Analysis of Contrast Enhancement Method Using Modified Dynamic Histogram Equalization

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Abstract: The proposed method is based on dynamic histogram equalization and for handling gray-level and color image as well. As far as HE methods for gray-level images are concerned, current methods tend to change the mean brightness of the image to the middle level of the gray-level range. To overcome this drawback of HE, Bi-histogram equalization methods for both preserving the brightness and contrast enhancement have been proposed. Although these methods preserve the input brightness on the output image with a significant contrast enhancement, they may produce images which do not look as natural as the ones which have been input. In order to overcome this drawback, a method is adopted, which consists of decomposing the input image histogram into several sub-histograms, and then applying the HE process to each one of them. This methodology performs a less intensive image contrast enhancement, in a way that the output image presented looks more natural. Experimental results show that mentioned method is better in preserving the brightness and producing more natural looking images than the other HE methods.

I. INTRODUCTION

A. Contrast Enhancement of an Image
Contrast enhancements improve the perceptibility of objects in the scene by enhancing the brightness difference between objects and their backgrounds. Contrast enhancements are typically performed as a contrast stretch followed by a tonal enhancement, although these could both be performed in one step. A contrast stretch improves the brightness differences uniformly across the dynamic range of the image, whereas tonal enhancements improve the brightness differences in the shadow (dark), mid tone (grays), or highlight (bright) regions at the expense of the brightness differences in the other regions. Contrast enhancement processes adjust the relative brightness and darkness of objects in the scene to improve their visibility. The contrast and tone of the image can be changed by mapping the gray levels in the image to new values through a gray-level transform. The contrast and tone of the image can be changed by mapping the gray levels in the image to new values through a gray-level transform. The mapping function reassigns the current gray level GL to a new gray level GL’ (Fig. 1).

![Fig 1: A gray-level transform maps the gray levels to new values](image1.png)

B. Histogram equalization
Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.

![Fig 2: Spreading the intensity values](image2.png)

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Consider a digital image with gray levels in the range \([0, L-1]\). Probability Distribution Function of the image can be computed as equation:

\[
P(r_k) = \frac{n_k}{N}; \quad k = 0, ..., L-1
\]

(1.1)

Where \(r_k\) is the \(k\)th gray level and \(n_k\) is the number of pixels in the image having gray level \(r_k\). Cumulative Distribution Function (CDF) can also be computed as followed:

\[
C(r_k) = \sum_{i=0}^{k} P(r_i)
\]

(1.2)

Cumulative Distribution Function (CDF) can also be computed as followed:

\[
k=0,..,L-1, \quad 0 \leq C(r_k) \leq 1
\]

Histogram Equalization (HE) appropriates gray level \(S_k\) to gray level \(r_k\) of the input image using equation. So we have:

\[
S_k = (L - 1) \times C(r_k)
\]

(1.3)

Gray level \(S_k\)’s changes can be computed in usual histogram equalization method:

\[
\Delta S_k = (L - 1) \times P(r_k)
\]

(1.4)

Equation (1.4) means that distance between \(S_k\) and \(S_{k+1}\) has direct relation with PDF of the input image at gray level \(r_k\).

Undesirable effects of the usual histogram equalization method (HE) are resulted from equation (1.2) because of the quantization operation and summarizing properties of this equation.

C. Bi Histogram Equalization (BHE)

Bi Histogram Equalization is considered as an improved histogram equalization (HE) method for contrast enhancement in this section. This method divides the image histogram into two parts as shown in Fig.1.6. In this method, the separation intensity \(X_T\) is presented by the input mean brightness value, which is the average intensity of all pixels that construct the input image. After this separation process, these two histograms are independently equalized. By doing this, the mean brightness of the resultant image will lie between the input mean and the middle gray level. BHE first finds average point in histogram of the image and then divides histogram to two segments based on this point. After that histogram equalization operation is applied on each segment.

![Fig. 3. Bi-histogram equalization](image)

There are two cumulative distribution functions for two segments. Gray level \((r_k)\) under the average point are pointed to the new gray level \((S_k)\) as it can be seen in equation (5).

\[
S(k) = (L_1) \times C_1(r_k)
\]

(1.5)

\[
C_1(r_k) = \frac{\sum_{j=0}^{r_k} n_j}{\sum_{j=0}^{L_1} n_j}; \quad k=0,1,...,L_1
\]

(1.6)

Gray level \((r_k)\) above the average point are pointed to the new gray level \((S_k)\) as it can be seen in equation (6).

\[
S_k = (L - 1 - L_1) \times C_2(r_k) + L_1
\]

(1.7)

Where \(L_1\) is the average of gray levels of the histogram and it can be computed as in equation (1.8)

\[
L_1 = \frac{\sum_{k=0}^{L-1} P(r_k) \times r_k}{\sum_{k=0}^{L-1} P(r_k)}
\]

(1.8)

Gray level \((r_k)\) above the average point are pointed to the new gray level \((S_k)\) as it can be seen in equation (1.8).
Results of applying BHE method comparing to HE and proposed method are depicted in results section.

