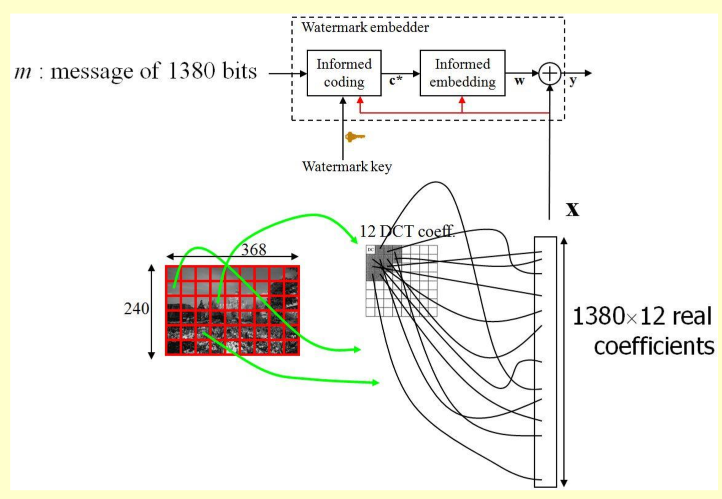
A Novel Embedding Technique for Dirty Paper Trellis Codes Watermarking

Marc CHAUMONT
marc.chaumont@lirmm.fr
LIRMM, UMR CNRS 5506, University of Nîmes, University of Montpellier II

Few words about Dirty Paper Trellis Codes (DPTC):

The original DPTC algorithm [1]:

→ Security weakness (Kerckhoffs's framework).
Code book estimable on a simplified version [2].
→ High computational complexity of the Embedding part
Lin *et al.* [3] solution is not enough satisfying in term of robustness-distortion tradeoff.
→ DCT artifacts.

