ABSTRACT

Color image enhancement is an important research area due to the huge development in the digital image processing scope and its wide usage in many applications, and exist the needing in some applications such as engineering, military and medical imaging. All applications still need to enhance those images, which have some problems when taken by the camera, for not applying enough light, as taking it in cloudy weather or on bright light or dark area or taking it from a far distance, all these reasons make the picture not clear having ambiguous details and colors. So, through this research, an efficient color image contrast enhancement technique is proposed based on Undecimated Wavelet Transform (UWT) to adjust the light for dark images, to make them have deep detail, sharp edges and better quality. To enhance the image, the histogram equalization is used for each clustered for the K-means clustering of lower band coefficient. The performance evaluated by some measurements including correlation coefficient as well as Signal Noise Ratio (SNR), Mean Square Error (MSE), and Peak Signal to Noise Ratio (PSNR). Experimental results of this study suggest that UDWT and K-means clustering of the proposed system provide high image quality.

Keywords: Digital Image Processing, Color Model, K-Means, Undecimated Wavelet Transformation.

1. Introduction

Contrast enhancement is an important area in digital image for both image processing and computer vision. It is widely used for engineering, medical image processing and as a preprocessing step in image/video processing applications [1]-[2].

There are several reasons for an image to have poor contrast: the poor quality of the used imaging device, lack of expertise of the operator, and the adverse external conditions at the time of acquisition. These effects result in under-utilization of the offered dynamic range. As a result, such images and videos may not reveal all the details in the captured scene, and may have a washed-out and unnatural look. Contrast enhancement targets to eliminate these problems, thereby to obtain a more visually pleasing or informative image or both. Different methods have already been developed for this purpose [3]-[4]. A new way of image enhancement approach is implemented using transform coefficient histogram [5].

Three methods of image enhancement algorithms; are developed in [6]. It comprised of three stages; logarithmic transform histogram matching, logarithmic luminance distribution approach for statistical image transform histogram shifting and logarithmic transform histogram shaping using Gaussian distributions are described based on logarithmic transform domain histogram and HE. An advanced image contrast enhancement approach is discussed in [7] based on non overlapped sub-block HE function. It is obtained by employing a low pass filter type mask. It produces the high contrast associated with local HE.

Modified Histogram equalization (HE) has proved to be a simple and effective image contrast enhancement technique [8]. It worked on a novel technique called Multi-HE, which uniformly of decomposing the input image into various sub-images, and then devoting the classical HE process to each one. This scheme performs a less increase produce image contrast enhancement, in a way that the output image presents a more natural look. It proposed two discrepancy functions for image decomposing, imagining two new Multi-HE methods. A cost function was also used for automatically deciding in how many sub-images the input image will be decomposed on. The work was tested a new framework called MHE for image contrast enhancement and brightness preserving which generated natural looking images. The results showed that there methods was better on preserving the brightness of the processed image (in relation to the original one) and yields images with natural appearance, at the cost of contrast enhancement.

Chao Wang and Zhongfu Ye in 2005 worked for preserving the original brightness to avoid annoying
artifacts. This provided an extension of histogram equalization, really histogram detailed description, to overcome drawback of HE [9].

K-means clustering techniques calculate the mean value by reducing the distance between the centroid and values. K-means clustering is the statistical and data mining techniques, which is used for cluster analysis and then divide the n data points with k clusters. The clustering procedure first extracts the features of the image and then to combine similar pixels in one group and dissimilar pixels in another group [10].

In this paper, an approach for color image contrast enhancement based on wavelet and K-means clustering to improve the digital image quality is presented.

2. HSI Color Space Conversion

The HSI color model represents every color with three components: hue (H), saturation (S), intensity (I). The Hue component describes the color itself in the form of an angle between [0, 360] degrees. 0 degree mean red, 120 means green 240 means blue. 60 degrees is yellow. Each normalized H, S, and I components are then using the cosine. It is a mapping mi that counts the value of an image and then to combine similar pixels in one group and dissimilar pixels in another group [10].

In this paper, an approach for color image contrast enhancement based on wavelet and K-means clustering to improve the digital image quality is presented.

