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# Image Enhancement using DWT

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***Abstract*— Image enhancement is the method by which we try to develop an image so that it looks subjectively better. We do not really know how the image should look, but we can tell whether it has been improved or not, by considering, for example, whether more detail can be seen, or whether unwanted flickering has been removed, or the contrast is better etc. Satellite images are used in many applications such as Geosciences lessons, stargazing, and terrestrial info systems. One of the most chief quality aspects in images comes from its resolution. Interpolation in image handling is a familiar method to increase the resolution of a digital image. The technique resolution enhancement is used as a process that enlarges the given input in the way that the output is sharper. The performance of the technique over performs all available state-of-art methods for image resolution improvement. In image Resolution enhancement method a bicubic interpolation technique have been used.**

***Keywords*— Wavelet, DWT, IDWT, Interpolation.**

## I. INTRODUCTION

There are several methods which have been used for satellite image resolution enhancement. Resolution of an image as been always an important issue in many image and video processing applications, such as video resolution enhancement feature extraction , facial reconstruction and satellite image resolution enhancement .Interpolation in image processing is a method to increase the number of pixels in a digital image. The resolution can be enhanced using different interpolation technique such as bilinear interpolation, nearest neighbour interpolation, and bi-cubic interpolation. Interpolation is the process by which we can estimate unknown data values from known data values. In this model, i have used bi-cubic interpolation to interpolate the low resolution images in image processing as bi-cubic interpolation is better over bilinear interpolation or nearest neighbour interpolation technique in terms of image re-sampling. Images re-sampled with bi-cubic interpolation are smoother than the other two techniques[7].

The one dimensional wavelet transform can be applied to the rows of the image head, and then the results are decomposed laterally the columns by decomposing into four quadrants with different interpretations. Thus Two Dimensional wavelet breakdown of an image is performed by applying the one Dimensional discrete wavelet transform (DWT). This result is decomposed into four sub-band images referred to low-low (LL), low-high (LH), high-low (HL), and high-high(HH)[8].

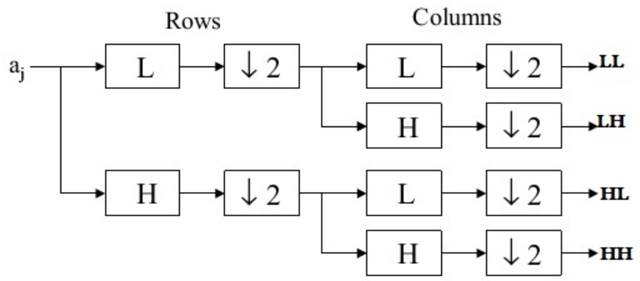


Fig. 1. Wavelet decomposition for 2-D pictures

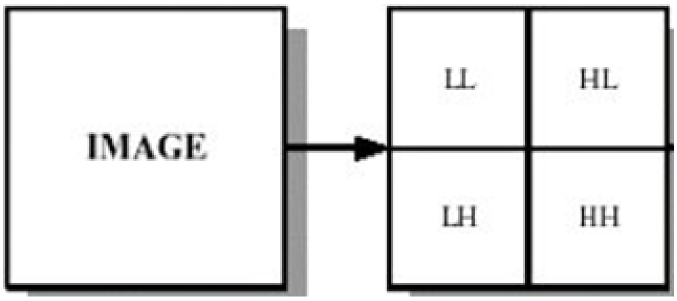


Fig. 2. LL, HH, LH AND HL SUBBAND OF IMAGE

Filter bank should operate on the image in order to generate different sub-band frequency images.Low-Low (LL): The upper left quadrant consists of all coefficients, which were filtered by the low pass filter ˜h along the rows and then filtered along the corresponding columns with the low pass filter again.

This sub block is denoted by LL and represents the Approximated version of the original at half the resolution.Low-High (LH): The lower left and High-Low (HL): the upper right blocks are filtered along the rows and columns with ˜h and ˜ g, alternatively. The LH block contains vertical edges, the HL blocks shows horizontal edges .High-High (HH): The lower right quadrant is derived by applying high pass filter ˜ g which belongs to the given wavelet. We can interpret this block as the area, where we find edges of the original image in diagonal direction[1].

