Image Enhancement Using Recursive Adaptive Gamma Correction

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Abstract- Histogram equalization is an effective image enhancement technique, but brightness of an image can be changed after the histogram equalization, which is mainly due to the flattening property of the histogram equalization. Image enhancement improves an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image. Histogram Equalization is widely used to perform contrast enhancement in images. As a result, such image creates side-effects such as washed out appearance and false contouring due to the significant change in brightness. In order to overcome these problems, mean brightness preserving histogram equalization based techniques have been proposed. Generally, these methods partition the histogram of the original image into sub histograms and then independently equalize each sub histogram with Histogram Equalization. To overcome this problem many modifications on histogram equalization have already been proposed such as BBHE and RMSHE etc. But these methods can generate undesirable artifacts in images such as, over enhancement or excessive noise generation in some cases. So a method should be generated that can enhance image contrast as well as preserve image brightness and having low computational complexity and having results better than existing techniques. So, we have proposed a new technique named Recursive Adaptive Gamma Correction. Objective of this technique is to analyze and to enhance the image contrast while preserving image brightness & to improve the adaptive gamma correction with weighting distribution technique. Results are analyzed on the basis of Calculation of the different image quality measurement parameters such PSNR, MSE & AMBE. The proposed technique give better results compared to BBHE,HE,RSWHE and AGCWD in all three parameters with recursion value as 2 and gamma co-relation value as zero which preserves brightness and edges as an enhancement.

I. INTRODUCTION

Images are the most common and convenient means of conveying or transmitting information. An image is significance a thousand terms. Pictures in brief convey information on positions, sizes and inter-relationships among objects. They describe spatial information that we can recognize as objects. Human beings are superior at derive information from such images, because of our native visual and mental abilities. About 75% of the information received by human is in pictorial form.

The image enhancement is one of the significant techniques in digital image processing. It has an important role in many fields such as medical image analysis, remote sensing, high description television, hyper spectral image processing, microscopic imaging etc [6]. The contrast is the difference in visual properties that distinguish an object from other object and from the background. In other words, it is the difference between the darker and the lighter pixels of image. If the difference is large the image will have high contrast otherwise the image will have low contrast. The contrast enhancement increases the total contrast of an image by making light colors lighter and dark colors darker at the same time. It does this by surroundings all color components below a specified lower bound to zero, and all color components above a particular upper bound to the maximum intensity i.e. 255. Color components between the upper and lower bounds are set to a linear ramp of values between 0 and 255. Because the upper bound must be larger than the lower bound, the lower bound must be between 0 and 254, and upper bound must be between 1 and 255. Enhanced image can also be described as if a curtain of fog has been removed from the image [4].

There are a number of reasons for an image to have poor disparity:

- The device used for imaging is of poor quality.
- Lack of expertise of the operator.
- The undesirable outside conditions at the time of acquisition.

Original Image Enhanced Image

Figure 1. Image Enhancement

Image enhancement is among the simplest and most appealing areas of digital image processing. Fundamentally, the idea behind enhancement techniques is to bring out detail that is hidden, or simply to highlight certain features of interest in an image. An example of enhancement is shown in Figure in which when contrast is increased and filtering is done to remove the noise it looks better from input image.

Image enhancement methods based on redistributing the probability densities are indirect methods of contrast enhancement. In these methods, the image intensities can be redistributed within the dynamic range without defining a specific contrast term. Histogram modification techniques are most popular due to their easy and fast implementation [8]. In these methods histogram equalization (HE) is one of the most frequently used technique. The fundamental principle of Histogram equalization is to make the histogram of the enhanced image to have approximately uniform distribution so that the dynamic range of the image can be fully exploited. However the original HE always causes several problems:

- It lacks of adjustment mechanism to control the level of the enhancement and cannot make satisfactory balance on the details between bright parts and dark parts.
- It may over enhance or generate excessive noise to the image in certain applications.
- It may sometimes dramatically change the average brightness of the image.

Various methods have been published to limit the level of contrast enhancement in Histogram Equalization (HE). Most of them are carried out through modifications on the HE. For example, in the Brightness preserving Bi-Histogram Equalization (BBHE) [14], two separate histograms from the same image are formed and then equalized independently, where the first one is the histogram of intensities that are less than the mean intensity and the second one is the histogram of intensities that are greater than the mean intensity. BBHE can reduce the mean brightness variation. In Dualistic Sub-image Histogram Equalization (DSIHE) [16], two separate histograms are created according to the median gray intensity instead of the mean intensity. Although DSIHE can maintain the brightness and entropy better, but both DSIHE and BBHE cannot adjust the level of enhancement and are not robust to noise. Consequently, several problems will emerge when there are spikes in the histogram. The Recursive Mean Separation Histogram Equalization (RMSHE) [11] enhances image by iterating BBHE. The mean intensity of the output image will converge to the average brightness of the original image when the iteration increases. Accordingly the brightness of the enhanced image to the original image can be maintained much better. Although the methods mentioned above can often increase the contrast of the image, these approaches usually bring some undesired effects.

