Contrast Enhancement of Images with Poor Lighting Based on Watersheds

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Abstract

The contrast enhancement is the general problem in digital image processing and it can be solved from different techniques. In this paper, an innovative method is proposed to enhance the images with poor lighting using the frequency of watersheds. Here, watersheds are used to identify the dark regions depending on the difference parameter which describes the homogeneity of a region. To increase the contrast of these regions, contrast Adjust (CA) is added to the dull image pixels which are identified by the watersheds in the local neighborhood of an image of N X N order. The contrast Adjust is changes region to region depending on the frequency of watersheds in the neighborhood. The proposed method is applied on different images with poor lighting and the results are shown to analyze the performance of the method.

Key Words: *Enhancement, watershed frequency, Contrast Adjust, Histogram, Catchment basin*

1. INTRODUCTION

Digital cameras are the most used devices to capture images and they are everywhere, including mobile phones, personal digital assistants (PDAs), and surveillance and home security systems. The quality of the images obtained from digital cameras has been improved over the years. Contrast enhancement is frequently referred to as one of the most important issues in image processing. Contrast is produced by the difference in luminance reflected from two adjacent surfaces. Common techniques for global contrast enhancements like global stretching and histogram equalization may not always produce good results, especially for images with large spatial variation in contrast. Image enhancement is the general process [1, 2, 3] of improving the visual quality of a poor image subject to further processing and analysis.

Local contrast stretching (LCS) is an enhancement method performed on an image for locally adjusting each picture element value to improve the visualization of objects in both darkest and lightest portions of the image at the same time. LCS is performed by convolution across the image and adjusting the center element [4]. Partial contrast is an auto scaling linear mapping function that is usually used to increase the contrast level and the brightness level of the image. This technique will be based on the original brightness and contrast level of the images to make the adjustment. Dark stretching is known as part of partial contrast stretching, dark stretching is a reverse process of bright stretching process. Bright stretching is a process used to scale in the brightness and contrast level of an image [5]. Image histogram is a powerful tool to represent image information graphically. It can be used to provide solutions to improve quality control, but again has never been used on improving the high quality of an image. Some of the improved techniques of histogram equalization with brightness preserving include the bi-histogram equalization (BHE) [6].

Histogram equalization is the most popular simple algorithm for contrast enhancement and can be classified into two categories according to the transformation function used: global or local. Global histogram equalization is a fast contrast-enhancement technique but its effectiveness is relatively low. Local histogram equalization can enhance overall contrast more effectively, but due to its fully overlapped sub-blocks, the required complexity of computation is very high [7]. Global histogram equalization method uses only global histogram information over the whole image and hence it cannot focus on local bright features. This fact limits the contrast- stretching ratio in some parts of the image, and causes significant contrast losses in the background and other small regions. To overcome this limitation, a local histogram-equalization method has been developed, which can also be termed block-overlapped histogram equalization [8]. Most conventional contrast enhancement algorithms usually fail to provide detailed contrast information in the dark and bright areas of remotely sensed images. The fuzzy-based and homomorphic filter approaches were proposed for dynamic range images and increasing contrast of images [9, 10]. The organization of the paper is as follows. Section 2 describes the basic watershed transformation. The proposed method and experimental results are presented in section 3 and section 4 respectively. In Section 5, conclusions are drawn with reference to the results and assumptions.

2. WATERSHED TRANSFORM

The watershed transform is computed on the gradient of the original image, so that the catchment basin boundaries are located at high gradient points. The watershed transform has been widely used in many fields of image processing, including medical image segmentation. Watershed is identified in 3x3 mask, as shown in the Fig. 1., is calculated by taking magnitude which describes the slope from the neighboring pixels to central pixel which is treated as catchment basin [11].

