JPEG Image Encoding and Compression

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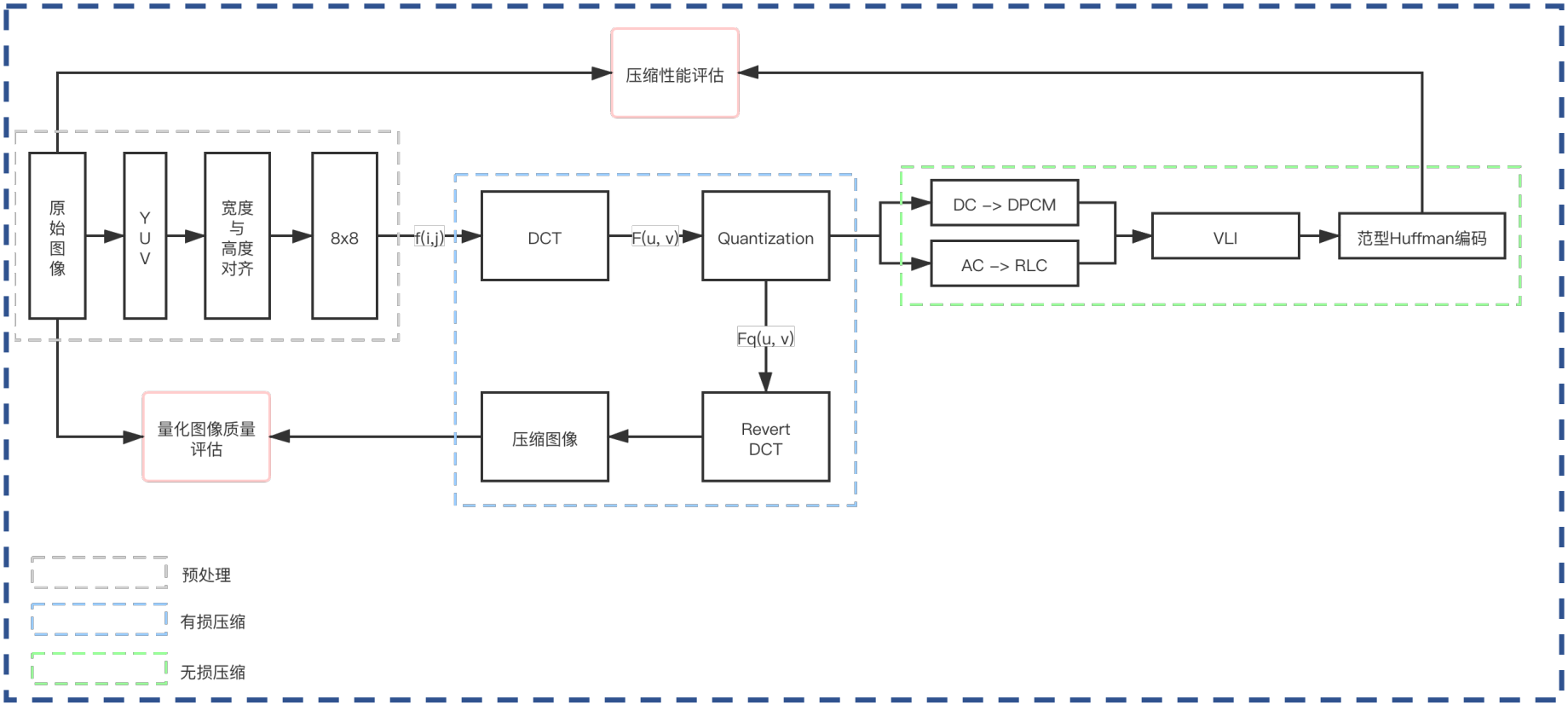
Catalog

1 Introduction

Three Stages: Preprocessing、Quantization(loss compression)、Entropy Encoding(lossless compression)

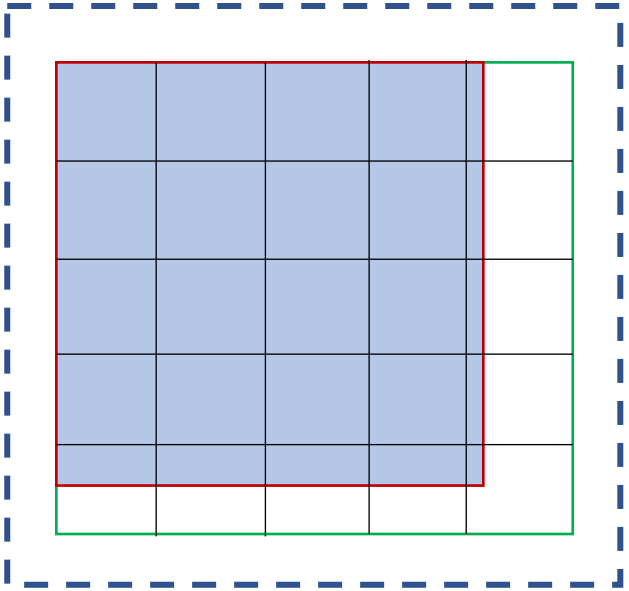
Two Tests: Compression Quality, Compression Ratio