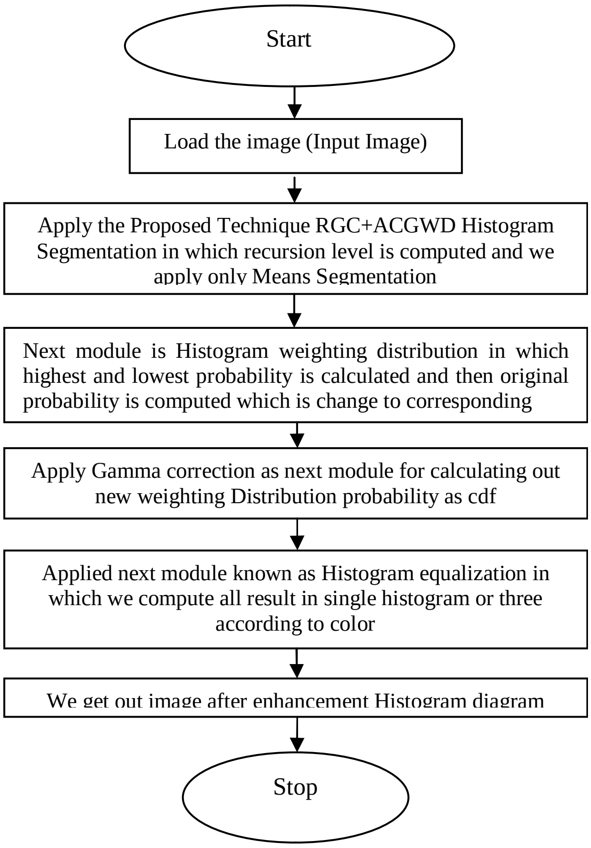
In [8] the technique known as Adaptive gamma correction using weighting distribution (AGCWD) was presented that modify histograms and enhance contrast in digital images. A hybrid HM (histogram modification) method was proposed by combining TGC (Transform based gamma correction) and THE (Traditional histogram equalization) methods. In this method cumulative distribution function (CDF) is utilized directly and normalized gamma function is applied to modify the transformation curve. In adaptive gamma correction (AGC) method compensated CDF is used as an adapted parameter. The AGC method increases low intensity and avoids significant decrement of high intensity. In Weighting distribution the input histogram or probability distribution function (PDF) is modified in such way that the infrequent gray levels are given relatively more probabilities (or weights) than the frequent gray levels. Results of this proposed technique have shown that this method produced enhanced images of comparable or higher quality than those produced using previous methods.

In recursively separated and weighted histogram equalization (RSWHE) method preserves the image brightness and enhances the image contrast. RSWHE first segments the histogram into two or more sub histograms recursively based on the mean or median of image. Then the histogram weighting module modifies the sub histogram through weighting process and then the histogram equalization module equalizes the weighted sub histograms independently. The recursive separation helps in preservation of mean brightness.

The research worked is focused on improving brightness of images by preserving mean brightness and avoiding unfavorable artifacts by integrating RSWHE and AGCWD methods.

II. Proposed Algorithm

Flow chart of Proposed Algorithm



Proposed Algorithm

Our implementation is based on these steps:

1. Select or Load the image on which image enhancement is to be done either on grayscale or color.
2. Browse the image form browsing window
3. In this histogram of image is computed by diving it into various module

a) First module is **histogram segmentation** in which we divide the input image into histogram i.e. H(X) recursively up to some recursion level r, generated as 2^r sub histograms. In this two segmented are resulted: Means sub-Histogram segmentation and Medians sub-Histogram segmentation.

Means sub-Histogram segmentation: In this segmentation is computed on grayscale level range [X_L, X_U] at a recursion level t $(0 \leq t \leq r)$ by formula

$X^t_m = (\sum^u_{k=l} K.P\,(k)) | (\sum^u_{k=l} P\,(k))$

b) Second Module is **Histogram weighting Module** in which recursion level is computed for i $(0 \leq i \leq 2^r - 1)$. In this we compute both highest and lowest probability with P_{max} and P_{min} by formula:

$P_{max}=max_{0\leq k\leq l-1}P\ (k)$
$P_{min}=min_{0\leq k\leq l-1}P\ (k)$

In this then accumulative probability value is computed for each sub-histrogram as α_i value sum of all α_i is equal to 1

