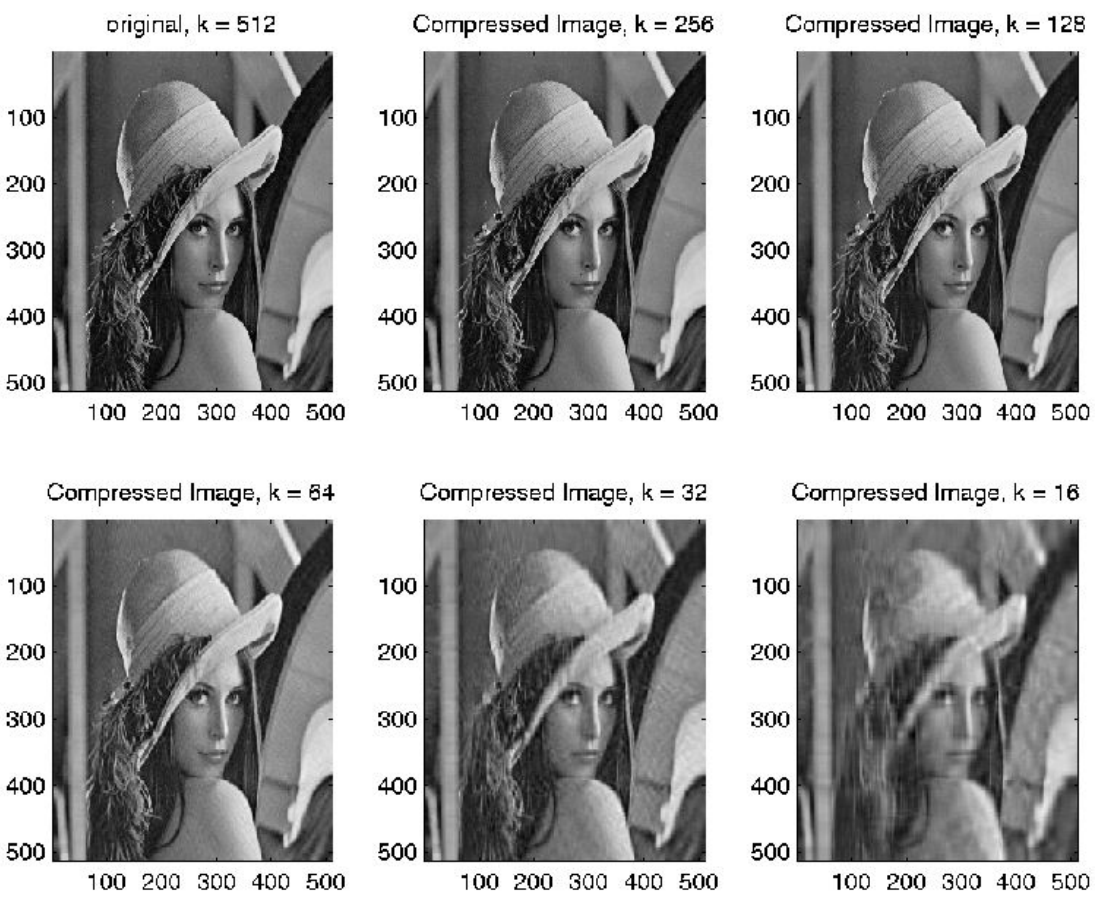
On the Selection of Image Compression Algorithms

