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An adaptive image steganography using AMBTC compression and interpolation technique

Mingwei Tang[a,*], Shenke Zeng[a], Xiaoliang Chen[a], Jie Hu[b], Yajun Du[a]

[a] School of Mathematics and Computer Science Technology, Xihua University, Chengdu 610039, China
[b] School of Information Science and Technology, Southwest Jiaotong University, Chengdu 610031, China

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ABSTRACT

It is a hot topic in the design of information hiding algorithm by a combination of compressed technique and interpolation technique in the future. Higher capacity and better image quality are one of the foremost research contents of information hiding. In recent years, an adaptive information hiding has been a hot content of research in the field of information hiding and network security. This paper proposed an adaptive image steganography using absolute moment block truncation coding compression (AMBTC compression) and interpolation technique (ASAI), which can improve the performance of information hiding scheme. The ASAI scheme proposed can offer the benefits of high embedding capacity with low computational complexity and good image quality. The experimental results demonstrate that the proposed ASAI scheme has superior performance than others.

1. Introduction

Steganography or information hiding is early from the Greek word “steganos” and means concealed “writing” [1]. With the development of network and image processing techniques, there are a lot of images in the network since 21 century. The redundancy of digital image pixels has led to the rapid development of image steganographic techniques. Steganographic techniques had been proposed to hide information into a cover image without showing visual difference on the image itself. The performance of a steganographic method will be judged by its transparency, robustness, statistical undetectability and capacity provided. Now, an adaptive information hiding method is another hot research topic in the field. A steganographic algorithm should have a big capacity, statistical undetectability and better transparency. However, these criteria are often mutually exclusive each other. It is difficult for researchers to balance all these factors simultaneously. High embedding capacity and undetectability are two main properties which demanded to be carefully considered in the practical applications.

The capacity and quality of image are often considered in the design of information hiding algorithms. Hiding information introduces inevitably image some distortion. In some applications of military images and medical images, any distortion produced is not acceptable. So, reversible information hiding techniques are proposed to solve the problem. Barton proposed the initial reversible information hiding method [2]. The algorithm showed that if and if it was authenticated, the digital information block might be restored to its original image. Celik et al. [3] presented a novel reversible (lossless) information hiding (embedding) method, which enabled the exact recovery of the original image on the process of the embedded information extraction. Tian [4] presented a novel reversible information embedding algorithm for digital images. The method explored the redundancy in digital images to gain very high embedding capacity when keeping the distortion low. Ni et al. [5] proposed a novel reversible information hiding algorithm. The method used the minimum or the zero points of the histogram of image and slightly changed the pixel grayscale values to hide information into the image. Based on a binary tree structure, Tai et al. [6] solved the problem of communicating pairs of peak points. While keeping the distortion low, the method obtained large hiding capacity by utilizing distribution of pixel differences. Li et al. [7] proposed a new reversible watermarking method which uses prediction-error expansion (PEE), pixel selection and adaptive embedding. By calculating the absolute difference of its neighboring pixels, Chang et al. [8] proposed a reversible information hiding method which could judge whether a pixel is embeddable or not. Tang et al. [9] proposed a high capacity information hiding scheme using multi-layer embedding (CRS), which could enhance the performance of information hiding system while keeping the distortion low. But, they all used raw image

* Corresponding author. Tel.: +86 028 87720101.
E-mail address: tang4415@126.com (M. Tang).

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formats rather than the compressed image formats. In the network transmission, the transmission efficiency is also very important due to the lack of bandwidth. The above methods have made some achievements. Therefore, it is meaningful to explore reversible information hiding in compressed domain because the transmission bandwidth is restricted.

So far, there are a number of compression algorithms or techniques proposed, including discrete wavelet transform (DWT) [10], discrete cosine transform (DCT) [11], number theoretic transform (NTT) [12], vector quantization (VQ) [13] and side match vector quantization (SMVQ)[14]. These methods can reduce the transmission size of multimedia files, such as image and so on, on the Internet. The latter two are two famous block-based image compression techniques. In 2005, Yang et al. [15] first presented a reversible images watermarking method using VQ-compressed by modifying fast correlation VQ (MFCVQ). However, very low hiding capacity was the lack of Yang et al.'s method. To make up for the shortcoming of Yang et al.'s scheme, Lu et al. [16] designed a reversible information hiding method which using the VQ-index residual value coding technique. Lee et al. [17] proposed a novel highly efficient lossless information hiding scheme to achieve the aim of hiding secret information into vector quantization (VQ)-compressed images which could be losslessly recreated when the secret information was extracted in the receiver.

