Survey on Various Wavelets Based and Fuzzy Based Methods for Satellite Image Enhancement

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Abstract

Nowadays, Satellite pictures are utilized in several fields of research and in several applications like physical science, geographical info systems & geosciences studies. Satellite picture is also not clear because of several reasons, the vital info within the pictures is also not therefore clear. Different image enhancement methods can be used which can perform improvement in satellite images. Image improvement technique is employed to boost the eminence of the image to get helpful information. Several methods are developed to enhance the satellite pictures. Objective of this paper is to discuss the different types of transform techniques used for image enhancement. The edges of a picture are often improved by using a good transform technique so some fuzzy techniques will be studied for this purpose and therefore the resolution are often improved by using different interpolation techniques. So, the mixture of different transform techniques associated with interpolation ways will helps to provide an overall increased image. There are various wavelet domain based methods such as Wavelet Zero Padding, Dual Tree-Complex Wavelet Transform, Discrete Wavelet Transform and Cycle Spinning. On the basis of analysis, the most efficient method is proposed. Here given a discussion of the previous work of authors to deal with these issues. So that information which is visible from the image is more informative and helpful to human beings in many applications.

Keywords - *Satellite Image, Image improvement, DWT, Fuzzy Enhancement*

I. 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 methods have been developed to increase eminence of image resolution improvement. There are three main interpolation methods, which are nearest neighbour, bilinear & bicubic. Among these three methods, Bicubic interpolation is more sophisticated than other two & results in smoother edges. Noise removal & preservation of useful information are important aspects of image improvement. Image improvement 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.

Digital images are consisting of pixels. Each pixel has its own color. Digital images are useful for conveying information. But usually these images are low contrast or contain noise. This makes the images less interpretable. So image improvement is needed for better interpretation. There are various types of noises. Some are: Gaussian Noise, Speckle noise, Salt-Pepper Noise and Poisson Noise. Gaussian is also known as additive noise. In image in which Salt-Pepper Noise is present, dark pixels are present in bright regions and bright pixels are present in dark regions. Poisson Noise is also known as short noise. It is a type of electronic noise. Speckle Noise is known as multiplicative noise. The image improvement methods are basically divided into two domains. They are: Spatial Domain and Frequency Domain. In spatial domain, the pixel values are manipulated for image improvement. The spatial domain methods are usually used to achieve contrast improvement. In frequency domain, the Fourier Transform concept is used. The basic idea for the frequency domain methods is to manipulate the transform coefficients for image improvement.

The improvement of the image is also necessary to improve the visibility of the image to remove unwanted

noise, artifacts, to improve contrast and to find more details. So that the some useful information is extracted to get enhance image. This is important reason behind image improvement methods. [1,2]. The main objective of this paper is to understand the term related to the improvement of satellite images. Image Improvement methods are used for making satellite images more informative and so that it readily interpreted by human eye. The meaning of improvement is the alteration of the appearance of an production forecast, forest cover and type mapping, weather prediction, watershed development and monitoring, disaster management and many more [2].

Figure1: Bad contrast, low resolution Satellite Image

Figure2: Output good contrast, high resolution Satellite Image

II. RESEARCH AREA

1 Application:

1.1 Underwater Image Enhancement

Kashif Iqbal et al. (2007) proposed a an approach based on slide stretching algorithm to enhance the underwater images in which the clarity of the images is degraded by light absorption and scattering and as a result one color dominates the image. This involves image in such a way that the information contained in that image is more readily interpreted visually. In the fig. no. 1 we have taken one example of sample image before improvement which is taken from satellite of crop producing area, after improvement its result visible in fig. no. 2 [1]. We can see the difference by using normal human eye. These satellite images are processed and used for crop

contrast stretching of *RGB* algorithm which is applied to equalize the colour contrast in images. Further, Saturation and intensity stretching of *HSI* is used to increase true colour and solve the problem of lighting in images. Interactive software is developed for under water image enhancement and quality of images which is statistically illustrated through histograms. The methodology for underwater image enhancement is explained in Fig. 1.

Figure 3: Methodology for underwater image enhancement

Figs. 2 and 3 present the snapshot of the tool used and a comparison of results before and after image enhancement.

1.2 Image Enhancement of low light scenes with infrared flash images

Sosuke Matsu et al. (2010) developed a technique for enhancing an image using near infrared flash images.

