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Satellite Image Contrast Enhancement Using Lifting Wavelet Transform and Singular Value Decomposition

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ABSTRACT: In this paper, Lifting Wavelet Transform (LWT) and Singular Value Decomposition based technique for satellite contrast enhancement has been proposed. In this methodology using LWT the input image decomposes into four frequency sub-bands and the singular value matrix of the low-low sub-band image is predictedimage and after that the improved quality image is rebuilt by employing inverse LWT. This methodology is then compared with local histogram equalization and standard general histogram equalization which are techniques of conventional image equalization ,also the state of the art techniques such as brightness preserving dynamic histogram equalization and singular value equalization. The experimental outcomes illustratesthe excellence of proposed method extending conventional and state of the art techniques.

KEYWORDS: Lifting wavelet transform, image equalization, satellite image contrast enhancement.

I. INTRODUCTION

In many applications alike geographical information systems ,geosciences studies, and astronomy satellite images are required and used. In satellite images their contrast is referred as utmost significant quality factor. Several of the satellite images persist with low contrast, blur impact and noisy data in it . In image processing contrast enhancement of the captured satellite image is oftentimes stated as the most important issue. The contrast is formed by variance in luminance reflected from two contiguous surface. The visual system of human is extra sensitive to the contrast than consummate luminance. So in visual acuity, the variance in the color and brightness of an object with other objects determines the contrast.

There is a chances of information loss of the extremely and unvaryingly concentrated area , if the contrast of captured satellite image is exceedingly concentrated on a precise range. The issue is to augment the contrast of an image in form to represent all the information in the input image. The quite a few techniques are there to beaten up this problem [1]-[4], just as local histogram equalization (LHE) and general histogram equalization(GHE). The outcomes can also be calculated with two techniques of state-of-art named as singular value equalization (SVE) [5] and brightness preserving dynamic histogram equalization (BPDHE) [6].

In numerous image processing applications, for contrast enhancement the GHE technique is referred as one of the uncomplicated and utmost impressive fundamental [7], which pursuit to produce an outcome histogram that is in variable[8]. The information rested on the histogram or probability distribution function (PDF) of the image will be lost is drawback of GHE. The PDF off ace images can be used for face recognition is explained by Demirel and Anbarjafari[9], therefore conserving the form of the PDF of an image is of vigorous important. To conserve the general pattern of the PDF of image there are few techniques which can used BPDHE or SVE. From dynamic histogram specification [10]BPDHE is gained that helps to produces the described histogram dynamically from the input image.

The singular-value-based image equalization (SVE) method [6], [9] is grounded on equalizing the singular value matrix attained by singular value decomposition (SVD). The image's SVD can be construed as a matrix, which is inscribed as follows:

$$A = U_A \Sigma_A VAT \qquad (1)$$

Here U_A and V_A are orthogonal square matrices recognized as hanger and aligner, correspondingly, and the $\sum_A$ matrix encompasses the sorted singular values on its main diagonal. The main inkling of using SVD for image equalization derives from this fact that ΣA holds the intensity information of a given image [11].

In previous slog [6], [9], SVD was avail to deal with an illumination issue. That method customs the ratio of the largest singular value of the generated normalized matrix, with mean zero and variance of one, done with a normalized image which can be computed conferring to

$$\xi = \max(\sum N\ \mu=0, var=1) \max(\sum A) \qquad (2)$$

Here $\Sigma_{N(\mu=0,var=1)}$is the singular value matrix of the synthetic intensity matrix. This coefficient is used to rebuilt an equalized image using

$$\Xi_{equalized\ A} = U_A(\xi \Sigma_A) VAT \qquad (3)$$

Here $\Xi_{equalizedA}$ is depicting the equalized image A. This work is removing the illumination issue.

At the present time, in image processing wavelets are frequently used, which is avail for denoising[12], face recognition[13], satellite image super-resolution [14], feature extraction[15], and compression [16]. The disintegration of images into distinct frequency bands consent the desolation of frequency fundamental popularized by "extrinsic factors" within assertive sub-bands [17]. This procedure outcomes in desolating cramped changes of an image in high frequency sub-band images. Thus, Lifting Wavelet Transform (LWT) is convenient technique to be worth for scheming a pose invariant face recognition system. The 2D wavelet decomposition of an image is perform by applying 1D wavelet transform first on the rows of image and then results are decomposes along the columns. The image is divided into four sub-band images as low-low(LL), low-high(LH), high- low(HL), high-high(HH). The frequency Components of the original image is covered by the frequency components of those sub-band images
The filter bank shows in Fig.1.

