Comprehensive Survey: Techniques for Satellite Image Enhancement

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Abstract- *Image is a 2D Function of x and y respective coordinates. Astronomy, geographical information systems & geosciences studies are applications where Satellite images are used. Resolution has been an issue of Satellite Images. To overcome resolution problems found in Satellite images, for image resolution and brightness enhancement, various techniques have been proposed like DWT(Discrete Wavelet Transform) and SVD(Singular value decomposition). 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, comparison of various satellite image enhancement techniques based on interpolation of the high frequency sub bands obtained by DWT and techniques used DWT to decompose the input images into different sub bands are done.*

Keywords- Satellite Images, Image Resolution, Image Enhancement, Techniques for Image Enhancement, Mean Filter, DWT, SVD

I. HISTORY

Satellite imagery can be considered images of Earth or other planets collected by various satellites. Governments and businesses around the world operates Imaging Satellites. Though its usefulness and applications have been came across, enhancement are needed for the same.

II. INTRODUCTION

Pictures or images has been considered the most convenient way of conveying or transmitting information across the world. Images worth thousand words. Image processing is the field of processing images for the betterment. Increasing number of pixels(Interpolation),is a way to enhance image. Nowadays, many interpolation techniques have been developed to increase quality of image resolution enhancement. There are three main interpolation techniques, which are nearest neighbor, bilinear & bicubic. Among these three techniques, Bicubic interpolation is more sophisticated than others and results are in smoother edges. Noise removal & preservation of useful information are important aspects of image enhancement.

Image enhancement is a focused image processing technique where the processed image is more suitable than the original for the specific application. For spatial domain, various techniques has been proposed.

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

a) Mean Filter: Mean filtering is a technique for replacing each pixel value in an image with mean(average) value of its neighbor, including itself [3]. This is simply done using 3*3 kernels.

b) Median Filter: The median is calculated by sortingfirst 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 inreplacing 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, it is mostly suitable for weather and typically free.

b) Medium resolution: 100m -1km, suitable for more than

1:250,000 and typically low for 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 less than1:50,000,it is high to very high cost per scene.

Resolution of a remote sensing is of different types and some of them are explained below:

a) **Spatial Resolution:** Spatial resolution of an imaging system can be measured in many different ways depending on user specific purpose.

b) **Spectral Resolution:** Spectral resolution is defined as number of specific wavelength intervals in the electromagnetic spectrum to which a sensor is sensitive and the dimension.

c) **Radiometric Resolution:** Radiometric resolution is a measure number of gray levels measured between pure black & pure white.

d) **Temporal Resolution:** Temporal resolution is defined as the length of time it takes for a satellite to complete one entire orbit cycle.

III.APPLICATIONS

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

IV.ADVANTAGES

Lot of information can be contained within a single image. The light spectrum satellite uses 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

Sometime it becomes harder to find information what you are looking for within an image. 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. Need of memory storage and power increases to store such satellite images. 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. VARIOUSIMAGEENHANCEMENT TECHNIQUES

a) **Wavelet Zero Padding (WZP) [4]:** For Image Resolution Enhancement, Wavelet zero padding is one of the simplest method, which is shown in Fig. 1. In this method, wavelet transform of Low Resolution (LR) image has been taken and zero matrices are padded into the transformed image by discarding high frequency sub bands using inverse wavelet transform technique and hence High Resolution (HR) image is obtained.

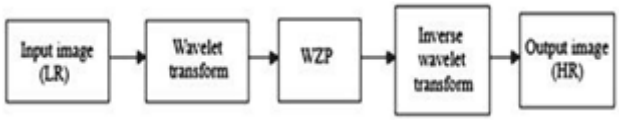

Fig 1: WZP Method[4]

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

- First an intermediate High Resolution (HR) image can be obtained through WZP method.
- Next, we will obtain N number of images through spatial shifting, wavelet transformation and discard of high frequency component.
- WZP process will be applied again 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.

