Watermarking authentication based on the orthogonality of pseudo-random binary sequences

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Contents

Introduction

- Watermarking consists of the insertion of information (the watermark) inside the image.
- The watermark is desired to be invisible and robust.
  - It does not introduce perceptual changes in the image
  - It is not easy to remove, and
  - It can be recovered after the so-called attacks: lossy compression, cropping, smoothing, adding noise, etc.

Introduction

- Our watermarking procedure works on the coefficients of the Haar DWT.
- Insertion of the watermark
  - addition of pseudo-random binary sequences generated for each bit in the watermark to DWT coefficients selected according to their magnitude.
- The watermark extraction
  - testing the correlation of the pseudo-random binary sequences generated for the watermark bits with the selected DWT coefficients.

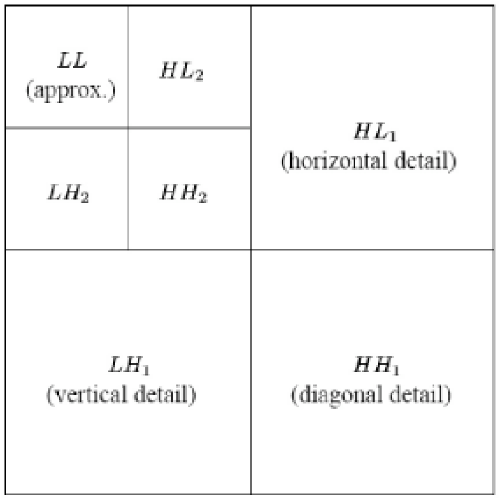
Algorithm features

- The watermark is a binary image,
- Each pixel in the watermark image is associated with a pair of pseudo-random binary number {-1,1} sequences.

Algorithm features

- The watermark insertion is performed on the difference coefficients:

$$(LH_n, HL_n, HH_n; n = 1, 2)$$



Algorithm features

- The watermark extraction is performed at each pixel independently,
  - through the regeneration of their associated pseudo-random binary {-1, 1} sequences.
  - we compare the correlation among the DWT selected coefficients and its associated pseudo-random binary {-1,1} sequences

Algorithm features

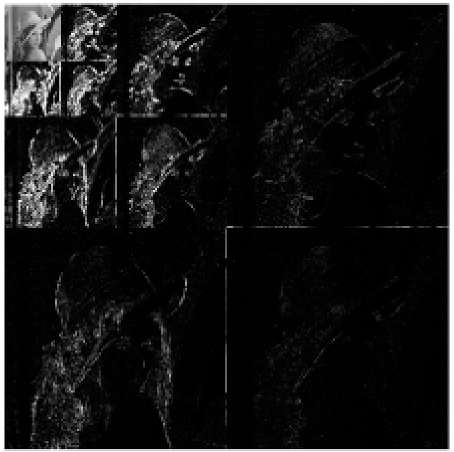
- For watermark extraction we require the knowledge of
  - the random number seed (the key in the figures below),
  - the position of the DWT coefficients affected by the watermark and
  - the watermark itself.

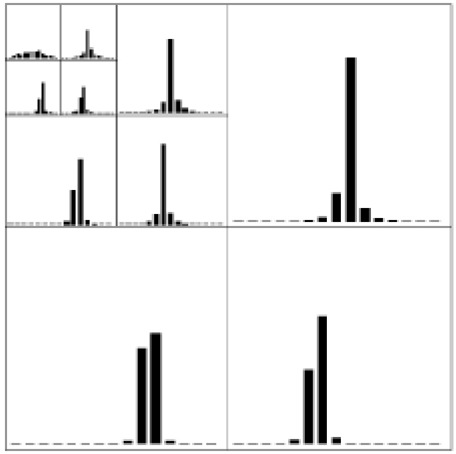
Algorithm features

- a key fact for our approach to work is that the pseudo-random binary sequences are (almost) orthogonal

DWT coefficient selection

1. All the $(LH_n, HL_n, HH_n; n = 1, 2)$ are sequenced into a vector Z.
2. We initialize the selection threshold as the maximum absolute value of the coefficients.
3. We select the coefficients according to the threshold $P = \{j \,|Z(j) > Threshold\}$.
4. If $|P| < n_r$ then decrease threshold and go to 3,
5. Save the values of the DWT coefficients $C = \{Z(j), j \in P\}$.





