嘉南藥理學院教師專題研究計劃成果報告

計劃名稱: A Hybrid w-transform, normalized, and Entropy Coding for Image

計劃編號: CNMI-89-01

計劃類別: 個別型

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摘要

W-transform is a new appproach for a multiresolution signal decompo-sition. The major difference between the W-transform and wavelet transform is that the W-transform leads to a nonorthogonal signal decomposition. In this papaer, we proposed a compression technique for retaining the certain portion of the largest absolute components of the W-transform coefficients in each decomposition domain. Experimental results show that the proposed method achives higher compression rate for comparing JPEG and other techniques.

關鍵字: W-transform, Wavelet transform, image compression, subbands.

前言

The wavelet transform has received considerable attention in the image compression community over the past several years. The classical theory of wavelets can be refered to Chui[1] and Daubechies[2]. Multiresolution analysis is introduced and popularized by Mallat[3]. Kwong and Tang[4] introduced the concept of W-matrices and used them to construct nonorthogonal multire-solution analyses applicable to finite signals of arbitrary length. Reynolds[5] presents the W-transform for a multiresolution signal decomposition.

This paper extends Reynold's method and presents a new method for retaining the certain portion of the largest absolute components of the W-transform coefficients in each decomposition domain. Next section we introduce the concept of W-matrix and W-transform. In section 3, the propsed algorithm will be described and the experimental results will be shown in section 4. Followed by disscussion and conclusions.

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An example of a 2-D single-level decomposed image using the W-transform is depicted in Figure 1. The decomposit-ion results in four sub-bands. The subbands represent low-pass (upper-left), horizontal (upper-right), vertical (lower-left) and diagonal (lower-right) frequency information.

Since the upper-left subband holds most of the information from the original image, the lowpass subband is decomposed further. thus W-transform can also be thought of as a subband coding scheme. Figure 2 shows the original 512 by 512 pixel image. In this research, we use three-level decomposition and the matrix symbol is depicted in Figure 3. Since the high frequency domain phase has the negative values, the figures WL12, WL13, WL14, WL22, WL23, WL24, WL32, WL33, and WL34 can not be seen clearly. We can make each matrix positive and quantized to the range between 0 and 255 to display the detail images of each phase. The image can be compressed by retaining the largest absolute value of every high frequence images. then we normalize each image and entropy coding them.

The peak signal-to-noise ratio (PSNR) is defined as

$$PSNR(dB) = 10\log_{10}\frac{(255)^2}{\frac{1}{256^2}\sum_{i=1}^{256}\sum_{j=1}^{256}[x(i,j)-\hat{x}(i,j)]^2} \quad \dots(8)$$

where x is the original image and $\hat{x}$ is the reconstruected image. Table 1 shows the original size and compressed size by using the proposed algorithm of each submatrix after W-transform decomposition. For each submatrix, a minimum value (could be negative) of all the elements and the number of bits used to store each element should be included as a decompression infor ? mation. Therefore, The compression ration is computed as (512*512)/(6924+10*8) = 37.43, which means each sample is using 0.21-bit. The psnr of such decompressed image is 33.42. The decompressed image is shown in Figure 4. In order to make a comparison, the compression artio and PSNR by using the JPEG mathod and W-transform Quantized method by Reynolds are shown in Tables 2 and 3, respectively. Figure 5 shows the comparison result by using the pro-posed method, JPEG, and Reynold's method.

We have presented a modified W-transform for image compression. The experimental results showed that the proposed method is better than the JPEG and Reynold's method. Several compression techniques, such as vector quantization, can be applied to the W-transform algorithm as our further research.

References

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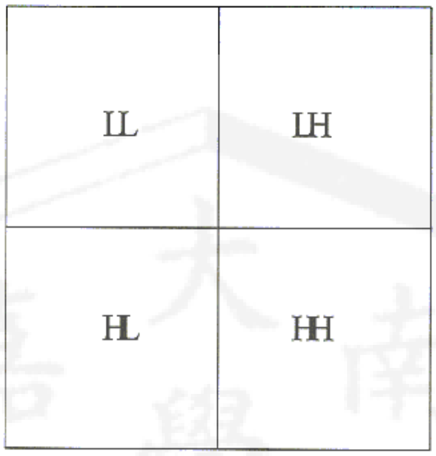

Fig 1: 2-D single-level decomposed images using W-transform

Matrix	Original Size	Compressed Size (bytes)
WL12	256*256	2053
WL13	256*256	1139
WL14	256*256	107
WL22	128*128	152
WL23	128*128	58
WL24	128*128	400
WL31	64*64	1529
WL32	64*64	893
WL33	64*64	378
WL34	64*64	215
L	512*512	6924

Table 1. The original size and compressed size by using the proposed algorithm of each submatrix after W-transform decomposition

Coefficient	Compressed Size	Compression Ratio	BPP	PSNR
0	3,697	70.91	0.11	18.00
5	5,715	45.87	0.17	27.38
10	8,054	32.55	0.25	30.46
20	11,940	21.96	0.36	33.02
30	15,161	17.29	0.46	34.33
40	18,094	14.49	0.55	35.19
50	21,109	12.42	0.64	35.86
60	24,165	10.85	0.74	36.51
70	29,676	8.83	0.91	37.37
80	38,583	6.79	1.18	38.57
90	60,103	4.36	1.83	40.82
100	160,440	1.64	4.90	58.84

Table 2: JPEG Compression Ratio and PSNR (Orginal image - lena (512*512))

Coefficient	Compression ratio	BPP	PSNR
256 256 256	51.02	0.16	22.32
512 256 128	49.21	0.16	23.67
256 128 64	43.38	0.18	25.57
64 64 64	35.08	0.23	25.59
128 64 32	31.09	0.26	27.34
64 32 16	15.60	0.51	27.55
32 16 8	13.45	0.59	33.42
16 8 4	11.81	0.68	33.42
1 1 1	8.86	0.90	33.42

Table 3: W-transform Quantized method by W.D. Reynolds