$a_i={}^{ui}\sum_{k=il} P(k)$
$_{L=0}\sum^{2n-1}$ a1=a0+a1+a2+……..+a_2^{n-1}=1

Original probability value i.e. P(k) changes into weighted probability such as $P_w(k)$ by computing value as:

$$P_w(k) = P_{max} * \left[\frac{P(k) - P_{min}}{P_{max} - P_{min}}\right]^{\alpha_i} + \beta, (l_i \leq k \leq u_i)$$

Where $\beta \geq 0$ and $P_w(k)$ such as r=2

c) Next Module is **Gamma correction** in which weighting distribution is again calculated with cdf probability with formula:

$T(l) = l_{max}|\ (l/l_{max})^{y} = l_{max}\ (l/l)_{max})^{1-cdf\ (l)}$

$Y=1-cdf_w\ (l)$

$cdf_w\ (l) = \sum^{lmax}{}_{l=0}\ pdf_w(l)/_{\sum pdfw}$

$$Pdf_w(l) = pdf_{max}\left(\frac{pd_f(l)-pdf_{min}}{pdf_{max}-pdf_{min}}\right)^{a}$$

Last Module is **Histogram Equalization** in which P_w (k) consists 2^r curve segments where i-th curve segment is computed. Each sub histogram equalization is separately equalized for all 2^r for histogram equalization to get combined result

III. EXPERIMENT AND RESULT

The proposed algorithms have been experimentally worked out on gray scale images as well as on color images. Our performance on is meseaured with various parameters such as PSNR. MSE, AMBE which are tested on images of gray scale and color. In each testing image we have used all image enhancement techniques such as Histogram equalization (HE), Brightness preserving bi histogram equalization (BBHE) and Recursively separated and weighted histogram equalization (RSWHE) for comparing our results. These techniques are compared using parameters PSNR (Peak Signal-to-Noise Ratio), MSE (Mean Square Error) and AMBE (Absolute Mean Brightness Error). Comparison of these techniques on grayscale images is shown in Figure 2 and comparison on color images is shown in Figure 3.

RESULTS ON GRAYSCALE IMAGES

Figure 2. Comparison on Grayscale test images for Couple image, War-plane image, Girl image

The values of Parameters i.e. quality metrics for the gray scale images had been imputed by the proposed algorithm and existing techniques which is shown in table 1, 2, 3. From the table below it is verified that PSNR, MSE, ABME values are better of our proposed method as compared to the existing techniques.

TABLE 1
PSNR (Peak Signal-to-Noise Ratio)

Images	**HE**	**BBHE**	**RSWHE (r=2)**	**AGCWD (r=0,g=0)**	**Rec+AGCWD (r=2,g=0) (Proposed)**
Couple image	**64**	**64**	**70**	**66**	**72**
War-plane image	**58**	**61**	**69**	**59**	**71**
Girl image	**72**	**72**	**70**	**72**	**73**

TABLE 2
MSE (Mean Square Error)

Images	HE	BBHE	RSWHE (r=2)	AGCWD (r=0,g=0)	Rec+AGCWD (r=2,g=0) (Proposed)
Couple image	2.38	2.37	6.70	1.51	4.27
War-plane image	9.49	4.65	8.95	8.57	5.60
Girl image	3.68	3.89	6.82	2.25	2.95

TABLE 3
AMBE (Absolute Mean Brightness Error)

Images	HE	BBHE	RSWHE (r=2)	AGCWD (r=0,g=0)	Rec+AGCWD (r=2,g=0) (Proposed)
Couple image	4.30	7.30	1.78	9.47	1.10
War-plane image	4.78	1.46	1.86	5.44	9.04
Girl image	5.32	7.90	1.91	8.93	1.24

The performance of image contrasting or enhancing technique is compared through the evaluation of quantitative measure such as MSE, PSNR and AMBE quality metrics. There is large improvement in the value of PSNR (Peak Signal to Noise Ratio) for our proposed algorithm as compared to other techniques. As MSE (Mean Square error) and AMBE (Absolute Mean Brightness Error) is less in case of proposed algorithm for all the images shown above in figure 2 of gray scale.

