

HISTOGRAM EXPANSION-A TECHNIQUE OF HISTOGRAM EQUILIZATION

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Abstract

In this paper I have described histogram expansion. Histogram expansion is a technique of histogram equalization. In this I have described three different techniques of expansion namely dynamic range expansion, linear contrast expansion and symmetric range expansion. Each of these has their specific uses and advantages. For colored images linear contrast expansion is used. These all methods help in easy study of histograms and helps in image enhancement.

Index Terms: Histogram expansion, Dynamic range expansion, Linear contrast expansion, Symmetric range expansion

1. INTRODUCTION

HISTOGRAM

Histogram can be defined as the graphical distribution of pixels over the tonal range or luminous intensity.

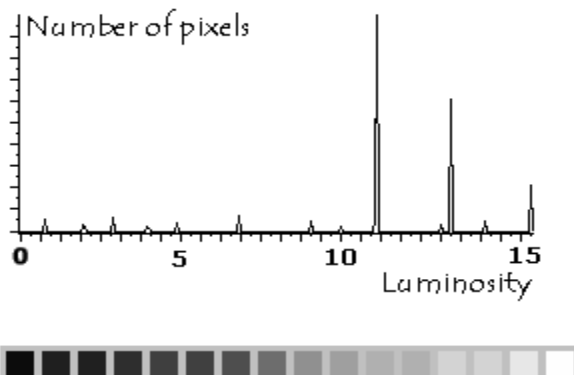


Figure 1

We can do modification of histogram in order to correct the contrast of under-exposed and over-exposed images. Histograms are also used to study distribution of various components of the images. Various histogram processing are histogram equalization and histogram matching. In this section histogram expansion-a technique of histogram equalization have been described.[1]

HISTOGRAM EQUALIZATION

Histogram equalization can be described as method in which histogram is modified by spreading the gray level areas.this can be shown as;

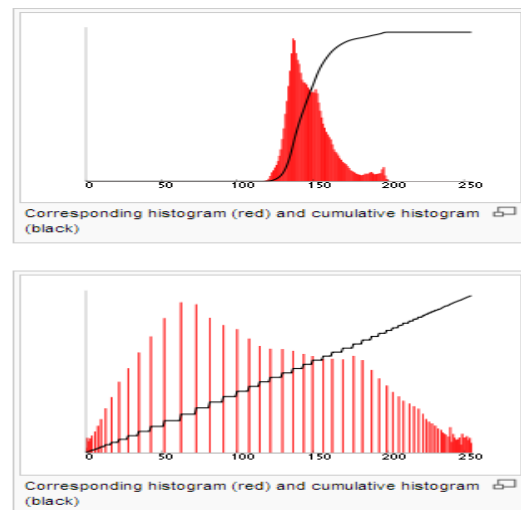


Figure 2

Let us consider an input histogram h_i and that produces a modified histogram h by histogram expansion that is close to any uniformly distributed histogram u , then histogram equalization can be described as :

$$\min \|h - h_i\| + \lambda \|h - u\| \quad (1)$$

ADJUSTABLE HISTOGRAM EXPANSION

For this we have

$$h' = \frac{h_i + \lambda u}{1 + \lambda} = \left(\frac{1}{1 + \lambda}\right) h_i + \left(\frac{\lambda}{1 + \lambda}\right) u \quad (2)$$

By using this equation we show enhancement of image.

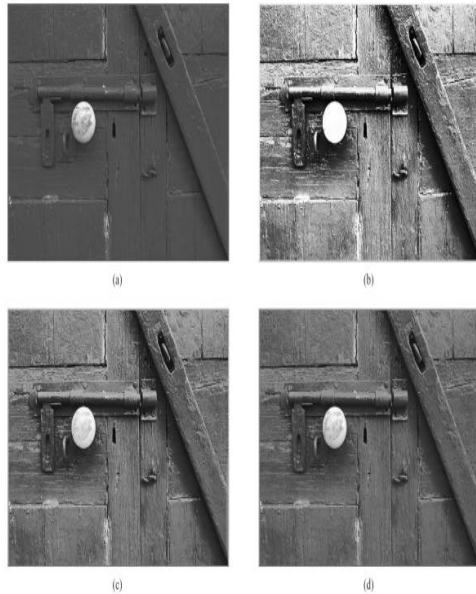


Fig-3 Modified histogram equalization results using (2) for image Door. (a) Original image, (b) enhanced image using (2) with $\lambda = 0$, (c) enhanced image using (2) with $\lambda = 1$, (d) enhanced image using (6) with $\lambda = 2$.

