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Image Enhancement Using DWT DCT and SVD

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ABSTRACT: Image enhancement deals with enhancing the image so that it provides more details. Several techniques are proposed for contrast enhancement of a low-contrast satellite images and CT scans. Here a new technique has been proposed based on the Discrete Wavelet Transform(DWT) Singular Value Decomposition (SVD) and Discrete Cosine Transform (DCT). The proposed technique divides image into blocks and converts each block of image into the DWT-SVD-DCT domain after normalizing the singular value matrix. Then the modified image is reconstructed by using inverse DCT and DWT and the blocks are combined. Adaptive Histogram Equalization (AHE) has been used here. Results of the proposed method clearly indicates increased efficiency and flexibility perceptually and quantitatively over the existing methods like DWT-SVD technique.

***Keywords*–** Adaptive histogram, DCT, DWT, Histogram Equalization, SVD

I. INTRODUCTION

Digital Image processing deals with processing of digital images. Digital images have digitized value of intensities. Image enhancement deals with enhancing images so that visual quality of image improves thus providing more information. Medical Imagery deals with images that are used for medical purposes like from CT scans MRI scans. Enhancement of such images gives better understanding of diseases. Here an enhancement method using DWT DCT and SVD transform is proposed. This uses advantages of the three transforms for image enhancement.

II. PROPOSED METHOD

Satellite images are low contrast and dark images, which has complete information but is not visible. Similarly CT scans are also dark images . So the enhancement of such images will help to get more information. The problem is how the contrast of an image can be improved from the input satellite images and CT images. Here a new contrast enhancement technique is proposed. There are 3 parts involved. First one is dividing the image into 4 blocks so that the operation can be done on each block. Then DWT followed by DCT and SVD. The result shows that images are visibly enhanced using DWT-DCT-SVD method by incorporating AHE.

2.1 Histogram Manipulation

The histogram of an image is a plot of number of occurrences of gray levels in the image against the gray level values. The histogram provides a convenient summary of the intensities in an image. Equalisation is the process that attempts to spread gray level in an image so that they are evenly distributed across their range. Histogram equalization reassigns the brightness values of pixels based on image enhancement. Histogram equalization provides more visually pleasing results.

Adaptive Histogram Equalization (AHE) 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. Adaptive histogram equalization transforms each pixel with a transformation function derived from a neighborhood region. It enhances the contrast of images by transforming the values in the intensity image using contrast-limited adaptive histogram equalization (CLAHE). It operates on small data regions (tiles) and each tile's contrast is enhanced, so that the histogram of the output region approximately matches the specified histogram. The neighboring tiles are then combined using bilinear interpolation in order to eliminate artificially induced boundaries. The contrast, especially in homogeneous areas, can be limited in order to avoid amplifying the noise which might be present in the image.

2.2 DWT

The decomposition of images into various frequency ranges permits the isolation of the frequency into certain sub-bands. This process results in isolating small changes in an image mainly in low frequency sub-band images. The 2D wavelet decomposition of an image is performed by applying 1D DWT along the rows of the image first, and, then, the results are decomposed along the columns. This Decomposition results in four decomposed sub-band images referred to as low-low (LL), low-high (LH), high-low (HL), and high-high (HH). The Haar wavelet was introduced in 1910. It is a bipolar step function. The other wavelets are Daubechies Wavelet, Morlet Wavelet, Mexican Hat Wavelet and Shannon Wavelet.

2.3 DCT

The DCT transforms or converts a signal from spatial domain into a frequency domain. DCT is real-valued and provides a better approximation of a signal with few coefficients. This approach reduces the size of the normal equations by discarding higher frequency DCT coefficients. Important structural information is present in the low frequency DCT coefficients. Hence, separating the high-frequency DCT coefficient and applying the illumination enhancement in the low–frequency DCT coefficient, it will collect and cover the edge information from satellite images. The enhanced image is reconstructed by using inverse DCT and it will be sharper with good contrast.

2.4 SVD

SVD is based on a theorem from linear algebra which says that a rectangular matrix A, which is a product of three matrices that is (i) an orthogonal matrix UA, (ii) a diagonal matrix ΣA and (iii) the transpose of an orthogonal matrix VA. The singular-value-based image equalization (SVE) technique is based on equalizing the singular value matrix obtained by singular value decomposition (SVD). SVD of an image, can be interpreted as a matrix, is written as follows:

$$A = U_A \Sigma_A V_A^T$$

Basic enhancement occurs due to scaling of singular values of the DCT coefficients. The singular value matrix represents the intensity information of input image and any change on the singular values change the intensity of the input image.

