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Reversible Data Hiding Based on Adaptive Block Selection Strategy

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ABSTRACT

Recently, a reversible data hiding (RDH) method was proposed based on local histogram shifting. This method selects the peak bin of the local histogram as a reference and expands the two neighboring bins of the peak bin to carry the message bits. Since the peak bin keeps unchanged during the embedding process, the neighboring bins can be easily identified at the receiver end, and the original image can be restored completely while extracting the embedded data. In this article, as an extension of the algorithm, the authors propose an RDH scheme based on adaptive block selection strategy. Via a new block selection strategy, those blocks of the carrier image may carry more message bits whereas introducing less distortion will take precedence over data hiding. Experimental results demonstrate that higher visual quality can be obtained compared with the original method, especially when the embedding rate is low.

KEYWORDS

Block Selection, Histogram Shifting, Localization, Reversible Data Hiding, Visual Quality

INTRODUCTION

Reversible data hiding (RDH) technique aims to embed message bits into a carrier image by slightly modifying its pixels, and more importantly, it can completely restore the original carrier image while extracting the embedded data from the marked image. As a special case of information hiding, RDH can be applied to some areas when the reversibility is desirable, such as medical and military image processing.

Many RDH algorithms have been proposed so far. Basically, there are three fundamental strategies: lossless compression (Celik, Sharma, Tekalp, & Saber, 2005; Fridrich, Goljan, & Du, 2002), difference expansion (Hu, Lee, & Li, 2009; Sachnev, Kim, Nam, Suresh, & Shi, 2009; Tai, Yeh, & Chang, 2009; Tian, 2003), and histogram shifting (Huang, Qu, Kim, & Huang, 2016; Ni, Shi, Ansari, & Su, 2006; Xuan, Shi, Ni, Chai, Cui, & Tong, 2007). The lossless compression-based methods apply lossless compression to the carrier image, and utilize the statistical redundancy to create a free space for data hiding. This strategy has received less attention recently, since it cannot provide large embedding capacity and may lead to severe degradation in image visual quality. The difference expansion (DE) strategy was firstly proposed by Tian (Tian, 2003), where the carrier image is divided into pixel pairs and the difference value of two pixels in a pair is expanded to carry one message bit. The histogram shifting (HS) strategy was proposed by Ni et al. (Ni, Shi, Ansari, & Su, 2006). The method utilizes the peak bin of the original histogram of the carrier image for data hiding. After that, many RDH algorithms based on HS strategy have been proposed. Recent research has demonstrated that the HS

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strategy can also be applied to the difference histogram and the prediction-error histogram (Li, Li, & Yang, 2013; Li, Yang, & Zeng, 2011; Li, Zhang, Gui, & Yang, 2013; Li, Li, Li, & Yang, 2013; Li, Zhang, Gui, & Yang, 2017; Ou, Li, Zhao, Ni, & Shi, 2013; Peng, Li, & Yang, 2014; Wu, & Sun, 2014; Huang, Huang, & Shi, 2016), which can achieve larger embedding capacity and better image visual quality.

In 2015, Pan et al. (Pan, Hu, Ma, & Wang, 2015) proposed a novel RDH algorithm based on local histogram shifting. In this method, the peak bin of the local histogram of the carrier image is selected as the reference bin, and the two neighboring bins of the peak bin are expanded to carry message bits. Although Pan et al.'s method achieves large embedding capacity, it may result in unsatisfactory image visual quality, because some of the blocks that will introduce much distortion may be selected for data hiding, even if the embedding rate is low.

In this paper, we propose a new adaptive RDH scheme based on Pan et al.'s method. The main idea of the proposed method is to design an adaptive block selection strategy, and thus the blocks with higher embedding capacities and less distortion will take precedence for data hiding. Compared with Pan's method, the proposed method keeps the same maximum embedding capacity, and achieves better image visual quality at the same payload. Extensive experimental results demonstrate the effectiveness of the proposed method.

The rest of this paper is organized as follows. In Section 2, Pan et al.'s scheme is introduced. Section 3 presents the proposed method in detail. The experimental results are given in Section 4, and the conclusion is drawn in Section 5.

1. PAN ET AL.'S METHOD

In 2015, Pan et al. proposed a RDH method based on local histogram shifting. The embedding procedure is as below. First, divide the pre-processed (the pre-processing process will be introduced at the end of this section) carrier image I into non-overlapping blocks with the size of $s \times s$. Then, for each block B, its local histogram is obtained. Suppose that B_p is the grayscale value of the pixels associated with the peak bin of the local histogram. The embedding algorithm of Pan et al.'s RDH scheme can be described as Equation (1),

$$B'_{i,j} = \begin{cases} B_{i,j} - 1 & if\ 1 \le B_{i,j} \le B_p - 2 \\ B_{i,j} - b & if\ B_{i,j} = B_p - 1 \\ B_{i,j} & if\ B_{i,j} = B_p \\ B_{i,j} + b & if\ B_{i,j} = B_p + 1 \\ B_{i,j} + 1 & if\ B_p + 2 \le B_{i,j} \le 254 \end{cases} \tag{1}$$

where $b = \{0, 1\}$ denotes the message bit to be embedded, $B_{i,j}$ represents the pixel value at the position (i, j) in the block B, and $B'_{i,j}$ represents the pixel value at the position (i, j) in the embedded block B'.

The message extraction and image restoration can be described as Equation (2) and Equation (3),

$$b' = \begin{cases} 0 & if\ B'_{i,j} = B_p + 1\ or\ B_p - 1 \\ 1 & if\ B'_{i,j} = B_p + 2\ or\ B_p - 2 \end{cases} \tag{2}$$