Problems of Intensity Transformation Methods and Selecting Appropriate Histogram Technique

D. P. Sharma, Dr. N. Chandra Sekhar Reddy, Prof. A. Praveen, Prof. Uma Shankar

***Abstract*— Image transformation methods in the category of spatial domain are based on direct manipulation of pixels of an image. The spatial domain processing has two distinct categories: Intensity transformation and Spatial filtering. The Histogram method falls within the category of Intensity transformation.**

Histograms are the base techniques for a number of spatial domain processing techniques. Histogram can be used effectively for image quality enhancement. In addition to providing image statistics, the information inherent in the histogram is also quiet useful in other image processing applications, such as image compression and segmentation. Histograms are also simple in manipulation as well as economic for hardware implementations, thus making it a useful tool for image processing.

However, it is noteworthy that all the histogram methods are not so effective for image transformation, thus we need to choose the most effective method for specific purpose.

The present study shows - how much it is effective to use Histogram Equalization method for image transformation, its problems and the way-out in terms of an advance Histogram Equalization (Contrast Limited Adaptive Histogram Equalization -CLAHE) method. The study is also followed by restricted number of experiments to prove its theme.

***Index Terms*— Histogram Equalization, Contrast Limited Adaptive Histogram, /Intensity Transformation, Colour transformation.**

I. Introduction

Considering Intensity transformation the histogram equalization used for grey scale image contrast enhancement is a well-known technique in the literature of image processing. Given a grey scale image I with grey levels in the range [0, L-1], its normalized histogram is a discrete function H(l)=nl/n, where the l is the lth grey level, nl is the frequency of occurrence of the corresponding grey level and n is the total pixel population in the image. Histogram equalization can be achieved by using a Cumulative Distribution Function (CDF), and its discrete version is as follows:

Manuscript received Feb. 02, 2014.

D. P. Sharma, M. Tech., Final, CSE Dept. JNTUH, Hyderabad 500043.
Dr. N. Chandra Sekhar Reddy, Professor, CSE Department, Institute of Aeronautical Engineering, Hyderabad 500043.
Prof. A. Praveen, Professor,CSE&IT Department, IARE, Hyderabad 500043.
Prof. Uma Shankar, Professor, CSE Department, IARE, Hyderabad 500043.

$$S_l = T(l) = (L-1)\sum_{j=0}^{l} H(j) = (L-1)\sum_{j=0}^{l} \frac{n_j}{n} \quad \text{.........(1)}$$

The equation uniformly distributes the pixel population of an image to all the available grey levels of visualization devices, and thus maximizing the contrast. With the rapid development of colour media,

the requirement for enhancing colour image has become more and more demanding. Histogram equalization, originally designed for grey scale images has been extended to enhance colour.

II. The Literature Survey - Problems of Intensity Transformation Methods

While considering the intensity transformation by applying Histogram method, we have following difficulties:

A. Less image clarity (i.e., the clarity is not to its fullest intensity)

B. Unequal contrast projection.

Ordinary histogram equalization uses the same transformation derived from the image histogram to transform all pixels. This goes well when the distribution of pixel values is similar throughout the image. However, under generalized shade, that is, when the image contains regions that are significantly lighter or darker than most of the image, the contrast in those regions will not be sufficiently enhanced.

Thus, we can consider step ahead by applying the Adaptive Histogram Equalization method to improve the contrast. Here we encounter the following new set of problems:

The prominent characteristic of adaptive method is that it computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. It is therefore suitable for improving the local contrast of an image and bringing out more details of the image. However, AHE has a tendency to over-amplify noise (that is, the random fluctuation of image signals) in relatively homogeneous regions of an image.

Figure 1 (a) An unequalized image

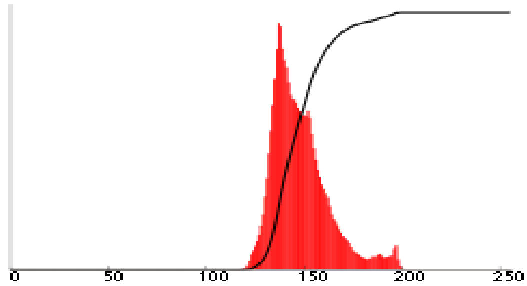

Figure 1 (b) Corresponding histogram (red) and cumulative histogram (black)

Figure 2 (a) The same image after histogram equalization

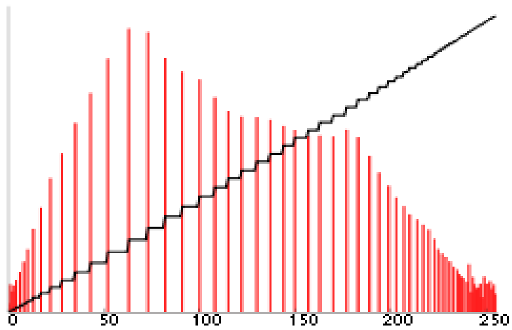

Figure 2 (a) Corresponding histogram (red) and cumulative histogram (black)

Simple Filtering

Figure 3 (a) Step 1 Filtering

Figure 3 (b) Step 2 Filtering

III. Selecting the Appropriate Histogram Method

A variant of adaptive histogram equalization called *contrast limited adaptive histogram equalization* (CLAHE) prevents the problems of over-amplification of AHE (Adaptive Histogram Equalization) method by limiting the amplification.

