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Resolution Enhancement of Images using Multi-wavelet and Interpolation Techniques

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Abstract: Many digital imaging applications requires high resolution images or videos for later image processing and analysis. The need for high quality image is one of the major challenges in image processing. In this paper a study of image resolution enhancement methods using multi-wavelet and interpolation in wavelet domain is done. One of the most important quality factors in images comes from its resolution. Visual appearance of an image and image quality can be improved by the various enhancement techniques. Some spectral and spatial problems still prevail in digital images such as motion blur, pixelation and poor perception. The super resolution images are obtained by applying enhancement techniques on noisy and blurred images. In this paper, some of the resolution enhancement techniques such as Discrete Wavelet Transform, DWT-SWT and interpolation methods are described. Of these methods DWT-SWT method improves the visual appearance of the images is highlighted.

Keywords: Discrete Wavelet Transform, Stationary Wavelet Transform, Inverse Discrete Wavelet Transforms, High Resolution, Low Resolution, Interpolation.

I. INTRODUCTION

Digital image plays a vital role in this technological world. It finds application in medical image processing like X-ray imaging, military applications, representation of multimedia content in web, satellite images processing for geographical studies, weather forecasting, industrial inspection for defective manufactured parts which requires image resizing, high resolution, Digital Image is a discrete representation of its continuous signals perceived through our eyes, a camera or any such devices.

So enhancement of images has become a major challenge in image processing area of research. Resolution enhancement of satellite images has become the important need. Resolution is an important parameter in satellite image processing. Resolution enhancement is used to enlarge the input image in a way to make the output image looks sharper.

Thus, increasing the resolution of an image affects the system performance. In image resolution enhancement by interpolation techniques, the main loss is in high frequency a component (edges) which is due to the smoothing caused by interpolation. It is therefore a need to remove the noise and thereby increase image quality. Image Enhancement techniques improve the image quality for human viewing by blur removal and noise, contrast enhancement, and presenting more details.

An important aspect of an image is its resolution. The processing of an image is done in order to obtain more enhanced resolution. The details contained in an image are defined by the resolution of an image. The higher the resolution, the more image details.

Spatial techniques are used for changing the gray level values of the individual pixels and hence enhance the overall quality of the image. Frequency domain techniques [1] are adapted for image processing in terms of frequency contents.

II. INTERPOLATION METHODS

Interpolation [2], [14] is a technique of enhancement which is used to estimate the continuous function values from discrete samples. This technique is used to find the missing values so as to obtain a clearer image. Interpolation defines many image processing applications such as image decompression, sub-pixel image registration, image resolution enhancement, image fusion etc.

A. Nearest neighbor interpolation

The nearest neighbor[3] algorithm selects the value of the adjacent points and does not consider the values of neighboring points at all instead it yields a constant interpolant. The algorithm is very simple to implement and has applications in real-time 3D rendering to choose color values for a textured surface.

B. Bilinear Interpolation

The closest four pixel coordinate is taken into account and assigns that value to the output coordinates. Initially, two interpolations are performed linearly in one direction (horizontally) and then another linear interpolation is performed in the perpendicular direction. The number of grid points needed to evaluate the interpolation function for one- dimensional Linear Interpolation [2], is two and

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for Bilinear Interpolation [3] it is four. Bilinear Interpolation produces an image of smoother appearance than nearest neighbor interpolation, but the grey levels are altered in the process, results in blurred images [2].

C. Bicubic interpolation
Bicubic interpolation [3],[15] is sophisticated and produces smoother edges than bilinear interpolation. The computational time of bicubic interpolation is more than other two methods. A new pixel is a bicubic function of 16 pixels in the nearest 4 x 4 neighborhood of the pixel in the original image The image is slightly sharper than that produced by Bilinear Interpolation, and it does not have the disordered appearance produced in Nearest Neighbor Interpolation.

First, four one-dimension cubic convolutions are performed in one direction and then one more one-dimension cubic convolution is performed in the perpendicular direction. Thus to implement a two dimension cubic convolution, a one-dimension cubic convolution is needed.

