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Survey on Satellite Image Enhancement Techniques

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***Abstract*—Satellite images are used in many fields of research (quality factors in images comes from its resolution) and in many applications such as astronomy, geographical information systems & geosciences studies. One of the main issues of this type of images is its resolution. Nowadays, a new satellite image resolution & brightness enhancement technique is based on the DISCRETE WAVELET TRANSFORM (DWT) & SINGULAR VALUE DECOMPOSITION (SVD) that has been proposed. Interpolation in image processing is a well known technique to increase the resolution of a digital image & also used in many image processing applications such as facial reconstruction, multiple description coding & resolution enhancement. In this paper, I propose a new satellite image enhancement technique based on interpolation of the high frequency sub bands obtained by DWT & proposed technique uses DWT to decompose the input images into different sub bands.**

***Keywords* - Satellite Image, Image enhancement, Techniques for Image Enhancement**

I. HISTORY

The first image taken from space were on sub orbital flights every 1.5 seconds, launched by US named V-2 flight on 24th October, 1946.

II. INTRODUCTION

Pictures or images are the most convenient and common means of conveying or transmitting information. Images are worth a thousand words. Human receives 75% of information in a pictorial form.

Interpolation in image processing is a method to increase the number of pixels in a digital image. Nowadays, many interpolation techniques have been developed to increase quality of image resolution enhancement.

There are three main interpolation techniques, which are nearest neighbour, bilinear & bicubic. Among these three techniques, Bicubic interpolation is more sophisticated than other two & results in smoother edges.

Noise removal & preservation of useful information are important aspects of image enhancement.

Image enhancement is a process focused on processing an image in such a way that the processed image is more suitable than the original for the specific application. A number of enhancement techniques exist in the spatial domain.

For study of every filter, we have considered following algorithms for implementation.

a) *Mean Filter*: Mean filtering is a simple process of replacing each pixel value in an image with average (mean) value of its neighbour, including itself [3]. This is simply done using 3*3 kernels.
b) *Median Filter*: The median is calculated by sorting first all pixel values from the surrounding neighbourhood in numerical order and then replacing pixel being considered with the middle pixel value [3]. This is also implemented using 3*3 kernels.
c) *Mode Filter*: Mode filtering is simply involved in replacing of each pixel value in an image by the mode value of its neighbours, including itself [3]. This is also implemented by 3*3 kernels.
d) *Circular Filter*: Circular filter is implemented using product of original matrix and convolution mask provided [3]. Here, 5*5 kernels are used.
e) *Pyramidal Filter*: Pyramidal filter is also implemented using product of original matrix and convolution mask provided [3]. Here, 5*5 kernels are used.
f) *Cone Filter*: Cone filter is also implemented using product of original matrix and convolution mask provided [3]. Here, 5*5 kernels are used.

A general & common categorization of satellite sensors by resolution is as below:

a) *Low resolution*: 1km-10km, mostly suitable for weather, typically free.
b) *Medium resolution*: 100m -1km, suitable for > 1:250,000, typically free to low cost
c) *High resolution*: 10m-100m, suitable for 1:50,000 - 1:250,000, medium to high cost per scene.

d) *Very High resolution*: 1m-10 meters, suitable for < 1:50,000, high to very high cost per scene.

The ability of an entire remote sensing system to render a sharply defined image is called as resolution. Resolution of a remote sensing is of different types. They are as follows [6]:

a) *Spatial Resolution:*

Spatial resolution of an imaging system is not exactly defined but can be measured in many different ways depending on individual's purpose. Commonly, measure used is based on the geometric properties of imaging system is instantaneous field of view.

b) *Spectral Resolution:*

Spectral resolution defines as the dimension and number of specific wavelength intervals in the electromagnetic spectrum to which a sensor is sensitive.

c) *Radiometric Resolution:*

Radiometric resolution is a measure of how many gray levels are measured between pure black & pure white.

d) *Temporal Resolution:*

Temporal resolution defines as the length of time it takes for a satellite to complete one entire orbit cycle.

