Adaptive Gamma Correction With Weighted Distribution And Recursively Separated And Weighted Histogram Equalization: A Comparative Study

Meenu Dailla
Student
AIMT,Karnal
India

Prabhjot Kaur
Asst. Professor
AIMT , Karnal
India

Viney Dhawan
Asst. Professor
KITM, Karnal
India

Abstract – **Aerial images are used extensively in many trip and mapping software packages, such as Microsoft Virtual Earth and Google Earth. These software packages provide a wealth of geospatial information including transportation, terrain, places, etc. So, main objective of this paper is to enhance the aerial images with the help of image enhancement techniques. We propose two algorithms that are used for enhanced the aerial images. In first algorithm, that is AGCWD (Adaptive Gamma Correction Weighted Distribution) enhanced the images using weighted distributed function. In second algorithm, is same as AGCWD but in which, we also optimize the adjusted parameter that is alpha parameter using RSWHE (Recursively Separated and Weighted Histogram Equalization) for brightness preservation and image contrast enhancement. These two algorithms are also used for enhanced the dimmed images.**

Index Terms ----- Contrast Enhancement, Histogram Equalization, AGCWD (Adaptive Gamma Correction Weighted distribution), RSWHE (Recursively Separated and Weighted Histogram Equalization).

I. INTRODUCTION

Contrast enhancement plays an important role in the improvement of visual quality for computer vision, pattern recognition, and the processing of digital images. Many conditions that become the reason for poor contrast in digital images, including lack of operator expertise and inadequacy of the image capture device. In general, the enhancement techniques are broadly classified into two categories: spatial domain methods and frequency domain methods [1]. The term spatial domain refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image. Frequency

domain processing techniques are based on modifying the Fourier transform of an image. In this paper, we describe two techniques that are based on spatial domain.

In this paper both techniques used Histogram equalization for contrast enhancement in digital images or aerial images. Histogram Equalization (HE) [4] technique is used to stretch the histogram of the given image. Greater is the histogram stretch greater is the contrast of the image. In other words if the contrast of the image is to be increased then it means the histogram distribution of the corresponding image needs to be widened. Histogram equalization is the most widely used enhancement technique in digital image processing because of it's simplicity and elegancy. In an image processing context, the histogram of an image normally refers to a histogram of the pixel intensity values.

AGCWD [3] and Optimization adjusted parameter (Adaptive Alpha Parameter) are two algorithms that are used for enhanced the Aerial images and Dimmed images. In AGCWD approach that is gamma correction method. In this technique, we optimize the gamma parameter based on the weighted distribution function. We optimize the gamma parameter with the help of PDF (Probability distribution function) and CDF (Cumulative distribution function). In AGCWD the main drawback come about the adjusted parameter, that is used for adjust the intensity level of image, selected manually in AGCWD. So, we remove this problem in our proposed method that is optimizing the adjusted parameter (Alpha parameter). This method used

RSWHE [5] histogram equalization for optimize the alpha parameter.

The rest of this paper is organized as follows. Section II presents AGCWD method. In section III presents the proposed method that is alpha optimizing method. Section IV shows the qualitative and quantitative results between these two methods. Finally, our concluding remarks are presented in section V.

II. AGCWD (ADAPTIVE GAMMA CORRECTION WEIGHTED DISTRIBUTION)

As we know that Power-law transformation (PLT) [2] method, in which main drawback is to give the value of gamma manually for image enhancement. This problem solved by the Adaptive gamma correction weighted distribution method. In which the value of gamma is find out automatically with the help of weighted distribution function. Gamma correction techniques make up a family of general HM (Histogram Modification) techniques obtained simply by using a varying adaptive parameter ΄Y (Gamma). The simple form of the transform-based gamma correction is derived by

$$T(l) = l_{max} (l / l_{max})^{\gamma} \quad (1)$$

Where l_{max} is maximum intensity of the input. The intensity l of each pixel in the input image is transformed as T (l) after utilize the Eq. (1).

