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Improvement of histogram equalization using bi-histogram equalization technique for image enhancement

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Abstract

Enhancement of an image is used to improve, emphasize and sharpen the features of an image for visual perception of human beings. It's basic application is used to preprocess for computer vision applications. It is an analysis method in which the set of pixel values of one image is transformed to a new set of pixel values so that the new image formed is in visual ,desirable form and suitable for post processing analysis. In this paper we proposed Histogram equalization and Bi-histogram equalization for grey scale images. We have simulated our techniques in Mat-lab environment and tested successfully comparing the Psnr and Mse values. From the estimated statistical parameters in all the techniques, we found Bi-histogram equalization to be the most efficient technique in case of grayscale images.

Keywords: Image Enhancement, Histogram, Bi-histogram equalization, MSE, PSNR, MATLAB

1. Introduction

An image is used to convey useful information in a visible format. An image is nothing but an arrangement of tiny elements i.e. pixels in a two-dimensional plane. A large number of pixels combine together to form an image, whether small or large. Image Enhancement is done to improve the quality of an image whether grayscale or color. It means that the information stored in an image is increased or altered by means of a computer program. Image Enhancement is done for a copious amount of reasons. It may be for brightness and contrast compensation, sharpening, de-noising, highlighting, color correction, lens aberration, distortion and many more. Below are some techniques discussed in elaborate for better image processing.

Proposed methodologies:-

2. Histogram Equalization:-

Histogram Equalization (HE) is one of the most popular, computationally fast and simple to implement technique for enhancement of digital grayscale images.

It's a Contrast Enhancement process in which the histogram of discrete grey- level represents the frequency of occurrence of all grey levels in the image. A histogram graphically represents the distribution of data. Histogram Equalization has its own advantages as it is simple and effective in equalizing the brightness of an image.

Let $X = \{X(i,j)\}$ denotes a given image composed of L discrete gray levels denoted as

$$L = \{X_0, X_1, \dots, X_{L-1}\}.$$

The Probability Density Function $p(X_k)$ is defined as $p(X_k) = n^k/n$ for $k=0,1,\dots,L-1$.

where n^k =number of times & n =number of samples

Now, Cumulative Density Function $c(x) = \sum_{j=0}^k p(x_j)$

Now, Transfer Function $f(x)$ based on cumulative density is defined as

$$f(x) = X_0 + (X_{L-1} - X_0)c(x)$$

Histogram equalization's output can be defined as

$$Y = f(X) = \{ f(X(i,j)) \mid \forall X(i,j) \in X \}$$

Histogram Equalization(HE) being simple and effective has some flaws associated with it. The (HE) enhances the brightness of an image but is not able to preserve it as it shifts the mean intensity value to middle gray level of the intensity range. The (HE) has the image flattening property and creates unnecessary visual distortion.

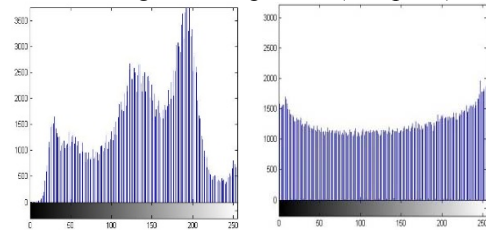
Test Samples (He):-

Sample1 (Airfield.Bmp)



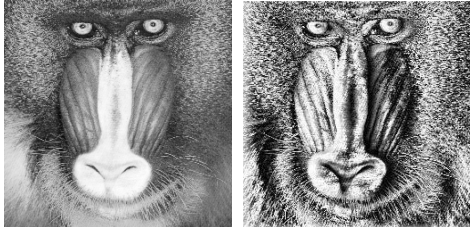
(Input Image) (Output Image)

Histogram Comparison (Sample 1)



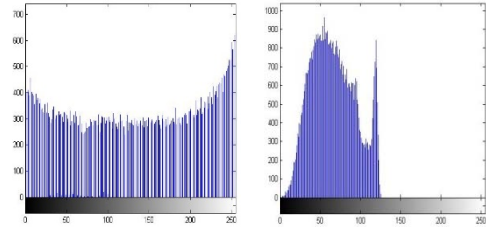
Histogram (I/P Image) Histogram (O/P Image)

Sample2 (Baboon.Bmp):-



(Input Image) (Output Image)

Histogram Comparison (Sample 2)



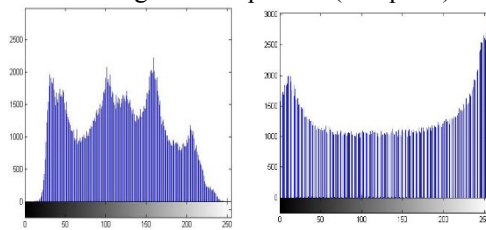
Histogram (I/P Image) Histogram (O/P Image)

