Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier

LIRMM

PSYCHOVISUAL ROTATION-BASED DPTC WATERMARKING SCHEME

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The 17th European Signal Processing Conference (EUSIPCO'2009), August 24-28, 2009, Glasgow, Scotland.

OUTLINE

- Few words about high rate watermarking schemes
- The Rotation-Based Dirty Paper Trellis Code Algorithm: RB-DPTC
- How to add a psycho-visual space ?
- Experimental evaluations
- Conclusion

Few words about high rate watermarking schemes

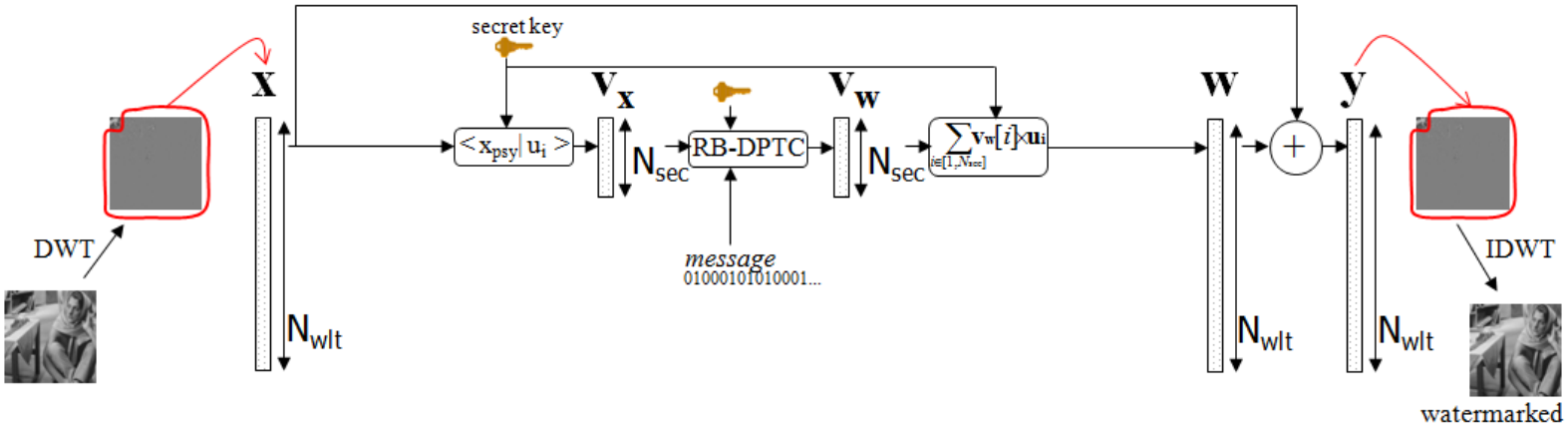
HIGH RATE WATERMARKING SCHEMES

- 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 256×256 ⇒ 1024 bits embedded)

The Rotation-Based Dirty Paper Trellis Code Algorithm: RB-DPTC

RB-DPTC WATERMARKING SCHEME [1]
- EMBEDDING SPACE -



- **x** : host signal
- **w** : watermark signal
- **y** : watermarked signal
- $\{\mathbf{u}_i\}_{i=1}^{N_{sec}}$: carriers (normalized bipolar pseudorandom sequences)
- $\mathbf{v_x}$: host vector = secret space
- $\mathbf{v_w}$: watermark vector = (watermark in the secret space)

