International Journal of Electronic and Electrical Engineering.
ISSN 0974-2174, Volume 7, Number 2 (2014), pp. 165-170

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A Novel Algorithm for Image Contrast Enhancement

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Abstract

The rapid introduction of direct and indirect digital imaging systems in natural images has created a wide selection of computer-based methods for analyzing imaging. Utilizing the computational power along with the application of digital imaging algorithms, has a significant impact on analyzing utility. It is crucial to understand the mechanisms by which a given imaging algorithm modifies an image to assess its impact on image quality and hence better visibility. Region Based Segmentation and several other techniques have been widely used in many applications involving image processing. One such application in low contrast images is using digital image analysis. For effective and correct analysis it is necessary to segment out blurred regions, low contrast regions in the image. In this present work, region based segmentation has been chosen. Although there are many contrast enhancement techniques which enhances the contrast of the image, but the proposed technique enhances the contrast of the image to a great extent. The proposed technique is compared both subjectively and objectively by using suitable quality metrics with the existing contrast enhancement techniques. On the basis of experimental results it shows that the proposed technique shows better quality of an image as compared to other techniques.

Keywords: Histogram equalization, Segmentation, Power-Law transformation, and Unsharp masking.

1. Introduction

Contrast enhancement plays a crucial role in image processing applications, such as digital photography, medical image analysis, remote sensing, LCD display processing, and scientific visualization. Image enhancement is a technique which reduces image noise, remove artifacts, and preserve details. Its purpose is to amplify certain image features for analysis, diagnosis and display. Contrast enhancement increases the total contrast of an image by making light colors lighter and dark colors darker at the same time. It does this by setting all color components below a specified lower bound to zero, and all color components above a specified upper bound to the maximum intensity (i.e. 255). Color components between the upper and lower bounds are set to a linear ramp of values between 0 and 255. Because the upper bound must be greater than the lower bound, the lower bound must be between 0 and 254, and the upper bound must be between 1 and 255. Some users describe the enhanced image that if a curtain of fog has been removed from the image [3].

Enhancement of an image can be implemented by using different operations of brightness increment, sharpening, blurring or noise removal. While categorizing Image Enhancement operations can be divided in two categories: i) Noise removal, and ii) Contrast Enhancement. Noise Removal is an operation to remove unwanted details from an image. Noise may be due to environment particles, capturing device inability, lack of experience, or some other reason. Noise removal helps an image processing system to extract necessary information only. On the other hand, Contrast Improvement process is used to make the image brighter, visual and detail worth full [5]. Contrast Enhancement is broadly categorized into two groups: i) direct methods, and ii) indirect methods. In direct method of contrast enhancement, a contrast measure is first defined, which is then modified by a mapping function to generate the pixel value of the enhanced image. On the other hand, indirect methods improve the contrast through exploiting the under-utilized regions of the dynamic range without defining a specific contrast term. Indirect methods can further be divided into several subgroups: i) techniques that decompose an image into high and low frequency signal for manipulation, e.g., homomorphic filtering, ii) histogram modification techniques, and iii) transform-based techniques. Out of these three subgroups, the histogram modification received the most attention due to its straightforward and intuitive implementation qualities [1].

Histogram equalization is the technique that assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in x-ray images, and to better detail in photographs that are over or under-exposed. Normally, the histogram is a graph showing the number of pixels in an image at each different intensity value found in that image. Sometimes this method refers to as Segmentation [2].

Segmentation is accomplished via thresholds based on the distribution of pixel properties, such as intensity values or color. Several segmentation techniques have been introduced to find the regions directly. These techniques are: i) Region Growing, and ii) Region Splitting and Merging. Region Growing is a procedure that groups the pixels or sub-regions into larger regions based on the approach that is to start with a set of “seed” points and from these grow regions by appending to each seed those neighboring pixels that have predefines properties similar to the seed. On the other hand, Region splitting methods take the opposite approach to region growing. These methods start from the entire image. If it does not meet homogeneity criteria, it is split into 4 sub-images. This procedure is applied recursively on each sub-image until each and every sub-image meets the uniformity criteria. When a homogeneous region is created, its neighboring regions are checked and the newly created region is merged with an existing one if they have identical properties. If the similarity criteria are met by more than one adjacent region, the new region is merged with the most similar one [3].

2. Results and Discussion

The proposed method is based on the selection of appropriate seed point and the threshold value. If the current pixel satisfies the threshold value then it is added to the foreground otherwise to background. Once the foreground and background are enhanced individually, they are combined to form the final enhanced image.
The Steps of proposed Algorithm are as follows:

Step I: Select a pixel in the input image and make it a seed point. Add the seed pixel into an empty queue.

Step II: From top of the queue start finding immediate 8-connected neighbors of each unprocessed pixel and for each neighbor point, check whether the gray level value of that neighbor pixel is within the specified deviation from the seed pixel's gray level value. The proposed deviation (revised formula from Rangayyan, 2005) is specified as:

$$(f\ (m, n)\text{-seed}) <= £ \qquad (1)$$

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

Step III: The Step II is repeated till all the pixels in the queue are processed. If some pixel is encountered that is already on the queue then ignore it and process the next pixel in the queue.

Step IV: Alter the gray level values of each pixel in the foreground buffer by power law transformation.

Step V: Alter the gray level values of each pixel obtained after Step IV by adaptive histogram equalization.

Step VI: Combine the pixels in foreground and background buffer to form the enhanced image.

Step VII: Display the final enhanced image.

The Fig. 1 and Fig. 2 shows the different images consist of original images that are enhanced through contrast enhancement techniques such as power law transformation, unsharp masking and the proposed technique.

(a) **(b)** **(c)** **(d)**

Fig. 1: Comparison of various Contrast Enhancement techniques for image Pelvis: (a) Original image, (b) Power-Law transformation, (c) Unsharp masking, (d) Proposed technique

(a) **(b)** **(c)** **(d)**

Fig. 2: Comparison of various Contrast Enhancement techniques for image Hand: (a) Original image, (b) Power-Law transformation, (c) Unsharp masking, (d) Proposed technique.

The Table 1 represents the values of quality measures implemented on different set of images for comparing the resultant images with each other. The range of Entropy and Tenengrad (TEN) is not defined, but a higher value of these matrices are always considered good and comparatively its higher values are coming corresponding to the proposed method as compared to other contrast enhancement techniques.

Table 1: Quality measure on Different Images.

Sr. No.	Image	Quality Metric	Power Law Transformation	Unsharp Masking	Proposed Algorithm
1.	Pelvis	Entropy	6.5462	6.7387	7.1210
		TEN	187710000	174819484	521450816
2.	Hand	Entropy	5.8734	6.2129	6.8787
		TEN	202240000	191577232	501326562

Thus, it is proved from the obtained results that the proposed technique helps to reduce the problem of low contrast to a great extent as compared to other existing techniques.

3. Conclusion

In the proposed technique, first of all, the user selects a pixel from the image. Then the adaptive region is grown from that pixel and thereafter adaptive histogram equalization is applied and then the whole image is enhanced. The experimental results show the effectiveness of the algorithm. Obtained images are visually pleasing, artifact free, and natural looking. A desirable feature of the proposed algorithm is that it does not introduce flickering. This is mainly due to the fact that the proposed method uses the input histogram, which does not change significantly within the same scene. Proposed method also offers a level of controllability and adaptability through which different levels of contrast enhancement, from histogram equalization to no contrast enhancement, can be achieved.

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