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Image Super Resolution using Wavelet Analysis: A Survey

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Abstract – Resolution had been frequently regarded as an essential aspect of an image. Images are being processed in order to get more enhanced resolution. One of the commonly used techniques for image super resolution is Interpolation. Interpolation is been widely used in many image processing applications for example, facial reconstruction, multiple description coding, and super resolution. The three well known interpolation techniques, namely nearest neighbor interpolation, bilinear interpolation, and bi-cubic interpolation. The principal objective behind of image enhancement is to process a given image so that the result is more particular and accurate than the original image for a specific application. It accentuates or sharpens image features more clear such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis. The enhancement doesn't perform any increase in the inherent information content of the data, but it increases the dynamic range of the selected features so that they can be detected easily. Here we propound an image resolution enhancement technique build on interpolation of the high frequency sub-band images obtained from discrete wavelet transform (DWT) and the input image. The edges are enhanced by introducing an intermediate stage by the usage of stationary wavelet transform (SWT). DWT is applied for the purpose to decompose an input image into various sub-bands. Then the high frequency sub-bands and also the input image are interpolated. The estimated high frequency sub-bands are being Improved and adjusted by using high frequency sub-band obtained through SWT. Then all these sub-bands are Merged together to generate a new high resolution image by using inverse DWT (IDWT). The quantitative and visual outcome are showing the precedence of the proposed technique over the ordinary and state-of-art image resolution enhancement techniques.

Keywords—*Discrete wavelet transform, image super resolution, stationary wavelet transform.*

1 INTRODUCTION

Out of all five senses vision is most advanced, so it is not surprised that images play the single most important role in human perception. Human vision is limited to visual band of electromagnetic (EM) spectrum, while imaging machines cover almost the entire EM spectrum, ranging from gamma to radio waves. They can work on images created by source that humans are not customary to associate with images. These include electron microscopy, computerize images. Digital image processing works same way as the human vision system. It involves the process of acquiring, analyzing and manipulating images using digital computers. There are various physical devices to capture digital images like camera, satellite, magnetic resonance imaging machine and microscope etc. The area of application of digital image processing is very vast. With increase in demand and performance of personal computing digital image processing is widely being used in many applications. Digital image process has advantage in term of cost, speed and flexibility. The objective is to bring out information from the scene being viewed. Digital image processing can be classified in following subareas on the basis of nature of application.

(i) Image Enhancement
(ii) Image Restoration
(iii) Image Compression
(iv) Image Segmentation
(v) Image Understanding

A digital can be represented by function of two dimensional variables and mathematically can be represented as

$$I = f(x, y) \qquad (1)$$

here I is an image, x and y are spatial coordinates, and f is the amplitude of any pair of coordinates (x,y) and is called as intensity or grey level of the image at that point. When the values of coordinates (x,y) and amplitude f all are finite and discrete quantities, the image is called digital image. A digital image is composed of finite number of elements, all of which has particular location and value. [1]These elements are called picture elements, image elements, pels and pixels.

There are various image processing application requires high resolution images for processing and analysis. The desire for high resolution images came from two principal application areas: improvement of pictorial information for human elucidation; and helping representation for automatic machine perception. Image resolution describes the amount of information contained by images. Lower resolution less would be the amount of information, higher resolution more would be amount of considered. Interpolation filters are designed by analyzing correlation between sub-bands having different sampling stages in the lower level, and applied to the correlated sub-bands information in images. Resolution of a digital image can be classified in many ways: pixel resolution, spatial resolution, spectral resolution, temporal resolution, and radiometric resolution.[1] A digital image is made from small picture elements called pixels. Spatial resolution mentions the pixel density in an image and measures in pixels per unit area.

Resolution has been often referred as an important aspect of an image. Images are being processed in order to obtain more improved resolution. One of the commonly used techniques for image resolution enhancement is Interpolation. Interpolation has been used in various image processing applications such as facial reconstruction, multiple description coding, and super resolution. There are three well known interpolation techniques, namely nearest neighbor interpolation, bilinear interpolation, and bi-cubic interpolation. Image resolution enhancement in the wavelet domain is a relatively new research topic and recently many new algorithms are proposed. [9] Discrete wavelet transform (DWT) is one of the recent wavelet transforms used in image processing. DWT decomposes an image into different sub-band images, namely low-low (LL), low-high (LH), high-low (HL), and high-high (HH). Another recent wavelet transform which has been used in various image processing applications is stationary wavelet transform (SWT). In short, SWT is similar to DWT but it does not use down-sampling, therefore the sub-bands have the same size as the input image.