Sample 3(Barbara.Bmp)



(Input Image) (Output Image)

Histogram Comparison (Sample 3)



Histogram (I/P Image) Histogram (O/P Image)

3. Bi-Histogram Equalization:-

The Bi-histogram Equalization is another advanced approach in contrast enhancement process. Here the image is broken down to two sub-images taking into account the mean of the image from intensity range. The Pdf (probability density function) & the Cdf (cumulative density function) of individual sub-image is found out. Using the Cdf we get the transform function and finally use the same, to be fed into the mapper to get the desired enhanced image.

Let X_m be the mean of an image X and $X_m \in \{X_0, X_1, \dots, X_{L-1}\}$

The mean of the image is a deciding factor for the input image to be decomposed into two sub-images X_L and X_U , i.e $X = X_L \cup X_U$

where $X_L = \{X(i,j) | X(i,j) \leq X_m, \forall X(i,j) \in X\}$ and $X_U = \{X(i,j) | X(i,j) > X_m, \forall X(i,j) \in X\}$.

We have to note that $X_L = \{X_0, X_1, \dots, X_m\}$ and $X_U = \{X_{m+1}, X_{m+2}, \dots, X_{L-1}\}$

Respective Pdf (probability density function) of sub-images X_L and X_U can be defined as X_L and X_U as

$$P_L(X_k) = n_L^k / n_L, \text{ where } k=0, 1, \dots, m \text{ and}$$

$$P_U(X_k) = n_U^k / n_U, \text{ where } k=m+1, m+2, \dots, L-1.$$

The Cdf (cumulative density function) for $\{X_L\}$ and $\{X_U\}$ are defined as:-

$$c_L(x) = \sum_{j=0}^k p_L(X_j) \text{ and}$$

$$c_U(x) = \sum_{j=0}^k p_U(X_j).$$

So, based on cdf, the transform function is defined as-

$$f_L(x) = X_0 + (X_m - X_0) c_L(x) \text{ and}$$

$$f_U(x) = X_{m+1} + (X_{L-1} - X_{m+1}) c_U(x)$$

The output (HE) can be expressed as

$$Y = \{Y(i,j)\} = f_L(X_L) \cup f_U(X_U)$$

In the above equation, $f_L(X_L) = \{f_L(X(i,j)) | \forall X(i,j) \in X_L\}$ and

$$f_U(X_U) = \{f_U(X(i,j)) | \forall X(i,j) \in X_U\}.$$

It helps to cover up the flaws that were associated with histogram equalization. The Bi-Histogram Equalization (BHE) enhances as well as preserves the brightness of an image. The (BHE) as helps in restoring the mean brightness of an image within the intensity range. The (BHE) also helps in refraining from the image flattening property which creates unnecessary visual distortion.

