

# Reversible Data Hiding in Image Based on Wavelet Transform

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## ABSTRACT

This paper represents a new approach to reversible data-hiding using discrete wavelet transform in frequency domain. The continuous set of zero coefficient produced by quantization of the coefficients of the wavelet is used to conceal the data. Most of time, the amount of hidden data and the quality of the image are contradictive. As an advantage, our method can give consideration to both of the two issues. We first transform the cover-image with 3-order wavelet and then do quantization procedure. After doing FDWT & quantization procedures the cover-image were consists of several 64-pixel blocks, and the method presented in this paper is used to insert the secret information into the continuous zero coefficient in the blocks, and then apply wavelet reverse transformation to compose the stego-image. To extract the secret information, we first calculate the quantized wavelet transform coefficients from the stego-image. Compose each 64-pixel block by combining and permuting due to the extraction method, then using the extraction rules of the combination and permutation of each block to recover the secret information. Besides, the experiments of alternatively using Haar function for discrete wavelet transform and using 9/7 convolution discrete wavelet transform prove that our method offers expectable and acceptable quality and reversibility of the stego-image. The experiments use a general gray-level image as the cover-image and hide the randomly produced secret bits into this gray-level image, and the evaluation is done by calculating and comparing the amount of hidden data and the quality of the stego-image. Our method is improved from the method of Chang et al. in 2007 and the results of PSNR value and the amount of hidden data are 1.1 times higher than that of the results of Chang et al., respectively. The experiments show that not only the amount of the hidden data but also the quality of the stego-image are both improved in our method.

Keywords : discrete wavelet transformation ; reversible data hiding ; stego-image ; cover-image

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## REFERENCES

- [1] R.L. Rivest, A. Shamir, and L. Adelman, "A method for obtaining digital signatures and public-key cryptosystem," *Communications of the ACM*, vol. 21, no. 2, pp. 120 – 126, 1978.
- [2] W. Diffie and M.E. Hellman, "Exhaustive cryptanalysis of the NBS data encryption standard," *IEEE Computer*, vol. 10, pp. 74 – 84, 1977.
- [3] Y.K. Lee and L.H. Chen, "High capacity image steganographic model," *Proceedings of the IEE International Conference on Vision, Image and Signal Processing*, vol. 147, no. 3, pp. 288 – 294, 2000.
- [4] C.C. Chang, J.Y. Hsiao, and C.S. Chan, "Finding optimal least-significant-bit substitution in image hiding by dynamic programming strategy," *Pattern Recognition*, vol. 36, no. 7, pp. 1595 – 1683, 2003.
- [5] Chin-Chen Chang, Chih-Yang Lin, and Yu-Zheng Wang, "New image steganographic methods using run-length approach," *Information Sciences*, vol. 176, pp. 3393 – 3408, 2006.
- [6] K.L. Chung, C.H. Shen, and L.C. Chang, "A novel SVD- and VQ-based image hiding scheme," *Pattern Recognition Letters*, vol. 22, no. 9, pp. 1051 – 1058, 2001.
- [7] P. Tsai, Y.C. Hu, and C.C. Chang, "An image hiding technique using block truncation coding," *Proceedings of the Pacific Rim Workshop on Digital Steganography*, Kitakyushu, Japan, pp. 54 – 64, July 2002.
- [8] C.C. Chang, T.S. Chen, and L.Z. Chung, "A steganographic method based upon JPEG and quantization table modification," *Information Sciences*, vol. 141, pp. 123 – 138, 2002.
- [9] M. Iwata, K. Miyake, and A. Shiozaki, "Digital steganography utilizing features of JPEG images," *IEICE Transactions on Fundamentals E87-A*, no. 4, pp. 929 – 936, 2004.
- [10] H. Kobayashi, Y. Noguchi, and H. Kiya, "A method of embedding binary data into JPEG bitstreams," *IEICE Transactions on Fundamentals J83-D2*, no. 6, pp. 1469 – 1476, 2000.
- [11] Chin-Chen Chang, Chia-Chen Lin, Chun-Sen Tseng, and Wei-Liang Tai, "Reversible hiding in DCT-based compressed images," *Information Sciences*, vol. 177, Issue 13, pp. 2768-2786, 1 July 2007.
- [12] J. Tian, "Reversible data embedding using a difference expansion," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 13, no.8, pp. 890 – 896, 2003.
- [13] M.U. Celik, G. Sharma, A.M. Tekalp, and E. Saber, "Lossless generalized-LSB data embedding," *IEEE Transactions on Image Processing*, vol. 14, no. 2, pp. 253 – 266, 2005.
- [14] J. Fridrich, M. Goljanb, and R. Du, "Invertible authentication watermark for JPEG images," *IEEE International Conference on Information Technology: Coding and Computing*, Las Vegas, Nevada, April 2 – 4, pp. 223 – 227, 2001.
- [15] G. Xuan, J. Zhu, J. Chen, Y.-Q. Shi, Z. Ni, and W. Su, "Distortionless data hiding based on integer wavelet transform," *IEE Electronics Letters*, vol. 38, no. 25, pp. 1646 – 1648, 2002.