A Study for Applications of Histogram in Image Enhancement

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--- **ABSTRACT** ---

Image Enhancement aims at improving the visual quality of input image for a particular area. The criterion used by enhancement algorithms to enhance the image is; using histogram details of that image. This paper defines the various applications of histograms through which they help in the enhancement process. The paper also represents three basic histogram processing techniques- histogram sliding, histogram stretching, and histogram equalization, and how these techniques help in enhancement process, which factors effect these techniques. We examine subjectively the effect of these processing techniques. Comparative analysis of these techniques is also carried out.

Keywords: Histogram Equalization, Histogram Sliding, Histogram Stretching, Image Enhancement, Visual Quality.

I.   INTRODUCTION

Image enhancement is indispensable step of digital image enhancement, in which an image is taken as input; enhancement algorithm is applied on it and then taken as enhanced output image. Basically, there are two techniques accordingly those images are enhanced. These techniques are-

SPATIAL DOMAIN TECHNIQUES
FREQUENCY DOMAIN TECHNIQUES
In spatial domain techniques, the enhancement algorithm or transformation method is applied directly to image pixels; whereas, in frequency domain methods the Fourier transform of the image is obtained, enhancement algorithm or transformation method is applied then inverse Fourier is obtained to get the resultant enhanced output image.
Histograms are considered as the basis for a number of spatial domain techniques. Histograms are having a significant role in enhancing digital images. Histograms are used to set out the image statistics in a clarified visual format.
Histogram of an image describes the frequency of intensity values that occur in an image.
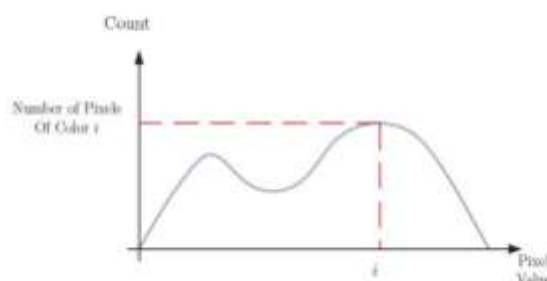

Figure 1: Histogram of an Image

 The x-axis of the histogram represents the range of intensity (pixel) values whereas; y-axis represents the count (frequency) of these intensities values that occurs in an image. The histogram of a digital image with intensity levels in the range [0, L-1] is a discrete function given as:

$$h(r_k) = n_k \qquad (1)$$

where, r_k denotes the kth intensity value and n_k is the count of pixels having intensity equal to r_k. In this paper we will study the numerous applications of the histogram in image processing and that how histogram manipulation can be used for image enhancement.

II.   APPLICATIONS OF HISTOGRAM IN IMAGE ENHANCEMENT

- A popular tool for real-time processing: Histograms are simple to calculate in software and also lend themselves to economic hardware implementations
- Histograms are used to analyze image: We can predict the properties of an image just by looking at the details of the histogram.
- Histograms are used for brightness purpose: We can adjust the brightness of an image by having the details of its histogram.
- Histograms are used to adjust the contrast of an image: The contrast of an image is adjusted accordingly required need by having the details of x-axis or gray level intensities of a histogram
- Histograms are used for image equalization: The gray level intensities are expanded along the x-axis to produce a high contrast image.
- Histograms are also used in thresholding.
- Histograms improve the visual appearance of an image.
- By having the histograms of input and output image, we can easily determine that which type of transformation or enhancement algorithm is applied.
- Histogram of an image depicts the problems that originate during image acquisition such as dynamic range of pixels, contrast, etc.
- Histograms reflect a wide range of vulnerabilities such as saturation, spikes, and gaps, the impact of image compression.
- The shape of histogram predicts information about the possibility of contrast enhancement.

Histograms are processed for these kind of applications. In histogram processing, the input image is enhanced by modifying or manipulating the histogram of image.