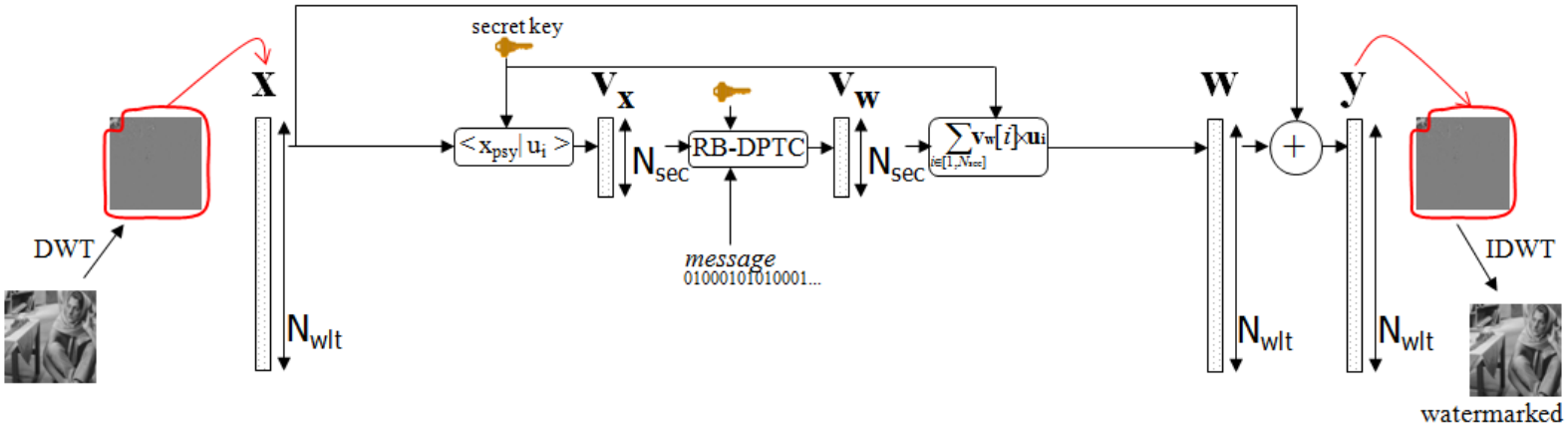
[1] M. Chaumont, « A Novel Embedding Technique For Dirty Paper Trellis Watermarking", in submission.

How to add a psycho-visual space ?

RB-DPTC

WATERMARKING SCHEME [1]