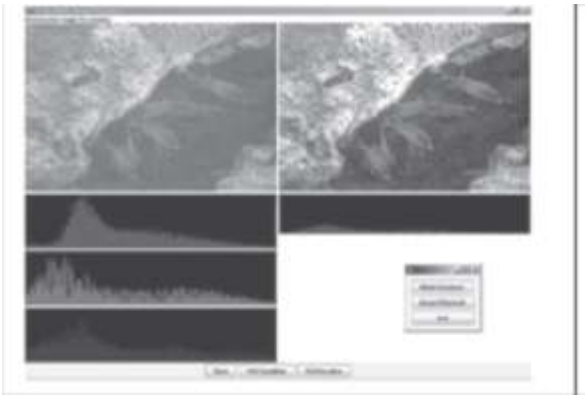

Figure 4: Snapshot of tool (Kashif Iqbal et al., 2007)

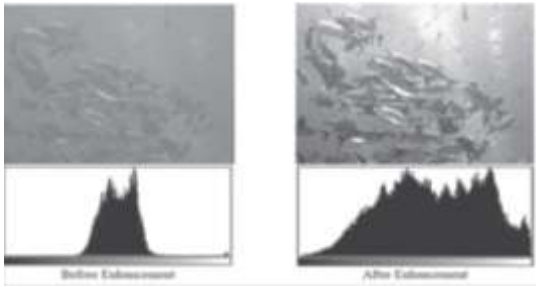

Figure 5: Comparision of results before and after enhancement
(Kashif Iqbal et al., 2007)

In this technique, near infrared flash images are effectively used in removing annoying effects in images of dimly-lit environments like image noise and motion blur where dual bilateral filters are used to decompose the colour image into a large scale image and a detail image.

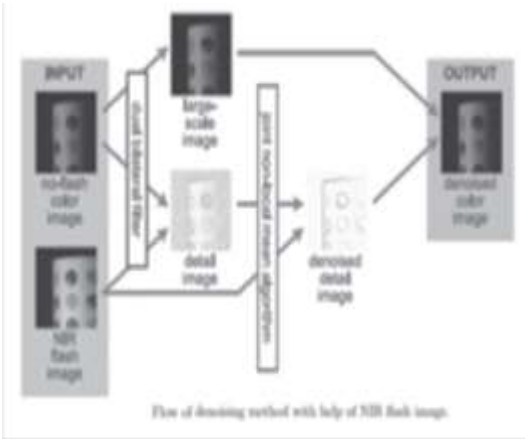

Figure 6: (Sosuke Matsu et al., 2010)

This method is applicable for dynamic scenes. A joint local mean algorithm is used to remove noise and motion blur. A multispectral imaging system is implemented which captures a color image and NIR flash images without causing any interference. The effectiveness of the technique is confirmed through experiments using real images. The flow of denoising and deblurring methods is explained with the help of NIR flash images as shown in Figs. 4 and 5 respectively.

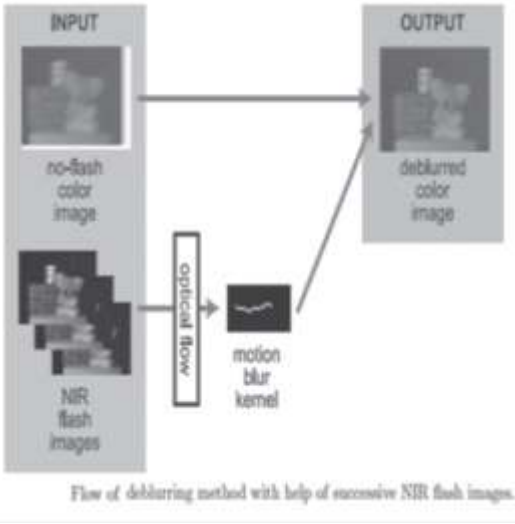

Figure 7: (Sosuke Matsu et al., 2010)

1.3 Color image enhancement using minimum mean brightness error dynamic histogram equalization

Md. Foisal Hossain et al. (2011) made an attempt to synthesis some paths to develop a method for colour image enhancement. The proposed method is known as Minimum Mean brightness Error Dynamic Histogram Equalization (*MMBEHDE*) and overcomes the unwanted visual deterioration caused by Histogram Equalization (*HE*) technique. The technique involves smoothening the histogram, detection of local minima from smoothed histogram, determination of threshold in portion using absolute mean brightness error, mapping of each partition into a new dynamic range and applying histogram equalization in each partition. Experimental results show that the proposed method produces less brightness error than other methods. Image Enhancement through equalize various channels of HIV, RGB, YUV AND HSV Colour spaces are presented in Fig. 6.

