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Medical Image Contrast Enhancement using Range Limited Weighted Histogram Equalization

Monika Agarwal[a] and Rashima Mahajan*[b]

[a]*Dept. of ECE, G.D. Goenka University ,Gurugram,122102, India*
[b]*Dept. of CSE, Manav Rachna International Institute of Research and Studies, Faridabad, India*

Abstract

Contrast enhancement and brightness preservation are the crucial steps for image quality control for developing informative and visually pleasing images. Histogram equalization based image enhancement tool does not provide the brightness preservation and better contrast enhancement. This may cause loss in diagnostic information in case of medical images. An attempt has been made to integrate range limited and weighted histogram equalization with adaptive gamma correction followed by homomorphic filtering to study the improvement in contrast as well as to preserve the essential details of the image. An image segmentation based on an efficient Otsu's method has been implemented. The experimental results obtained are found to be optimal for generating enhanced images according to both quantitative estimation and qualitative human visual inspection. An excellent performance in terms maximum entropy preservation, better contrast enhancement and the best visual appearance of low contrast medical images has been achieved.

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*Keywords:*Medical Image; Contrast Enhancement; Histogram Equalization; Adaptive Gama Correction; Homomorphic Filtering; Weighted Distribution; Probability Density function

1. Introduction

Recent advances in medical imaging techniques have led to an increased interest in digital image processing. Image contrast enhancement is a preprocessing step and most important issue in the field of image processing. The main aspiration of image contrast enhancement is to enlarge the intensity difference between the objects and their background. This enlargement in intensity difference can be obtained by stretching more frequent gray levels to a greater extent. Image contrast enhancement is extensively used in numerous applications such as digital photography, satellite imaging, face recognition, medical image processing, iris detection followed by certain

*Dr. Rashima Mahajan, rashimamahajan@gmail.com

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applications in LCD display processing [1]. Histogram equalization is the most admired and widely used contrast enhancement technique due to its accuracy and easy implementation. It is achieved by normalizing the intensity distributions using its cumulative density function so that improves the contrast of an input image and resultant image may have a uniform intensity distribution.

In recent years, many researchers proposed various global histogram equalization methods to deal with the mean shift problem in the output image. Initially a novel method was proposed known as brightness preserving bi histogram equalization (BBHE) to preserve the mean brightness and for contrast enhancement of an input image [2]. A similar technique dualistic sub image histogram equalization (DSIHE) was proposed by Wang et. al. which incorporates segmentation based on the median value [3], [4]. On the basis of experimental results DSIHE gives better results as compare to BBHE in terms of brightness preservation and entropy. To remove the problem of annoying side effects two techniques recursive mean separate histogram equalization (RMSHE) [5] & recursive sub image histogram equalization (RSIHE) [6] were proposed. Both techniques are recursive algorithms of previous techniques BBHE and DSIHE. Then further research investigates a new approach named as recursively separated weighted histogram equalization (RSWHE) based algorithm to enhance the image contrast. This method is exactly similar to RMSHE and RSIHE, the difference is that in RSWHE the normalized power law function is applied [7]. These multiple HE methods RSIHE, RMSHE and RSWHE provides good contrast enhancement and acceptable level of brightness preservation, but generates the over enhancement problem in resultant image. To remove these drawbacks a group of researchers presented another new automatic transformation technique named as adaptive gamma correction with weighted distribution (AGCWD) [8]. This technique increases the brightness level of a low contrast image by applying the Gama Correction and thus modifying the probability distribution of luminance pixels. This is followed by the another research which involves the combination of bi level weighted histogram equalization and adaptive gamma correction to achieve the good brightness preservation and contrast enhancement but this method creates the problem of uneven illumination [9]. Thus these latest findings investigate another efficient AGC based method to make the balance between the high level visual quality and low computational cost. This method is the hybrid of range limited bi-histogram equalization (RLBHE) and AGC techniques [10]. On the basis of experimental results this proposed method more efficiently enhances the low contrast images as compare to RLBHE & adaptive gamma correction with weighted distribution (AGCWD).

Table 1.Literature Summary of Various Contrast Enhancement Techniques

Author Name& Year	Method	Performance Measurement Parameters	Remarks
Kim (1997)[2]	BBHE: Division based on the mean brightness	Images& respective Histograms	Over enhancement& over brightness along with annoying artifacts
Wang et. al.(1999)[3]	DSIHE: Same as BBHE but division based on the median	Mean, Entropy & Background gray level	Over enhancement but preserves the entropy more than BBHE
Chen (2003)[5]	RMSHE: Recursive segmentation based on the mean brightness	Visual quality assessment	removes the problem of over enhancement and preserves the more brightness
Sim (2007)[6]	RSIHE: Same as RMSHE but division based on the median.	MSSI & PSNR	Preserves more brightness, good contrast enhancement and better MSSI and PSNR.
Kim & Chung (2008)[7]	RSWHE: Same as RMSHE & RSIHE, difference is including the weighting process	AMBE, PSNR and Entropy	preserves good brightness as compare to RMSHE & RSIHE with better contrast enhancement
Haung et. al. (2013)[8]	AGCWD: AGC with WD applied to the V component of the colour image	AMBE and Colour distortion	less distortion for both colour images and video sequences
J. Baby andV.Karunakaran (2014) [9]	Apply constrained PDF and weighted PDF to the color components of the input image followed by the AGC method	PSNR, AMBE	Combined the bi-level weighted histogram equalization with AGC for better brightness preservation and contrast enhancement.
C. Gautam and N. Tiwari (2015) [10]	Hybrid of range limited bi-histogram equalization method (RLBHE) and adaptive gamma correction	AMBE	Make the balance b/w high level visual quality and low computational cost but