2 Image Preprocessing and Quantization

1. **luminance and chrominance signal extraction**
2. **Splitting padded matrix into 8x8 blocks**
3. **Quantization**

YUV



Padding and Splitting

3 Image Compression based on DCT

3.1 Principles

Algorithms

The image spatial signal can be represented by the trigonometric signal, and DCT can distinguish the high energy signals from the lower ones and concentrate them in the upper left corner.

Compression：$\mathrm{F}(u,v) = DCT\big(f(x,y)\big)$, $F_q(u,v) = round\left(\frac{f(u,v)}{Q}\right)$

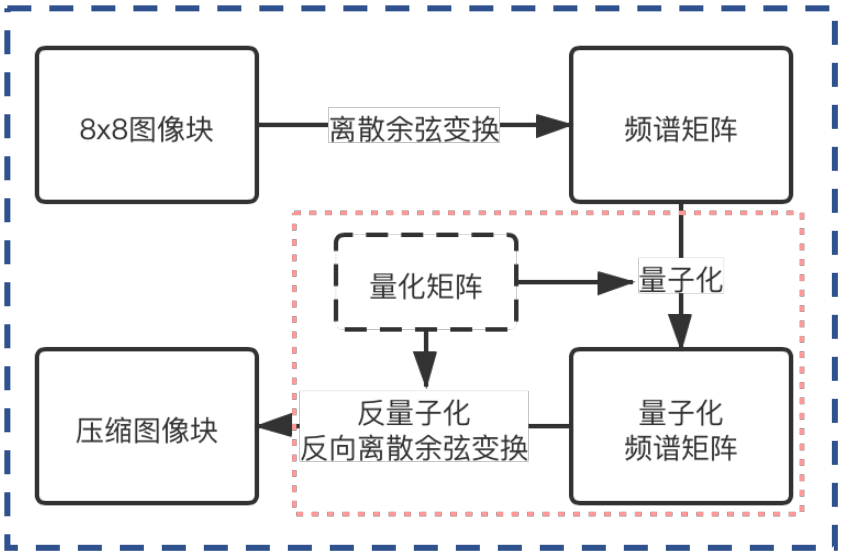
Decompression：$f_q(x,y) = DCT_{revert}(F_q(u,v) * Q)$