RESULTS ON COLOR IMAGES

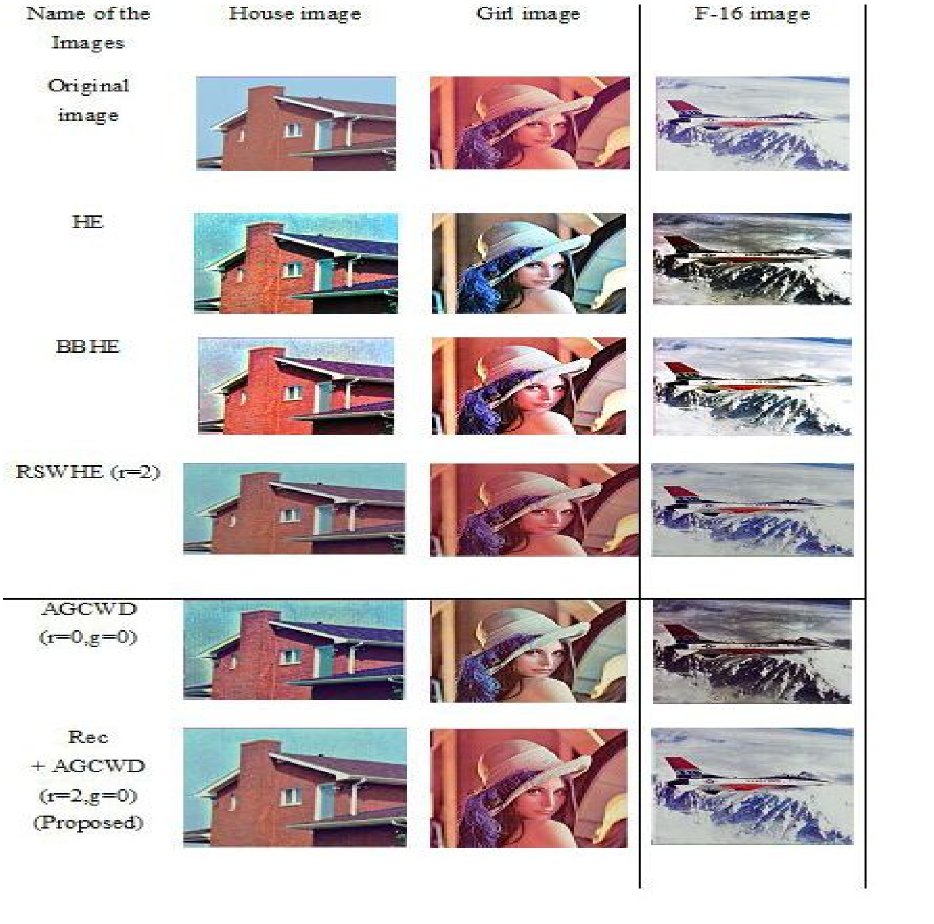


Figure 3. Color test images for comparison on House image, Girl image, F-16 image

Table 5
MSE (Mean Square Error)

Images	HE	BBHE	RSWHE (r=2)	AGCWD (r=0,g=0)	Rec+AGCWD (r=2,g=0) (Proposed)
House image	**2.17**	**1.78**	**7.91**	**1.65**	**4.24**
Girl image	**3.77**	**1.58**	**8.41**	**1.48**	**4.44**
F-16 image	**7.64**	**1.15**	**1.55**	**9.32**	**7.96**

Table 6
AMBE (Absolute Mean Brightness Error)

Images	HE	BBHE	RSWHE (r=2)	AGCWD (r=0,g=0)	Rec+AGCWD (r=2,g=0) (Proposed)
House image	1.29	1.39	1.97	2.31	1.21
Girl image	3.44	1.04	2.12	1.90	1.43
F-16 image	5.43	2.40	3.14	7.19	2.20

The Figure 2 and 3 shows the comparison of results for image enhancing by using techniques such as HE, BBHE, RSWHE (r=2), AGCWD (r=0, g=0), Rec+ AGCWD (r=2, g=0) our proposed method. The proposed method give better results as compared by other techniques in term of quality metrics as well as in term of visual quality.

IV. CONCULSION

Recursively Separated and Weighted Histogram Equalization (REC+ACGWD) with scalable brightness preservation is analyzed with HE and BBHE. Histogram analysis providing spatial information of single image, based on probability and statistical inference. Main goal is to provide high level brightness preservation to unpleasant artifacts and equalization while enhancing contrast. By using weighting distribution we smooth fluctuant for avoiding generation of unfavorable artifacts. Automatically gamma correction is used for smoothing curves. It also reduces computational time. The analysis shows that the output mean will converge to the input mean as the number of recursive mean-separation increases. This allows scalable degree of preservation range from 0% (output of HE) - 100% (getting back the original image). In real life applications, the variety of image involve are often too wide to be covered with only a specific level of brightness preservation.

V. FUTURE WORK

The work which has been done up to the current stage shows that how it enhance the images, next our purposed method is to work on Novel enhancement method video sequences. It is also suggested to look into proper mechanism to automate the selection of the recursion level that gives optimum output. This research work also - Mean-Separate HE has been proposed as a cost reduced implementation for BBHE.

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