HIGH CAPACITY DATA HIDING USING SEMI-HEXAGONAL PIXELS VALUE DIFFERENCE

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ABSTRACT

This paper proposes a novel data hiding scheme that employs human visual sensitivity (HVS) to hide a large amount of secret bits into a still image with a high imperceptibility. In this method, the cover image is divided into sub-blocks of semi-*hexagonal shape. The embedding technique is based on pixel value difference (PVD) approach. The semi-hexagonal (SH-PVD) technique enjoys better objective and subjective qualities over the standard PVD methods.*

It has been found that the capacity of the proposed algorithm is higher than that of the most recent published algorithms. The simulation results give an increased in the capacity ranged between 10348 to 366637 bits. The visual quality of the cover images is of excellent quality. The new algorithm adds no complexity to the existing PVD methods.

Keywords – High capacity data hiding, Steganography, Human visual system (HVS).

1. INTRODUCTION

Steganography aims to hide secret information such that its presence cannot be detected. Secret messages are encoded in a manner such that the very existence of the information is concealed. Paired with existing communication methods, steganography can be used to carry out hidden exchanges [1] - [2].

In steganography, image quality and security are two important factors. Quality implies that stego cover image should not be visually distinguished from the original digital cover, while security implies that the message should be undetectable and no one other than the eligible person should be able to extract the secret message [1].

In this paper, the pixel value differencing is adapted with LSB replacement methods proposed in [3] for data hiding with some modification. The cover image is divided into sub-blocks of semi-hexagonal shapes and then, the PVD concept is implemented. This method enjoys better objective and subjective qualities over the standard square shaped PVD given in [3] – [4]. Also, it embeds more secret data bits than that in the above two methods without any additional complexity.

This paper is organized as follows: An introduction is presented in Section 1. The semi-hexagonal algorithm is described in Section 2. The proposed technique is discussed in Section 3. The simulation results and comparison with other methods are given in Section 4. Conclusions are presented in Section 5.

2. THE SH-ALGORITHM

The autocorrelation function (R_{xx}) for a block with highly correlated pixels (stationary field) can have several kinds of models. According to experimental data, the most appropriate model to images of natural objects is the isotropic model [5]. This model is given by:

$$R_{xx}(k_h, k_v) = \sigma_{xx}^2 \rho^{d_{k_h k_v}} + \eta_x^2 \qquad (1)$$

Where σ_{xx}^2 is the ensemble variance, η_x is the ensemble mean, ρ describes the amount of correlation, and $d_{k_h k_v}$ is the Euclidean distance = $\sqrt{k_h^2 + k_v^2}$.

For Isotropic autocorrelation function [5]:

$$E\{\sigma^2\} = \sigma_{xx}^2 \left\{ 1 - \frac{1}{m^2} \sum_{i=1}^{m} \sum_{j=1}^{m} \rho^{d_y} \right\}, \qquad (2)$$

minimizing $E\{\sigma^2\}$ implies maximizing the quantity $\sum_{i=1}^{m} \sum_{j=1}^{m} \rho^{d_y}$ for a given block of size m.

Unfortunately most of the resulting optimum block shapes (close to circular shape) cannot cover the whole image without overlapping. The proposed algorithm has been developed to find sub-optimum block shapes with some constraints that prevent the overlapping blocks. In previous work, an algorithm for video compression called " Semi-Hexagonal absolute moment block truncation coding" SH-AMBTC have been developed [6]. The shapes of these blocks are close to hexagonal. It has been found that SH-AMBTC gave an improvement in the objective quality (reduction of MSE) over the standard AMBTC. Also, the SH-sub-block method improves the subjective quality. This is gained without any additional complexity [6]. This improvement is due to the fact that the block edges are not as sharp as those of the squared sub-block. Another reason for the improvement of the subjective quality is due to the fact that the blocks in the SH-sub-block are organized in interlaced lattice (quincunx pattern) rather than rectangular lattice as in the standard sub-block as shown in Figure 1. The quincunx pattern is generally found to be superior in terms of subjectively judged image quality [7]. In this paper, the same concept is adapted for high capacity data hiding.

3. THE PROPOSED TECHNIQUE

The goal of the proposed (SH-PVD) method is to increase hiding capacity with improving image visual quality. The PVD with 3LSB method proposed in [3] is adopted. To achieve this goal, cover image is divided into sub-blocks of size 4x4 pixels each. The embedding of data is applied on two consecutive pixels vertically. It depends on the pixel value differencing with three least significant bits method. The proposed method consists of two main procedures: the embedding procedure and the extraction procedure. Some details of each phase will be described in the following subsections.

