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A DWT-DCT-SVD Based Enhancement Technique for Low Contrast Satellite Images

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Abstract: ***Satellite images are used in many applications such as astronomy, geographical information system and geosciences. They are having narrow range of brightness values and contain low dynamic region of intensity values thus there is a need for enhancement. The paper presents a contrast and brightness enhancement approach based on Discrete Wavelet Transform, Discrete Cosine Transform and Singular Value Decomposition (DWT-DCT-SVD) technique for quality improvement of low contrast satellite images. The input image is decomposed into four frequency sub bands through DWT of each band R, G and B of input image. DCT is applied to LL band of DWT to protect illumination information and then obtains singular value matrix of low frequency components of DCT and finally, it reconstructs the enhanced image by applying IDWT, IDCT and ISVD. Singular value matrix gives intensity information of particular image and any change in singular values directly change in image intensity. The experimental results show superiority of proposed technique in terms of PSNR, MSE, Mean and Variance over other techniques.***

Keywords: Image enhancement, DCT, DWT, SVD, IDWT, IDCT, ISVD, MSE, PSNR, Mean, Variance

1. Introduction

Satellite images used in many fields of remote sensing, geology, ecology, weather forecast, biodiversity conservation, agriculture, etc. [1,2]. When information is transmitted from transmitter to receiver they get distorted from noise or environmental conditions which affect human interpretation and accuracy in measurements of satellite images. Satellite images are of poor contrast due to huge distance and insufficient enlightenment which results to be processed for good contrast image, thus enhancement comes into existence.

Image enhancement is done for highlighting specific features of image or to change a low contrast image to high contrast image [3]. Image enhancement can be done by using techniques like spatial domain and frequency domain [4, 5].

Spatial domain techniques such as digital negative, contrast stretching, image thresholding, logarithmic transformation, gamma correction [6], Histogram Equalization [7], Brightness Preserving Dynamic Histogram Equalization [1], Global Histogram Equalization, Bi Histogram Equalization, Dualistic Sub image Histogram Equalization, DWT-SVD, DCT-SVD [2]. In frequency domain various techniques have been developed for enhancement of gray and colored satellite images it includes filtering, sharpening [5], domains like DCT [8], DWT, SVD-DWT [9], SVD-DCT, Fourier series, Laplace transform. Frequency domain techniques are better than spatial domain techniques [1].

Cosine transform is similar to Fourier transform the only difference is Fourier uses a set of complex exponential functions and cosines uses only real valued function i.e. cosine functions. DCT is efficient in exploiting low frequency components and is mainly used in compression to reduce storage of device and improves transmission efficiency [10]. Wavelets have some advantages over Fourier i.e. temporal resolutions and reducing computations. [11, 12] Wavelet decomposition is used to increase more contrast in the image, [6] allows good localization in time and spatial frequency domain. Singular value decomposition is fast to implement and improves intensity by scaling singular matrix [13].

A new enhancement technique has been introduced by Dr. Muna F. Al Samaraie [14] for enhancing the image of digital cameras that have been modified to enhance global brightness and contrast of the image by preserving its detail. [15] A new technique based on DWT, SWT and Dynamic HE Brightness Preserving. Wavelet transform is used to make high resolution image. The research [16,17] was carried out using different Histogram Equalization technique, due to its simplicity and less expenses it becomes popular for contrast adjustment. HE has a demerit of causing washed out thus BHE [16] is introduced.

A new approach of using multiwavelets with SVD [18] which is superior that DWT-SVD and GHE. Where Multiwavelets separate the input low contrast image into one low frequency sub band and fifteen high frequency sub band then undergoes SVD process to preserve illumination details. In proposed a technique [22] to overcome the problem that occurs in color satellite images that is the dark light and contrast of the image due to the huge distance while capturing image. The input image is processed by GHE. DCT is applied on the input satellite image and equalized image of each band i.e. red, green, blue to extract the best features from low contrast colored satellite image. DCT decomposes the image into low and high frequency

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sub bands and scaling the singular values of low frequency coefficients restore the image by IDCT. The results are more effective, sharper and good contrast. This technique is useful for betterment of the color INSAT and LANDSAT images.

In this paper a new method is introduced based on the use of DWT, DCT and SVD with GHE. Therefore, the aim is to provide a contrast and brightness of low resolution remote sensing images along with their performance measures, a new DWT-DCT-SVD based enhancement technique is introduced which is modified and extended versions of previous works[21,23,24]. In order to enhance image using DWT-DCT-SVD method [21] with adaptive histogram equalization increases flexibility and efficiency for gray image, [23] watermarking for gray images proves robustness of hybrid DWT-DCT-SVD. [24] Results are optimized by cuckoo search with DWT-SVD. In 2011, DCT-SVD is given by using GHE on gray image for contrast enhancement [25] is improved in 2012 using same DCT-SVD with AHE [26]. Various wavelet filters are used to enhance low contrast and brightness of satellite image has been proposed [27], where Meyer filter with GHE-SVD shows better results when compared with other wavelet filters.

