



JPEG - codificação de entropia



Codificação de entropia

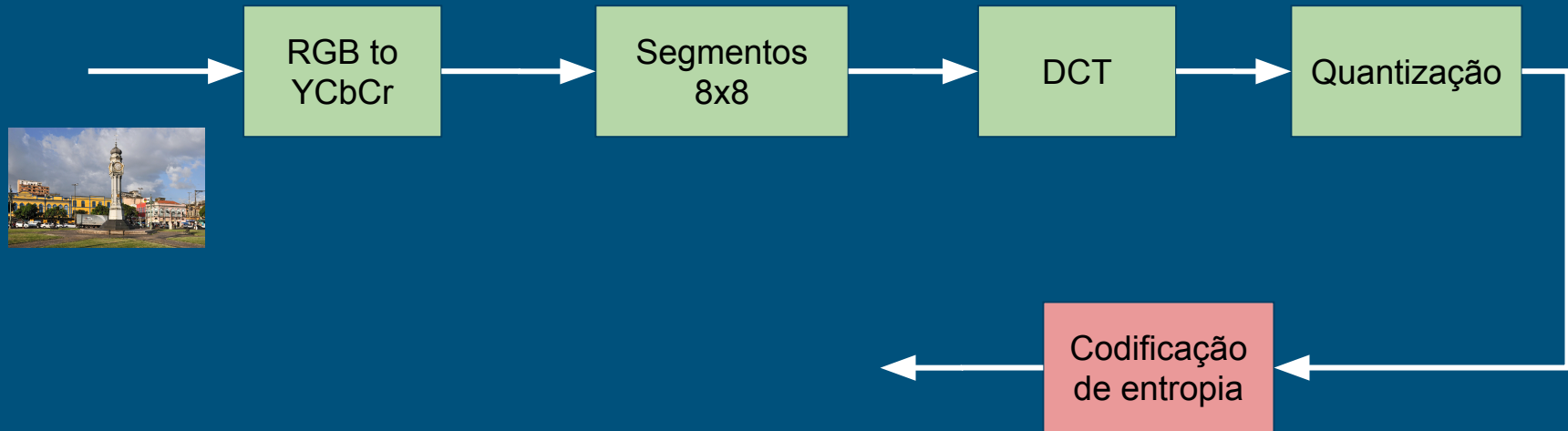
Objetivo:

- Compressão sem perdas

Etapas:

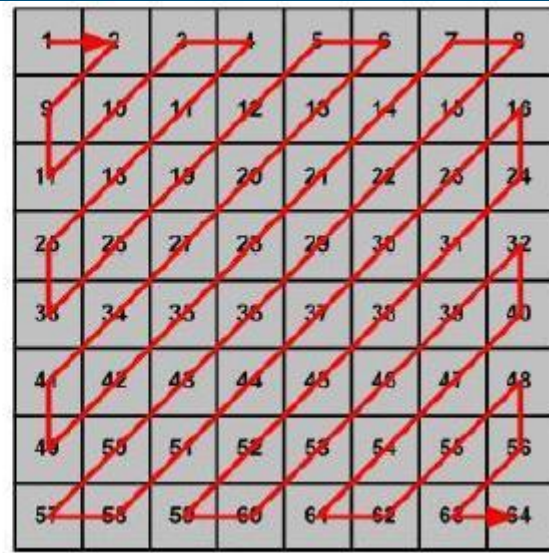
- Ordenamento zigzag do bloco DCT quantizado
- Codificação da diferença do coeficiente DC
- Codificação dos coeficientes AC

Contexto



Ordenamento zigzag do bloco DCT quantizado

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64



1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64

Ordenamento zigzag do bloco DCT quantizado

Exemplo:

-415	-29	-62	25	55	-20	-1	3
7	-21	-62	9	11	-7	-6	6
-46	8	77	-25	-30	10	7	-5
-50	13	35	-15	-9	6	0	3
11	-8	-13	-2	-1	1	-4	1
-10	1	3	-3	-1	0	2	-1
-4	-1	2	-1	2	-3	1	-2
-1	-1	-1	-2	-1	-1	0	-1

Bloco 8x8 DCT

-26	-3	-6	2	2	0	0	0
1	-2	-4	0	0	0	0	0
-3	1	5	-1	-1	0	0	0
-4	1	2	-1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Bloco 8x8 DCT quantizado