Watermark insertion

- Pseudo random sequence

$$\{w_0(i) \in \{-1, 1\}, w_1(i) \in \{-1, 1\}, i = 1, .., n_r\}.$$

- Modification of the selected DWT coefs

$$C(i) = \begin{cases} C(i) + kw_0(i) & \text{black pixel} \\ C(i) + kw_1(i) & \text{white pixel} \end{cases}$$

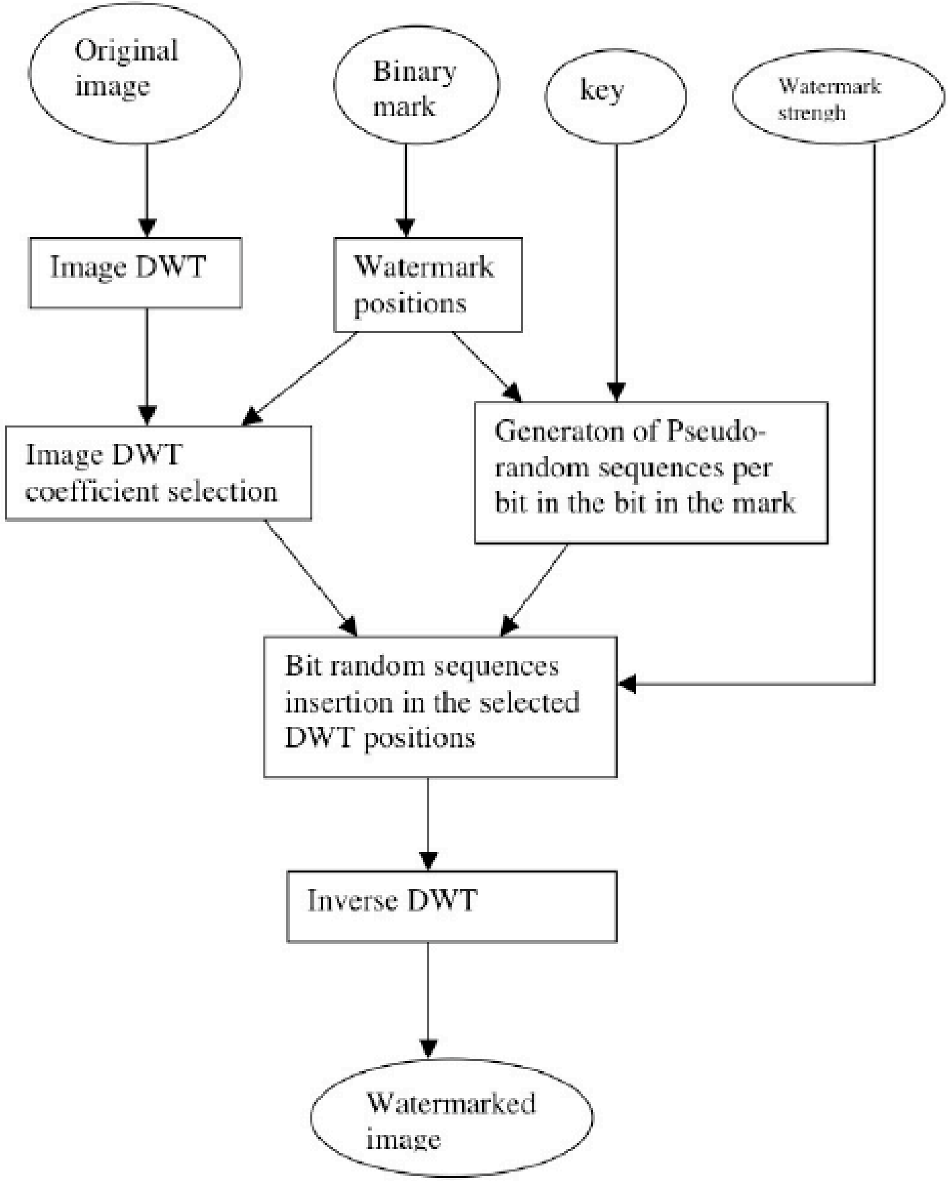


Fig. 4: Watermark insertion

Watermark extraction

- We regenerate the pseudo-random sequences
- Recovery is performed computing the correlation

$$W(p) = \begin{cases} 0 & corr(C^*, C^0) > corr(C^*, C^1) \\ 1 & else \end{cases},$$

