Resolution Enhancement of Satellite Image Using DCT and DWT

Mr.Mansing Rathod
Department of Information Technology
Assistant. Professor
K.J.Somaiya Institute of Engineering & IT
Mumbai 400022, India
Research Scholar Pacific Academy of Higher Education and Research University, Udaipur, 313003
rathodm@somaiya.edu

Dr.Jayashree Khanapuri
Department of electronics and Telecommunication
Professor
K.J.Somaiya Institute of Engineering &I.T
Mumbai 400022, India
jayashreek@somaiya.edu

Abstract: In today's world, satellite images are essential for many applications such as defense monitoring, geosciences studies, medical and geographical information. The main drawback of these images is change in their resolution due to the instrument used and the height of the satellites orbits used to capture the images. It is necessary to modify the resolution of images so that modified images are better than original images. Image resolution enhancement is one of the major applications in image processing. This application preserves edges of satellite images .Various domains such as spatial and transform domains are used to enhance the satellite images. Transform domain method provides the better quality image as compared to spatial domain method. Different transform methods are implemented such as Discrete Cosine Transform (DCT) and Discrete wavelet Transform (DWT) for resolution enhancement of satellite images. In this paper we have carried out image resolution enhancement using DCT and DWT. The resultant images are compared in terms of Peak-Signal to Noise Ratio (PSNR), RMSE (Root Mean Square Error), TIME and Mean Absolute Error (MAE) to determine superior method. We conclude that DWT provide the better quality image as compared to DCT as DWT preserves high frequency components.

***Keywords**: Resolution enhancement, Discrete Cosine Transform and Discrete Wavelet Transform.*

I.INTRODUCTION

Today better quality of images is essential requirement for many applications. Different applications such as object recognition, medical, advertisement crime and astronomy etc use good quality images with high resolution. Image resolution enhancement is the most important requirement for the above mentioned applications. Apart from this, image enhancement is also required for GPS system, construction of building, recognition of bridges etc. The main problem of satellite images is that their resolution is low, due to environment and instrument problem. Therefore, Resolution enhancement process is considered to avoid this type of problem in many applications. Transform domain and spatial domain are most important tools for improving the resolution enhancement of satellite images. It is observed that transform domain methods produce best as compared to spatial domain methods. But the need in transform domain is to determine the suitable transform that can be used for the better resolution enhancement of satellite images. Different interpolation techniques are also available (such as nearest neighbor, bilinear and bi-cubic interpolations etc), for resolution enhancement, but they produce blurred image. There exist many algorithms that are based on DCT, DWT and SWT etc. A lot of literature survey has been carried out about both spatial and transform domain methods in order to find the suitable method to enhance the resolution of satellite image. The paper [1] presents Projection onto Convex Sets (POCS) algorithm. This method determines the simultaneous restoration and interpolation on a set of low resolution images and iteratively provides the high resolution image. The system point spread function removes the blurre of image and image size is also increased in POCS algorithm. But it required the prior knowledge about the imaging system .This is the main disadvantage of POCS algorithm. Paper [2] discusses about the super resolution algorithm such as SRVPLR. The objective of algorithm is the detection of objects in which the size approaches the limiting spatial resolution scale thus providing some examples of its applications. Implementation of this algorithm is known as drizzle and works under the combination of sampled images. The main disadvantage of this algorithm is that it is not suitable for remote sensing data set. Paper [3] has discussed about downscale Cokriging for the super resolution prediction. This method increases the spatial resolution of the remotely sensed images by preserving the spectral content of the original images. Cokriging requires many cross covariance and covariance information, but some of which is not empirically accessible (i.e. from the pixel values of the image) this is the main disadvantage of this method. Paper [4] has presented the bilateral filter which is a nonlinear filter that does spatial averaging without smoothing the edges; it provides an effective image denoising technique.