This paper presents a combination of three independent methods that is DWT-DCT-SVD for low resolution remote sensing satellite images. This method proves to be robust and more accurate than other conventional and state-of-art techniques. The ability of the method is given by singular matrix obtained by low-low sub band of input image after applying DCT. It contains intensity information, provides sharp image and edges.

This paper focuses on transformation techniques used for image enhancement and is organised as follows. Section 2. gives an overview of DWT, DCT and SVD. Section 3 describes proposed methodology. Section 4 discusses the along with other techniques supported by Mean, Variance, PSNR and MSE. Conclusion and future work are given in Section 5 and Section 6.

2. OVERVIEW OF DWT, DCT AND SVD

This section provides general detail about the techniques used to enhance the low contrast satellite images.

2.1 Discrete Wavelet Transform (DWT)

[28] The DWT is the technique that captures both frequency and location information of an image. The Discrete Wavelet Transform (DWT) is an implementation of wavelet transform that uses a discrete set of wavelet scales. It transforms a discrete time signal to a discrete wavelet representation. It decomposes the input signal using translational and dilation property. It uses low pass and high pass filter banks to find the desire information. For 2-D wavelet decomposition 1-D DWT is applied along the rows of the image and after that results are decomposed along the columns [29]. The result gives four sub bands of image that is low-low (LL), low-high (LH), high-low (HL), high-high (HH). The block diagram of 2-D DWT using filter banks and subbands of DWT for 1-D level and 2-D level are shown below in fig 1 and 2

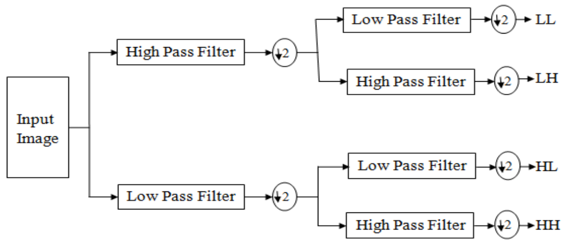
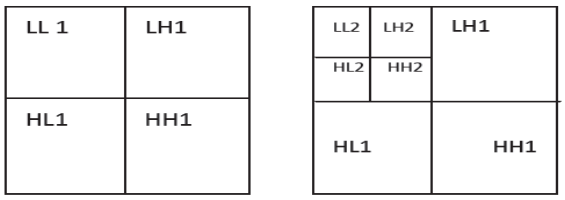


Fig-1: Block Diagram for 2-D DWT Using Filter Banks



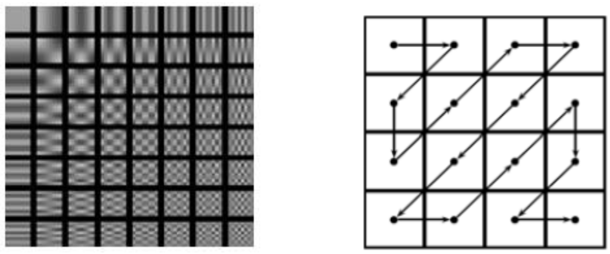
(a) (b)

Fig- 2: (a) Sub-Band of DWT (b) 2-D Level Sub-Bands of DWT

It is easy to implement and reduces the computation time and resources required. It gives more accurate result than DCT and FFT. IDWT function is used to recover the data from given coefficients. [30] The advantages of DWT are fast computation, provides sufficient information of signal, more precise, efficient and accurate. It also suffers from some drawbacks like poor directionality, lack of phase information and translational invariant. The Discrete Cosine Transform (DCT) did not perform well at high compression ratios. It produced severe blocking effects which made it impossible to follow the ridge lines in the fingerprints after reconstruction. This did not happen with Wavelet Transform due to its property of retaining the details present in the data. As compared to DCT, DWT uses more optimal set of functions to represent sharp edges than cosine [10].

2.2 Discrete Wavelet Transform (DCT)

DCT is more commonly used for image compression algorithms [32] as it reduces the number of computational complexities [32]. It is a technique to convert a signal into its frequency components so it works by separating images into parts of different frequencies. It is similar to Fourier transform as both transform the signal from spatial to frequency domain as shown in fig-3 below which provides lower and higher frequency distribution of DCT and shows zigzag distribution from highest to lowest energy coefficients.