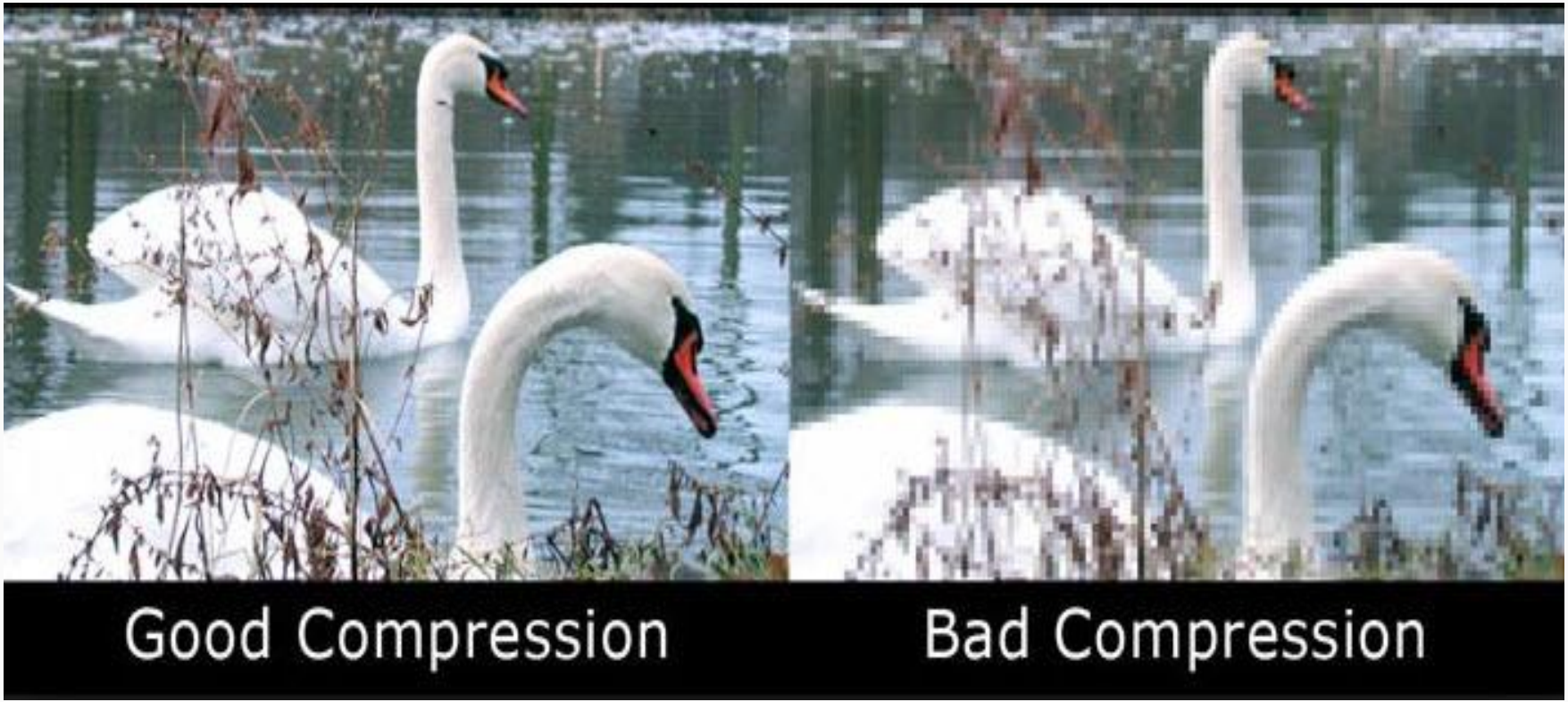
Intro

- What is compression?
- Types of image compression
- JPEG compression
- Wavelet compression
- VQ compression
- Fractal compression
- Experimental results
- Conclusion

What is compression?



Different types of compression



Different types of image compression

Lossy compression methods

- Better Portable Graphics, also known as BPG (lossless or lossy compression)
- Cartesian Perceptual Compression, also known as CPC
- DjVu
- **Fractal compression**
- ICER, used by the Mars Rovers, related to JPEG 2000 in its use of wavelets
- JBIG2 (lossless or lossy compression)
- **JPEG**
- JPEG 2000, JPEG's successor format that uses wavelets (lossless or lossy compression)
- JPEG XR, another successor of JPEG with support for high dynamic range, wide gamut pixel formats (lossless or lossy compression)
- **Vector quantization (VQ compression)**
- PGF, Progressive Graphics File (lossless or lossy compression)
- S3TC texture compression for 3D computer graphics hardware
- **Wavelet compression**

Lossless compression methods

- PNG – Portable Network Graphics
- TIFF – Tagged Image File Format
- WebP – (high-density lossless or lossy compression of RGB and RGBA images)
- BPG – Better Portable Graphics (lossless/lossy compression based on HEVC)
- FLIF – Free Lossless Image Format
- JPEG-LS – (lossless/near-lossless compression standard)
- TGA – Truevision TGA
- PCX – PiCture eXchange
- JPEG 2000 – (includes lossless compression method, as proven by Sunil Kumar, Prof San Diego State University[citation needed])
- JPEG XR – formerly WMPhoto and HD Photo, includes a lossless compression method
- ILBM – (lossless RLE compression of Amiga IFF images)
- JBIG2 – (lossless or lossy compression of B&W images)
- PGF – Progressive Graphics File (lossless or lossy compression)

JPEG Compression

Appeared in 1974.

Compression ration <= 50

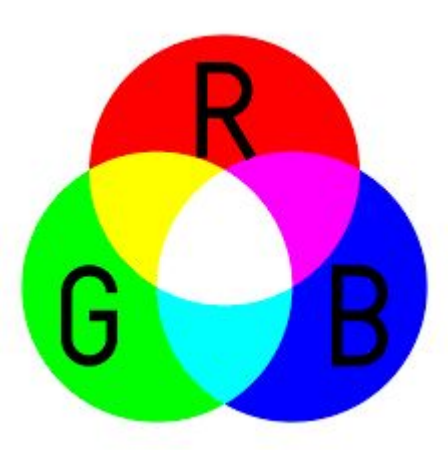
Pro :

- Current standard

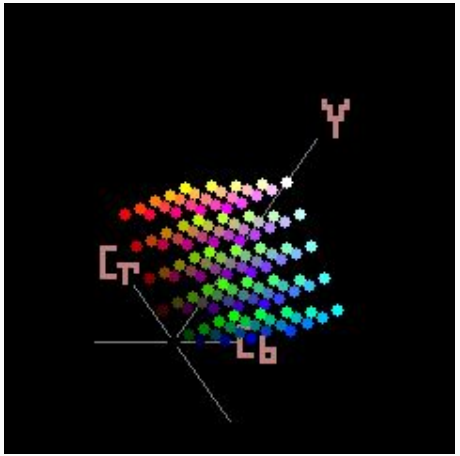
Cons:

- Coefficient quantization
- Bit allocation

JPEG Compression - Step 1(Color space conversion)

