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INTERPOLATION METHOD OF PHOTOGRAMMETRIC IMAGES BASED ON WAVELET TRANSFORMATION

In the work discusses and analyzes the impact of interpolation methods for photogrammetric multi-channel image. The research results indicate that the images obtained after wavelet - interpolation are more informative than images obtained after the application of classical interpolation methods (bicubic, bilinear, nearest neighbor). A quantitative evaluation of the multi-channel image in terms of informative and signal entropy, PSNR.

Keywords: digital image, interpolation, satellite, multichannel, panchromatic image, wavelet, spatial resolution, PSNR, information and signal entropy.

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МЕТОД ІНТЕРПОЛЯЦІЇ ФОТОГРАММЕТРИЧНИХ ЗОБРАЖЕНЬ НА ОСНОВІ ВЕЙВЛЕТ-ПЕРЕТВОРЕННЯ

У роботі розглянуто та проаналізовано вплив методів інтерполяції на якість багатоканальних фотограмметричних зображень. Результати досліджень свідчать про те, що зображення, отримані після вейвлет – інтерполяції, відрізняються більшою інформативністю ніж зображення, отримані після застосування класичних методів інтерполяції (бікубічної, білінійної, найближчого сусіду). Проведена кількісна оцінка отриманих багатоканальних зображень за показниками інформативної та сигнальної ентропії, PSNR.

Ключові слова: цифрові зображення, інтерполяція, вейвлет, просторова розрізненість, PSNR, інформаційна та сигнальна ентропія.

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В работе рассмотрено и проанализировано влияние методов интерполяции на качество многоканальных фотограмметрических изображений. Результаты исследований свидетельствуют о том, что изображения, полученные после вейвлет-интерполяции, отличаются большей информативностью, чем изображения, полученные после применения классических методов интерполяции (бикубической, билинейной, ближайшего соседа). Проведена количественная оценка полученных многоканальных изображений по показателям информативной и сигнальной энтропии, PSNR.

Ключевые слова: цифровые изображения, интерполяция, вейвлет, пространственная разрозненность, PSNR, информационная и сигнальная энтропия.

Introduction

Image interpolation is the process of increasing the resolution of a given image. In this work presents a method of image interpolation based on wavelet for remote sensing images. Image interpolation addresses the problem of generating a high-resolution image from its low-resolution. 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, 2]. 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.

Formulation the problem

It is necessary to explore the classical interpolation techniques and methods to quantify the impact on photogrammetric digital images.

Materials for research

One of the major problems to be solved in the field of remote sensing, are the objectives of association. Pansharpening, a branch of image fusion, may be defined as the process of synthesizing multispectral images at a higher spatial resolution, and is receiving an ever increasing attention from the remote sensing community [3]. Pansharpening techniques have become very important for various remote sensing applications, such as enhancing image classification, temporal change-detection studies, and image segmentation studies. The use of multi-channel image is an integral part of the methods more informative.

