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Wavelet based pixel-by-pixel image interpolation for edge preserving

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Abstract. In this paper, a new edge-preserving wavelet based image interpolation algorithm using pixel-by-pixel image interpolation is proposed for images which include many high frequency elements. Because bilinear or bicubic interpolation approaches have blurring or blocking effects, the quality of interpolated remote sensing images is not good over that of standard test images in lines and edges. The proposed interpolation method uses pixel-by-pixel interpolation and DWT to address these problems preserving thin lines and edges information. The obtained result proves the superiority of the proposed technique.

Keywords: wavelet transform, interpolation, pixel-by-pixel

1 Introduction

Image interpolation algorithms obtain a high-resolution image from the available low-resolution image. It is applied when the image need to be resized or remapped from one pixel grid to another. A good interpolation method can improve the quality of the image. However conventional linear interpolation techniques cannot enhance the contrast and smooth edges simultaneously, including nearest neighbor interpolation, bilinear interpolation and bicubic interpolation [1-3]. The resulting image may be inevitably blurred, and sometimes have block effects. Therefore in the case of remote sensing images that the edges or high frequency elements have importance, the quality of the interpolated images is noticeably poor over the standard images [4]. In this paper, we propose an interpolation technique using pixel-by-pixel cubic interpolated DWT high-frequency subband images and input low-resolution image. The pixel-by-pixel cubic interpolation is based on optimizing the standard cubic image interpolation formula at each estimated pixel [5]. Thus the mean square error (MSE) in the entire image is minimized. Inverse DWT has been applied to combine all these images. In order to achieve a sharper image, we use de-blocking filter.

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2 Proposed method

The schematic diagram of our proposed algorithm can be seen in Figure 1. After pixel –by-pixel cubic interpolation is carried out on original image, the result image is wavelet decomposed. While the three high frequency component images are maintained, a low frequency component image is substituted with interpolated image. Inverse DWT is carried out on these subband images.

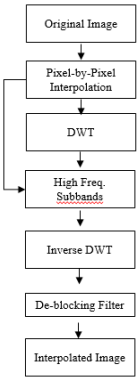

Fig. 1. Watermark embedding

The pixel by pixel (PBP) cubic interpolation algorithm has been proposed in [5]. The previous cubic image interpolation formula is as follows.

$$\mathrm{l}(x_{k+1}) = g(x_{n-1})[as^3 - 2as^2 + as] + g(x_n)[(a+2)s^3 - (3+a)s^2 + 1] + g(x_{n+1})[-(a+2)s^3 + (2a+3)s^2 - as] + g(x_{n+2})[-as^3 + as^2] \quad (1)$$

where $\mathrm{l}(x_{k+1})$ is the value of the sample to be estimated and $\mathrm{g}(x_n)$ is the equally spaced data and a is a parameter that controls the rate of decay of the cubic interpolation basis function and s is the distances between x_{k+l}, x_n and x_{n+l}as :

$$\mathrm{s} = x_{k+1} - x_n, 1 - s = x_{n+1} - x_{k+1} \quad (2)$$

Equation (1) has two main controlling parameters s and a which can be optimized to give the best interpolation results.

Wavelets interpolation is based on pixel-by-pixel cubic interpolation. Suppose that the required magnification factor is 2. Wavelet decomposition is carried out on a result amplified with the pixel-by-pixel cubic interpolation method, thus the low frequency component image and three high frequency component images.

Compared to other existing interpolation methods, our proposed method seems to enhance the high frequency information and to reduce the undesirable artifacts, such as blurring, ringing, block effects and edge distortion.

3 Simulation Results

The proposed method has been tested with different gray-scale images, standard natural images and satellite photograph images. Two-dimensional separable length 9-7 biorthonormal wavelet filter is used for wavelet packet decomposition. Wavelet packet coefficients are selected for watermark embedding

In figure 2 and 3, a comparison of the suggested algorithm performance with other different interpolation techniques including bilinear interpolation and bicubic interpolation. Experimental results show that bilinear interpolation often causes block effects, while bicubic interpolation suffers from the blurring problem in edge regions. The result from the proposed algorithm exhibits a better performance. This method can eliminate zigzagging artifact efficiently and smooth the inside of a region.

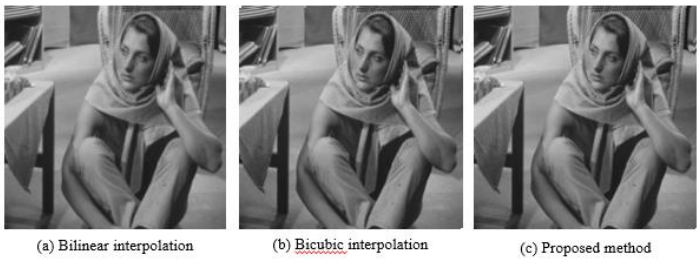

Fig. 2. Interpolated images of Barbara

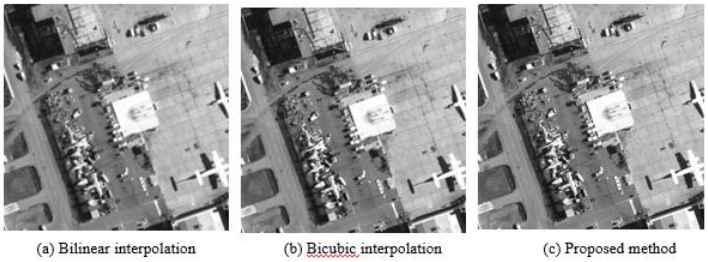

Fig. 3. Interpolated images of Airfield

Table 1 shows that in the conventional techniques, the PSNR values of Airfield with many high frequency components are lower than that of Barbara. The PSNR of proposed method is too, but image quality improvement degree is relatively high. The proposed method shows 1.52dB higher performance in Airfield and 1.41dB higher performance in Barbara.

Table 1. The PSNR(dB) of watermark embedded image

	Barbara	Airfield
Bilinear Interpolation	23.90	23.67
Bicubic Interpolation	24.08	24.72
Proposed method	24.79	25.92

4 Conclusions

In this paper, a new wavelet based image interpolation algorithm is proposed for images with many high frequency components. Remote sensing images such as aerial and satellite photograph images include many mid and high frequency elements. These frequency elements contain important information. We apply the wavelet transform on pixel-by-pixel cubic interpolated image and hybrid filter to maintain information about high frequency of images. From experimental results, it is shown the proposed method is simple and higher performance than the conventional method for images which include many high frequency elements such as satellite photograph images

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