An Approach for Contrast Enhancement of Color Images with the help of Adaptive Region Growing Segmentation

Neeraj Bhalla,
M-Tech (CSE), B.M.S. College of Engg.
Muktsar, India
Neeraj780@yahoo.co.in

Navdeep Kanwal,
Asstt. Prof., Dept. of CSE,
GTB Khalsa Inst. of Engg. & Tech.
Chhapianwali (Malout), India
navdeepkanwal@gmail.com

Akshay Girdhar,
Associate Professor, Dept. of IT,
Guru Nanak DevEngg. College
Ludhiana, India
akshay1975@gmail.com

Preetinder Kaur Mann,
Asstt. Prof., Dept. of CSE,
B.M.S.College of Engg.
Muktsar, India
inderpreet_bti@yahoo.co.in

Abstract

Digital images are the most common application of now day's world. In almost every era of life and technology, the digital images are playing their roles. The problem with images is that, their quality depends on a number of other factors like lighting at the image capturing location, proficiency of the operator, and noise. Low contrast is the most common problem of digital images. A lot of techniques have been suggested earlier for the contrast enhancement of the color images which works on histogram of the image or on some particular region. Region based techniques are simple and more effective as they work according to the specified regions of the image. Seed selection is an optimal method for initiate any spatial enhancement. This paper suggests a new hybrid approach for contrast enhancement of the digital images. The suggested technique is based on region growing segmentation and works adaptively for contrast enhancement of the image.

Keywords: Digital Image, Histogram, Region Based, Seed Selection, Segmentation, Contrast Enhancement, Adaptive.

I. Introduction

Images are being used for representation of facts and scenes since centuries. With the evolution of computers the image has been converted in digital format and thus called as Digital Image. The Digital images are being used for both research and general purposes. The color images are being used widely in the industry and entertainment fields along the research areas. The images being used in different eras of life are usually captured by some digital cameras or scanners. Though there are high quality devices are available for the better quality of images but still all the devices are operator and light dependent. As in lesser light it is difficult to capture a higher contrast picture. Similarly, the images captured in space by some satellites also suffer from the problem of low contrast due to distance and negligible lighting in space. The images suffering from the problem of low contrast, needs to be enhanced. This enables the researchers and users to have more details form the image. The contrast of image can be enhanced with the help of various techniques and algorithms of contrast enhancement. Some of the leading approaches for contrast enhancement of the color images include gray-level stretching or transformation based techniques and histogram modification based techniques [1]. Gray level stretching is the simplest approach used for contrast enhancement. In this technique the intensity is increased uniformly for all the pixel values. Histogram Modification techniques uses various type of numerical formulas and calculations for modifying the histogram of an image which results in the enhanced one. Histogram modification method is usually considered as the better methodology in comparison to the earlier technique. Histgram based modification techniques are usually divided in two classes local and global [2-3]. Color image processing and enhancement is a more complicated process than its counterpart of black-and-white images [4] due to the involvement of multiple color channels and the need to preserve the color information content [5] while enhancing the contrast. Accordingly, with the rapidly improvement of computer processing capabilities, the color image processing is being more and more concerned by people [6]

The viewers of some image are usually interested in some specific portion of the image. These parts are more important in the user's view and are considered as foreground of the image whereas the other portion is called as background. For enhancement of the image, the respective algorithm usually targets to the foreground portion of the image. Image segmentation is one of the key steps of image processing. It enables the user to divide an image in various parts. This division can be automatic or user defined approach. Image segmentation is a technique and process which divide the image into different feature of region and extract out the interested target. Here features can be pixel grayscale, color, texture, etc.

2. Region Growing Methodology

Region growing is referred as region based image segmentation method. An image can be segmented in the regions on the basis of some fixed criteria. Region growing approaches generally use a seed pixel for start and then the process continue by evaluating neighboring pixels one by one. As the first step of the approach some pixel is chosen as the seed point. Some threshold value in accordance to seed value can be defined to make the approach adaptive. In the second step, the neighboring pixels are checked one by one against the given criteria. The pixels fulfilling criteria are considered to be connected and are added to the region, otherwise skipped. The procedure is iterative: at each step, a pixel is merged according to the homogeneity criterion. This process is repeated until no more voxels are assigned to the region. This process remain continue in the whole image, until all the pixels get processed. In the end all the connected pixels make a single region. The pixels are used to be processed in 4-connected or 8-connected approach.

3. Proposed Algorithm

Earlier studies have proved that the digital images face the problem of low contrast due the various factors. The factors may include the lesser light in the capturing area, low lens power of the capturing device and operator proficiency. For the betterment of the images, the contrast enhancement is usually considered as the most common technique of image enhancement. A number of contrast enhancement methods have been proposed for the purpose as discussed above. Classical image enhancement techniques cannot adapt to the varying characteristics of images. The proposed technique works on adaptively and region growing technique jointly. The region grows in the suggested technique on the basis of a threshold value. It evaluates for the pixels connected in the 8-nieubouring. The contrast of the image is enhanced for the foreground part and clubbed with its original gradient in the end. The detailed steps of the methodology are as below:

Step I. Select a pixel in the input image that will work as the seed point.

