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A Review: Histogram Equalization Algorithms for Image Enhancement using FPGA

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Abstract: Degradation in the captured image quality is a common problem. There are various techniques to enhance the image quality. Some of the techniques used are Contrast Stretching (CS) and Histogram Equalization (HE). These are the basic techniques which don't provide a significant improvement in enhancing image details. So this arises the need of advancement in these basic algorithms. The papers give a review of the several histogram equalization approaches. The paper also gives a comparative study on the results of implementation of the Adaptive histogram equalization (AHE) and Contrast Limited histogram equalization (CLAHE) and Dynamic histogram equalization (DHE) for gray scale images on FPGA. The proposed system describes Contrast Stretching and Dynamic histogram equalization based algorithms for hardware implementation on FPGA for color images.To validate the algorithms on FPGA, the simulation results are given based on visual analysis of the color input and output image.

Keywords: Histogram Equalization (HE), Dynamic Histogram Equalization (DHE), Adaptive histogram equalization (AHE), Contrast Limited histogram equalization (CLAHE) and Field Programmable Gate Array (FPGA).

I. INTRODUCTION

Image Enhancement is one of the major areas of research in image and video processing applications. Images obtained from cameras (infrared, daylight, etc.) over longer distances or under poor visibility conditions, like caused by inclement weather foggy effect, are often not suited for investigation and observation. Only a marginal improvement in the images captured form the camera can be obtained using standard camera settings like contrast, diaphragm, brightnesss and shutter time. To obtain a good and noticeable image quality improvement in long distance captured image for surveillance system becomes difficult.At a same time, the image enhancement technique must be able to increase the data quality very close to original. This can be achieved via effective and efficient image enhancement algorithms. The aim is to improve the image's visual appearance and transform representation of the image for future automated image processing, such as for analyzing, detecting, segmenting and recognizing [1].Image enhancement problem can be formulated as: given an input image of low quality and the output image of high quality for certain applications.

Contrast stretching and Histogram Equalization are commonly used technique for image enhancement in the field of removal of noise, contrast enhancement and edge enhancement. Among these contrast enhancement is a popular one. In this technique, contrast of an image is improved such that the image becomes better for human vision. The term contrast is nothing but the separation of dark and bright which are areas present in the image. Histogram equalization (HE) is one of the most common contrast enhancement methods. In case of contrast enhancement.Histogram equalization (HE) is a widely used technique because it is simple to use and better in performance on almost all types of images. HE works by first flattening the histogram of the original input image.

It stretches the dynamic range of gray levels by using the cumulative density function (CDF) of the image [2].

The main objective of the paper is to describe different Image Enhancement techniques based on Histogram Equalization algorithms. Also, another objective of the paper to give a comparison of the FPGA implemented Histogram Equalization algorithms. The paper also describes an overview of the proposed system for color image enhancement based on FPGA.

This paper is organized in six parts: A brief description of the Histogram Equalization methods is given in Section II, Section III gives a comparison of the hardware based HEalgorithms, the proposed system is given in Section IV, Section V shows the simulation results of the proposed system, and Section VI gives the conclusion of the paper.

II. HISTOGRAM EQUALIZATION METHODS

A review some of the existing HE approaches is discussed in this section. Here we discuss about GHE, LHE, DHS and DHE methods.

Basically, HE methods can be classified in two categories viz., Global and Local Histogram Equalization [2].

A. Global Histogram Equalization (GHE)

For a discrete gray scale image I(x,y) is constituted form the dynamic range of the gray scale values in the range form $[0, L_e - 1]$ levels. n_x be the number of occurrences of gray level x. Then the function $P_i(x)$ is defined as,

$$P(x)=\frac{n_x}{n} \quad (1)$$

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where $0 \le x \le L_e - 1$

The function $P_i(x)$ is the probability of occurrence of a pixel of level x in the input image i.e., Probability Density Function. Leis the total no of gray levels in the image. Typically gray levels are 256 i.e., 0 to 255. n is the total no of pixels in the image.

Now, Cumulative Density Function (CDF) is calculated based on PDF.

$$\text{Cdf}(x) = \sum_{x=0}^{m} Pi\,(x) = \sum_{x=0}^{m} \frac{n_x}{n} \qquad (2)$$

wherem=0, 1, 2…, $L_e - 1$

CDF needs to be found to do intensity mapping i.e., to get an equalized histogram. Therefore,

$$\text{Cdf}(x) = q_m \qquad (3)$$

where $0 \le q_m \le 1$

Here q_m can easily be mapped to dynamic range [0, L_e-1] multiplying it with (0, L_e-1). This mapping is Histogram Linearization or Global Histogram Equalization [2].

B. Local Histogram Equalization (LHE)

Although the global methods perform good overall contrast enhancement, but they do not enhance local areas of the image. This problem can be overcome by using local enhancement techniques [1].

