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Image Enhancement by Histogram Technique using MATLAB

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Abstract: The idea of this thesis is to enhance the visual quality of an image in order to make it more suitable for various applications. The enhancement is done to improve the brightness of image as well as the contrast to some extent. For this purpose four techniques have been implemented namely Histogram Equalization(HE), Brightness Preserving Bi-Histogram Equalization (BBHE), Non-Parametric Modified Histogram Equalization (NMHE) and Brightness Preserving Dynamic Fuzzy Logic Based Histogram Equalization (BPDFHE) . Some basic image enhancement methods like Thresholding and Gaussian filtering are also implemented and a comparison is made based on different performance measures. Also a review of commonly used enhancement techniques based on histogram modifications is presented in the thesis. The MATLAB software is used to develop a GUI (graphical user interface) which makes it easier for users to improve an image using different techniques. Uncompressed, JPEG, and png images are used in this thesis. The result is based on the comparison of the different techniques and then the best method is suggested based on the comparison.

Keywords: Histogram Equalization(HE), Brightness Preserving Bi-Histogram Equalization (BBHE), Non-parametric Modified Histogram Equalization (NMHE) and Brightness preserving dynamic fuzzy logic based histogram equalization (BPDFHE), GUI (Graphical User Interface)

INTRODUCTION

Image processing was first introduced in late 1960's. During that time it was mainly used in the field of medical sciences. Different techniques in image processing are mainly inspired by two major application areas:-
1. Improvement of visual information for human interpretation.
2. For machine applications.
In the machine vision application the purpose of image processing is not to improve the visual quality of an image but to extract certain features. This thesis central focus is on Image Enhancement. The principal application of this thesis is to improve the visual quality of an image for human perception. Visual images are a very important factor by which we analyse our surroundings. So there is a huge demand for techniques that process the images before they are presented to human eyes and this is where image enhancement plays a major role. Images are processed so that high quality images are available for human interpretation. Generally simple enhancement methods are preffered. These methods transform an input image by either linear or non- linear transformation and produces a new output image having same type of data structure as the input image. In this thesis the enhancement is done in order to improve the brightness of image as well as the contrast to some extent. For this purpose four techniques have been implimented namely Histogram equalization (HE), Brightness preserving bi-histogram equalization (BBHE), Non-parametric modified histogram equalization (NMHE) and Brightness preserving dynamic fuzzy logic based histogram equalization (BPDFHE). All these techniques are based on histogram modifications. The basic idea behind these techniques is quiet simple. Here the input image is sub divided based on different values like mean or median or local maximas etc and then histogram equalization is done seperately on each sub image. Finally all the sub images are combined to give the final output image. For understanding of enhancement, in this work a review of commonly used enhancement techniques based on histogram modifications is also presented. The MATLAB software is used to develop a GUI (graphical user interface) which makes it easier for users to improve an image using different techniques. Uncompressed, JPEG, and png images are used in this thesis. The result is based on the comparison of different techniques.

HISTOGRAM EQUALIZATION (HE)

Histogram Equalization is a widely used method for image enhancement as it is simple and fast as compared to others. What it actually does is it redistributes the histogram of the input image and gives a more uniform histogram or in other words we can say that it redistributes the levels to the entire range of 256 levels. The number of gray levels however changes in the output image as in order to give a more uniform distribution some adjacent levels are grouped together so

