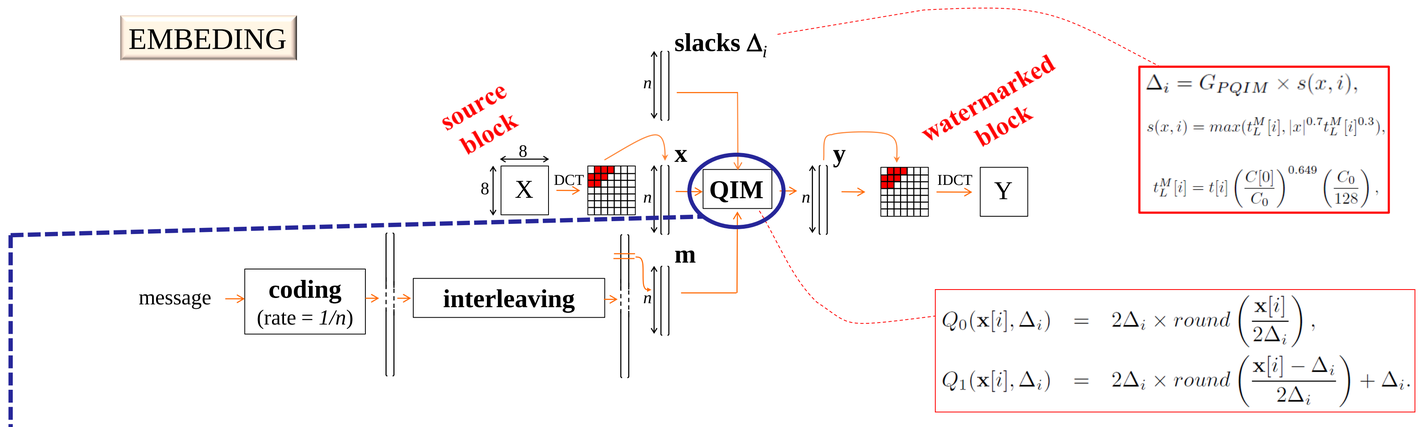
TCQ Practical Evaluation in the Hyper-Cube Watermarking Framework

Marc CHAUMONT and Dalila GOUDIA
marc.chaumont@lirmm.fr, dalila.goudia@lirmm.fr
LIRMM, UMR CNRS 5506, University of Nîmes, University of Montpellier II

The Hyper-Cube Watermarking Framework (≈P-QIM):



→ 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])

Substitution of QIM module by TCQ module:

New quantization formulas:

$$Q_0(\mathbf{x}[i], s, \Delta_i) = 2\Delta_i \times round\left(\frac{\mathbf{x}[i] - \delta}{2\Delta_i}\right) + \delta,$$

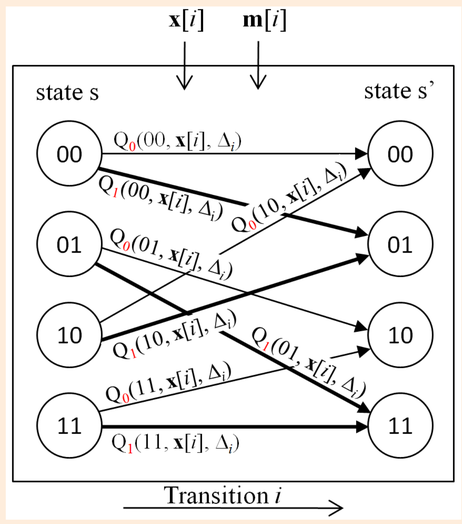
$$Q_1(\mathbf{x}[i], s, \Delta_i) = 2\Delta_i \times round\left(\frac{\mathbf{x}[i] - \Delta_i - \delta}{2\Delta_i}\right) + \Delta_i + \delta,$$

$$with\ \delta = \frac{\Delta_i \times s}{S}. \quad (1)$$

$\mathbf{x}[i]$	a host scalar value,
Δ_i	a quantization step,
$s \in \mathcal{S}$	a state,
$\mathcal{S} = \{0, 1, ..., S-1\}$	the set of states,
δ	a translation term.

Viterbi algorithm is used to find the host closest codeword (best path).

Trellis associated:



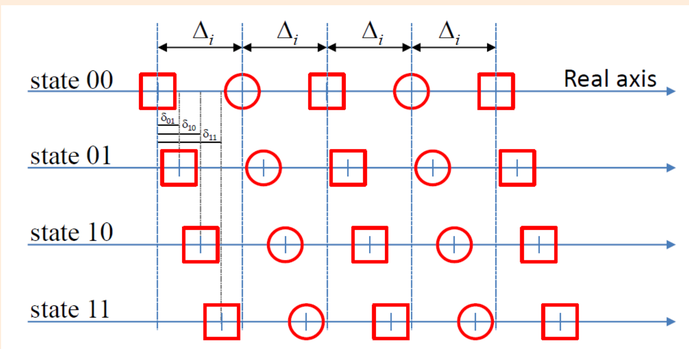


Fig. 3. Lattice illustration for a 4 states trellis. Red circles represent codewords obtained using quantizer Q_0 (Equation 1) and red squares represent codewords obtained using quantizer Q_1 (Equation 1).

Results and Conclusions:

Evaluation Protocol:

100 images 256×256 from BOWS-2 database.

Payload = 1 bit embedded in 64 pixels = 1024 bits.