3.1 Embedding Phase

Given a gray level cover image of NxN pixels, the image is divided into Semi-Hexagonal sub-block of size 4x4 pixels as shown in figure 1. Figure 2 shows the embedding process using semi-hexagonal block and square block. The data hiding processing steps of the embedding will be described as follows:

Step 1: Start with the first block in the corners pixels p_1, p_4, p_{13}, and p_{16}; respectively. Transform the pixels values into binary, and then replace the three least significant bits of the pixels values by three bits from the data stream. Reconvert the pixels values to decimal. Now already 12 bits are hidden into the corners pixels.

Step 2: Calculate the distance $d\ (p_2, p_6)$ which is given by $d(p_2, p_6) = |p_2 - p_6|$.

Step 3: Find the optimal R_i of $d(p_2, p_6)$ such that $R_i = min\ (u_i - k)$, where $u_i \geq k$, $k = d(p_2, p_6)$ and $R_i \in [l_i, u_i]$ is the optimum R_i for all $1 \leq i \leq n$.

We must judge the level of the optimal R_i, if R_i belongs to a higher-level, and proceed with the next step by using PVD method until data is hidden or hide 6-bit secret data into the two successive pixels.

Step 4: Repeat step 2 and step3 for (p_5, p_9), (p_{10}, p_{14}), (p_3, p_7), (p_{11}, p_{15}), and $(p_8\ p_{12},)$.

Step 5: Repeat steps 1 to 4 on the remaining sub blocks until the cover image is finished.

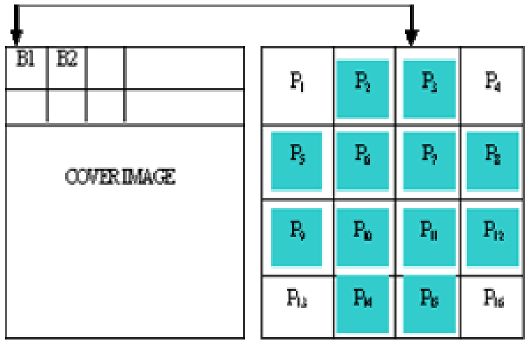

Figure 1. The shaded pixels represent the Semi-Hexagonal sub-block of size 4x4 pixels.

3.2 Extracting Phase

The following steps are executed to recover the original secret data.

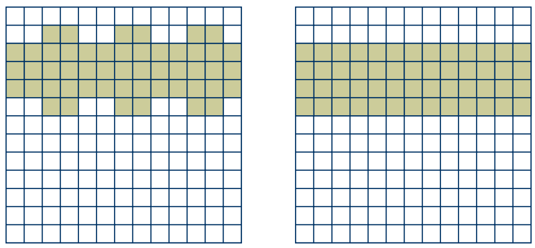

Figure 2. The image covered by: (a) – Semi-Hexagonal block, (b) – Square block.

Step 1: Partition the stego-image into sub-blocks of size 4x4 pixels each, and the partition procedure is identical with that used for embedding.

Step 2: Start with the first block in the corners pixels p_1', p_4', p_{13}', and p_{16}'; respectively. Transform pixels values into binary, and extract the 3-LSB of each pixel directly.

Step 3: calculate the distance d'(p_2', p_6').

Step 4: Find the optimal R_i of the $d'_i(p_2', p_6')$ according to the original range table and judge the level of the optimal R_i. Then, extract secret data by using Wu and Tsai's (PVD) method [3]. If R_i belongs to the higher-level carry out the next step to extract secret data; otherwise, proceed to Step 5.

Step 5: Extract the 3-LSB of the p_2' and p_6' of the stego-image directly, so the 3-LSB of the p_2' and p_6' is represented by the hidden secret data.

Step 6: repeat steps 3 to 5 on the remaining pixels (p_5', p_9'), (p_{10}', p_{14}'), (p_3', p_7'), (p_{11}', p_{15}'), and (p_8', p_{12}') pixels of the first block.

Step 7: Repeat steps 2 to 6 on the remaining sub blocks of the stego image.