BEFORE



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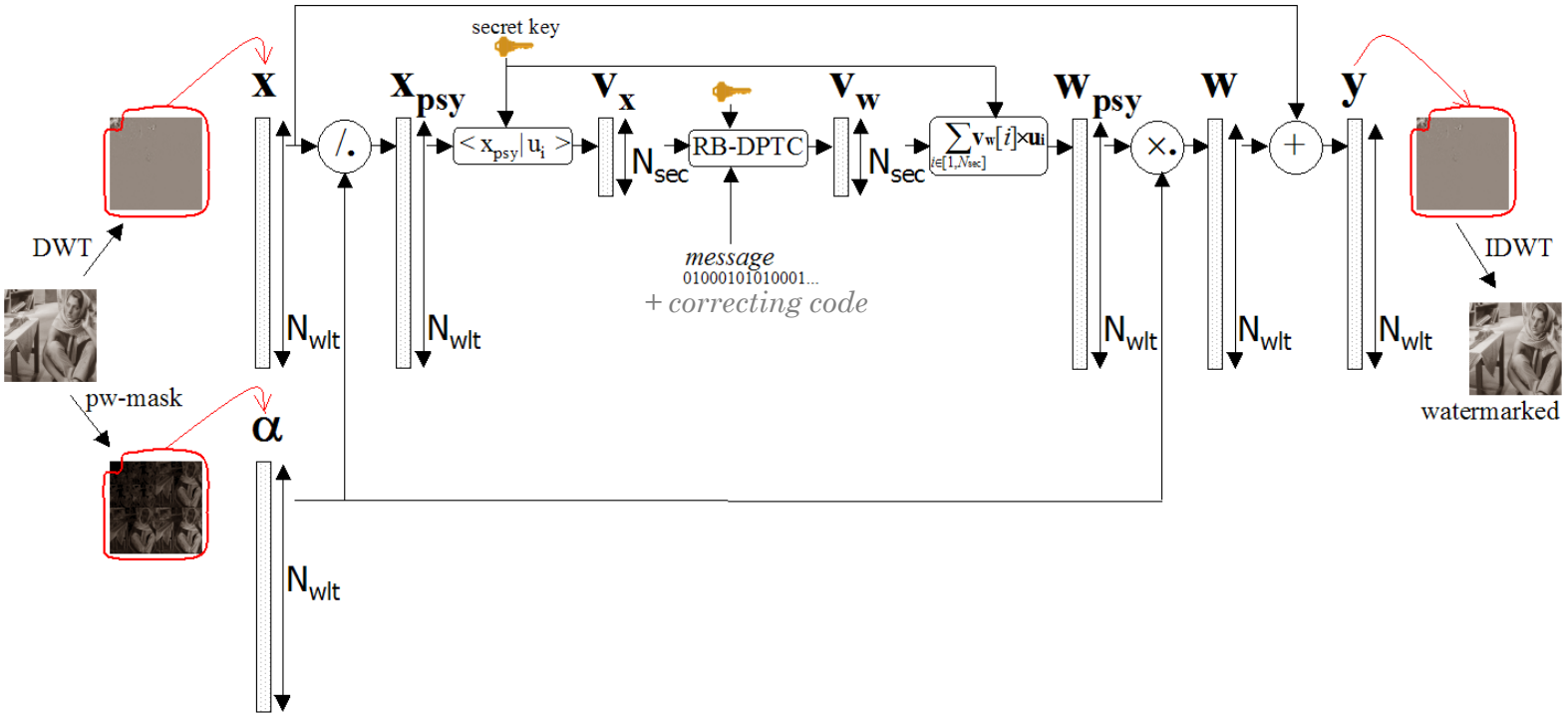
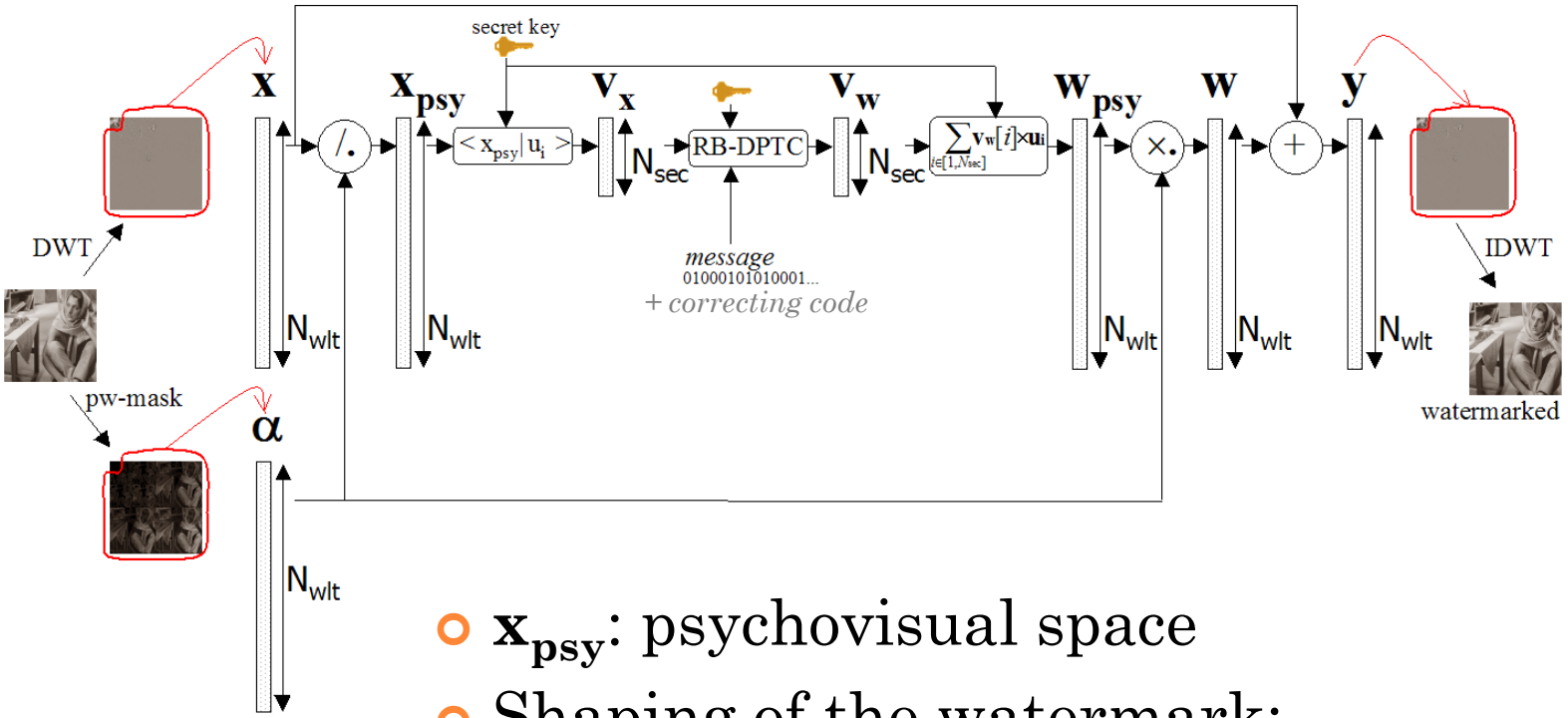
PSYCHOVISUAL RB-DPTC WATERMARKING SCHEME