The selection of the filter parameters of the bilateral filter changes the results drastically which is the main drawback to the method. Paper [5] has studied the resolution enhancement using Complex Wavelet Transform (CWT).This method has produced sharpness of the image, because CWT provides information in six different directions this contributing for the sharpness of edges and it is also called directional selectivity method. Paper [6] Offered Discrete Wavelet Transform (DWT) as a new resolution enhancement method for satellite images that obtains the resolution enhancement of the image by the interpolation of high-frequency sub bands of DWT with the input image. DWT gives Sharper image but loses high frequency contents of the image as the information loss occurs due to the down sampling in each sub band. Paper [7] has proposed SWT method and this method minimizes the loss in high frequency sub bands. The advantage of this method is that interpolated high frequency sub bands and high frequency sub bands are of same size. But in this method, distortion occurs in the image with the redundancy removed. DWT and Singular Value Decomposition (SVD) method is discussed in paper [8]. This method improves the brightness of an image. It is concluded that with SVD gives the better brightness when combined with DWT. The main drawback of this proposed method is it cannot give the clear image. Paper [9] suggests the combination DT-CWT and the adaptive histogram equalization for resolution enhancement. The contrast of the image is provided by an adaptive image processing method known as Adaptive Histogram Equalization (AHE) The method calculates several histograms belonging to various sections of the image thus, differing from the ordinary histogram equalization methods, The bright values present in the image are redistributed using AHE. Thus, providing the improvement in local contrast of the image and also helping in bringing out more image details. Paper [10] open the comparative study about various transforms such as SWT, DWT, SWT&DWT and DT-CWT. Paper [11] is implemented for medical and satellite images resolution enhancement. This is important for medical as well as satellite image resolution enhancement. The paper presents a resolution enhancement technique which gives the sharper image. Paper [12] discusses about spatial and Frequency domain methods. They have compared both the domains and concluded that frequency domain methods produce better quality of images. The pixel values are manipulated to reach the preferred enrichment, because spatial domain method openly operates among the image pixels, and leading to blurred quality of image.

The proposed paper provides an insight into two popular transform domain methods DCT and DWT for satellite images. Both these o methods are analyzed and the comparison of these methods is carried out for Peak Signal to Noise Ratio (PSNR), Root Mean Square Error (RMSE), TIME and MAE, which are considered to be the important parameters for the evaluation of these methods. Db1 wavelet is applied for implementation.

This paper is organized as follows. The introduction and literature survey of the paper is presented in section I. The theory related to DCT and DWT transform domain image resolution enhancement methods is discussed in section II. The methods discussed with block diagram in section III. The Evaluation parameters explained in section IV. The results of these transform domain methods are discussed and compared in section V followed by conclusion in section VI.

II.THEORY OF DCT AND DWT METHODS

1. Discrete Cosine Transform (DCT): DCT is used for resolution enhancement of image.The DCT is frequently used in image processing and signal processing applications that are HDTV,video disks,fax system and video conferencing.The main aim of DCT is image texture do not change quickly becouse DCT coefficents are interm of zero and need very small data through the compression .Wavelet method gives good result than DCT.

2. Discrete wavelet Transform (DWT): The DWT is also used in computer vision and image processing application. The 2-D DWT generate the high frequency components in the image. The DWT produce sharper image than DCT. DWT decompose input image into four sub band images such as LL, LH, HL and HH. All these sub band images are down sampled and bi-cubic interpolation method used to resize the down sampled image as well as low resolution input image. Inverse DWT is applied on both the images for generating high resolution image. The DWT generate the sharper image than DCT.

III. TRANSFORM DOMAIN IMAGE RESOLUTION ENHANCEMENT METHODS

A. Discrete Cosine Transform (DCT)

The DCT technique is commonly used for reducing the storage capacity, and also used for videos and audio compressing. DCT is also used in image processing for to increase the resolution enhancement of satellite images or medical images, due to supports stretching of the image with insignificant loss. DCT is more focused on lower frequencies and efficient energy compaction, because less sensitive to luminance than the chrominance in Human Visual System (HVS).This is very important characteristic of DCT. From low resolution DCT coefficients are computed and zeros are padded to computed coefficients as shown in Fig.1.High resolution image generated by using IDCT, because IDCT is performed with resulting coefficients.The resulting image is poor contrast this is the disadvantage of DCT method.

