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Low resolution satellite Images contrast Enhancement Using Regularized-Histogram Equalization and DCT

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Abstract: **-- In this research paper, an efficient enhancement technique is used for remote sensing images, to improve the global contrast and the local details. The proposed method constitutes an empirical approach by using the regularized-histogram equalization (HE) and the discrete cosine transform (DCT) to improve the image resolution. First regularized - histogram equalization is applied to Low resolution satellite image. This technique uses sigmoid function and histogram equalization to generate distribution function for low resolution image. This gives global contrast enhancement of image details. Second, the DCT coefficients of the previous contrast improved image are automatically adjusted to further enhance the local details of the image. Compared with conventional methods, the proposed method can generate enhanced remote sensing images with higher contrast and richer details without introducing saturation artifacts. This technique has better performance compared to conventional DWT technique.DWT generates artifacts, which is major drawback. Proposed technique is applied on NOAA-19-HRPT satellite images. The quantitative PSNR, RMSE, and CC are calculated for satellite portraits which has superior performance compared to conventional DWT technique.**

Index Terms **— Contrast enhancement, discrete cosine transform (DCT), histogram, image enhancement, discrete wavelet transform (DWT), remote sensing.**

I. INTRODUCTION

Now a day's high quality of remote sensing images is becoming very important. Image processing has many applications such as remote sensing, biomedical imaging, agriculture monitoring, land erosion, video surveillance, disaster management, glacier monitoring, and weather forecasting. The undesirable environmental conditions reduce the contrast and the hidden details of the captured remote sensing images. Since contrast is an important quality factor in remote sensing images [1], therefore, contrast enhancement techniques are required for better information representation and visual perception. An image is composed of pixels which mean picture elements. Image is composed of matrix. The coefficients of matrix are changed according to our requirement.

Contrast enhancement techniques are divide into 2 categories, i.e., Frequency domain technique and spatial domain technique. Histogram equalization is one of the spatial domain techniques, which is a simple and effective. The main disadvantage of HE algorithm is artifacts are added and harsh image is produced at the output. To avoid this drawbacks, some histogram-based algorithms in spatial domain are proposed i.e., brightness-preserving dynamic HE [3] and histogram modification frame work [4]. Both these algorithms reduces over enhancement to the maximum extent and gives good histogram. But details not prominently emphasized. Next another contrast enhancement technique is proposed which is known as adaptive gamma correction with weighting distribution (AGCWD) [5]. This method also introduces saturation artifacts and loss of details in bright regions. So 2-D histogram based algorithms are produced [6]-[8], which are very expensive, hence not preferred.

Transform-domain methods decompose an input image into different sub bands and enhance the contrast by modifying specific components [6]. In [9], a singular value equalization method is proposed to adjust the image brightness. This method is further improved by combining with discrete wavelet trans-form in [1] to achieve better contrast enhancement results. Another method, which uses discrete wavelet transform and adaptive intensity transformation to enhance the contrast of re-mote sensing images, is proposed in [10]. This method requires appropriate settings of the associated parameters, which makes it unfit for practical use. A sub band decomposed multi scale retinex method combined with a hybrid intensity transfer function is introduced in [11] to enhance the optical remote sensing images. In [12], a general illumination normalization method for multiple remote sensing images is proposed. This method first enhances the contrast in the gradient domain and then

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equalizes the singular value to adjust the brightness. However, contrast and details are not obviously emphasized since this algorithm primarily maintains the illumination consistency.

In this research paper, a novel and empirical enhancement method for remote sensing images is proposed to improve the global contrast and emphasize the local details. First, a new global contrast enhancement algorithm without the need of any parameter selection is presented. This new algorithm can be considered as an improvement of the traditional HE method. More specifically, the algorithm generates a new distribution function to regularize the input histogram by using the sigmoid function. The algorithm further maps the newly generated distribution function to a uniform distribution function. This uniform distribution function is used to obtain the global contrast enhanced image by adopting a standard lookup table-based HE procedure. Second, the discrete cosine transform (DCT) coefficients of the previous global contrast enhanced image are empirically adjusted with only one parameter to further emphasize on the local details. Moreover, a simple but effective thresholding approach is also presented with an automatic parameter setting design. The final output image is obtained by applying the inverse DCT. Since the advantages of both image spatial-domain (histogram) and transform-domain (DCT) methods are involved in the proposed method, the enhanced remote sensing image is characterized by high global contrast and rich local details. Meanwhile, the proposed method does not introduce unpleasing saturation artifacts like other contrast enhancement methods. Experimental results have demonstrated that the proposed method can generate promising results in both qualitative and quantitative assessments.