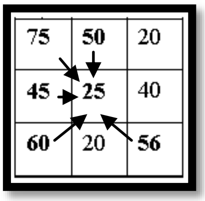


Fig.1. Watersheds with difference parameter (h) greater than or equal to 20

3. Watersheds for Contrast Enhancement

We proposed new method using watersheds to identify the dull region pixels for enhancing rather than for segmentation. We assume that the difference parameter plays a vital role in identifying dull pixels. If the difference parameter is low, then the frequency of watersheds obtained is more and this describes that the pixel under consideration falls in the same region. The increase in difference parmeter may yield less number of watersheds in the mask. So, the difference parameter (h) has been fixed in the range of {15 …25} and it depends on the input images. The pixel under consideration in the neighborhood mask is identified as dull pixel when the frequency of watersheds formed is more than 'n', where n is greater than 2 and is varies image to image. These identified dull pixels contrast is enhanced by adding the Contrast Adjust (CA) which is calculated by difference of the average frequency of watersheds (WSF) in the neighborhood and minimum of the neighborhood pixels.

x_1	x_2	x_3
x_8	P	x_4
x_7	x_6	x_5

Fig.2.Neighborhood of a mask

With reference to the neighborhood shown in Fig. 2., the watersheds(WS), Frequency of Watersheds (WSF) and Contrast adjust(CA) can be calculated by the following formulae .

$$WS = \{x_i \setminus (P - x_i) \in \{15..25\}\ where\ i = 1 \dots 8\}$$

$$WSF = Count(WS)$$

$$CA = Avg(WS) - Min(x_i)\ where\ i = 1\dots8$$

The following algorithm describes the implementation process of the proposed method.

Step 1: BEGIN

Step 2: Read the Input Image.

Step 3: Find the No. of Water Sheds in 3x3 mask with specified difference parameter.

Step 4: Watershed frequency (WSF) = Count (WS).

Step 5: CA= Average of Watershed Pixels – Minimum of Neighborhood mask

Step 6: If WSF>2

P=P+CA

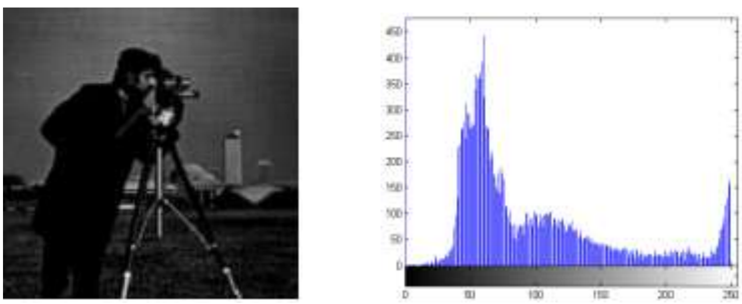
Step 7: Repeat Steps 3, 4, 5 and 6 on entire image by 3x3 moving mask.

Step 8: Display the Resultant Contrast Enhanced Image

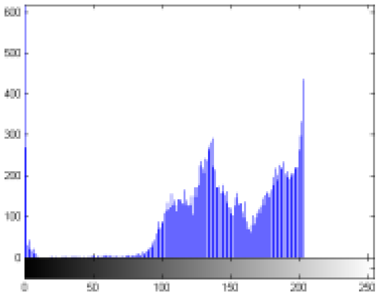
Step 9: END

4. Experimental Results

The proposed method is applied on various poor illuminated images which are taken from different environments. The performance of the proposed method is shown in Fig. 3 to Fig. 6. The results clearly indicate, when histograms of original image with enhanced image are compared, that the poor illuminated regions are progressively enhanced. Here the mask size is restricted to only 3x3 because the number of watersheds is less even some times zero when the mask size is increased. So, when mask size increases, the effect of contrast enhancement degrades.

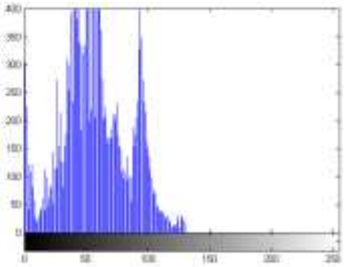


(a) (b)

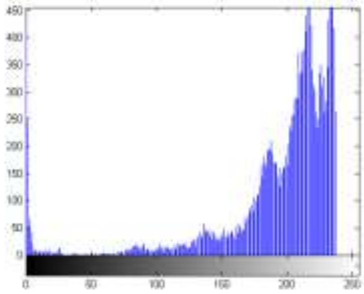



(c) (d)