$F(u,v)$：Original Frequency Domain

$F_q(u,v)$：Compressed Frequency Domain

$f(x,y)$：Original Space Domain

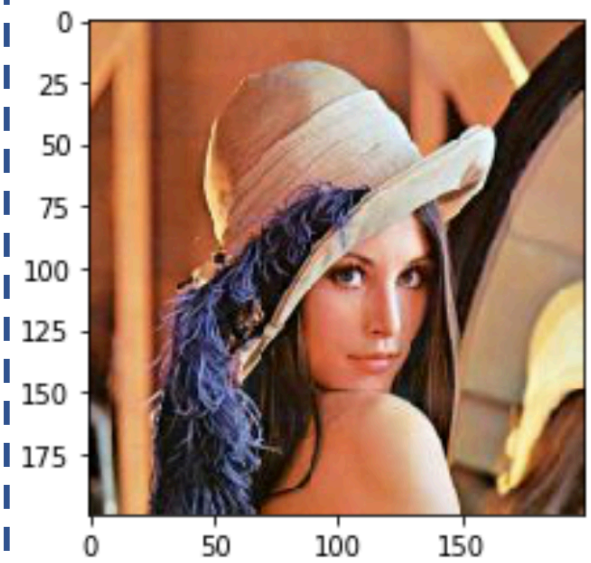
$f_q(x,y)$：Compressed Frequency Domain



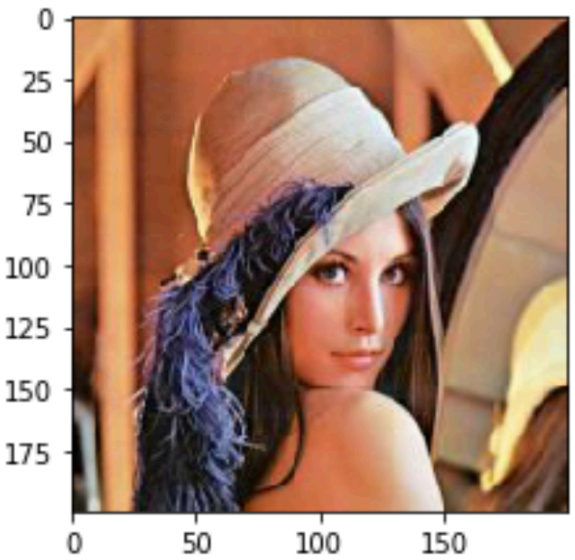
3 Image Compression based on DCT

3.2 Compression Quality Evaluation After Quantization

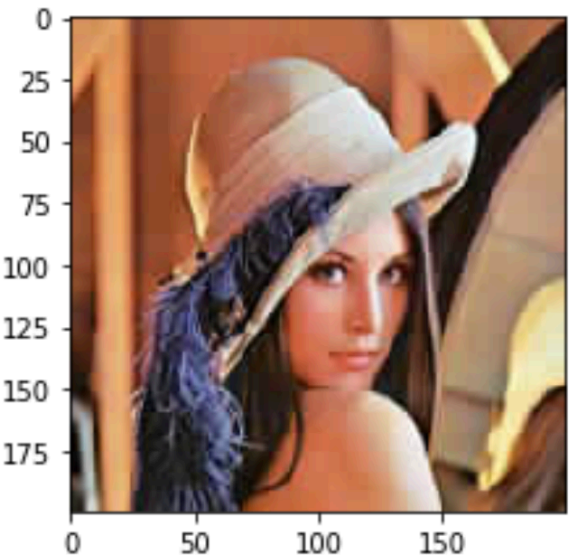
Subjective



Original



Canon-Digital-Fine[1]



Tutorial-Slide-42[2]

Objective

	MSE	RMSE	SNR	RSNR
Lena – High	7.534	2.745	33.859 dB	16.929 dB
Lena – Normal	88.629	9.414	23.105 dB	11.533 dB

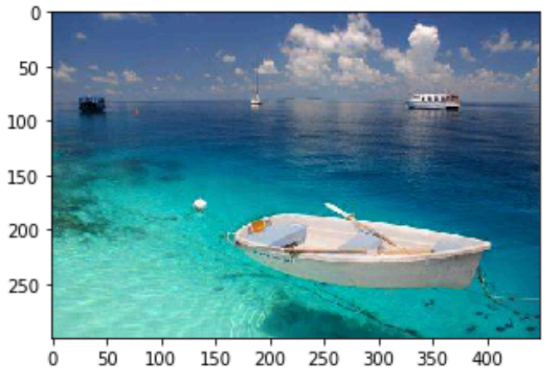
1 https://www.impulseadventure.com/photo/jpeg-quantization.html

2 《图像处理与模式识别》课件：《图像编码》P42

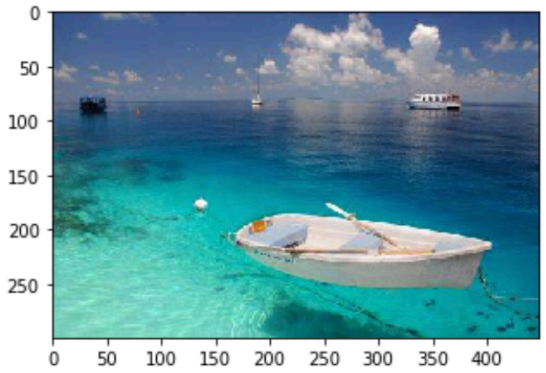
3 Image Compression based on DCT

3.2 Compression Quality Evaluation After Quantization

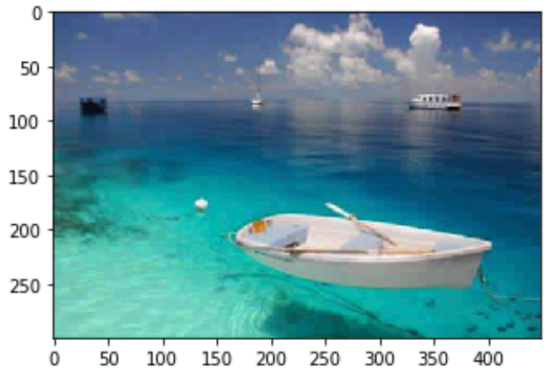
Subjective



Original



Canon-Digital-Fine[1]



Tutorial-Slide-42[2]

Objective

	MSE	RMSE	SNR	RSNR
Water – High	3.903	1.976	36.479 Db	18.240 Db
Water – Normal	57.346	7.572	24.767 Db	12.383 Db

1 https://www.impulseadventure.com/photo/jpeg-quantization.html

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4 Entropy Encoding

4.1 Why Need Compression and Introductions

Why： The quantized compressed spectrum matrix is stored in the shortest possible binary string.