When the contrast is directly or manually modified by gamma correction then different images will results the same changes in intensity as a result of the fixed parameter. So this problem can be solved by probability density of each intensity level in a digital image can be calculated. As we know that density function of image will be different. So, intensity of each image will be different. The probability density function (pdf) can be approximated by

$$Pdf(l) = n_1 / (MN) \quad (2)$$

Where n_1 is the number of pixels that have intensity l and MN is total number of pixels in the image. The cumulative distribution function (cdf) is based on pdf, and is formulated as:

$$Cdf(l) = \sum_{K=0}^{l} pdf(k). \quad (3)$$

After the cdf of the digital image is obtained from Eq. (3) traditional Histogram Equalization (THE) directly uses cdf as

$$T(l) = cdf(l)\, l_{max}. \quad (4)$$

The flow chart of proposed adaptive gamma correction as given below:

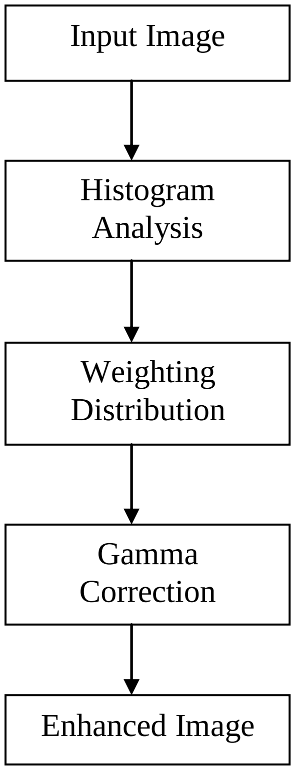

Fig. 1. Flowchart of the AGCWD method.

Fig. 1 shows the flowchart of proposed AGCWD [3] method. Digital image used as input. After that the next step is histogram analysis in which RSWHE method is used. In the third step weighted distribution function, the fluctuant phenomenon cab be smoothed, thus reducing the over-enhancement of the gamma correction. And last enhanced image is at the output.

The proposed adaptive gamma correction (AGC) is formulated as follows:

$$T(l) = l_{max}(l / l_{max})^{\gamma} = l_{max}(l / l_{max})^{1 - cdf(l)}. \quad (5)$$

The weighted distribution (WD) function is formulated as:

$$Pdf_w(l) = pdf_{max} \left(\frac{Pdf(l) - pdf_{min}}{Pdf_{max} - pdf_{min}} \right)^{\alpha}$$

Where α is adjusted parameter, in which we give the value of alpha manually. Experimentally we set to 0.5 value of alpha. So, we optimize this alpha parameter in the propose method in next section with the help of RSWHE method. pdf_{max} is the maximum pdf of the statistical histogram, and pdf_{min} is the minimum pdf. The modified cdf is approximated by

$$Cdf_w(l) = \sum_{l=0}^{l_{max}} pdf_w(l) \;/\; \sum pdf_w \quad (6)$$

Where the sum of pdf_w is calculated as follows:

$$\sum pdf_w = \sum_{l=0}^{lmax} pdf_w(l). \quad (7)$$

Finally the gamma parameter based on cdf of Equation (5) is modified as follows:

$$\acute{Y} = 1 - cdf_w (l). \quad (8)$$

So, as we can see the upper equations of AGCWD that provides us Adaptive Gamma Correction and enhanced the dimmed and aerial images.

III. PROPOSED METHOD (ALPHA OPTIMIZATION)

As we know that in previous method AGCWD, we give the values of alpha parameter or adjusted parameter manually. We experimentally set 0.5 value of alpha in AGCWD method for enhancement the images. So, we utilize RSWHE [5] method for optimize the alpha parameter. Firstly, we have to define the advantages of RSWHE. Why we utilize this histogram technique for optimize method.

As we know that Histogram equalization (HE) [4] is a very popular method for image enhancement. Basically it stretches the dynamic range of input image by virtue of the cumulative distribution function, so we will get the image enhancement. But, HE has a problem of mean shift that is the mean brightness of the input image is significantly different from that of the output image. This mean shift problem is main drawback for consumer electronics products. So this problem can be removed with the help of BBHE (Brightness preserving Bi-Histogram Equalization) [6]. BBHE basically divides the first segments of the input histogram into two sub-histogram based on the mean of the input image's brightness and then executes histogram equalization on each sub-histogram independently. Another proposed method is DSIHE (Dualistic Sub-Image Histogram Equalization) [7] method, which is similar to BBHE, but in which we segment the input histogram image based on median instead of mean.