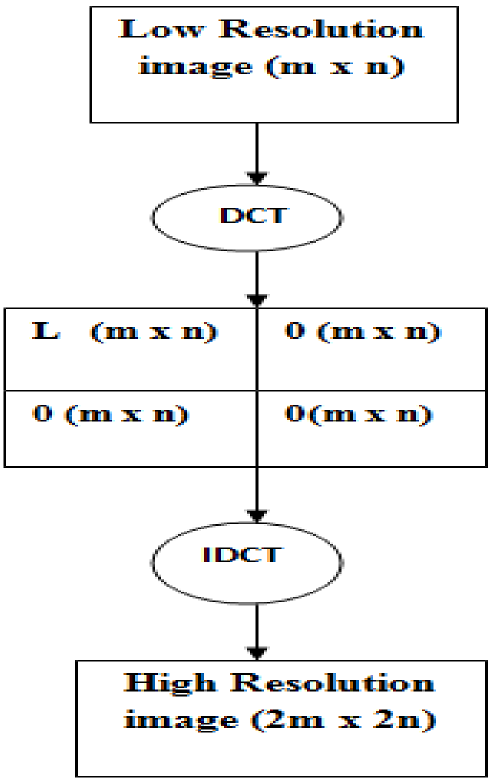

Fig.1. Block Diagram of DCT based image Resolution Enhancement Method

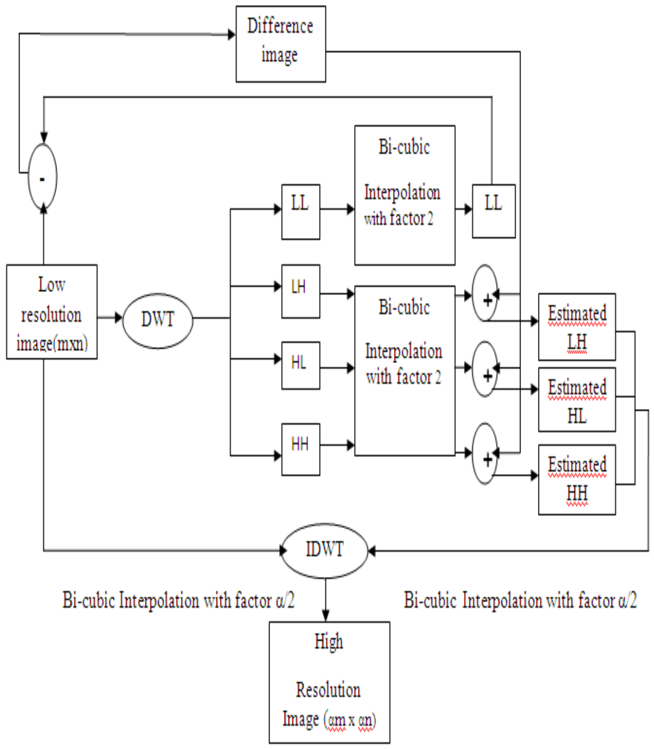

Fig.2.Block Diagram of DWT-based Resolution Enhancement Method

B. Discrete Wavelet Transform (DWT)

DWT preserved the high frequency components.DWT used down sample image. This method provides four sub band images after decomposition of the input mage. The four sub band images are low-low, low-high, high-low, and high-high (LL.LH, HL, HH) .Bi-cubic interpolation with factor 2 is used on all four band images. Intermediate stage is provided through the difference between interpolated LL sub band image and the low resolution input image. The intermediate stage corrects the expected high frequency components. The variation image is get by low resolution input image and the interpolated sub band image. The interpolated high frequency sub band images are added with difference image to achieve the high frequency estimated images such as LH, HL and HH sub band images. The estimated sub band images and low resolution input image are resized with Bi-cubic interpolation with factor α/2 .The Inverse DWT is used to generate the high resolution image. The main advantage of intermediary stage in high frequency sub band interpolation process is to preserve additional edge information. Thus, provides sharp image containing more edge information. Hence, the quality of the image is improved automatically by this method in terms of the sharpness of image. The DWT method gives sharper image but loses high frequency contents.

IV. Evaluation methods

The evaluation methods are used to determine the performance of the transform domain technique such as DWT and DCT. The following important methods to evaluate the above satellite image resolution enhancement techniques. These methods show the superiority of the particular techniques. Both the techniques are evaluated by using satellite images.

1.Root Mean Square Error (RMSE): The euquivalent pixels in the reference image and the obtained high resolution image (Hr) is calculated by Root Mean Squqre Error(RMSE) formula.

$$\mathbf{RMSE} = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(H_r\,(i,j) - H\,(i,j))^2}$$

2. Mean Square Error (MSE): MSE formula is measuring the MSE between the input image I (in) and the original image I (org).

$$\mathbf{MSE} = \frac{\sum_{i,j}(I\text{ in }(i,j) - I\text{ org }(i,j))^2}{MXN}$$

3. Peak-Signal to Noise Ratio (PSNR): The quantitative results are compared with following parameters such as Root Mean Square Error (RMSE) and Peak signal-to-noise ratio (PSNR). PSNR gives the peak signal to noise ratio and MSE gives the MSE between the input image I (in) and the original image I (org). R indicates the maximum fluctuation of input image.