(a) (b)

Fig-3: (a) Lower and Higher Frequency Distribution

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(b) Highest To Lowest Energy Coefficients of DCT (Zigzag)

It provides three frequency sub bands these are low frequency sub-band, mid frequency sub-band, and high frequency sub-band. It is efficient for exploiting low frequency sub-bands. High frequency sub-bands are coarsely quantized and reconstruct the quality of image at edges. 1-D DCT is used for processing of speech signals and 2-D DCT for 2 dimensional signals such as images. [9,10] 2-D DCT is done by computing the 1-D DCT of each individual rows of the two dimensional image and then computing 1-D DCT of each column of the image. Important information present at low frequency coefficients thus, separating the high frequency DCT coefficients and apply illumination enhancement at low frequency DCT coefficients. Enhance image is reconstructed by inverse DCT which is sharper and good contrast. IDCT reconstructs a sequence from its DCT coefficients. [26] Mathematically for M*N matrix, transform of x is given as:

$$y(u,v) = \sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}}\,\alpha_u\alpha_v \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} x(m,n)\cos\frac{(2m+1)u\pi}{2M}\cos\frac{(2n+1)v\pi}{2N}$$

(Eq. 1)

Where,

$$\alpha_v = \begin{Bmatrix} \frac{1}{\sqrt{2}} & v = 0 \\ 1 & v = 1,2,\ldots\ldots.N-1 \end{Bmatrix} \&$$

$$\alpha_u = \begin{Bmatrix} \frac{1}{\sqrt{2}} & u = 0 \\ 1 & u = 1,2,\ldots\ldots.N-1 \end{Bmatrix}$$

Reconstructed image by applying IDCT given as:

$$x(m,n) = \sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}} \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} \alpha_u\alpha_v\, y(u,v)\cos\frac{(2m+1)u\pi}{2M}\cos\frac{(2n+1)v\pi}{2N}$$

(Eq. 2)

It has numerous advantages like implementation on single integrated circuit; minimize blocking artifact and ability to pack most information in fewest coefficients.

2.3 Singular Value Decomposition Transform (SVD)

Singular value decomposition method is used to improve the brightness of the image [33] and provides intensity information. It is based on theorem linear algebra that transforms matrix A into product as $U\sum V^T$ which helps to refactoring the digital image in three matrices. Using singular values allows us to represent the image with a smaller set of values, which preserves useful features of original image but uses less space in the memory. It is used for data reduction, feature detection and for enhancement purpose. Image equalization using SVD is done by equalizing singular value matrix. The complete decomposition process is called singular value decomposition (SVD) of image A. Mathematically, it is represented as:

$A = U\sum V^T$

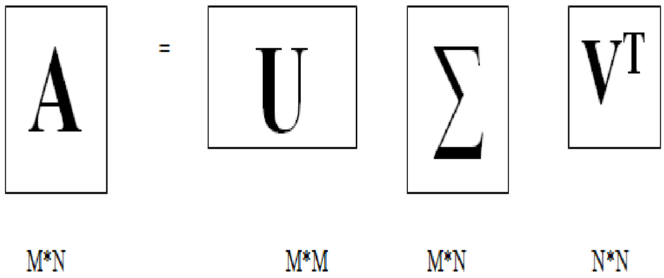

Fig-4: Diagrammatic Representation of SVD Decomposition

$U = [U1, U2,\ldots.., U_M]$, $V = [V1, V2,\ldots..,V_M]$

[34] Where A is matrix with M rows and N columns, U and V^T are orthogonal square matrices known as hanger and aligner. U is called left singular vectors; V is called right singular vectors, T represent transpose of matrix V. $\sum$ is diagonal matrix that contains the sorted singular values and it contains the intensity information of given image. It is robust, simple, easy and fast to implement. It gives good results for image compression and recognition [9].

The method uses the ratio of largest singular value of the generated normalized matrix with zero mean and variance one to a normalized image which can be calculated as

$$\xi = \frac{max(\sum_{N(\mu=0,var=1)})}{max(\sum_A)} \quad \text{(Eq. 3)}$$

By these coefficients equalized image or new singular matrix is regenerated as

$$E_{equalizedA} = U_A(\xi\sum_A)V_A^T \quad \text{(Eq. 4)}$$

Where equalized A is the equalized image termed as A. Singular values provide energy information and distribution.