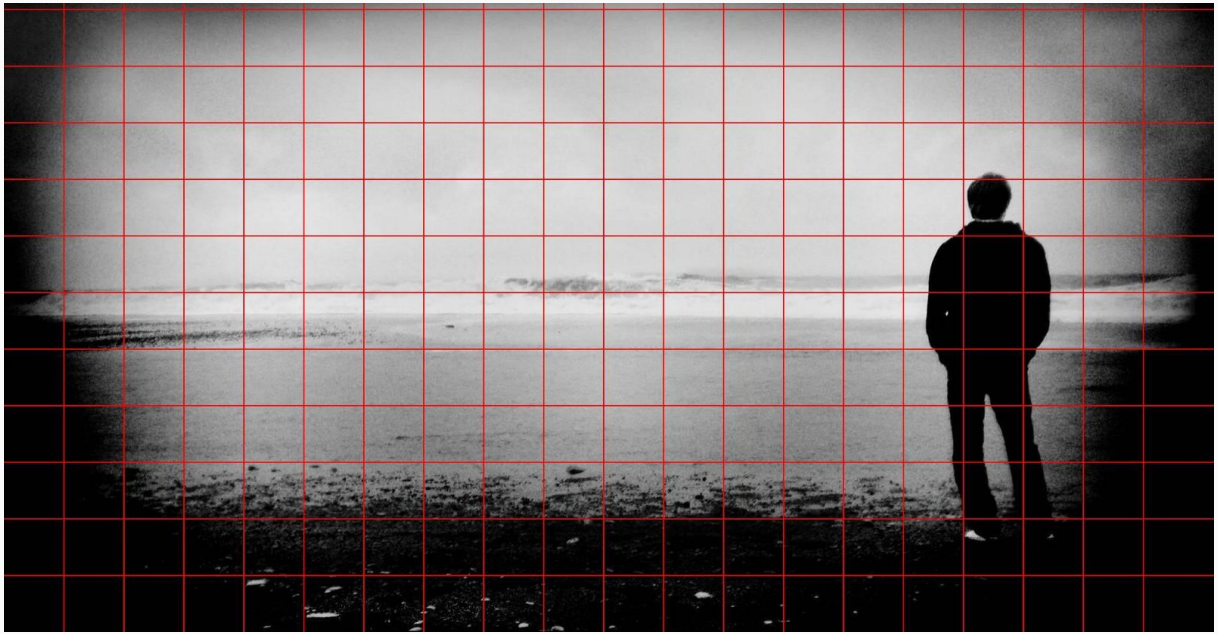


RGB

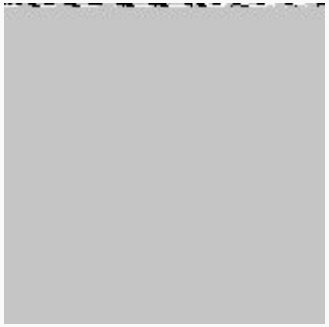


YCbCr

JPEG Compression - Step 2(Preparing for DCT)



Partitioned image for 8*8 blocks



One block of the image

JPEG Compression - Step 3(Applying DCT)

Cosine Wave

-27.500	-213.468	-149.608	-95.281	-103.750	-46.946	-58.717	27.226
168.229	51.611	-21.544	-239.520	-8.238	-24.495	-52.657	-96.621
-27.198	-31.236	-32.278	173.389	-51.141	-56.942	4.002	49.143
30.184	-43.070	-50.473	67.134	-14.115	11.139	71.010	18.039
19.500	8.460	33.589	-53.113	-36.750	2.918	-5.795	-18.387
-70.593	66.878	47.441	-32.614	-8.195	18.132	-22.994	6.631
12.078	-19.127	6.252	-55.157	85.586	-0.603	8.028	11.212
71.152	-38.373	-75.924	29.294	-16.451	-23.436	-4.213	15.624

DCT values

JPEG Compression - Step 4(Coefficient quantization)

```
17,18,24,47,99,99,99,99,
18,21,26,66,99,99,99,99,
24,26,56,99,99,99,99,99,
47,66,99,99,99,99,99,99,
99,99,99,99,99,99,99,99,
99,99,99,99,99,99,99,99,
99,99,99,99,99,99,99,99,
99,99,99,99,99,99,99,99
```