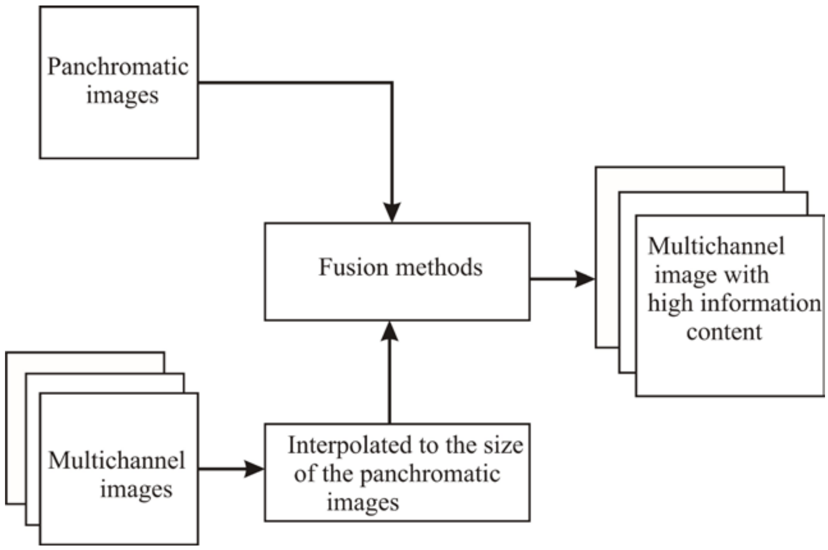


Fig. 1. Common problems

Panchromatic images have a higher spatial resolution than multispectral. The information contained in the image, resulting from the merger, are more complete, leading in particular to improve the quality of object recognition and better "understanding" of their properties. The paper research satellite images from Worldview-2, the original size panchromatic image is 4600x4604 and 1150x1151 multichannel. The multichannel bands (Band1 = Coastal, Band2 = Blue, Band3 = Green, Band4 = Yellow, Band5 = Red, Band6 = Red Edge, Band7 = Near-Infrared 1, Band8 = Near-Infrared 2) cover the spectral range from 400 nm - 1050 nm at a spatial resolution of 1.84 m, while the panchromatic band covers the spectrum from 450 nm – 800 nm with spatial resolution 0.46 m.

The first and very important step in addressing these challenges is a multichannel image interpolation up to the size of the panchromatic image. It can be concluded that the quality of the resultant image after fusion method is directly dependent on the interpolation method.

Image interpolation addresses the problem of generating a high-resolution image from its low-resolution. 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. 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.

The schematic diagram of our proposed algorithm can be seen in figure 2. After bicubic interpolation is carried out on original image, the result image is wavelet decomposed.

The first step algorithm, apply SWT on low-resolution image of size m x n which produce four sub bands (ll, lh, hl, hh) with size of m x n each. SWT is same as Discrete Wavelet Transform (DWT) but SWT generates each sub band of the size of image while in DWT each sub band is half the size of image. In parallel with the operation of SWT spend bicubic interpolation and displayed using wavelets. Now apply denoising algorithm on HH sub band only, because LL sub band contains main information about the image while main noise is present in other three sub bands and maximum high frequency noise present in HH. Below given is the description of denoising algorithm that is based on the algorithm [2].