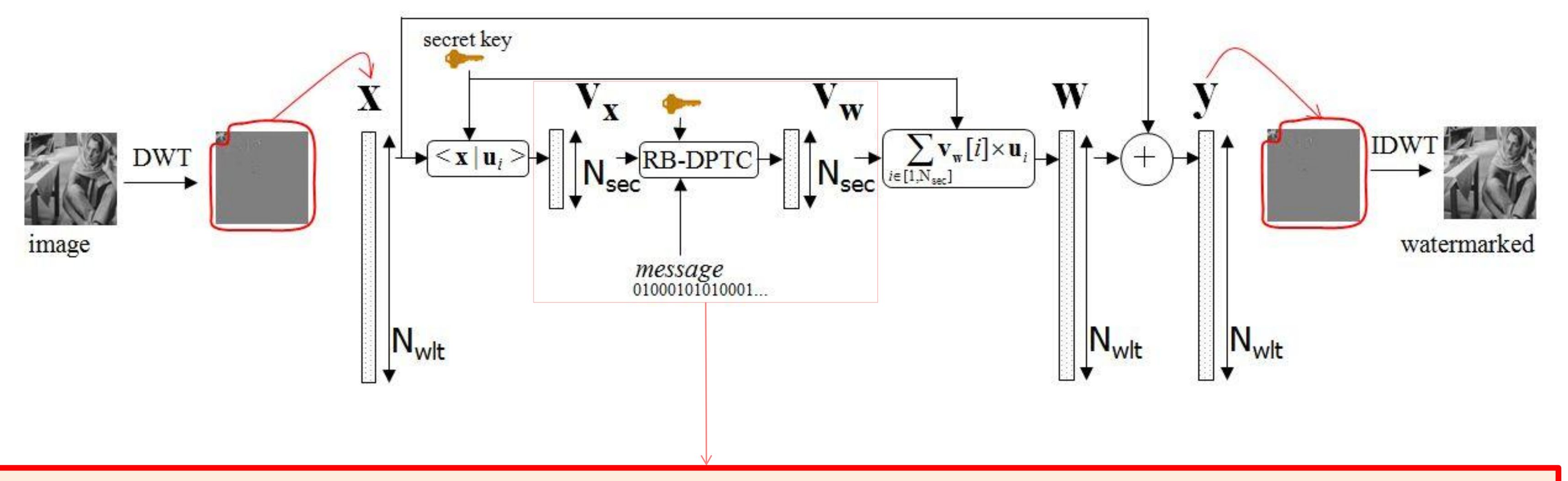


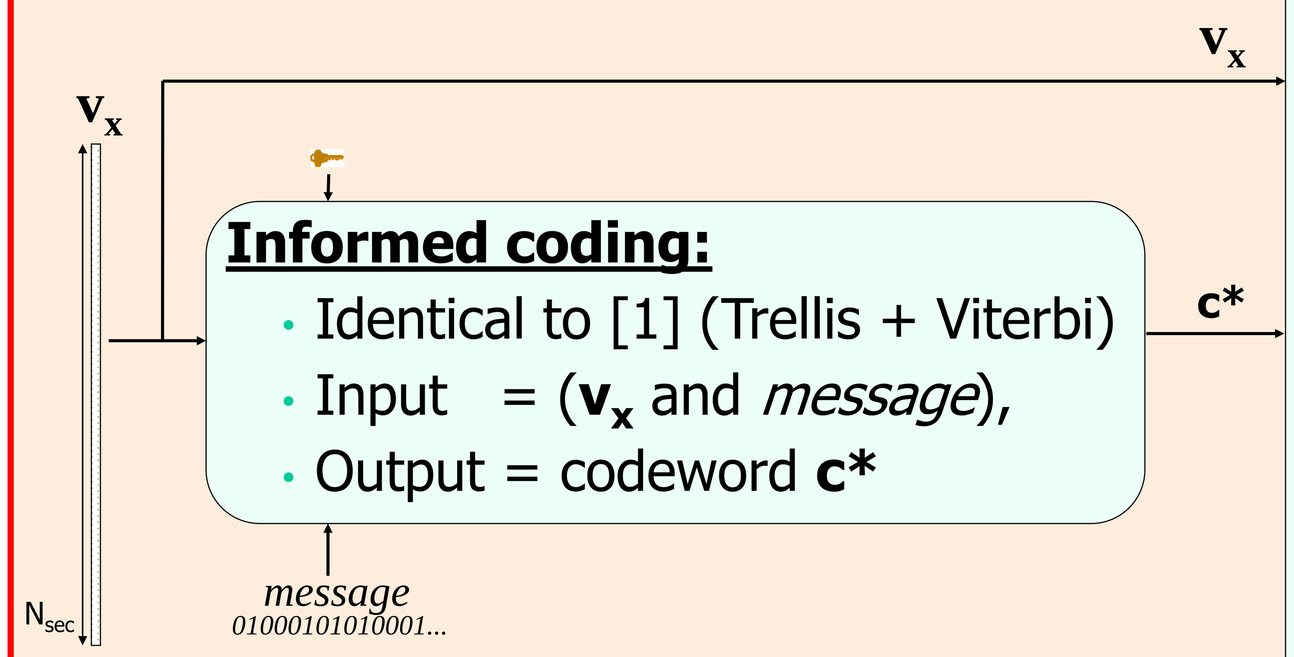
[1] "Applying Informed Coding and Informed Embedding to Design a Robust, High Capacity Watermark", Miller, Doërr, and Cox, IEEE TIP 2004.
[2] "Evaluation of an Optimal Watermark Tampering Attack Against Dirty Paper Trellis Schemes", Bas and Doërr, MM&Sec'2008.
[3] "An Efficient Algorithm for Informed Embedding of Dirty Paper Trellis Codes for Watermarking", Lin, Cox, Doërr, and Miller, ICIP'2005.
[4] "Fast Embedding Technique For Dirty Paper Trellis Watermarking", Chaumont, IWDW'2009.
[5] "Broken Arrows", Furon and Bas, EURASIP Journal on Information Security, 2008.
[6] "Psychovisual Rotation-based DPTC Watermarking Scheme", Chaumont, EUSIPCO'2009.