Figure 8: Image Enhancement through Equilize Various Channels of HIV, RGB, YUV AND HSV Colour spaces (Md. Foisal hossain et al., 2011)

Figure 9: (Bo fu et al., 2012)

1.4 See-through image enhancement through sensor fusion

Bo fu et al. (2012) proposed a novel image enhancement method to improve the frame visual quality captured by camera behind the see through screen. An algorithm is developed which out-performs the traditional image enhancement method in recovering colored image with less noise and more detail information. The Novel image enhancement framework proposed in this paper utilizes an auxiliary color depth camera that is mounted on the side of the screen and camera behind the see through screen (Fig. 7). A Significant improvement in the quality of image is reported by fusing the information from both the cameras. Experimental results of this study prove favorable against traditional image enhancement and warping methods that uses only a single image. Fig. 8 explains the process pipeline. Green blocks are Input; Red blocks are output; while the rest of the modules are intermediate processing modules.

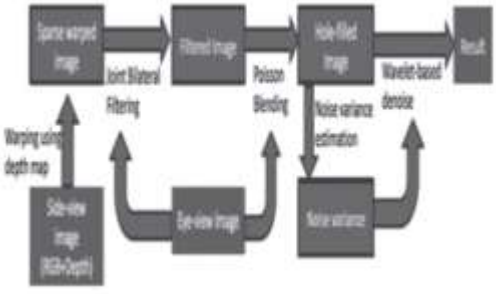

Figure 10**:** (Bo fu et al., 2012)

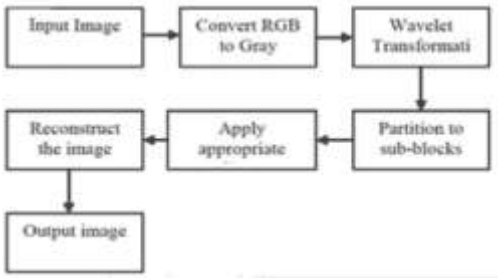

Figure 11: (Muna et al., 2011)

Colored satellites image enhancement using wavelet and threshold enhancement using wavelet and threshold decomposition Muna et al. (2011) made a study to enhance the satellite image using an intelligent aspect of filtering and describe multi-threshold technique with an additional step in order to obtain the perceived image. A new enhancement filter is introduced for digital satellite images as explained in Fig. 9. This method involves conversion of *RGB* to gray, wavelet transformation, partition into sub locks and appropriate filters such as mean filter, mode filter, median filters for image filtering of weak edges, sharp edges, homogeneous block filtering. The visual examples shown have demonstrated that the proposed method was significantly better than many other sharpener type filters in respect of edge and fine detail restoration (Fig. 10). Wang et al. (2012) made studies on the effect of quality of depth map on depth image base rendering (*DBIR*), which enables a variety of advanced 3D video related applications such as perceived depth adjustments for multi view auto-stereoscopic displays. A novel depth image enhancement is proposed for view synthesis. The technique involves two stages, one on the depth images that correspond to the reference views and another on the warped depth image that correspond to virtual view.

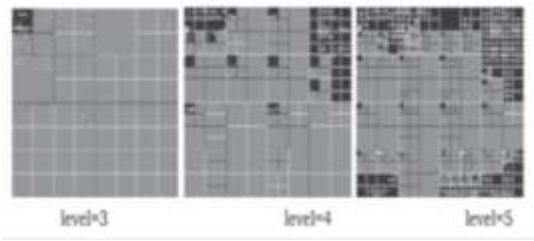

Figure 12: (Muna et al., 2011)