III. APPLICATIONS

Satellite images have many applications in oceanography, fishing, agriculture, meteorology, forestry, landscape, cartography, education, biodiversity conservation, geology, regional planning, etc.

IV. ADVANTAGES

They can see and store a lot of information. The light spectrum they use can be manipulated to pick up very minute detail and phenomenon on the earth's surface. For example, archaeologists may use them to locate subtle variations in soils to find potential sites. Or, environmentalists can use them to detect variations in vegetation and moisture.

V. DISADVANTAGES

You may not be able to locate or see what you are looking for. For example, the soil in the rain forest may be blocked by tree cover. Cloud cover can affect quality. In few areas, specifically cloudy places, in order to get a clear image, you have to work patch wise or select images from different time periods. They also take up lots of data storage and computer power. In few cases, they all can be expensive. Also, weather conditions affect image quality depending on the sensor that is used, for example, its difficult to take images of mountain tops where it is covered with cloud.

VI. TYPES OF TECHNIQUES FOR IMAGE ENHANCEMENT

a) *Wavelet Zero Padding (WZP)*[4]: Wavelet zero padding is one of the simplest methods for image resolution enhancement shown in Fig. 1. In this method, wavelet transform of Low Resolution (LR) image is taken and zero matrices are embedded into the transformed image by discarding high frequency sub bands through the inverse wavelet transform and thus High Resolution (HR) image is obtained.

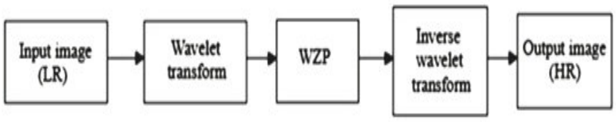

Fig 1: WZP Method

b) *Cycle spinning*[4]: In this method, below steps are followed to get highly resolved image as shown in Fig. 2:

- First we obtain an intermediate High Resolution (HR) image through WZP method.
- After that we obtain N number of images through spatial shifting, wavelet transforming and discarding high frequency component.
- Again, WZP process is applied to all Low Resolution (LR) images to obtain a number of High Resolution (HR) images.
- These High Resolution (HR) images are realigned and averaged to give a final High Resolution (HR) image.

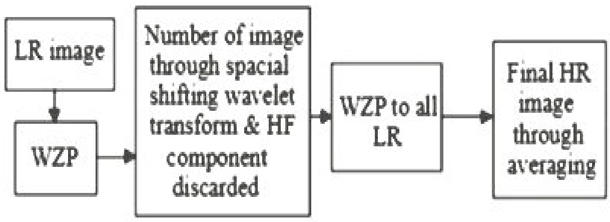

Fig 2: Cycle Spinning

c) *Undecimented Wavelet Transform (UWT)*[4]: Un-decimated wavelet transform is wavelet transform technique which does not use decimation after the decomposition of images into different frequency sub bands. In this method, first WZP method is applied to obtain an estimate of HR image. If the LR image is denoted with Y of size m*n then the estimated HR image is given by:

$$\hat{x}=\text{IDWT}\begin{bmatrix} Y & b \\ b & b \end{bmatrix}$$

Where, b is the zero matrix of size m*n and IDWT is the inverse discrete wavelet transform. In next step, undecimated wavelet transform is implemented on the estimated HR image, as a result of which image is decomposed into two bands called estimated details and approximation coefficients. Then these approximation coefficients are replaced by initially estimated HR image and inverse UWT is taken to obtain the final HR image refer to Fig. 3

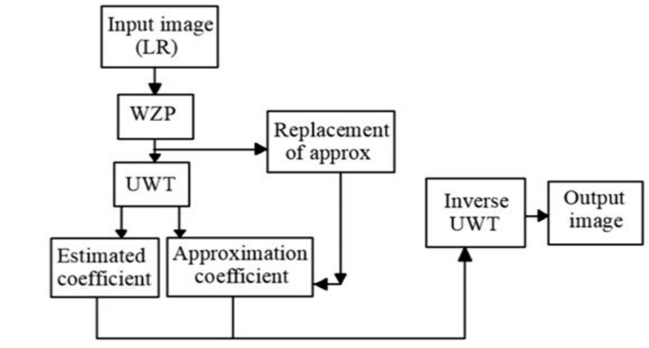

Fig 3: UWT Method

d) Discrete Wavelet Transform (DWT)[5]:

Discrete wavelet transform based technique is most widely used technique for performing image interpolation. DWT is used to decompose a low resolution (LR) image into 4 sub band images LL, LH, HL and HH (Fig 4). All the obtained low and high-frequency components of image are interpolated then. A difference image is obtained by subtracting the interpolated LL image from the original Low resolution (LR) image. Then, this difference image is added to the interpolated high frequency components to obtain estimated form of HF sub band images. Finally IDWT is used to combine these estimated images along with the input image to obtain high resolution images.

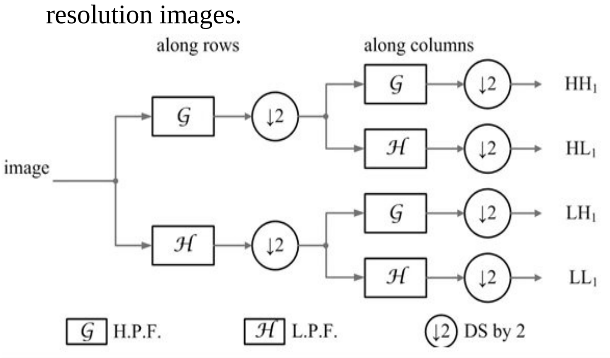

Fig 4: Block Diagram of DWT filter banks of level-I

e) Dual Tree-Curvelet Wavelet Tranform (DT-CWT)[4]:

It is also an efficient technique to obtain a high resolution image. Block diagram for implementation of this method is shown in the Fig. 5. DT-CWT is applied to decompose an input image into different sub band images. In this technique, direction selective filters are used to generate high-frequency sub band images, where filters show peak magnitude responses in the presence of image features oriented at angle +75, +45, +15, -15, -45 and -75 degrees, respectively. Then the six complex-valued images are interpolated. The two up scaled images are generated by interpolating the low resolution original input image and the shifted version of the input image in horizontal and vertical directions. This two real valued images are used as real and imaginary components of the interpolated complex low-low (LL) image, respectively, for the IDT-CWT operation. Finally IDT-CWT is used to combine all these images to produce resolution enhanced image.

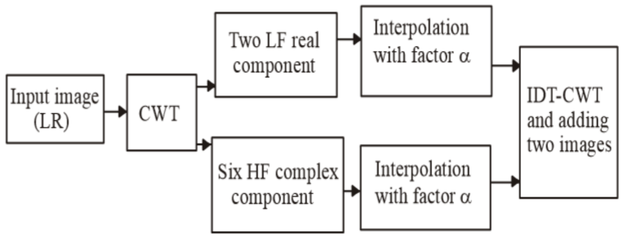

Fig 4: DT-CWT Method

VII. IMAGE QUALITY EVALUATION

The result or output image can be evaluated with two characteristics, parameters, distortion & sharpness. According to distortion evaluation, adjusting errors are required by computing Mean Square Error (MSE). Peak Signal to Noise Ratio (PSNR) adjusts quality of the image which refers higher the PSNR, better is the quality of the image [2].

The formulas for MSE & PSNR are as follows:

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

$$\text{MSE}=\frac{\sum_{i,j}(I_{in}(i,j)-I_{org}(i,j))^2}{M\times N}$$

Where, M & N-number of rows & columns of input image respectively.

R in PSNR- maximum fluctuation in the input image data type.

Expression of MSE generally referred to absolute error equation because the former error is analytically tractable. The main and most common error in image processing is normalized brightness of the image.

VIII. CONCLUSION

This survey paper gives idea and analyses the performance of various and different resolution enhancement techniques. Resolution enhancement schemes are not based on wavelets have the drawback of losing the high frequency contents which resulting in blurring. Also, CWT technique is almost shift invariant and results in better performance. In future, Multi Wavelet Transform can be used to produce fewer artefacts when compared to other techniques for hyper spectral satellite images. Also enhance performance of an satellite image in terms of MSE and PSNR.

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