TABLE 1: BASIC ADVANTAGES AND DISADVANTAGES OF DWT, SVD, AND DCT [29, 33, 31]

Resolution Technique	Advantages	Disadvantages
DWT	Gives Sharper image	Loses high frequency contents
SVD	Improves the brightness of an image	Cannot give clear image
DCT	Uses real computation, better energy compaction, simple hardware	Serious blocking artifacts, truncation of higher spectral coefficients

3. Proposed Methodology

DWT-DCT-SVD based enhancement of Low contrast satellite images: The proposed work of enhancement of low contrast satellite images is carried out by the combination of three robust techniques. These techniques DWT, DCT, SVD are mentioned in section 2. As mentioned in sections 1, that the illumination information is surrounded in LL subband. The edges are concentrated in other subbands i.e. LH, HL, and HH. Therefore applying DCT and SVD at LL subband of DWT protects the necessary information and then the last image is reconstructed by using inverse of DCT. The final satellite image will not only be enhanced with respect to contrast but will also provide brightness and sharper image.

A complete flowchart routine for the proposed method is shown in Fig. 5

The algorithm of the suggested technique is as follows. In the given suggestion, initially the low contrast input multi spectral satellite image 'Ai' is processed by GHE to generate 'Ai ^'. After getting this, both of these images are transformed by DWT into LL, LH, HL, and HH. The DCT is applied for LL band of DWT. After separating DCT components of equalized and direct DWT, on LL sub band of DCT coefficients SVD is applied for the calculation of U, Σ, V and then the max element in U1 and U2 are obtained.

The correction coefficient for the singular value matrix can be calculated by using

$$\xi = \frac{\max(U_1)}{\max(U_2)} \qquad \text{(Eq. 5)}$$

$$New\ \textstyle\sum_{1^\wedge} = \xi(\textstyle\sum 1) \qquad \text{(Eq. 6)}$$

$$Inverse\ of\ SVD = U1(new\textstyle\sum_{1^\wedge})\ V_1^T \qquad \text{(Eq. 7)}$$

After taking inverse SVD, it will reconstruct new LL SVD sub band image. Now, the (new LL SVD, LH, HL, HH) sub band images of the original image are recombined by applying IDCT and IDWT to generate the resultant enhanced satellite image. The mechanism of contrast enhancement can be attributed to scaling of singular values of LL DWT and DCT coefficients. Since, singular values denote luminance of each image layer after decomposition, scaling of these values leads to variation (enhancement) of luminance of each layer and hence, leads to overall contrast enhancement.

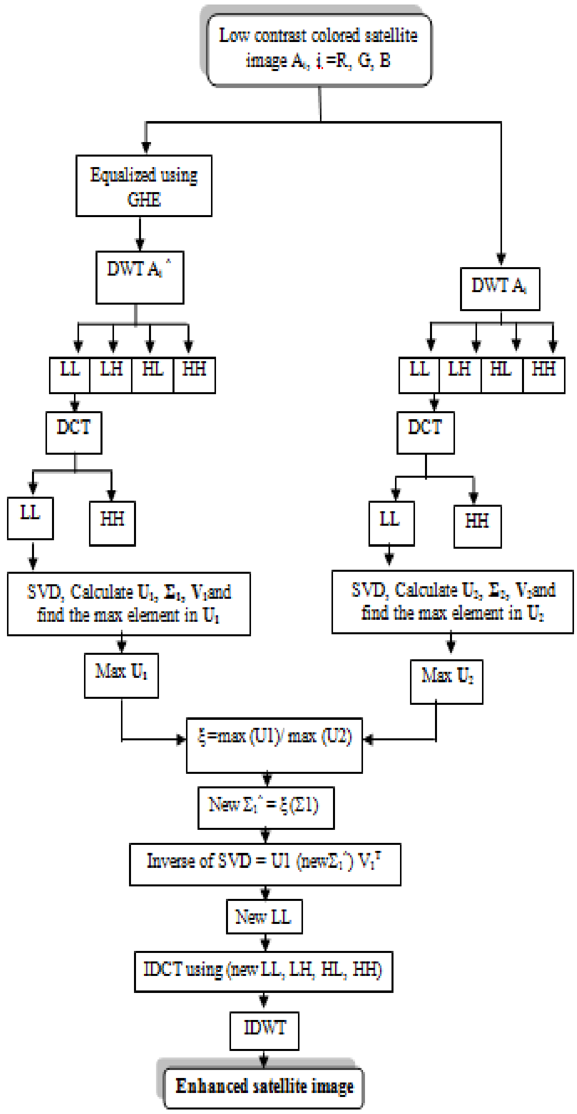

Fig.-5: Block diagram of the proposed DWT-DCT-SVD technique

Following steps are undertaken to explain the process of proposed algorithm:

Step 1: A low contrast multispectral satellite colour image is taken for processing.

Step 2: Equalize the image by using general histogram equalization (GHE) technique.