Step II. Repeat Step-III to Step-X for 'Red', 'Green' & Blue color individually.

Step III. Add the respective color value of seed pixel into an empty temporary buffer.

Step IV. From the top of the buffer pop first point and find its immediate 8-connected neighbors and add them to temporary buffer.

Step V. Check for the Connectivity of pixels to the chosen point (Step IV) on the basis of specified deviation from the seed pixel's gray level value. The deviation is specified as:

(f (m, n)-seed) / seed<= £

where f(m,n) is the gray level value of the current pixel and the threshold £ = 0.5 [7]. If the current pixel satisfies the criteria then it is added to the foreground queue, otherwise to background queue.

Step VI. The Step IV & V is repeated till all the pixels in the temporary buffer have not been processed. If some pixel is encountered that has already been processed then ignore it and process the next pixel in the buffer.

Step VII. Alter the gray level values of each pixel in the foreground buffer in proportion to mean ratio[8], that can be calculated as:

(mean-seed)/seed

Step VIII. Perform Contrast limited adaptive histogram equalization on the altered foreground buffer and generate foreground image.

Step IX. Expand the pixels of background buffer and generate background image.

Step X. Combine the foreground and background image of Step IX and Step X to construct the respective color region.

Step XI. Combine all enhanced outcomes of 'Red', 'Green' & 'Blue' to form the enhanced RGB image.

Step XII. Obtain the gradient of the original image and add it to the image obtained in Step XI.

Step XIII. Display the final enhanced image of Step XII.

4. Quality Evaluation

Every suggested technique requires evaluation of its results on the basis of qualitative & quantitative methods. Qualitatively the technique has been tested visually. Visual results of proposed algorithm seem much better in comparison to the state of the art technique CLAHE. Verification of the results have been done on the basis of quality metrics: Tenangrad Measurement, Entropy & SNR (Signal – to – Noise Ratio)

Table 1: Mathematical Formulas for Quality Factors

Sr. No.	Quality Factor	Implementation
1.	Tenangrad Measurement (TEN)	$\sum_y \sum_x [S(x,y)]^2$ for S(x, y) > T
2.	Entropy	sum(p.*log2(p))

TEN involves computing gradient magnitude at every location in image and sums all magnitudes greater than a threshold T [9]. The entropy is an important factor to estimate whether the digital image is basically the same with the original image [10]. While comparing results for images, higher value of TEN and Entropy represent better edges and contrast respectively.

5. Results

A. Test Images

The first image i.e. Figure1 is low contrast scenic image of a building with lawn. The image has been captured in a low light day. The second image Figure 2 is another low contrast scanned capture of popular lenna image. Final and third image is Figure3, which is a low contrast cave painting which is usually captured in very low light environment causing low contrast.

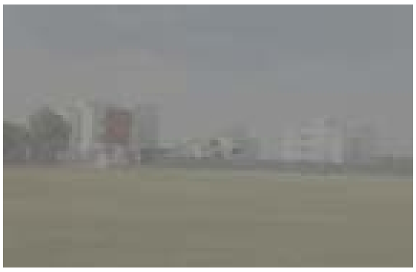

Figure 1: Building with ground

Figure2: low contrast lenna

Figure3: Painting of a Cave

B. Results

The test images have been enhanced using proposed algorithm & Contrast Limited Adaptive histogram equalization.

Figure 1, represents visual results for the first test image (Building with ground). In visual analysis it is observed that contrast has been enhanced to various levels by both methods but the proposed algorithm is enhancing the image more precisely in comparison to Contrast Limited Adaptive HE. Though visual results are appearing better but the human visualization is not considered as benchmark for image quality, so to evaluate the performance of above mentioned algorithms quality metrics have been calculated for the output images. Values for Entropy and Tennanangrad Measurement have been calculated for the resultant images in comparison to the original image.

The evaluation derives that Proposed Enhancement technique produces better quality values for enhanced image. Visual results and Quality test metrics for the mentioned algorithms have also been evaluated for the other two images i.e. Figure 2 and Figure 3. Table 2 is displaying metric values for the results of Figure 1.

Figure 4(clockwise): 4a. Original Image 4b. Image Enhanced through proposed method 4c. Enhanced through adaptive enhancement.

Table 2: Performance Evaluation for Figure1

Algorithm→ Quality Parameter	**CLAHE**	**Proposed Algorithm**
TEN	18467475	**18599397**
ENTROPY	7.4429	**7.4506**

Figure 5 is representing visual results for the Figure 2, whereas Figure 6 is elaborating the results for Figure 3. Similarly Table 3 and Table 4 are the numerical values for the quality metrics of resultant images respectively.