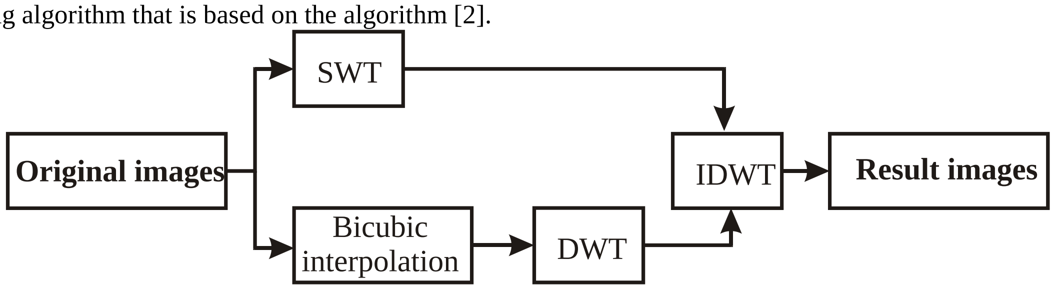
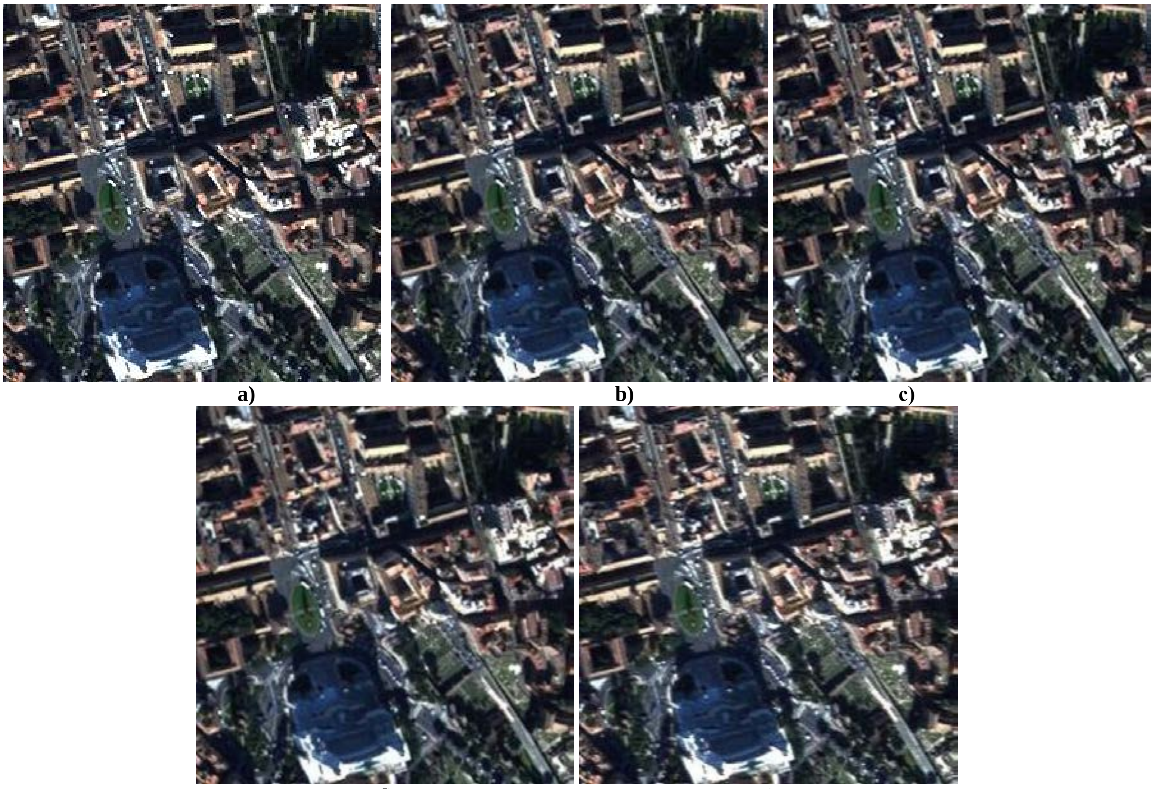


Fig. 2. Algorithm wavelet interpolation images

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.

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.



a) b) c) d) e)

Fig. 3. Multichannel satellite images from Worldview-2:
a) original (256x256);
b) nearest neighbor interpolation (512x512);
c) bicubic interpolation (512x512);
d) bilinear interpolation (512x512) ;
e) Wavelet interpolation (512x512)

Many methods are available to evaluate both the spectral and spatial quality of pansharpened images, but there is currently no consensus in the literature regarding which quality index is the best. Methods decorrelation of spatial distribution brightness based on the calculation of statistical parameters of digital images, definitions are difficult for large volumes of raw data. Also, these methods only take into account the contribution of spectral information contained in the original multichannel images.

Numerous indexes and methods were used for image fusion assessment, such as correlation coefficient, standard deviation, RMSE, spectral distortion, bias index. To make it comparable with other fusion algorithms, both visual analysis and quantitative analysis are employed for more objective assessment of each algorithm.

Visual "quality" image can be evaluated according to the criteria of maximum information content characteristics. Entropy is a concept in information theory. Entropy is used to measure the amount of information. It is defined in terms of the probabilistic behavior of a source of information:

$$E(x) = -\sum_{k=0}^{N-1} p_k \cdot \log_2 p_k , \qquad (1)$$

where N - the number of brightness levels; p_k - frequency k - th luminance sample x; k - the level of brightness, which belongs to the interval [0, 255], $\sum p_k = 1$.