$$\text{PSNR}= 10\log_{10}\left(\frac{R^2}{MSE}\right)$$

4.Mean Absolute Error (MAE): Quntitative result is also measured in term of **Mean Absolute Error** (MAE) .MAE is of equivalent pixels in reference image and high resolution image(Hr).

$$\text{MAE}=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} \left| (H_r\,(i,j) - H\,(i,j) \right|$$

IV. Evaluation methods

The evaluation methods are used to determine the performance of the transform domain technique such as DWT and DCT. The following important methods to evaluate the above satellite image resolution enhancement techniques. These methods show the superiority of the particular techniques. Both the techniques are evaluated by using satellite images.

1.Root Mean Square Error (RMSE): The euquivalent pixels in the reference image and the obtained high resolution image (Hr) is calculated by Root Mean Squqre Error(RMSE) formula.

$$\text{RMSE} = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(H_r\,(i,j)- H\,(i,j))^2}$$

2. Mean Square Error (MSE): MSE formula is measuring the MSE between the input image I (in) and the original image I (org).

$$\text{MSE} = \frac{\sum_{i,j}(I\text{ in }(i,j) - I\text{ org }(i,j))^2}{MXN}$$

3. Peak-Signal to Noise Ratio (PSNR): The quantitative results are compared with following parameters such as Root Mean Square Error (RMSE) and Peak signal-to-noise ratio (PSNR). PSNR gives the peak signal to noise ratio and MSE gives the MSE between the input image I (in) and the original image I (org). R indicates the maximum fluctuation of input image.

$$\text{PSNR}= 10\log_{10}\left(\frac{R^2}{MSE}\right)$$

4.Mean Absolute Error (MAE): Quntitative result is also measured in term of **Mean Absolute Error** (MAE) .MAE is of equivalent pixels in reference image and high resolution image(Hr).

$$\text{MAE}=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} \left| (H_r\,(i,j) - H\,(i,j) \right|$$

V. Result discussion

The resolution enhancement of Satellite images has been implemented by using transform domain methods such as DCT and DWT and compared in term of evaluation parameters such as PSNR, RMSE, TIME and MAE. The resulting parameters produce superiority of methods. It is concluded that the resultant image obtained by using DWT is sharper than DCT. Table1 shows the results of RMSE, PSNR, TIME and MAE.

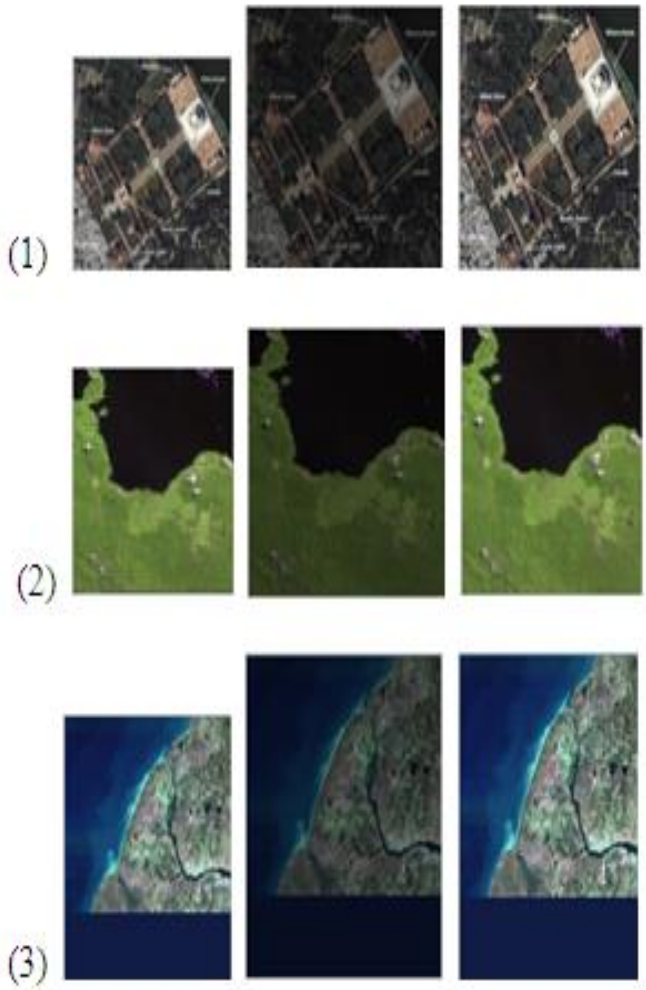

Fig.3. (a) Original low resolution image (b) enhanced image using DCT (c) enhanced image using DWT