II. DWT

Wavelet filters which are separable can be used to extend one dimensional DWT to two dimensional DWT. One dimensional transform is applied to all rows of input portrait and then repeat the same for all the columns of input portrait, which computes two dimensional transform of portrait. When two dimensional DWT is applied to an image then four transform coefficients are generated .These coefficients are LL sub-band, LH sub-band, HL Sub-band, and HH Sub-band. First letter corresponds to HPF or LPF applied to rows and second letter corresponds to HPF or LPF applied to columns.

In this RE method, method2 is applied on LR satellite portrait. Here haar wavelet is used for decomposition, then by using bicubic interpolation HF SB’s i.e., SB 2(sub bansd2), SB 3(sub band 3) and SB 4(sub band 4) are interpolated with a scale of 2. Haar wavelet is the most popular in wavelet family. Same analysis can be improved and achieved with undecimated haar wavelet transform also [14]. But at the cost of missing some features. Generally visible information is available in Low frequency bands only. These can be modified with the help of some standard thresholding techniques. Compared to original LR image SB1 contains less information. So difference of input image and SB1 after interpolation is added to all HF bands. Finally, input image is interpolated with a scale α/2 using bicubic interpolation to match its scale with other three HF SB’s. Again Bicubic interpolation is applied to all the three HF SB’s with a scale of α/2. Then Inverse DWT is applied. The output is high resolution portrait. Here difference of input image and SB1 is used instead of SB1 as shown in Fig.1. SB1 has less information compared to difference image.

Resolution Enhancement leads to loss of HF components. Loss of HF components leads to blurring. So DWT is used to preserve HF components. Method1 is shift variant, poor directionality, and there is an absence of phase, which causes artifacts [15]. To avoid artifacts method2 is used. Method2 is shift invariant and directional selective. DWT generates artifacts. So DT-CWT is used to avoid artifacts. DT-CWT gives minute artifacts compared to method1. DT-CWT is applied for image enhancement and image denoising. DT-CWT enhances contrast and resolution of a grey level or color image.

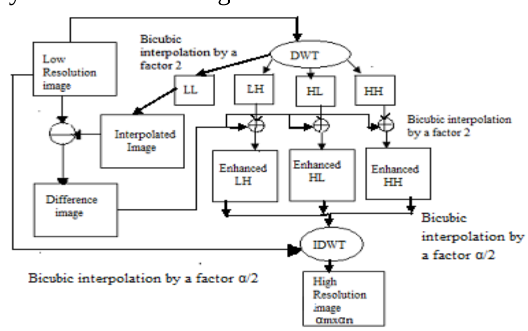

Fig. 1. Block diagram of DWT

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III. PROPOSED ALGORITHM

Step1: Global contrast enhancement

In global enhancement, satellite image X of size M ×Nwith dynamic range of [x_{min}, x_{max}] is considered. where x_{min}, x_{max} are minimum and maximum elements of matrix X. The main aim is to produce good contrast image with output Y. Y is size of M × N with dynamic range of [y_{min}, y_{max}]. Here the minimum value is 0 and maximum value is 255 for 8 bit image.

HE algorithm introduces high peaks in histogram and targeted distributed function which leads to over enhancement and saturation artifacts. So output is affected. Here sigmoid function is used for compression and smoothness which regulates the input histogram [13]. The distribution function f is given by

$$f(k) = s(k) + (1+h(k)) \text{ …………….(1)}$$

Where h is the normalized histogram, k is the number of gray levels of input image; where $k= 1, 2, 3 \ldots\ldots.n;$ and s is the sigmoid function. The modified sigmoid function is given by

$$\frac{1}{e^{-(-k-1)}} - \frac{1}{2} \qquad (2)$$

The distribution function is further normalized to

$$f(k) \leftarrow \frac{f(k)}{\sum_{t=1}^{k} f(t)} \qquad (3)$$

Uniform distribution F is computed by

$$F(k) = \sum_{t=1}^{k} f(t) \qquad (4)$$

Step2: Local details enhancement

In local detail enhancement, DCT coefficients are adjusted for previous global enhancement image in step1. 2-D DCT is applied for low resolution satellite image to get coefficients of matrix. The 2-D DCT coefficients of size M × N are calculated by

