ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

A Novel Super Resolution Enhancement Using Fusion of Wavelet Coefficients for Ariel Imagery

Leena Kataria
M.Tech (Embedded Systems),
Department of EECE,
The North Cap University, Huda, Sector 23A,
Near Rotary Public School, Gurugram,
Haryana 122017.

Amanpreet Kaur
Assistant Professor (Sr.Scale),
Department of EECE,
The North Cap University, Huda, Sector 23A,
Near Rotary Public School, Gurugram,
Haryana 122017.

ABSTRACT

In recent years there is a rapid growth in satellite or Ariel image processing applications. Satellite image which have been captured initially does not have good clarity, because of the fog, haze, clouds and also non uniform lighting conditions in the surrounding environment. Hence, we need to improve the quality of these type images without losing the original information from the images. So, Resolution enhancement is a major problem for this type of low resolution images. Higher resolution images will gives more visible clarity than low resolution images. Over past decades, many researchers have developed the enhancement algorithms based on interpolation techniques, super resolution algorithms and also using transformation methods. Here, we are going to study DWT- Bicubic interpolation approach with state of art algorithms such as bilinear, bi-cubic interpolation and wavelet zero padding. The relative comparison of these enhancement techniques for the image resolution is shown by using various aerial images and the corresponding results shows that the proposed technique is most effective among the variousenhancement techniques for image resolution.

INTRODUCTION

Image processing is defined as method to perform certain operations on an image in order to obtain an enhanced quality image or to extract some useful information from it. In this type of signal processing input is an image which needs to be processed and output may be an image or characteristics/features associated with that input image.Enhancement is the process of improving the quality of an electronic digital stored image. Image enhancement plays a very crucial role in various image processing applications where people are required to make decisions with respect to the digital image information. Various forms of image enhancement are noise reduction, edge enhancement and contrast enhancement.

Satellite/Ariel images are used in various fields of research. Resolution is the major issue in such kinds of images. Resolution is one of the major properties of an image. Images are transformed accordingly in order to obtain high resolution and quality . The most commonly used image resolution enhancement technique is interpolation. Interpolation is widely used while increasing the resolution of an image. Three different interpolation techniques are present. Nearest neighbor interpolation, bilinear interpolation and bicubic interpolation are three interpolation techniques[21].

The wavelet domain is currently a new topic for Image resolution enhancement and on this domain there are various algorithms present. Wavelet plays an important role in image resolution enhancement. Here, two wavelet based image resolution enhancement techniques are described. The first technique is based on discrete wavelet transform and the second technique is based on discrete wavelet and stationary wavelet transform. Both of these techniques are compared using various satellite images[21]

A new image resolution enhancement technique for satellite images is based on the interpolation of the high-

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

frequency sub bands is obtained by discrete wavelet transform (DWT) and the input image is proposed. Discrete wavelet transform is used to divide the input image into various sub bands in this resolution enhancement technique. After that the input low resolution image and all the high frequency sub bands have been interpolated. Then in order to generate high resolution image IDWT is applied on all these images.

Intermediate stage is proposed in order to achieve a sharper image. This technique is tested on satellite benchmark images[21]

Drawback of DWT based Resolution Enhancement is the down sampling nature of the decomposition of image in the DWT method. An image will be decomposed into four sub bands after applying DWT with 2 factor decimation. These sub bands are with the size of half of original images because of decimation factor. So, the information will be lost after DWT decomposition. For this reason we have extended to a new algorithm which is DWT-SWT based algorithm, this made it more efficient and will improve the PSNR performance.

INTERPOLATION

Interpolation is basically a process of estimating the unknown sample points using the known sample points. For the purpose of image resolution enhancement, Interpolation is being widely and adapted technique. Also it is being used in various image processing applications such as super resolution, facial reconstruction etc.The three main interpolation techniques used for the image enhancement are : Nearest neighbor interpolation, Bilinear interpolation, and bi-cubic interpolation.

Nearest neighbor interpolation

In this interpolation technique every output pixel value is basically provided the value of its nearest neighbor sample point. and is termed to be the simplest interpolation technique. Though this interpolation texhnique provides effective results but the quality of the image is poor.