Algorithms：Image Encoding（DPCM、RLC）、General Data Encoing（VLI、Huffman）

DPCM（DC）

1. Lage DC Values.
2. Small Difference Between DC Values → Differential coding technique

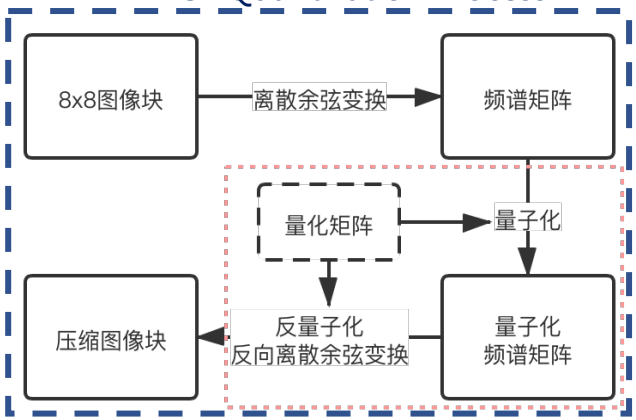
RLC（AC）

Many Zeros in AC Values

↓

Zig-Zag
（Strengthen Continuity of Zeros）→ For each non-zero number:
<Num of Pre Zero， Non-Zero Values>
* ”Num of Pre Zero” up to 15, or split
** <0, 0> indicats all zeros until to the end。

DCT Quantization Process



Distributions of DC and AC signals

DC AC

207	−25	2	−4	−2	0	0	0
−23	−13	−5	−1	1	0	0	0
−2	−7	−10	−2	1	0	0	0
6	−3	−6	2	0	0	0	0
−2	1	−1	−1	0	0	0	0
−4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

4 Entropy Encoding

4.2 Image Encoding Algorithms and General Data Encoding Algorithms

Examples of DPCM and RLC encoding

Decimal Format - [DC, AC1, AC2, AC3, ...]

[294, (0, 7), (0, 10), (0, 6), (0, 4), (2, -2), (5, -2), (0, 0)]

Binary Format

0000000100100110 0000.000000000000111
0000.000000000001010 0000.000000000000110
0000.000000000000100 0010.100000000000010
0101.100000000000010 0000.000000000000000

$$F(u,v)=\frac{1}{4}C(u)C(v)\left[\sum_{x=0}^{7}\sum_{y=0}^{7}f(x,y)\cos\frac{(2x+1)u\pi}{16}\cos\frac{(2y+1)v\pi}{16}\right]$$

$$F(u,v)\in[-2^{13},2^{13}]$$

```
[[294   7   0   0   0   0   0   0]
 [ 10   4  -2  -2   0   0   0   0]
 [  6   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]
 [  0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0]]
```

Frequency Matrix

DC：<DC Diff> - <16 bits>　　**AC**：<Num of Pre Zero，AC Non Zero> - <4bits, 16bits>

Option 1 VLI Encoding　16 bits → (Predefined Encoding Table) → 4 bits + binary string

DC：<16 bits> -> <4bits, binary string >　　AC：<4bits, 16bits> -> <4bits, 4bits, binary string>