In this model, image resolution-enhancement technique is carried out by using DWT .The input low resolution image is Decomposed into four sub band decomposed into four sub-band images referred to low-low (LL), low-high (LH), high-low (HL), and high-high (HH) and by using Low pass filter and high pass filter. The .The bi cubic interpolation technique is applied on four sub band separately .The Difference is calculated from the original high resolution image and interpolated LL sub band .The difference image calculated is added into the other three sub band to obtain high frequencies .again the bicubic interpolation with factor alpha/2 is applied on the low resolution image and the low-high (LH), high-low (HL), and high-high (HH) sub band. Inverse DWT (IDWT) has been applied to combine all these images to generate the High resolution image with high PSNR value. On this image again processing is done by extracting the feature with high frequency from original low resolution image and added with output image from IDWT to obtain higher PSNR value than previous one. The term peak signal-to-noise ratio (PSNR**)** is an expression for the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation. Because many signals have a very wide dynamic range, (ratio between the largest and smallest possible values of a changeable quantity) the PSNR is usually expressed in terms of the logarithmic decibel scale.Thus Higher PSNR is achieved using implemented system. PSNR can be obtained by using the following formula [5]:

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

Where R is the maximum fluctuation in the input image andMSEis representing the MSE between the given input image Iin and the original image Iorg which can be obtained by the following:

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

Where M and N are the size of the image

## II. DESIGN STAGES

*1. Discrete Wavelet Transform*

This module main function to transform input low resolution image to L & H frequency Samples. The input low resolution image is Decomposed into four sub band decomposed into four sub-band images referred to low-low (LL), low-high (LH), high-low (HL), and high-high (HH).and by using Low pass filter and high pass filter[5]. Resolution is an important feature in satellite imaging, which creates the resolution enhancement of such images to be of vital importance as increasing the resolution of these images will directly affect the performance of the system using these images as input. The highest loss of an image after being resolution enhanced by applying interpolation is on its high-frequency modules, which is due to the smooth out caused by interpolation. Henceforth, in demand to increase the quality of the improved image, conserving the edges is essential.

### *2. Bicubic Interpolation*

The L & H frequency image samples of DWT are interpolated using Bicubic interpolation technique and generate output interpolated images. The bicubic interpolation technique is applied on four sub band separately to increase the pixel in the image. Images re-sampled with bi-cubic interpolation are smoother. The low resolution input image and the interpolated LL image with factor 2 are very much interrelated. The variance between the LL sub band image and the low-resolution input image are in their high-frequency components. Hence, this alteration image can be use in the intermediate process to correct the estimated high-frequency components. This estimate is achieved by interpolating the high-frequency sub bands by factor 2 and then including the difference image which is high-frequency components on low-resolution input image into the estimated high-frequency images, trailed by another interpolation with factor α/2in order to reach the required size for IDWT process.

