

A Qualitative Approach for Resolution Enhancement of Satellite Images using 2-DWT

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Abstract

Image Resolution and Enhancement plays a vital role in analyzing images in various engineering and bio medical fields. Satellite color images are being used in many fields of research. One of the major issues of these types of color images is their resolution. Satellite color image resolution enhancement technique based on the interpolation of the high-frequency sub bands obtained by discrete wavelet transform (DWT) is useful to attain optimum results enriched with brightness and contrast rise. The input image is decomposed into different sub bands through DWT. The high-frequency sub band images and the input low-resolution color image have been interpolated, followed by combining all these color images to generate a new resolution-enhanced color image by using inverse DWT. To achieve a sharper color image, an intermediate stage for estimating the high-frequency sub bands is required. The quantitative parameters i.e., peak signal-to-noise ratio and root mean square error and visual results show the superiority of the proposed technique over the conventional and state-of-art color image resolution enhancement techniques.

Key words: Discrete wavelet transform (DWT), interpolation, satellite color image resolution enhancement

Introduction

Resolution of an image has been always an important issue in many image- and video-processing applications, such as video resolution enhancement [1], feature extraction [1]-[2], and satellite image resolution enhancement. Interpolation in image processing is a method to increase the number of pixels in a digital image. Interpolation has widely used in many image processing applications, such as facial

reconstruction [4], multiple descriptions coding [5], and image resolution enhancement [6]–[7]. The Interpolation based image resolution enhancement has been used for a long time and many interpolation techniques. Image resolution enhancement has been used for a long time and many interpolation techniques have been developed to increase the quality of this task. There are three well-known interpolation techniques, namely, nearest neighbor, bilinear, and bicubic. Bicubic interpolation is more sophisticated than the other two techniques and produces smoother edges. Wavelets are also playing a significant role in many image-processing applications.

The 2-D wavelet decomposition of an image is performed by applying the 1-D discrete wavelet transform (DWT) along the rows of the image first, and then the results are decomposed along the columns. This operation results in four decomposed sub band images referred to low-low (LL), low-high (LH), high-low (HL), and high-high (HH). The frequency components of those sub bands cover the full frequency spectrum of the original image. Theoretically, a filter bank shown in Fig. 1 should operate on the image in order to generate different sub band frequency images. Fig. 2 shows different sub bands of a satellite image where the top left image is the LL sub band, and the bottom right image is the HH sub band. Image resolution enhancement using the wavelets is a relatively new subject and recently many new algorithms have been proposed [10]. In this paper, we propose a resolution-enhancement technique using interpolated DWT high-frequency sub band images and the input low-resolution image. Inverse DWT (IDWT) has been applied to combine all these images to generate the final resolution-enhanced image. In order to achieve a sharper image, we propose to use an intermediate stage for estimating the high-frequency sub bands by utilizing the difference image obtained by subtracting the input image and its interpolated LL sub band.