Step 3: Compute DWT of each band R, G, and B of input image for the contrast enhancement.

Step 4: Sub bands of DWT are created as LL, LH, HL, and HH.

Step 5: After getting equalized DWT component and direct DWT components DCT is applied to LL band of DWT.

Step 6: SVD is applied at low frequency components of DCT for the calculation of U, Σ, V and then max element in U1 from LL and U2 from LL respectively are obtained.

Step7: Calculate ξ using Eq. (5) ξ =max (U1)/ max (U2).

Step8: Compute new Σ1^ using Eq. (6) Σ1^ = ξ (Σ1).

Step9: After computing new Σ1^, apply the inverse of SVD using Eq. (7) Inverse for generation of new LL SVD.

Step10: Apply IDCT using (LL SVD, LH, HL, HH) after getting new LL SVD.

Step11: Apply IDWT

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Step12: Enhanced multispectral satellite image using DWT-DCT- SVD.

4. Results and Discussion

In satellite images rate of information is high thus accurate enhancement of satellite image is demanding. A New technique DWT-DCT-SVD for multispectral satellite images is presented for effective enhancement in which combination of three robust methods are utilized to accomplish better results that exhibits efficiency of their enhanced results in the paper. In this section the execution of GHE, DWT-SVD, DCT-SVD, DCT-DWT-SVD and proposed DWT-DCT-SVD is evaluated for which Mean, Variance, MSE and PSNR parameters are considered. Performance of the method is measured by the following parameters:

Mean: it is the average of all the intensity values. It provides average brightness of the image.

$$mean(\mu) = \frac{1}{MN}\sum_{x=1}^{M-1}\sum_{y=1}^{N-1} I(x,y) \qquad \text{(Eq. 8)}$$

Where, I(x,y) is the intensity value of the pixel (x,y) and M, N are the dimension of the image.

Variance: it is the deviation of the intensity values about the mean. It provides average contrast of the image.

$$Standard\ Deviation(\sigma) = \sqrt{\frac{1}{MN}\sum_{x=1}^{M-1}\sum_{y=1}^{N-1}\{I(x,y)-\mu\}^2}$$
(Eq. 9)

Where, I(x,y) is the intensity value of the pixel (x,y) and M, N are the dimension of the image.

Mean Square Error (MSE): mean square error is the quality measuring parameter which is widely used and is simplest among all other metrics. It is calculated by taking average of the squared differences of the intensities of the original and estimated image. MSE value decreases quality of image increases so it should be as low as possible for effective compression. It is cumulative square error between the encoded and original image defined by:

$$MSE(\alpha) = \frac{\sum_{M,N}[I_1(m,n)-I_2(m,n)]^2}{MN} \qquad \text{(Eq. 10)}$$

Where, I_1 is the original image and I_2 is uncompressed image. M, N is the dimension of the images.

Peak Signal To Noise Ratio (PSNR): PSNR is widely used metric. It is measured in logarithmic scale in decibels (db). By calculating the ratio of maximum signal power to maximum noise power of given image which effects the quality of its representation defined as:

$$PSNR(\beta) = 10\log_{10}\left(\frac{R^2}{MSE}\right) \qquad \text{(Eq. 11)}$$

Where, R^2 is the maximum possible pixel value of the image. For color images with RGB values per pixel PSNR remains same but MSE is the sum of overall squared value differences divided by image size and by three or if color image is converted into different color space and PSNR is find against each channel of that color space. If PSNR value increases quality of image also increases.

Mean signifies the brightness and Variance indicates contrast of image. Higher PSNR signifies better quality of enhanced image. PSNR is a measure of peak error. MSE shows cumulative squared error between enhanced and original image. Lower the value of MSE shows lower error. Different satellite images are comprises to reveal the usefulness of this algorithm. Following are the results of Mean, Variance, MSE and PSNR of five techniques for eight different types of images. The given input image is four low contrast three band INSAT image and four low contrast three band LANDSAT image with different features. The results of implemented techniques together put in tables shown below that clearly shows the superiority of given algorithm for the following images:

A. Image 1

Table 2 shows high mean and variance with less MSE and high PSNR. Input mean and variance of image 1 is 124.0820 and 1.473e+003.

Table 2: Values of parameters for various techniques of image 1

IMAGE 1	GHE	DCT-SVD	DWT-SVD	DCT-DWT-SVD	DWT-DCT-SVD
MEAN	127.4820	130.3930	128.7648	127.905	129.9809
VARIANCE	5.5960e+003	6.018e+003	4.576e+003	5.5670e+03	6.879e+03
PSNR (db)	27.8812	42.4362	43.9727	27.57187	45.8972
MSE	11.11	3.6556	2.6050	114.6305	1.0023

Figure 6 shows the output for various techniques which displays enhanced contrast and brightness between the input image and enhanced images using various techniques and parameters.

