IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 10, October 2016

Contrast Enhancement Using Optimal Threshold Histogram Equalization

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Abstract: Image enhancement is one of the challenging issues in image processing concept. Contrast enhancement techniques are used for improving visual quality of low contrast images. Contrast enhancement plays a fundamental role in image/video processing. Histogram Equalization (HE) is one of the most commonly used methods for image contrast enhancement. However, HE and most other contrast enhancement methods may produce unnatural looking images. The images obtained by these methods are not suitable to use in applications such as consumer electronic products where brightness preservation is necessary to avoid annoying artifacts. To solve such problems, we proposed a novel and efficient contrast enhancement method based on genetic algorithm in this paper. This algorithm is fast and very less time consuming as compared to other techniques such as global histogram equalization by taking CDF and finding out the transfer function. Here in our work we are going to enhance images using histogram equalization of images by reconfiguring their pixel spacing using optimization through GA (Genetic algorithm). We will get more optimized results with the use of GA with respect to other optimization techniques.

Keywords: Contrast Enhancement, Foreground Enhancement, Genetic Algorithm, Histogram Equalization, Cumulative Density Function.

I. INTRODUCTION

The global histogram equalization (HE) has been the most frequently adopted image contrast enhancement technique. A brightness and detail-preserving HE method with good contrast enhancement effect has been a goal of much recent research in HE. Digital image enhancement is one of the most important image processing technology which is necessary to improve the visual appearance of the image or to provide a better transform representation for future automated image processing such as image analysis, detection, segmentation and recognition.

Y.-T. Kim [1] developed a method for contrast enhancement using brightness preserving bi-histogram equalization. Similar method for image contrast enhancement is developed by Y. W. Qian [2]. A block overlapped histogram equalization system for enhancing contrast of image is developed by T. K. Kim [3]. Other histogram based methods [4]-[6] etc. are also developed. V. Buzuloiu et al. [7] proposed an image adaptive neighborhood histogram equalization method, and S. K. Naik et al. [8] developed a hue preserving color image enhancement method without having gamut problem. Li Tao and V. K. Asari [9] presented an integrated neighborhood dependent approach for nonlinear enhancement (AINDANE) of color images.

Image contrast enhancement techniques are of particular interest in photography, satellite imagery, medical applications and display devices. Producing visually natural is required for many important areas such as vision, remote sensing, dynamic scene analysis, autonomous navigation, and biomedical image analysis.

II. HISTOGRAM EQUALIZATION

Histogram equalization stretches the histogram across the entire spectrum of pixels (0 –255). Histogram equalization is one of the operations that can be applied to obtain new images based on histogram specification or modification. It is a contrast enhancement technique with the objective to obtain a new enhanced image with a uniform histogram.

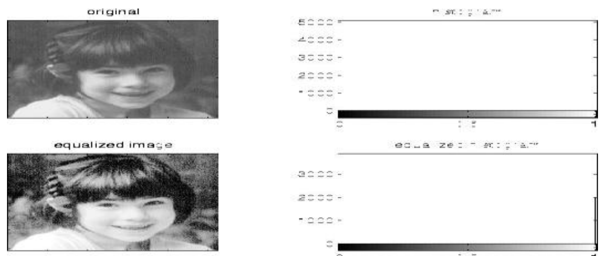

Fig 1. Image Enhancement using Histogram Equalization

A histogram simply plots the frequency at which each grey-level occurs from 0 (black) to 255 (white). Histogram represents the frequency of occurrence of all gray-level in the image, that means it tell us how the values of individual pixel in an image are distributed.