`[-26 -3 1 -3 -2 -6 2 -4 1 -4 1 1 5 0 2 0 0 -1 2 0 0 0 0 0 -1 -1 EOB]`

$b_n = [-26, (0,-3), (0,1), (0,-3), (0,-2), (0,-6), (0,2), (0,-4), (0,1), (0,-4), (0,1), (0,1), (0,5), (1,2), (2,-1), (0,2), (5,-1), (0,-1), \text{EOB}]$

Codificação da diferença do coeficiente DC

- Deve-se calcular a diferença do coeficiente DC em relação ao bloco anterior:

$b_n = [-26, (0,-3), (0,1), (0,-3), (0,-2), (0,-6), (0,2), (0,-4), (0,1), (0,-4), (0,1), (0,1), (0,5), (1,2), (2,-1), (0,2), (5,-1), (0,-1), \text{EOB}]$

$b_{\{n-1\}} = [-17, \dots, \text{EOB}]$

$\text{DC}_n - \text{DC}_{\{n-1\}} = -26 - (-17) = -9$

$b_n = [-9, (0,-3), (0,1), (0,-3), (0,-2), (0,-6), (0,2), (0,-4), (0,1), (0,-4), (0,1), (0,1), (0,5), (1,2), (2,-1), (0,2), (5,-1), (0,-1), \text{EOB}]$

Codificação da diferença do coeficiente DC

- Determina-se a categoria da componente DC:

$b_n = [-9, (0,-3), (0,1), (0,-3), (0,-2), (0,-6), (0,2), (0,-4), (0,1), (0,-4), (0,1), (0,1), (0,5), (1,2), (2,-1), (0,2), (5,-1), (0,-1), \text{EOB}]$

TABLE A.3 JPEG coefficient coding categories.

Range	DC Difference Category	AC Category
0	0	N/A
-1, 1	1	1
-3, -2, 2, 3	2	2
-7, ..., -4, 4, ..., 7	3	3
-15, ..., -8, 8, ..., 15	4	4
-31, ..., -16, 16, ..., 31	5	5
-63, ..., -32, 32, ..., 63	6	6
-127, ..., -64, 64, ..., 127	7	7
-255, ..., -128, 128, ..., 255	8	8
-511, ..., -256, 256, ..., 511	9	9
-1023, ..., -512, 512, ..., 1023	A	A
-2047, ..., -1024, 1024, ..., 2047	B	B
-4095, ..., -2048, 2048, ..., 4095	C	C
-8191, ..., -4096, 4096, ..., 8191	D	D
-16383, ..., -8192, 8192, ..., 16383	E	E
-32767, ..., -16384, 16384, ..., 32767	F	N/A

Categoria 4 !!

Codificação da diferença do coeficiente DC

- Determina-se o código base e o valor da componente em binário:

b_n = [-9, (0,-3), (0,1), (0,-3), (0,-2), (0,-6), (0,2), (0,-4), (0,1), (0,-4), (0,1), (0,1), (0,5), (1,2), (2,-1), (0,2), (5,-1), (0,-1), EOB]

Categoria 4 !!

Category	Base Code	Length	Category	Base Code	Length
0	010	3	6	1110	10
1	011	4	7	11110	12
2	100	5	8	111110	14
3	00	5	9	1111110	16
4	101	7	A	11111110	18
5	110	8	B	111111110	20

TABLE A.4 JPEG default DC code (luminance).

Código base + valor da componente: 1010110

- Valor da componente: expressa a magnitude usando k bits (k é a categoria).
- Se for negativo, acha o complemento a 1.

Codificação dos coeficientes AC

- Determina-se a categoria da componente AC:

$b_n = [-9, (0, -3), (0, 1), (0, -3), (0, -2), (0, -6), (0, 2), (0, -4), (0, 1), (0, -4), (0, 1), (0, 1), (0, 5), (1, 2), (2, -1), (0, 2), (5, -1), (0, -1), \text{EOB}]$

TABLE A.3 JPEG coefficient coding categories.