NOW



PSYCHOVISUAL RB-DPTC WATERMARKING SCHEME

NOW



- $\mathbf{x_{psy}}$: psychovisual space
- Shaping of the watermark:

$$\forall i \in [1, N_{wlt}],\ \mathbf{w}[i] = \mathbf{w_{psy}}[i] \times \boldsymbol{\alpha}[i]$$

EXAMPLE OF PSYCHOVISUAL MASKS

Rudimentary

- Construction:
  1. high pass filtering ($I^{filtered}$)
  2. DWT and filling of vector β
  3. $\boldsymbol{\alpha}$ = absolute coefficients from β scaled between [1, α_{max}]

Pixel-Wise Mask (PW-M)

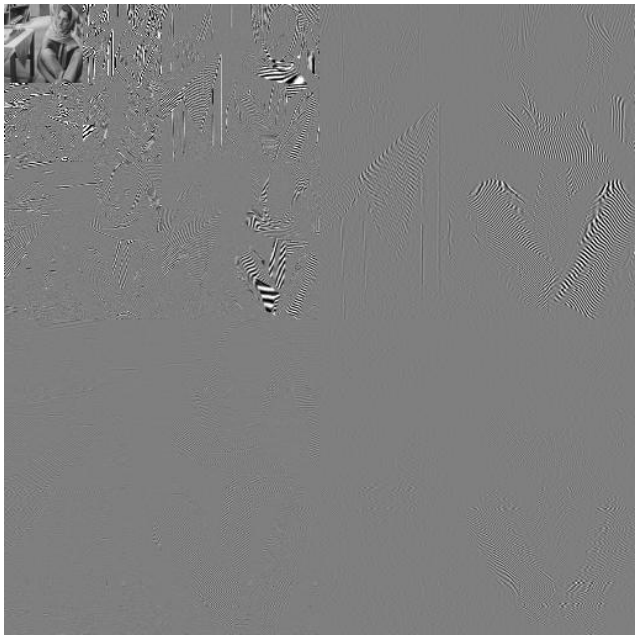
- PW-M [3]:

$$\alpha_l^{\theta}(i,j) = \Theta(l,\theta).\Lambda(l,i,j).\Xi(l,i,j)^{0.2}$$

  - (i,j): position in subband
  - l: resolution level
  - $\theta \in \{a,h,v,d\}$:orientation
- $\Theta(l,\theta)$: noise sensitivity
- $\Lambda(l,i,j)$: local brightness
- $\Xi(l,i,j)$: local texture activity
- $\boldsymbol{\alpha}$ scaled between [1, α_{max}]

[3] Gui Xie and Hong Shen, "Toward Improved Wavelet-Based Watermarking Using The Pixel-Wise Masking Model," ICIP'2005, 2005, vol. 1, pp. 689–692.

