NEARLY OPTIMAL WAVELET PAIRS FOR REMOTELY SENSED IMAGE COMPRESSION

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1. INTRODUCTION

A method to find the nearly optimal PSNR values for compression was tried to remotely sensed images. The multiresolution method using wavelet transform divide the image to four frequency band, i.e. LL LH HL HH., It analyzes the LL part again as the level goes up. The energy distribution pattern to four parts depends on the kind of wavelet [3]. The energy concentration of LL part was expressed by PSNR value [4]. For large PSNR value there is much energy in LL. Hence the PSNR value can be an index to the multiresolution image compression. In this paper for many wavelet pairs the variation of the PSNR values was analyzed. To calculate the real maximum PSNR value for a given set of wavelets costs too much at the level 3. An algorithm is introduced to get the PSNR value close to maximum one at the very little cost. It is a problem to choose the right wavelet filters. The choice of wavelet has some criterions such as vanishing moment, regularity, and size of support [1, 2]. However, it is hard to get the right wavelet in the real processing. The proposed algorithm does not show the maximum PSNR values for any case but give us a fairly close to the maximum.

2. WAVELET PAIRS MAKING PSNR NEARLY MAXIMUM

An algorithm was proposed to get the wavelet pairs making PSNR nearly maximum at level 1 [4]. It consists of six steps :

(i) fix the horizontal wavelet filter as shortest length filter in the set of filter bank

(ii) calculate the PSNR values with various wavelets as vertical filter

(iii) pick the vertical wavelet which shows the maximum PSNR value.

(iv) reversely fix the vertical wavelet filter as shortest length filter in the set of filter bank

(v) calculate the PSNR values with various wavelets as horizontal filter

(vi) pick the vertical wavelet which shows the maximum PSNR value.

This algorithm is tested to the four images. Table 1 shows the wavelets chosen. Figure 1 shows the images, three remotely sensed images (IKONOS Panchromatic image, WorldView-1 Panchromatic image, and Synthetic Aperture Radar image) and one photograph image of Barbara. Each image is 512 by 512 pixels.

<Table 1: wavelets and the numbering >

numbering	1	2	3	4	5
wavelet	db8	db10	coif5	bior4.4	bior6.8

(db: Daubechies, coif: coiflet, bior: biorthogonal)

Table 2 shows the results of expected maximum PSNR values from the above algorithm and real maximum PSNR values from the calculation of all possible wavelet pairs.

<Table 2: PSNR values for the four images out of three cases at the level 1>

	expected max PSNR			real max PSNR			hf=vf max PSNR		
image	hf	vf	PSNR	hf	vf	PSNR	hf	vf	PSNR
8	2	2	18.6024	2	2	18.6024	2	2	18.6024
10	2	3	34.2295	2	3	34.2295	3	3	34.2154
17	2	2	22.7269	2	2	22.7269	2	2	22.7269
29	2	4	25.8960	3	4	25.9055	5	5	25.8765

(hf: horizontal filter vf: vertical filter)

When the number of wavelets from the filter bank is greater than 3, the PSNR value from the algorithm in was proved to be bigger than that from the case, vf=hf, which uses identical filter for vertical and horizontal directions [5].

3. NEARLY OPTIMAL WAVELET PAIRS UP TO THE LEVEL 3.

The nearly optimal filter from level one was used up to level 3 in multiresolution analysis to get the wavelet pairs making PSNR nearly maximum at the level 3. The real maximum PSNR value was calculated from the whole combinations of wavelet filters up to the level 3. Table 4 shows the real maximum and expected maximum PSNR values. The expected and real maximum PSNR values for three out of four sampled images are identical. Those three examples are remotely sensed images. The last example Barbara shows the PSNR value very close to the real maximum one.

<Figure1: Test Images>

<Table 3: Elapsed times for the nearly optimal PSNR values and real maximum ones up to level 3>

image	time for expected PSNR(sec)	time for real max PSNR(sec)
8	14.5	19078.3
10	13.9	19313.8
17	13.9	19805.6
29	14.1	19330.9

Table 3 shows the elapsed time of calculating the expected maximum PSNR values and real one.
The case for the horizontal and vertical wavelet identical is shown in table 4 as vf=hf max PSNR.

<Table 4: PSNR values for the four images out of three cases at the level 3>

image	expected max PSNR			real max PSNR							hf=vf max PSNR		
	Level 1 ~ 3		PSNR	Level 1		Level 2		Level 3		PSNR	Level 1 ~ 3		PSNR
	hf	vf		hf	vf	hf	vf	hf	vf		hf	vf	
8	2	2	18.5912	2	2	2	2	2	2	18.5912	2	2	18.5912
10	2	3	34.2047	2	3	2	3	2	3	34.2047	3	3	**34.1948**
17	2	2	22.7001	2	2	2	2	2	2	22.7001	2	2	22.7001
29	2	4	25.8902	3	5	3	5	3	4	25.9456	1	1	**25.8756**

If we use the wavelet pair from the algorithm from the level 1 up to the level 3, we get PSNR values for each images. Let's denote that PSNR from the algorithm suggested above as PSNR(nop), and the PSNR value from the case vf=hf as PSNR(id). The relation between the real maximum PSNR denoted PSNR(max) is as follows;

$$PSNR(id) \le PSNR(nop) \le PSNR(max)$$

They are very close but different and the algorithm to get a PSNR(nop) is much faster than that of PSNR(id). The elapsed time for PSNR(nop) up to level 3 is 15 sec or less while the time for PSNR(max) is 19000 sec or more. The name "nearly maximum" follows the above relation.

4. CONCLUSIONS

The nearly optimal PSNR value up to the level 3 in multiresolution image compression can be calculated by two steps:

step 1: take the wavelet pair using the algorithm proposed

step 2: use the wavelet pair from step 1 up to the level 3

Therefore the nearly optimal wavelet pair can be predicted from the level 1.

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