Chrominance quantization table

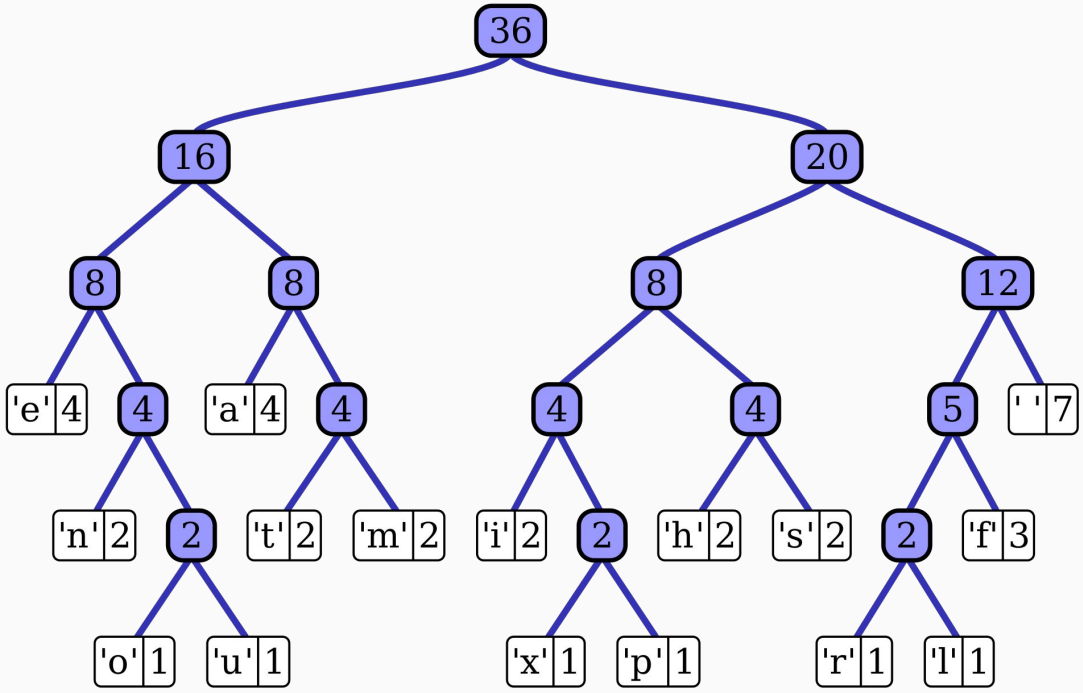
Luminance Quantization Table

```
16,  11,  10,  16,  24,  40,  51,  61,
12,  12,  14,  19,  26,  58,  60,  55,
14,  13,  16,  24,  40,  57,  69,  56,
14,  17,  22,  29,  51,  87,  80,  62,
18,  22,  37,  56,  68, 109, 103,  77,
24,  35,  55,  64,  81, 104, 113,  92,
49,  64,  78,  87, 103, 121, 120, 101,
72,  92,  95,  98, 112, 100, 103,  99
```

-2	-19	-15	-6	-4	-1	-1	0
14	4	-2	-13	0	0	-1	-2
-2	-2	-2	7	-1	-1	0	1
2	-3	-2	2	0	0	1	0
1	0	1	-1	-1	0	0	0
-3	2	1	-1	0	0	0	0
0	0	0	-1	1	0	0	0
1	0	-1	0	0	0	0	0

Matrix after quantization

JPEG Compression - Step 5(Encoding)



Huffman tree

Wavelet Compression

Appeared in **1992.**

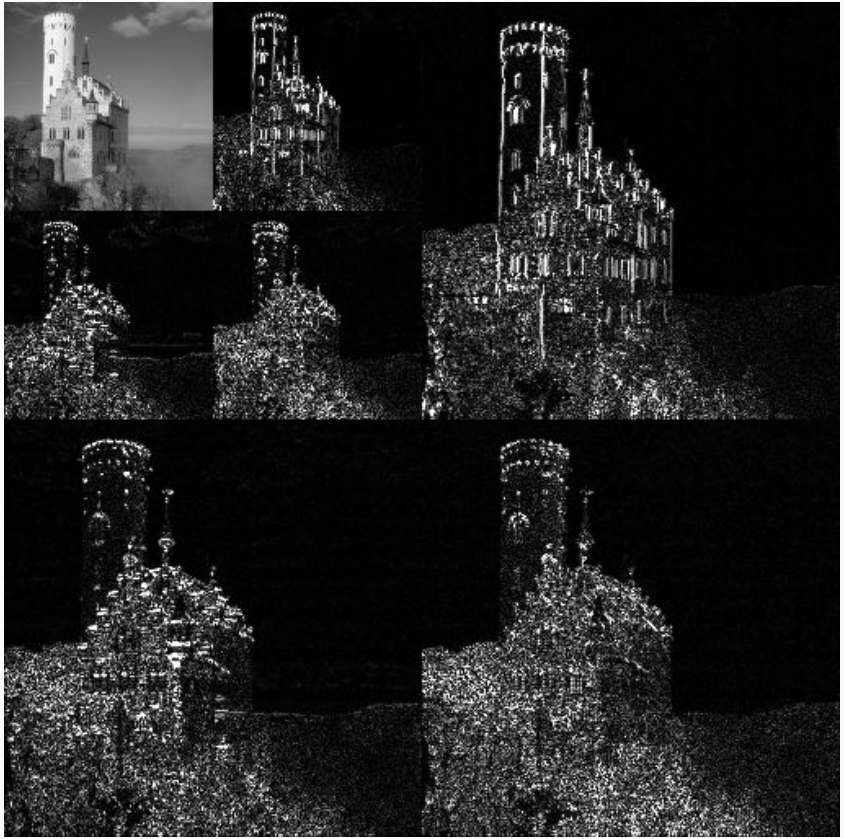
Compression ration > 32

Pro :