Barbara crop to 512×512



Wavelet decomposition

Rudimentary mask

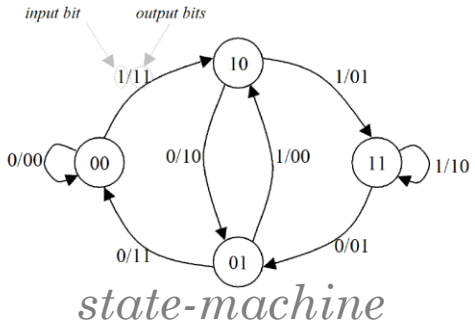
Xie and Shen mask

Correcting code

The use of a psychovisual mask may lead to a less robust scheme

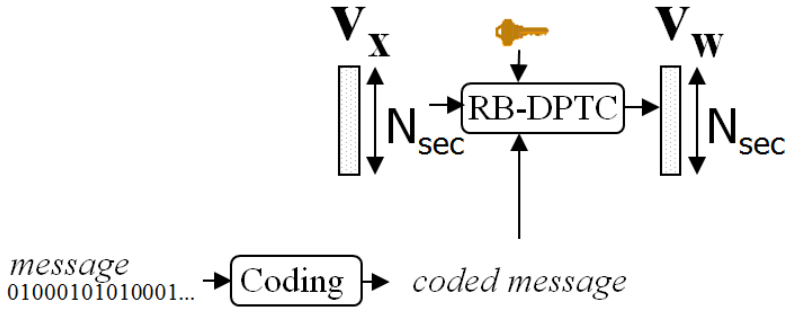
⇒ Add of a convolution correcting code
2-memory, 1/2-rate

- Encoding with the state machine
- Decoding with Viterbi algorithm



state-machine

The message is encoded before embedding



Experimental evaluations

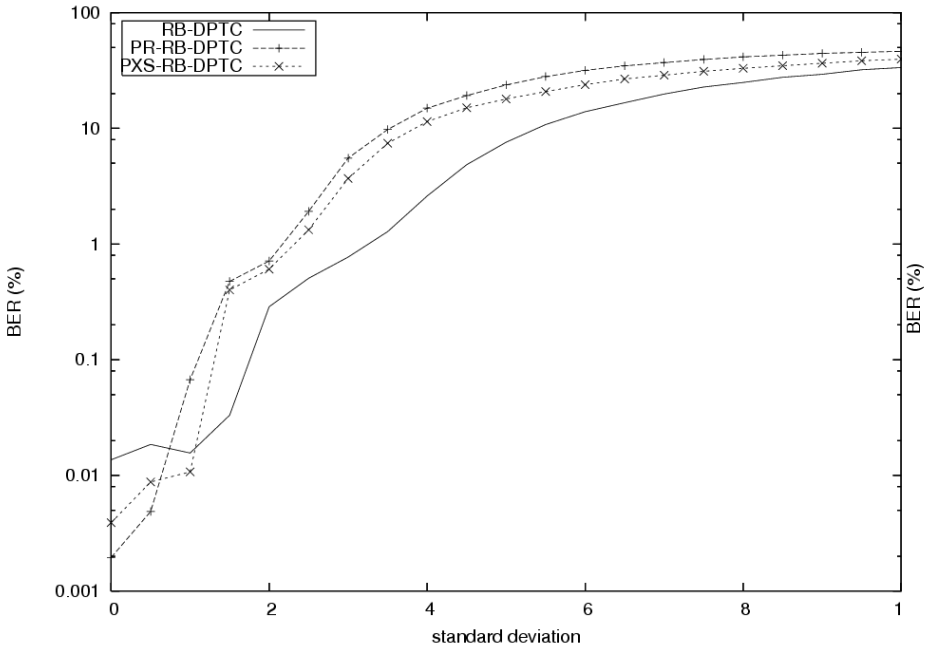
Evaluation protocol

- 100 images 256×256
- Payload = 1 bit (message) for 64 pixels
  - 1024 bits embedded for RB-DPTC.
  - 2048 bits embedded for new algorithms.
- Trellis : 128 states, 128 arcs by state
- Outputs arc labels : Gaussian distribution
  - number of labels by output arc: 12 (RB-DPTC) or 10.