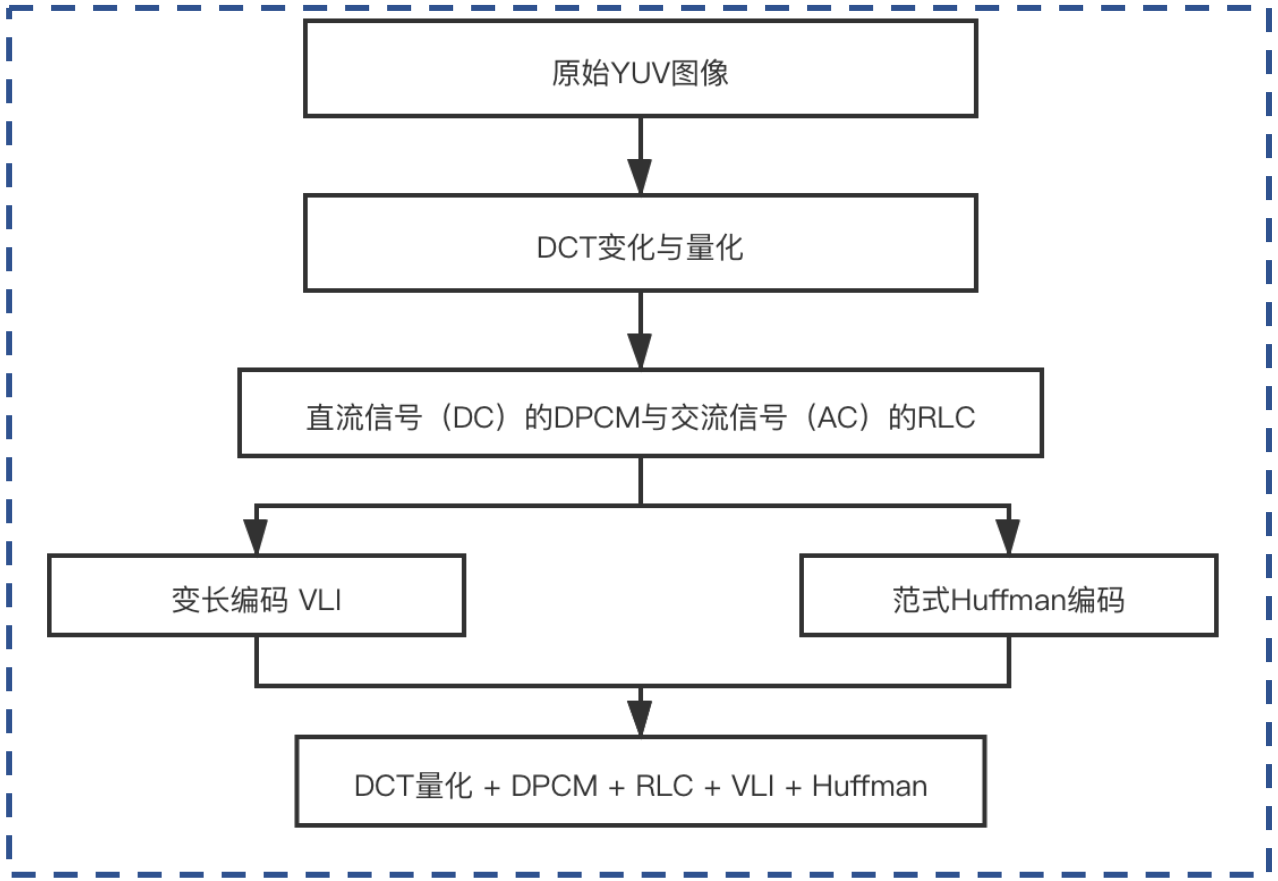
Option 2 Canonical Huffman　16 bits → (Probability Encoding Table) → binary string

DC：<16 bits> -> <binary string>　　AC：<4bits, 16bits> -> <binary string, binary string>

Option VLI Encoding+ Canonical Huffman，turn <4bits> in option 1 to varied binary string with option2

4 Entropy Encoding

4.3 Entropy Encoding Compression Evaluation



Experiment Process

Encoding Algorithms for Images

Encoding Algorithms for General Data

Algorithms Ensemble

4 Entropy Encoding

4.3 Entropy Encoding Compression Evaluation

Experiment

Environment： Python 3.7 (numpy)

Source Image： Lena， 200 x 200。

Quantization Matrix： Canon Digital Fine[1], Slide 42[2] 。

High Quality

	Size KB	Ratio
BMP - Original	117.188	1
DCT + DPCM + RLC	43.843	2.673
DCT + DPCM + RLC + Huffman	23.706	4.491
DCT + DPCM (VLI) + RLC (VLI)	19.227	6.095
DCT + DPCM (VLI) + RLC (VLI) + Huffman	17.965	6.623

Normal Quality

	Size KB	Ratio
BMP - Original	117.188	1
DCT + DPCM + RLC	23.357	5.017
DCT + DPCM + RLC + Huffman	10.919	10.733
DCT + DPCM (VLI) + RLC (VLI)	7.311	16.029
DCT + DPCM (VLI) + RLC (VLI) + Huffman	7.069	16.578

1 https://www.impulseadventure.com/photo/jpeg-quantization.html

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Thanks For Listening

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