Bilinear interpolation

In order to predict the known values at random points , the weighted average of the four corner closest pixel is taken and assigned to the output random points and this interpolation process is classified as Bilinear Interpolation. Both the Bilinear and Nearest neighbor technique are always performed in single direction while for the bicubic interpolation perpendicular direction is being used.

Bi-cubic interpolation

In comparison to other two interpolation techniques used for the purpose of image enhancement, the bicubic interpolation is highly advanced. The resultant interpolated image or surface received is smoother in comparison to above methods bilinear interpolation and nearest-neighbour interpolation techniques. This technique basically uses the cubic and polynomial algorithms.

EXISTING METHODS

Several algorithms have been developed in the past in order to enhance a LR image with improved and enhanced performances. The Hall .proposed a gray level transformation in 1974 [11] and this transformation is used for image enhancement . Also various filters has been deployed in [12-15] and for denoising and enhancement of the LR images. Also in [16] the author has recommended a fast filtering algorithm for enhancing the LR image. Also in others [8], [9],[16] and [17] the Ariel imagery or satellite image resolution enhancement method based on DT-CWT is proposed.

The current methods used in the field of image processing are Fourier Transform (FT) and Short Term Fourier Transform (STFT) .However due to various severe limitations imposed by both the Fourier Transform and Short Term Fourier Transform in analyzing signals makes them ineffective in analyzing complex and dynamic signals[4-7].

Fourier Transform has a drawback that it will work out for only stationary signals/continuous signals, which are

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

continuous with time period. Because, the Fourier Transform is applied for the entire signal but not on segments of a signal so if we consider non-stationary signal the signal will vary with the time period, which could not be transformed properly by FT and another drawback that we have with the FT is we cannot say that at what instant the particular event has occurred. In STFT, the size of the window is fixed due to which window will not change with the time period of the signal i.e., for both narrow resolution and wide resolution and we cannot predict the frequency content at each time interval section. In order to overcome the drawbacks of STFT, a wavelet technique has been introduced having window of variable size. In order to obtain more precise low-frequency information , wavelet analysis uses long time intervals whereas for high-frequency information the shorter regions are used.

WAVELET TECHNIQUE

Wavelet Technique is used as a substitute to overcome the shortcomings imposed by both the common signal processing methods .The wavelet technique is used to extract the features from an image by processing data at various different scales[3]. The wavelet technique changes the scales to provide a higher correlation in detecting the various frequency components present in an image. The figure fig.4 shows the comparison of various methods i.e FT, STFT and wavelet transform by considering an example of input signal and how the analysis of transformation techniques will apply to get the frequency information from the input signal taken.It can be observed that in wavelet analysis that the graphical representation shows that the wavelet has more number of features in comparison to FT and STFT. Wavelet is also known as multi resolution analysis (MRA).

Why wavelet transform is used?

The signal can be analyzed in a better manner in frequency domain than the time based domain, under the fact that the properties of a signal will be betterto analyze in frequency phase and Fourier Transform is one of the goodmethodavailable to transform the signal from time to frequency area. FT is basically aexisting technique which separates the signal into various frequencies of sinusoids.It is alsocalled as a numerical methodology/technique for changing thethe sign to frequency space from time domain[18][2]

Figure 1: Fourier Transform Analysis[20]

Fourier Transform has a drawback that it will work out for only stationary signals/continuous signals, which are continuous with time period. When the signal is transform into the frequency domain after applying FT then time related information gets lost. Also the results obtained after the Fourier transform of a signal, it is impossible to predict at what particular instant an event occurred. When the signal properties do not change much over time it is classified as a stationary signal and this drawback does not seems very important and relevant.Also most signals contain various transitory properties like trends, drift, abrupt changes, and starting and ends of various events. These features are the crucialelement of any signal as they contain information which used for further analysis .Also this method is not reliable for changing signals.