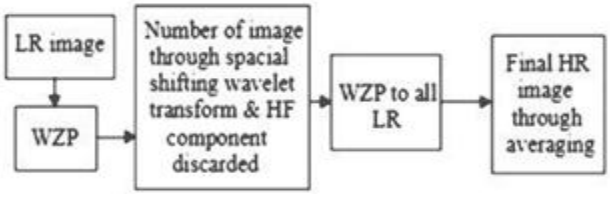

Fig 2: Cycle Spinning[4]

c) **Undecimented Wavelet Transform (UWT)[4]:** Un-decimated wavelet transform is wavelet transform technique which does not let us 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. Estimated HR image is given by BELOW If the LR image is denoted BY Y with the size m*n :

=IDWT

Where, b = zero matrix of size m*n
IDWT = inverse discrete wavelet transform.

In next step, undedicated wavelet transform has been implemented on the estimated HR images, as a next step image is decomposed into two bands called estimated details and approximation coefficients. 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

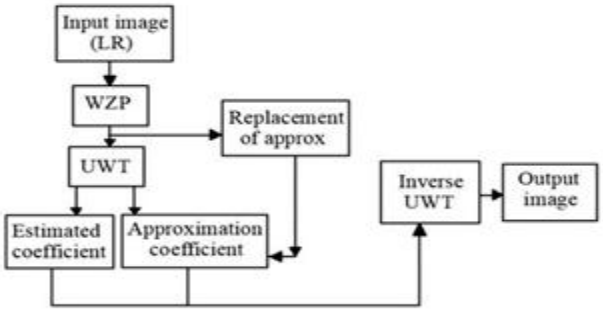

Fig 3: UWT Method[3]

d) Discrete Wavelet Transform (DWT)[5]: Most widely used technique for performing Image Interpolation is DWT(Discrete Wavelet Transform). By using of DWT user can decompose a low resolution (LR) image into four sub band images LL, LH, HL and HH (Fig 4). All the obtained low and high-frequency components of image are interpolated then. We can obtaindifference image by subtracting the interpolated LL image from the original Low resolution (LR) image. Then, new image is added to the interpolated high frequency components to obtain estimated form of HF sub band images. With the help of IDWT these estimated images can be combined along with the input image to obtain high resolution images.

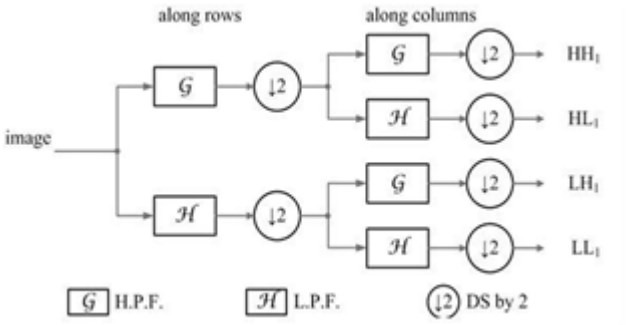

Fig 4: Block Diagram of DWT filter banks of level-I

e) Dual Tree-Curvelet Wavelet Tranform (DT-CWT)[4]: To obtain high resolution image, this is efficient way for it. 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 applied 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 enhanced resolution image.

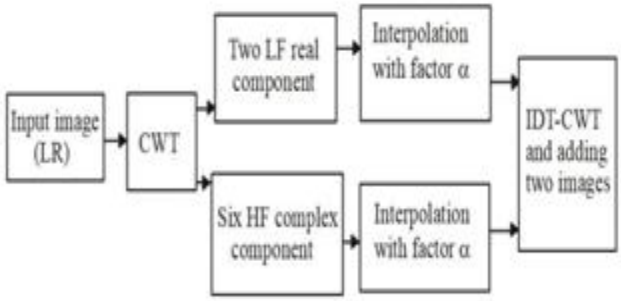

Fig 4: DT-CWT Method

VII. IMAGEQUALITYEVALUATION

The result or output image can be evaluated with two characteristics, parameters, distortion & sharpness. According to distortion evaluation, adjusting of 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: PSNR=10log

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

Various Image Enhancement Techniques are explained and compared. Resolution enhancement schemes which are not on the base of Wavelets have the drawback of losing the high frequency contents which resulting in blurring. CWT technique is almost shift invariant technique and it results in better performance. In future, we can enhance performance of an satellite image in terms of MSE and PSNR.

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