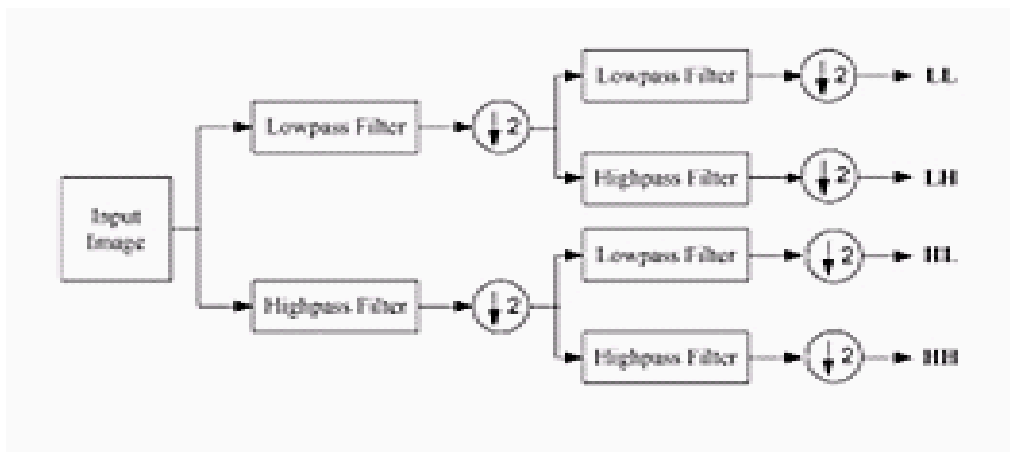


Figure 1: Block diagram of DWT filter banks of level 1

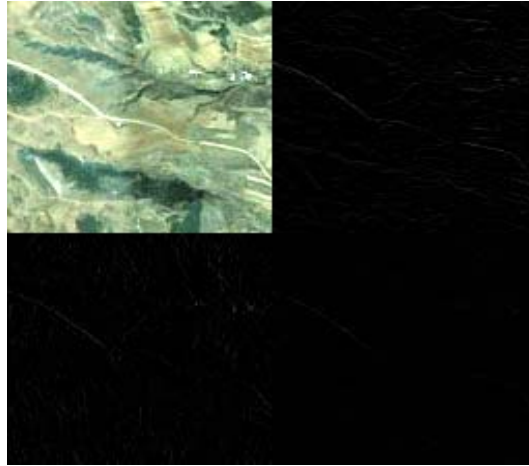


Figure 2: LL,LH,HL,HH sub bands of a satellite color image obtained by using DWT

The proposed technique has been compared with standard interpolation techniques, interpolation techniques. It is necessary to recall that in this paper the resolution enhancement is used as a process that enlarges the given input in the way that the output is sharper. The performance of the proposed technique over performs all available state-of-art methods for image resolution enhancement. The visual and quantitative results are given in the results and discussions section. In all steps of the proposed satellite image resolution enhancement technique, Daubechies wavelet transform as mother wavelet function and standard Bicubic interpolation as interpolation technique have been used.

The paper is organized as follows. Section II introduces the proposed wavelet based resolution enhancement technique. Section III discusses the qualitative results of the proposed method with the conventional and state-of-art resolution enhancement technique.

DWT Based resolution enhancement

As it was mentioned before, resolution is an important feature in satellite imaging, which makes 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 main loss of an image after being resolution enhanced by applying interpolation is on its high-frequency components, which is due to the smoothing caused by interpolation. Hence, in order to increase the quality of the enhanced image, preserving the edges is essential. In this paper, DWT has been employed in order to preserve the high-frequency components of the image. DWT separates the image into