SHORT TIME FOURIER TRANSFORM (STFT)

In order to overcome the inefficiency caused by FT there is another technique classified as windowing technique and as the name suggests it is based on the concept of window. This adjustment is being classified as the Short-Time Fourier Transform (STFT). In STFT the sign will be mapped according to the time and frequency data.

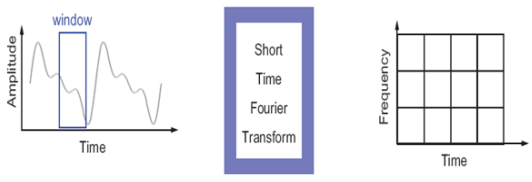

Figure 2: Short Time Fourier Analysis of a signal[20]

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

In STFT, the size of the window is altered due to which this window won't change depending on the day and age of the sign (Same for both tight determination and wide determination).

Wavelet Analysis

A wavelet is a waveform of effectively limited duration that has an average value of zero [20].

In Wavelet analysis alsouses the windowing technique but here the variable-sized regions of windows are used. Wavelet analysis allows the use of smaller regions where its required to have high-frequency info andlarger time regions where its required to have precise low-frequency information.

Figure 3: Output of Wavelet Transform[20]

Different views of signal in Time Domain called Shannon, Frequency domain called as Fourier Transform,STFT View of a signal called Gabor analysis and wavelet analysis is shown below for the comparative analysis in all four existing methods.

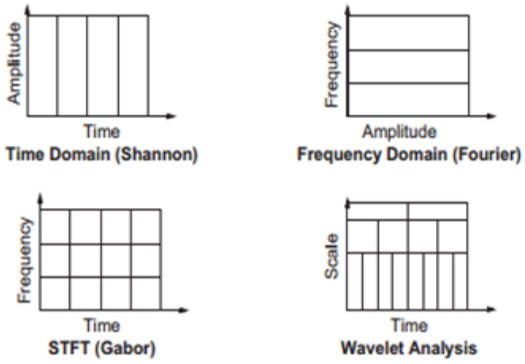

Figure 4: Comparative Views of Signal

Wavelet analysis is capable of analyzing different aspects of data which is not present in other signal analysis techniques. It also has a capability of finding breakdowns, trends, any discontinuities present in the higher derivatives along with the self-similarity. Seeing these capabilities it is also used for the purpose of compressing and de noising a signal with a lot of degradation.

3.4.1.3 TYPES OF WAVELETS TRANSFORMS

CONTINUOUS WAVELET TRANSFORM

The continuous wavelet transform (CWT) as the name suggests is defined as the total sum divided by all time of the signal which is being multiplied by the scaled version, shifted version function called the wavelet function[20].

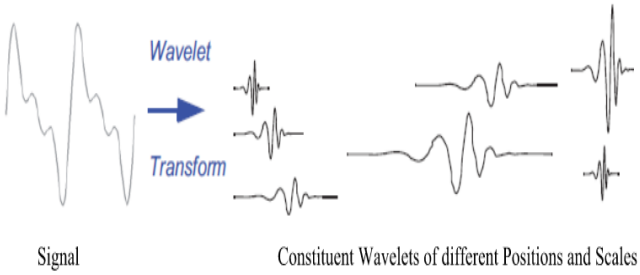

Figure 5: Continuous Wavelet Transform[20]

In Continuous wavelet transforms, the signal containing finite energy is extend over a continuous frequency bands. Through Continuous Wavelet transform we get wavelet coefficients at every scale which is possible but due to this we get a very large amount of data. If we find only a subset of positions and scales whose value we need to use further for calculation then that would be a better approach. This can be achieved if we choose positions and scales based on power of two which is known as Dyadic Scales and Positions. This will make our analysis more accurate and efficient. This type of analysis can be achieved from Discrete Wavelet Transform.

DISCRETE WAVELET TRANSFORM

- Discrete wavelet transform is a wavelet transform for which the wavelets are sampled discretely.
- The very important feature in DWT is that it captures both location and frequency information.
- The Discrete Wavelet Transform can be implemented using Filters.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

PROPOSED IMPLEMENTATION

Resolution is considered as a major feature of satellite images due to which the resolution enhancement is of great importance. The high frequency components are mainly lost when an image is being resolution enhanced by applying interpolation which is caused by the smoothing caused by interpolation.

