Image Contrast Enhancement using DWT-SVD

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Abstract - *In this paper, we have proposed DWT-SVD based contrast improvement of the digital images. The input image contrast is improved by altering intensity information obtained by applying SVD into the original image and the reconstructed approximation coefficient of the input image. The contrast of the image is enhanced by applying mask technique effectively between ISVD and reconstructed approximate, then mask image added with the original image. The proposed approach has tested for ordinary images by measuring its Peak Signal to Noise Ratio (PSNR) and Absolute Mean Brightness Error (AMBE) to check its performance.*

Keywords — *Discrete Wavelet Transformation (DWT), Reconstruction Approximation, Singular Value Decomposition (SVD), Masking function, Inverse Singular Value Decomposition (ISVD)..*

I. INTRODUCTION

Image enhancement is one of the important research areas, it helps to improve the appearance and enhances the finer details of the low luminance image. The transform and spatial domain are the two categories of image enhancement techniques. The transform domain operates on the frequency and spatial domain directly operates on the pixel level of the image [1].

Histogram equalization (HE) is the simple and extensively utilized contrast enhancement technique, it flattens the density distribution and stretches the gray level range of the input image but the drawback of HE is generating annoying art facts and intensity saturation effect [2]. To overcome the drawback several enhancement techniques emerged such as General Histogram Equalization (GHE) [3], Local Histogram Equalization [4], Kim in 1997 proposed the method of Brightness Preserving Bi-Histogram Equalization (BBHE) by calculating its mean gray level of the input image and separate image into two sub-images [5]. In 1999, wan et al proposed Dualistic Sub image Histogram Equalization (DSIHE) by using median values instead of mean of the gray level [6]. Sim et al (2007) proposed the method of Recursive Sub Image Histogram Equalization (RSIHE) in which median-based histogram separation has applied several times [7]. Some of the advancements in the field of HE such as Adaptive Histogram, Automatic Histogram, Selective dynamic histogram Equalization, Threshold optimized histogram equalization [8-10]. Wavelet transformation also widely used in contrast enhancement [11-12]. DWT-SVD and DCT_SVD based enhancement technique apply to Low- Low sub band of DWT and update the illumination information of the image [13-14]. Contrast enhancement achieved by masking technique in which mask is formulated then added with the original image for sharpening input image [15-18].

This paper is organized as follows. Section 2 gives an overview of DWT, reconstruction of approximation and SVD. Section 3 present the proposed methods. Section 4 contains the experiment result and simulated figures. Section 4 gives the conclusion of the algorithm.

II. OVERVIEW OF DWT AND SVD

A. *Wavelet decomposition and Reconstruction of approximate coefficient*

Wavelet transforms based image processing is useful and essential because it's based on small waves called wavelet of varying frequency and limited duration. The most important advantages are performing local analysis that is used to analyse the localized area of a larger signal [19]. The DWT uses dilation and translation property to decompose the image into four sub-band called LL, LH, HL, HH as shown in figure 1. This coefficient deals with the full frequency spectrum of the given image signal. The LL sub band is the low-frequency coefficient contains illumination information and the other sub-bands are high-frequency coefficients [20].

The contrast enhancement was achieved by manipulating its illumination information stored in the LL sub-band. The decomposed approximate coefficients are obtained from equation (1) and reconstructed approximate coefficients are obtained using Inverse Discrete Wavelet Transformation (IDWT) as given in equation (2).

$$W_\varphi(j_0,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\varphi_{j_0,m,n}(x,y) \quad (1)$$

$$f^A_{(x,y)} = \frac{1}{\sqrt{MN}}\sum_m \sum_n W_\varphi(j_0,m,n)\varphi_{j_0,m,n}(x,y), \quad (2)$$

where, $W_\varphi(j_0, m, n)$ is the approximation coefficient, $f(x, y)$ is the input time-domain image with discrete variable x,y with the size M x N. $\varphi_{j_0,m,n}(x, y)$ is the scale function and $f^A_{(x,y)}$ is the reconstructed approximation coefficient[1][21].