III. PROPOSED METHODOLOGY

A. Discrete Wavelet Transform (DWT)
Discrete Wavelet Transform (DWT) [5],[11] based technique is most widely used technique for performing image interpolation [3]. DWT use filter banks and special wavelet filters for the analysis for the reconstruction of the multi- resolution time frequency plane [8]. Here DWT is used to decompose a low resolution image into 4 subband images LL, LH, HL and HH. All low and high-frequency components of image are then interpolated.

Then a difference image is obtained by subtracting LL image from the original LR image. Resulting image is then added to the interpolated high frequency components to obtain estimated form of HF subband images. Finally IDWT used to combine these estimated images along with the input image to obtain high resolution images [3].

Few applications of DWT are:

i) Data compression,
ii) ECG analysis,
iii) Climatology,
iv) Blood pressure etc.

B. DWT-SWT
DWT-SWT stands for Discrete wavelet transform-Stationary wavelet transform. In this technique DWT is used in order to preserve the high frequency components of the image (stationary wavelet transform uses high and low pass filters [8]). The DWT and SWT [7] are used to decompose the input image into different subbands. In this technique DWT is used in order to preserve the high frequency components of the image [8].

But because of DWT, information loss occurs due to the down sampling in each sub-band. Hence to minimize this loss SWT is employed.

The corresponding one level DWT is used to decompose an input image into different sub-band images. In that four coefficients LL is approximation image and remaining three are horizontal(LH), vertical(HL) and Diagonal(HH). High frequency sub-bands (LH, HL, and HH) will contain the high frequency components of the input image.

In this project we propose bicubic interpolation with enlargement factor if 2 is applied to high frequency sub-band images. On those sub-bands we are applying the down sampling. In each of the DWT sub-bands,' information loss is occurred in the respective sub-bands. That's why SWT is employed to minimize these losses.

The high frequency interpolated sub-bands and the SWT[3] high frequency sub-bands have the same size which means that the same size can be added with each other. Then the corrected high frequency sub-bands can be interpolated for higher enlargement. It is known that the wavelet domain, the low resolution image is obtained by low pass filtering of high resolution image.

Instead of using the low frequency sub-bands which contains less information than the original high resolution images; here we are using the by 2 and N in the intermediate and final interpolation stages respectively and then applies IDWT as illustrated in the fig2. If the output image getting sharper edges then directly apply the interpolation of the input image.

Due to the fact of interpolation is isolated high frequency components are in high frequency sub-bands corrected by adding the high frequency sub-bands of SWT of the input image will preserve more high frequency components after the interpolation than interpolating input image directly.

TABLE I PERFORMANCE OF VARIOUS METHODS

Methods	MSE	RMSE	PSNR (db)	Quality
WZP	0.0467	0.2161	32.2722	0.75
Cycle Spinning	0.0706	0.2658	27.4267	0.82
DWT/ Bilinear	0.0387	0.1966	32.8275	0.85
DWT/ Bicubic	0.0342	0.1849	34.0733	0.88
DWT-SWT	0.0420	0.0021	38.086	0.92