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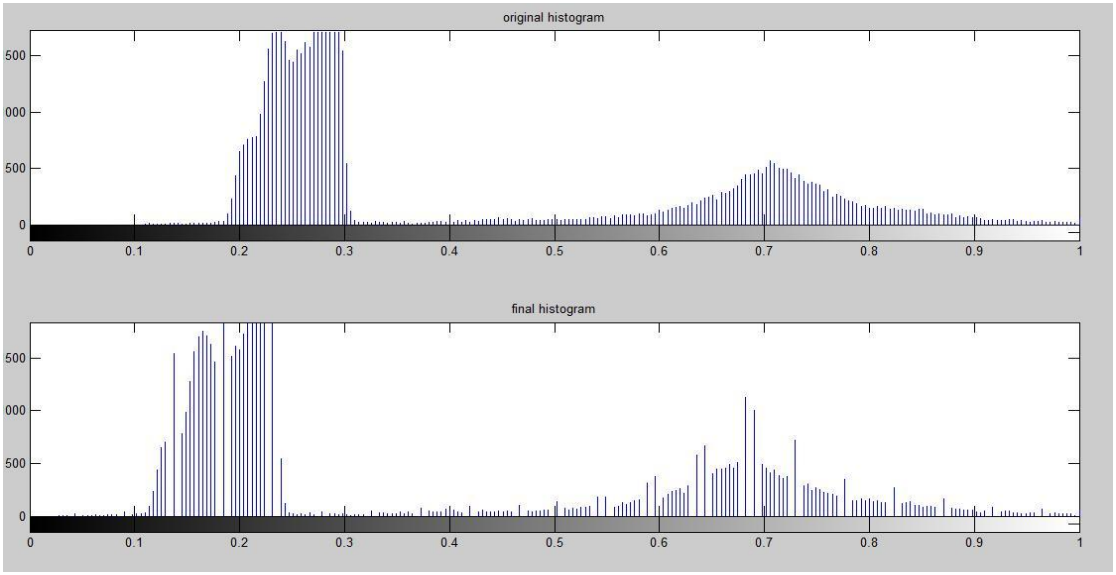
the number of gray levels is lesser as compared to the input image.

HE provides some level of contrast enhancement as the gray levels are pulled far apart and are redistributed over a bigger range thus making it easy to differentiate between areas of image having similar densities. It also helps to preserves brightness of input image on the output image. After histogram equalization the mean of output image is the middle gray level value of the input image thus preserving brightness to some extent. Histogram equalization also have some major drawbacks it causes over enhancement of the images and also results in loss of contrast. However, it is mainly used for brightness preservation and in this thesis we have discussed and implimented different techniques based on histogram equalization which helps in enhancement and also brightness preservation of images.

(a) (b)

Illuatration of HE (a) original image (b) Processed image after HE



Histogram of original image and processed image

DIFFERENT ENHANCEMENT TECHNIQUES

1. Brightness Preserving Bi Histogram Equalisation (BBHE)

BBHE technique[1] was given by Kim. It is based on histogram equalization. In this method an input image is divided into two parts on the basis of the mean value of the gray levels then the histograms of the two sub images is formed.The histogram of first sub image contains gray level values from minimum to the mean value while the other one contains gray level values from mean to the maximum value. These histograms are equalized seperately and the final image is the combination of both the sub images.

2. Equal Area Dualistic Sub-Image Histogram Equalization (DSIHE)

This method was given by Wan.Et.Al. DSIHE[2] divides the input image in two equal parts based on the median of the gray level values. Then the histograms of the two sub images is developed and it is equalized seperately. The output image is the combination of both the sub images. The main idea behind seperating the image based on the median value is firstly

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to obtain sub images of equal area and secondly to obtain maximum Shanon entropy. As we all know that entropy of an image gives the average information content in an image and therefore this technique plays a major role for enhancement of discreet images.

3. Recursive Mean Separate Histogram Equalization (RMSHE)

This technique was given by Chen and Ramli. RMSHE [5] is an extention to the BBHE technique as it also divides the test image into two parts by using the mean value of the gray levels but the difference is that the seperation is done recursively. If the number of recursions is r then it produces 2^r sub images. Then the histograms of the 2^r sub images are generated and they are equalized seperately. Finally all the sun images are combined to form a final output image. This method provides scalable brightness preservation and as the value of r increases the brightness of the output image or the mean value becomes equal to the input brightness value. However to get maximum brightness preservation it the value of r plays a major role. To find the optimum value of r is rather difficult and for this different types of optimization methods are used. The most commonly used method to obtain the optimized value of r is particle swarm optimization.