Four competing algorithms (SSIM = 98%):

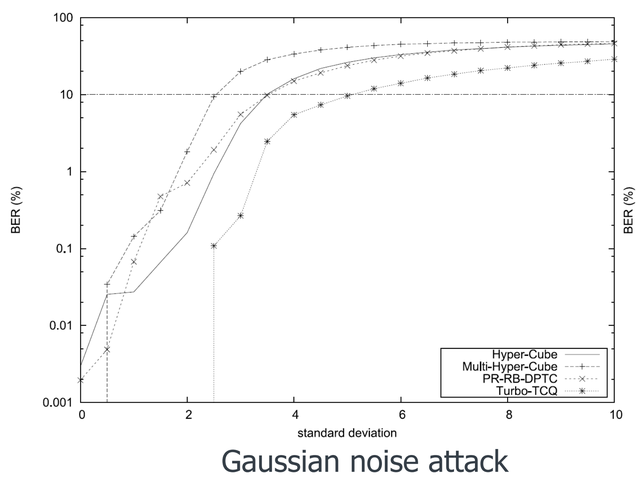
- PR-RB-DPTC (= **Fast DPTC, Treillis based**),
- Turbo-TCQ (**Quantized based + Turbo principle**),
- Hyper-Cube (**≈ P-QIM, Quantized based**),
- Multi-Hyper-Cube (**Hyper-Cube with TCQ**).

[P-QIM] *"Using Perceptual Models to Improve Fidelity and Provide Resistance to Valumetric Scaling for Quantization Index Modulation Watermarking,"* Q. Li and I. J. Cox, IEEE TIFS'2007.

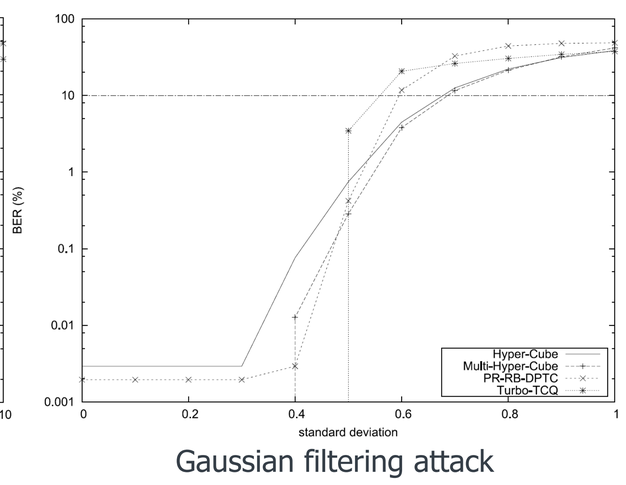
[Hyper-Cube] *"Hyper-Cube Watermarking Scheme,"* M. Chaumont, D. Goudia, and W. Puech, SPIE2011.

[Turbo-TCQ] *"Tatouage Robuste d'Images par Turbo TCQ,"* G. Le Guelvouit, Traitement du Signal 2009, http://www.gleguelv.org/wt/ttcq/.

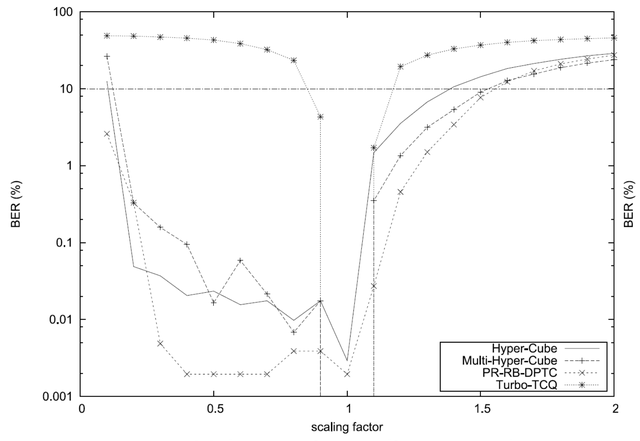
[PR-RB-DPTC] *"Psychovisual Rotation-based DPTC Watermarking Scheme,"* M. Chaumont, EUSIPCO'2009.



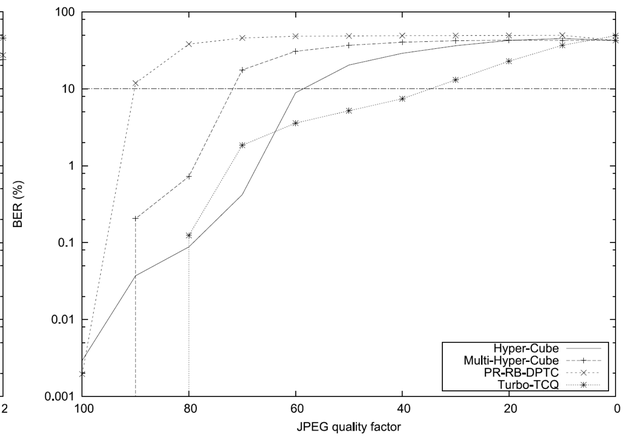
Gaussian noise attack



Gaussian filtering attack



Valumetric scaling attack



Jpeg attack

Conclusion:

- Slightly better performances (than Hyper-Cube) at low power attacks,
- React equally well to four representatives attacks, (average performance are better than PR-RB-DPTC and Turbo-TCQ).

Perspectives:

- Selection of coefficients for the embedding,
- Vectorial QIM,
- Spreading approaches,
- Better management of coders/decoders,
- Other robust psychovisual metrics.