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III. METHOD ANALYSIS

In [10], a modified approach an Otsu‟s method is proposed to reduce the processing time involved in otsu‟s threshold computation by performing multi-level thresholding. Y. T. Kim proposed a Contrast Enhancement scheme using Brightness Preserving Bi-histogram Equalization (BBHE) [11], [12]. BBHE separates the input image histogram into two parts based on input mean. After separation, each part is equalized independently. This technique tries to overcome the brightness preservation problem. In [13] a method based on recursive mean separation to provide scalable brightness preservation is proposed. In [14] a fast algorithm for computing two dimensional Otsu„s threshold is proposed. Another framework for contrast enhancement based on histogram modification is proposed in [15]. HE is an effective technique to transform a narrow histogram by spreading the gray-level clusters over a dynamic range. It produces images with mean intensity that is approximately in the middle of the dynamic range because it equalizes the whole image as such. In conventional contrast enhancement methods, the image content of both the foreground and background details are held together in performing the histogram equalization process. These global contrast enhancement techniques produce undesirable effects on the visual quality of the image. Hence a new method was introduced which enhances the image using Bi-histogram Equalization, performed using mean of the objects and the background. This method not only preserves brightness but also improves the visual quality of the image.

Here we propose a modified approach through image Segmentation [16] by means of opening by reconstruction. After that object based histogram equalization is proposed. After extracting the segmented image using opening by reconstruction, the mean of each individual foreground object is calculated as

$$c_i = \sum_{j=1}^{m} o_j$$

Where „c_i" is the mean of object „i" and i=1 to n where „n" is the number of objects. Then the obtained mean values are averaged as m1.

$$m1 = \frac{1}{n}\sum_{i=1}^{n} c_i$$

Similarly the mean of the background pixels is calculated as m2. Finally the mean values m1 and m2 are averaged as m. This mean „m" is further used as a threshold in bi-histogram Equalization. Bi-Histogram Equalization can be used to enhance the low contrast image and it divides the gray level of the image into two sub-levels based on the threshold that is obtained and equalizes each sub-level independently. This process is represented in the flow diagram below:

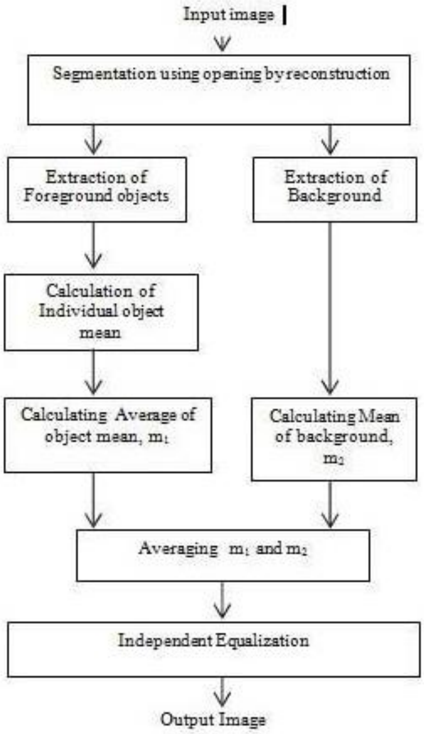

Fig 2 Flow diag. for separation of foreground and background of the image

IV. PROPOSED SCHEME

A. Genetic Algorithm:

Genetic Algorithm involves various processes as under:

- Random Initialization (Parent Chromosomes): Initially many individual solutions are (usually) randomly generated to form an initial population. The population size depends on the nature of the problem, but typically contains several hundreds or thousands of possible solutions. Traditionally, the population is generated randomly, allowing the entire range of possible solutions (the search space).
- Mutation (formation of child chromosomes): In mutation process, child chromosomes are formed by changing a value from each group of parent chromosome and calculating the fitness value of each group.
- Selection: During each successive generation, a proportion of the existing population is selected to breed a new generation. Individual solutions are selected through a fitness-based process. The fitness function is defined over the genetic representation and measures the quality of the represented solution. The fitness function is always problem dependent.
- Sorting: After selection process, the groups are sorted in ascending order of the values of fitness function obtained in the selection process.
- Elimination: in elimination process, the worst groups (which have higher value of fitness function) are replaced with the best groups (which have least value of fitness function).