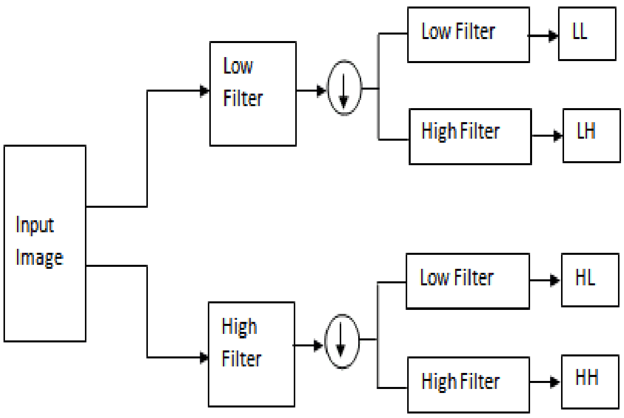

Fig.1 Filter Bank

In this paper, a new technique for satellite equalization is proposed which is an extent of SVE, and the technique is situated on the SVD of an low-low(LL) sub-band image which is gained by LWT. LWT helps to detached the low contrast input satellite image into distinct frequency sub-band, Where the low-low(LL) sub-band focusses the illumination information. Because of this only low-low(LL) sub-band undergo through the SVE procedure, which conserves the high-frequency components (i.e., edges).Hence, afterward inverse LWT (ILWT), the conclusion image will be shriller with respectable contrast. In this work, the anticipated process has been related with the conventional GHE technique in addition to LHE and state-of-the-art techniques for example BPDHE and SVE. The outcomes specify the dominance of the anticipated process over the aforementioned methods.

II. PROPOSED IMAGE CONTRAST ENHANCEMENT

LWT-BASED CONTRAST ENHANCEMENT

Previously it was mentioned that the contrast of an image is an important feature in satellite image, which makes the contrast enhancement of satellite image to be of vital importance as the abnormal that is excess contrast of an image will directly affect the information of image i.e. there is high chances of information loss.In this paper, LWT has been used in order to sustain the high frequency component of the image. LWT segregate the input image into different sub-band frequency images such as LL,LH,HL, and HH. The output image will not only be improved with contrast but also will be sharper after reconstructing the image by applying ILWT.

There are mainly two parts of the proposed method, first is the use of SVD. The illumination information is encapsulated in the singular value matrix which is obtained by SVD. That's why the small change in singular value will directly affects the illumination of the image. The second part is LWT. The illumination information is encapsulated in the LL sub-band image. The edges are concerted in other sub-band i.e. LL,LH,HL,HH. Applying the illumination enhancement in the LL sub-band and the segregation of high frequency sub-band only will defend the information from degradation. Afterwards rebuilding the final image via ILWT, the consequential image will not only be improved with respect to illumination but also will be shriller.

The rough procedure of the defined technique is as follows:

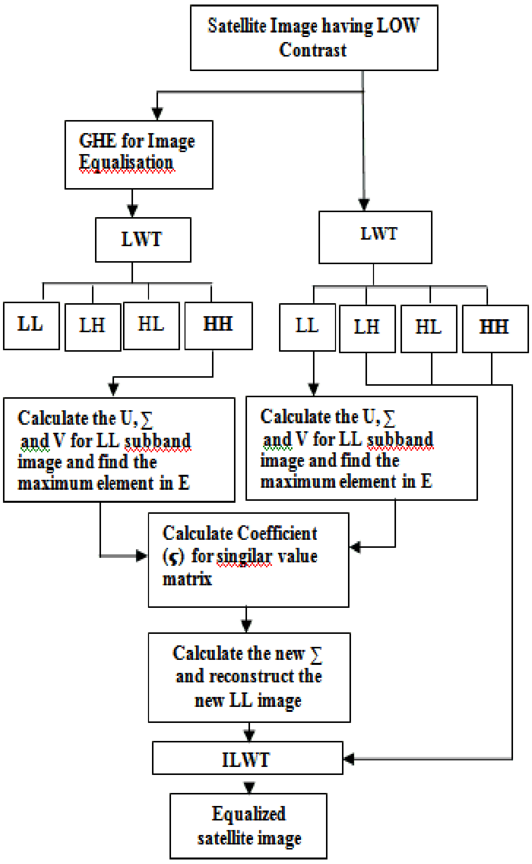

Fig. 2 Steps of Equalization Technique

Step 1 : First of all with the help of GHE the input image A will be processed to generate new image A.