1.5 A local depth image enhancement scheme for view Synthesis

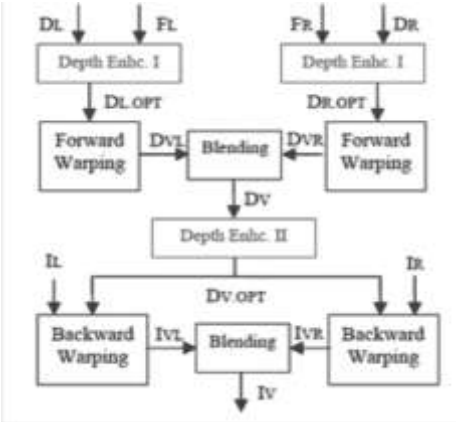

Figure 13: Proposed Depth Enhancement Techniqu Integrated in DIBR System (Wang, Y et al., 2012)

Sparse depth features and cost function are used in finding depth values of various candidates. In each stage, first set of candidates are identified. Then cost of each candidate is calculated by referencing the depth map itself and pixel value of lowest cost is updated. Experimental results show that the rendering artifacts can be reduced and the vertical structures can be better preserved in the virtual view image. Figure 11 illustrates the proposed Depth Enhancement Technique Integrated in *DIBR* System. Combining depth information and local edge detection for stereo image enhancement Studies made by Walid Hachicha et al. (2012) reflect an improved stereoscopic image quality by a novel contrast enhancement method that combines local edges and depth information. The stereo image contrast enhancement approach combines the sensibility of the human visual system to edge information and position of objects in 3D scene.

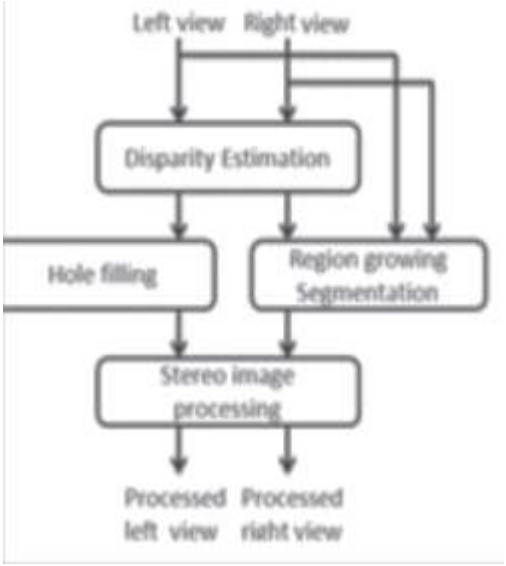

Figure 14 Comparative study of Image enhancement using median filter and high pass filter (Walid Hachicha et al. 2012)

The disparity estimation, hole filling, region growing segmentation are major steps involved in this technique. Increase of contrast is controlled based on the depth information and aims at promoting the nearest objects in the scene. Psychophysical results show that the proposed method produce stereo images which are less stressful on the eyes. Figure 12 presents a comparative study of Image enhancement using median filter and high pass filter. A cones image disparity map before and after hole filling is shown in Fig. 13.

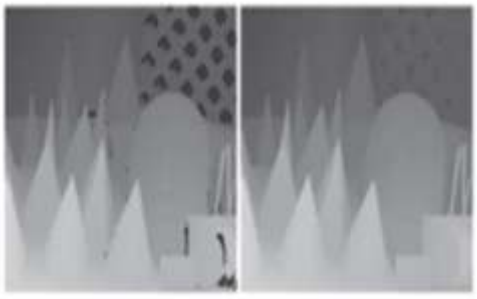

Fig. 13: (Walid Hachicha et al., 2012)

Figure 15: Output of Unsharp Masking(Sanjay Singh et al.,
2012)

Sanjay Singh et al. (2012) made a study about image enhancement using various filtering techniques to improve the interpretability of information. In their comparative study, they developed a technique which involves median filter, spatial domain high pass filter which are mainly used for smoothness and sharpening of images and extracting the useful information for analysis of image enhancement. Filters such as median filter are an effective tool to minimize salt and pepper noise while high pass filter is to enhance image through image sharpening. The outputs are compiled in MATLAB environment. The output of Unsharp masking is depicted in Fig. 14.

III. LITERATURE SURVEY

To study the concepts of satellite image improvement we have studied many papers. As we know the satellite images has some issues improvement of gray-scale/colour image, noise, artifacts, distortion, large size, resolution, weak colour information, high frequency content and many more. But it is difficult to deal with all problems together. Here discussing some previous papers from which authors view and proposed methods. P. Suganya, N. Mohanapriya et. al. [1] in this work author proposed method for satellite image improvement which includes Haar filter for pre-processing, Multi Wavelet Transform, Interpolation Process, Inverse Process of Multi Wavelet Transform for the low resolution image. The Multi Wavelet Transform and Interpolation method used to produce fewer artifacts. Limitation of this method is not effective method to reduce distortion and for losing of high frequency content.