Where $0 \le i, h \le M - 1$, $0 \le j$, and $w \le N - 1$. ch and cw are calculated by

$$D(h,w) = c_w c_h \times \sum_{i=0}^{M} \sum_{j=0}^{N} \text{Yglobal}(i,j) \cos \pi((2i+1)h)/(2M) \times \cos \pi((2j+1)h)/(2N) \qquad (6)$$

Where $0 \le i, h \le M - 1$, $0 \le j$, and $w \le N - 1$. c_h and c_w are calculated by

$$c_h = \begin{cases} \sqrt{\frac{1}{M}}, & h = 0 \\ \sqrt{\frac{2}{M}}, & 1 \le h \le M - 1 \end{cases} \qquad (7)$$

$$c_w = \begin{cases} \sqrt{\frac{1}{N}}, & w = 0 \\ \sqrt{\frac{2}{N}}, & 1 \le w \le N - 1. \end{cases} \qquad (8)$$

Note that lower absolute values of D represent the lower energy components, i.e., details and textures, and vice versa.

Moreover, $D(0, 0)$ is the largest energy component that represents the mean value of the image. To emphasize the local details, low energy parts should be adjusted, whereas high energy parts should be maintained to avoid any significant change.

IV. RESULTS AND DISCUSSIONS

In this research paper, a low resolution satellite image as shown in Fig.2 is enhanced by DWT and regularized –histogram equalization & DCT techniques as shown in figures Fig.3 and Fig.4. The proposed technique has superior performance in parameters such as Peak signal-to-noise ratio (PSNR), Root mean square error (RMSE), and correlation coefficient (CC) and these values are shown in table I.

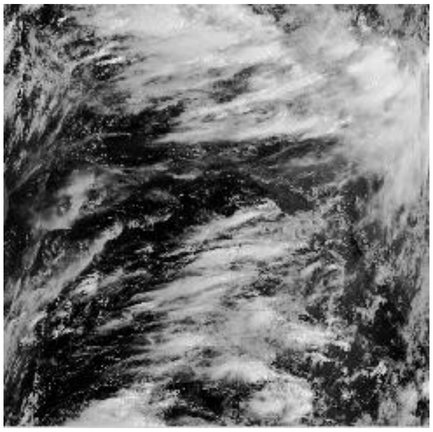

Fig.2. Low resolution input satellite image.

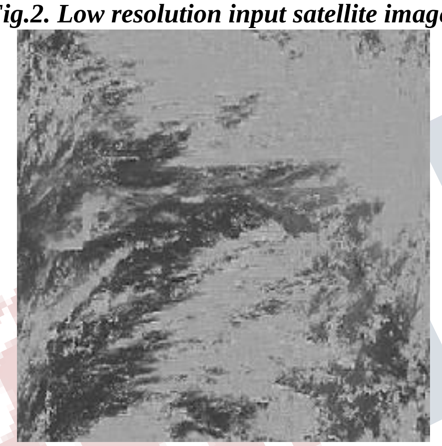

Fig.3. contrast enhanced by DWT

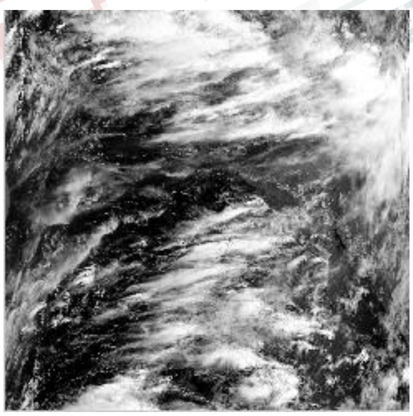

Fig.4. contrast enhanced by regularized-histogram equalization and DCT Enhancement using DWT and Regularized-histogram DCT

TABLE I

ALGORITHM	*PSNR*	*RMSE*	*CC*
DWT	17.5358	33.9978	0.5531
Regularized-histogram DCT	21.7096	21.0262	0.9942

V. CONCLUSION

In this research paper, a novel remote sensing algorithm is proposed on image enhancement. First, histogram regularization is applied which gives global contrast enhancement. Sigmoid function combined with input histogram a uniform distribution has been generated without parametric setting. Second, DCT is applied which gives local details enhancement. Compared to other enhancement techniques the proposed method is having superior performance in reducing artifacts. It is having good PSNR ,RMSE, and CC values compared to DWT technique.

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