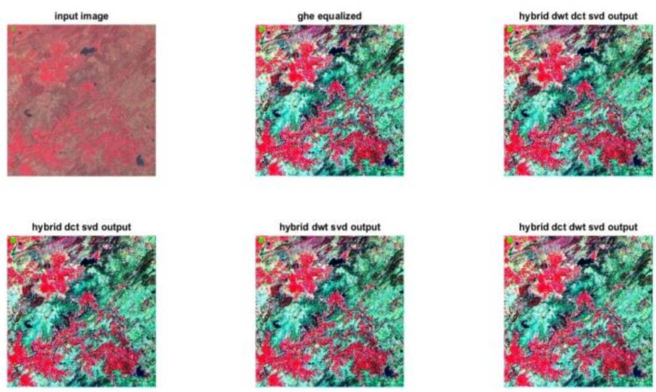

Fig-6: Input image and improved images using GHE, DWT-DCT-SVD, DCT-SVD, DWT-SVD AND DCT-DWT-SVD for image

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B. Image 2

Table 3 shows high mean and variance with less MSE and high PSNR. Input mean and variance of image 2 is 114.8540 and 937.7782.

Table 3: Values of parameters for various techniques of image 2

IMAGE 2	GHE	DCT-SVD	DWT-SVD	DCT-DWT-SVD	DWT-DCT-SVD
MEAN	127.672	144.2394	140.7473	125.6315	133.1298
VARIANCE	5.598e+003	7.508e+003	5.490e+003	5.3897e+03	9.988e+03
PSNR (db)	27.739	42.8017	44.4440	27.7981	45.89982
MSE	104.82	4.3045	2.4533	108.8113	1.8031

Figure 7 shows the output for various techniques which displays enhanced contrast and brightness between the input image and enhanced images using various techniques and parameters.

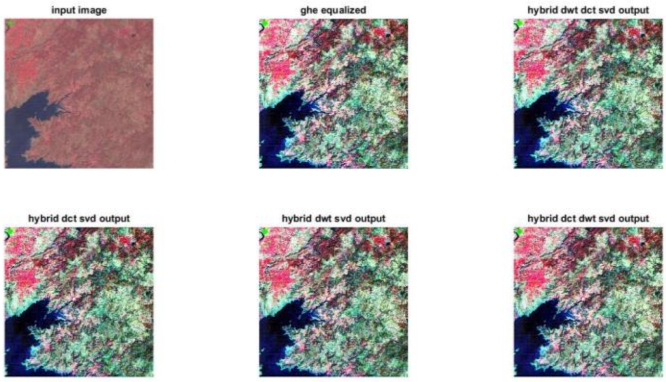

Fig-7: Input Image and Improved Images by using GHE, DWT-DCT-SVD, DCT-SVD, DWT-SVD AND DCT-DWT-SVD for Image 2

C. Image 3

Table 4 shows high mean and variance with less MSE and high PSNR. Input mean and variance of image 3 is 169.0433 and 1.069e+003.

Table 4: Values of parameters for various techniques of image 3

IMAGE 3	GHE	DCT-SVD	DWT-SVD	DCT-DWT-SVD	DWT-DCT-SVD
MEAN	127.577	145.8480	125.6842	126.0049	131.8051
VARIANCE	5.558e+003	7.458e+003	4.394e+003	5.4138e+03	8.959e+03
PSNR (db)	25.267	42.1515	43.3754	25.6874	45.6646
MSE	169.118	4.1458	42.3654	127.517	1.7553

Figure 8 shows the output for various techniques which displays enhanced contrast and brightness between the input image and enhanced images using various techniques and parameters.

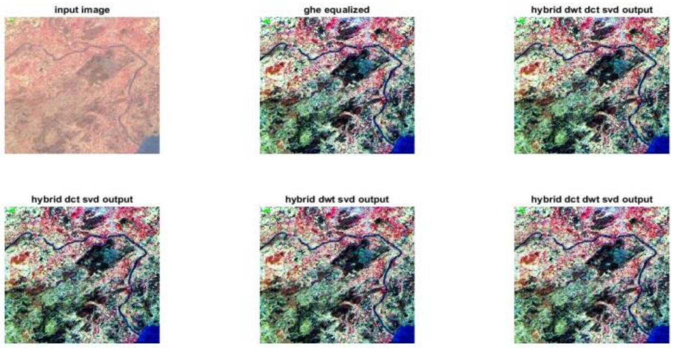

Fig-8: Input Image and Improved Images by using GHE, DWT-DCT-SVD, DCT-SVD, DWT-SVD AND DCT-DWT-SVD for image 3

D. Image 4

Table 5 shows high mean and variance with less MSE and high PSNR. Input mean and variance of image 4 is 188.4100 and 1.381e+003.