Delp et al. [18] proposed the block truncation coding (BTC) which was another efficient lossy block-based image compression scheme besides VQ compression technique and SMVQ compression technique in 1979. High efficiency and an acceptable compression rate were obtained for image compression using BTC transforms technique. Chang et al. [19] proposed reversible information hiding method for block truncation coding compressed (BTC-compressed) color images. In order to increase the compression rate, the original three was replaced by an approximate optimal common bitmap using a genetic algorithm (GA). By introducing the joint neighboring coding (JNC) to BTC-compressed images, Sun et al. [20] presented a reversible data hiding scheme to enhance the hiding capacity. The extra information is needed in the process of their reconstructed images and cannot be obtained by a conventional BTC-decoding scheme directory for Chang et al.'s method and Sun et al.'s scheme. This made a hidden secret information insecure. Li et al. [7] proposed a reversible data hiding scheme for BTC-compressed images in order to improve the security of embedded confidential information. The flipping and histogram shifting bitmap are used for the high mean values and low mean values. But, hiding capacity is not acceptable.

Maximo and Mitchell [21] presented an absolute moment block truncation coding technique (AMBTC technique) in 1984. AMBTC technique is an optimizational variant of BTC technique. It can further deflate the size of the compression codes while providing the same image quality for the compressed image by BTC. To improve the hiding capacity and obtain the good quality of the stego image after embedding secret information, Lin et al. [22] presented a reversible data hiding scheme that is based on the absolute moment block truncation coding compression (AMBTC-compression) domain. The method could judge whether the block is embeddable or non-embeddable by utilizing the redundancy in a block of AMBTC-compressed images. The method designed four disjoint sets, including scenario (00), scenario (01), scenario (10) and scenario (11). By using different combinations of the mean value and the standard deviation, four disjoint sets are constructed for embeddable blocks to embed information. The method can not only achieve very high embedding capacity, but also keep the distortion low. However, when the number of different values of the current sub-block is 1 or 2, there are no secret bits embedded in the current sub-block and subsequent sub-blocks. In the current block, this often happens when all of secret information are 1 or 0 in a sub-block. This will result in the algorithm failure.

In order to improve the reliability and robustness of algorithm, increase the hiding capacity and maintain the quality of the stego image after embedding the secret information, in this paper, we proposes an adaptive image steganography using the absolute moment block truncation coding compression (AMBTC-compression) and interpolation technique (ASAI). The paper can embed adaptively secret information by using different combinations of the high mean value and the low mean value to improve embedding capacity and obtain the distortion low. The rest of this paper is organized as follows. Section 2 introduces the image AMBTC-compression technique proposed by Maximo and information hiding schemes proposed Lin et al. Section 3 describes the proposed information hiding scheme in detail how an improvement in the image information hiding method can improve the embedding capacity while preserving better image quality. Section 4 shows the experimental results and performance analysis. Conclusions and future work are finally drawn in Section 5.

2. Related work

Throughout this article, we will describe absolute moment block truncation coding (AMBTC) in Section 2.1. Next, related AMBTC-compression based reversible information hiding method that will be used to compare with our proposed scheme are presented in Section 2.2. Discussions of their limitations are also contained in the same section. Let a $W \times R$ size input image be "I". The input image "I" is changed down into 1/4 of its initial size, which then becomes the original image O by AMBTC-compression. That is, the length and width of the original image O become $W/2$ and $R/2$, respectively. It then uses image interpolation to process this scaled up the original image into a cover image of size $W \times R$ before embedding secret information. A stego-image is produced after secret information has been embedded in the cover image.

2.1. Absolute moment block truncation coding (AMBTC) [21]

In 1984, to improve the compression performance, Maximo and Mitchell. [21] proposed a performance optimization variation of BTC called absolute moment block truncation coding compression (AMBTC-compression). The AMBTC-compression scheme preserves the first absolute moment along with the mean value instead of using the standard deviation. In AMBTC-compression scheme, an image is first decomposed into some non-overlapping $k \times k$-sized sub-blocks, such as 2×2, 3×3 or 4×4 and so on. k is often set to be 4 in the conventional AMBTC encoding phase. For pth sub-block, its sample mean pixel value $Avg_{(p)}$ and its sample absolute central moment $Var_{(p)}$ are then described in Eq. (1).

$$Max = \lfloor \frac{W}{k} \rfloor \times \lfloor \frac{R}{k} \rfloor, \quad Avg_{(p)} = \frac{\sum_{i,j}^{k,k} O_{(i,j)}}{k \times k},$$

$$Var_{(p)} = \frac{\sum_{i,j}^{k,k} |O_{(i,j)} - Avg_{(p)}|}{k \times k} \qquad k = 2, 3, 4, \ldots;$$

$$p = 0, 1, \ldots, Max - 1. \tag{1}$$

Table 1
Four different scenarios for each pixel in a given sub-block.

Scenarios	Scenario (00)	Scenario (01)	Scenario (10)	Scenario (11)
Secret bit m	0	0	1	1
Bit in bitmap BM	0	1	0	1