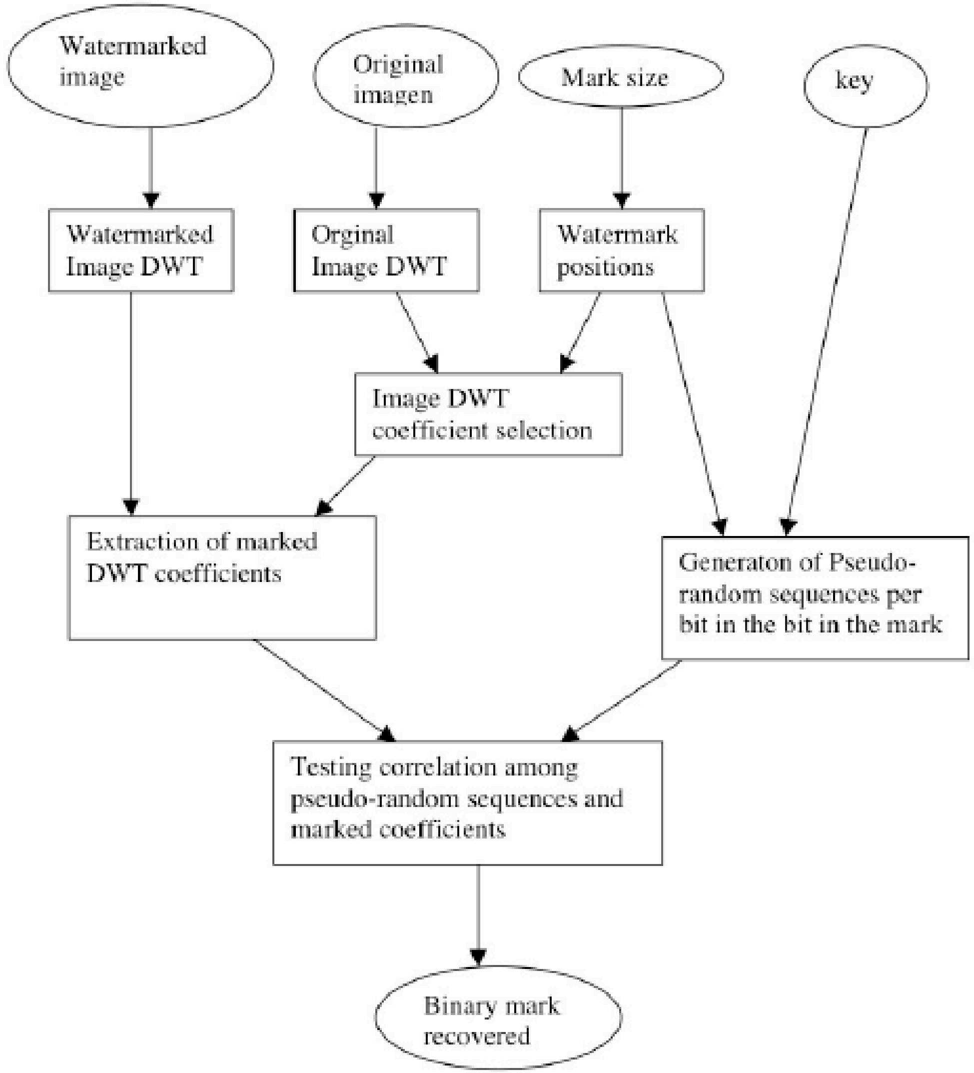
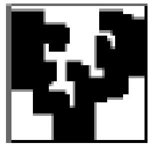