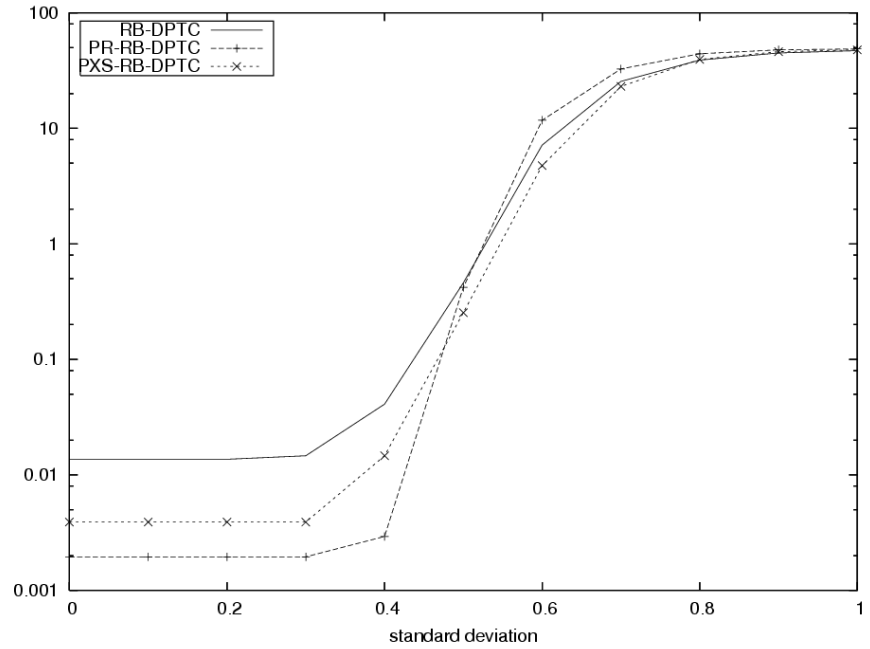
Algorithms

- 3 Algorithms are competing (fix SSIM = 98%):
  - RB-DPTC (no psychovisual mask, no correcting code)
  - **PR-**RB-DPTC (rudimentary mask + correcting code)
  - **PXS-**RB-DPTC (Xie and Shen mask + correcting code)
- 4 attacks:
  - Gaussian noise,
  - Gaussian filtering,
  - Valumetric scaling,
  - Jpeg attack.