Adaptive Histogram Equalization (AHE) works such that it does the transformation of each pixel using a transformation function derived from a neighboring region. The transformation function is proportional to the Cumulative Density Function of the pixel values.AHE improves the local contrast of an image but this method increases the noise level. Another variant of LHE is Contrast Limited Histogram Equalization (CLAHE). CLAHE is different from the AHE in the case of contrast limiting. For CLAHE a transformation function is derived from each neighbouring pixels. Now to this, on then neighboring pixels the contrast limiting procedure is applied. Thus CLAHE provides limiting on the amplification by clipping the histogram at a predefined values. This clipping is done before the CDF calculation. This limits the slope of CDF.This lessens the level of noise in AHE by enhancing the brightness to a certain range and hence facilitates the comparison of the different areas of an image [2].

C. Local Histogram Specification (HS)

A specified histogram which achieves highlighted gray levels can be achieved by applying Histogram Specification [3]. This means, to perform Histogram Specification (HS) the GHE is performed first. The gray levels are remapped to the existing gray levels in specified histogram. The transformation function for q_m is same as in Global Histogram Equalization i.e., (1)

$$b_m = cdf^{-1}(q_m) \qquad (4)$$

wherem=0,1,2…,$L_e - 1$

And b_m is the desired level (i.e., the mapping of the input gray level x) which is found from (4).

D. Dynamic Histogram Specification (DHS)

This approach is more complex than the Histogram Specification. In this method, it selects some critical points (CP) from the image histogram, then it creates specified histogram. Then histogram equalization is applied on the image based on the generated Specified Histogram. Dynamic Histogram Specification does enhancement of the image keeping some histogram characteristics of the image preserved. Since this specified histogram is created from the original input image histogram. This method doesn't change the overall contrast of the image but causes artifacts in the image like white pixels.

E. Dynamic Histogram Equalization (DHE)

This method does the dividing of the original histogram into numbers of sub-histograms. It continues to do this until it ensures that no dominating portion is present in any of the newly created sub-histogram.After this a dynamic gray level is defined for each sub-histogram. Then to this sub-histogram its gray levels are mapped by histogram equalization. This all is performed by distributing the total available dynamic range in the input image Cumulative Frequency Distribution (CDF) of the histogram values. Now for each sub-histogram a separate transformation function is calculated. This transformation function is calculated based on the traditional histogram method. And after this the gray levels are remapped to theoutput image accordingly. The advantage of this method is that the small features of the input image doesn't get dominated, washed out Also this method provides moderate contrast enhancement of the each portion of the whole image [1].

III.COMPARATIVE STUDY OF HARDWARE IMPLEMENTATION OF HE TECHNIQUES ON FPGA

The AHE [4] and CLAHE [5] both are the approaches for real time processing of the Histogram Equalization using FPGA. These systems worked on HD images (1920 x 1080 pixels). The Computational complexity of AHE is high but this generates smooth enhanced images. The output images are computed without interpolation. Whereas in case of CLAHE,it also has higher computational complexity. But the amount of the over-amplifying noise gets significantly reduced as compared to that in AHE.

The DHE [1] based approach describes the Contrast Stretching and Histogram Equalization algorithms for contrast enhancement for images captured from a long distance. This approach also uses FPGA. This approach works on DHE based methods like local and global methods. The use of DHE produces better results for visual analysis as well as reduces resource utilization in case of FPGA. Operating frequency is low in case of this approach as compared to that in case of AHE and CLAHE.

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The table below summarizes the resource utilization of FPGA in case of AHE, CLAHE and DHE based approaches. Out of these, the minimum number of resources are consumed by the DHE based FPGA implementation methods. And this approach also uses minimum frequency as compared to other methods.

TABLE I SIZE OF THE CIRCUITS

FPGA RESOURCES	METHODS		
	AHE[4]	**CLAHE[5]**	**DHE based method [6]**
LUTs	36123	43915	3568
Block RAMs	67%	67%	34%
Operational Frequency	209.4MHz	209.4MHz	39.4MHz

IV. THE PROPOSED SYSTEM

The implementing process proposes image enhancement algorithms to recover the degraded image for color images using FPGA. Image enhancement is such, to obtain a significant image quality improvement in long distance captured image for surveillance system with minimum time and less utilization of resources [6]. Fig. 1 shows the block diagram of the proposed system.

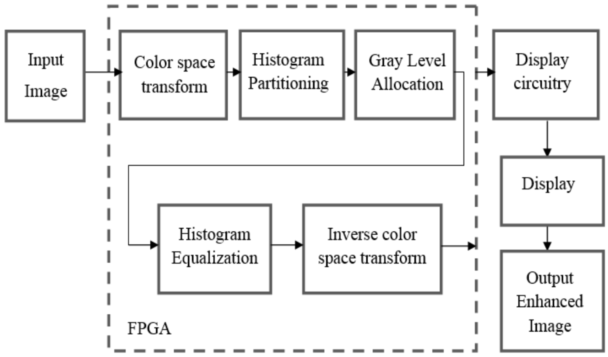

Fig.1 The proposed System

The parts implemented in the FPGA are shown in dotted block. The hardware implementation for the complete design will be developed using VHDL. As shown in figure 1 image will be stored in FPGA memory taken from a data set. Then the image enhancement algorithms will be applied. The different variants of the histogram equalization such local and global histogram equalization based on dynamic histogram equalization will be developed using VHDL. This code will be applied using FPGA. Output image along with input image will be displayed on VGA monitor. The proposed system will be first coded in the MATLAB and then using VHDL code which will be will be dumped in FPGA. Also a comparisons of the previously used algorithms will be shown using MATLAB.