Figure 3

There are various methods present for histogram equalization. Few of these are histogram expansion which is described in this paper. others are Dualistic sub-image histogram equalization(DSIHE), by modifying ‘cumulationfunction’, gray level grouping(GLG),etc.all these techniques are used for image enhancement purposes.[2][3]

HISTOGRAM EXPANSION

This is denoted by HE. It is explained as remap of a sub-range intensity of an input image to full range in an output image. Input range is $x[x_{min},x_{max}]$ and output range to which it is stretched is $y[0,255]$. This mapping can be described by using the following linear mapping function:

$$y = \frac{x-x_{min}}{x_{max} - x_{min}} y_{max} \quad (3)$$

histogram expansion can be shown in figure 4.

MODIFIED HISTOGRAM EXPANSION

Provides greater enhancement in the cases where histograms have narrow peak and tails to end of each side of peak. In this we have new lower and upper bounds described as:

$$x_{min}' : \frac{(100-P)}{2} = \frac{100}{T} \sum_{x=x_{min}'} h(x) \quad (4)$$

Where $T = \sum_{x_{min}'}^{x_{max}'} h(x)$

$$x_{max}' : \frac{(100-P)}{2} = \frac{100}{T} \sum_{x=x_{max}'} h(x) \quad (5)$$

Where P is user selected cut-off percentage and it ranges from 98% down to 85%.

The mid P% of intensities are stretched to full range and tails that comprise of $(100-P)/2\%$ each are compressed.[4]

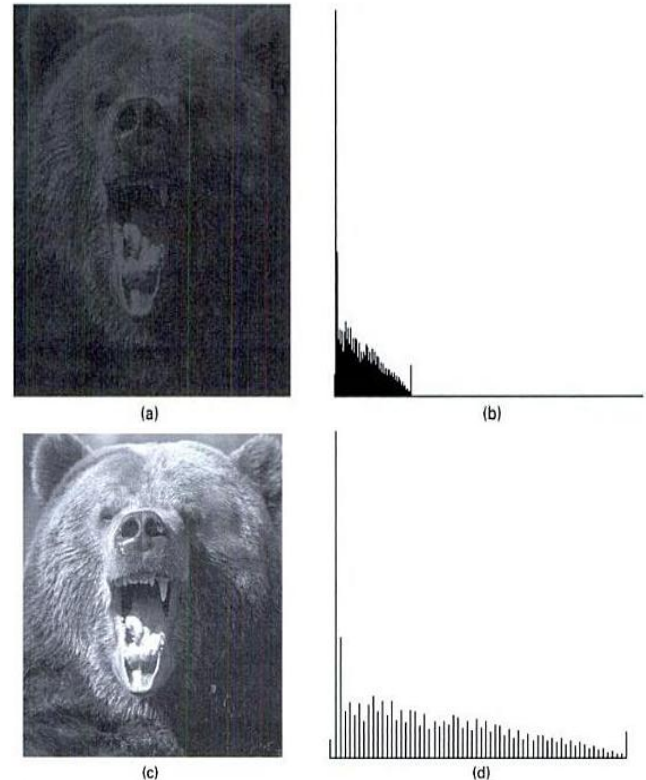


Figure 4 Pictorial Example. Illustration of contrast enhancement by histogram expansion: (a) original image with poor contrast; (b) histogram of (a), the narrow range of occupied histogram bins indicating poor contrast, the concentration of intensities at the high end indicating dark image; (c) result of enhancing contrast in (a); (d) histogram of (c). (This product/publication includes images from Corel Stock Photo Library, which are protected by the copyright laws of the U.S., Canada, and elsewhere. Used under license.)

Figure 4

2. DYNAMIC RANGE EXPANSION:

Dynamic range expansion can be explained as expansion of unused range. This can be on both the sides i.e. lower bound and upper bound here pixel values remain same. This is mainly done so that visualizing the image can be relieved from stress and fatigue i.e. into range that suits normal eye.

This is also called as normalization. There can be two kinds-linear and nonlinear normalization.

We can explain this by taking initial range as I: {Min ,Max } And new range as IN:{ newMin , newMax } then linear normalization is as shown:

$$I_N = (I - Min) \frac{(newMax - newMin)}{(Max - Min)} + newMin \quad (6)$$

Nonlinear normalization can be shown as:

$$I_N = (newMax - newMin) \frac{1}{1 + e^{-\frac{I - \beta}{\alpha}}} + newMin \quad (7)$$

Where α is width of input intensity range and β is intensity around which range is centered.

Advantage of dynamic range expansion is that it can preserve the losses that occur due to contrast gains or clippings as in case of shadows, or in photographs that have back lit background (eg direct sunlight, light snow).