Abdullah-Al-Wadud et al., 2007 [2] proposed one method which uses global histogram modification method. Generally local histogram modification method performs equalization over small patches so that the small scale details become clear. However it can create several artifacts. Histogram Equalization and specification A good contrast improvement method should specifically address several significant properties, some of which are listed below. (1) Noise tolerance: The contrast improvement method should exhibit appropriate noise immunity. (2) Uniform contrast: The contrast improvement method should provide uniform contrast of the entire image. (3) Brightness preservation: The contrast improvement tec hnique should enhance the contrast of the image without losing brightness. (4) Convenient implementation: The contrast improvement method should be able to be set up quickly and reliably.

Pavithra C, Dr. S. Bhargavi [3] author proposed a method for fusing two dimensional multi-resolution 2-D images using wavelet transform by using the combine gradient and smoothness criterion. Basically it decompose each registered image into sub-images by using forward wavelet transform which have same resolution at that same level and different resolution at different levels. Image fusion is performed based on the high frequency sub-images and final image is obtained using inverse wavelet transform. Using the inverse wavelet transform it can reconstruct the image. This reconstructed image has information gather from all the different images sources so this is more informative.

Shamna K. S. et.al. proposed a resolution enhancement techniques for satellite images The proposed image resolution enhancement technique is based on high frequency sub-band images obtained by discrete wavelet transform (DWT) of the input image. First of all interpolate the input image using
bicubic interpolation then perform DWT on the interpolated input image to obtain different sub-bands. The high frequency subband's edges are enhanced using stationary wavelet (SWT).Combine these two high frequency subband's which are

modified and interpolated. Then perform inverse DWT (IDWT) to get high resolution image[4]. Anumolu Lasmika, K. Raveendra [5] author proposed a method for improving eminence of satellite images. Author present a method, DWT to decompose the input image into different sub bands and apply threshold method on it. Identify the areas of the edges by using threshold decomposition method. After that the edges are sharpened by using morphological filters. This method works for sharpening and reduce the distortion of an image. Limitation of this work may be extended for other problems related to satellite images such as artifacts.

Milindkumar V. Sarode et.al [6] proposed one method using a mandani fuzzy inference system. This method enhances color of a tumor which helps to diagnose different region of tumor based on its enhanced color which not prominent from the original image. Further .

A new image improvement method for enhancing the satellite images has been proposed in [8]. In this approach, Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) have been used. The experimental results show that this method is better than the conventional and state-of-the-art methods for image improvement.

In [9], satellite images are firstly enhanced by using DWT-SVD method and then segmentation is applied on the enhanced using MRR–MRF Model. 3-level DWT method for image improvement has been implemented in [10]. In [5], a novel method for image improvement has been presented which is

based on Cuckoo Search Algorithm and DWT-SVD. DWT is used to decompose the image into four sub-band images (LL, HL, LH and HH). Cuckoo Search Algorithm is applied for optimizing each sub- band and then singular value matrix of LL thresholded sub band image is obtained and finally image is reconstructed by using inverse discrete wavelet transform (IDWT). The experimental results show that this approach is better than conventional methods and stateof-the-art methods. An image resolution improvement method has been proposed in which discrete wavelet transform and stationary wavelet transform have been used [11].

G. D. Rode et. al. proposed a new method which focus on edge preservation and enhancement. In this new method uses the concept of wavelet and morphological filtering. As the Gabor filter is used for efficiently detects the edges from image, while these detected edges are sharpened by using morphological filters. Also the other intermediate steps are applied so that it works on other important aspects such as noise removal, color and useful information preservation etc.[12] H. Demirel et. al. proposed resolution enhancement technique uses DWT to divides the input image into different sub bands of the system. The high-frequency sub band images and the input low-resolution image have been interpolated followed by combining all these images to generate a new resolution-enhanced image by using inverse DWT in the system. To achieve a sharper image an intermediate stage for estimating the high-frequency sub bands has been proposed in this technique[13].