Fig. 5: Watermark extraction

Computational results



watermark

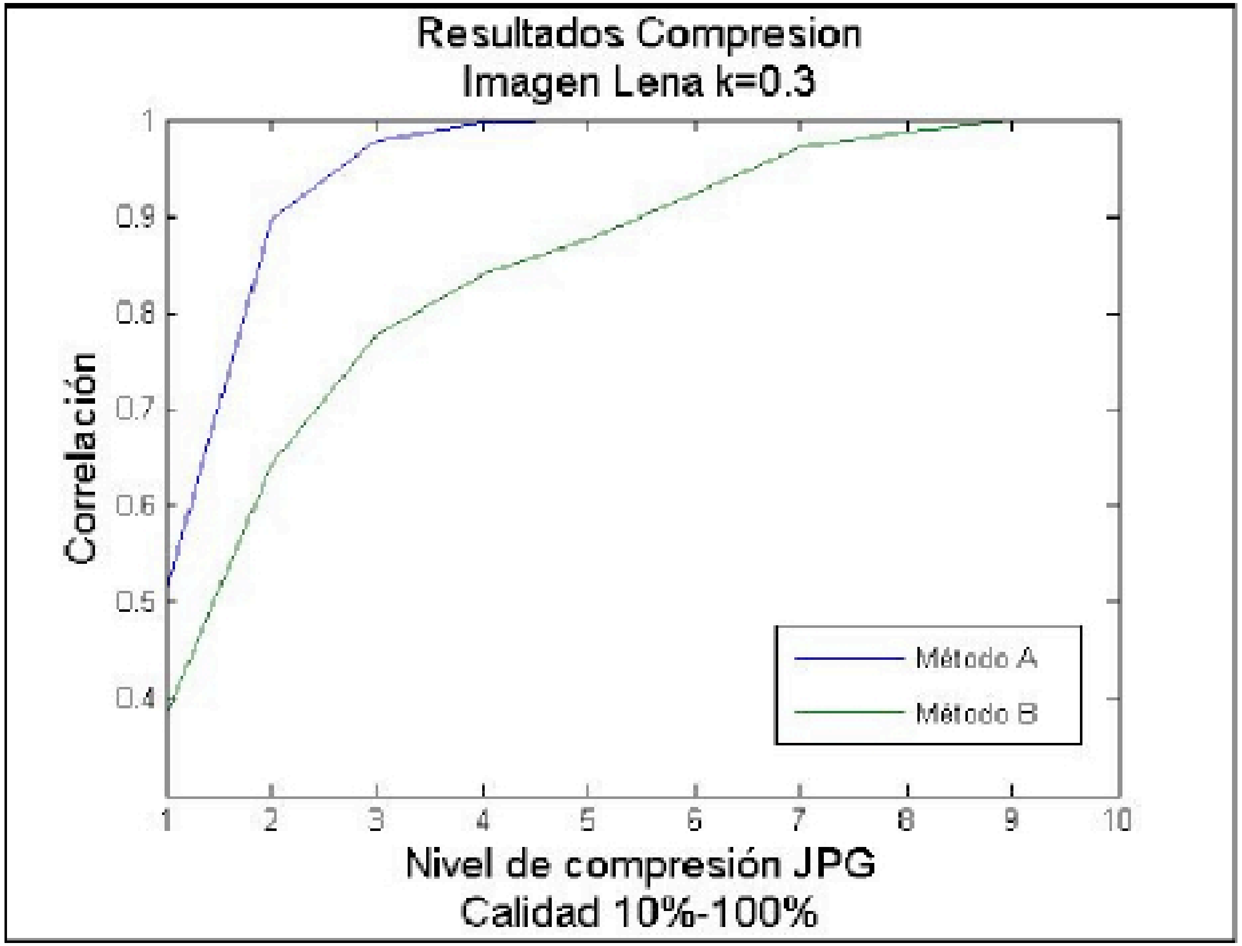


Fig. 9: Lena watermarked with $k = 0.3$. Correlation of the recovered watermark with the true one after JPEG lossy compression attacks