Range	DC Difference Category	AC Category
0	0	N/A
-1, 1	1	1
-3, -2, 2, 3	2	2
-7, ..., -4, 4, ..., 7	3	3
-15, ..., -8, 8, ..., 15	4	4
-31, ..., -16, 16, ..., 31	5	5
-63, ..., -32, 32, ..., 63	6	6
-127, ..., -64, 64, ..., 127	7	7
-255, ..., -128, 128, ..., 255	8	8
-511, ..., -256, 256, ..., 511	9	9
-1023, ..., -512, 512, ..., 1023	A	A
-2047, ..., -1024, 1024, ..., 2047	B	B
-4095, ..., -2048, 2048, ..., 4095	C	C
-8191, ..., -4096, 4096, ..., 8191	D	D
-16383, ..., -8192, 8192, ..., 16383	E	E
-32767, ..., -16384, 16384, ..., 32767	F	N/A

Codificação dos coeficientes AC

- Determina-se a o código base e o valor da componente:

$b_n = [-9, (0, -3), (0, 1), (0, -3), (0, -2), (0, -6), (0, 2), (0, -4), (0, 1), (0, -4), (0, 1), (0, 1), (0, 5), (1, 2), (2, -1), (0, 2), (5, -1), (0, -1), \text{EOB}]$

Código base + valor da componente:
0100

- Valor da componente: expressa a magnitude usando k bits (k é a categoria).
- Se for negativo, acha o complemento a 1.

Run 0
Categoria 2

Run/ Category	Base Code	Length	Run/ Category	Base Code	Length
0/0	1010 (= EOB)	4			
0/1	00	3	8/1	11111010	9
0/2	01	4	8/2	11111111000000	17
0/3	100	6	8/3	111111110110111	19
0/4	1011	8	8/4	111111110111000	20
0/5	11010	10	8/5	111111110111001	21
0/6	111000	12	8/6	111111110111010	22
0/7	1111000	14	8/7	111111110111011	23
0/8	111110110	18	8/8	111111110111100	24
0/9	111111110000010	25	8/9	111111110111101	25
0/A	111111110000011	26	8/A	111111110111110	26
1/1	1100	5	9/1	111111000	10
1/2	111001	8	9/2	111111110111111	18
1/3	1111001	10	9/3	111111111000000	19
1/4	111110110	13	9/4	111111111000001	20
1/5	11111110110	16	9/5	111111111000010	21
1/6	111111110000100	22	9/6	111111111000011	22
1/7	1111111110000101	23	9/7	111111111000100	23
1/8	1111111110000110	24	9/8	111111111000101	24
1/9	1111111110000111	25	9/9	111111111000110	25
1/A	1111111110001000	26	9/A	111111111000111	26
2/1	11011	6	A/1	111111001	10
2/2	11111000	10	A/2	111111111001000	18
2/3	1111110111	13	A/3	111111111001001	19
2/4	111111110001001	20	A/4	111111111001010	20
2/5	1111111110001010	21	A/5	111111111001011	21
2/6	1111111110001011	22	A/6	111111111001100	22
2/7	1111111110001100	23	A/7	111111111001101	23
2/8	1111111110001101	24	A/8	111111111001110	24
2/9	1111111110001110	25	A/9	111111111001111	25
2/A	1111111110001111	26	A/A	111111111010000	26
3/1	111010	7	B/1	111111010	10
3/2	111110111	11	B/2	111111111010001	18
3/3	11111110111	14	B/3	111111111010010	19
3/4	1111111110010000	20	B/4	111111111010011	20
3/5	1111111110010001	21	B/5	111111111010100	21
3/6	1111111110010010	22	B/6	111111111010101	22
3/7	1111111110010011	23	B/7	111111111010110	23

TABLE A.5 JPEG default AC code (luminance).

(Continued)

Codificação dos coeficientes AC

- Determina-se a categoria da componente AC:

$b_n = [-9, (0,-3), (0,1), (0,-3), (0,-2), (0,-6), (0,2), (0,-4), (0,1), (0,-4), (0,1), (0,1), (0,5), (1,2), (2,-1), (0,2), (5,-1), (0,-1), \text{EOB}]$

TABLE A.3 JPEG coefficient coding categories.

