Fast Embedding Technique for Dirty Paper Trellis 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] 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] *"A Novel Embedding Technique for Dirty Paper Trellis Watermarking", Chaumont, In submission.*
[5] *"Broken Arrows", Furon and Bas, EURASIP Journal on Information Security, 2008.*

Rotation-based DPTC [4]:

Our method : RB-DPTC [4]:

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

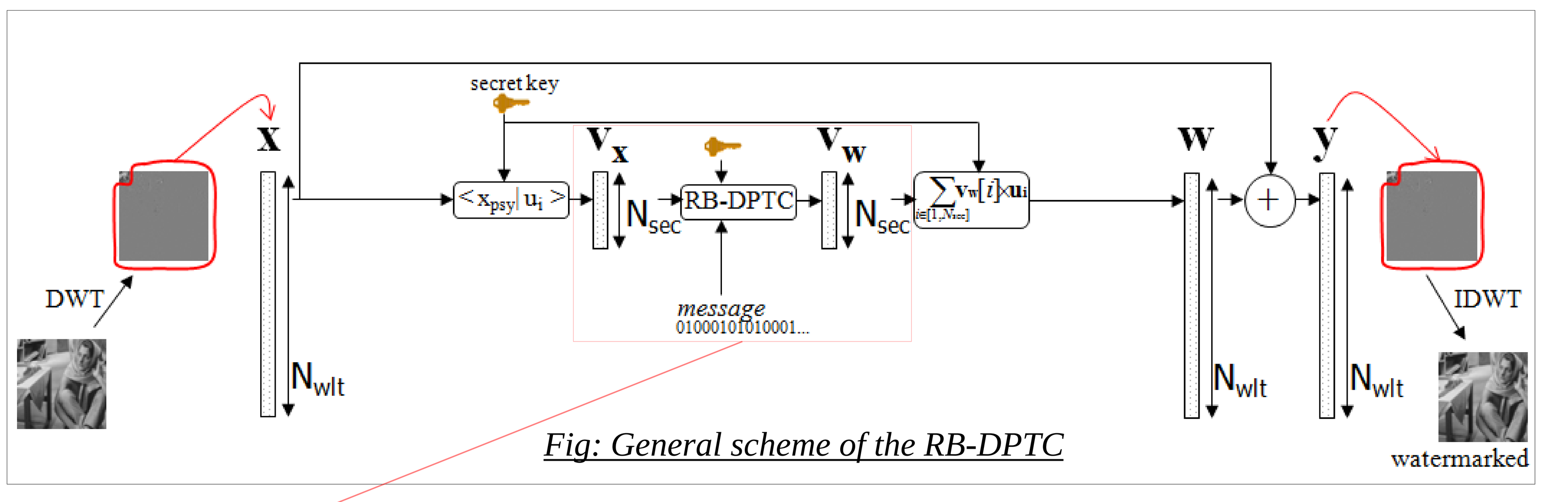


Fig: General scheme of the RB-DPTC

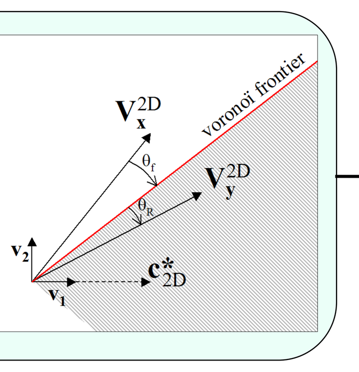
$\mathbf{v_x}$ N_{sec}

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

message
01000101010001...

$\mathbf{c^*}$

Informed embedding:
- rotate $\mathbf{v_x}$ in the "Miller, Cox, Bloom plane"
- and penetrate inside the Voronoï region
- $\mathbf{v_w} = \mathbf{v_y} - \mathbf{v_x}$



$\mathbf{v_w}$ N_{sec}

Space Division Multiplexing:

Complexity problem in [4]:

Projection onto carriers = $N_{wlt} \times N_{sec}$ multiplications (resp. sums)
= $\mathcal{O}(N^2)$ with N the image size