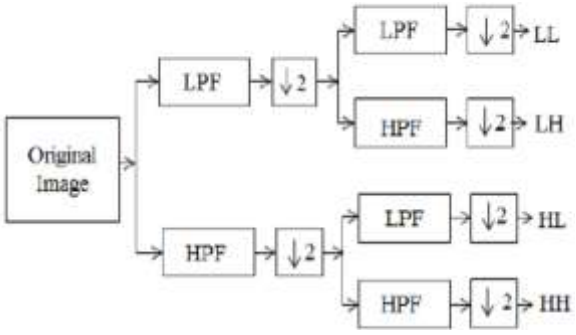

Fig 1. Block diagram of DWT of level 1.

B. *Singular Value Decomposition (SVD)*

The SVD used in the image processing field and is a decomposition of a real and complex matrix. It is the process of data recognizing and organizing, which exhibits most variations [20]. The idea about the SVD is decreasing the higher dimensional, highly changeable set of data onto lesser dimension space that exposes original data structure more smoothly and rearranges its variation on most to least [22]

In SVD single rectangular matrix I decomposed into three product matrices of U, S and V. U and V are orthogonal matrix is known as Hanger and aligner, a column of U are identified as the left singular vector of I matrix, and column of V are a right singular vector of I matrix. S matrix contains the singular value of its diagonal and it does contain intensity information about the input image. Any changes in the S singular matrix will affect the image intensity. The most promising approach to image contrast enhancement is altering the image intensity information store in the S matrix [23].

SVD decomposition as shown in equation (3)

$$I = U \times S \times V \qquad (3)$$

To enhance the image ξ is calculated and new image is obtained by Inverse Singular Value Decomposition (ISVD) as shown

$$NI = U \times \xi S \times V \qquad (4)$$

III. PROPOSED METHOD

The proposed work of contrast enhancement achieved by step by step process of image decomposition and reconstruction approximation coefficient which has been mentioned in section 1. The intensity information is obtained by applying the SVD method has been mentioned in section 2. The SVD is applied to both the original image and reconstructed image, its SVD decompositions are given in the equation (5) and (6)

$$I1 = U1 \times S1 \times V1 \qquad (5)$$

$$I2 = U2 \times S2 \times V2 \qquad (6)$$

Here U1, V1, U2, and V2 are the orthogonal matrices. S1 and S2 are diagonal matrices. To enhance the image ξ is calculated from the diagonal matrices of the original image and reconstructed approximate coefficient matrix as given in equation (7).

$$\xi = \frac{\max(S1) + \max(S2)}{2\ X\max(S1)} \qquad (7)$$

The new image NI is obtained by Inverse singular value decomposition is given in equation (8).

$$NI = U1 \times \xi S1 \times V2 \qquad (8)$$

The masking technique proposed, in which masking formulation is obtained by subtracting inverse singular value decomposition and reconstructed approximation coefficient matrix. This mask image is added with the original image as shown in figure 2, to get output image with improved contrast.

A. *Proposed algorithm step by step computational process*

Step 1: Read the input image

Step 2: Perform DWT to decompose into four sub-band

Step 3: Reconstruction approximation coefficient of LL

Step 4: SVD applied to the original image and reconstructed approximation for getting $U1 \times S1 \times V1$ and $U2 \times S2 \times V2$ then $\max(S1)$ and $\max(S2)$ obtained

Step 5: Calculate ξ by using equation (7)

Step 6: Applying ISVD to generate new image $NI = U1 \times \xi S1 \times V2$

Step 7: Subtract the new image from the reconstructed approximate matrix [mask]

Step 8: Add the mask with the original image to get an enhanced output image.

IV. RESULT AND DISCUSSION

In this section, the performance of the proposed method has analysed and compared with existing histogram equalization methods are HE, BBHE, DSIHE, RSIHE by using the different formats of eight ordinaries tested images: Lena, Woman, Jet, Plane, Cat, Pepper and Elian.