Step 2: After that both images are transformed by LWT into four sub-band images.

Step 3: By using mentioned formula the correction coefficient for singular value matrix is calculated.

$\zeta = \max(\sum LLA)\max(\sum LLA)$ (4)

Here. $\sum_{LLA}`$ = LL singular value matrix of output of GHE.

$\sum_{LLA}$ = LL singular matrix of input image.

Step 4 :The new LL image is composed by

$$\sum_{LLA} = \zeta \sum_{LLA}$$

$$LL_{A} = U_{LLA} \sum_{LLA} V_{LLA} \quad (5)$$

Step 5: Now, to generate final equalized image Athe LL_A, LH_A, HL_A, and HH_Asub-band images are recombined by applying ILWT.

$$A = ILWT\ (LL_A, LH_A, HL_A, HH_A) \quad (6)$$

In this letter, the db.9/7 wavelet function is used as the main function of the LWT.

Lifting Wavelet Transform Process

The wavelet ananlysis is new algorithm which developed in recent years. The lifting wavelet transformation's basic arithmetic is through a female wavelet / lazy wavelet to construct new better image. It has three different steps as follows: Split , Predict and Update.

1.Split : Decompose input signal into two subset that do not intersects mutually S_{j-1} and D_{j-1},

$$F (S_j) = (S_{j-1}, D_{j-1}).$$

2. Predict : In the view of relevant data , available S_{j-1} precognise D_{j-1} . So be premitted to use one uncreative precognised operatore P , fulfilled $d_{j-1} = P(S_{j-1})$, like this to be allowed to use the child data set Sj . If replaces D_{j-1} and the precognised subset $P(S_{j-1})$, then this distinction revert both approach degree. If precognised is fair then the difference data set involve information is lower than the information of premitive subset $D_{j-1.}$ Precognised processing is as folllows:

$$D_{j-1} = D_{j-1} - P(S_{j-1})$$

3.Update : As disintegrate the subset , original set it looses some characteristtics , produce the subset data and original set data that have same characteristics likewise has a superior sub data set S_{j-1} over operator U, compose it to preserve original dataset S_j some characteristics. The definition of $S_{j-1}$is as follows :

$$S_{j-1} = S_{j-1} + U (D_{j-1})$$

The recreating data build up formula is as same as the disintegrating formula , Only the change in computation order is needed : $S_{j-1} = S_{j-1} – U (D_{j-1})$

$D_{j-1} = D_{j-1} + P(S_{j-1})$

$$S_j = Merge (S_{j-1,} D_{j-1})$$

Merge is the consolidation that uses the splitted subset S_{j-1} and D_{j-1} to recreate, redevelop initial signal.

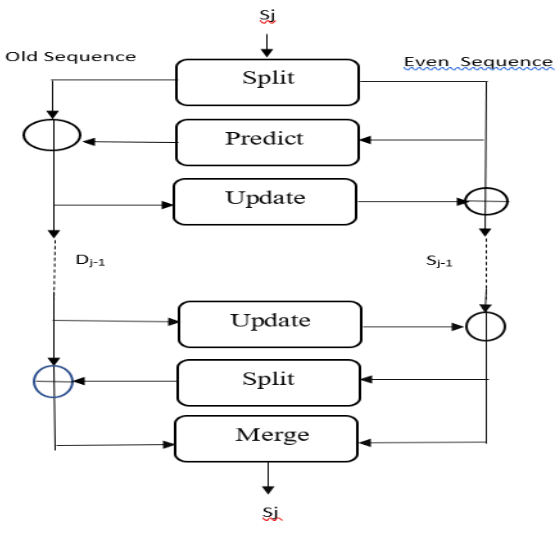

Fig. 3 LWT Algorithm Diagram

In the succeeding sector, the experimental outcomes and the evaluation of the aforementioned conventional and state-of-the-art techniques are deliberated.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