Signal entropy is as follows:

$$E_{\text{sign.}}(x) = -\sum_{i=0}^{N-1} p_i \cdot \log_2 p_i , \qquad (2)$$

where N - the number of brightness levels;

$p_i = \frac{i \cdot x_i}{\sum_{J=0}^{255} J \cdot x_J}$ - the level of brightness x,

i which belongs to the interval [0, 255], $\sum p_i = 1$.

Graphical representation of the results shown in figure 4.

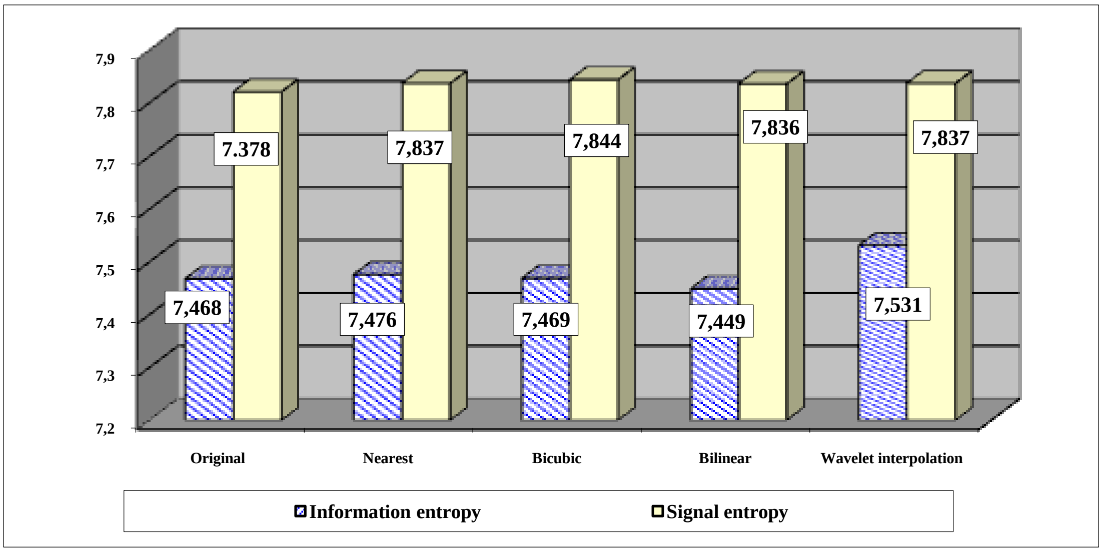


Fig. 4. Graphical representation of entropy values for images

Table 1 represents the measured PSNR in all the algorithms, these results shows the superiority of the proposed model compared to the other algorithms. We use Peak Signal-to-Noise Ration (PSNR) to compare image (original image in higher resolution) and Image (interpolated image). PSNR is calculated according to:

$$PSNR = 20\log_{10}\left(\frac{L^2}{\frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y) - I_f(x,y))^2}\right), \qquad (3)$$

where L - number of gray levels in the image.

Table 1 - PSNR

Methods interpolation /Multichannel images	Nearest	Bilinear	Wavelet
R	32.5565	39.5808	29.3965
G	32.5559	39.6307	29.4072
B	32.5551	39.5530	29.3915

The paper obtained quantitative impact assessment methods for multi-image interpolation. Information and entropy alarm designed for multichannel satellite image.

Conclusions

In this work presents a method of image interpolation based on wavelet for remote sensing images with many high frequency components. Remote sensing images include many mid and high frequency elements. These frequency elements contain important information. We apply the wavelet transform on bicubic interpolated image 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 remote sensing images, which include many high frequency elements such as satellite photograph images. Our experimental results show that our new algorithm significantly outperforms linear interpolation in subjective quality, and in most cases, in terms of PSNR as well.

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