2.2 HSI To RGB

The proposed system clustering the I component of the original image into its dark and bright parts using K-means clustering technique after converting the RGB (Red, Green, and Blue) values of each pixel of any cluster of the original image to HSI (Hue, Saturation, and Value) values. The K-means is a clustering algorithm, which partitions a data set into clusters according to some defined distance measure. Images are considered as one of the most important medium of conveying information. K-Means algorithm is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. The algorithm assumes that the data features form a vector space and tries to find natural clustering in them [12], [13]. The K-means function is given by:

\[ \text{Kmeans(ima,k)} \] (7)

where mu is the vector of class means, mask is the classification image mask, ima is the color image and k is the number of classes. The points are clustered around centroids in (8) which are obtained by minimizing the objective. Let \( m = \text{max(ima)} \), then

\[ \text{mu} = \frac{(2k+1)m}{k+1} \] (8)

The max() function is the maximum value in the matrix ima that represents the colored image to get the maximum value of the content colors where the colors values are represented as a single value for each pixel. This is used to define the maximum number of levels used to calculate the histogram. The summary of the algorithm is given below:

- Compute the intensity distribution (also called the histogram) of the intensities as given in the Eq. (7). The histogram represents the number of pixels in that particular tone. It is a mapping \( mi \) that counts the number of pixels that have the same value, whereas the
graph of a histogram is merely one way to represent a histogram. Thus, if we let \( n \) be the total number of observations and \( k \) be the total number of tones, the histogram \( m_i \) meets the following conditions:

\[
n = \sum_{i=1}^{k} m_i \quad (9)
\]

ii. Initialize the centroids with \( k \) random intensities as in (8).

iii. Repeat the following steps until the cluster labels of the image do not change anymore.

iv. Cluster the points based on distance of their intensities from the centroid intensities.

v. Compute the new centroid for each of the clusters.

4. Two–Dimensional Undecimated wavelet transform

Undecimated (UWT) means there is no decimation. Undecimated wavelet transform is applied on both down sampling in the forward wavelet transform and up-sampling in the inverse wavelet transform process. The undecimated wavelet \( W \) using the filter bank \( (h,g) \) of a one-dimensional \( C_0 \) leads to a set \( W\{w_1, \ldots , w_1, c_1\} \) the passage from one resolution to the next one is obtained using " a trous" algorithm [14].

\[
c_{j+1}[l] = (\hat{h}(j) * c_j)[l] = \sum_{k} h[k]c_j[l + 2^j k]
\]

\[
w_{j+1}[l] = (\hat{g}(j) * c_j)[l] = \sum_{k} g[k]c_j[l + 2^j k] \quad (10)
\]

where \( h[j][l] = h[l] \) if \( l/2^j \) is an integer and 0, otherwise.

The Reconstruction is obtained by:

\[
c_j[l] = \frac{1}{2} \left[ (\hat{h}(j) * c_{j+1})[l] + (\hat{g}(j) * w_{j+1})[l] \right]. \quad (11)
\]

The filter bank \( (h,g,\hat{h}, \hat{g}) \) needs only to verify the exact reconstruction condition:

\[
H(z^{-1})H(z) + G(z^{-1})\hat{G}(z) = 1 \quad (12)
\]

The algorithm can be extended to 2-D by

\[
c_{j+1}[k,l] = (\hat{h}(j)\hat{h}(j) * c_j)[k,l]
\]

\[
w_{j+1}[k,l] = (\hat{g}(j)\hat{h}(j) * c_j)[k,l]
\]

\[
w^2_{j+1}[k,l] = (\hat{h}(j)\hat{g}(j) * c_j)[k,l]
\]

\[
w^3_{j+1}[k,l] = (\hat{g}(j)\hat{g}(j) * c_j)[k,l]
\]

Where \( hg^*c \) is the convolution of \( c \) by the separable filter \( hg \). At each scale there are three wavelet images, \( w^1, w^2, w^3 \), and each has the same size as the original image. The redundancy factor is, therefore, \( 3(J-1)+1 \).

Undecimated wavelet transform is then applied to the luminance value component of each cluster, dark and bright, of the color image to get the approximate component which is converted by applying gray level contrast enhancement technique based on proposed system. The saturation components are enhanced by histogram equalization. The H components are not changed, because changes in the H components could degrade the color balance between the HSI components. The enhanced S and I together with H are converted back to RGB values.