Figs. 4(a) illustrates the low-contrast images seized from some aerospace and geosciences resources declared in the acknowledgment segment. This image been shown inRed Green Blue color band[Figs.4(b),4(c)4(d)],[Figs.4(e), 4(f), and 4(g)] has been equalized by GHE, Fig 4(h),4(i) is by proposed technique. The superiority of the visual outcomes specifies that the planned equalization method is shriller and brighter than the image accomplished by using PDHE, SVE, GHE, and LHE. The resulting image produced by BPDHE is analogous with the image completed by the anticipated technique.

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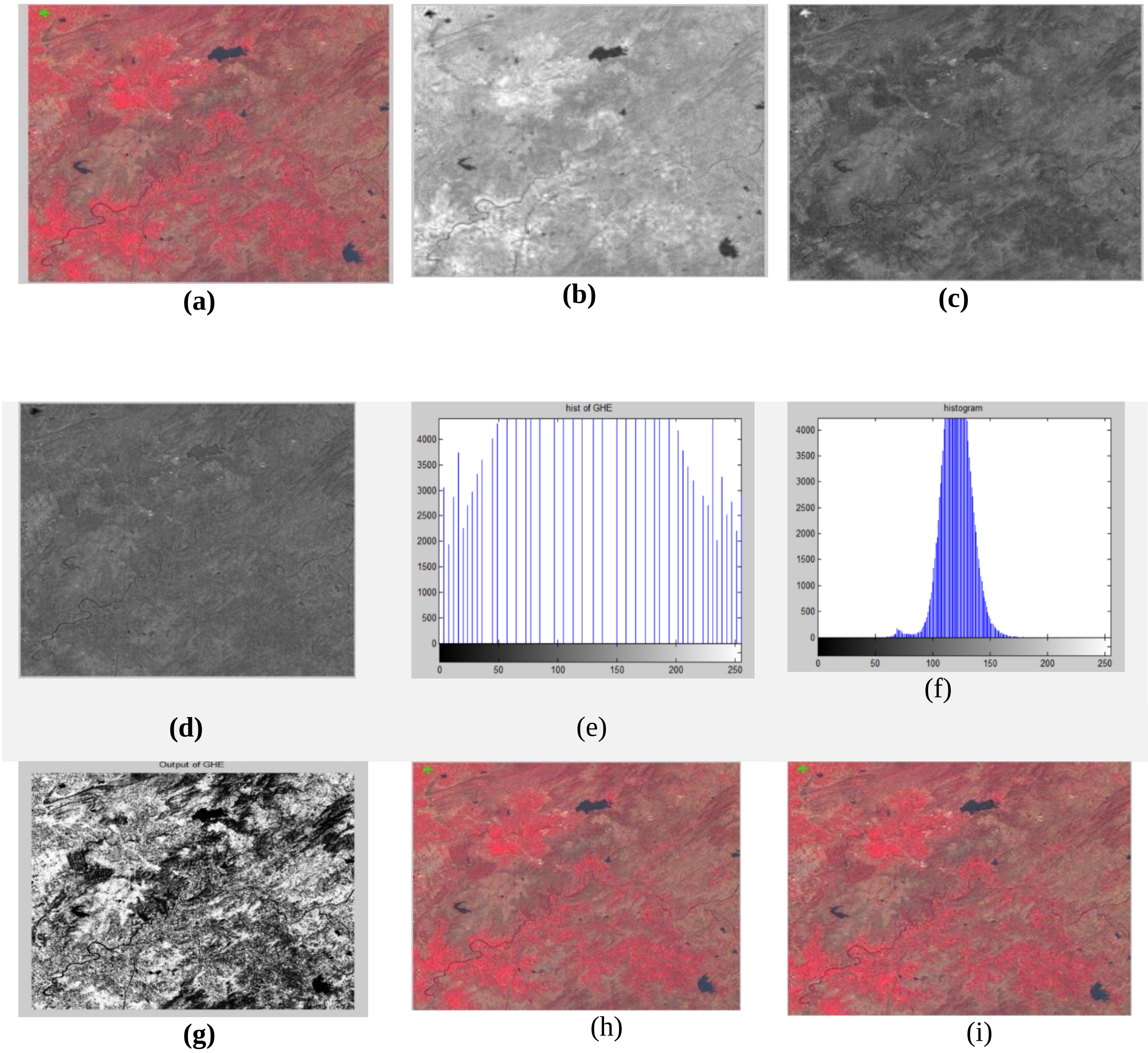