In the work, an image resolution enhancement technique is being proposed which generates sharp high resolution image. The proposed technique utilizes DWT to decompose a low resolution image into different sub-bands. Then the three high frequency sub-band images are then interpolated using bi-cubic interpolation. The high frequency sub-bands which are obtained by SWT of the input image are being incremented into the interpolated high frequency sub-bands in order to correct the calculated coefficients. In parallel, the input image is interpolated separately.

Finally, improved interpolated high frequency sub-bands and interpolated input image are combined using inverse DWT (IDWT) to get a high resolution output image. [9] The proposed technique has been compared with conventional and the state-of-art image resolution enhancement techniques. The conventional techniques used are the following.

(i) Bilinear interpolation
(ii) Bi-cubic interpolation.
(iii) Wavelet zero padding (WZP).

According to the quantitative and qualitative experimental results, the proposed technique well over performs the abovementioned conventional and state-of-art techniques for image resolution enhancement.

2 LITERATURE SURVEY

Below are the literature review in image enhancement by some authors and their main observations:

Regularity-preserving image interpolation:
Author estimated the regularity of edges by measuring the decay of wavelet transform coefficients across scales and restores the underlying regularity by extrapolating a new sub-band to be used in image re-synthesis. The algorithm produces visibly sharp edges than traditional techniques and gives an average peak signal-to-noise ratio (PSNR) improvement of 2.5 dB over bilinear and bi-cubic techniques. By W.K. Carley, D.B. Chuang and S.S.Hemami.

Optimal image scaling using pixel classification:
Author introduced a new approach to optimal image scaling called resolution synthesis (RS). In RS, the pixel interpolated is first classified in the context of a window of neighboring pixels; and the corresponding high resolution pixels are obtained by filtering with coefficients that depend upon the classification. By C.B. Atkins, C.A. Bouman and J.P. Allebach.

Shape-adaptive coding using binary set splitting with k-d trees: An embedded wavelet image coder based on the popular bitplane-coding paradigm, BISK is designed specifically for the coding of image objects with arbitrary shapes. Empirical results indicate that the proposed BISK coder consistently gives efficient performance when compared to a variety of other shape-adaptive coders. By J.E. Fowler.

Image resolution enhancement utilizing inter-sub-band correlation in wavelet domain: In this paper, author proposed a new resolution enhancement method utilizing inter-sub-band correlation in which the sampling phase in DWT in the higher level. By Y. Piao, I.Shin and H.W. Park.

The wrinkle generation method for facial reconstruction based on extraction of partition wrinkle line characterizes and patterns interpolation: Because of the high putrescibility of the body, in general condition only part of bones can be found when the victim body was discovered. Therefore, in the first step of the criminal investigation is to reconstruct the facial characteristics in order to find the victim. Because wrinkle is the most remarkable and intuitionistic characteristics in the human skin, the wrinkle generation method for reconstructed face is an important step of facial reconstruction. By L.Yi-bo, X.Hong and Z.Senyue.

Downsample-based multiple description coding and post-processing of decoding: This work proposed an image resolution enhancement technique which is build on the interpolation of high frequency sub-bands obtained by DWT. The proposed technique uses DWT to decompose an image into different sub-bands, and then the high frequency sub-band images are interpolated. By H. Demirel and G.Anbarjafari.

Image resolution enhancement by utilizing discrete and stationary wavelet decomposition: In this correspondence the authors proposes an image resolution enhancement technique build on interpolation of the high frequency sub-band images obtained by DWT and the input image. The edges are then enhanced by introducing an intermediate stage by utilizing SWT. DWT is applied to decompose an input image into different sub-bands. Then the high frequency sub-bands as well as the input image are interpolated. By A.Bouman.

3 CONCLUSIONS

The work proposed an image resolution enhancement technique based on the interpolation of high frequency sub-bands obtained by DWT, improving the high frequency sub-band evaluation by utilizing SWT high frequency sub-bands, and the input image. The proposed technique utilizes DWT to decompose an image into different sub-bands, and then the high frequency sub-band images are been interpolated. The interpolated high frequency sub-band coefficients are been corrected by utilizing high frequency sub-bands achieved by SWT of the given input image. An original image is interpolated with half of the interpolation characteristic used for interpolating the high frequency sub-bands. Then all these images have been combined using IDWT to create a super resolved image. The proposed technique has been checked on well-known benchmark images, where the PSNR and visual results shows the superiority of proposed technique over the conventional and state-of-art image resolution enhancement techniques.

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