Another technique is MMBEBHE (Minimum Mean Brightness Error Bi-Histogram Equalization) [8]. It determines the histogram segmentation threshold in such a way that the brightness difference between input and output image will be minimized. RMSHE (Recursive Mean Separate Histogram Equalization) [9] that is the generalized of BBHE. In BBHE we find the mean based histogram segmentation only once but in the case of RMSHE does it more than once recursively. As we know that HE usually introduces two types of artifacts into the equalized image. First is over-enhancement for the image regions with more frequent gray levels. Second is loss of contrast for the image regions with less frequent gray levels. So, the main motive of HE and all aforementioned algorithms have been more focused on the preservation of image brightness than the improvement of image contrast.

As discuss above the HE techniques can be seen that these methods do not modify an input histogram at all. A new histogram equalization method, named RSWHE (Recursively Separated and Weighted histogram Equalization), to enhance the image contrast as well as preserve the image brightness. However, RSWHE changes the input histogram before running the equalization procedure. This the fundamental difference between the previous methods and RSWHE.

RSWHE changes the input histogram before running the equalization procedure. It consists of three modules histogram segmentation, histogram weighting, and histogram equalization. The histogram segmentation part takes the input image, computes the input histogram and recursively divides the input histogram into two or more sub-histograms. In second step, it modifies the sub-histogram by using a normalized power law function. Lastly, the histogram equalization module finds histogram equalization individually over each of the modified sub-histogram.

A. *Histogram Segmentation Module*

In which, it divides the input histogram H(X) recursively up to some specified recursion level r, thus generating 2^r sub-histograms. This module provides two types of segmented results. One is based on the mean of the sub-histograms and the other one is medians of the sub-histograms. We will discuss only mean segmentation because; we utilize the mean method in our algorithm.

1) *Segmentation by Mean*

Segmented histogram $H^t(X)$ of gray level range $[X_l, X_u]$. The mean X^t_M of sub-histogram $H^t(X)$ is computed by

$$X^t_M = \left(\sum_{K=l}^{u} k.p(k)\right) / \left(\sum_{K=l}^{u} p(k)\right)$$

Based on above equation, we computed the mean X^t_M, the histogram $H^t(X)$ is then divided into two sub-histograms $H^{t+1}_L(X)$ and $H^{t+1}_u(X)$. Where $H^{t+1}_L(X)$ and $H^{t+1}_u(X)$ are defined over $[X_l, X^t_M]$ and $[X^t_M + 1, X^u]$. Here P(k) is the normalized histogram of the input image.

B. *Histogram Weighting Module*

The histogram segmented modules divide the input histogram image into two sub-histogram images. In histogram weighting module then modifies the PDF of sub-histogram as follows:

(a) Compute both the highest probability p_{max} and the lowest probability p_{min} by using below equations

$$P_{max} = \max P(k) \quad (9)$$

$$P_{min} = \min P(k) \quad (10)$$

(b) Compute the adjusted parameter or accumulative probability value α by using below equation (11)

$$\alpha_i = \sum_{K=l_i}^{u_i} P(k) \quad (11)$$

(c) After optimize the adjusted parameter, change the corresponding original PDF p(k) into weighted PDF $p_w(k)$ by using precumputed values.

$$P_w(k) = p_{max}\left(\frac{P(k) - P_{min}}{P_{max} - P_{min}}\right)^{\alpha i} \qquad (12)$$

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(d) After the modification in PDF value, the next step is normalized the modified PDF. The equation given below (13).

$$P_{wn}(k) = P_w(k) \Big/ \left(\sum_{J=0}^{L-1} P_w(j)\right) \qquad (13)$$

C. *Histogram Equalization Module*

In histogram equalization module is then to separately equalize each of all sub-histograms by using below equations (14), (15), and (16).