Table 5: Values of parameters for various techniques of image 4

IMAGE 4	GHE	DCT-SVD	DWT-SVD	DCT-DWT-SVD	DWT-DCT-SVD
MEAN	128.824	109.5149	134.8720	126.5139	135.4431
VARIANCE	5.873e+003	4.367e+003	4.679e+003	5.5308e+03	1.844e+03
PSNR	25.351	42.200	43.667	25.279	45.999
MSE	185.376	3.9168	30.1761	194.306	1.2268

Figure 9 shows the output for various techniques which displays enhanced contrast and brightness between the input image and enhanced images using various techniques and parameters.

Fig-9: Input Image and Improved Images by using GHE, DWT-DCT-SVD, DCT-SVD, DWT-SVD AND DCT-DWT-SVD for Image 4

E. Image 5

Table 6 shows high mean and variance with less MSE and high PSNR. Input mean and variance of image 5 is 134.3337 and 1.570e+003.

Table 6: Values of parameters for various techniques of image 5

IMAGE 5	GHE	DCT-SVD	DWT-SVD	DCT-DWT-SVD	DWT-DCT-SVD
MEAN	127.460	151.1095	119.6784	125.0351	142.0435
VARIANCE	5.593e+003	8.961e+003	4.610e+003	5.2902e+03	1.308e+03
PSNR (db)	26.955	43.9643	40.4032	26.7373	48.0014
MSE	134.18	3.2869	5.9260	137.958	1.0173

Figure 10 shows the output for various techniques which displays enhanced contrast and brightness between the input image and enhanced images using various techniques and parameters.

Fig-10: Input Image and Improved Images by using GHE, DWT-DCT-SVD, DCT-SVD, DWT-SVD AND DCT-DWT-SVD for Image 5

F. Image 6

Table 7 shows high mean and variance with less MSE and high PSNR. Input mean and variance of image 6 is 95.5495 and 3.245e+003.

Table 7: Values of parameters for various techniques of image 6

IMAGE 6	GHE	DCT-SVD	DWT-SVD	DCT-DWT-SVD	DWT-DCT-SVD
MEAN	127.559	136.2362	133.4787	126.0931	140.2562
VARIANCE	5.603e+003	6.712e+003	5.479e+003	5.4514e+03	8.872e+03
PSNR (db)	30.157	49.5645	49.5058	30.0316	53.1263
MSE	62.1498	0.7188	0.7286	65.0608	0.3994

Figure 11 shows the output for various techniques which displays enhanced contrast and brightness between the input image and enhanced images using various techniques and parameters.

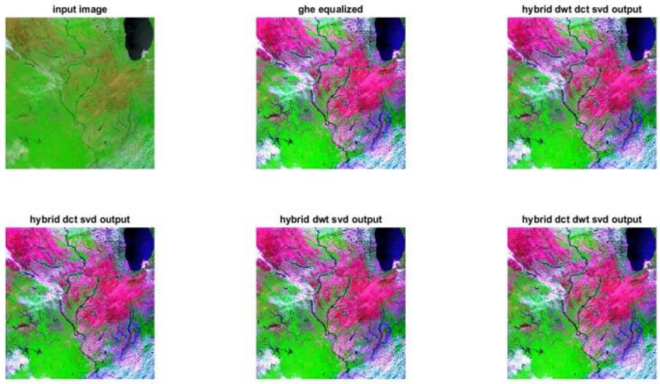

Fig-11: Input Image and Improved Images by using GHE, DWT-DCT-SVD, DCT-SVD, DWT-SVD AND DCT-DWT-SVD for Image 6

G. Image 7

Table 8 shows high mean and variance with less MSE and high PSNR. Input mean and variance of image 7 is 179.5113 and 2.434e+003.

Table 8: Values of parameters for various techniques of image 7

IMAGE 7	GHE	DCT-SVD	DWT-SVD	DCT-DWT-SVD	DWT-DCT-SVD
MEAN	127.464	128.0500	119.8880	124.7802	150.1966
VARIANCE	5.572e+003	5.704e+003	4.764e+003	5.2919e+03	7.786e+03
PSNR	25.123	43.1583	40.3139	24.9918	46.898
MSE	198.901	3.2155	6.1490	207.635	1.1269

Figure 12 shows the output for various techniques which displays enhanced contrast and brightness between the input image and enhanced images using various techniques and parameters.