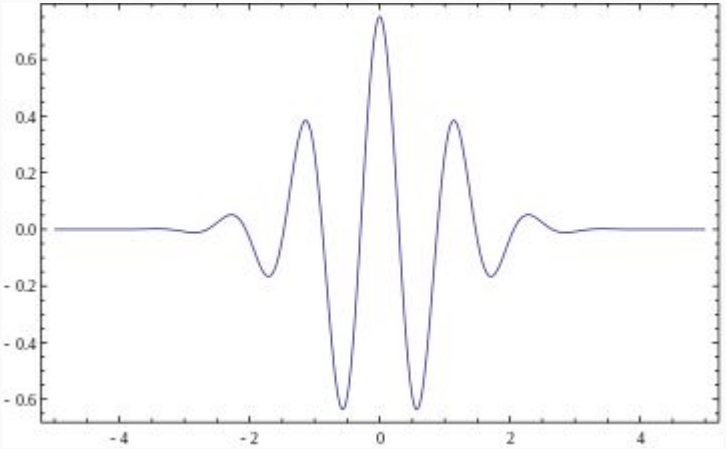
- High compression ratio

Cons

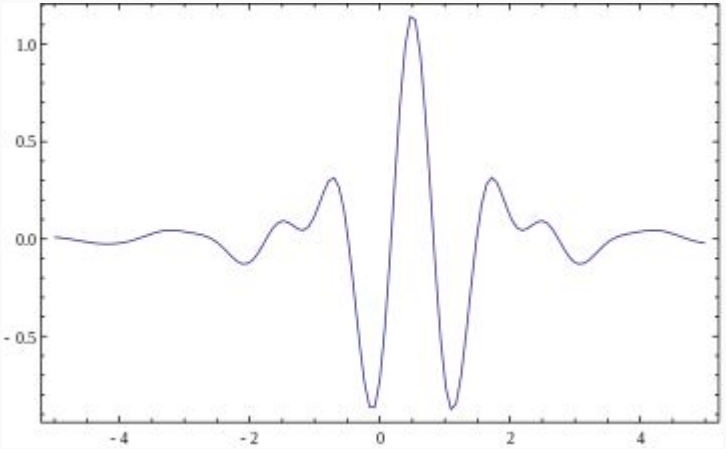
- Coefficient quantization
- Bit allocation



