On the Selection of Image Compression Algorithms

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Acknowledgments: The author thanks Professor Anil K. Jain, Chairman of Department of Computer Science, Michican State University, for his encouragements and valueable suggestions for this paper. The author also thanks Mr. Lin Hong for providing the fingerprint image used in this paper. Dr. Chen was supported by NSC-35139F during his sabbatical leave at Michigan State University. The financial support for attending this conference from National Science Council, Taiwan is also appreciated.

Outline

♢ Save storage space and transmission time

- Wavelet Compression
- JPEG/DCT
- VQ
- Fractal
- Characteristics of the above four methods
- Experimental comparison
- Conclusion

Wavelet Compression

Embeded Zerotree Wavelet Transform

[16,17]

JPEG/DCT

Joint Photographic Experts Group
Discrete Cosine Transform

[1,20]

VQ

Vector Quantization

[4,7,12]

Fractal Coding

[5,9,10]

Characteristics of Algorithms

Method	Advantages	Disadvantages
Wavelet	• high compression ratio • state-of-the-art	• coefficient quantization • bit allocation
JPEG (DCT)	• current standard	• coefficient quantization • bit allocation
VQ	• simple decoder • no coefficient quantization	• slow codebook generation • small bpp
Fractal	• good mathematical encoding frame • resolution-free decoding	• slow encoding • bit allocation

Method	Compression ratio	Appeared in
Wavelet	$\gg 32$	1992 [2] 1993 [17] 1996 [16]
JPEG (DCT)	≤ 50	1974 [1] 1993 [14]
VQ	< 32	1980 [12] 1989 [7]
Fractal	≥ 16	1992 [10] 1992 [8]

Table 1: Characteristics of Four Compression Methods.

Experimental Comparison

$$MSE = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} [\hat{f}(i,j) - f(i,j)]^2 \tag{1}$$

$$PSNR = 10 \log_{10} \left[\frac{255 \times 255}{MSE} \right] \; dB \tag{2}$$

MSE	4	9	16	25	36	49	64
PSNR	42.11	38.59	36.09	34.15	32.57	31.23	30.06
MSE	81	100	121	144	169	196	225
PSNR	29.04	28.13	27.30	26.55	25.85	25.21	24.61
MSE	256	289	324	361	400	441	484
PSNR	24.05	23.52	23.03	22.56	22.11	21.69	21.28

Algorithm	*PSNR values (in dB)*				*CPU time*	
	Jet	Lenna	Mandrill	Peppers	Encoding	Decoding
Wavelet	32.48	34.66	26.54	34.99	0.35 sec	0.27 sec
JPEG	30.39	31.73	25.15	31.95	0.12 sec	0.12 sec
VQ	26.76	29.28	24.45	29.12	2.45 sec	0.18 sec
Fractal	26.70	29.04	24.29	29.13	5.65 hrs	1.35 sec

Table 2: Performance on various 256×256 Images.

Algorithm	*0.50 bpp*			*0.25 bpp*		
	PSNR values	Encoding	Decoding	PSNR value	Encoding	Decoding
Wavelet	36.71	0.8 sec	0.7 sec	32.47	0.7 sec	0.5 sec
JPEG	34.27	0.2 sec	0.2 sec	29.64	0.2 sec	0.2 sec
VQ	28.26	6.0 sec	0.7 sec	N/A	N/A	N/A
Fractal	27.21	6.3 hrs	3.5 sec	N/A	N/A	N/A

Table 3: Performance on a 400×400 fingerprint image.

Original Images

(a) (b)

Figure 1: Original images of (a) Lenna and (b) fingerprint.

Decoded Lennas

(a) (b)

(c) (d)

Figure 2: (a) Wavelet, (b) JPEG, (c) VQ, and (d) Fractal algorithms.

Decoded Fingerprint

(a) (b)

(c) (d)

Figure 3: (a) Wavelet, (b) JPEG, (c) VQ, (d) Fractal algorithms.

Conclusion

A recipe is suggested as follows.

- Any of Wavelet, JPEG/DCT, VQ, and Fractal approaches is satisfactory for the request of 0.5 bpp
- For a low bit rate, say, 0.25 bpp, EZW is superior to others
- JPEG/DCT is the current standard but might use an adaptive quantization table to increase compression ratio
- VQ has a computation-free decoder
- Fractal compression accelerator may be pursued

References

[1] N. Ahmed, T. Natarajan, and K.R. Rao, Discrete cosine transform, *IEEE Trans. on Computers*, vol. 23, 90-93, 1974.

[2] M. Antonini, M. Barlaud, P. Mathieu, and I. Daubechies, Image coding using wavelet transform, *IEEE Trans. on Image Processing*, vol. 1, 205-220, 1992.

[3] M.F. Barnsley and L.P. Hurd, Fractal Image Compression, AK Peters, Ltd. Wellesley, Massachusetts, 1993.

[4] Y.W. Chen, Vector Quantization by principal component analysis, M.S. Thesis, National Tsing Hua University, June, 1998.

[5] H.S. Chu, A very fast fractal compression algorithm, M.S. Thesis, National Tsing Hua University, June, 1997.

[6] I. Daubechies, Ten Lectures on Wavelet Analysis. *SIAM*, 1992.

[7] W.H. Equitz, A new vector quantization clustering algorithm, *IEEE Trans. on Acoustics, Speech, and Signal Processing*, vol. 37, 1568-1575, 1989.

[8] Y. Fisher, Fractal Image Compression, SIGGRAPH Course Notes, 1992.

[9] Y. Fisher, Editor, Fractal Image Compression: Theory and Applications, Springer-Verlag, 1994.

[10] A.E. Jacquin, Image coding based on a fractal theory of iterated contractive image transformations. *IEEE Trans. on Image Processing*, vol. 1, 18-30, 1992.

[11] A.S. Lewis and K. Knowles, Image compression using 2D wavelet transform, *IEEE Trans. on Image Processing*, vol. 1, 244-250, 1992.

[12] Y. Linde, A. Buzo, and R. M Gray, An algorithm for vector quantizer design, *IEEE Trans. on Communications*, vol. 36, 84-95, 1980.

[13] S.G. Mallat, A theory for multiresolution signal decomposition: the wavelet representation, *IEEE Trans. on PAMI*, vol. 11, 674-693, 1989.

[14] W.B. Pennebaker, J. Mitchell, JPEG Still Image Compression Standard, New York: Van Nostrand Reinhold, 1993.

[15] N.M. Nasrabadi and R.A. King, Image coding using vector quantization: a review, *IEEE Trans. on Communications*, vol. 36, 957-571, 1988.

[16] A. Said and W.A. Pearlman, A new, fast, and efficient image codec based on set partitioning in hierarchical trees, *IEEE Trans. on Circuits and Systems for Video Technology*, vol. 6, 243-250, 1996.

[17] J.M. Shapiro, Embedded image coding using zerotree of wavelet coefficients, *IEEE Trans. on Signal Processing*, vol. 41, 3445-3462, 1993.

[18] G.K. Wallace, The JPEG still picture compression standard, *Communication ACM*, vol. 34, 31-44, 1991.

[19] C.J. Wein and I.F. Blake, On the performance of fractal compression with clustering, *IEEE Trans. on Image Processing*, vol. 5, 522-526, 1996.

[20] ftp.uu.net:/graphics/jpeg/jpegsrc.v6a.tar.gz

[21] http://wwwam.hhi.de/mpeg-video/#MPEG7

[22] http://links.uwaterloo.ca

[23] http://www.amara.com/current/Wavelet.html