Figure 5(clockwise): 5a. Original Image 5b. Image Enhanced through proposed method 5c. Enhanced through adaptive enhancement.

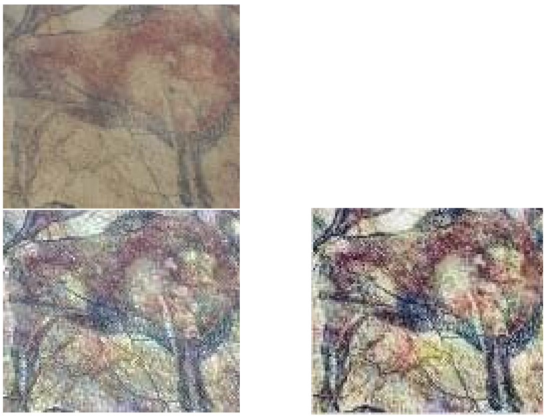

Figure 6(clockwise): 6a. Original Image 6b. Image Enhanced through proposed method 6c. Enhanced through adaptive enhancement.

Table 3: Performance Evaluation for Figure2

Algorithm→ Quality Parameter	**CLAHE**	**Proposed Algorithm**
TEN	4659832	**4765337**
ENTROPY	6.1882	**6.2351**

Table 4: Performance Evaluation for Figure3

Algorithm→ Quality Parameter	**CLAHE**	**Proposed Algorithm**
TEN	7.9437e+006	**7.9495e+006**
ENTROPY	7.5728	**7.6580**

For all the images considered, the proposed technique is producing better results. The quantitative metrics are representing a significant growth in the metric values.

6. Conclusion

The paper is describing a hybrid approach for the enhancement of digital image. The image having low contrast can be enhanced by the technique suggested above. A manual seed selection method has been used to implement region growing segmentation for contrast enhancement of the image. Gradient of the image has also been improved to make the edges of the regions more strong. The algorithm works on an adaptive approach as the connectivity of the pixels in the region are tested against a threshold value. In the end of the paper the results of the proposed technique have been compared with existing technique of contrast limited adaptive histogram equalization i.e. CLAHE. The results are justifying the proposed technique as the better one.

7. Future Scope

Future work in this domain may include implementation of multiple seed points. Further, the selection of seed point can be made automatic. The approach may be adopted for medical images. The algorithm may be fused with some denoising technique to deal with high noise images.

References

1. R. C. Gonzalez and R. E. Woods (2002), *Digital Image Processing*, 2^{nd} ed. Englewood Cliffs, NJ: Prentice-Hall, ISBN: 0-201-18075-8.
2. T. Arici, S. Dikbas, and Y. Altunbasak (2009), "A Histogram Modification Framework and Its Application for Image Contrast Enhancement," *IEEE Trans. Image Process,* vol. 18, no. 9, pp. 1921-1935, Sep.
3. Y. T. Kim (1997), "Enhancement Using Brightness Preserving Bi-histogram Equalization," *IEEE Trans. Consum. Electron*, vol. 43, no. 1, pp. 1–8, Feb.
4. N. M. Kwok, Q. P. Ha, D. Liu, and G. Fang (2009), "Contrast enhancement and intensity preservation for gray-level images using multi objective particle swarm optimization," *IEEE Trans. on Automation Science and Engineerin*g, vol. 6, no. 1, pp. 145–155.
5. S. K. Naik and C. A. Murhty (2003), "Hue-preserving color image enhancement without gamut problem," *IEEE Trans. on Image Processing*, vol. 12, no. 12, pp. 1591–1598.
6. Peck, M. ACell (2002), *Image Segmentation of Gastric Cancer Based on Region-Growing and Watersheds*. Quebec City, Que. Univelt Inc.
7. Rangayan, R.M. (2005), "Biomedical Image Analysis", CRC Press, pp. 338, ISBN 0-8493-9695-6.
8. Kanwal, N., Girdhar, A., Gupta, S. (2011), "Region Based Adaptive Contrast Enhancement of Medical X-Ray Images" *Proceeding of 5th International Conference (IEEE) on Bioinformatics and Biomedical Engineering, (iCBBE)*, May 2011, pp 1-5, ISBN: 978-1-4244-5088-6.
9. Wei, Liyang, Kumar, Dinesh, Khemka, Animesh, Turlapti, Ram, Suri, Jasjit S (2008). "Clinical Validation and Performance Evaluation of Enhancement Methods Acquired from Interventional C-ARM X-ray", *Medical Imaging 2008: Image Processing*. Edited by Reinhardt, Joseph M.; Pluim, Josien P. W. *Proceedings of the SPIE*, Volume 6914, pp. 691426-691426-8.
10. Qiu-Ming Huang, Xiao-Jun Tong, Shan Zeng, Wen-Ke Wang (2007), "Digital Image Resolution and Entropy", *International Conference on Machine Learning and Cybernetics*, Hong Kong, pp. 1574 – 1577.