A Joint JPEG2000 Compression and Watermarking System using a TCQ-based Quantization Scheme

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Outline

• Few words about watermarking & compression
• The proposed joint JPEG2000 compression & watermarking scheme
• Experimental evaluations
• Conclusions
A Joint JPEG2000 Compression & Watermarking System using a TCQ-based Quantization Scheme
Definitions of watermarking
basic design of a system

Original work

Watermark embedder

Message (regarding work)

Watermark key

Watermarked work (looks like original)

Attacks

Attacked watermarked work

Watermark extractor

Watermark key

Extracted message

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Watermarking & Compression

Watermarking encoder → Marked image → Compression → Compressed/marked bitstream

Extracted watermark → Watermarking decoder → Decompressed/marked image → Decompression

Degradation of the watermark & less robustness

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A Joint JPEG2000 Compression & Watermarking System using a TCQ-based Quantization Scheme
The proposed joint JPEG2000 compression and watermarking scheme
The joint JPEG2000 encoder/watermark embedding scheme.
Partitioning of a scalar quantizer into 4 subsets combined to form 2 union quantizers:

\[ A_0 = D_0 \cup D_2 \quad \& \quad A_1 = D_1 \cup D_3 \]
The TCQ quantization used in the proposed joint scheme

- Use of shifted TCQ quantizers
- 2 groups of union quantizers:
  - **Group 0**: The bit to be embedded is 0
    \[ A_0^0 = D_0^0 \cup D_2^0, A_1^0 = D_1^0 \cup D_3^0 \]
  - **Group 1**: The bit to be embedded is 1
    \[ A_0^1 = D_0^1 \cup D_2^1, A_1^1 = D_1^1 \cup D_3^1 \]
- Modification of the trellis structure
Watermarking strategy

The TCQ quantization used in the proposed joint scheme

- Modification of the trellis structure

Labeling with the trellis used in JPEG2000

Labeling with the modified trellis used in our joint scheme
Watermarking strategy

• Modification of the trellis structure
Watermarking strategy

The message is embedded by choosing between two TCQ quantizers from the 2 groups of union quantizers at each transition in the trellis.
The proposed joint JPEG2000 compression and watermarking scheme

Quantization and watermark embedding

Step 1: Generation of the group 0 and group 1 shifted TCQ quantizers

Step 2: Trellis pruning

Step 3: TCQ quantization Viterbi Algorithm
The proposed joint JPEG2000 compression and watermarking scheme

Quantization and watermark embedding

- **Step 1**: Generation of the group 0 and group 1 shifted TCQ quantizers
- **Step 2**: Trellis pruning
- **Step 3**: TCQ quantization Viterbi Algorithm

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Step 1

Trellis construction with branch labelling

0  \( D_0^0 / D_0^1 \)
\( D_2^0 / D_2^1 \)

1  \( D_2^0 / D_2^1 \)
\( D_0^0 / D_0^1 \)

2  \( D_2^0 / D_2^1 \)
\( D_0^0 / D_0^1 \)

3  \( D_2^0 / D_2^1 \)
\( D_0^0 / D_0^1 \)

4  \( D_2^0 / D_2^1 \)
\( D_0^0 / D_0^1 \)

5  \( D_2^0 / D_2^1 \)
\( D_0^0 / D_0^1 \)

6  \( D_2^0 / D_2^1 \)
\( D_3^0 / D_3^1 \)

7  \( D_2^0 / D_2^1 \)
\( D_3^0 / D_3^1 \)
Quantization and watermark embedding

Step 1: Generation of the group 0 and group 1 shifted TCQ quantizers

Step 2: Trellis pruning

Step 3: TCQ quantization Viterbi Algorithm

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Step 2

Trellis pruning

\[ m = \{ 1, 0, 1 \} \]
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Quantization and watermark embedding

Step 1: Generation of the group 0 and group 1 shifted TCQ quantizers

Step 2: Trellis pruning

Step 3: TCQ quantization Viterbi Algorithm

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Viterbi Algorithm

\[ m = \{1, 0, 1\} \]
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Watermark extraction

During JPEG2000 decompression
- Dequantization by using the simplified trellis

After JPEG2000 decompression
- Discrete Wavelet Transform (DWT)
- Viterbi Algorithm applied onto the whole trellis

JPEG2000 bitstream
Decompressed/marked image
Experimental evaluations
Evaluation protocol 1:

- 4 test images of size 512 x 512
- 5 levels of wavelet decomposition, one tile, no ROI coding
- Variation of the bitrate from 2.5 bpp to 0.2 bpp
- Payload = 1 bit (message) for 16 pixels
  - 1024 bits embedded in the HL sub-band of the second resolution level
Experimental evaluations

Visual quality performances under various compression bitrates

Bike image

Lena image

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Experimental evaluations

Evaluation protocol 2:

• 200 images of size 512 x 512
• Robustness of the watermark: 4 attacks
  – Gaussian filtering
  – Gaussian noise
  – Valumetric scaling
  – JPEG attack
Gaussian filtering attack

Gaussian noise attack

Attacks (1)
Experimental evaluations

Attacks (2)

Valumetric scaling attack

JPEG attack

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Conclusions & Discussion
Conclusions & Discussion

• Quantization & watermarking at the same time
• 2 types of watermark extraction
• Good compression performances
• Robust to JPEG2000 compression at low bitrates
• Robustness to attacks: depends on the value of $\Delta_{TCQ}$

• Prospects:
  – Sensitivity to volumetric & jpeg attacks
  – Integration of Turbo TCQ
  – Consider ROI processing and progressive transmission functionnality
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Annexes
Trellis structure of the joint scheme

Group 0: $A^0_0$ & $A^0_1$

$$\hat{x}[i] = Q_{D_j}^0 (x[i] - d[0, i]) + d[0, i]$$

Group 1: $A^1_0$ & $A^1_1$

$$\hat{x}[i] = Q_{D_j}^1 (x[i] - d[1, i]) + d[1, i], \quad |d[1, i] - d[0, i]| = \Delta/2$$
The message is embedded by choosing between two TCQ quantizers from the 2 groups of union quantizers at each transition in the trellis.