The Spatial Relationship of DCT Coefficients Between a Block and Its Sub-blocks

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Introduction

• Popular digital images and videos
  – JPEG 、BMP
  – MPEG-1 2 4 7 、RMVB 、AVI

• Transferred in compressed format
  – discrete cosine transform (DCT)
Introduction

- MPEG (JPEG) Encode Flow

Spatial Domain

Frequency Domain

DCT

for each 8x8 block

量化

zigzag 排序

Huffman 011010...

Y

Cr

Cb

畫面(frame)

DPCM

DC

RLE

AC
Introduction

• DCT coefficients of block
  – directly obtained from its sub-blocks

• Corresponding coefficient matrix
  – linear combination

• Proposed algorithms ↔ existing methods.
  – computational complexity
  – significantly lower
Related work

- Abdel-Malek et al. 1996
  - detect oriented line features
  - variance of sliding window

- Shen et al. 1998
  - strength and orientation of edges
  - 20 times faster
Related work

• J. R. Hernandez et al. 2000
  – Watermarking
  – Gaussian distribution statistically model
  – Allows examination
Problem Formulation

- **Block of pixels B**
  - L*N rows
  - M*N columns

- **L*M Sub-blocks**
  - SB_{ij} size of N*N
    \[ i = 0, 1, \ldots, L - 1 \]
    \[ j = 0, 1, \ldots, M - 1 \]

Fig. 1. Schematic illustration of the problem to be solved.
Case of 1-D Signals

\[ C(u) = \sqrt{\frac{2}{MN}} \alpha(u) \sum_{i=0}^{MN-1} x(i) \cos \left( \frac{(2i + 1)u\pi}{2MN} \right) \]

\( (u = 0, 1, \ldots, MN - 1) \) (1)

and

\[ C_P(u) = DCT(T_P) \]

\[ = \sqrt{\frac{2}{N}} \alpha(u) \sum_{i=0}^{N-1} x(pN + i) \cos \left( \frac{(2i + 1)u\pi}{2N} \right) \]

\( (p = 0, \ldots, M - 1, u = 0, \ldots, N - 1) \) (2)

where \( T_P = x(pN + i) \), and

\[ \alpha(u) = \begin{cases} \sqrt{\frac{1}{2}}, & \text{for } u = 0 \\ 1, & \text{otherwise.} \end{cases} \]
Case of 1-D Signals

- block\([16*16]\) → sub-block\(4*[8*8]\)
Case of 2-D Signals

\[ C_B(u, v) = \sqrt{\frac{4}{L^N \cdot M^N}} \alpha(u) \alpha(v) \sum_{i=0}^{L^N-1} \sum_{j=0}^{M^N-1} x(i, j) \]

\[ \cdot \cos \left( \frac{(2i + 1)u\pi}{2LN} \right) \cos \left( \frac{(2j + 1)v\pi}{2MN} \right) \]

\[ = \sqrt{\frac{2}{M^N}} \alpha(v) \sum_{j=0}^{M^N-1} \left( \sqrt{\frac{2}{L^N}} \alpha(u) \sum_{i=0}^{L^N-1} x(i, j) \cos \left( \frac{(2i + 1)u\pi}{2LN} \right) \right) \]

\[ \cdot \cos \left( \frac{(2j + 1)v\pi}{2MN} \right). \]
Case of 2-D Signals

• block[16*16] → sub-block4*[8*8]
Experimental results
Experimental results

One block size of $8 \times 8$ to four sub-blocks size of $4 \times 4$

- proposed algorithm
  - 80 additions and 44 multiplications

- traditional algorithm
  - 96 additions and 128 multiplications
Conclusions

- Reducing the computing cost
- Improving the processing speed
- Extending from 1-D signals to 2-D signals
- Decomposing a block into sub-blocks directly in the DCT domain
~~The End~~

Thank you