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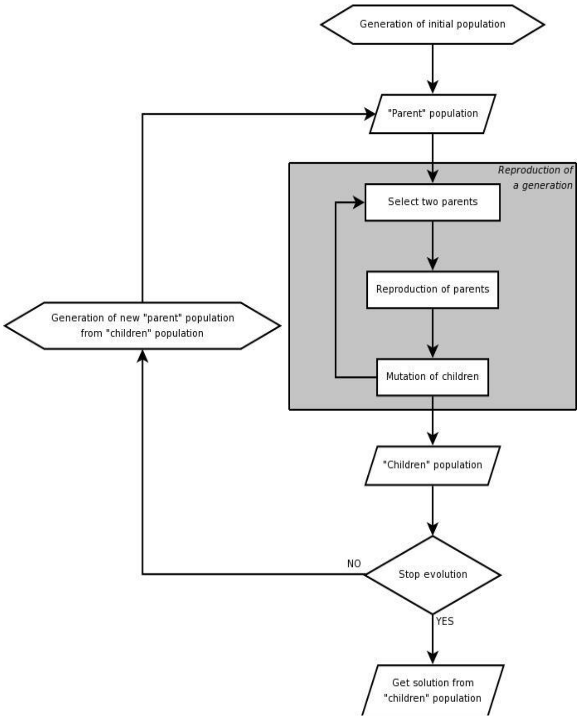

Fig 3 Flow Diag. for Genetic Algorithm

Now, a new generation is formed. These processes ultimately result in the next generation population of chromosomes that is different from the initial generation. Generally the average fitness will increase by this procedure for the population, since only the best organisms from the first generation are selected for breeding, along with a small proportion of less fit solutions. This generational process is repeated until a termination condition has been reached.

B. Calculation of PSNR:

PSNR is most easily defined via the mean squared error (MSE). PSNR between two images can be expressed in equation:

PSNR $= 20 \log \left[\frac{L-1}{\sqrt{MSE}}\right]$

where ‘L-1’ is the maximum gray level in the image.

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(R_{ij} - I_{ij})^2$$

Where R_{ij} is the enhanced image and I_{ij} is the original image and M,N are the dimensions of the images.

C. Calculation of Tenengrad:

The tenengrad of the image is calculated as:
Where

$$G_h = \sum_{i=1}^{M}\sum_{j=1}^{N} G_{i,j}$$

$$G_{i,j} = \sqrt{(G_x^2 + G_y^2)}$$

where „Gx’ is the horizontal gradient of the image and Gy’ is the vertical gradient of the image.

D. Calculation of Contrast:

The contrast in a particular 3×3 window of pixels x1, x2, x3, x4, x5, x6, x7, x8, x9 where x5 is the pixel to be replaced, is calculated based on the joint occurrence of Local Binary Pattern and Contrast as follows:

$$C(x_5) = \left(\frac{1}{n}\right)\sum_{m=1}^{n} x_m - \left(\frac{1}{9-n}\right)\sum_{k=1}^{9-n} x_k$$

x_k x_5

Where $x_m > x_5$ for m=1 to n and < for k=1 to (9-n)

V. EXPERIMENTAL RESULTS

The proposed algorithm is tested for various images having the size of 256 x 256. Gray scale images are used for experimentation. The proposed method is compared with the various conventional histogram equalization methods. The following images, “hands.jpg”, “boy.jpg”, “couple.jpg” images are used to verify the performance of the proposed algorithm.