Rotation-based DPTC:

Our RB-DPTC algorithm:

→ Use of a secret space [4] (projection onto secret carriers as in Broken Arrows algorithm [5]).
→ Use of a fast embedding approach (rotation-based).
→ Embedding in the wavelet domain.



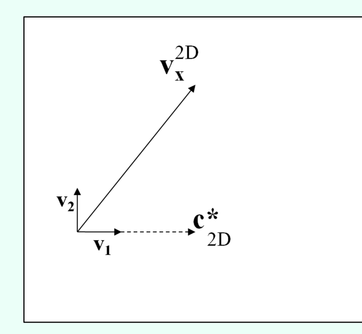
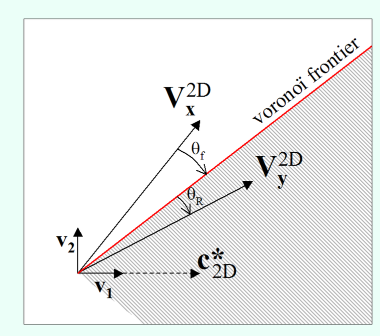


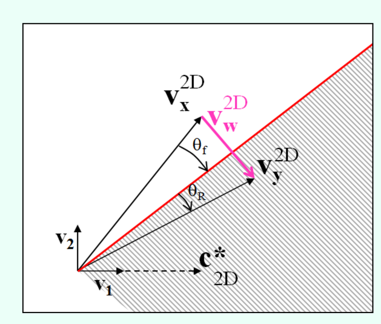
Informed coding:
- Identical to [1] (Trellis + Viterbi)
- Input = ($\mathbf{v_x}$ and *message*),
- Output = codeword **c***

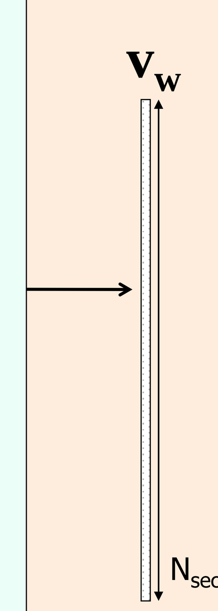
Informed embedding:

1. Compute the "**Miller, Cox, Bloom plane**" i.e. the orthonormalized base (v1, v2): $\mathbf{v_1} = \frac{\mathbf{c}^*}{||\mathbf{c}^*||}$ $\mathbf{v_2} = \frac{\mathbf{v_x} - (\mathbf{v_x}.\mathbf{v_1})\mathbf{v_1}}{||\mathbf{v_x} - (\mathbf{v_x}.\mathbf{v_1})\mathbf{v_1}||}$.
2. Obtain a **Voronoï frontier** (angle θ_f) by an iterative dichotomous approach.
3. **Rotate $\mathbf{v_x}$** in the "Miller, Cox, Bloom plane" and penetrate inside the Voronoï region of an oriented angle equals to $\max(\theta_f + \theta_R, \widehat{(\mathbf{v_x}, \mathbf{c}^*)})$.