To evaluate the quantitative performance of the proposed method is tested and compared based on Peak Signal to Noise Ratio (PSNR) and Absolute Mean Brightness Error (AMBE) values.

The proposed method enhances the image of small scale details. To check its produced noise artefacts and over enhancement, PSNR value of the enhancement results are calculated using equation (9), PSNR is representing a measure of the peak error between original and enhanced image

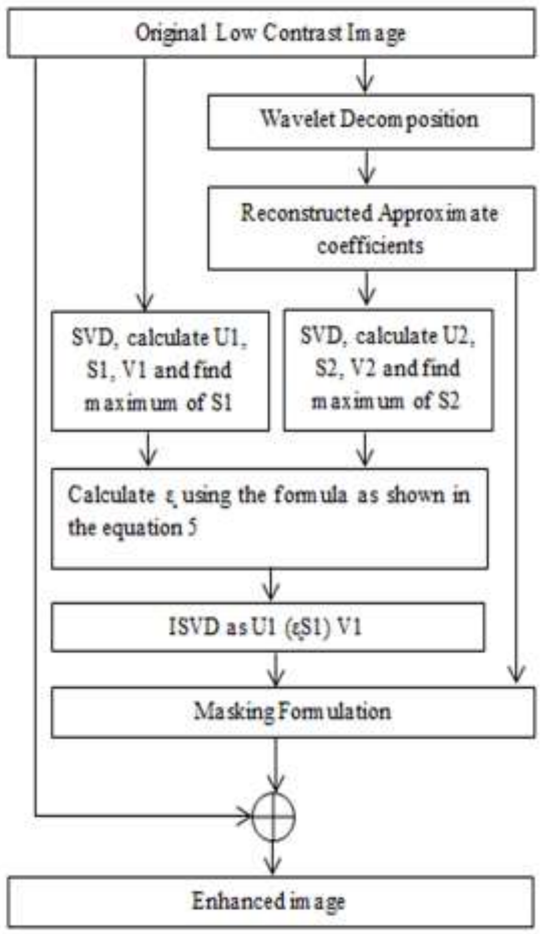

Fig 2. Block diagram of the proposed method

$$PSNR = 10 * log10 \frac{(max\_vlaue \wedge 2)}{MSE} \quad (9)$$

$$MSE = \frac{sum((original\ image - enhanced\ image) \wedge 2)}{MXN}$$

(10)

In table 1, the higher PSNR values show the proposed method better than the existing method for eight tested images.

The performance of the brightness preservation is measured based on AMBE, which define absolute gray level mean between original and enhanced image

$$AMBE = |I_e - \hat{I_e}| \quad (11)$$

Where I_e and $\hat{I_e}$ are green level mean of the original and enhanced image respectively. Table 2, lists of AMBE values compared with existing methods of eight tested images. The proposed method achieved lower AMBE value effectively shows that it preserves its mean brightness [24].

The qualitative results are given in Figures 1, 2 and 3. In figure 1 shows the flow of the proposed algorithm and figure 2 and 3 have seven tested images before and after the contrast enhancement.

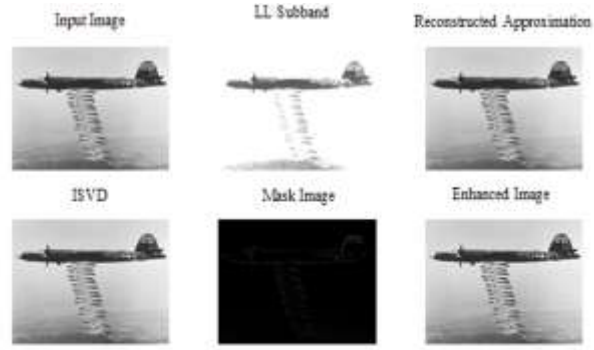

Fig 3. Step by step process of proposed algorithm.