The main advantage of using SVD for image equalization, ΣA contains the intensity information of the image.

2.5 Algorithm

In the proposed technique, initially the input image 'A' is processed through AHE to generate 'newA' image. Then the DWT of the orginal image and 'newA' image is taken. After getting this, the LL of both of these images are transformed by DCT into the lower frequency DCT coefficient and higher–frequency DCT coefficient. Then, the correction coefficient for the singular value matrix can be calculated by using:

$$\varepsilon = \frac{max\Sigma_{L\hat{L}_A}}{max\Sigma_{LL}}$$

Where numerator is the lower-frequency coefficient singular matrix of the DWT of satellite input image, and denominator is the lower-frequency coefficient singular matrix of the DWT of satellite output image of the Adaptive Histogram Equalization (AHE). The new satellite image (D) is determined by:

$$\Sigma_{\bar{D}} = \varepsilon * \Sigma_{LL}$$

$$newLL = U_D \Sigma_{\bar{D}} V_D$$

---- is the lower DCT frequency component of the original image that is reconstructed by applying the inverse operation (IDCT) to produce equalized image is …………………………

$$\bar{A} = IDCT(newLL)$$

Then the IDWT of newA with LH HL HH components gives the enhanced image.
The steps is as follows

$$EnhancedImage = IDWT(\bar{A}, LH_A, HL_A, HH_A)$$

1. Divide the image into 4 blocks
2. Apply AHE to the image A to get newA
3. Take DWT of the resultant image and decompose into LL LH HL and HH
   [LL, LH, HO, HH] = DWT (newA)
4. Take DCT of LL component
5. Apply DWT to Orginal Image A and decompose them into LL_A LH_A HL_A HH_A
6. Apply DCT to LL_A
7. Take SVD of the two DCT applied images and take correction coefficient for the singular value
8. Obtain new LL image by multiplying U, correction coefficient, ∑ ,V values from SVD
9. Take IDCT of the LL image to get A
10. Apply IDWT to A image and LH_A HL_A HH_A
11. Combine the 4 blocks of the image to form the original image

2.6 Performance measures

The performance of this method is measured in terms of following significant parameters:

$$Mean(\mu) = \frac{1}{MN}\Sigma_{x=1}^{M-1}\Sigma_{y=1}^{N-1} I(x,y)$$

$$standarddeviation(\sigma) = \sqrt{\frac{1}{MN}\Sigma_{x=1}^{M-1}\Sigma_{y=1}^{N-1}(I(x,y)-\mu)^2}$$

Mean (μ) is the average of all intensity value. It denotes average brightness of the image, where as standard deviation is the deviation of the intensity values about mean. It denotes average contrast of the image. Here I(x, y) is the intensity value of the pixel (x, y), and (M, N) are the dimension of the Image.

RESULT

Mean (μ) is the average of all intensity value. It denotes average brightness of the image, where as standard deviation is the deviation of the intensity values about mean. It denotes average contrast of the image. Here I(x, y) is the intensity value of the pixel (x, y), and (M, N) are the dimension of the Image [6]. The results for the enhancement of satellite images and CT Scans are given in fig 3.1. The visual and quantitative result shows that the proposed method has increased efficiency and flexibility. The resultant images for the enhancement of satellite images are given below fig 3.3, the following resultant images of DWT-DCT-SVD gives the better contrast as well as high image quality.

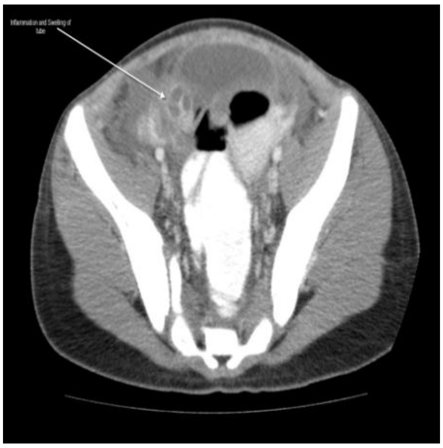

Fig 3.1 Input CT Scan. Image Courtesy[13]

Fig 3.2 Output CT Scan.