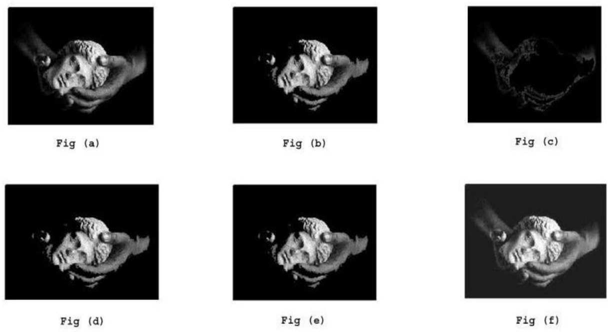

Fig. 4

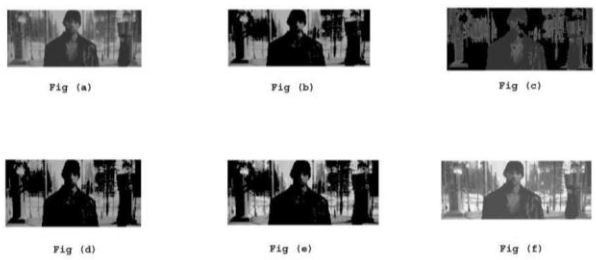

Fig. 5

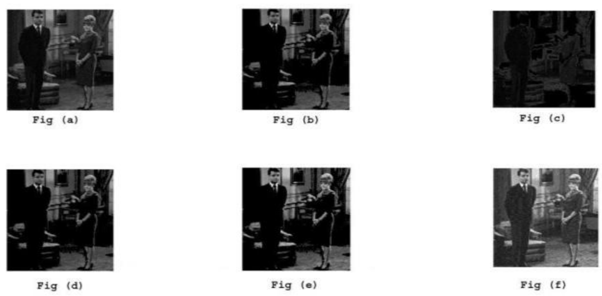

Fig. 6

Fig4, 5, 6 a) Original Image, **b)** Foreground **c)** Background, **d)** Foreground after quantization, **e)**

Foreground after Reallocation of Pixel levels, **f)** Proposed
To demonstrate the performance of the proposed method, PSNR, tenengrad and contrast are used to compare the results of the proposed method and the conventional methods.
This is illustrated in the following table:

The parameter measures in the above table reveal that the proposed method of all given images, generate better results, than the conventional methods. Hence, Genetic algorithm not only computes faster than other methods but also generates better results than the other methods used in the past.

Table I. Parameter Measures

Boy Image	PSNR	Tenengrad	Contrast	Hands Image	PSNR	Tenengrad	Contrast
Original Image		380702	10.4067	Original Image		181533	8.7383
DSIHE	18.9265	384866	10.7824	DSIHE	18.0401	105627	11.0626
MMBBHE	15.2255	663101	11.9595	MMBBHE	21.6635	203726	9.3951
MPHE	21.0029	408213	10.7748	MPHE	28.4239	132225	8.7229
RMSHE	23.1784	385903	10.9204	RMSHE	30.0502	196018	9.1472
BBHE	19.3076	382840	10.7303	BBHE	20.0156	321606	9.514
Using Segmentation	25.8152	485089	12.7874	Using Segmentation	32.4353	342229	13.44
Proposed Method	46.3804	522421	89.0449	Proposed Method	38.3434	360854	59.3171
Couple Image							
Original Image		215723	11.0209				
DSIHE	16.7246	1140386	14.8277				
MMBBHE	23.4913	415597	11.6169				
MPHE	18.041	915332	13.639				
RMSHE	21.9149	622673	12.8265				
BBHE	15.929	1696442	16.2763				
Using Segmentation	28.9848	2307862	19.77				
Proposed Method	44.3184	811264	109.5837				

VI. DISCUSSION ANALYSIS

In the present scenario it can easily be understood the need of Enhancing Images. Whether it"s a visual for a designer, an artist: who wants a distorted and ugly image? Even a viewer of Cricket Match back at his home, or a movie enthusiast in a theatre wants lovely looking images. In literature many algorithms are proposed for image enhancement. In literature most common algorithm is is swarm optimization. But it has disadvantages such as

- The method easily suffers from the partial optimism, which causes the less exact at the regulation of its speed and the direction.
- The method cannot work out the problems of scattering and optimization.
- The method cannot work out the problems of non-coordinate system, such as the solution to the energy field and the moving rules of the particles in the energy field.

Hence to overcome all these problems, Genetic Algorithm is being used in this case. The aim of this dissertation is to use the fast optimization technique for enhancement of images so as to reduce the processing time and get effective and accurate results.

VII. CONCLUSION

In this paper, an efficient algorithm based on object mean is implemented. The brightness of the image is preserved by using BBHE based histogram equalization. Here in our work we are going to enhance images using histogram equalization of images by reconfiguring there pixel spacing using optimization through GA (Genetic algorithm). We get more optimized results with the use of GA with respect to other optimized techniques.

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