Then $\mathbf{v_w} = \mathbf{v_y} - \mathbf{v_x}$

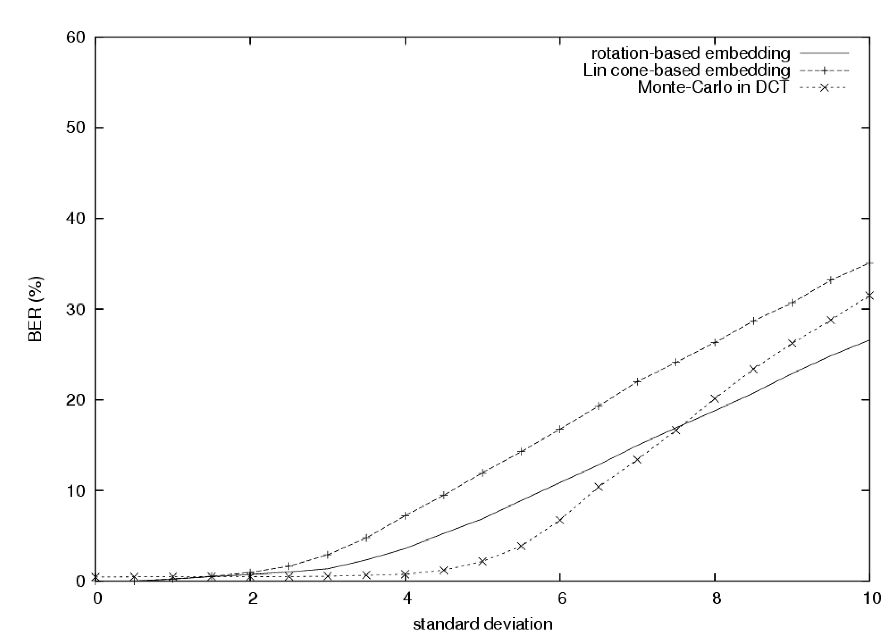




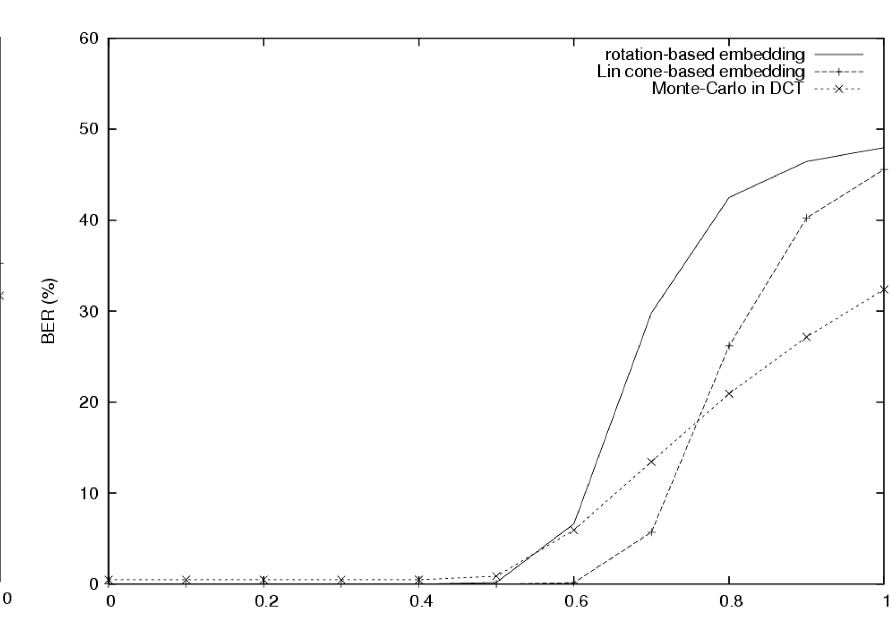
Results and Conclusions:

Evaluation Protocol:
100 images 256×256 from BOWS-2 data-base.
Payload = 1 bit embedded in 64 pixels = 1024 bits.
Trellis: Output arc labels = Gaussian distribution,
Number of labels by output arc = 12.

