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Medical Images Contrast Enhancement using Quad Weighted Histogram Equalization with Adaptive Gama Correction and Homomorphic Filtering

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Abstract

Image contrast enhancement plays a vital role in various applications of digital image processing field like face recognition, satellite imaging and medical imaging. This paper proposes an efficient algorithm to cater the limitation of over enhancement with maximum entropy preservation. In the proposed algorithm, input image histogram is segmented first based on its valley positions and then weighted distribution is applied to all segmented sub histograms followed by the histogram equalization, gamma correction and homomorphic filtering. Results reveal that the proposed technique outer performs other conventional histogram equalization techniques both in terms of visual quality along with maximum entropy preservation and contrast enhancement.

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

1. Introduction

Image contrast enhancement plays a very important role in digital image processing. The aim of image contrast enhancement is to produce the better image quality with improved interpretability by changing the characteristics of original input image. Image contrast enhancement is extensively used in several areas like finger print recognition, face recognition, medical image processing, iris detection followed by certain applications in video processing [1].

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Histogram equalization is the most popular and widely used contrast enhancement technique due to its accuracy and easy implementation. This technique flattens the probability distributions and improves contrast of an input image by stretching the dynamic range of gray levels. However, it does not contribute to improve the local contrast of an image since it only uses the global information. It utilizes the cumulative density function (CDF) to enhance the gray levels of input image [1]. The main drawback of histogram equalization technique is that it varies mean brightness level of an input image up to the middle level of dynamic range which causes intensity saturation and over enhancement of image. Also while emphasizing the high frequency histogram bins, it may lead to elimination of the low frequency histogram bins resulting in washed out effect.

A more efficient technique to limit the level of enhancement was proposed using mapping functions based Histogram equalization [1]. Followed by this few more techniques like Brightness Preserving Bi Histogram Equalization (BBHE) came into existence which helps to preserve the mean brightness while enhancing the contrast of input image [2]. It first divides the input image histogram into two sub histograms based on the mean brightness of an input image and then both sub histograms are equalized independently. A similar technique Dualistic Sub Image Histogram Equalization (DSIHE) was proposed by Wang et. al. which incorporates segmentation based on the median value [3]. It was proved to be better than BBHE as it helps in preserving more brightness along with average information content of the image. A more efficient technique named Minimum Mean Brightness Error by Histogram Equalization (MMBEBHE) was introduced to preserve maximum brightness [4].It utilized threshold level based segmentation and resulted in minimum absolute mean brightness error (AMBE).To overcome the problem of over enhancement two techniques Recursive Mean Separate Histogram Equalization RMSHE [5] & Recursive Sub Image Histogram Equalization RSIHE [6] were proposed. Both techniques were based on similar principle, however, threshold point based on mean and median for segmentation is different. RSIHE technique was found to preserve more brightness as compared to RMSHE. Both techniques generate the 2r sub histograms after the r^{th} recursion, where r is the natural number. So the major concern with these techniques is to find the best value of r.

This problem was addressed by Kim and Chung in 2008 and proposed a Recursively Separated and Weighted Histogram Equalization (RSWHE) based algorithm to enhance the image contrast as well as to preserve the image brightness [7]. These multiple HE methods contribute well towards contrast enhancement while preserving acceptable levels of brightness, however, generate the undesirable artifacts in resultant image. In 2013 another new segmentation approach (SHE) was proposed which deals with the histogram equalization. This technique includes the image smoothening by Gaussian filter, segmentation based on its valley positions, Histogram Equalization and in last full dynamic range stretching followed by normalization. This proposed technique provides the highest Peak Signal to Noise Ratio (PSNR) value and lowest Absolute Mean Brightness Error (AMBE) value as compare to others [8]. Another automatic transformation technique was developed to increase the brightness level of a low contrast image by applying the Gama Correction and thus modifying the probability distribution of luminance pixels. Hue Saturation Value (HSV) color model is used to enhance the quality of the color images. In this model H & S are used to preserves the color information. V component represents the luminance intensity of the images. To enhance the visual quality of color images only V component has been changed. So in this technique Adaptive Gama Correction (AGC) with Weighting Distribution (WD) is applied to the V component for color contrast enhancement. This is followed by modification of Cumulative Distribution Function (CDF) using Probability Weighted Distribution model and then Gama parameter is modified according to this weighted CDF function. This technique provides the best enhancement result in case of both images and video sequences [9]. Recently a new method Adaptive Gama Correction with Homomorphic filtering AGC-FIL has been suggested to enhance the contrast of medical images and this method does not change the mean brightness of an input image. It is based on first enhancing the global contrast of medical images by using Gama correction and weighted probability distribution of luminance pixels. After that Homomorphic filtering is used for local contrast enhancement followed by normalization to minimize the difference between mean brightness of input and processed image. This method is very effective for enhancing the visual details of medical images along with preservation of mean brightness [10].