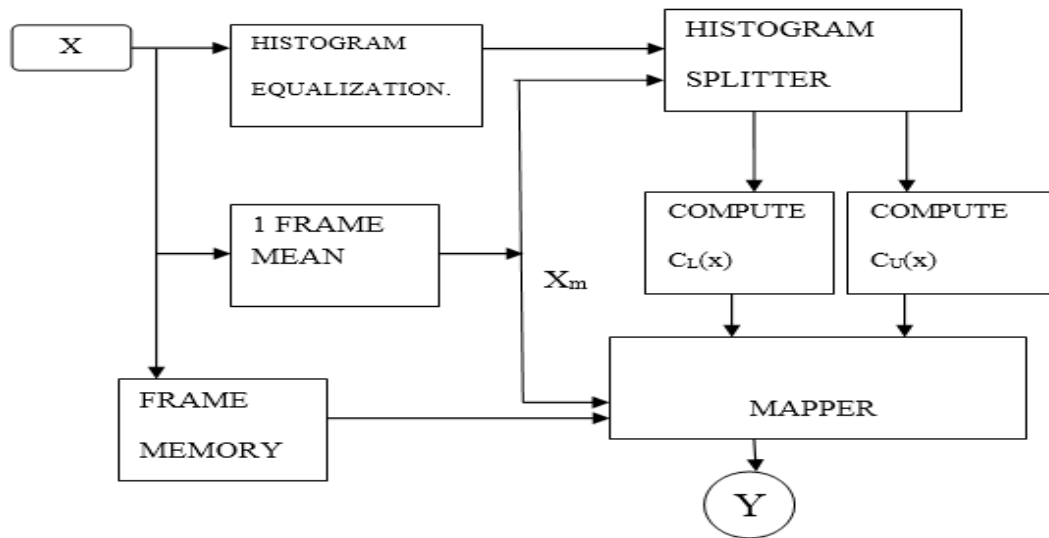
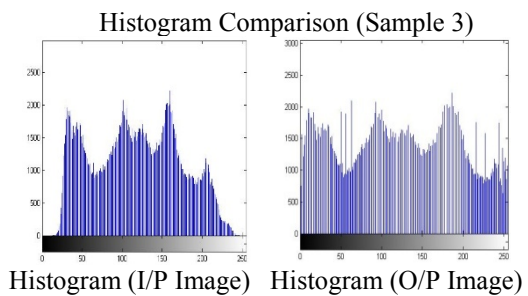
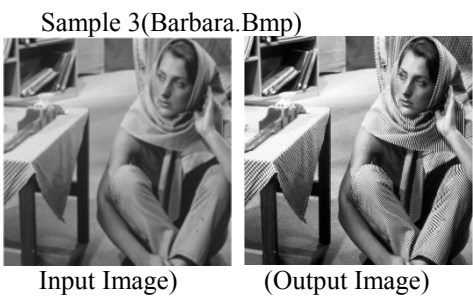
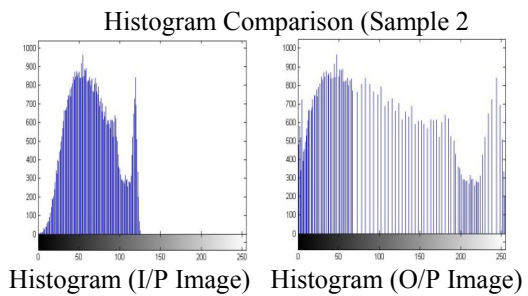
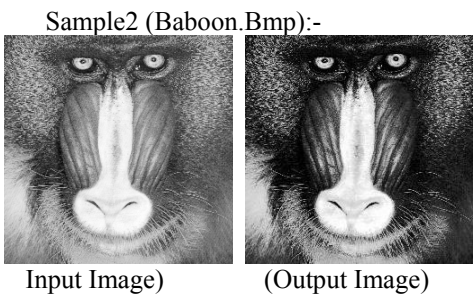
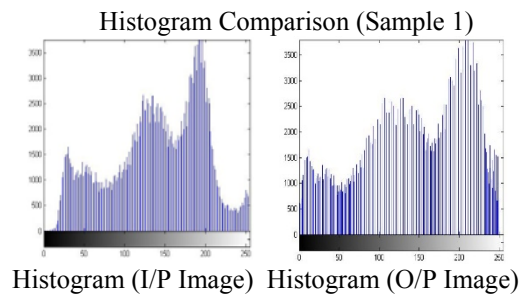
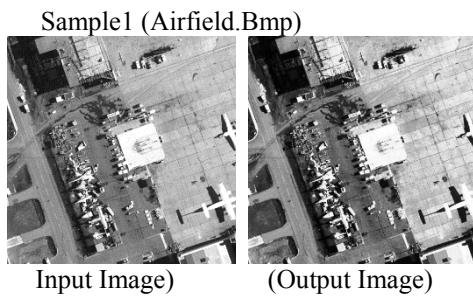


Fig 1: Proposed algorithm

Test Samples (Bhe):-



4. Psnr and Mse Comparison (Histogram & Bi-Histogram)

Image Name	Enhancement Technique	Psnr Values	Mse Values
Airfield.Bmp	HISTOGRAM	10.7596	5.4591e+003
	BIHISTOGRAM	23.6791	278.7244

Image Name	Enhancement Technique	Psnr Values	Mse Values
Baboon.Bmp	HISTOGRAM	8.4457	9.3006e+003
	BIHISTOGRAM	13.2722	3.0610e+003

IMAGE NAME	ENHANCEMENT TECHNIQUE	PSNR VALUES	MSE VALUES
Barbara.bmp	HISTOGRAM	10.1074	6.3437e+003
	BIHISTOGRAM	21.8204	427.6018

5. Conclusion

In this paper we have given the detailed description of histogram-equalization and bi-histogram equalization in the field of image enhancement. Our inferred results in bi-histogram equalization proves very promising and also concludes that the flaws associated with the previous technique have been resolved. The bi-histogram equalization also brought about some appreciable Psnr and Mse values as

compared to histogram-equalization. It also justifies further research for the illumination changes task. In the future works, we may implement more advanced fusion techniques in the bi-histogram equalization for more accurate and better imaging output.




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