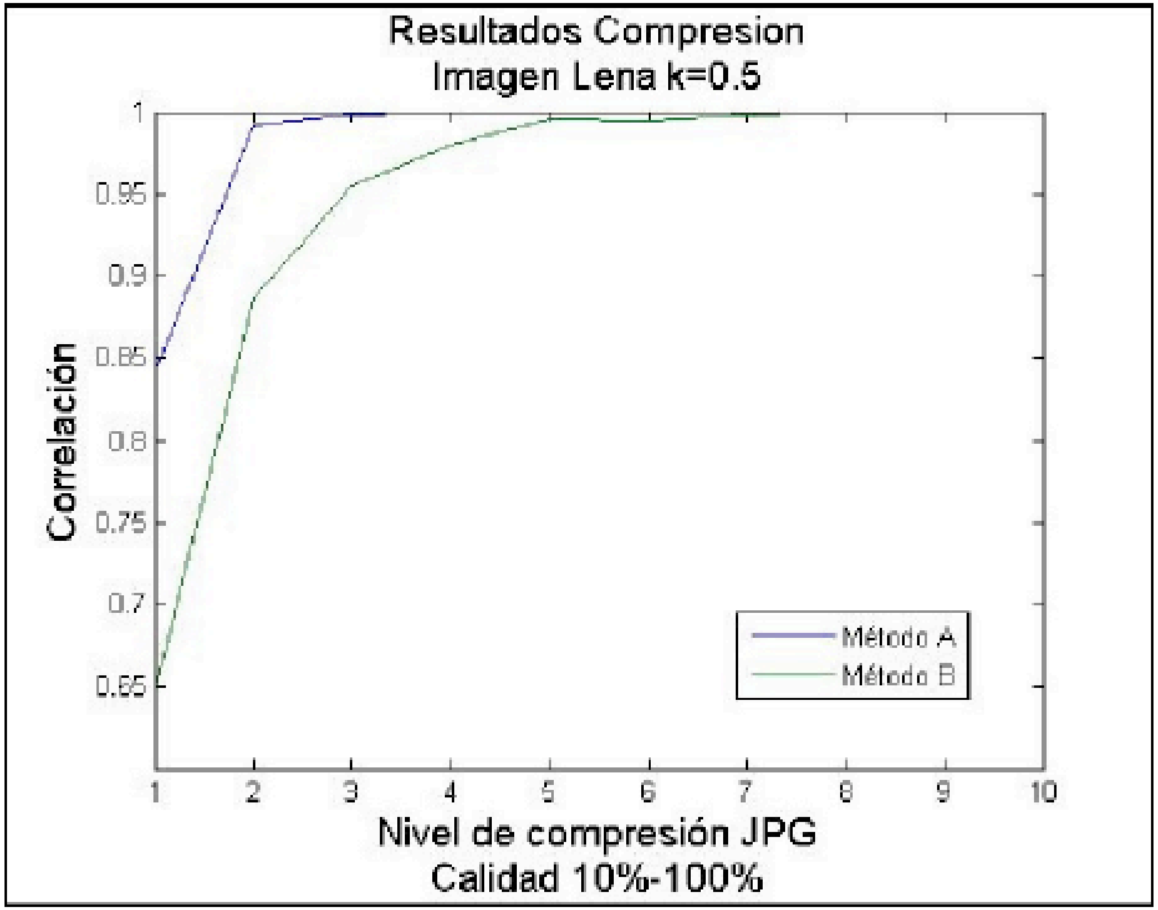


Fig. 10: Lena watermarked with $k = 0.5$. Correlation of the recovered watermark with the true one after JPEG lossy compression attacks