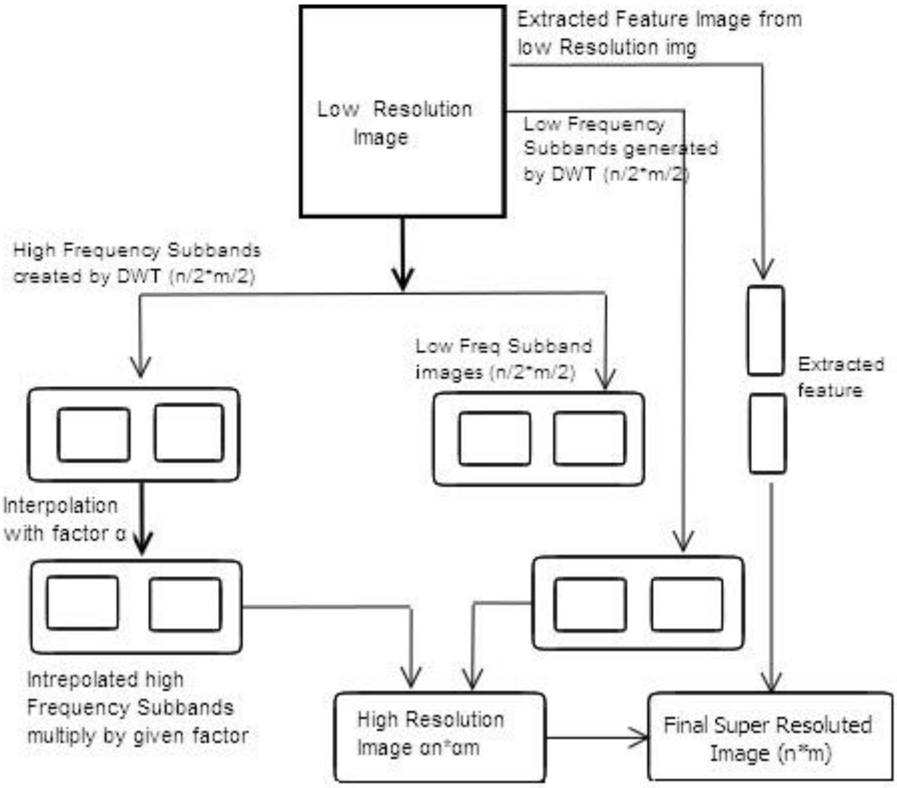


Fig.3. Block Block Diagram of Resolution Enhancement by DWT

### *3. Inverse Discrete Wavelet Transform*

The intermediate process of adding the difference image, having high-frequency components, produces significantly sharper and richer final image. This sharpness is improved by the circumstance that, the interpolation of insulated high-frequency mechanisms in HH, HL, and LH will preserve more high-frequency components than interpolating the low-resolution image directly. The difference image calculated is added into the other three sub band to obtain high frequencies .again the bicubic interpolation with factor α/2 is applied on the low resolution image and the low-high (LH), high-low (HL), and high-high (HH) sub band. Inverse DWT (IDWT) has been applied to combine all these images to generate the High resolution image with high PSNR value.

### *4. Implemented system*

On output image from IDWT again processing is done by extracting the feature with high frequency from original low resolution image and added with output image from IDWT to obtain higher PSNR value than previous one

## III. RESULTS

Using the same set of tests images, different image enhancement algorithms can be compared systematically to identify whether a particular algorithm produces better results. The metric under investigation is the **peak-signal-to-noise ratio**. If we can show that an algorithm or set of algorithms can enhance a degraded known image to more closely resemble the original, then we can more accurately conclude that it is a better algorithm.

The result are taken by testing images of different category Ies.the TABLE I shows Airport Category images and also the PSNR calculated for the IDWT and Implemented system. The Fig 4 shows how the original image is going through different process. (a) Original Low Resolution Image, (b) Image after applying DWT,(c) cubic interpolation-based resolution enhancement, (d) Difference image calculated from Original Low Resolution Image, (e) Image obtain from IDWT, (f)Image from Implemented System.