A. Gupta et. al. proposed a new satellite image resolution enhancement technique based on the interpolation of the high-frequency sub-band images obtained by discrete wavelet transform (DWT) and the input image. DWT is applied in order to decompose an input image into dissimilar sub-bands. Then the high frequency sub-bands as well as the input image are interpolated. All these sub-bands are combined to generate a new high resolution image by using inverse DWT (IDWT)[14].

R. Swaminathan et. al. discuss the different types of transform techniques used for image enhancement. The edges of an image can be improved by using an effective transform technique and the resolution can be improved by using interpolation technique. The combination of transform techniques and interpolation methods helps to produce an overall enhanced image[15].

R. B. Mehta et. al. 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[16].

Thriveni R. et. al. they propose a DWTPCA based fusion and Morphological gradient for enhancement of Satellite images. The input image is decomposed into different sub bands through DWT. PCA based fusion is apply on the low-low sub band, and input image for contrast enhancement. IDWT is used to reconstructs the enhanced image. To achieve a sharper boundary discontinuities of image, an intermediate stage estimating the fine detail sub bands is required. This is done by the success of threshold decomposition, morphological gradient based operators are used to detect the locations of the edges and sharpen the detected edges[17].

Jadhav B. D. et. al. proposed a satellite image enhancement algorithm based on interpolation of the high-frequency subbands obtained by discrete wavelet transform (DWT) and the low resolution input image is proposed. This method uses a DWT and high frequency subband image interpolation into the low resolution input images. The sharpness of image is obtained by the estimation high frequency subband. Inverse DWT is performed to reconstruct the resultant image [18].

Sharma A. et. al. proposed a technique which decomposes the input filtered image into the four frequency sub-bands by using DWT and then the high frequency subband images and input image have been interpolated along with this the technique also estimates the singular value matrix of the low–low sub band of histogram equalized image and input filtered image then normalize both singular value matrices to obtain brightness enhanced image[19].

IV. COMPARATIVE ANALYSIS OF EXISTING METHODS:

Table below shows the comparison of existing methods to find out challenges of future work:

Sr. No.	Authors	Method	Advantage	Limitation
1	P.Suganya, N.Mohanapriya et. al.[20]	Multi Wavelet Transform	Reduces noise, artifacts, distortion	Used only for low resolution images, Does not effective in edge enhancement
2	Arya Unni [21]	2D Discrete wavelet transform uses haar filter	Noise removal and edge enhancement	Weak color information is often a problem
3	YongYang, Shuying Huang et. al [22]	Discrete wavelet transform	Apply on multi focus image.	Does not apply on Multi sensor images
4	Pavithra C, Dr. S. Bhargavi et. al. [23]	Image fusion using DWT	Apply on multi-modal image, Used for both color and grey scale images.	Method is computationally expensive and need more space. Does not apply on multi resolution images.
5	Wenkao Yang, Jing Wang et. al. [24]	Principal components analysis using image fusion	Effective method to sharpening of image information.	Dominant spatial information and weak color information is often a Problem
6	Lasmika, K. Raveendra et. al. [25]	DWT using morphological filter.	Effective method to edge detection and fine detail restoration	Does not work on multi modal images.
7	S. Oudaya Coumar and et.al [26]	Discrete Wavelet Transform (DWT), , Adaptive Intensity Transfer Function Estimation, Contrast Enhancement,	Suitable for Low contrast satellite image; uses LL, LH, HL&HH Subband of DWT then Segmentation of Blocks	Only Suitable for low contrast input images
8	B. D. Jadhav and P. M. Patil [27]	Discrete Wavelet Transform (DWT), Interpolation, Interpolation Discrete Wavelet Transform (IDWT)	DWT and IDWT Used	Time Taking Process

V. CHALLENGES IN EXISTING METHODS:

1. Most of the methods are suitable for very low resolution images, method which can be suitable for all types of input images is required.

2. Discrete Wavelet Transform method is efficient but more time taking , so only one level of decomposition may be applied to reduce the required time.

3. Less computationally expensive method will be a challenge.

4. Method which can deal with multiple type of problems like edge enhancement, low focused input image and low color information image will be challenge.

VI . CONCLUSION & FUTURE WORK

This paper gives a brief review of the image enhancement methods which uses a combination of transform techniques and interpolation.. 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 and fuzzy inference system based enhancement 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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