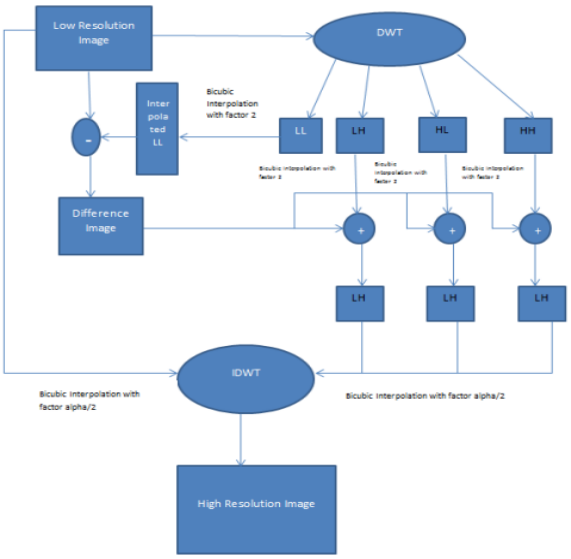

Figure 6: Existing DWT-RE Block diagram

Due to this reason, in order to increase the quality of the enhanced output image, edges preservation of the edges is important. In the corresponding paper DWT has been used to preserve basically the high-frequency components present in an image. DWT divides the image into various sub band images called LL, LH, HL, and HH I which the high-frequency sub bandsrepresents the high frequency component of an image.
On all four sub band the interpolation is applied. The LL sub band without any quantization is used as an input for the proposed enhancement process.

Since the low frequency sub band images are basically low resolution of the original image. Thus inspite of using sub band which are low in frequency and contains less information than the original image then we aretaking this as input image through interpolation. Hence the input LR(low resolution) image is interpolated with the half of the interpolation factor α/2.

Thus in order to preserve images an intermediate process is being used. The difference between the low frequency sub band LL and the low-resolution image is basically in their high-frequency components. So basically the difference image is used in the intermediate process in order to correct high-frequency components(estimated ones). The estimation is done by initially interpolating the high-frequency sub bands by an interpolation factor 2 followed by including the difference image into the estimated high-frequency images., Then after this another interpolation process is done with factor α/2 to achieve required size for the IDWT process.

Using interpolation in Image enhancement process the main loss occurs to its high frequency components called edges. Therefore in this research, DWT has been used in order to preserve edges which are the high frequency components of the image. Here in the technique proposed bicubic interpolation with factor of 2 is applied to high frequency components or we can say high frequency sub band of images. Due to down sampling nature of DWT information loss in the respective subbands occurs. And in order to overcome this SWT wavelet technique is implemented in order to reduce the loss.

Since the size of both the interpolated high frequency bands and SWT high frequency subbands is same, thus the addition of these can be done. Further interpolation can be applied to new corrected high frequency subbands in order to achieve enhanced size. The low frequency subband is basically the low resolution of the original input image. Thus inspite of using less information contained low frequency sub band as compared to high resolution original image, we are using input image for the interpolation of low frequency subband image. Fig. 7shows the block diagram for the proposed technique of image resolution enhancement.
Thus by applying the interpolation with the corresponding factors shown in the figure 7 ,the output resultant image will contain sharper or refined edges as compared to the the interpolated image which was obtained from the interpolation of the input image directly.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