Upper and Lower dynamic range expansion is shown in fig 5.[5][6]

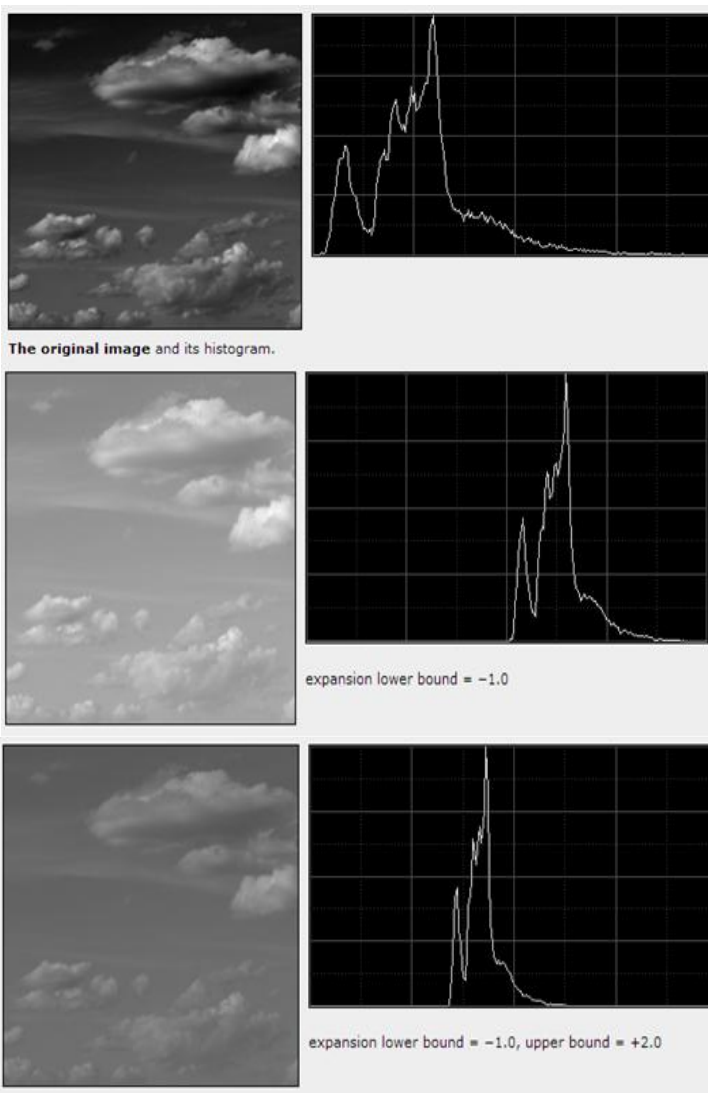


Figure 5

3. LINEAR CONTRAST EXPANSION

This method is used to solve brightness saturation problem. Visibility is improved by stretching the contrast this is done by assigning the new values to the pixels. The pixels to the darkest side are taken as black and to lightest side are taken as white. The pixels lying between light and dark are changed the pixel values to improve the contrast.

This is also applied in color images. This is done by increasing the intensity, lightness while leaving the color information same. We can also produce color shifts in image by expanding the RGB values fully individually, but the colors should be few or only single color. Expansion may make it possible to compare images acquired with slightly different brightness ranges by adjusting them all to same expanded contrast scale. This only works if brightest and darkest images are present in all of image.

New gray level that is obtained after contrast stretching can be mathematically explained as:

$$(8)Y = \left[\frac{(x - xmin)}{(xmax - xmin)} \right] (y_{max} - y_{min}) + y_{min}$$

Where $(xmin, xmax)$ is range of original image and $(ymin, ymax)$ are range of final image.

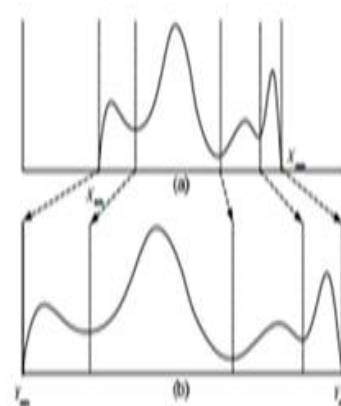


Figure 6 Linear contrast expansion (a) Original histogram (b) New histogram.

Figure 6

APPLICATIONS OF CONTRAST STRETCHING

Its use in microscopic images can be shown in following figures.

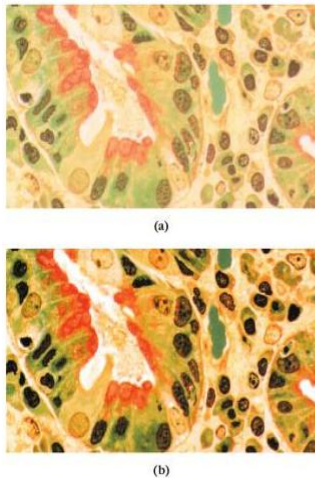


Figure 7 Light microscope image of stained tissue (a) and the result of expanding contrast by converting to HSI space and linearly expanding the intensity only (b).