Fig:4 (a) Original low contrast image.Equalised image by using (b)Red Color Band (c) Blue color band (d) Green color band (e) GHE Hist.. (f) GHE (g) GHE Image (h) DWT (i) Proposed Technique

Fig. 4.: (a) (b) (c) (d) show the low contrast satellite images. These images have been equalized by using GHE [Figs. 4.1: (e) (f) (g) (h)] , DCT-SVD [Figs. 4.2:(i) (j) (k) (l)], DWT-SVD [Figs4.3 (m) (n) (o) (p)] and the proposed equalization technique LWT-SVD [Figs. 4.4 (q) (r) (s) (t)]. Proposed algorithm is giving good mean value and minimum standard deviation, same as PSNR and MSE are also indicating comparatively maximum and minimum values for all the 4 sample satellite images, and also it is tested to many more low contrast satellite images. The performance in terms of visual aspect is also better than the GHE, DCT-SVD and DWT-SVD. The satellite images used is of different sizes and different contrast level.

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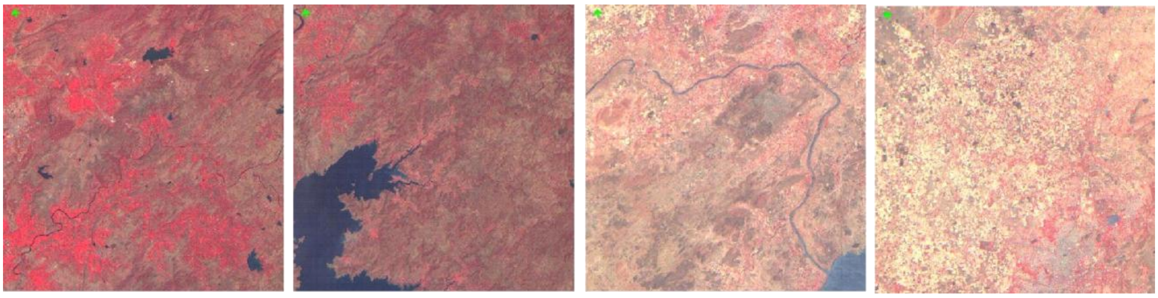
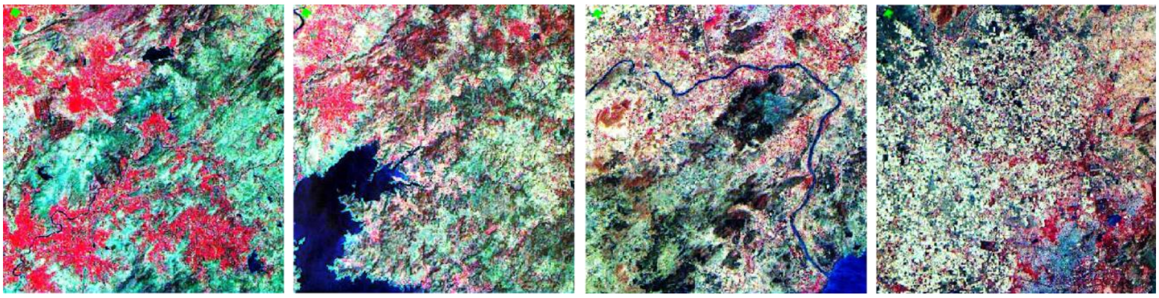