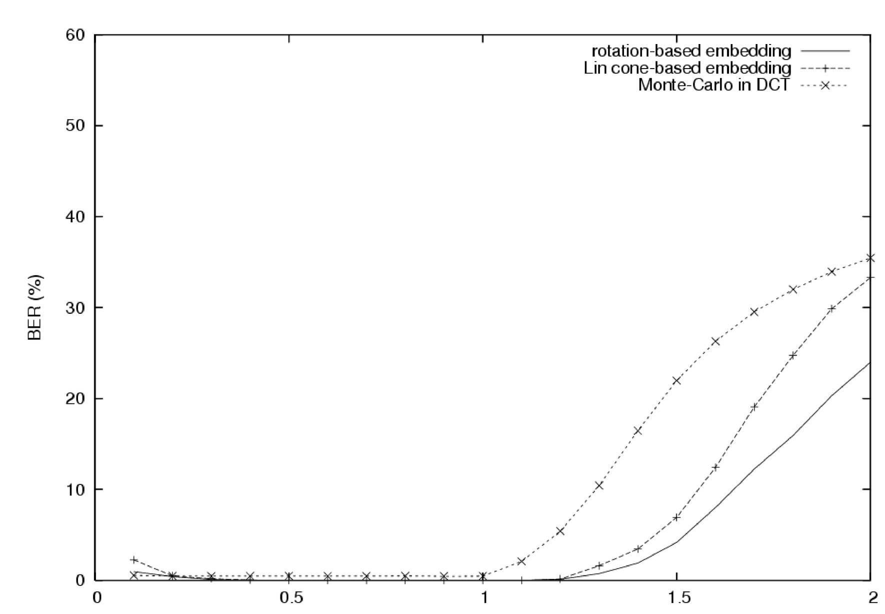
Three competing algorithms (average embedding PSNR = 42.4 dB):
- Original DPTC (**Monte-Carlo in DCT**- 64 states, 64 arcs/state),
- RB-DPTC (**rotation-based** - wavelet - 128 states, 128 arcs/state),
- ~~**Lin cone-based** (wavelet - 128 states, 128 arcs/state), average PSNR = 34.2 dB!~~



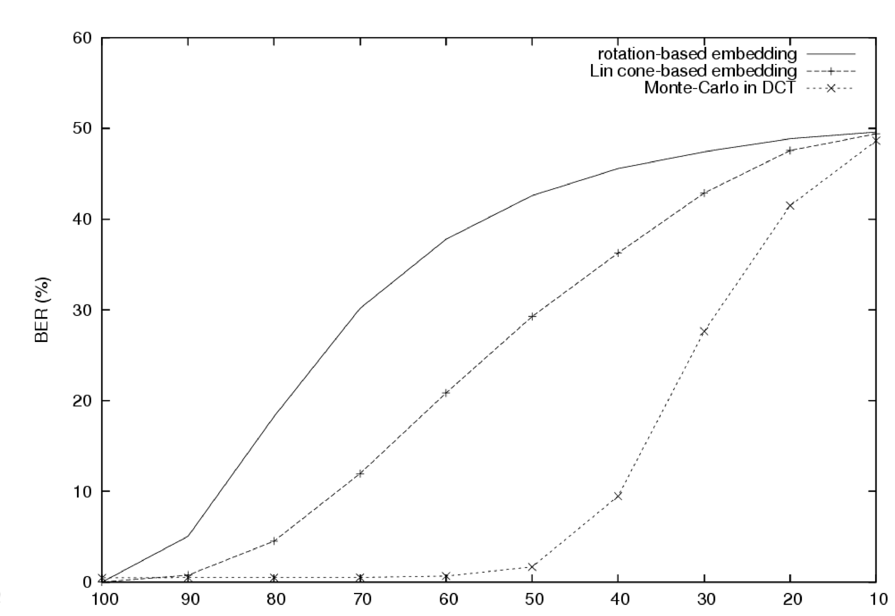
Gaussian noise attack



Gaussian filtering attack



Valumetric scaling attack



Jpeg attack

Conclusion:

- **Secret space** owning good properties
  psychovisual, channel, super-robustness;
- Good **rotation-based embedding strategy**
  - low computational complexity,
  - good robustness-distortion tradeoff,
  - as secure as the original DPTC;
- Good **performances** (except against jpeg attack)

Tackled problems:

- Computational projections complexity [4],
- Psychovisual space [6].

Open problems:

- Robustness to jpeg,
- Robustness to Westfeld regression attack,
- Security analysis,
- Relation between SSIM and penetration angle,
- Robust psychovisual mask,
- Comparison with quantized approaches, …

This investigation was supported by the VOODDO project which is a French national project of the ANR (Agence Nationale de la Recherche) "Contenu et Interaction". We would also like to thank the Languedoc-Roussillon Region.