Figure 7

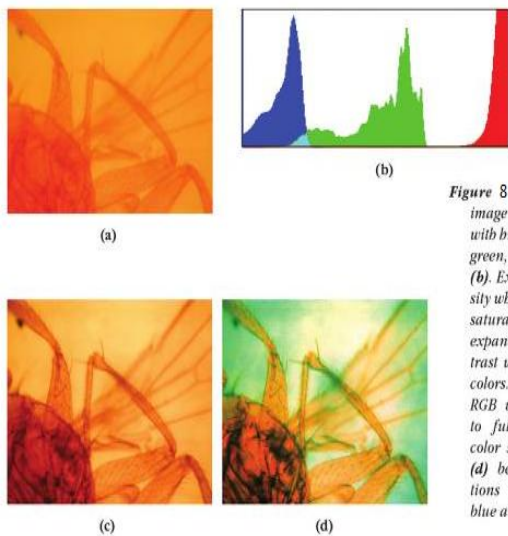


Figure 8 Light microscope image of an insect (a) with histograms of the red, green, and blue values (b). Expanding the intensity while leaving hue and saturation unchanged (c) expands the visible contrast without altering the colors. Expanding the RGB values individually to full range produces color shifts in the image (d) because the proportions of red, green and blue are changed.

Figure 8

ADVANTAGES

- 1). Simple to implement
- 2). Increase contrast of image i.e too dark image will become more visible.

DISADVANTAGES

If there are gray values that are physically far apart from each other in the image, then this method fails.[7]

4. SYMMETRICAL HISTOGRAM EXPANSION

This is histogram expansion in spatial domain with high embedding. For embedding bins are evacuated by moving them to both sides. In this a pivotal bin is chosen and bin pixel value is embedded into its left or right of pivotal bin. For this we use n-buddy number-in which lower n bits of any number

differ by 1 bit. 2 and 3 are 1-buddies of each other, 4,5,6,7, are 2 buddies of each other. In this expansion is done by moving the pixel value to empty neighbor n-buddy. Embedding process can be mathematically written as:

$$C_W = \lceil C/2^n \rceil \cdot 2^n + W \quad (9)$$

This is shown in following figures 9 and 10.

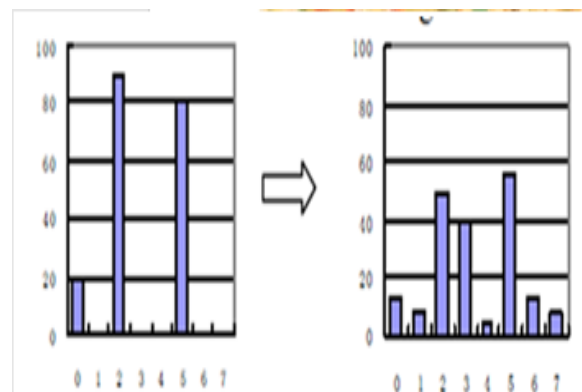


Fig 9. Histogram modification for embedding data

Figure 9

ADVANTAGES

- (1)The algorithm is simple one.
- (2)There is no need to evacuate all the bins for embedding purpose because pivot bins can be shifted on both sides
- (3)Here fewer watermarks bits need histogram shifting

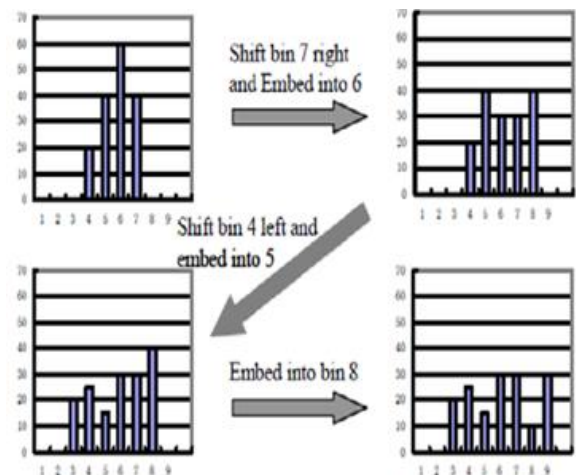


Figure 10 Symmetrical histogram expansion for data embedding

Figure 10

- (4)This results in enhanced images shown in figure.[8]



Fig11The original image (Left) and the watermarked image with 16298 byte hidden data and 34.04dB PSNR (Right)

Figure 11

CONCLUSION

Histogram expansion leads to enhancement of image .This is mainly used when histogram contain one very tall spikes and it becomes difficult to interpret the rest of information. Various methods like symmetric histogram expansion can be used for study of these histograms. The images with shadows can be clearly observed using dynamic range expansion. Contrast expansion can be used to solved brightness issues.Each technique of expansion have its own uses. Further many more algorithms can be explained for this technique of histogram expansion. Also we can use various methods of histogram equalization for improving contrast of images.

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