Range	DC Difference Category	AC Category
0	0	N/A
-1, 1	1	1
-3, -2, 2, 3	2	2
-7, ..., -4, 4, ..., 7	3	3
-15, ..., -8, 8, ..., 15	4	4
-31, ..., -16, 16, ..., 31	5	5
-63, ..., -32, 32, ..., 63	6	6
-127, ..., -64, 64, ..., 127	7	7
-255, ..., -128, 128, ..., 255	8	8
-511, ..., -256, 256, ..., 511	9	9
-1023, ..., -512, 512, ..., 1023	A	A
-2047, ..., -1024, 1024, ..., 2047	B	B
-4095, ..., -2048, 2048, ..., 4095	C	C
-8191, ..., -4096, 4096, ..., 8191	D	D
-16383, ..., -8192, 8192, ..., 16383	E	E
-32767, ..., -16384, 16384, ..., 32767	F	N/A

Categoria 1 !!

Codificação dos coeficientes AC

- Determina-se a o código base e o valor da componente:

$b_n = [-9, (0,-3), (0,1), (0,-3), (0,-2), (0,-6), (0,2), (0,-4), (0,1), (0,-4), (0,1), (0,1), (0,5), (1,2), (2,-1), (0,2), (5,-1), (0,-1), \text{EOB}]$

Código base + valor da componente: 001

- Valor da componente: expressa a magnitude usando k bits (k é a categoria).
- Se for negativo, acha o complemento a 1.

Run 0
Categoria 1

Run/ Category	Base Code	Length	Run/ Category	Base Code	Length
0/0	1010 (= EOB)	4			
0/1	00	3	8/1	11111010	9
0/2	01	4	8/2	11111111000000	17
0/3	100	6	8/3	111111110110111	19
0/4	1011	8	8/4	111111110111000	20
0/5	11010	10	8/5	111111110111001	21
0/6	111000	12	8/6	111111110111010	22
0/7	1111000	14	8/7	111111110111011	23
0/8	111110110	18	8/8	111111110111100	24
0/9	111111110000010	25	8/9	111111110111101	25
0/A	111111110000011	26	8/A	111111110111110	26
1/1	1100	5	9/1	111111000	10
1/2	111001	8	9/2	111111110111111	18
1/3	1111001	10	9/3	111111111000000	19
1/4	111110110	13	9/4	111111111000001	20
1/5	11111110110	16	9/5	111111111000010	21
1/6	111111110000100	22	9/6	111111111000011	22
1/7	1111111110000101	23	9/7	111111111000100	23
1/8	1111111110000110	24	9/8	111111111000101	24
1/9	1111111110000111	25	9/9	111111111000110	25
1/A	1111111110001000	26	9/A	111111111000111	26
2/1	11011	6	A/1	111111001	10
2/2	11111000	10	A/2	1111111111001000	18
2/3	1111110111	13	A/3	1111111111001001	19
2/4	1111111110001001	20	A/4	1111111111001010	20
2/5	1111111110001010	21	A/5	1111111111001011	21
2/6	1111111110001011	22	A/6	1111111111001100	22
2/7	1111111110001100	23	A/7	1111111111001101	23
2/8	1111111110001101	24	A/8	1111111111001110	24
2/9	1111111110001110	25	A/9	1111111111001111	25
2/A	1111111110001111	26	A/A	1111111111010000	26
3/1	111010	7	B/1	111111010	10
3/2	111110111	11	B/2	1111111111010001	18
3/3	11111110111	14	B/3	1111111111010010	19
3/4	1111111110010000	20	B/4	1111111111010011	20
3/5	1111111110010001	21	B/5	1111111111010100	21
3/6	1111111110010010	22	B/6	1111111111010101	22
3/7	1111111110010011	23	B/7	1111111111010110	23

TABLE A.5 JPEG default AC code (luminance).

(Continued)

Codificação dos coeficientes AC

- Determina-se a categoria da componente AC:

b_n = [-9, (0,-3), (0,1),
(0,-3), (0,-2), (0,-6), (0,2),
(0,-4), (0,1), (0,-4), (0,1),
(0,1), (0,5), (1,2), (2,-1),
(0,2), **(5,-1)**, (0,-1), EOB]

TABLE A.3 JPEG
coefficient coding
categories.