Table1.The table1 shows the results obtained by DCT and DWT. The resolution is enhanced from 128x128 to 512x 512(α=4)

Parameters/ Methods	DCT			DWT		
	Fig.1	Fig.2	Fig.3	Fig.1	Fig.2	Fig.3
RMSE	48.96	41.66	48.87	24.78	08.12	20.82
PSNR	38.46	39.85	38.45	44.36	54.04	45.87
TIME	03.05	03.00	03.07	05.00	05.04	06.08
MAE	39.72	34.15	39.38	16.96	04.24	11.60

VI. CONCLUSION

This paper has proposed an image resolution enhancement technique based on interpolation of high frequency sub band estimated images by using DWT and DCT. DWT is used down sample image, so interpolation factor 2 used in DWT to resize the sub band images.DCT produce poor quality image because zero padding.. It is clear that DWT produce better quality image than DCT. The PSNR, RMSE and TIME and MAE show the superiority of DWT over DCT.

REFERENCES

[1] Amy E. Galbraith and Richard W. "Resolution enhancement of multilook Imagery for the multispectral Thermal Imager" *IEEE transactions on Geoscience and remotely sensing,* Vol.43, No.9, pp-1964-1977, 2005.

[2] M.T.Merion, j.Nunze "Super resolution of remotely sensed image", *IEEE transactions on geosciences and remote sensing*, vol.45, No. 5, pp-1446-1457, May 2007.

[3]P.M. Atkinson, R. Webster, and P. J. Curran, "Downscaling Cokriging for super resolution Mapping of Continua in remotely sensed images", *IEEE transaction on geosciences and remote sensing,*Vol.46. No. 2, pp. 573–580, Feb. 2008.

[4]Ming Zhang and Bahadir K.Gunturk,"Multi resolution Bilateral Filtering for Image Denoising", *IEEE transactions on Image processing,* Vol.17, No.12, pp-2324-2333, Dec, 2008.

[5] H. Demirel and G. Anbarjafari,"Satellite image resolution enhancement using complex wavelet transform", *IEEE Geosci. Remote Sens. Lett.* Vol. 7, No. 1, pp. 123–126, Jan. 2010.

[6] H. Demirel, G. Anbarjafari,"Discrete Wavelet Transform-Based Satellite Image Resolution Enhancement", *IEEE Geosciences and Remote Sensing*, Vol. 49, pp. 1997-2004, June, 2011.

[7]D Hasan, F. Gholamreza, "Image Resolution Enhancement by Using Discrete and Stationary Wavelet Decomposition", *IEEE Transactions on image processing,*Vol. 20, No.5.pp-1458-1460, May 2011.

[8].Ammu Anna Mathew, S. Kamatchi "Brightness and Resolution Enhancement of Satellite Images using SVD and DWT", *International Journal of Engineering Trends and Technology (IJETT)* - Volume4, Issue4, pp. 712-718, April 2013

[9] Ms.M.Merlin Bhakiya, Ms.N.T.Sasikala "Satellite Image Resolution Enhancement Using Dual-Tree Complex Wavelet Transform and Adaptive Histogram Equalization", *International research of Advances in Electronics and Communication Engineering (IJARECE)*, Volume 3, Issue 4, ISSN: 2278 – 909X, pp, 467- 470, April 2014.

[10] P.Bala Srinivas, B.Venkatesh "Comparative Analysis of DWT, SWT, DWT & SWT and DT-CWT-Based Satellite Image Resolution Enhancement", ISSN: 2230-9543, *International Journal of Electronics & Communication Technology (IJECT)* ,Vol.5, Issue-4, pp. 137 – 141, Oct-Dec 2014.

[11]Aparna Gupta,Miss Sonika "Image Resolution Enhancement Technique by Interpolation in wavelet domain" *International journal of proresses in engineering,management, science and humanities(IJPE),*SSN-2395-7786,PP-2395-7794,vol.No.1,ISSUE-3,2015.

[12] R.U.Shekokar,Yuvaj S.Pawar" Resolution Enhancement of Image Captured by Satellite using DWT" *International journal of Multidisciplinary Research and development*, Vol.No.2,Issue:7,238-234,july,2015,e-ISSN2349-4182,P- ISSN:2349-5979