Wavelet Compression

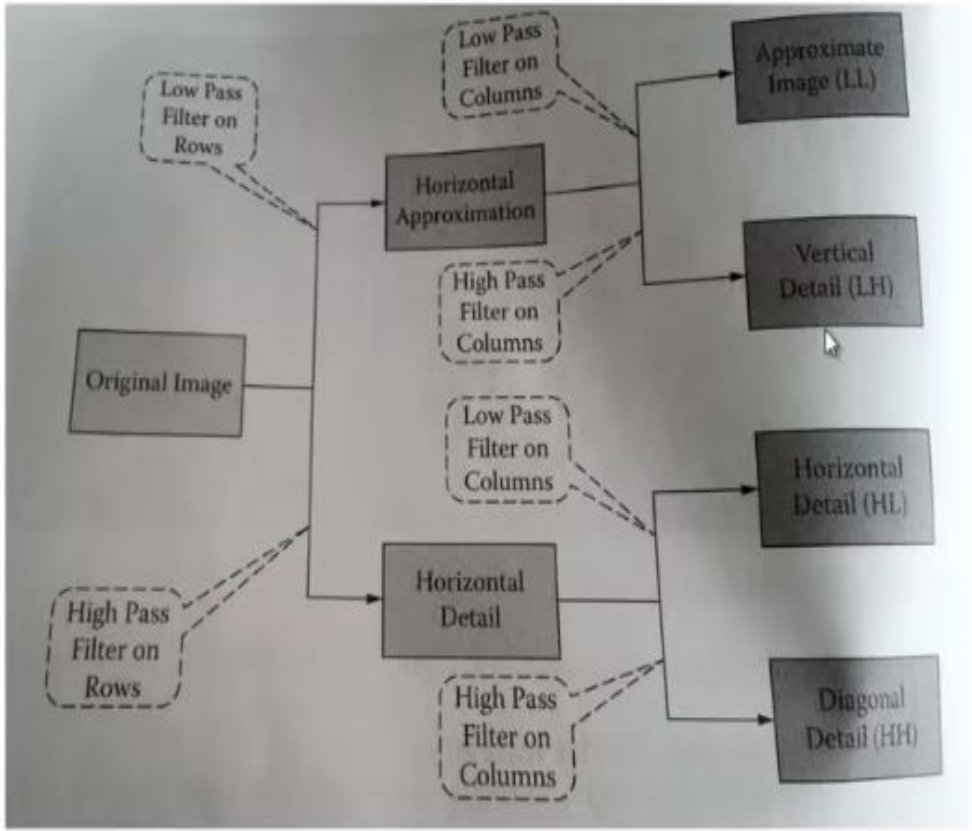


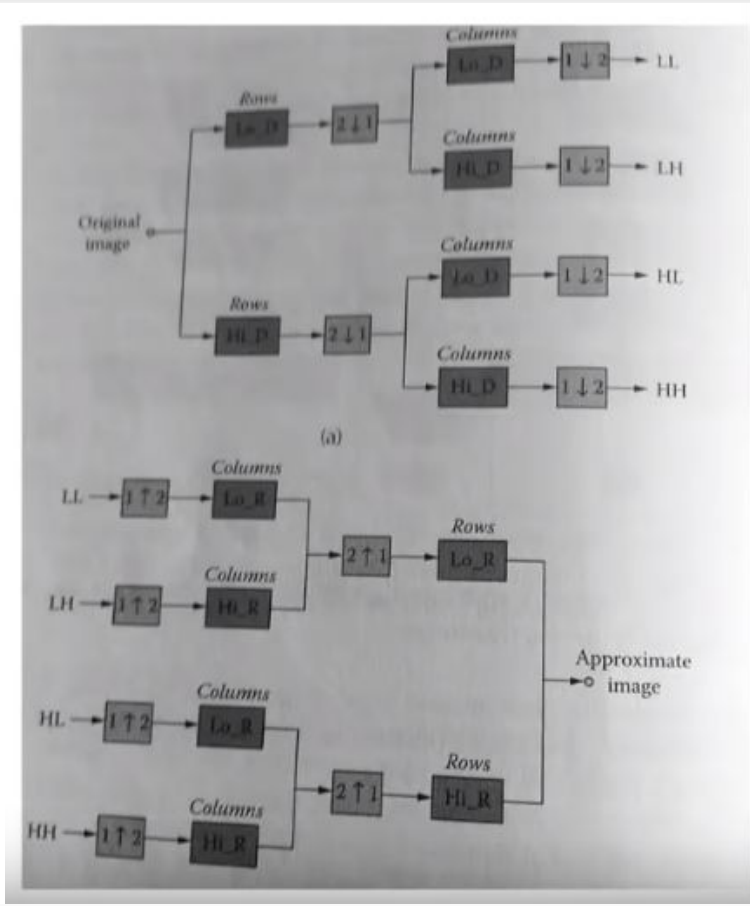
Morlet wavelet



Mayers wavelet

Encoding and decoding





Examples

Figure 3.3: Original Lena image

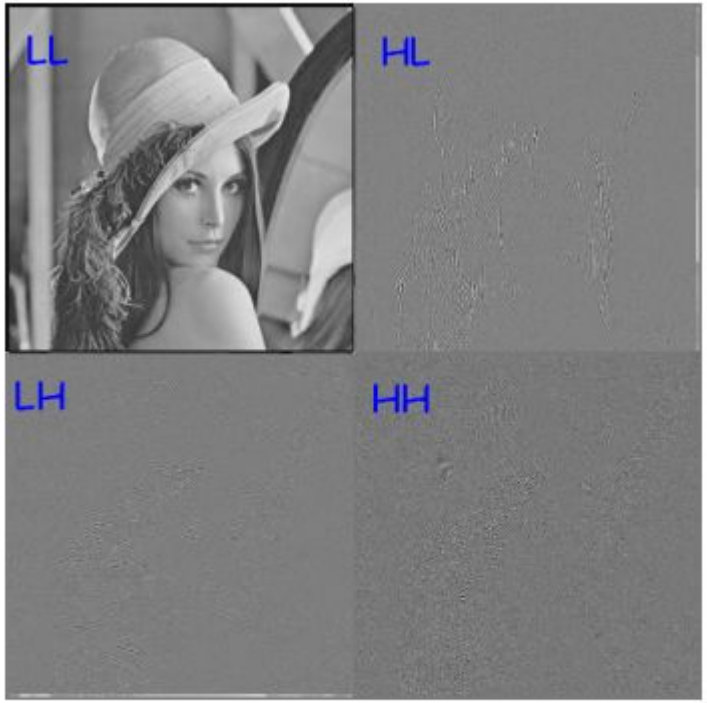


Figure 3.4: Lena image after wavelet decomposition

VQ (Vector Quantization) Compression

Appeared in **1980.**

Compression ratio < 32

Pro:

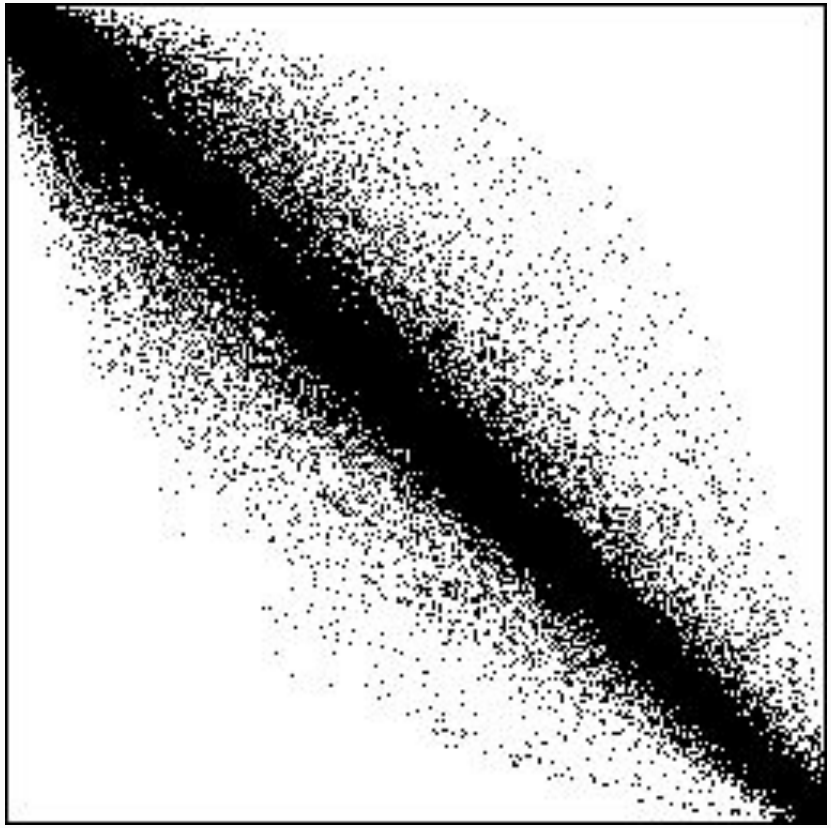
- Simple decoder
- No coefficient quantization
- Blindingly fast decompression
- Good quality at excellent compression ratios

Cons:

- Slow codebook generation
- Small bpp
- Nonstandard, not widely supported in hardware.