Thus, the application of Contrast Limited Adaptive Histogram Equalization (CLAHE) is found to be more suitable alternative as it fulfills all the following objectives:

i. Image clarity (i.e., the clarity is to its fullest intensity),
ii. Equalizing the contrast projection, and
iii. prevents over-amplification of noise signals by limiting the amplification

The Contrast Limited Adaptive Histogram Equalization (CLAHE) differs from ordinary adaptive histogram equalization in its contrast limiting aspect. This feature can also be applied to global histogram equalization, giving rise to contrast limited histogram equalization (CLHE), which is rarely used in practice. In the case of CLAHE, the contrast limiting procedure has to be applied for each neighbourhood from which a transformation function is derived. CLAHE was developed to prevent the over amplification of noise that adaptive histogram equalization can give rise to.

Thus, it is achieved by limiting the contrast enhancement of AHE method. The contrast amplification in vicinity of a given pixel value is given by the slope of the transformation function. This is proportional to the slope of the neighbourhood *cumulative distribution function* (CDF) and therefore to the value of the histogram at that pixel value. CLAHE limits the amplification by clipping the histogram at a predefined value before computing the CDF. This limits the slope of the CDF and therefore of the transformation function. The value at which the histogram is clipped, the so-called clip limit, depends on the normalization of the histogram and thereby on the size of the neighbourhood region. Common values limit the resulting amplification to between 3 and 4 times the histogram mean value.

It is to note that, it is always advantageous not to discard the part of the histogram that exceeds the clip limit but to redistribute it equally among all histogram bins.

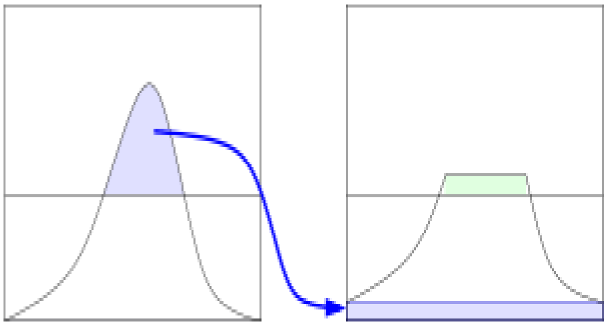

Figure 4 Redistributed Histogram

The redistribution will push some bins over the clip limit again (region shaded green in the figure), resulting in an effective clip limit that is larger than the prescribed limit and the exact value of which depends on the image. If this is undesirable, the redistribution procedure can be repeated recursively until the excess is negligible.

To perform the Contrast Limited AHE, let us device a balanced algorithm that can present a true picture of the Contrast Limited Adaptive Histogram Equalization (CLAHE).

Algorithm:

1. Read the image,
2. Convert indexed image to true-color (RGB) format,
3. Convert image to L*a*b* color space,
4. Scale values to range from 0 to 1,
5. Perform CLAHE,
6. Convert back to RGB color space,
7. Display the results,

The result of Contrast Limited Adaptive Histogram Equalization obtained from R2013a version of MatLab.

a) CLAHE result on black and white image:

Figure 5(a) Image before applying CLAHE

Figure 5(b) Image after applying CLAHE

b) CLAHE result on colour image:

Figure 6 (a) Image before applying CLAHE

Figure 6(b) Image after applying CLAHE

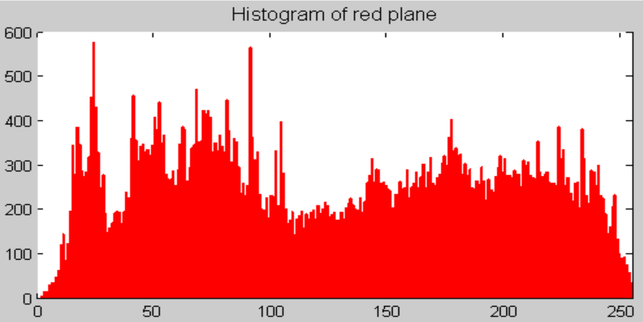

Figure 7 (a) Histogram of Figure 7 (a)

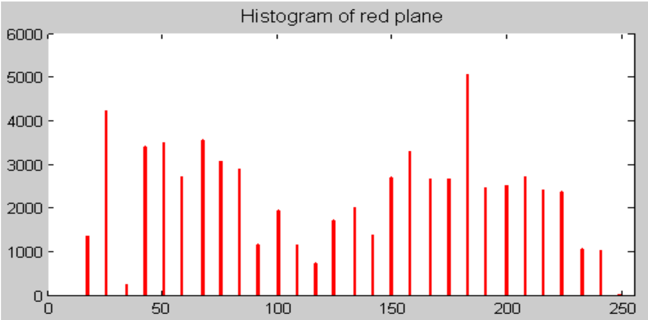

Figure7 (b) Histogram of Figure 7 (b)

IV. Findings of Experiments

There are interesting findings of application of Contrast Limited Adaptive Histogram Equalization on the given image. It shows that:

A. Details of the image are exposed out.

B. Proper equalizing of contrast projection is found, and

C. over-amplification of noise signals is prevented by limiting the amplification (i.e., the even distribution of amplification effect)

These features of the CLAHE method makes it appropriate for its uses in intensity transformation of images overcoming all shortcomings of the previous methods.