$$P(k) = n_k / N \quad \text{for } k = 0, 1, 2,\ldots L-1 \qquad (14)$$

Where N is the total number of pixels in the image. From the PDF, the CDF is defined as

$$C(k) = \sum_{J=0}^{k} P(j) \quad \text{for } k=0, 1, 2\ldots\ldots L-1. \qquad (15)$$

On the value of CDF, histogram equalization now maps an input gray level into an output gray level f(k). where f(k) is level transformation function.

$$f(k) = X_0 + (X_{L-1} - X_o).C(k) \qquad (16)$$

So, through these methods, we can enhance the Aerial images also Dimmed images.

IV. EXPERIMENTAL RESULTS

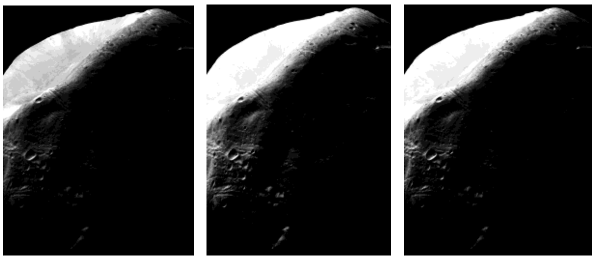
In this section, we will discuss about the experimental results of both the techniques. We will show the Qualitative and Quantitative results of both the algorithms.

A. *Qualitative Results*

We take the input images of Aerial. It is important to qualitative assess the contrast enhancement. The major goal of the qualitative assessment is to judge if the output image is visually acceptable to human eyes and has a natural appearance. In which, we will take four images that images are Aerial images. First image is Aerial image as shown in Fig. 2. Second, image is Mars image shown in Fig. 3. Third image is Pentagon image shown in Fig. 4. Fourth image is Moon shown in Fig. 5.

Original AGCWD Propose Method

Fig. 2 Enhancement results for the Aerial image.



Original AGCWD Propose Method

Fig. 3. Enhancement results for Mars image.

Original AGCWD Propose Method

Fig. 4. Enhancement result for Pentagon image.

Original AGCWD Propose Method

Fig. 5. Enhancement result of Moon image.

B. *Quantitative Results*

In this section, we will describe the quantitative results between both techniques. We will take the three parameters for analysis the results. These parameters are PSNR (Peak Signal to Noise Ratio), AMBE (Absolute Mean Brightness Error), and Correlation. Below given table, we can see the comparison between these two techniques.

TABLE I
COMPARISON OF AERIAL IMAGE

Parameters	**AGCWD (α = 0.5)**	**Alpha Optimization method**
PSNR	17.16 dB	17.53 dB
AMBE	0.1282	0.1224
Correlation	0.9739	0.9762

TABLE II
COMPARISON OF MARS IMAGE

Parameters	**AGCWD (α = 0.5)**	**Alpha Optimization method**
PSNR	21.99 dB	25.74 dB
AMBE	0.0379	0.0204
Correlation	0.9870	0.9968

TABLE III
COMPARISON OF PENTAGON IMAGE

Parameters	**AGCWD (α = 0.5)**	**Alpha Optimization method**
PSNR	15.57 dB	15.63 dB
AMBE	0.1551	0.1540
Correlation	0.9800	0.9804

TABLE IV
COMPARISON OF MOON IMAGE

Parameters	**AGCWD (α = 0.5)**	**Alpha Optimization method**
PSNR	17.87 dB	20.00 dB
AMBE	0.0725	0.0541
Correlation	0.9925	0.9956

V. CONCLUSION

According to these two methods for image enhancement, we conclude that optimization alpha method is better than AGCWD. Experiment results are showing that, PSNR parameter is better than the AGCWD. Another parameter is AMBE is small as compared to AGCWD, so it is important for brightness preserving that, AMBE parameter is to be lesser than the AGCWD. And last parameter is about the correlation. It is better than the AGCWD. In our experiment, we took the aerial images and dimmed images, and apply these two methods on these images.

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