III.   HISTOGRAM PROCESSING TECHNIQUES

Image enhancement is a collection of transformation techniques which seek to improve the visual appearance of an image for analysis in a particular area. The transformation function (processing technique) T is applied to an input image f(x, y) which gives the processed output image g(x, y).

$$g(x, y) =T (f(x, y)) \qquad (2)$$

III.I Histogram Sliding

Histogram Sliding is a technique, in which the complete histogram is simply shifted towards rightwards or leftwards. By shifting the histogram towards right or left a clear change is seen in the brightness of image.
Brightness is defined as the intensity of light emitted by a particular light source. In order to increase the brightness of an image, we will slide its histogram towards the right or lighter (brighter) portion. Fig. 2 below shows the concept of histogram sliding, by applying desired sliding transformation in order to change the brightness, the histogram of an image is shifted towards left or right.
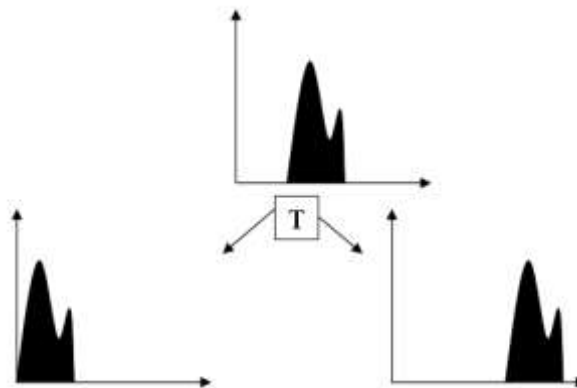

Figure 2: Histogram Sliding

III.II Histogram Stretching

Histogram Stretching is process of increasing the contrast of an image. Contrast is defined as the difference between maximum and minimum pixel intensity values in an image. In order to increase the contrast of image or stretch the histogram of an image the range of intensity values are stretched to cover the full dynamic range of histogram. Histogram of an image depicts, that the image is having low or high contrast. A histogram having the full range of dynamic intensity values is considered as high a contrast image. Fig.3 shows the basic concept of histogram stretching.
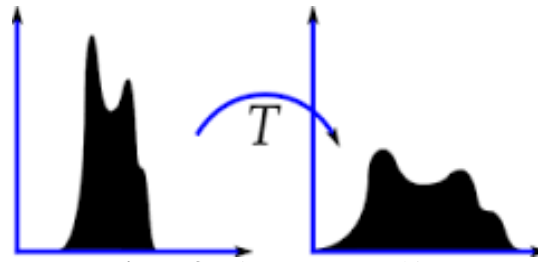
Figure 3: Histogram Stretching

III.III Histogram Equalization

HE enhances the contrast of images by equalizing all the pixel values of an image; it transforms the image in a way that produces a uniform flattened histogram. HE increases the dynamic range of pixel values and also makes an equal count of pixels at each level, which produces a flat histogram having full dynamic range and result is a high contrast image. In histogram stretching the shape of histogram remains same, it also allow interactive enhancement whereas in histogram equalization the shape of histogram is changed and it does not allow interactive image enhancement, it generates only one result. Fig.4 shows an equalized image and it's Histogram.
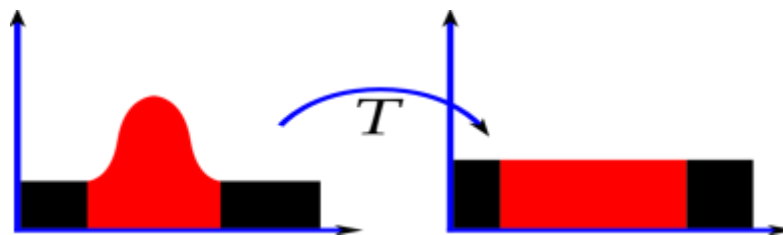
Figure 4: Equalized Image and its Histogram

IV.   RESULTS AND DISCUSSION

We have applied above processing techniques to an image, and perform the subjective analysis on given outputs. Table 1 shows the input image and its histogram and the resultant images with their histograms of different processing techniques.

