HYPER-CUBE WATERMARKING SCHEME

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OUTLINE

- Few words about high rate watermarking schemes
- The P-QIM algorithm [Li and Cox 2007]
- Improvements: Framework + Quality Improvement + ECC integration + Proof integration inside JPEG/H.264
- Experimental evaluations
- Conclusion
Few words about high rate watermarking schemes
HIGH RATE WATERMARKING SCHEMES

- General watermarking scheme

message ➔ EMBEDING ➔ marked ➔ channel ➔ attacked ➔ EXTRACTION ➔ message

host

attack
HIGH RATE WATERMARKING SCHEMES

- **Quantized-based:**
  - DC-QIM, SCS, RDM, Perceptual-QIM...

- **Trellis-based:**
  - DPTC

- **Mix of Quantized-based and Trellis-based:**
  - T-TCQ

⇒ payload ≈ 1 bit embedded for 64 pixels
  (image $256 \times 256 \Rightarrow 1024$ bits embedded)
P-QIM algorithm
[Li and Cox 2007]
P-QIM interesting points

P-QIM [Li and Cox 2007]:

- Quantized based use of QIM [Chen and Wornell 2001]
- Robustness to valumetric attack use of RDM principle [Perez-Gonzalez et al. 2004]
- Psychovisual masking use of a modified Watson Model [Watson 1993]

→ A MATURE QUANTIZED BASED APPROACH

OUR PROPOSITION:

- There is not a clear Framework:
  - There is lots of incremental and experimental tests
  - Correcting codes are not enough evoked
  → **Give a clear and generic Framework**

- Non classical payload (2 bits in 64 pixels)
  → **Use a more realist payload**
  and draw comparisons with known approaches

- Possible block artifacts
  → **Suppress some block artifacts**

- Proof of integration inside JPEG/H.264

IMPROVEMENTS: FRAMEWORK + QUALITY IMPROVEMENT + ECC INTEGRATION + PROOF INTEGRATION INSIDE JPEG/H.264
Hyper-Cube Watermarking:

\begin{align*}
Q_0(x[i], \Delta_i) &= 2\Delta_i \times \text{round} \left( \frac{x[i]}{2\Delta_i} \right), \\
Q_1(x[i], \Delta_i) &= 2\Delta_i \times \text{round} \left( \frac{x[i] - \Delta_i}{2\Delta_i} \right) + \Delta_i.
\end{align*}
HYPER-CUBE WATERMARKING:
→ PSYCHOVISUAL IMPROVEMENT

P-QIM, SSIM=98%
payload = 1/64

Hyper-Cube, SSIM=98%
payload = 1/64
Hyper-Cube Watermarking: → Psychovisual Improvement

P-QIM

Hyper-Cube
HYPER-CUBE WATERMARKING:

→ PSYCHOVISUAL IMPROVEMENT

\[ \Delta_i = G_{PQIM} \times s(x, i), \]
\[ s(x, i) = \max(t_L^M[i], |x|^0.7 t_L^M[i]^{0.3}), \]
\[ t_L^M[i] = t[i] \left( \frac{C[0]}{C_0} \right)^{0.649} \left( \frac{C_0}{128} \right), \]

Hyper-Cube Watermarking: \(\rightarrow\) Psychovisual Improvement

- Slacks computed on a previously watermarked block B (top) or D (left) for current block X

```
A  B  C
D  X
```

- Selection of the spatially closest block B or D
Hyper-Cube Watermarking: → Psychovisual Improvement

P-QIM

Hyper-Cube
Hyper-Cube Watermarking:
→ ECC Integration

Hyper-Cube Watermarking: → ECC Integration

- Convolutional Correcting code

State machine of the convolution code 1/8-rate 2-memory.
HYPER-CUBE WATERMARKING: → ECC INTEGRATION

message → **coding**
(rate = 1/n) → **interleaving**

**EMBEDING**

attacked block

8

8

DCT

source block

slacks

Δ; i ∈ [1, n]

8

8

DCT

QIM soft decoding

de-interleaving

Viterbi decoding

→ message

8

8

DCT

X

→

Y

→

Y

→

Y

→

Y

→

Y

→

Y

→

Y

→

Y

→

Y

→

Y

→

Y

→
Experimental evaluations
Evaluation & Algorithms

- 100 images 256×256
- 5 different versions are competing with a fix SSIM = 98% and a fix payload = 1/64:
  - P-QIM like approach with adapted parameters,
  - Version « + slacks JPEG », → Scheme integrable inside JPEG/H.264
  - Version « + slacks JPEG + neighborhood »,
  - Version « + ECC 1/8-rate 6-memory »,
  - Hyper-Cube (slacks JPEG + neighborhood + ECC 1/8-rate 2-memory).

- 4 attacks:
  - Gaussian noise,
  - Gaussian filtering,
  - Valumetric scaling,
  - Jpeg attack.
Attacks (1) – Fixed SSIM = 98%

Gaussian noise attack

Gaussian Filtering attack
**Attacks (2) – Fixed SSIM = 98%**

Valumetric scaling attack

Jpeg attack
CONCLUSION & DISCUSSION
CONCLUSION & DISCUSSION

- Practical framework,
- Better psychovisual results,
- Easy to improve using the framework (QIM + ECC + psychovisual models),
- Easy to integrate jointly to JPEG/H.264 (experimental proof).

Future work:
- Integration of the T-TCQ,
- Use of lattices suitable for large dimension,
- Robustness to additional attacks.
HYPER-CUBE WATERMARKING SCHEME

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