4. Minimum Mean Brightness Error Bi-HE Method (MMBEBHE)

MMBEBHE technique [3] of image enhancement was developed by Chan and Ramli. It is also based on HE. This method also divides an input image into sub images but here the divison is done on the basis of a pre difined threshold value. The threshold level is so chosen such that it gives the maximum value of the Absolute mean brightness error. Then the image is divided on the basis of the determined threshold and histograms of the two sub images are generated. These histograms are then equalized and finally an output image is produced by combining both the sub images. This technique however gives better results but is very time consuming as the process of finding the threshold value is quiet tiresome.

5. Non-parametric Modified Histogram Equalization (NMHE)

The NMHE technique [9] was given by S.Poddar and it is mainly used for contrast enhancement however it also provides a good amount of brightness preservation. In this method firstly the histogram of an input image is formed and then it is modified according to an already defined histogran which has the features of the original image and also has a uniform distribution. Finally histogram equalization is performed. This method is based on histogram specification and it not only preserves brightness but also presreves the enhancement efforts.

6. Brightness preserving dynamic fuzzy logic based histogram equalization (BPDFHE)

This technique was given by Sheet.et.al [11]. It is based on fuzzy logic here the remapping of gray levels does not take place instead the values in tha valley region between two successive peaks are re distributed. It is implimented by following the steps given below:

1. Fuzzy histogram creation
2. Histogram partition
3. Dynamic histogram equalization
4. Normalization

Table 1: Comparison of different technique

Enhancement Techniques	Advantages	Disadvantages
HE	Simple to impliment and effective	produces unnatural looking images
BBHE	Brightness is preserved to a good extent	Higher degree of brightness preservation is not possible
DSIHE	Provides maximum shanon entropy	Poor contrast enhancement
RMSHE	Provides scalable brightness preservation	Processing time is more
MMBEBHE	Provides good result	Computational complexity is more
NHME	Preserve brightness and also provides contrast enhancement	No specific disadvantage
BPDFHE	Gives good performance for brightness preservation	No specific disadvantage

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RESULTS AND QUANTIATIVE ANALYSIS

1. Different performance measures

The performance of different enhancement techniques is determined by certain quantiative parameters namely absolute mean brightness error (AMBE), Entropy, structure similarity index measure (SSIM) and Mean square error (MSE). Absolute mean brightness error is mainly used to analyse the amount of brightness preservation in an image while entropy is used to analyse the contrast enhancement.

1. Absolute Mean Brightness Error

As the mame suggests it gives the mean brightness error between the input and the output image and thus tells the degree of brightness preservation. The value of AMBE should be high for good quality images.

2. Entropy

It gives rhe amount of randomness in an image and gives information regarding texture of input image. It also gives the average information content of an image. So if the entropy is high of the processed image then it means it has more information content which is desireable.

3. Structured Similarity index

It is used to measure the similarity between the input and the output image.

4. Mean Square Error

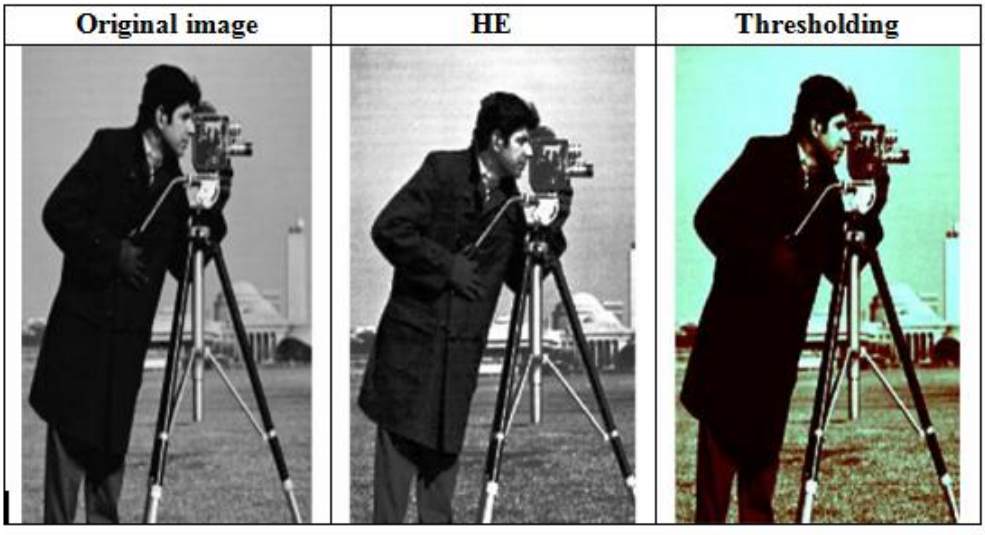
It gives the amount of error between the input and the output image and is usefull when studting compressed images. Lower value of MSE is generally preffered.