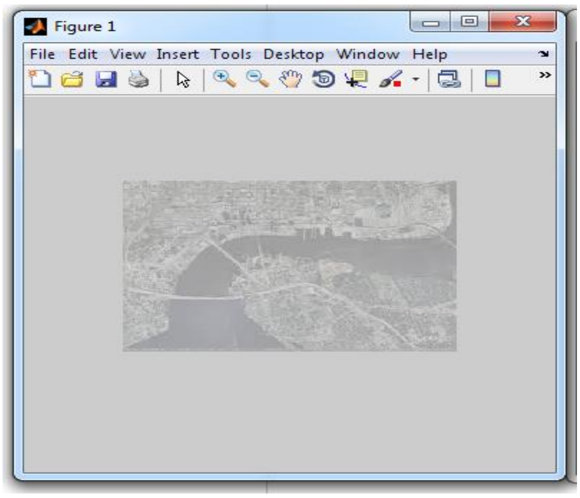

Fig 3.3 Input Satellite Image. Image Courtesy[14]

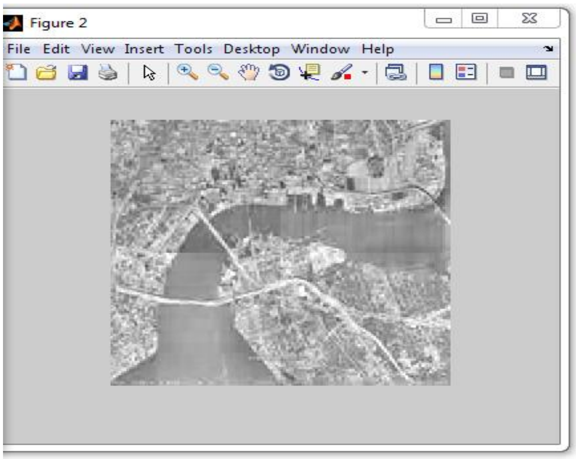

Fig 3.4 Output Satellite Image

The quality of the visual results indicates that the proposed technique is sharper and brighter than existing technique as compared. After obtaining mean and standard deviation, it is found that the proposed algorithm gives better results in comparison with the existing techniques. Mean (μ) represent the intensity of the image and the standard deviation represent (σ) the contrast present in the images. The proposed method represents the better contrast as well as better brightness with appropriate contrast. In order to exhibit the superiority of the proposed methodology two different images have been taken for analysis. The singular values denote luminance of each image layer after decomposition using DWT and DCT methodology. The **Mean** (μ) & **standard deviation** (σ) values are given below for analysis of this result. Here we can observe that the proposed method gives better contrast as well as better brightness than the DWT SVD method.

Table 3.1: Comparison of the results between proposed methodology and already existing technique

	Mean	Standard Deviation
Input Satellite Image	179.0545	12.3043
DWT+SVD	157.0131	11.1123
Proposed Technique	168.5849	29.1964
Input CT Scan Image	88.2227	88.1706
DWT+SVD	90.5319	90.4389
Proposed Technique	94.3802	98.2193

From the Table 3.1 above its clear that the mean and standard deviation of the CT scans have increased significantly and the output image shows increase in visibility. For satellite image mean has decreased but standard deviation has increased.

III. CONCLUSION

In this paper, a new technique has been proposed based on the Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD) and Discrete Cosine Transform (DCT) that means DWT-DCT-SVD domain for enhancement of low-contrast satellite and CT Scan images. As the block decomposition approach is used each block is processed separately thus providing more local enhancement. The basic enhancement occurs due to scaling of singular values of the DCT coefficients of the lower Sub-band of DWT. Performance of this technique has been compared with existing contrast enhancement techniques DWT-SVD based technique. From the above experimental results, it can be concluded that the proposed algorithm is effective in enhancing low contrast images and the visibility improvement. The results show that the proposed technique gives better performance in terms of contrast (variance) as well as brightness (mean) of the enhanced. Thus, this technique can be considered suitable for enhancement of low contrast satellite image and CT Scans.

In future this work can be extended to color images as well. Instead of SVD PCA method can be used for enhancement.

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