Range	DC Difference Category	AC Category
0	0	N/A
-1, 1	1	1
-3, -2, 2, 3	2	2
-7, ..., -4, 4, ..., 7	3	3
-15, ..., -8, 8, ..., 15	4	4
-31, ..., -16, 16, ..., 31	5	5
-63, ..., -32, 32, ..., 63	6	6
-127, ..., -64, 64, ..., 127	7	7
-255, ..., -128, 128, ..., 255	8	8
-511, ..., -256, 256, ..., 511	9	9
-1023, ..., -512, 512, ..., 1023	A	A
-2047, ..., -1024, 1024, ..., 2047	B	B
-4095, ..., -2048, 2048, ..., 4095	C	C
-8191, ..., -4096, 4096, ..., 8191	D	D
-16383, ..., -8192, 8192, ..., 16383	E	E
-32767, ..., -16384, 16384, ..., 32767	F	N/A

Categoria 1 !!

Codificação dos coeficientes AC

- Determina-se a o código base e o valor da componente:

$b_n = [-9, (0,-3), (0,1), (0,-3), (0,-2), (0,-6), (0,2), (0,-4), (0,1), (0,-4), (0,1), (0,1), (0,5), (1,2), (2,-1), (0,2), (5,-1), (0,-1), \text{EOB}]$

Código base + valor da componente:
11110100

- Valor da componente: expressa a magnitude usando k bits (k é a categoria).
- Se for negativo, acha o complemento a 1.

TABLE A.5
(Continued)

Run/ Category	Base Code	Length	Run/ Category	Base Code	Length
3/8	111111110010100	24	B/8	111111111010111	24
3/9	1111111110010101	25	B/9	111111111101000	25
3/A	1111111110010110	26	B/A	1111111111011001	26
4/1	111011	7	C/1	1111111010	11
4/2	1111111000	12	C/2	111111111011010	18
4/3	1111111110010111	19	C/3	1111111111011011	19
4/4	1111111110011000	20	C/4	1111111111011100	20
4/5	1111111110011001	21	C/5	1111111111011101	21
4/6	1111111110011010	22	C/6	1111111111011110	22
4/7	1111111110011011	23	C/7	1111111111101111	23
4/8	1111111110011100	24	C/8	1111111111100000	24
4/9	1111111110011101	25	C/9	1111111111100001	25
4/A	1111111110011110	26	C/A	1111111111100010	26
5/1	1111010	8	D/1	11111111010	12
5/2	1111111001	12	D/2	1111111111100011	18
5/3	1111111110011111	19	D/3	1111111111100100	19
5/4	1111111110100000	20	D/4	1111111111100101	20
5/5	1111111110100001	21	D/5	1111111111100110	21
5/6	1111111110100010	22	D/6	1111111111100111	22
5/7	1111111110100011	23	D/7	1111111111101000	23
5/8	1111111110100100	24	D/8	1111111111101001	24
5/9	1111111110100101	25	D/9	1111111111101010	25
5/A	1111111110100110	26	D/A	1111111111101011	26
6/1	1111011	8	E/1	111111110110	13
6/2	11111111000	13	E/2	1111111111101100	18
6/3	1111111110100111	19	E/3	1111111111101101	19
6/4	1111111110101000	20	E/4	1111111111101110	20
6/5	1111111110101001	21	E/5	1111111111101111	21
6/6	1111111110101010	22	E/6	1111111111110000	22
6/7	1111111110101011	23	E/7	1111111111110001	23
6/8	1111111110101100	24	E/8	1111111111110010	24
6/9	1111111110101101	25	E/9	1111111111110011	25
6/A	1111111110101110	26	E/A	1111111111110100	26
7/1	11111001	9	F/0	111111110111	12
7/2	11111111001	13	F/1	1111111111110101	17
7/3	1111111110101111	19	F/2	1111111111110110	18
7/4	1111111110110000	20	F/3	1111111111110111	19
7/5	1111111110110001	21	F/4	1111111111111000	20
7/6	1111111110110010	22	F/5	1111111111111001	21
7/7	1111111110110011	23	F/6	1111111111111010	22
7/8	1111111110110100	24	F/7	1111111111111011	23
7/9	1111111110110101	25	F/8	1111111111111100	24
7/A	1111111110110110	26	F/9	1111111111111101	25
			F/A	1111111111111110	26

Run 5
Categoria 1