2. Results

In this thesis we have shown both the qualitative as well as quantitative results. We have shown results of HE, Thresholding ,BBHE, NMHE and BPDFHE on four different input images namely the girl, beach, cameraman and lena. The quantitative results are tabulated based on the above measures.

2.1 Qualitative results

In this section visual results have been shown. For this purpose four differebt images have been considered and it is observed that different techniques gives different level of enhancement. By visualizing it is seen that NMHE and BPDFHE gives better looking images.



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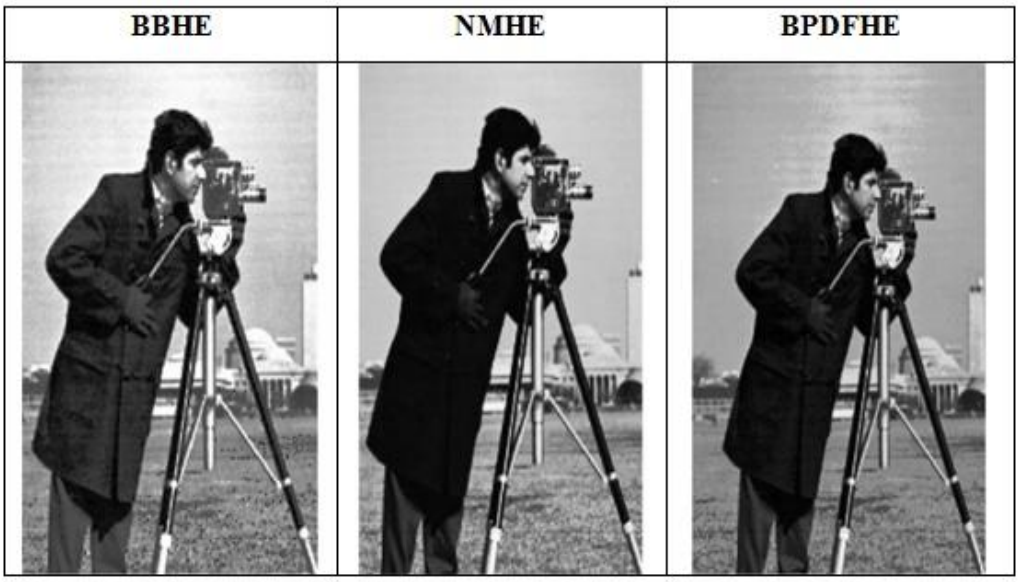

Fig. 1 : Result of different techniques on image of cameraman

2.2. Quantitative analysis

Here the techniques namely Histogram equalization, Brightness preserving bi histogram equalization,Non parametric modified histogram equalization and Brightness preserving dynamic fuzzy logic based histogram equalization are compared quantitatively on the basis of measures like MSE, SSIM, AMBE and Entropy.