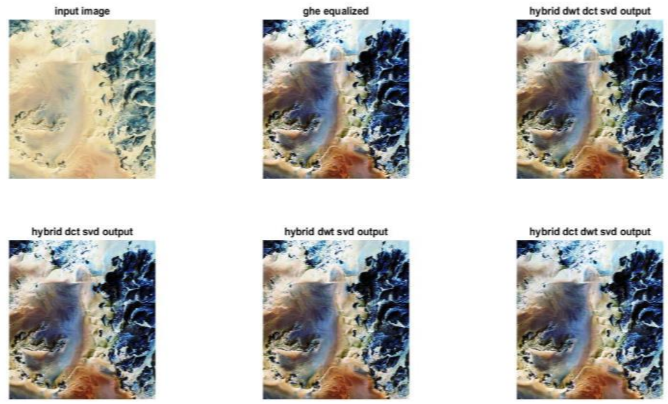

Fig-12: Input Image and Improved Images by using GHE, DWT-DCT-SVD, DCT-SVD, DWT-SVD AND DCT-DWT-SVD for Image 7

H. Image 8

Table 9 shows high mean and variance with less MSE and high PSNR. Input mean and variance of image 8 is 108.4103 and 1.719e+003.

Table 9: Values of parameters for various techniques of image 8

IMAGE 8	GHE	DCT-SVD	DWT-SVD	DCT-DWT-SVD	DWT-DCT-SVD
MEAN	127.506	126.1237	125.5332	126.4969	134.8141
VARIANCE	5.593e+003	5.594e+003	4.748e+003	5.5114e+03	7.900e+03
PSNR (db)	29.731	43.9801	45.6989	29.3217	47.8721
MSE	69.1829	2.6006	1.7506	76.6147	0.7218

Figure 13 shows the output for various techniques which displays enhanced contrast and brightness between the input image and enhanced images using various techniques and parameters.

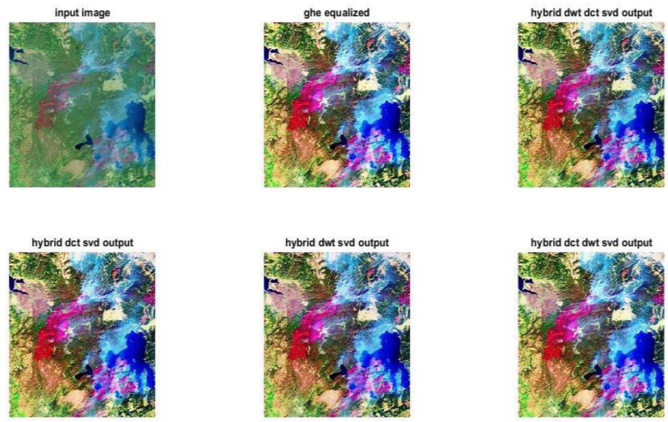

Fig-13: Input Image and Improved Images by using GHE, DWT-DCT-SVD, DCT-SVD, DWT-SVD AND DCT-DWT-SVD for Image 8

There are various methods used for image contrast and brightness enhancement i.e. GHE, DWT-SVD, DCT-SVD, DCT-DWT-SVD for comparison purposes with the proposed DWT-DCT-SVD technique shows in tables 2-9. Figures 6-13 shows low contrast input image is equalized by GHE, DWT-SVD, DCT-SVD, DCT-DWT-SVD and the proposed DWT-DCT-SVD technique. Given algorithm gave good MSE, PSNR, Mean and Variance for all methods and sample images.

The values of above table 2-9 shows advantage of proposed technique over other techniques.

5. Conclusion

In this paper, improved technique is based on combinations of techniques is applied in order to find best method that can be followed for preserving the necessary information of image for enhancement. Format for image used is JPEG and even dimensions. The analysis of all the obtained experimental results demonstrates that the proposed technique gives best results for brightness and contrast of all mentioned images. DWT-DCT-SVD has high PSNR value and less MSE that is low noise in image. DWT-DCT-SVD technique gives more precise results that show apprehensive improvement for low resolution remote sensing images. In the proposed technique basic enhancement is done by scaling of singular values of low sub bands of DWT and DCT coefficients after normalizing the singular value matrix; the enhanced image is reconstructed using inverse of DWT and DCT.

6. Future Work

In future work, the proposed enhancement technique will combine with bio-inspired algorithms for optimization of results. By applying metaheuristic algorithm problem can be optimized for better quality and results of an image in terms of contrast and brightness. Cryptography and Stegnography can be used along with image enhancement technique for safe and secure transmission of data. By using AHE instead of GHE and interpolation techniques better results may found.

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