IV.I Histogram Sliding- As we can see in 2nd row of Table 1, the histogram of input image is in middle of x-axis (intensity values), in the range approx. 45-210, as we can see that intensities whose count is more than 550 lies in first half portion of histogram, this portion defines the darker portion, that's why image is a bit darker. In order to increase the brightness of image we will slide its histogram towards the right or lighter (brighter) portion. Third row of table 1shows the image and its histogram after sliding towards right. As we can see the brightness of image is increased and results in a lighter image. The details of image are not clearly visible because of high brightness.
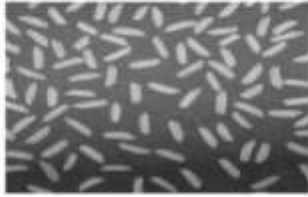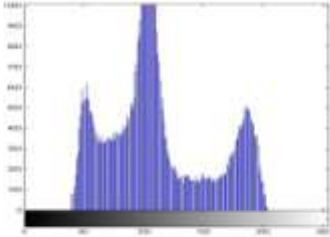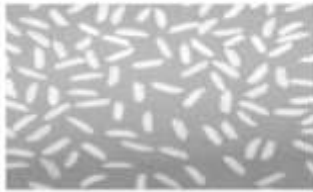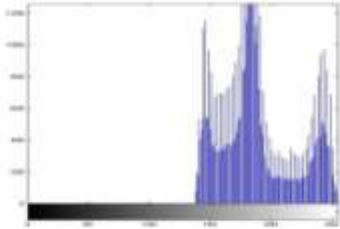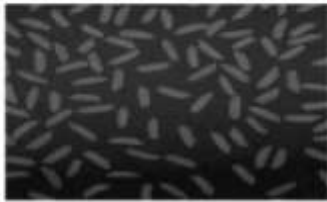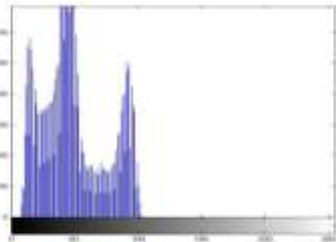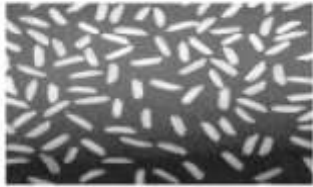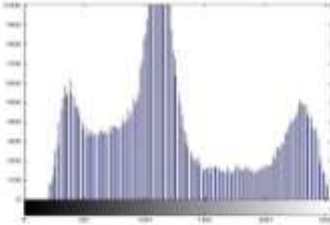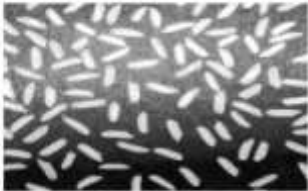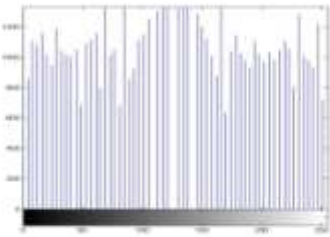
Decreasing Brightness: In order to decrease the brightness of image, its histogram is shifted towards left side or darker side. The results of left sliding decreasing brightness can be seen in row fourth of Table 1, which shows a darker image. The details are clearly visible but there is interference of noise in this left slide image.

So, the brightness of an image is increased or decreased accordingly the requirement by shifting the histogram towards right or left to have darker or lighter image.

IV.II Histogram Stretching- The histogram of input image in row one depicts that range of intensity values lies in-between 45-210 to stretch its range from 0-255 we use histogram stretching. The results of histogram stretching are shown in fourth row of Table 1, which depicts a high change in contrast of the image. The edges of grains are more clearly visible in this resultant image. So, the contrast of an image is increased or decreased by having the details of histogram of an image.

IV.III Histogram Equalization- The last rows of Table1represents the results of histogram equalization which stretches the range of intensity values and also makes similar count of pixels at each level. The results are high contrast image, there is a huge change in contrast and brightness of image and it alters noise in upper part of image with edge deterioration.

Table 1: Results of histogram processing techniques

Type	Image and its Histogram
Input Image	
Histogram Sliding (Right Sliding)	
Histogram Sliding (Left Sliding)	
Histogram Stretching	
Histogram Equalization	

TABLE2: Comparison of Histogram Processing Techniques

Processing Technique	Fully Enhanced image	User Interactive	Complex	Histogram Shape Affected	Full Dynamic Range	Characteristics Affected
Histogram Sliding	No	Yes	No	No	Accordingly user input	Brightness
Histogram Stretching	Yes	Yes	No	No	Accordingly user input	Contrast
Histogram Equalization	Yes	No	Yes	Yes	Yes	Contrast

V.   CONCLUSION

In this paper the different applications of histogram in image enhancement are discussed, there are a number of histogram processing techniques, to choose the appropriate technique for a particular application such as enhancement, compression etc. from a number of available techniques, we can simply select a particular technique by just having a look on the histogram of image. So, we can say that having a huge number of other applications, histograms also reduce the complexity of choosing a processing technique in order to process an image.

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