)} \tag{8}$$

To include the standard of the histogram specification into the AGC , a weighting function is employed on the discrete probability density values. The weighted histogram is computed from,

$$g_{we}(h) = g_{max}\left(\frac{g(h) - g_{min}}{g_{max} - g_{min}}\right)^{\Upsilon} \tag{9}$$

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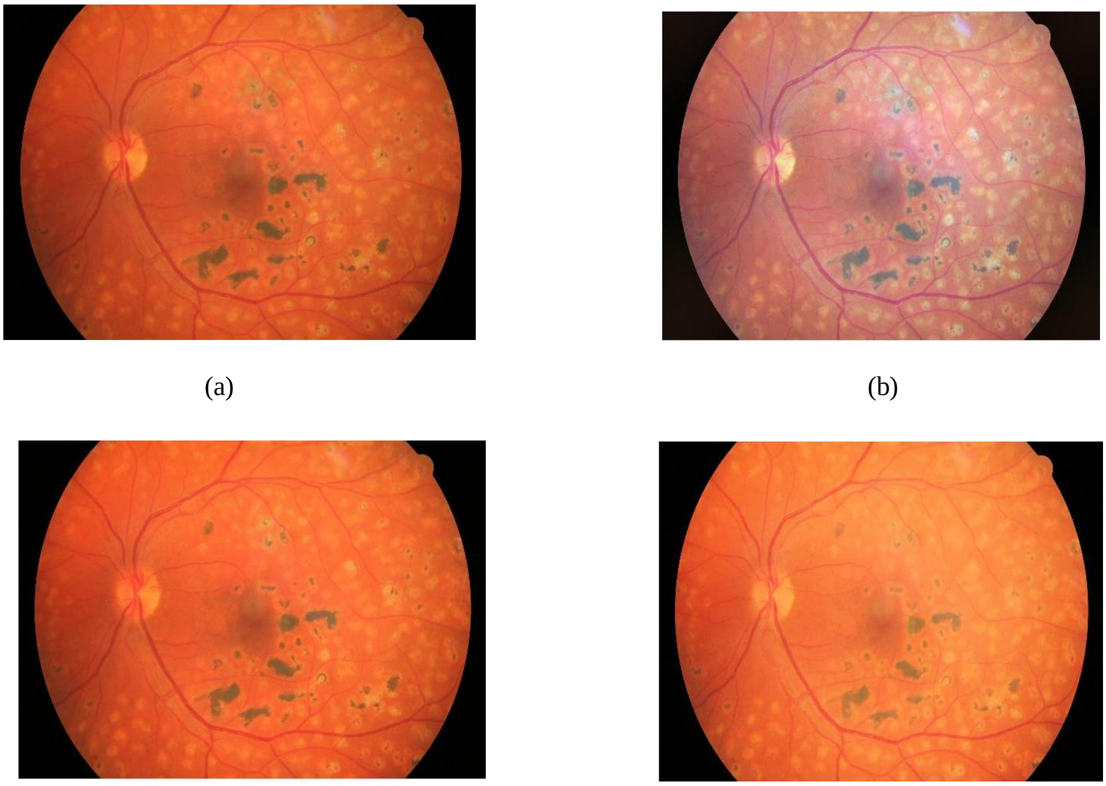
here, ‘γ’ is an arbitrary parameter which decide the shape of the CPD. g_{max} and g_{min} are the maximum and minimum values of the pdf in the statistical histogram. Here the arbitarary parameter (‘γ’) value is taken as 0.5.

B.Experimental Results

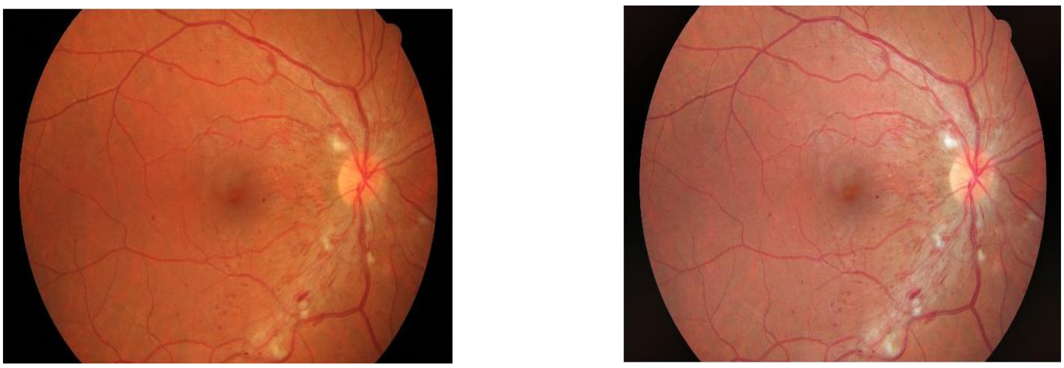
Fundus images after processing Homomorphic filtering, adaptive gamma correction and modified adaptive gamma correction are shown below. In fig 2(b) and fig 3(b), the uneven illumination between the pixels nearer to each other has been corrected by homomorphic filtering. In fig 2(c) and fig 3(c), group of pixels are taken,so spatially separated pixels can be corrected. This is the main advantage of adaptive gamma correction over homomorphic filtering. By changing the gain of adaptive gamma correction, the illumination can be corrected in a better way which leads to modified adaptive gamma correction.



(a) (b)

(c) (d)

Fig 2: (a) Original image (b) Homomorphic filtered image (c) Adaptive gamma corrected image (d) Modified adaptive gamma corrected image



(a) (b)

(c)

(d)

Fig 3. (a) Original image ,(b) Homomorphic filtered image, (c) Adaptive gamma corrected image (d) Modified Adaptive gamma corrected image

III. CONCLUSION

In this paper, we propose a well organized technique for the enhancement of medical image modalities as well as to preserve brightness of images. This paper provide information of a single image based on probability and statistical inference. By using the weighted distribution the fluctuant phenomenon is smoothened and it may reduce unfavorable artifacts. The experimental results shows that our proposed system performs well when compared to the existing systems.

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