V. Future Scope

The present work can be extended further in the field of medical diagnosis through coloured imaging, which is expected to help in the direction of diagnosis of ailments on the basis of comparative study of colour of organ under investigation versus lesion. It may also be used in the field of qualitative recovery of images on the basis of colour reformation.

VI. Conclusion

Entire experiment suggests that the Contrast Limited Adaptive Histogram Equalization method is far more appropriate in favour of –

A. Image clarity (i.e., the clarity is to its maximum intensity),

B. Equalization of the contrast projection is found to a significant level, and

C. Over-amplification of noise signals is prevented by limiting the amplification.

It can, therefore, be used for medical imaging and diagnostics with lesser or absolutely no errors getting a better visual quality of images. Though the result of Contrast Limited Adaptive Histogram Equalization (CLAHE) is found to be comparatively better in terms of monochromic images, yet the experiment with colour images also provided quiet a satisfactory empirical result that can readily be used for various practical utilities. It also opens a new avenue for diagnostics and qualitative recovery of images.

References

[1] *Contrast Enhancement by Multi-scale Adaptive Histogram Equalization*, Yinpeng Jin, Laura Fayad, Andrew Laine, department of Biomedical Engineering, Columbia University, New York, NY Department of Radiology, Columbia-Presbyterian Medical Center, New York, NY.

[2] *Contrast Limited Adaptive Histogram Equalization Image Processing to improve the detection of simulated spiculations in dense Mammograms*, Etta D Pisano, Suquan Zong, Bradley M Hemminger, Marla DeLuca, R. Eugene Johnston, Keith Muller, M. Patricia, Braeuning, Stephen M Pizer, Depart. Of Radiology, Computer Science, Biomedical Engineering and Biostatistics, Univ. of North Carolina.

[3] *Enhancement of Images Using Histogram Processing Techniques*, Komal Vij, Yaduvir Singh, Department of Electrical & Instrumentation Engineering, Thapar University, Patiala, India,

[4] *Image Contrast Enhancement based Sub-histogram Equalization Technique without Over-equalization Noise*, Hyunsup Yoon, Youngjoon Han, and Hernsoo Hahn. International Journal of Electrical and Electronics Engineering 3:6 2009

[5] *Novel Histogram Processing for Colour Image Enhancement*, Jiang Duan and Guoping Qiu, School of Computer Science, The University of Nottingham, United Kingdom.

[6] Shape Preserving Local Histogram Modication, Vicent Caselles, Jose-Luis Lisani, Jean-Michel Morely, Guillermo Sapiro, Dept. of Mathematics and Informatics, University of Illes Balears, 07071 Palma de Mallorca, Spain.3.

[7] S. Naik and C. Murthy, “Hue-preserving color image enhancement without gamut problem,” IEEE Trans. Image Processing, vol. 12, no. 12, pp. 1591–1598, Dec. 2003

[8] P. E. Trahanias and A. N. Venetsanopoulos, “Color image enhancement through 3-D histogram equalization,” in Proc. 15th IAPR Int. Conf. Pattern Recognition, vol. 1, pp. 545–548, Aug.-Sep. 1992.

[9] N. Bassiou and C. Kotropoulos, "Color image histogram equalization by absolute discounting back-off," Computer Vision and Image Understanding, vol. 107, no. 1-2, pp.108-122, Jul.-Aug. 2007
R. J. Vidmar. (1992, August). On the use of atmospheric plasmas as electromagnetic reflectors. *IEEE Trans. Plasma Sci.* [Online]. *21(3).* pp. 876—880. Available: http://www.halcyon.com/pub/journals/21ps03-vidmar

D. P. Sharma, M. Sc. (Comp. Sc.), MCA, M. Phil. (Comp. Sc.), M. Tech. (Final), MIAE, MEE, MCSTA (USA). Fellow IETE (India), MIARCS (TIFR), MIACSIT (Singapore).

Dr. N. Chandra Sekhar Reddy, B.Tech (CSIT), M.Tech (S.E), LMCSI, CSI-SBC, Professor, CSE Department, Institute of Aeronautical Engineering, Hyderabad 500043.

Dr. Nagu Chandra Sekhar Reddy, B.E (C.S.E), M.Tech (C.S.E),Ph.D(C.S.E), LMISTE, LMCSI, CSI-NC-MEMBER,FIE, Professor-CSE Dept.,I/C M.Tech CSE/IT/SE, Discipline Committee Chairman, Institute of Aeronautical Engineering,Hyderabad-500 043, Andhra Pradesh, India. Academic Consultant for ISTE, CSI, NBA, Faculty Recruitment's, Micro Soft & IBM Academic Tech clubs,.

Prof. Uma Shankar, Professor, CSE Department, IARE, Hyderabad 500043