V. SIMULATION RESULTS

As the aim of the system is to generate enhanced image for the input image, the validity of proposed algorithm is tested by simulating the estimated result before actually implementing the algorithm on the hardware.The software implementation results of proposed algorithm by using MATLAB are given as below.Fig. 2 and Fig. 3 shows the input test image of office image and input test image of outdoor image, histogram of gray scale image of input image, equalized histogramand enhanced output image. Image enhancement results are obtained by running the MATLAB code which is based method of DHE of histogram equalization. The input image is in .jpg format.

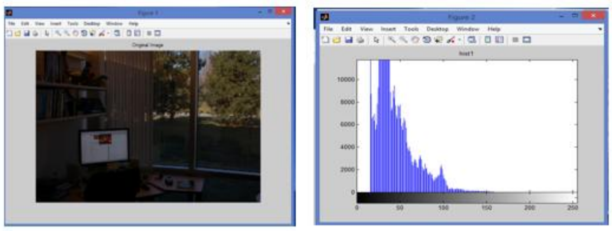

Fig.2.1a) Input Image of office and its Histogram

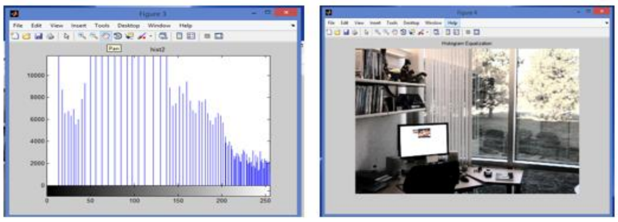

Fig.2. 2 b) Equalized Histogram and Output Image

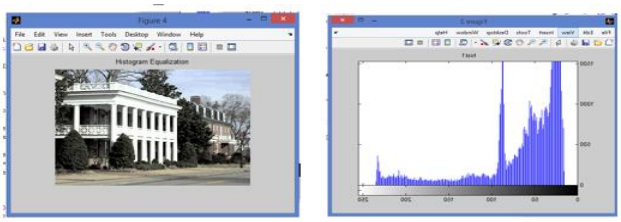

Fig.3.1a) Input Outdoor Image and its Histogram

VI. CONCLUSION

In this paper a survey of Histogram Equalization variants is presented. The HE, GHE, LHE, HS, DHS and DHE methods were explained. The advantages and disadvantages of this method are also mentioned, such that DHE approach doesn't allow the small features of the input image get dominated washed out. And this method provides moderate contrast enhancement of the each portion of the whole image. A comparison of the hardware implementation of the AHE, CLAHE and DHE algorithms for gray scale images on FPGA is shown. The paper also gives an overview of the proposed system based on applying image enhancement algorithms for color images on FPGA using VHDL code. The paper also gives the software results based on MATLAB of the Image Enhancement algorithm before actually implementing it

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on FPGA. MATLAB results show a significant and smooth image enhancement on the output image as compared to the input image.

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REFERENCES

[1] M. Abdullah-Al-Wadud, M. H. Kabir, M.A.A Dewan. And Oksam Chae, "A Dynamic Histogram Equalisation for Image Contrast Enhancement," IEEE Transactions on Consumer Electronics, vol. 53, no. 2, pp.593-600, May 2007.

[2] R. C. Gonzalez, R. E. Woods, Digital image processing. 2nd ed. Reading, MA. Addison-Wesley, 1992, pp. 85-103.

[3] C.-C. Sun, S.-J. Ruan, M.-C. Shie, and T. -W. Pai, "Dynamic contrast enhancement based on histogram specification," IEEE Transactions on Consumer Electronics, Vol. 51, No. 4, pp. 1300–1305, 2005

[4] K. Kokufuta, and T. Maruyama, "Real-time processing of local contrast enhancement for real time processing of adaptive histogram equalization using FPGA", pp.288-293, 2009.

[5] K. Kokufuta, and T. Maruyama, "Real-time processing of contrast limited adaptive histogram equalization on FPGA", Proc. of International Conference on Field Programmable Logic and Applications, pp.155-158, Aug. 31 2010-Sept. 2 2010.

[6] Manvendra Singh, ManojPurohit, Sudhir Khare and Brajesh Kumar Kaushik, "FPGA based Implementation of Real Time Image Enhancement Algorithms for Electro-Optical Surveillance Systems" 12th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 24-27 June 2015.