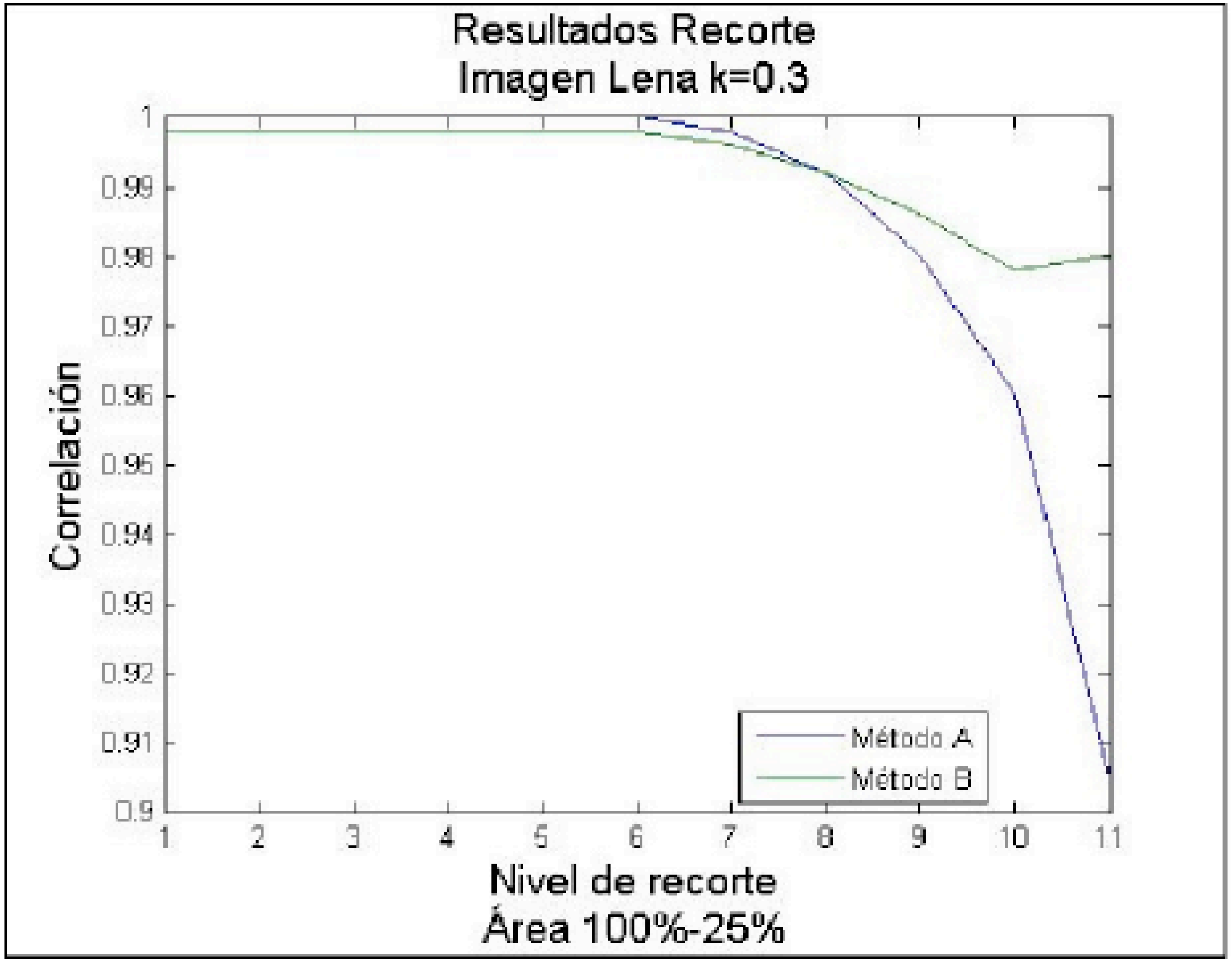


Fig. 11: Lena watermarked with $k = 0.3$. Correlation of the recovered watermark with the true one after cropping attacks

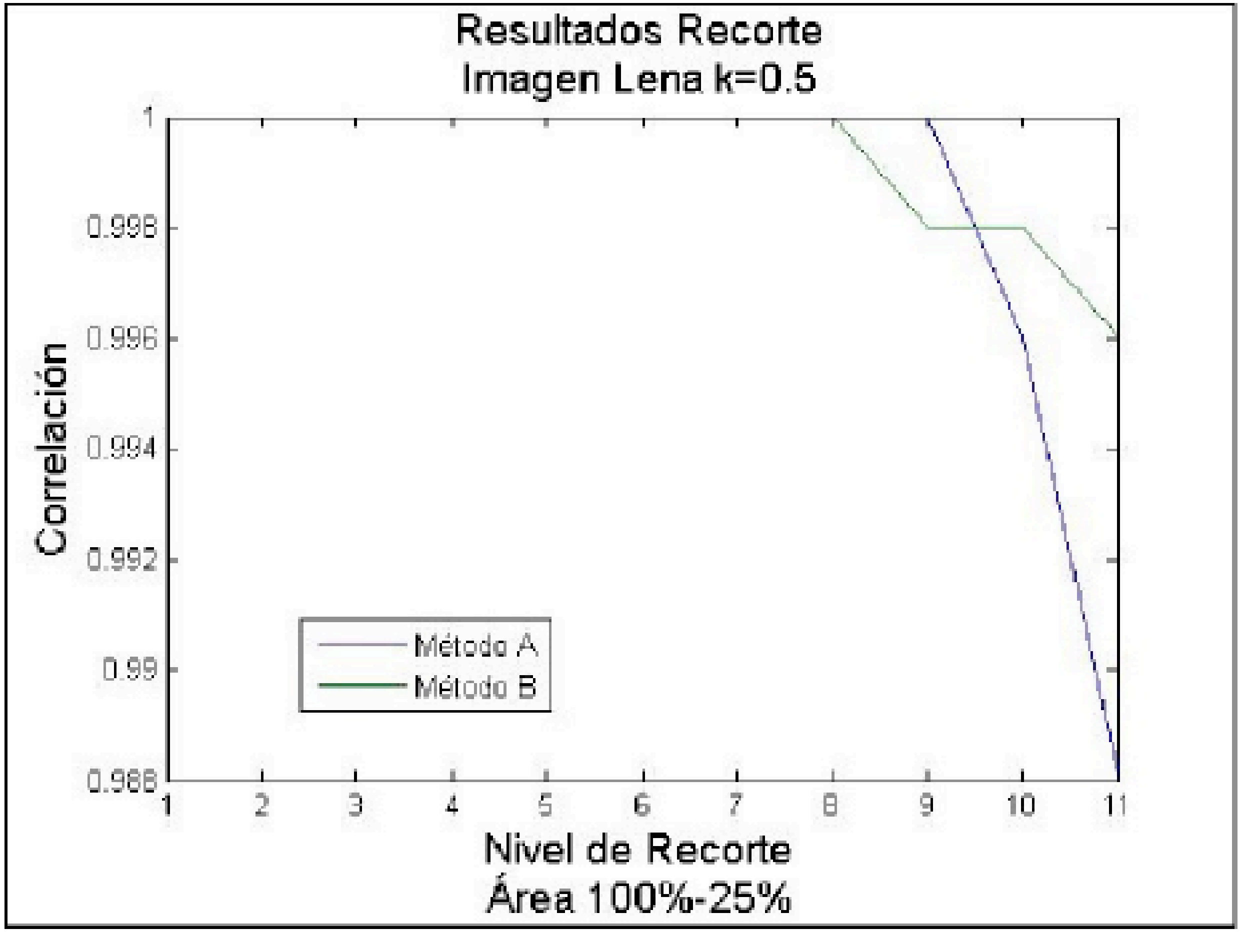


Fig. 12: Lena watermarked with $k = 0.5$. Correlation of the recovered watermark with the true one after cropping attacks