ATTACKS (1) – FIXED SSIM = 98%

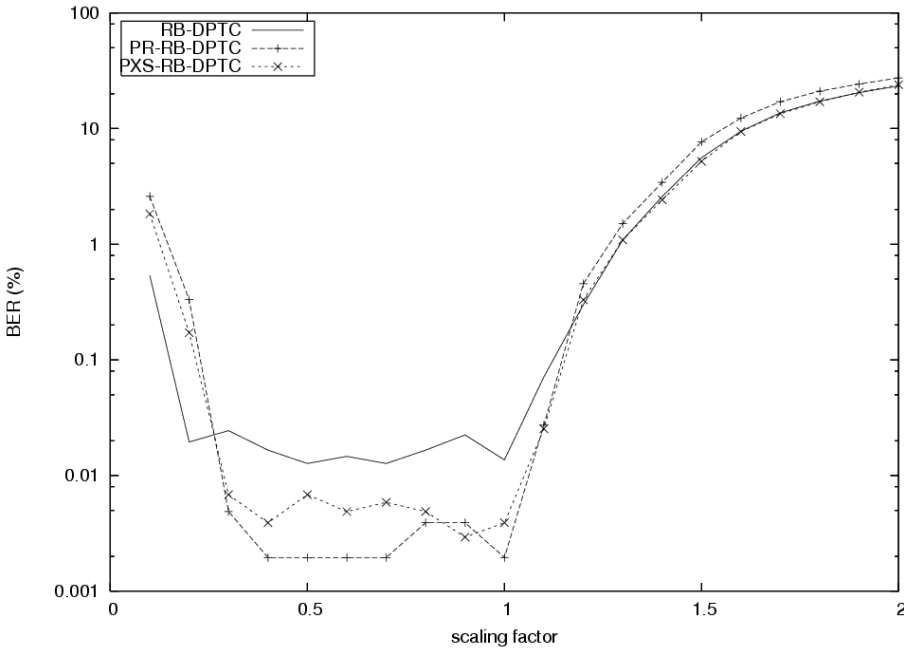


Gaussian noise attack

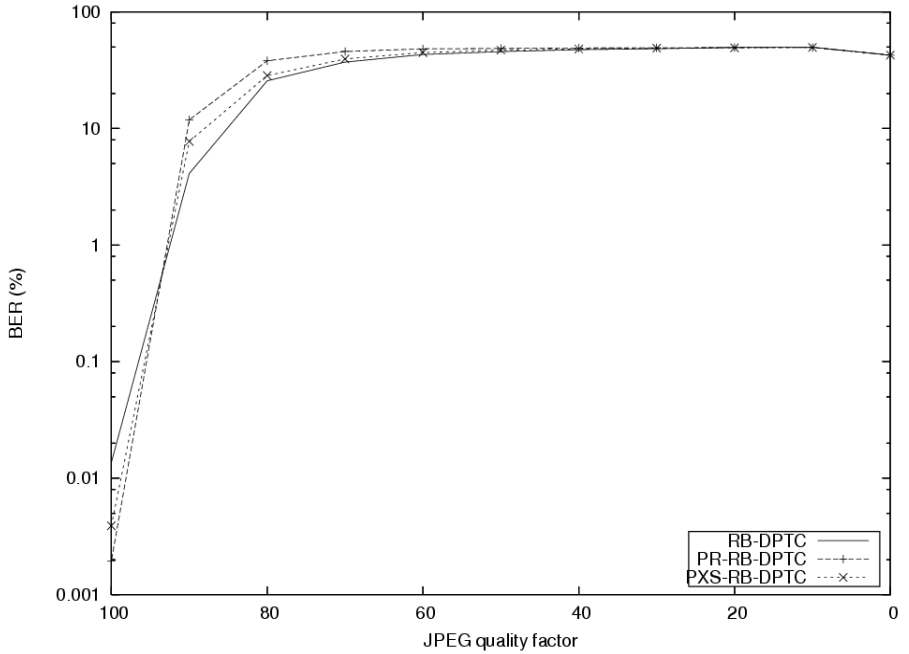


Gaussian Filtering attack

Attacks (2) – Fixed SSIM = 98%



Valumetric scaling attack



Jpeg attack

Conclusion & discussion

Conclusion & Discussion

- Integration of a psychovisual mask inside RB-DPTC
- 10% BER saving (filtering & valumetric attack) for low power attacks
- OPEN ISSUES:
  - Sensitivity to Jpeg attack
  - Sensitivity to Westfeld [4] regression-based attack
  - Relation between SSIM and penetration angle
  - Construction of a robust psychovisual mask

[4] Andreas Westfeld, « A Regression-Based Restoration Technique for Automated Watermark Removal », Multimedia & Security ACM Workshop MM&Sec2008, Oxford, United Kingdom, Sept.2008.

