$$PSNR(f, f_w) = 10\lg\left[\frac{\max_{(m,n)} f^2(m,n)}{\frac{1}{R}\sum_{(m,n)}(f_w(m,n) - f(m,n))^2}\right] \quad (13)$$

where f represents the original image, f_w the watermarked image, (m,n) represents a particular pixel location and R the number of pixels in the original/watermarked image. Typical PSNR values for high quality images exceed 30-40 dB in the case of image compression, but the values should be better for fragile watermark embedding.

Similar to the indicator presented above, the normalized inter-correlation coefficient can be used in order to measure the resemblance between the original image and the watermarked image. It has to be as close as possible to 1:

$$E(f) = \frac{1}{N}\sum_{(m,n)} f(m,n) \quad (14)$$

$$r(f, f_w) = \frac{\frac{1}{N}\sum_{(m,n)}(f(m,n) - E(f))(f_w(m,n) - E(f_w))}{\sqrt{\frac{1}{N}\sum_{(m,n)}(f(m,n) - E(f))^2}\sqrt{\frac{1}{N}\sum_{(m,n)}(f_w(m,n) - E(f_w))^2}} \quad (15)$$

For the human eye, the watermarked image obtained with our algorithm seems identical to the original image. The comparative results, presented in table 2, clearly indicate the effectiveness of our algorithm.

TABLE 2 COMPARATIVE PERFORMANCES

	CWSA	Proposed algorithm
PSNR	77.5628	79.8531
Inter-correlation coefficient	0.9993	0.9995

6. Conclusion

A new fragile watermarking scheme for JPEG image integrity has been proposed. The main features of the proposed algorithm are: robustness against cryptographical attacks, high imperceptibility of the added watermark and greater speed than the CWSA algorithm. Our algorithm can be used in some applications such as image transfer over the Internet with integrity check and watermark of images for use as forensic evidence in court of laws.

For the future work we propose an extension of the presented algorithm to include a copyright claiming mechanism.

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