A Reversible Data Hiding Scheme Using Segmentation Strategy and Histogram Adjustment

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Abstract. Because a stego medium is easier to cheat an unexpected user's observation, Steganography technique is more suitable for delivering secret data. Histogram adjustment is a good way for concealing secret data into a cover image with small distortion. The proposed method is to increase the height of peak in difference histogram as many as possible.

Keywords: Data hiding, Histogram adjustment, Steganography

1 Introduction

Vleeschouwer et al. presented a reversible data hiding technique by using histogram adjustment [6]. Ni et al. also utilized histogram adjustment concept to design a data hiding technique with reversibility [5]. Ni et al.'s method analyzes the pixels distribution in a cover image to generate the histogram and then to figure out the peak point and zero point. After that the secret data is concealed into cover image by adjusting the histogram. Hwang, et al. presented a reversible data hiding technique [1] to achieve the reversibility by extending Ni et al.'s method. Further, Lin and Hsueh utilized bin exchange to modify histogram for increasing pure embedding capacity and get lower distortion [3]. Then, Kim et al. presented a histogram shift based reversible data hiding scheme which selects two peak points and zero points for increasing the embedding capacity [2]. Luo et al. applies pixel prediction strategy to generate the prediction error [4]. Because a higher peak point can get a larger embedding capacity in histogram modification based method. The proposed method uses segmentation strategy for trying to increase the height of peak point for improving the performance of data embedding.

2 The Proposed Method

The proposed method segments the range of difference between a maximum and minimum pixels in a block into several segments. For every segment, a pseudo

pixel will generated by calculating the central point of the segment. In order to achieve the reversibility, the border blocks will be reserved for concealing the extra data. Here, the extra data include the Left Zero (LZ), Left Peak (LP), Right Peak (RP), Right Zero (RZ), and non-embeddable blocks' information. Further, the secret data stream $S = \{b_k | k = 1, 2, \ldots, N_S\}$, where $b_k \in \{0, 1\}$ and N_S represents the length of the secret stream. For a block B_i, except reserved blocks, calculate the length $D_i = B_{\max} B_{\min}$ between the maximum pixel $B_{\max} = \max\{x_j \in B_i\}$ and minimum pixel $B_{\min} = \min\{x_j \in B_i\}$ in B_i. According to the proposed embedding procedure, some blocks that cannot be used to conceal data are called non-embeddable blocks when a block satisfies one of following cases.
Case 1: If $D_i < N_{seg}$, then do nothing.
Case 2: $B_{\min} \leq N_{seg}$, then add $B_{\min}$ to extra data and set $B_{\min}$ as 0.
Case 3: $B_{\max} \geq 255 N_{seg}$ then add $B_{\max}$ to extra data and set $B_{\max}$ as 255.
In order to reduce the size of extra information, the extra information is compressed by using data compression algorithm.

Next, for embeddable block B_i, $B_{\min}$ and $B_{\max}$ where modified as $B'_{\min} = B_{\min} - N_{seg}$ and $B'_{\max} = B_{\max} + N_{seg}$. After that, segment the range D_i into N_{seg} segments. The original pixel will also be adjusted for prevent ambiguous problem. The adjusting rule is making a gap (2 pixels) between two neighboring segments. Then, generate the pseudo pixel for each segment. The pseudo pixel is calculated by $\lfloor (seg_k^{\max} - seg_k^{\min})/2 \rfloor$, where $seg_k^{\max}$ and $seg_k^{\min}$ represent the maximum and minimum value of k-th segment for a block, respectively.

Then, the difference image is generated by calculating the difference between original pixels and pseudo pixels. After that, the difference histogram can be gained by statistically counting the difference values from whole image. Then, scan the histogram to figure out LP and RP. Then, scan the histogram to figure out the LZ and RZ. Then decrease the difference histogram between LZ to LP-1 by one to make LP-1 become zero. Again, increase the histogram between RP+1 to RZ by one to make RP+1 become zero. Thus, the secret can be embedded by checking the pixel difference equivalent to LP or RP.

The extracting procedure is a reverse work from the embedding procedure. First, the extra information can be extracted by taking the LSB bits from the reserved blocks. Then, the LP, RP, LZ, and RZ information can be reconstructed. Then, calculate the difference D_i between $B_{\min}$ and $B_{\max}$. If $D_i < 2 \times N_{seg}$, then the block is a non-embeddable block. Also, if $B_{\min} = 0$ or $B_{\max} = 255$, the block is non-embeddable, otherwise, the block is embeddable. In **Case 2**, the pixels equal to $B_{\min}$ will be reconstructed by using the information from extra data. In **Case 3**, the pixels equal to $B_{\max}$ will reconstructed by using the information from extra data. For an embeddable block, the segment length is calculated by $\lfloor D_i / N_{seg} \rfloor$.

After finishing the segmentation procedure, generate the pseudo pixel for every segment and calculate the difference between pixel and pseudo pixel. The secret data extraction can be done by using following rules.
Rule 1: If the difference equal to LP-1 or RP+1 then output secret bit '1'.

Rule 2: If the difference equal to LP or RP, then output secret bit '0'. If the difference is located in LP-2 to LZ then increase the difference by one. If the difference is located in RP+2 to RZ, then decrease the difference by one. After that, the pixels will be reconstructed by calculating pseudo pixel plus difference. Finally, the pixel is readjust to the original.

3 The Experimental Results

The visual quality of stego image and embedding capacity are two most important factors for evaluating a data hiding technique performance. Peak-signal-to-noise-ratio (PSNR) is adopted for measuring the visual quality of stego image. On the other hand, the embedding capacity is to count the total bits embedded into a cover image. From experimental results, we found that a complex content image (e.g., Baboon) will get higher embedding capacity when the segment number increased. In general content image (e.g., Lena), 5 is a suitable segment number. The proposed method has better performance than Luo et al.'s method in terms of embedding capacity when the segment number is greater than 1.

4 Conclusions

The proposed scheme utilizes the segmentation strategy for trying to increase the height of peak point in histogram as many as possible. From experimental results, the proposed method significantly improves the performance of Luo et al.'s method in terms of embedding capacity.

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