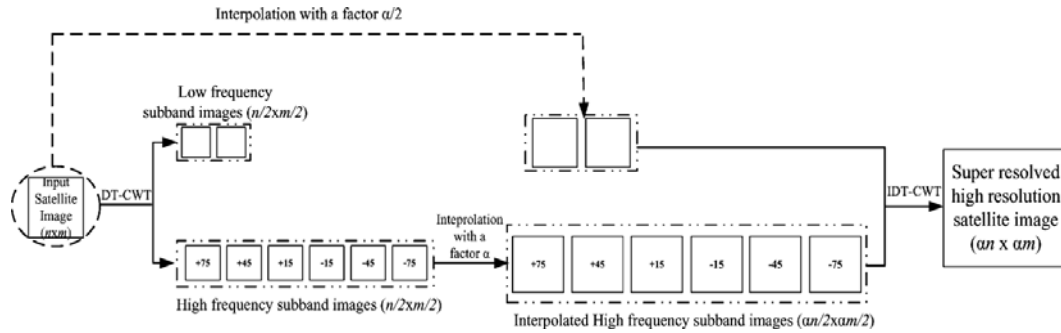


Figure 3: Block diagram of the proposed resolution enhancement algorithm

Different sub band images, namely, LL, LH, HL, and HH. High-frequency sub bands contain the high-frequency component of the image. The interpolation can be applied to these four sub band images. The low-resolution In order to preserve more edge information, i.e., obtaining a sharper enhanced image, we have proposed an image (LL sub band), without quantization (i.e., with double-precision pixel values) is used as the input for the proposed resolution enhancement process. In other words, low frequency images are the low resolution of the original image. Therefore, instead of using low-frequency sub band images, which contains less information than the original input image, we are using this input image through the interpolation process. Hence, the input low-resolution image is interpolated with the half of the interpolation factor, $\alpha/2$, used to interpolate the high-frequency sub bands, In order to preserve more edge information i.e obtaining sharper enhanced image. An intermediate stage in high-frequency sub band interpolation process. As shown in Fig 3, the low-resolution input satellite image and the interpolated LL image with factor 2 are highly correlated The difference between the LL sub band image and the low-resolution input image are in their high-frequency components. Hence, this difference image can be use in the intermediate process to correct the estimated high-frequency components. This estimation is performed 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, followed by another interpolation with factor $\alpha/2$ in order to reach the required size for IDWT process. The intermediate process of adding the difference image, containing high-frequency components, generates significantly sharper and clearer final image. This sharpness is boosted by the fact that, the interpolation of isolated high-frequency components in HH, HL, and LH will preserve more high-frequency components than interpolating the low-resolution image directly. Difference between the high-resolution color images with the enhanced image by using the proposed resolution enhancement technique, the difference obtained by using bicubic interpolation directly.

Results and Discussions

This paper has proposed a new resolution enhancement technique based on the interpolation of the high-frequency sub band images obtained by DWT and the input image. The proposed technique has been tested on original color images. In order to show the superiority of the proposed method over the conventional and state-of-art techniques from visual point of view Figs.4 (a)-(f)- are included.

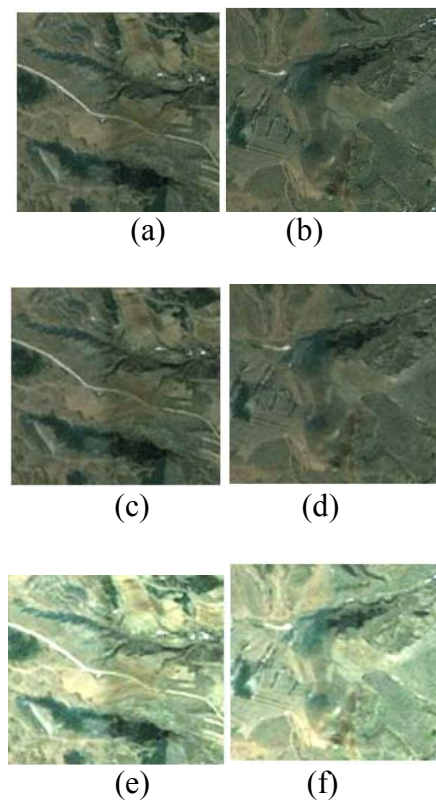


Fig 4.(a)original color image1 (b) original color image2 (c) bicubic interpolation based resolution enhancement technique for original color image1 (d) bicubic interpolation based resolution enhancement technique for original image2 (e)the proposed image resolution enhancement technique for original color image 1 (f) In those figures with low-resolution satellite images, the enhanced images by using bicubic interpolation, enhanced images by using the proposed technique are shown. It is clear that the visual resultant color images, enhanced by using the proposed technique, are sharper than the other technique. The quantitative (peak signal-to-noise ratio and root mean square error) result show in table 1.

Table1. coparision of PSNR and RMSE for input images using Bicubic interpolation and proposed method

Interpolation methods	RMSE Fig(a)	RMSE Fig(b)	PSNR Fig(a)	PSNR Fig(b)
Bicubic interpolation	2.46	1.97	28.67	29.52
Proposed method	0.22	0.15	33.55	35.12

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