Table 2: Analysis of different technique

Image	Enhancement Techniques	AMBE	MSE	Entropy	SSIM
Cameraman	HE	9.37	826.20	5.91	0.82
	Thresholding	9.76	1877.3	6.36	0.85
	BBHE	23.63	1077.0	6.84	0.76
	NMHE	16.61	493.54	6.93	0.95
	BPDFHE	0.087	55.24	6.78	0.93
Beach	HE	9.33	143.1	5.98	0.97
	Thresholding	1.166	29.33	7.66	0.98
	BBHE	0.73	62.58	7.75	0.95
	NMHE	1.34	4.08	7.88	0.99
	BPDFHE	0.20	20.39	7.69	0.98
Lena	HE	13.36	591.4	5.98	0.92
	Thresholding	9.01	1972.7	6.23	0.25

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	BBHE	11.86	623.61	7.50	0.87
	NMHE	7.84	81.24	7.64	0.99
	BPDFHE	0.019	12.58	7.44	0.98
Girl	HE	23.48	1056.2	5.98	0.84
	Thresholding	3.24	81.44	7.22	0.97
	BBHE	9.92	694.3	7.54	0.81
	NMHE	4.52	65.94	7.55	0.99
	BPDFHE	1.62	8.25	7.53	0.98

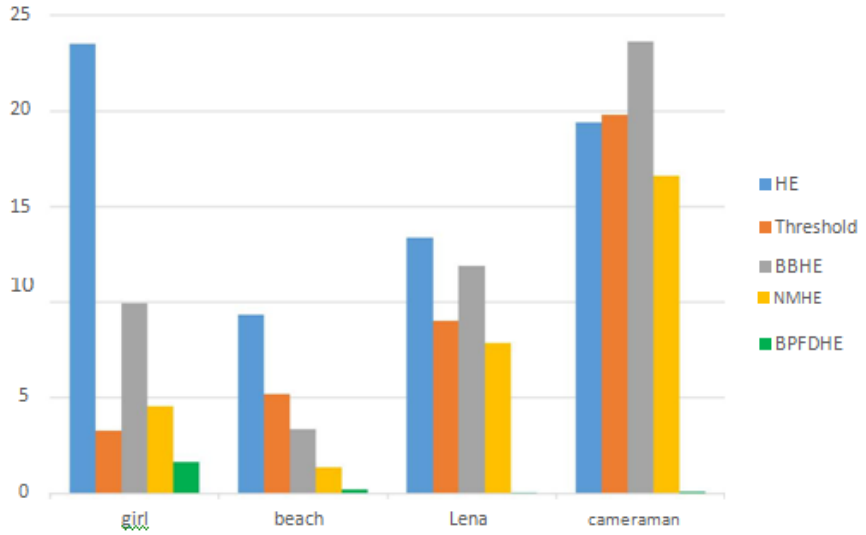

Fig. 2 : AMBE bar graph of image enhancement of various techniques

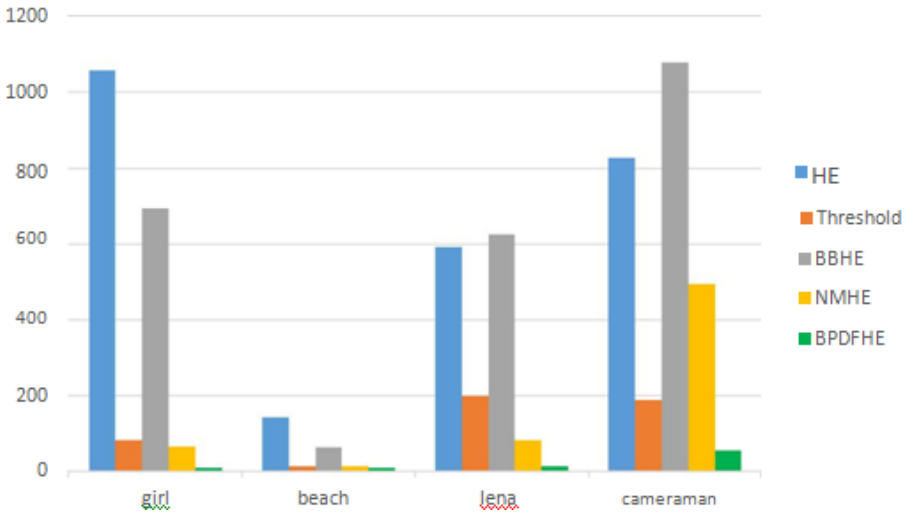

Fig. 3 : MSE bar graph of image enhancement of various techniques

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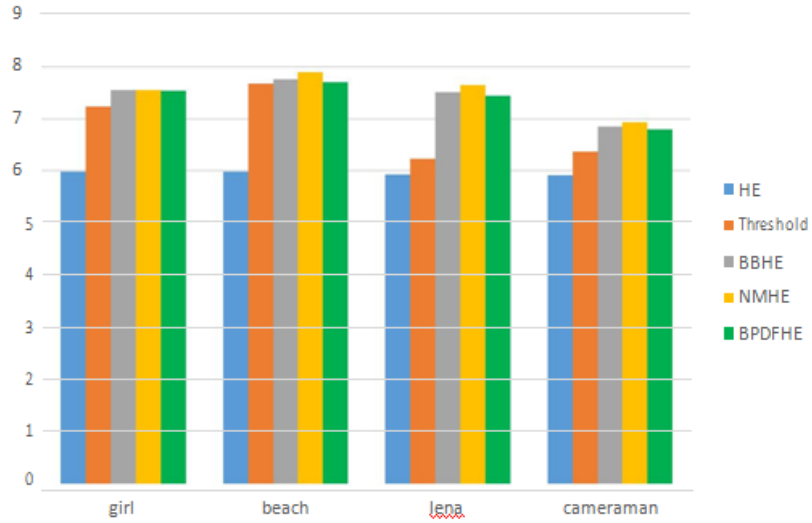

Fig. 4 : Entropy bar graph of image enhancement of various techniques

From the above table and the figures we can show that BPDFHE and NMHE gives lower AMBE value which is a measure of brightness preservation and also lower value of MSE which implies higher PSNR along with high value for entropy which are measures for contrast enhancement. So we can say that these techniques gives better performance than others.

CONCLUSIONS

This thesis primary focus is on enhancement of images. Throughout the thesis we have discussed about different techniques for enhancement and brightness preservation. Some are basic techniques like thresholding, gray level slicing etc and some techniques based on histogram equalization. Our expectation was to find a method that provides lower value of AMBE which tells the degree of brightness preservation and higher value of entropy which tells the degree of contrast enhancement. From experimental results shown in the table 4.1 in chapter 4 we can conclude that thresholding does not give expected results as both the values of