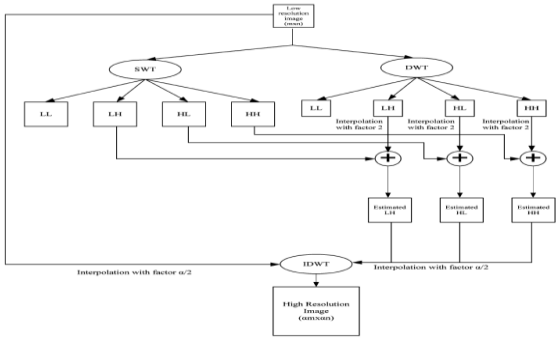

Figure 7. Block diagram of the proposed algorithm

SIMULATION RESULTS

Figure: 8 below shows that the comparison between original LR image, bilinear interpolated, bicubic interpolated ,wavelet zero padded enhanced , DWT-RE method and proposedmethod images. The output of all the four existing methods(bilinear interpolated, bicubic interpolated ,wavelet zero padded enhanced , DWT-RE method) along with the proposed method is also shown in Figure 9 below, in which the quality of the image has been increased over the conventional interpolation techniques. Figure 10 shows that the proposed hybrid model, we can observe that the proposed approach has provided with the better resolution image compared to the existing enhancement techniques. Quality metrics of various enhancement techniques has been shown in Table 1 for Image 1. It shows that the PSNR and MSE values of conventional interpolation(bilinear and bicubic), wavelet zero padding (WZP) and DWT-RE with proposed method.

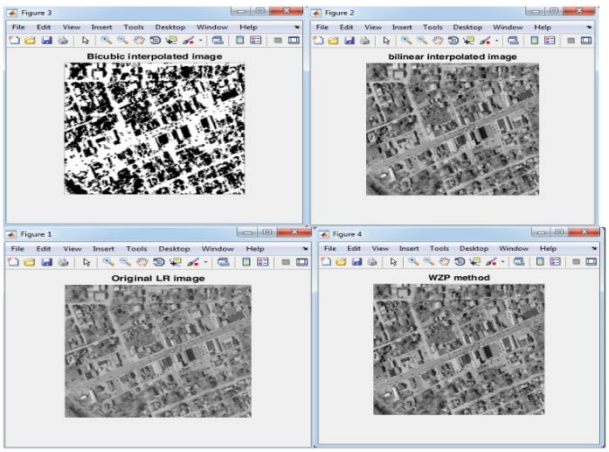

Figure 8. Original LR image, Bilinear, Bi-cubic and WZP method

Figure 9 : DWT-RE Method

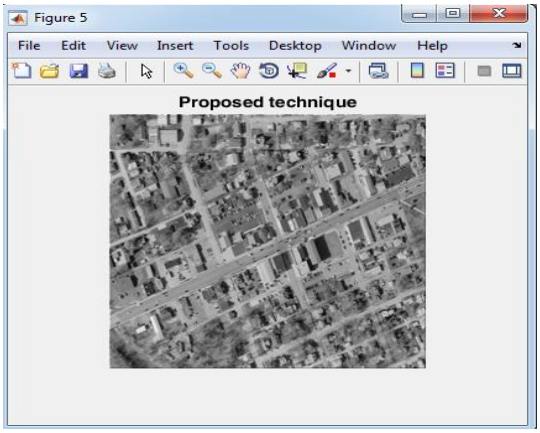

Figure 10. Proposed resolution model

Table 1: PSNR vs MSE for Satellite Image

Methods	PSNR in db	MSE
Bilinear	51.38	7.29
Bicubic	53.42	9.56
WZP	58.74	8.68
DUWT-RE	59.29	7.64
Proposed(DWT+SWT)	64.45	2.33

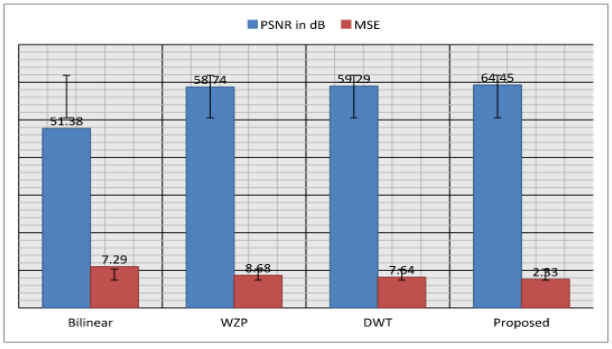

Figure 11. Comparison of PSNR and MSE values

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

CONCLUSION

A review on various Ariel image enhancement techniques has been implemented, also compared the simulation results with the conventional interpolation and decimated wavelet techniques. By observing the results we can conclude that the proposed enhancement has given better performance than the existed methods.