V. TABLE I

PSNR VALUES OF TESTED IMAGES

Images	*HE*	*BBHE*	*DSIHE*	*RSIHE*	*Proposed method*
Lena	16.6746	19.6195	19.3112	24.4033	**31.5710**
Woman	17.8270	17.7926	18.3150	22.6265	**34.0070**
Jet	11.9202	20.6928	16.0345	16.6083	**29.1439**
Plane	10.0494	14.9109	13.2561	13.4218	**28.2622**
Boat	17.9821	18.0720	18.0801	21.7637	**28.5814**
Cat	15.4340	19.1703	18.5818	18.5818	**30.6367**
Pepper	19.2244	19.7440	19.7314	19.8540	**29.8773**
Elain	18.6226	18.7900	18.8154	23.7119	**38.6963**

TABLE II: AMBE VALUES OF TESTED IMAGES

Images	*HE*	*BBHE*	*DSIHE*	*RSIHE*	*Proposed method*
Lena	29.6081	12.7515	13.6411	9.4043	**0.1259**
Woman	15.3867	15.6674	11.0657	9.5363	**0.0742**
Jet	49.7900	6.1260	16.1451	12.0606	**0.1495**
Plane	63.8809	16.9610	27.9712	13.9303	**0.2907**
Boat	20.1950	18.8947	10.1940	4.8315	**0.1261**
Cat	33.2338	11.4700	13.8341	13.9341	**0.1223**
Pepper	12.7117	5.8611	5.9397	5.6704	**0.0361**
Elain	8.1194	4.9531	4.9531	8.1518	**0.1279**

VI. CONCLUSION

In this paper, we presented Image Contrast Enhancement using DWT-SVD based Masking Technique. The proposed approach has higher performance than other state of art enhancement techniques. The proposed method tested for different format ordinary images, in which both quantitative and qualitative performance carried out. The quantitative analysis achieved using PSNR and AMBE measures. The generated enhanced image has good visual quality and performance.

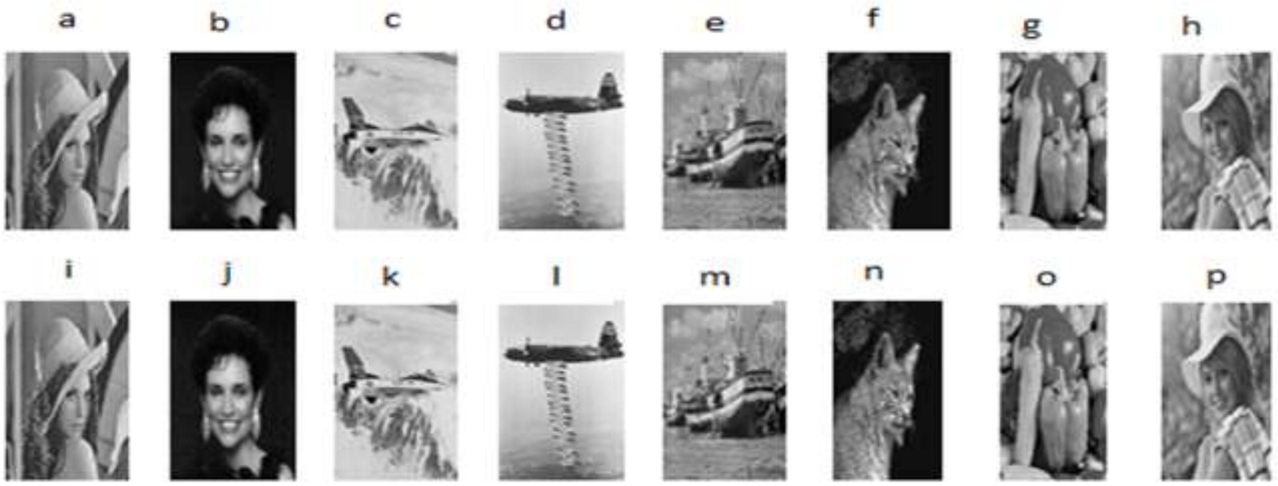

Fig 4: (a-h) input images and (i-p) enhanced images, Lena, Woman, Jet, Plane, Boat, Cat, Pepper, Elain

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