AMBE and entropy are not satisfactory and they changes as the threshold values are varied. So this method is not dependable. By visual inspection also it is clear that thresholding does not give proper results. Now coming to histogram equalization technique. It does not solve the mean shift problem and also gives unnatural looking images however this problem is solved by BBHE because of it's partition based enhancement. From the table in chapter 4 we can see that it does provides significant increase in entropy and brightness preservation but the best results are given by NMHE and BPDFHE. These techniques give lower values of AMBE along with lower values of MSE which implies higher value of PSNR. They also give higher values of entropy thus we can conclude that NMHE and BPDFHE outperform other techniques and meets our expectations. Also these techniques give best results through qualitative visual inspection. Thus it is best to conclude that out of all the techniques discussed NMHE and BPDFHE are the best methods both quantitatively and qualitatively for brightness preservation and contrast enhancement.

FUTURE SCOPE

There is enough scope for future work. Future work concerns analysis of more techniques based on histogram manipulations. These techniques can be based on average histogram equalization and fuzzy logic. We can also modify the existing NMHE technique in the future to give more promising results. The modification suggested is as follows: The image can be divided into layers based on the RGB colours and then histogram can be generated for the layers. NMHE should be applied separately to all the layers so that each layer is enhanced separately and finally all the layers should be combined to give the final processed image. We can study and implement another technique based on fuzzy logic called as fuzzy histogram equalization as an extension to the current work. This technique is similar to BPFDHE however here partition of fuzzy histogram is done on the basis of median value of the input image and then equalization of sub images is done.

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