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# 基于小波域HMM模型的稳健多比特图像水印算法

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## Abstract

Robustness is an important issue in the development of multi-bits watermarking algorithm. A new algorithm for robust multi-bits image watermarking based on Hidden Markov Model (HMM) in wavelet domain is proposed. The algorithm is characterized as follows: (1) the proposed blind detector based on vector HMM, which is employed to describe the statistics of wavelet coefficients, achieves significant improvements in performance compared to the conventional correlation detector; (2) an adaptive watermark embedding scheme is applied to achieve the low distortion according to the human visual system; (3) an optimal multi-bit watermark embedding strategy and a maximum-likelihood detection for tree structure of vector HMM are proposed through system robustness analysis. Simulation results show that relatively high capacity for watermark embedding in low frequency subbands of wavelet domain is achieved with the proposed algorithm, and high robust results are observed against Stirmark attacks, such as JPEG compress, adding noise, median cut and filter.

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## 摘要

稳健性是多比特图像水印的关键问题之一,提出了一种基于小波域隐马尔可夫模型(hidden Markov model,简称HMM)的多比特图像水印算法,该算法的主要特点为:(1) 利用向量HMM模型精确描述图像小波系数间的统计特性,基于此统计模型的水印盲检测系统较之传统的相关检测器,在性能上有显著的提升;(2) 结合视觉掩盖特性,自适应地调整水印嵌入强度,使之在一定的嵌入强度下,视觉主观失真较小;(3) 提出了一种适合隐马尔可夫模型树型结构的多比特数据优化嵌入策略和最大似然检测.数值仿真结果表明,该算法可以较好地利用图像小波域的低频子带以实现较大容

量图像水印的嵌入,并在抵抗Stirmark平台攻击,如JPEG压缩、加噪、中值滤波和线性滤波等方面具有很强的稳健性.

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## References:

[1] Huang J, Tan T. A review of Invisible Image watermarking. *ACTA Automatica Sinica*, 2000,26(5):646-655 (in Chinese with English abstract).

[2] Cox IJ, Kilian J, Leighton T, Shamoon T. Secure spread spectrum watermarking for multimedia. *IEEE Trans. Image Processing*, 1997,6(12):1837-1687.

[3] Huang J, Shi YQ, Shi Y. Embedding image watermarks in DC components. IEEE Trans. on Circuits and Systems for Video Technology, 2000,10(6):974-979.

[4] Huang DR, Liu JF, Huang JW. An embedding strategy and algorithm for image watermarking in DWT domain. Journal of Software, 2002,13(7):1290-1297 (in Chinese with English abstract). <http://www.jos.org.cn/1000-9825/13/1290.pdf>

[5] Chen B, Wornell GW. An information-theoretic approach to the design of robust digital watermarking systems. In: Proc. of the 1999 IEEE Int'l Conf. on Acoustics, Speech, and Signal Processing. 1999. 2061-2064.

[6] Chou J, Pradhan SS, Ramchandran K. On the duality between distributed source coding and data hiding. In: Proc. of the 33rd Asilomar Conf. on Signals, Systems and Computers. 1999. 1503-1507.

[7] Cox J, Miller ML, McKellips AL. Watermarking as communications with side information. Proc. of the IEEE, 1999,87(7): 1127-1141.

[8] Hernandez JR. DCT-Domain watermarking technique for still image: Detector performance analysis and a new structure. IEEE Trans. on Image Processing, 2000,9(1):55-68.

[9] Fei CH, Kundur D, Kwong RH. Analysis and design of watermarking algorithms for improved resistance to compression. IEEE Trans. on Image Processing, 2004,13(2):126-144.

[10] Cheng Q, Huang TS. Blind digital watermarking for images and videos and performance analysis. In: Proc. of the Int'l Conf. Multimedia Expos. New York, 2000. 389-392.

[11] Cheng Q, Huang TS. An additive approach to transform-domain information hiding and optimum detection structure. IEEE Trans. Multimedia, 2001,3(9):273-284.

[12] Crous MS, Nowak RD, Baraniuk RG. Wavelet-Based statistical signal processing using hidden Markov models. IEEE Trans. on Signal Processing, 1998,46(4):886-902.

[13] Do MN, Vetterli M. Rotation invariant texture characterization and retrieval using steerable wavelet-domain hidden Markov models. IEEE Trans. on Multimedia, 2002,4(4):517-527.

[14] Watson AB, Yang GY, Solomon JA, Villasenor J. Visibility of wavelet quantization noise. IEEE Trans. on Image Processing, 1997,6(8):1164-1175.

[15] Lewis AS, Knowles G. Image compression using the 2-D wavelet transform. IEEE Trans. on Image Processing, 1992,1(2):244-250.

[16] Van Trees HL. Detection, Estimation and Modulation Theory. New York: John Wiley & Sons, 1968.

[17] Stirmark. <http://www.cl.cam.ac.uk/~fapp2/watermarking/stirmark/>

[18] Mayer J, Silva RA. Efficient informed embedding of multi-bit watermark. In: Proc. of the IEEE Int'l Conf. on Acoustics, Speech, and Signal Processing, ICASSP 2004. 2004. 389-392.

附中文参考文献:

[1] 黄继武,谭铁牛.图像隐形水印综述.自动化学报,2000,26(5):646-655.

[4] 黄达人,刘九芬,黄继武.小波变换域图像水印嵌入对策和算法,软件学报,2002,13(7):1290-1297.

<http://www.jos.org.cn/1000-9825/13/1290.pdf>

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