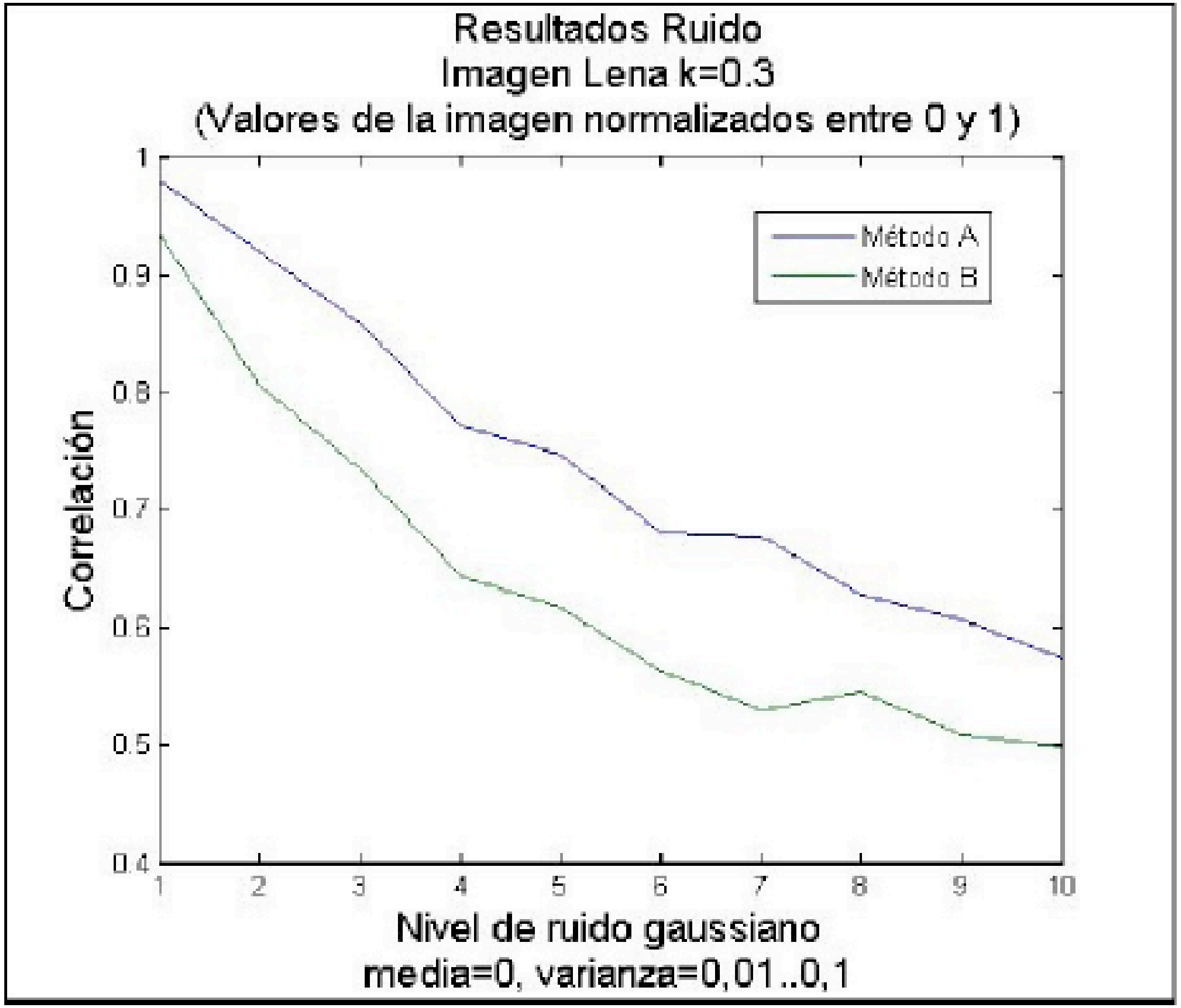


Fig. 13: Lena watermarked with $k = 0.3$. Correlation of the recovered watermark with the true one after gaussian additive attacks