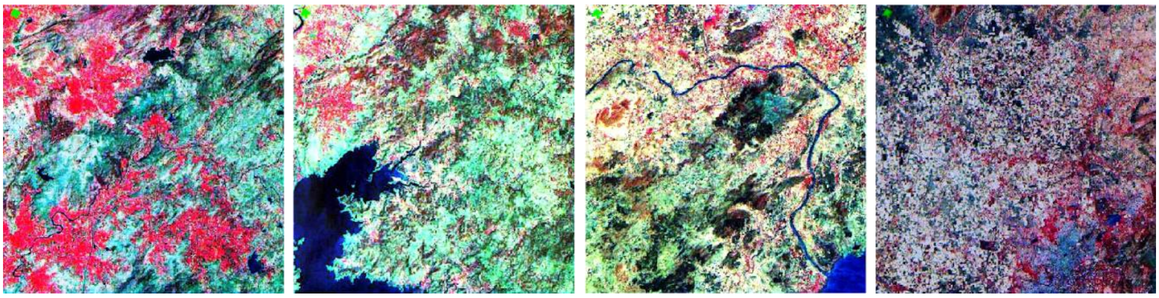
(a) (b) (c) (d)

Fig 4.: Input low contrast image (a) - (d)



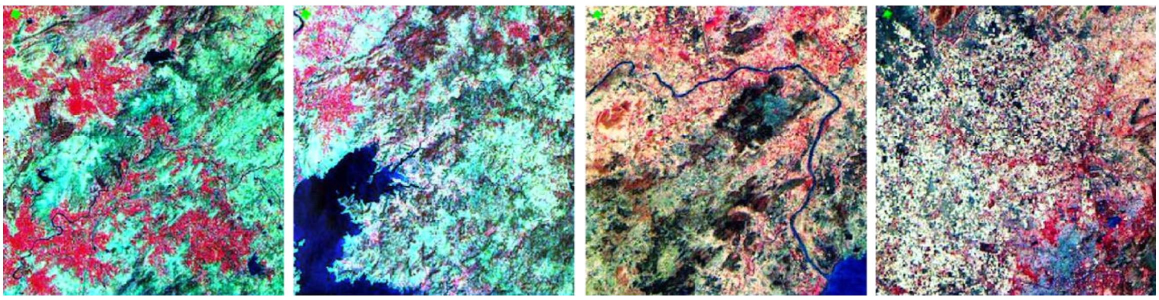
(a1) (b1) (c1) (d1)

Fig 4.1: Equalised images by GHE (a1) - (d1)



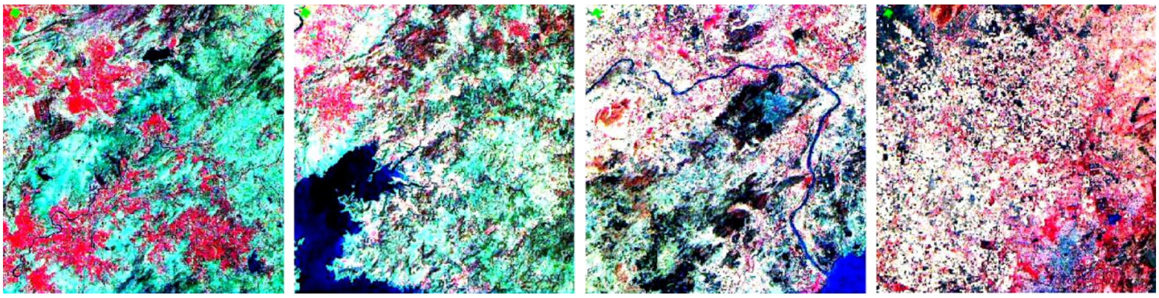
(a2) (b2) (c2) (d2)

Fig 4.2: Enhanced images by DCT-SVD (a2) - (d2)



(a3) (b3) (c3) (d3)

Fig 4.3: Enhanced images by DWT-SVD (a3) - (d3)



(a4) (b4) (c4) (d4)

Fig 4.4: Enhanced images by LWT-SVD (a4) - (d4)

Experiments have been completed on over 100 haphazardly certain images from numerous sources which confirmed the approximate outcome. In order to backing the approximate inferences on the dominance ofthe anticipated technique,a measurable analysis is essential. However, when the crushed certainty that signifies the original image is mislaid, a measurable error analysis on the enhanced image is not possible.

IV. CONCLUSION

In this paper, for satellite image contrast enhancement new technique is proposed based on LWT and SVD. In this technique the input image is decomposes into LWT four sub-band (LL,LH,HL,HH) and upgradation of the singular value matrix of LL sub-band is done. After that reconstruction of an image is done by applying ILWT. The proposed technique is differentiated with GHE, LHE, BPDHE and SVE techniques. The final result shows the supremacy over the all previously defined techniques..

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