II. DHE (DYNAMIC HISTOGRAM EQUALIZATION)

Modified DHE
Modified DHE can understand by following steps:

1. Identify image is color or not.
The very first step is identifying the image is color or not. If the image is color the algorithm converts it into intensity files. And proceed to next step of the algorithm. If it is gray image then it bypass the step of conversion into intensity files.

2. Make the histogram of image & normalize it.
In this step we make the histogram of the given image & normalize it with the help of filter, because the histogram of the digital image is normally fluctuated and also the probability for some brightness levels is missing.\[11\]

3. Detect local minima & divide the histogram based on it.
The histogram is divided into sub-histograms based on local maximums. We choose to use local minimums as the separating intensities this selection is better in maintaining the mean brightness. Let \(m0, m1, ..., mn\) are \((n+1)\) gray levels correspond to the local maximums detected in the previous step. If the original histogram before the smoothing is in the range of \([I_{min}, I_{max}]\), then, the first sub-histogram is in the range of \([I_{min}, m0]\), the second sub-histogram in the range of \([m0+1, m1]\), the third one \([m1+1, m2]\), and so on until the last sub-histogram \([mn+1, I_{max}]\).\[11\]

4. Calculate mean & standard deviation to avoid dominating portion.
To test the presence of any dominating portion, we first find the mean, \(\mu\), and standard deviation, \(\sigma\), of the GL frequencies (histogram components) of each sub-histogram regions. If in a sub-histogram the number of consecutive gray levels having frequencies within the range from \((\mu - \sigma)\) to \((\mu + \sigma)\) becomes more than 68.3% of the total frequency of all gray levels of that sub-histogram, then we can consider it to have a normal distribution of frequencies \[18\] and there is no dominating portion of histogram that might affect others. However, on the other hand, if this percentage is less than 68.3%, we may be worried about the presence of some dominating portion in the sub-histogram. In this case, DHE splits the sub-histogram into three smaller sub-histograms by partitioning it at gray levels \((\mu - \sigma)\) and \((\mu + \sigma)\).\[10\]

5. Assign specific gray level to each partition
However, the equalized version of these sub-histograms does not assure a very good enhancement, because sub histograms with small range will not be enhanced significantly by HE. Hence, following the same concept as DHE. This method spans each sub-histogram first before the equalizations are taking place. The spanning function used is based on the total number of pixels contained in the sub-histogram. This function is described by the equations given below, as suggested by \[10\]:

\[
C_k(r_k) = \frac{\sum_{i=L_k+1}^{k} n_i}{\sum_{j=L_k+1}^{L} n_j};
\]

\[
k = L_k + 1, ..., L - 1
\]
Where $\text{high}_i$ is the highest intensity value contained in the sub histogram $i$, $\text{low}_i$ is the lowest intensity value in that section, and $M$ is the total pixels contained in that section. The dynamic range used by the sub-histogram $i$ in input image is given by $\text{span}_i$, while the dynamic range used by in output image is $\text{range}_i$. Let the range of the output sub-histogram $i$ is $[\text{start}_i, \text{end}_i]$. If we set the first sub-histogram of the output image is in the range of $[0, \text{range}_1]$, then the $\text{start}_i$ and $\text{end}_i$ (for $i > 1$) can be calculated as follow:

$$\text{start}_i = \sum_{k=1}^{i-1} \text{range}_k + 1$$
$$\text{end}_i = \sum_{k=1}^{i} \text{range}_k$$

vi. **Apply HE to each partition**
HE is applied to each sub-histogram, but its span in the output image is allowed to confine within the allocated GL range that is designated to it.

vii. **Induce true color**
If the image is RGB then induce the true color of the original image. If not i.e. in case of gray image skip the step and continue with the next one.

viii. **Normalize the image brightness**

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**Fig 5**: flow chart of proposed method
In this step, the mean brightness of the input, $M_i$, and the mean brightness of the output obtained after the equalization process, $M_o$, is calculated. In order to shift back the mean brightness to the mean brightness of the input, we apply the brightness normalization, as define by equation:

$$g(x, y) = (M_i / M_o) f(x, y)$$

Where $g(x, y)$ is the final output image and $f(x, y)$ is the output just after the equalization process. This normalization will make sure that the mean output intensity will be almost equal to the mean input intensity.[11].

### III. RESULTS AND DISCUSSIONS

In addition to this method, I am also implemented other methods, HE, BHE and DHE, to demonstrate the performance of the proposed method and calculate the contrast, rms contrast & mean brightness of each resulting image.

**Result of gray image:**

1. GUI
2. Load the image from data base
3. After applying proposed method.
4. After HE
The results show that this method successfully enhanced the images without introduce undesirable artifacts, such as saturation effect, changing of image focus, and also enhancement of the partial volume effect.
This paper is an extension to DHE. This method is similar to DHE in terms of spanning the dynamic range. However, unlike both HE and DHE, this method utilizes brightness normalization in order to keep the input mean intensity. One advantage of this method is that there is no parameter need to be tuned. Experimental results shows that this method can enhance the images without introducing unwanted artifacts, while at the same time maintain the input brightness. Furthermore, similar to other HE based algorithms this method is easy to implement and can be used in real time system because of its simplicity.

REFERENCES


AUTHOR BIOGRAPHY

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