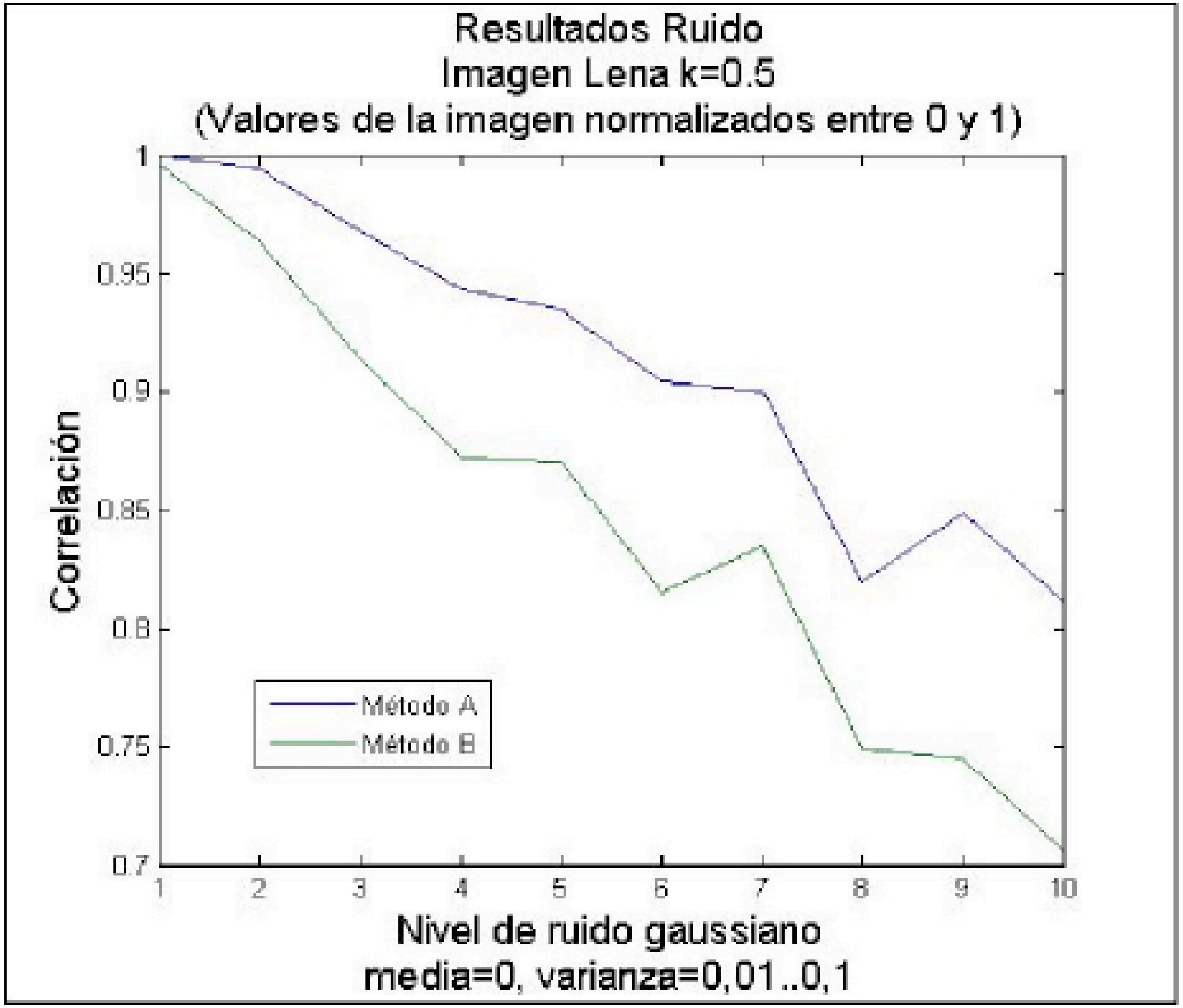


Fig. 14: Lena watermarked with $k = 0.5$. Correlation of the recovered watermark with the true one after gaussian additive attacks

Conclusions

- We present in this paper a watermak authentication procedure based on the DWT.
- The procedure tries to ascertain if the image contains a certain logo or binary image, given the original image and the watermarked image.
- The algorithm is based on the orthogonality of pseudo-random bynary number suquences, so that storing information over a mark pixel does not interfere with others stored previously or in the future.

Conclusions

- We have tested is robusted with some encouraging success for the case of lossy compression and cropping, however the algorithm fails heavily when the attack consist of Gaussian noise addition.
- We need to do further computational experiments to test whole approach, also some improvements of the algorithm to correct the discovered problems when additive noise corrupts the images.