

ECE6258 Lecture 26

Wavelet image compression

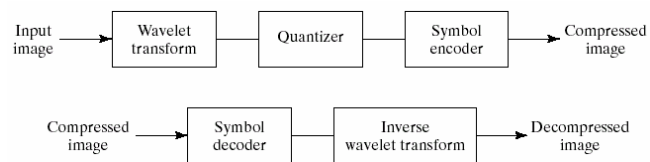
Announcement

- A second full-color test image and its CFA image have been placed on the class web site in the PROJECT section.

houses.tif



Wavelet image compression



- Similar, in principle to transform coding, except the input is not broken into blocks
 - No blocking artifacts
- Wavelet coefficients decorrelate pixels
- Wavelet coefficients can track nonstationary nature of images.

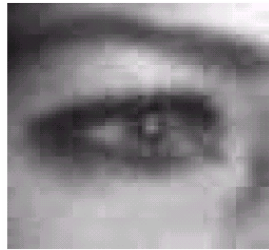
Wavelet coded results



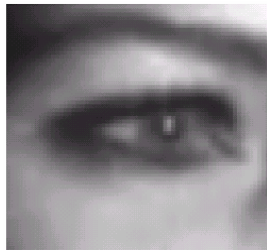
34:1

68:1

Comparison with transform coding



Transform coding
34:1

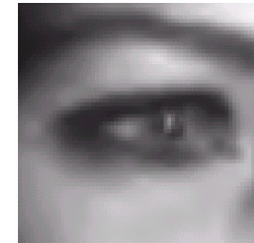


Wavelet coding
34:1

Comparison (cont'd)



Transform coding
68:1



Wavelet coding
68:1

Comparison with transform coding

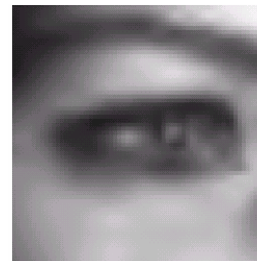


Transform coding
34:1

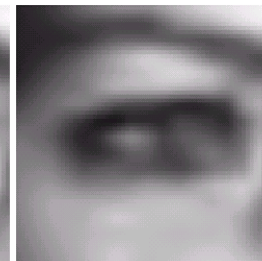


Wavelet coding
34:1

Higher compression rate results

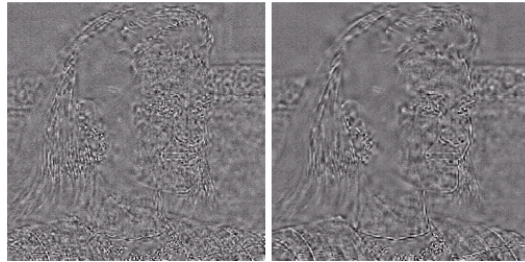


108:1



167:1

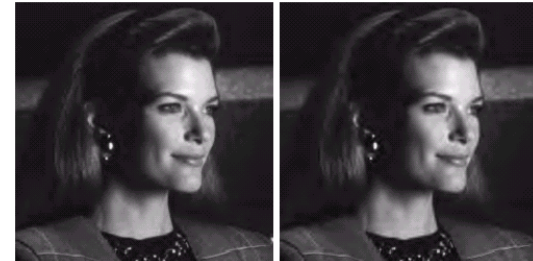
Higher compression rate results



108:1

167:1

Higher compression rate results



108:1

Rms error=3.72 levels

167:1

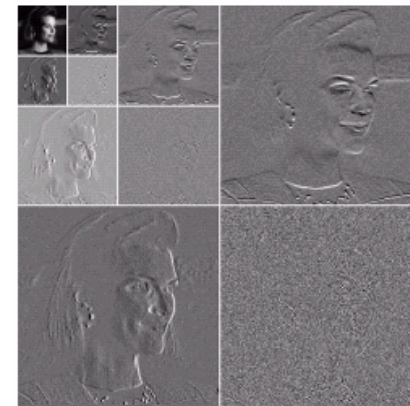
Rms error=4.73 levels

■ Rms error of transform coder at 67:1 = 6.33 levels

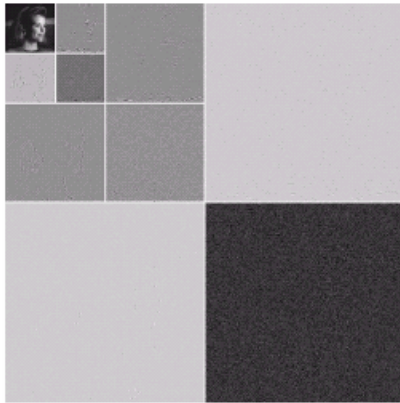
Wavelet selection

- All wavelets are not created equal.
 - Choice of wavelets affects computational efficiency of the transforms.
 - Choice of wavelets affects coefficient compaction.
 - Choice of wavelets affects presence of artifacts after quantization.
- Most widely used wavelets for compression
 - Daubechies wavelets
 - Biorthogonal wavelets

