
Generalized quantization, Epsilon-entropy
“Lossless” and “Lossy” coding.

Coding-decoding quality estimation: collective user vs expert user in biomedical applications


Discretization; variety of bases. Global and block-wise transforms.

Shift bases: decorrelation by prediction,

\[ \Delta_k = x_k - \bar{x}_k; \quad \bar{x}_k = \sum_{n=1}^{N} g_n a_{k,n} ; \quad \{g_n\} = \text{arg min} \left[ \text{MathExp} \left( |\Delta_k|^2 \right) \right] \]

For \( N=1 \): \( g_1 = \text{MathExp} (a_k \cdot a_{k-1}) / \text{MathExp} (a_{k-1}) \)

Predictive coding methods: Delta-modulation, DPCM, multi-resolution, sub-band decomposition and wavelet coding.


Hybrid bases in video coding; movement prediction

Element-wise quantization:
- uniform and non-uniform;
- homogeneous and inhomogeneous
- zonal, adaptive,

Combined discretization-quantization procedures:
- Vector quantization
- Adaptive discretization;
- DPCM with feedback; DPCM with feedback and adaptive quantization;

Statistical coding:
- Shannon-Fano-Haffmen coding;
- Coding of coordinates of sparse symbols,
- Run length coding;
- Coding with tracing contours.

Coding color and stereoscopic images. Video coding.

Additional literature on image coding:

Problems
1. Explain general quantization and basic principles of signal coding.
2. Explain principles of the design of DPCM coding; DPCM with feedback.
3. Formulate principles and give examples of transform coding methods.
4. Describe statistical coding methods you know.

Home work: For an ECG test signal (ecg1024.mat), compute optimal weight coefficient for 1-D predictive coding
Classification of digital data compression methods

Linear transforms

- Predictive transforms:
  - Recursive
  - Multiresolution (image pyramid) decomposition and sub-sampling

Orthogonal Transforms

- Frame-wise:
  - DFT
  - DCT
  - Walsh
  - Haar
- Block-wise:
  - DCT

Element-wise quantization:

- Nonuniform homogeneous
  - Zonal
  - Adaptive

Binary statistical coding

- Zig-zag scanning 2-D data
- Variable length coding
- “Rare” symbol coding (Run length coding; coding coordinate of rare symbols)

Hybrid “predictive” and orthogonal transforms

Combined decorrelation/quantization:

- DPCM with feedback
- LZW coding
- Adaptive discretization
- Vector quantization

Coded binary stream
DPCM coding flow chart

Input signal → ⊕ → Nonuniform quantizer → Statistical encoder → Compressed coded signal

Predictor → ⊕

DPCM decoding flow chart

Compressed signal → Statistical decoder → ⊕ → Decompressed signal → +

Predictor → ⊕

Flow chart of

DPCM with feedback coding
Input image: mean=182.8241, stdev=37.4671

Horizontal differences:
mean=0.333927, stdev=8.0463

Vertical differences:
mean=0.417656, stdev=8.93394

2-D prediction error:
mean=0.525653, stdev=7.54791
dpcm2D.m: Input image; stdnoise=0
Output image, mxm=50; BPP=2.5 P=0.3
Coding/decoding error, STDerr=6.7234

Dpcm2D.m: Input image; stdnoise=0
Output image, mxm=25; BPP=1 P=0.3
Coding/decoding error, STDerr=15.9943

dpcm2D.m: Input image; stdnoise=20
Output image, mxm=50; BPP=2.5 P=0.3
Coding/decoding error, STDerr=21.2588

dpcm2D.m: Input image; stdnoise=0
Output image, mxm=55; BPP=2 P=0.3
Coding/decoding error, STDerr=11.3159
The principle of signal coding by sub-band decomposition

Unit that performs signal low pass filtering and 2-fold decimation of signal samples

Unit that performs signal 2-fold zooming and interpolation

The principle of signal coding by sub-band decomposition
Image multi-resolution pyramid
Table of zonal quantization "DCT16"

Bit allocation table for DCT 16x16 block coding

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B/W images:

- Image is subdivided into 8x8 blocks; DC component is subtracted.
- 2-D DCT of each block is computed.
- The DCT coefficients are threshold coded using a quantization matrix and then reordered into 1-D sequence using zigzag scanning.
- The nonzero AC quantized coefficients are Huffman coded; zero coefficients are run length coded.
- DC coefficient of each block is DPCM coded relative to the DCT coefficient of the previous block.

Color images:

- R-G-B components are transformed into Luminance-chrominance space Y-Ch-Cb:
  \[
  Y = 0.3R + 0.6G + 0.1B \\
  Cr = \frac{B - Y}{2} + 0.5 \\
  Cb = \frac{R - Y}{1.6} + 0.5
  \]

- Chrominance channels are subsampled by 2 in both directions.
- Obtained Y Cr and Cb components are JPEG coded individually.
<table>
<thead>
<tr>
<th>DCT image coding: Input image</th>
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</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Input Image" /></td>
<td><img src="image2.png" alt="Input Image" /></td>
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</table>

<table>
<thead>
<tr>
<th>Restored image, SzW=8; SzMask=5; Q=4; P=0.2</th>
<th>Restored image, SzW=8; SzMask=5; Q=8; P=0.2</th>
<th>Restored image, SzW=8; SzMask=5; Q=4; P=0.2</th>
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<tr>
<td><img src="image3.png" alt="Restored Image 1" /></td>
<td><img src="image4.png" alt="Restored Image 2" /></td>
<td><img src="image5.png" alt="Restored Image 3" /></td>
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<tr>
<th>Restoration error; std=10.5965; BPP=0.7</th>
<th>Restoration error; std=2.5088; BPP=0.94</th>
<th>Restoration error; std=5.0654; BPP=0.7</th>
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<tbody>
<tr>
<td><img src="image6.png" alt="Restoration Error 1" /></td>
<td><img src="image7.png" alt="Restoration Error 2" /></td>
<td><img src="image8.png" alt="Restoration Error 3" /></td>
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