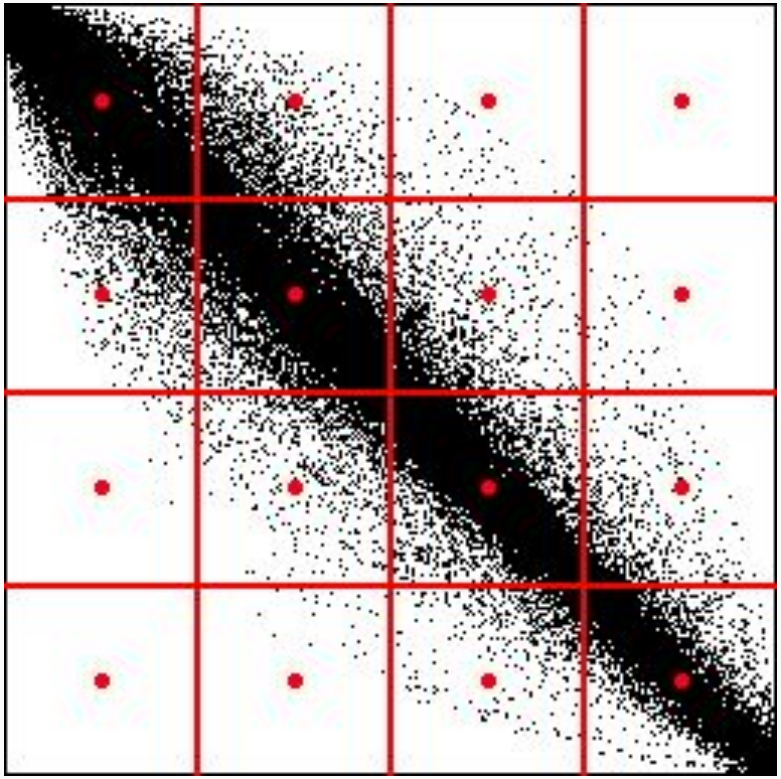
VQ Compression - Explanation

2D Image (Lena)

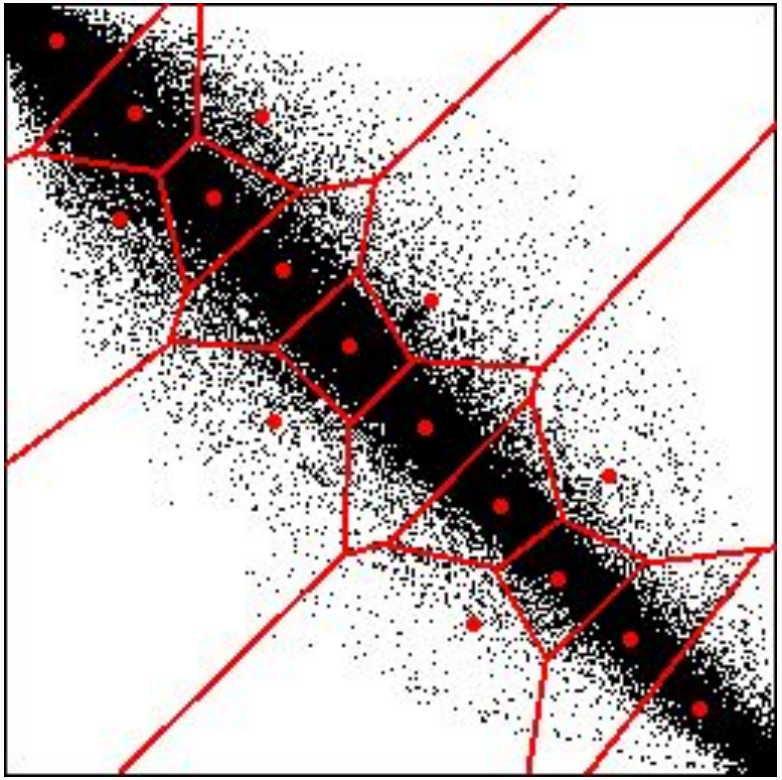


Distributia de perechi de pixeli

VQ Compression - Explanation



Scalar quantization to 2 bits/pixel



Vector quantization to 4 bits per 2D-vector

Fractal Compression

Appeared in **1992**.