Haar wavelet decomposition



Daubechies wavelet decomposition

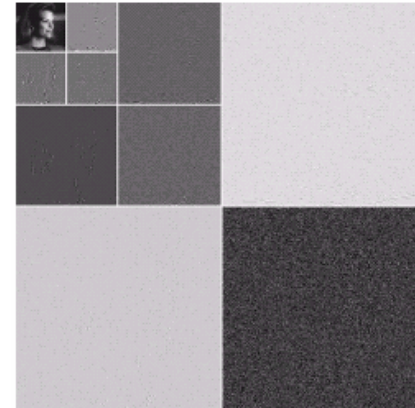


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Symlet decomposition

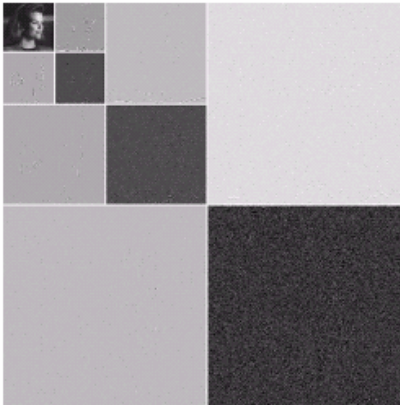


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CDF biorthogonal wavelets



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Wavelet comparison

Wavelet	Filter Taps (Scaling + Wavelet)	Zeroed Coefficients
Haar (see Ex. 7.10)	2 + 2	46%
Daubechies (see Fig. 7.6)	8 + 8	51%
Symlet (see Fig. 7.24)	8 + 8	51%
Biorthogonal (see Fig. 7.37)	17 + 11	55%

- Zeroed coefficients are number of detail coefficients below 1.5 in first level of decomposition.

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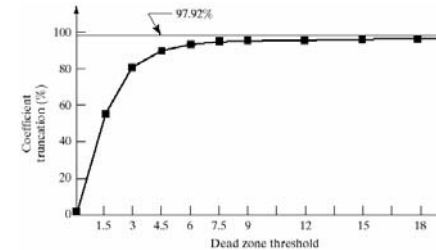
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Effect of number of scales

Scales and Filter Bank Iterations	Approximation Coefficient Image	Truncated Coefficients (%)	Reconstruction Error (rms)
1	256 × 256	75%	1.93
2	128 × 128	93%	2.69
3	64 × 64	97%	3.12
4	32 × 32	98%	3.25
5	16 × 16	98%	3.27

- Detail coefficients below 25 are truncated.
- Most of the coding gain comes from the first three levels.

Effect of dead zone



- Quantization effectiveness can be improved significantly by introducing an enlarged quantization zone around zero.
- rms error at value of 4.5 is 1.77 gray levels.

JPEG 2000

- Wavelet coding technique.
- Coefficient quantization is adapted to individual scales and subbands.
- Quantized coefficients are arithmetically coded on a bit-plane basis.

Pre-transform coding steps

- The images are first level-shifted by subtracting one-half the peak value.
- If a color image, the components are first decorrelated (RGB-YCbCr transformation)

$$Y_0[m, n] = 0.299I_0[m, n] + 0.587I_1[m, n] + 0.114I_2[m, n]$$

$$Y_1[m, n] = -0.16875I_0[m, n] - 0.33126I_1[m, n] + 0.5I_2[m, n]$$

$$Y_2[m, n] = 0.5I_0[m, n] - 0.41869I_1[m, n] - 0.08131I_2[m, n]$$

- (optional) The components can be divided into **tiles**.
- The FWT is computed using 9-7 coefficient scaling-wavelet filters.

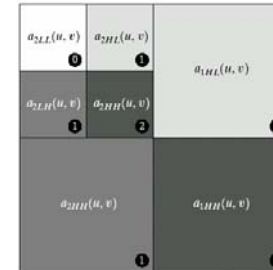
JPEG 2000 filter coefficients

Filter Tap	Highpass Wavelet Coefficient	Lowpass Scaling Coefficient
0	-1.115087052456994	0.6029490182363579
± 1	0.5912717631142470	0.2668641184428723
± 2	0.05754352622849957	-0.07822326652898785
± 3	-0.09127176311424948	-0.01686411844287495
± 4	0	0.02674875741080976

- Symmetric extension is used for the filtering.

Coding steps continued

- The transformation is applied to the approximation component, N_L times.



Coding steps concluded

- Wavelet coefficients are quantized (sign-magnitude representation)
- The final steps are
 - Coefficient bit modeling
 - Hierarchical trees of significant coefficients are constructed
 - Arithmetic coding
 - Bit-plane layering
 - Packetization