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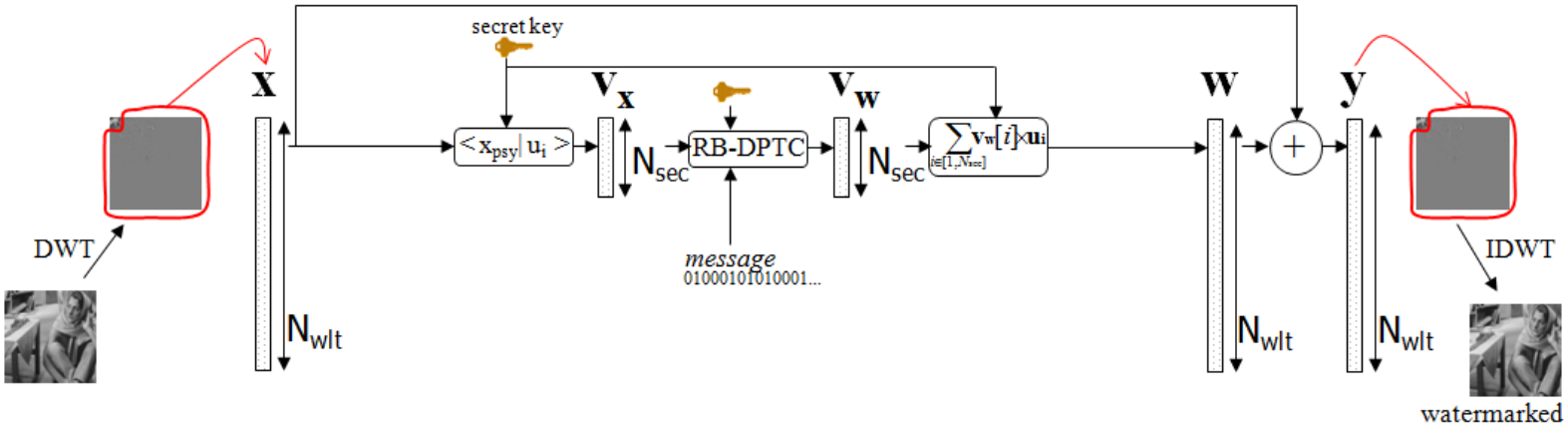
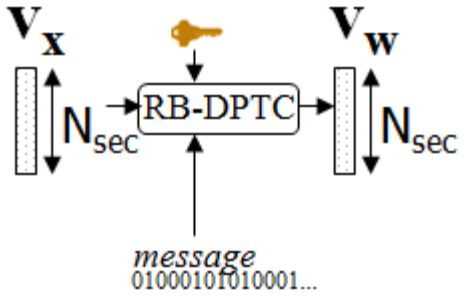
Annex

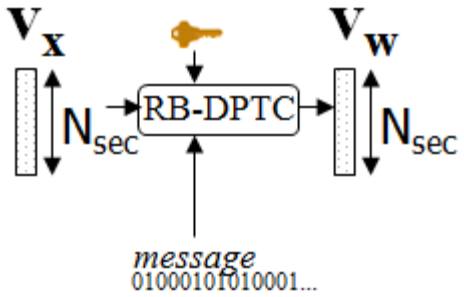
RB-DPTC WATERMARKING SCHEME
- EMBEDDING SPACE -



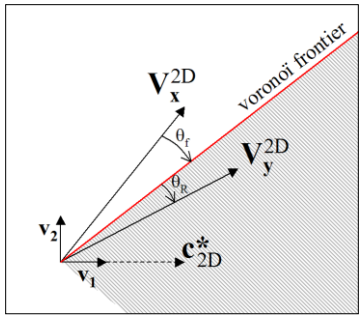
RB-DPTC WATERMARKING SCHEME
- INFORMED CODING & EMBEDDING -



RB-DPTC WATERMARKING SCHEME - INFORMED CODING & EMBEDDING -



- Informed coding:
  - identical to [2] (Trellis + Viterbi)
  - Input = ($\mathbf{v_x}$ and *message*), Output = codeword $\mathbf{c^*}$
- Informed embedding:
  - rotate $\mathbf{v_x}$ in the "Miller Cox Bloom plane"
  - and penetrate inside the Voronoï region
  - $\mathbf{v_w} = \mathbf{v_y} - \mathbf{v_x}$



[2] M. L. Miller, G. J. Do¨err, and I. J. Cox, "Applying Informed Coding and Informed Embedding to Design a Robust, High Capacity Watermark," IEEE Transactions on Image Processing, vol. 13, no. 6, pp. 792–807, 2004.