4. EXPERIMENTAL RESULTS

In this section, some experimental results for the proposed data hiding algorithm will be presented and compared it with the latest published techniques in literature. Two types of messages (secret data) have been used in this study. These data are a random data stream and a text file.

We set the range table with $w_i \in \{8, 8, 16, 32, 64, 128\}$ and Div is 15. The lower-level ranges are R_1, and R_2. The higher-level ranges are R_3, R_4, R_5, and R_6. Four cover images (Lena, Baboon, Pepper and Jet) are used. These test images are of size 512 x 512 pixels each. The performance of the proposed method is evaluated in terms of visual quality the of stego images, the maximum embedding capacity that cover images can carry, and the PSNR(dB). The stego images are displayed and this performance is measured.

Figures 3 and 4 give a comparison between the proposed (SH-PVD) algorithm and the PVD techniques given in [3] – [4]. It can be seen that the visual quality of the stego image using our approach is better than PVD algorithms and very comparable to the original cover image.

Table 1 shows the capacity and PSNR (dB) for the four test images. The hidden data used in this paper are regular text of more than 20 pages (A4) and random numbers as shown in Table 1. Table 2 gives a comparison between the proposed technique and other published algorithms for the test image (Lena). It can be seen that the PSNR (dB) of our method is improved with about 0.6 dB more than PVD with 3LSB method. Moreover, the visual quality of the proposed method is found to be better than all other technique and same as the visual quality of PVD given in [4]. The capacity is higher than other algorithms. The increase in capacity is ranged between 10348 to 366637 bits as shown in table 2.

Table 1. Experimental results of the SH-PVD method for random numbers and text.

		Random	Text
Cover Image 512x512	Capacity (bits)	PSNR (dB)	PSNR (dB)
Lena	776390	37.631	37.602
Baboon	733975	34.383	34.383
Peppers	775743	37.129	37.261
Jet	773579	37.198	37.167

Table 2. Comparison between our proposed method with published researches for the cover image Lena.

Method	PVD [5]	PVD + LSB [6]	Overlapping PVD [8]	SH-PVD Method
Capacity (bits)	409753	766042	763138	776390
PSNR (dB)	41.024	37.09	36.92	37.64
Visual Quality	Excellent	Acceptable	Acceptable	Excellent

5. CONCLUSIONS

In this paper, an algorithm based on that proposed by H.-C. Wu, N.-I. Wu, C.-S. Tsai and M.-S. Hwang in [3] has been designed, with emphasis on the human visual quality using Hexagonal approach. The performance of our algorithm has been compared with other published methods in terms of the visual quality of the stego-images and the amount of embedded data (capacity) in the cover images. It has been found that our proposed algorithm gives higher performance than that given in [3] –[4]. Also, the proposed method has been compared with recent results reported by Chin-Chen Chang, Jun-Chou Chuang, and Yu-Chen Hu in [8]. It turned out that the capacity is higher than that of other algorithms, and ranged between 10348 to 366637 bits for Lena test image as shown in table 2. Figures 3 and 4 show the visual quality of the cover images for Lena and Baboon test images. It can be seen that stego image is of excellent quality.

Figure 3. The Visual quality of the SH-PVD algorithm compared with PVD methods for Lena image. (a) Original, (b) PVD method, (c) PVD + 3LSB method, (d) SH-PVD method.

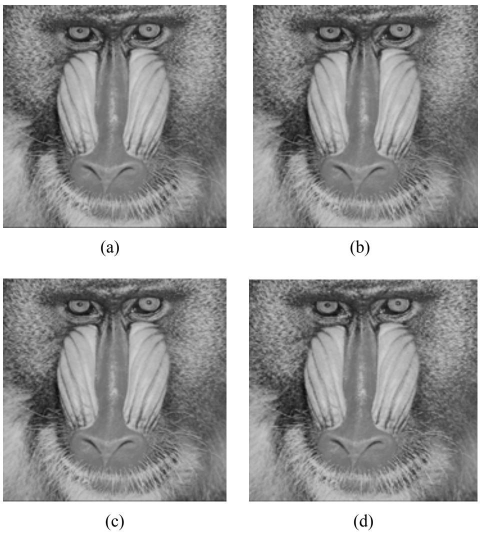

Figure 4. The Visual quality of the SH-PVD algorithm compared with PVD methods for Baboon image. (a) Original, (b) PVD method, (c) PVD + 3LSB method, (d) SH-PVD method.

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