Fig. 3. (a),(b) Original Cameraman Image and corresponding Histogram, (c),(d) Contrast enhanced Image and corresponding Histogram

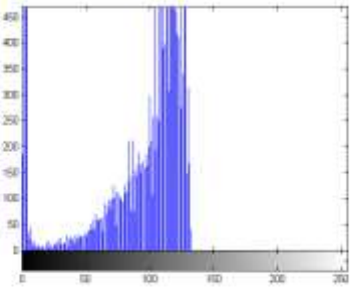



(a) (b)

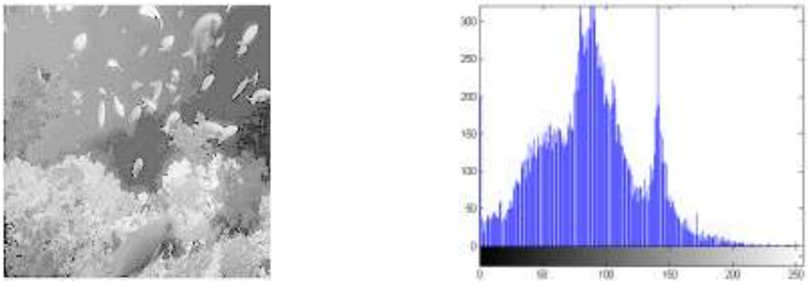



(c) (d)

Fig. 4. (a),(b) Original couple Image and corresponding Historgram, (c),(d) Contrast enhanced Image and corresponding Histogram

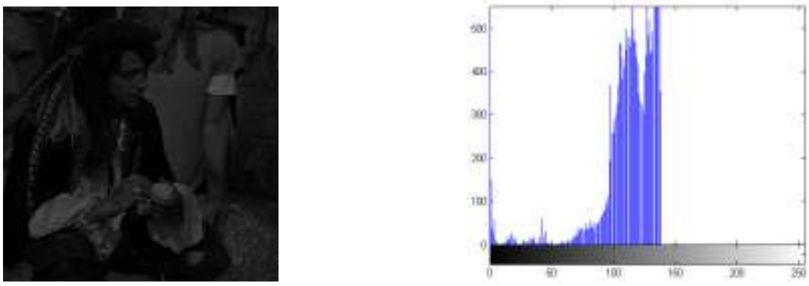



(a) (b)

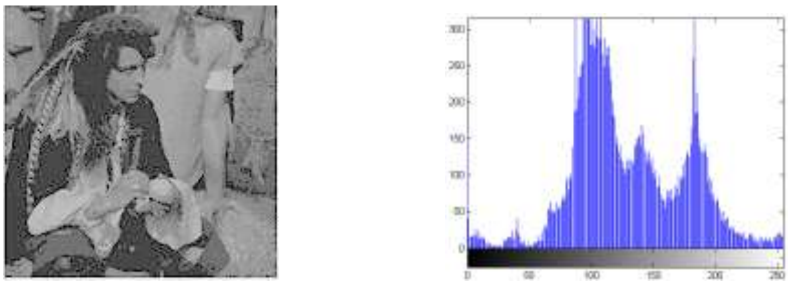


(c) (d)

Fig. 5. (a),(b) Under water Image and corresponding Historgram; (c),(d) Contrast enhanced Image and corresponding Histogram



(a) (b)



(c) (d)

Fig. 6. (a),(b) Pirate Image and corresponding Historgram, (c),(d) Contrast enhanced Image and corresponding Histogram

5. Conclusions

We proposed a new algorithm based on watersheds to enhance contrast rather than segmentation. The performance of the algorithm is mainly depends on watersheds formed with the difference parameter and is varies from image to image. The effectiveness of the algorithm can be easily evaluated by analyzing the histograms of poor image and enhanced image of the experimental results. The distribution of the poor illuminated grey levels are evenly distributed and is clearly shown in enhanced histogram. This algorithm is sensitive to the noise and when the neighboring pixels are less than the central pixel. The proposed algorithm works well for the mask size is restricted to 3x3 and is evident from the results shown above.

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