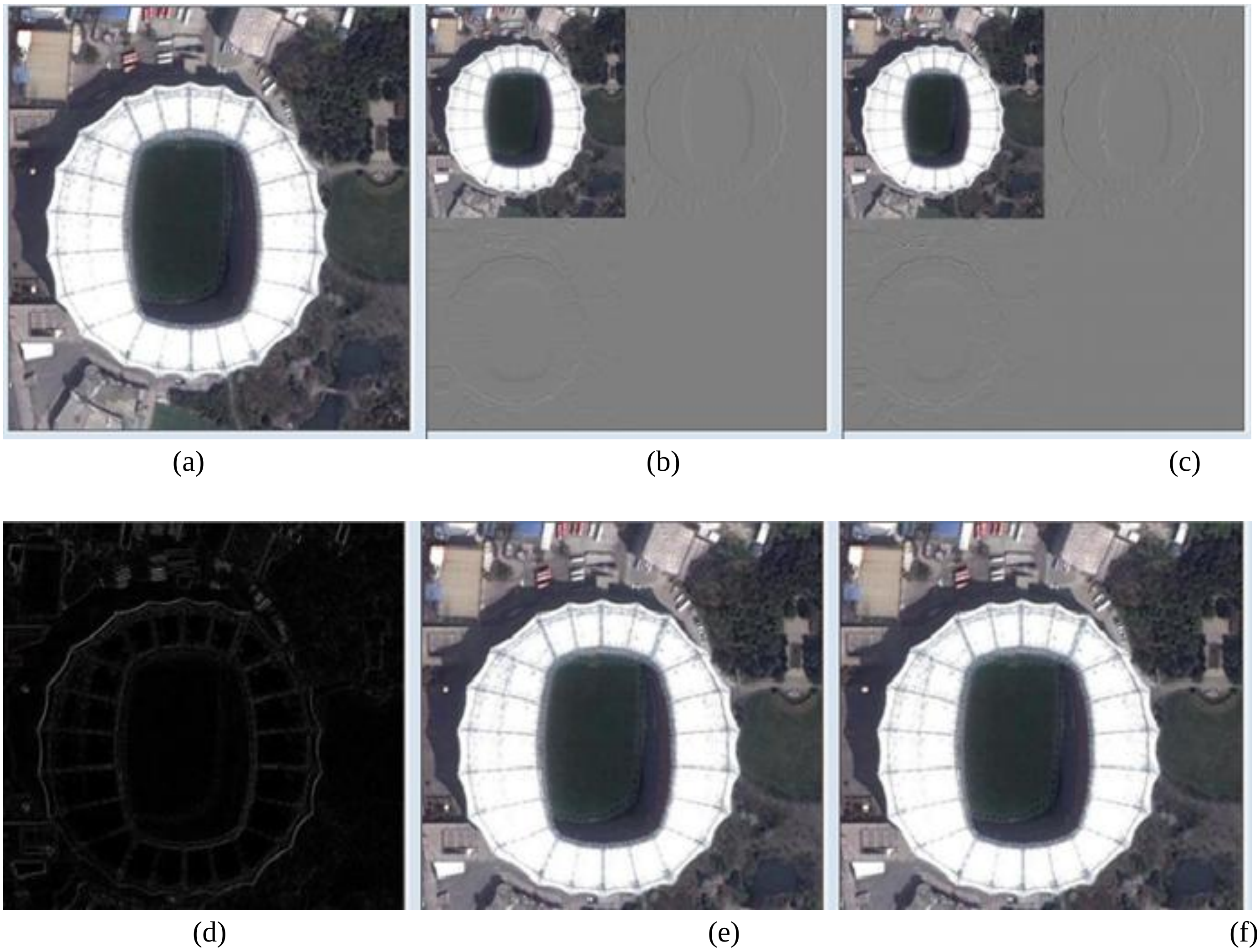


Fig. 4. (a) Original Low Resolution Image, (b) Image after applying DWT,(c) bicubic interpolation-based resolution enhancement, (d) Difference image calculated from Original Low Resolution Image, (e) Image obtain from IDWT, (f)Image from Implemented System.

TABLE I

PSNR RESULT FOR RESOLUTION ENHANCEMENT

| Image Name | ORIGINAL IMAGE PSNR | PSNR AFTER IDWT | PSNROF IMPLEMENTED SYSTEM |
|---|---|---|---|
| Airport_ (1).jpg | 14.04319921 | 36.27711424 | 41.91779218 |
| Airport_ (2).jpg | 12.2927025 | 34.72009089 | 40.47381833 |
| Airport_ (3).jpg | 11.18015685 | 37.00157461 | 42.57427405 |
| Airport_ (4).jpg | 13.72981572 | 33.91332224 | 39.70834329 |
| Airport_ (5).jpg | 15.88199092 | 35.88748567 | 41.59172589 |