Compression ratio >= 16

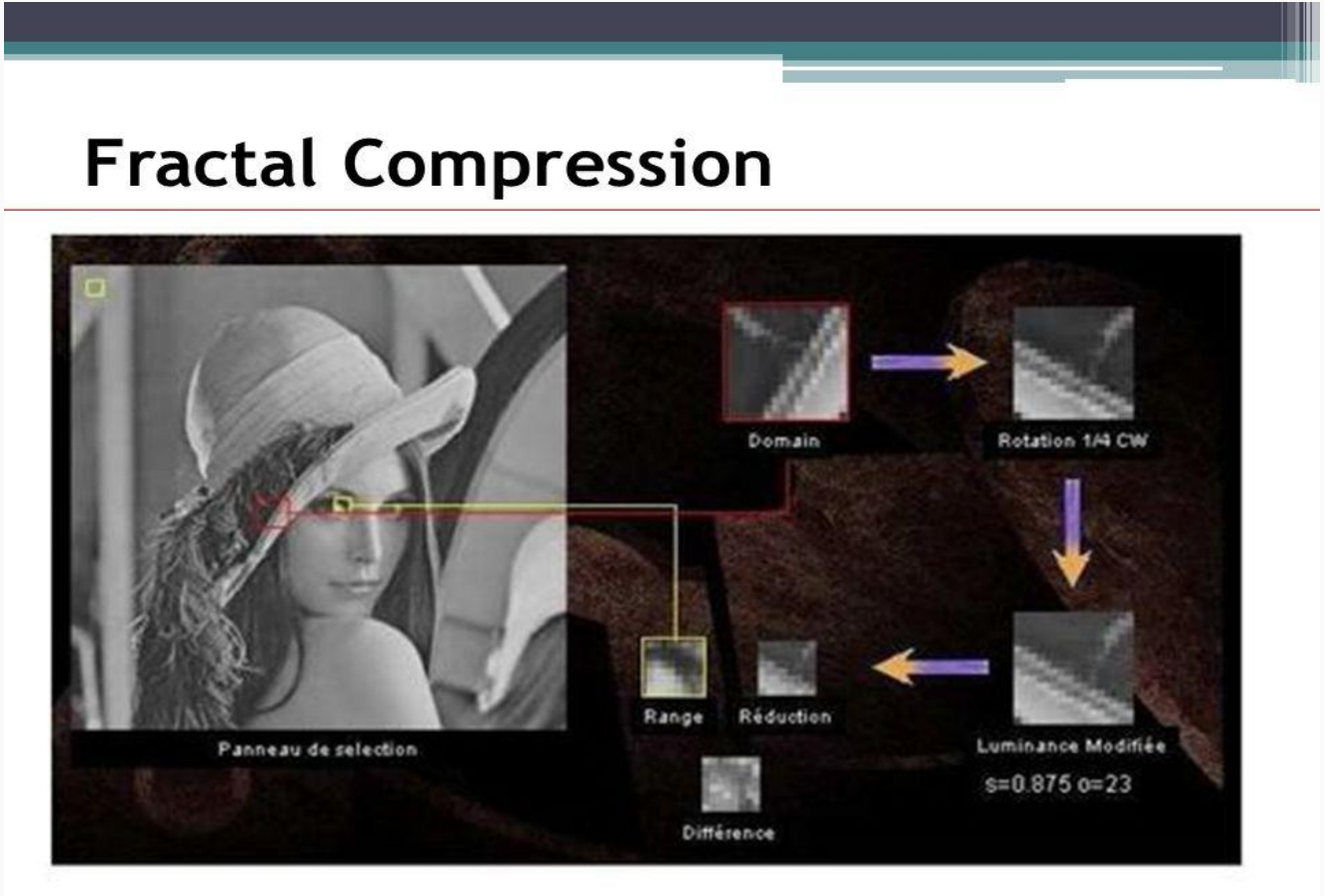
Pro:

- Good mathematical encoding frame
- Resolution-free decoding

Cons:

- Slow encoding

Fractal compression example



Lena with Fractal compression

(a) (b) (c)

Fig. 6 : (a) Original 'Lena' image; (b) decoded image of 'Lena' with no signature; (c) decoded ima

Experimental Comparison

Algorithm	*PSNR values (in dB)*			
	Jet	Lenna	Mandrill	Peppers
Wavelet	32.48	34.66	26.54	34.99
JPEG	30.39	31.73	25.15	31.95
VQ	26.76	29.28	24.45	29.12
Fractal	26.70	29.04	24.29	29.13

	CPU time	
	Encoding	Decoding
Wavelet	0.35 sec	0.27 sec
JPEG	0.12 sec	0.12 sec
VQ	2.45 sec	0.18 sec
Fractal	5.65 hrs	1.35 sec

Table 2: Performance of coding algorithms on various 256×256 images.

Conclusion

Algorithm	*0.50 bpp*		
	PSNR values	Encoding	Decoding
Wavelet	36.71	0.8 sec	0.7 sec
JPEG	34.27	0.2 sec	0.2 sec
VQ	28.26	6.0 sec	0.7 sec
Fractal	27.21	6.3 hrs	3.5 sec

Algorithm	*0.25 bpp*		
	PSNR value	Encoding	Decoding
Wavelet	32.47	0.7 sec	0.5 sec
JPEG	29.64	0.2 sec	0.2 sec
VQ	N/A	N/A	N/A
Fractal	N/A	N/A	N/A

Table 3: Performance of coding algorithms on a 400×400 fingerprint image.

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

Questions?

Sources

https://en.wikipedia.org/wiki/Peak_signal-to-noise_ratio

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