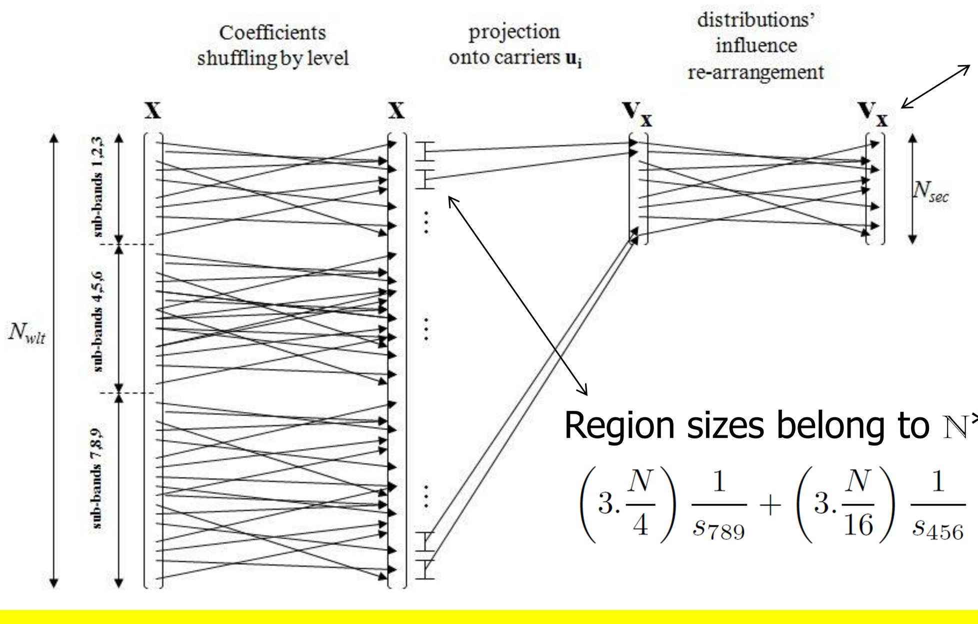
→ With a 256x256 image = 792 723 456 multiplications (resp. sums)

Space Division Multiplexing:

Projection onto carriers = $\mathcal{O}(N)$ with N the image size

divide the wavelet space into disjoint regions and use a carrier for each region

Solution 1: Structured SDM:

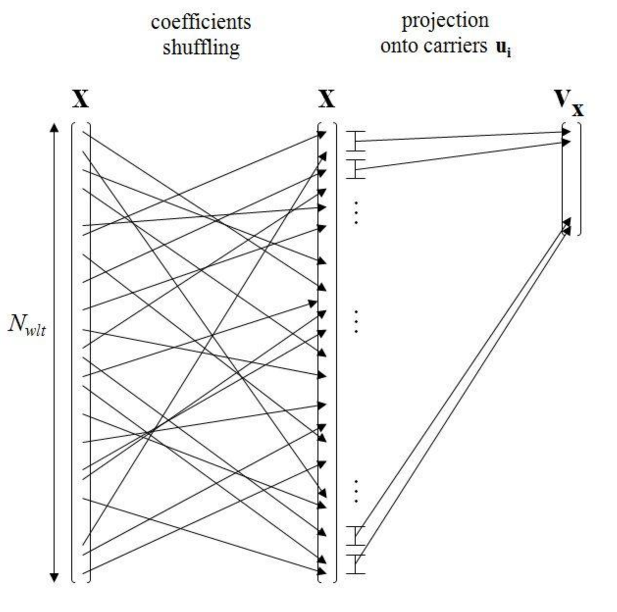


In a block of 12 coefficients of $\mathbf{v_x}$:
- 1 coefficient influences subband 1,2,3,
- 3 coefficients influence subband 4,5,6,
- 8 coefficients influence subband 7,8,9

Region sizes belong to $\mathbb{N}^*$

$$\left(3.\frac{N}{4}\right)\frac{1}{s_{789}} + \left(3.\frac{N}{16}\right)\frac{1}{s_{456}} + \left(3.\frac{N}{64}\right)\frac{1}{s_{123}} = N_{sec}$$

Solution 2: Random SDM:



A region r_i, with $i \in [0, N_{sec}-1]$, is a set of contiguous wavelet coefficients:

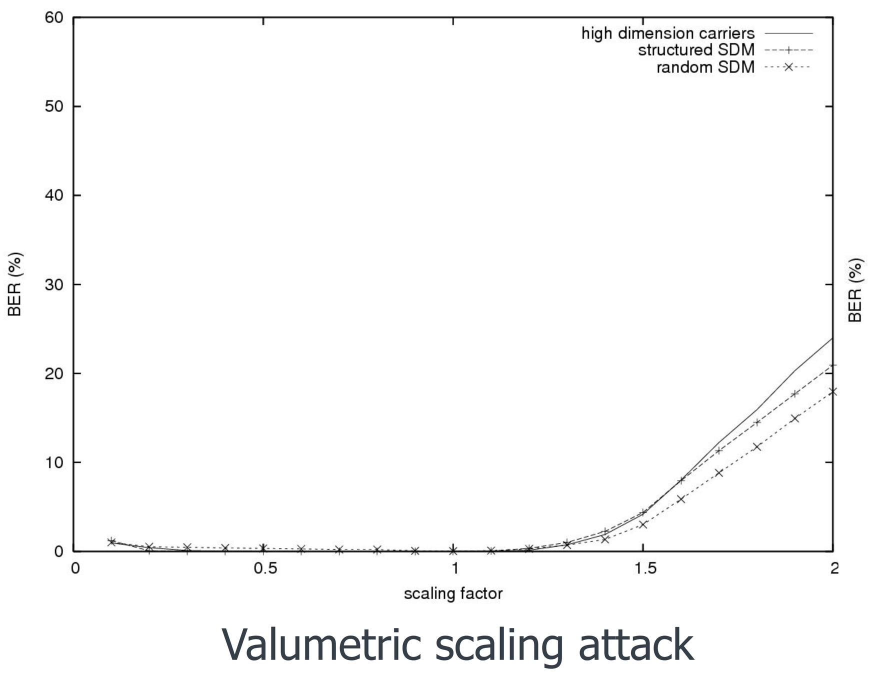
$$r_i = \{\mathbf{x}[i] | i \in [\lfloor i.\overline{s} \rfloor, \lfloor (i+1).\overline{s} \rfloor - 1]\}$$

with $\overline{s} = N_{wlt}/N_{sec}$

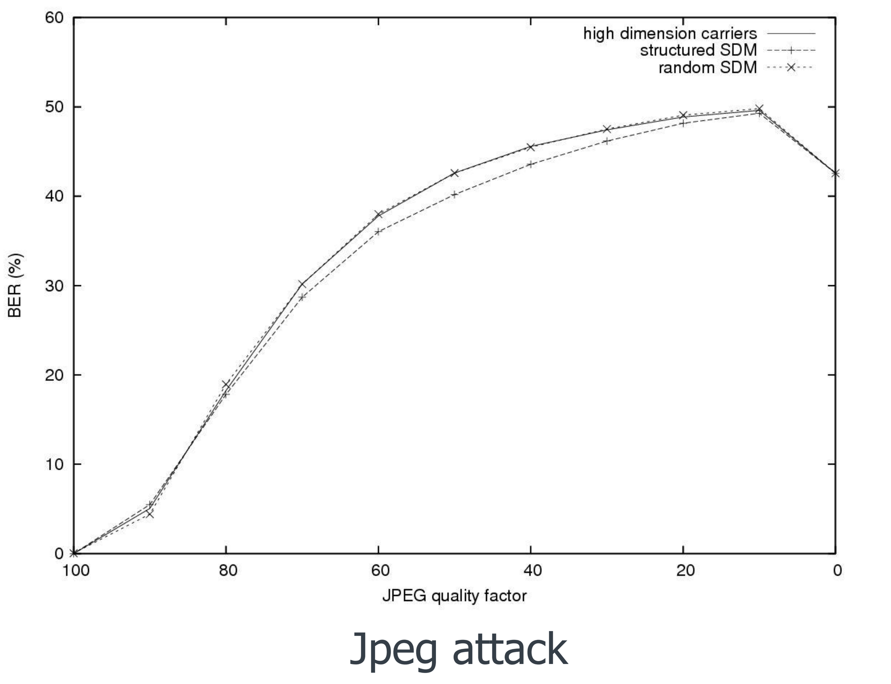
RESULTS AND CONCLUSIONS:

Evaluation Protocol:

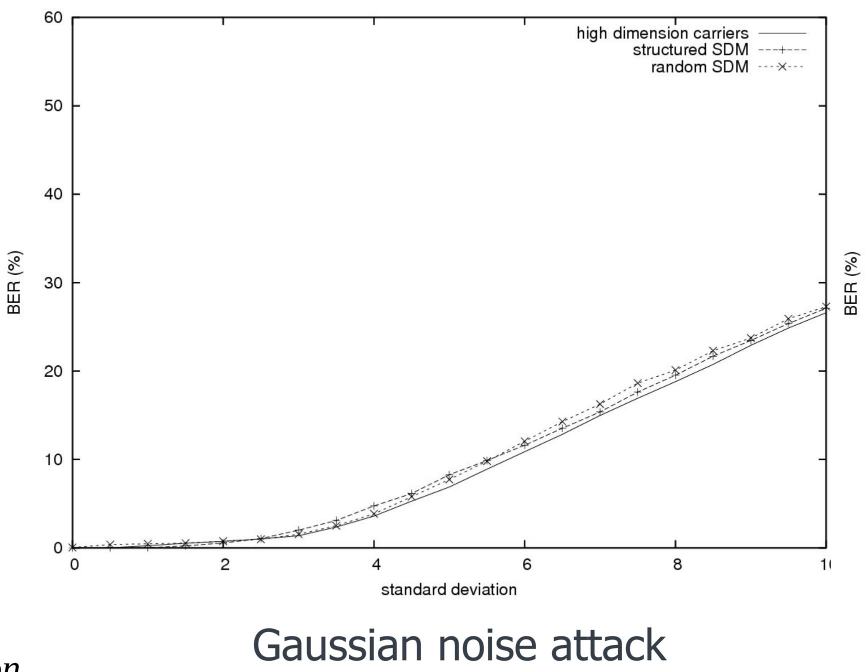
100 images 256×256.
Payload = 1 bit embedded in 64 pixels.
Trellis : 128 states, 128 arcs by state,
Output arc labels = Gaussian distribution,
Number of labels by output arc = 12.
Average embedding PSNR = 42.4 dB.



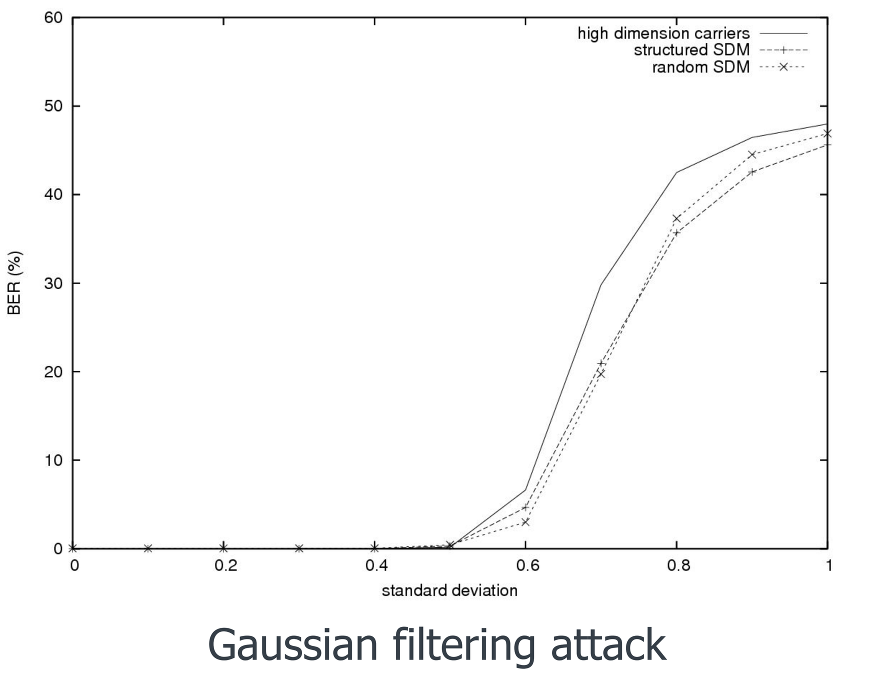
Valumetric scaling attack



Jpeg attack



Gaussian noise attack



Gaussian filtering attack

Conclusion:

- Random SDM is a simple way to reduce the complexity,
- RB-DPTC with random SDM:
  - is a very low complexity algorithm,
  - allows a good robustness-distortion compromise.

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.