5. A Proposed color image contrast enhancement method

Mainly the same formulas mentioned above are used and the proposed method is represented by the following steps:

i. Load a color image.

ii. Read (r, g, b) values for each pixel of the digital image.

iii. Convert RGB color space of the two segments to HSI color space.

iv. Apply the K-means for I component to clustering the color image into dark and bright clusters.

v. Apply the saturation enhancement on the S component of each cluster.

vi. Decompose I component using the undecimated wavelet transform to get the approximate coefficient of each cluster.

vii. Reconstruct I for each segment via inverse wavelet transform and merge them to get the enhanced I.

ix. Convert HSI color space to RGB color space.

x. Display the enhanced color image.

6. Experimental Results

This section examine the performance of the proposed system on a large number of images. The test is performed on color images that are corrupted with different noises such as Speckle noise and Gaussian noise. To assess the efficiency of the system, the results of reconstruction images from undecimated wavelet transform coefficients will be compared with the original images. The results are illustrated in Figure (1) , where the proposed system has been applied to a complex natural image. It can be observed that the enhanced images by the proposed system seem to be very clear with finer details. The performance evaluated by some measurements including correlation coefficient as well as Signal Noise Ratio (SNR) , Mean Square Error (MSE) , and Peak Signal to Noise Ratio (PSNR) as shown in Table 1. The maximum PSNR indicates the quality of reconstructed image. The proposed system achieves an average PSNR of 24.5544 dB and 28.1412 dB when applying Gaussian noise and Speckle noise respectively. Besides PSNR , the other quality attributes like MSE and correlation coefficient also achieves very good performance. The amount of convergence between the original images and reconstructed images using the proposed system away by a small amount as a result of increasing the amount of noise on these images. Table (1) has been illustrated through the Figure(2) and Figure (3) after reconstructing the original image of Figure (1) using proposed system, and removal of the noise . Hence, based on the introduced performance , the proposed system achieves good results.
Table 1: Performance of the proposed enhancement system using data base images.

<table>
<thead>
<tr>
<th>Noise Type</th>
<th>M</th>
<th>δ</th>
<th>SNR</th>
<th>PSNR</th>
<th>Correlation Coefficient</th>
<th>MSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaussian</td>
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<td>0.01</td>
<td>13.1192</td>
<td>25.3672</td>
<td>0.9745</td>
<td>22.1191</td>
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<td></td>
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<td>0.02</td>
<td>12.1325</td>
<td>22.2467</td>
<td>0.9736</td>
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<tr>
<td></td>
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<td>0.04</td>
<td>9.542</td>
<td>24.6341</td>
<td>0.9475</td>
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<td></td>
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<td>0.06</td>
<td>8.5127</td>
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<td>0.9344</td>
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<tr>
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<td>7.3524</td>
<td>19.2013</td>
<td>0.9347</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>10.1318</td>
<td>24.5549</td>
<td>0.9529</td>
<td>28.1317</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>10.1318</td>
<td>24.5549</td>
<td>0.9529</td>
<td>28.1317</td>
</tr>
</tbody>
</table>

| Speckle    | 0.1 | 0.02 | 15.5452 | 30.3620 | 0.9867 | 20.4233 |
|            | 0.04| 0.04 | 12.7613 | 27.6540 | 0.9740 | 23.2341 |
|            | 0.06| 0.06 | 10.9212 | 24.7232 | 0.9623 | 24.9884 |
|            | 0.08| 0.08 | 9.9988  | 23.8420 | 0.9475 | 26.1967 |
| Average    |     |     | 13.4115 | 28.1412 | 0.9727 | 22.7167 |

7. Conclusion

Color image contrast enhancement remains one of the major challenges in image analysis. It is a very important process for several applications such as multimedia access. This paper presented color image contrast enhancement using undecimated wavelet and K-means. Simulations were done on the clustering using undecimated wavelet with the results presented. It manifested that the combination of methods performed very well. The proposed method proves capable of achieving successful enhancement of any color image whether it is dark, has low contrast or it is a natural image, which can be exposed to many different types of noise. Finally, the experimental results illustrate the proposed system provides high stability, especially when reconstruction from undecimated wavelet transform coefficients when exposure the amount of different noise. The amount of difference when retrieving the
images no higher extent, which supports the lack affected the amount of added noise from Speckle noise and Gaussian noise.

8. References