Furthermore, it can be extended to enhance 3D RADAR images and multi directional RADAR images using image fusion enhancement techniques.

REFERENCES

1. Goetz J. A. H. F.,G. Vane, J.E. Solomon, B.N. Rock,"Imaging Spectrometry for Earth Remote Sensing," Science, 1985, vol. 228, pp. 1147-1153.
2. X. Li and M. Orchard, "New edge-directed interpolation," IEEE Trans. Image Process., vol. 10, no. 10, pp. 1521–1527, Oct. 2001.
3. L. Zhang and X. Wu, "An edge-guided image interpolation algorithm via directional filtering and data fusion," IEEE Trans. Image Process., vol. 15, no. 8, pp. 2226–2238, Aug. 2006
4. W. K. Carey, D. B. Chuang, and S. S. Hemami, "Regularity-preserving image interpolation," IEEE Trans. Image Process., vol. 8, no. 9, pp. 1293–1297, Sep. 1999.
5. Y. Piao, I. Shin, and H. W. Park, "Image resolution enhancement using inter-sub band correlation in wavelet domain," in Proc. ICIP, vol. 1,pp. I445–I-448,2007.
6. Q. Sun and J. Tang, "A new contrast measure based image enhancement algorithm in the DCT domain," IEEE International Conference Systems, Man and cybernetics, vol. 3, pp. 2055-2058, October 2003.
7. Eunjungchae, Wonseokkang, Joonkipaik, "Spatially Adaptive Antialiasing for Enhancement of Mobile Imaging System Using Combined Wavelet-Fourier Transform," IEEE transaction on consumer electronics vol 59, 4Nov 2013.
8. N.Kundeti, H.K.Kalluri, S.V.Krishna,"Image Enhancement Using DTCWT Based Cycle Spinning Methodology," IEEE Conference On Computational Intelligence andComputing Research, 2013.
9. H. Demirel and G. Anbarjafari, "satellite image resolution enhancement using complex wavelet transform," IEEE Transactions on Geosciences and Remote Sensing Letters, Vol. 7, pp. 123–126, 2010.
10. A.Temizel and T.Vlachos, "Wavelet Domain Image Resolution Enhancement Using Cycle Spinning," Electronics Letters, vol.41.pp119-121, 2005.
11. E. Hall, "Almost Uniform Distributions for Computer ImageEnhancement", Computers, IEEE Transactions, Volume: C23,Page(s):207-208,1974.
12. H. Keshavan, M. Srinath, "Interpolative models inrestoration and enhancement of noisy images", Acoustics,Speech and Signal Processing, Volume: 25, Page(s): 525-534, 1977.
13. FahmiFahmi, MuhfiAsbinSagala and Tigor H. Nasution,"Sequential — Storage of differences approach in medical image data compression for brain image dataset," IEEE 2016 International Seminar on application for technology of information and communication(ISemantic) ,Semarang,Indonesia
14. V. Algazi, "FIR Anisotropic filters for image enhancement",Acoustics, Speech, and Signal Processing, Volume: 11, Page(s): 2471-2474, 1986.
15. D. Keren, S. Peleg and R. Brada, "Image sequenceenhancement using sub-pixel displacements", ComputerVision and Pattern Recognition, Page(s): 742-746, 1988.
16. C. Hegang, L. Kaufman and J. Hale, "A fast filteringalgorithm for image enhancement", Medical Imaging,Volume: 13, Page(s): 557-564, 1994.
17. H. Demirel, G. Anbarjafari, "Satellite Image ResolutionEnhancement Using Complex Wavelet Transform",Geoscience and Remote Sensing Letters, Volume: 7, Page(s):123-126, 2010.
18. Seema Rani, Manoj Kumar, Bhatinda, "A Review of Image Contrast Enhancement Techniques". International Journal of Computer Science & Engineering Technology. Vol. 5 No. 07 Jul 2014.
19. B D Jadhav and p M Patil " An Effective Method for Satellite Image Enhancement ", International Conference on Computing, Communication & Automation (ICCCA), pp: 1171-1175, 2015.