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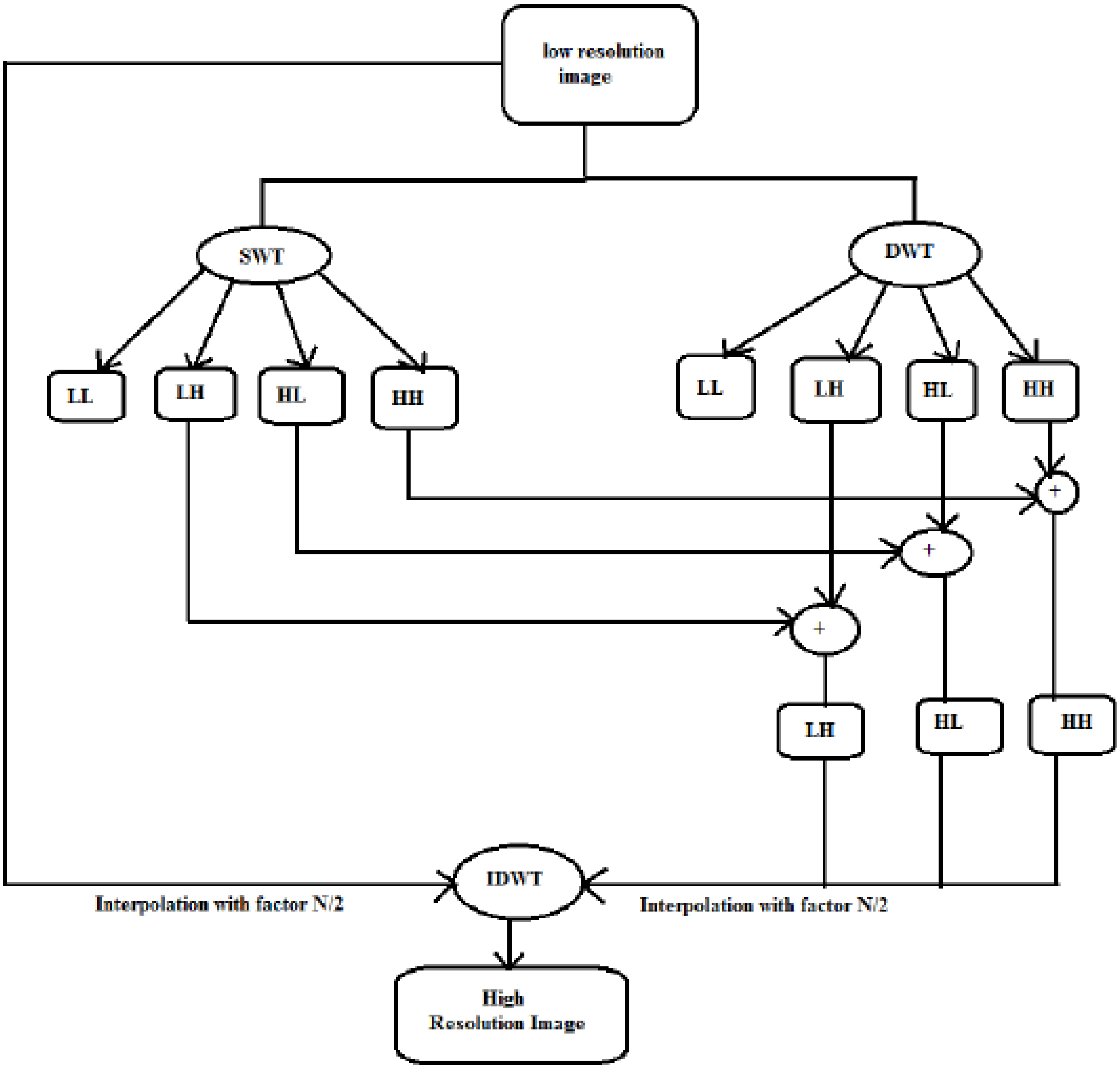

Fig2: Block Diagram of proposed DWT-SWT Algorithm

IV. RESULTS

Performance analysis of various resolution enhancement algorithms in wavelet domain is measured in terms of metrics such as PSNR, MSE and ENTROPY. The performance is shown in fig1. Multi-wavelet transform yields better output than other methods.

To avoid confusion, the family name must be written as the last part of each author name (e.g. John A.K. Smith).
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Figures and tables must be centered in the column. Large figures and tables may span across both columns. Any table or figure that takes up more than 1 column width must be positioned either at the top or at the bottom of the page. Graphics must not use stipple fill patterns because they may not be reproduced properly. Please use only SOLID FILL colors which contrast well both on screen and on a black-and-white hardcopy, as shown in Fig. 1.

V. CONCLUSION

This paper discusses about improvement in the resolution of satellite images based on the multi-wavelet transform using interpolation techniques. The quantitative metrics (PSNR, MSE) of the image calculated shows the superiority of DWT-SWT technique. For achieving visually acceptable HR images, image enhancement algorithm provides wide range of approaches. Based on the image type and noise type with which it is corrupted, a slight change in individual method or combination of any methods further improves visual quality. Here we have studied recent development methods of image enhancement and pointed out the area of research for image enhancement in spatial domain. The future scope will be the development of adaptive algorithms for effective image enhancement using Fuzzy Logic and Neural Network and curvelet enhancement techniques.

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