TABLE II

PSNR RESULT FOR RESOLUTION ENHANCEMENT

| Image Name | ORIGINAL IMAGE PSNR | PSNR AFTER IDWT | PSNROF IMPLEMENTED SYSTEM |
|---|---|---|---|
| Commercial_ (1).jpg | 10.94820263 | 34.50454225 | 40.26971597 |
| Commercial_ (2).jpg | 9.320418119 | 34.18280859 | 39.9768574 |
| Commercial_ (3).jpg | 10.6471296 | 34.14613377 | 39.93229391 |
| Commercial_ (4).jpg | 10.2380119 | 33.66643831 | 39.4857903 |
| Commercial_ (5).jpg | 10.45902362 | 33.82764897 | 39.62523386 |

The TABLE II shows Commercial Category images and also the PSNR calculated for ORIGINAL IMAGE PSNR,PSNR AFTER IDWT,PSNR OF IMPLEMENTED SYSTEM

TABLE III

PSNR RESULT FOR RESOLUTION ENHANCEMENT

| Image Name | ORIGINAL IMAGE PSNR | PSNR AFTER IDWT | PSNROF IMPLEMENTED SYSTEM |
|---|---|---|---|
| football Field_ (1).jpg | 9.538956076 | 39.09985611 | 44.44976738 |
| football Field_ (2).jpg | 11.31243539 | 36.40527615 | 42.04890139 |
| football Field_ (3).jpg | 8.97646312 | 35.03111319 | 40.7651664 |
| football Field_ (4).jpg | 9.932290058 | 36.27239229 | 41.92400152 |
| football Field_ (5).jpg | 9.371373239 | 36.8416902 | 42.46936382 |

The TABLE III shows Football Field Category images and also the PSNR calculated for ORIGINAL IMAGE PSNR,PSNR AFTER IDWT,PSNR OF IMPLEMENTED SYSTEM

TABLE IV

PSNR RESULT FOR RESOLUTION ENHANCEMENT

| Image Name | ORIGINAL IMAGE PSNR | PSNR AFTER IDWT | PSNROF IMPLEMENTED SYSTEM |
|---|---|---|---|
| Park_ (1).jpg | 10.8860836 | 34.60288383 | 40.36126623 |
| Park_ (2).jpg | 11.9450142 | 32.56390457 | 38.4177351 |
| Park_ (3).jpg | 14.17058921 | 35.42025186 | 41.1227629 |
| Park_ (4).jpg | 12.53680916 | 36.61564095 | 42.21953993 |
| Park_ (5).jpg | 11.29255983 | 33.24565749 | 39.06712359 |

The TABLE IV shows park Category images and also the PSNR calculated for ORIGINAL IMAGE PSNR,PSNR AFTER IDWT,PSNR OF IMPLEMENTED SYSTEM

TABLE V

AVERAGE PSNR RESULT FOR RESOLUTION ENHANCEMENT

| **Image category** | **Average PSNR Of IDWT** | **Average PSNR Of Implemented** |
|---|---|---|
| Airport | 35.55992 | 41.25319 |
| Commercial | 34.06551 | 39.85798 |
| Football Field | 36.73007 | 42.33144 |

| | | |
|---|---|---|
| Park | 34.48967 | 40.23769 |

The TABLE V shows Average PSNR Calculated for Football Field, Airport, Commercial, Park Category images AFTER IDWT, Average PSNR OF IMPLEMENTED SYSTEM. The Average PSNR Value of Implemented system is Higher than the IDWT .The quality of Image is increased.

## V. CONCLUSION

This project a new resolution enhancement technique based on the interpolation of the high-frequency sub-band images obtained by DWT and the input image. The technique has been tested on well-known benchmark images, where their PSNR results show the superiority of the Implemented technique over the conventional and state-of-art image resolution enhancement techniques. The PSNR improvement of the implemented technique is having higher PSNR value compared with the IDWT

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