Figure 1: Two examples of binary patterns of size $1024 \times 1024$. 
Figure 2: Representation of images "Lighthouse", "Colorbands" and "Parrots" in $xyY$ color space (d, e and f). Projection of color data in $xy$ chromatic plane (h, i and j) for $Y = 50$. 
Figure 3: Strategy of watermark insertion. Only the cells inside the locus are embedded. Cells outside the horseshoe shape of the $xy$-locus are not taken into account. Only colors belonging to *while cells* are changed in function of colors of neighboring *black cells* belonging to the color distribution of the original image.
Figure 4: 24 test images of sizes 512x768 or 768x512 pixels used in our experiments. These natural images belong to the Kodak PhotoCD.
Figure 5: Impact of cell size of patterns with respect to perceptive quality of image.
Figure 6: Impact of pattern size on image quality. Mean values and standard deviation values has been computed from images set of Figure 4 and from a set of 100 different keys.
(a) First class of pixels to watermark.
(b) Original data in $xy$ plane
(c) Watermarked data in $xy$ plane

(d) Second class of pixels to watermark.
(e) Original data in $xy$ plane
(f) Watermarked data in $xy$ plane

(g) Final watermarked image.
(h) Original data in $xy$ plane
(i) Watermarked data in $xy$ plane

Figure 7: Representation of image "Parrots" watermarked twice. Meanwhile some pixels (dark ones represented in (a)) are watermarked with a secret pattern, other pixels (dark ones represented in (d)) are watermarked with the inverse pattern.
Figure 8: Example of CWP-2DBP watermark (see full size images at http://color-watermarking.gartworld.org) with the copyright logo given in Figure 1b.
Figure 9: The $xyY$ 3D color space can be seen as a set (a pile) of $xy$ chromatic plane ordered from lower value to upper value of the $Y$ component. The more we use bits to digitize the $Y$ component, the more the $Y$ difference between one chromatic plane ($Y_i$) to following one ($Y_{i+1}$) is small.
Figure 10: Representation of image "Colorbands" watermarked by: a 1D pattern applied to $Y$ component (a, b), a 2D pattern (CWP-2DBP) applied to $xy$ components (c, d), a 3D pattern (CWP-3DIBP) applied to $xyY$ components (e, f).
(a) pattern 02x02: \( \Delta E_{ab}^{\text{mean}} = 0.649569 \), \( \sigma = 0.419291 \)
(b) pattern 04x04: \( \Delta E_{ab}^{\text{mean}} = 0.641811 \), \( \sigma = 0.433859 \)
(c) pattern 08x08: \( \Delta E_{ab}^{\text{mean}} = 0.798739 \), \( \sigma = 0.488431 \)
(d) pattern 16x16: \( \Delta E_{ab}^{\text{mean}} = 1.0291 \), \( \sigma = 0.58272 \)
(e) pattern 32x32: \( \Delta E_{ab}^{\text{mean}} = 1.53645 \), \( \sigma = 0.99099 \)
(f) pattern 64x64: \( \Delta E_{ab}^{\text{mean}} = 2.47449 \), \( \sigma = 1.68703 \)

Figure 11: CIELAB \( \Delta E_{ab} \) color differences, displayed with a logarithmic scale space, computed between the original image and the CWP-3DRBP watermarked image.
Figure 12: Impact of pattern size on image quality. Mean values and standard deviation values has been computed from images set of Figure 4 and from a set of 100 different keys.
Figure 13: Strategy of watermark detection.
Figure 14: Example of attacks on image "Parrots". Probability that the image has been watermarked versus several attacks. The more the percentage of pixels belonging to a white cell ($N_w$) is low, the more this probability is high.
Figure 15: Impact of JPEG compression on watermark detection (2D Pattern). Mean values has been computed from images set of Figure 4 and from a set of 100 different keys.
Figure 16: Impact of JPEG compression on watermark detection (3D Pattern). Mean values has been computed from images set of Figure 4 and from a set of 100 different keys.
Figure 17: Percentage of pixels detected as *watermarked* for a given set of images (see Figure 4), with a random key and different sizes of 2D pattern.
Figure 18: Percentage of pixels detected as watermarked for a given set of images (see Figure 4), with a random key and different sizes of 3D pattern.
Figure 19: Some examples of fragile watermarked images.
(a) Original watermarked image.  
(b) Attacked watermarked image.  
The tip of beak have been erased.

(c) Map of attacked area.

(d) Map of attacked area after JPEG compression of watermarked image  
(100% quality factor. Between original watermarked image and JPEG  
watermarked image $PSNR = 48.42dB$)

Figure 20: Example of image attack on fragile watermarked image.
Figure 21: Example of fragile watermark on a Driver’s license. In this experiment, the sentinel density is equal to 100%, and the detection threshold $N_b$ is equal to 100%.