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Forward Modified Histogram Shifting based Reversible Watermarking with Reduced Pixel Shifting and High Embedding Capacity

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Abstract

The modified histogram shifting method proposed by Hong et. al.(2010) is best method of reversible watermarking[16]. The shifting of pixels are more in Hong et. al.(2010) method. Even Hong et. al.(2010) method of modified histogram shifting has less embedding capacity and do not provide enough quality for general purpose image. Our forward modified histogram shifting method overcomes all these drawbacks of Hong et. al.(2010) method. Generally PSNR decreases when embedding capacity increases and shifting pixels also increases. But our modified histogram shifting method optimizes all these factors. Our forward modified histogram shifting method shifts required pixel values to right by 'n-1' numbers. 'n-1' may be 1,2,3 and so on. This also increases embedding capacity approximately to (n-1) times maximum number of pixels in the histogram. The complexity of our forward modified histogram shifting method is same as that of Hong et. al. (2010) modified histogram shifting method as both scans image twice during processing.

Keywords: Reversible Watermarking, histogram shifting, embedding capacity, processing time, PSNR, forward method.

Introduction

The earliest reference to reversible data embedding we could find is the Barton patent, filed in 1997[1]. In his invention, the bits to be overlayed will be compressed and added to the bitstring, which will be embedded into the data block. Honsinger et al.[2] utilised a robust spatial additive watermark combined with modulo additions to achieve reversible data embedding, also reconstructed the payload from an embedded image, then subtract the payload from the embedded image to losslessly recover the original image. Goljan et al.[3] proposed a two cycles flipping permutation to assign a watermarking bit in each pixel group. Celik et al.[4] presented a high capacity, reversible data-embedding algorithm with low distortion by compressing quantisation residues. Tian[5] presented a reversible data embedding approach based on expanding the pixel value difference between neighbouring pixels, which will not overflow or underflow after expansion. Thodi and Rodrguez[6] exploited the inherent correlation among the neighbouring pixels in an image region using a predictor. Xuan et al.[7] embedded data into high-frequency coefficients of integer wavelet transforms with the companding technique, and utilised histogram modification as a preprocessing step to prevent overflow or underflow caused by the modification of wavelet coefficients.

Macq[8] proposes an extension to the patchwork algorithm to achieve reversible data embedding. Fridrich, *et al.*,[9] developed a high capacity reversible data-embedding technique based on embedding message on bits in the status of group of pixels. They also describe two reversible data-embedding techniques for lossy image format JPEG. De Vleeschouwer, *et al.*,[10]proposed a reversible data-embedding algorithm by circular interpretation of bijective transformations. Kalker, *et al.*, [11]provide some theoretical capacity limits of lossless data compression based reversible data embedding and give a practical code construction. Celik, *et al.*[4],present a high capacity, low distortion reversible data-embedding algorithm by compressing quantization residues. They employ the lossless image compression algorithm CALIC, with quantized values as side-information, to efficiently compress quantization residues to obtain high embedding capacity.

Petitcolas et.al. in 1999 [12]have introduced data hiding initially for a copyright protection. Lin and Tsai, 2004[13], Lin and chen 2000[14] and Zhicheng Ni, Yun-Qing Shi, Nirwan Ansari, and Wei Su, 2006[15] have introduced copy right protection for which data are embedded. Rich redundancies provided by digital images are very suitable for data embedding because some redundancies are easily replaced by the data bits. To conceal data image into an cover image pixel values are modified. This cause certain distortion in image. This type of image is called watermarked image. Usually the distortion in the data hiding is not reversible, hence we can say that original image cannot be recovered to its original state after watermark is extracted. On the contrary, a reversible watermarking has the capability to restore original image. Some times, it is very important to have original image. For example a misreading of an x- ray picture may cause misdiagnosis of a patient.The techniques in the reversible watermarking can roughly be categorized into five types, namely Difference expansion[5], Histogram shifting[16], Contrast Mapping, Integer Wavelet Transform,modulo 256 addition [3], lossless multi resolution transform [8], lossless compression [4], [20], invertible noise adding [4], circular interpretation of bijective transformation [10],[21], etc. All other techniques are explained above. Here we have proposed increased embedding capacity histogram shifting technique.

Histogram shifting technique presented by Ni. Et. Al.[16], have disadvantage that it has more complexity due to image is scanned three times. A modified histogram shifting is presented by Wien Hong, Tung Shou Chen, Kai yung Lin, Wen Chin Chiang(2010)[16], who reduced complexity and improved quality of image. He presented a restricted payload by the distribution of pixel values. In general as an image histogram with greater peak height, the image should have a greater payload. This drawback is reduced in our proposed method.

Proposed Method

Embedding

Input: Original 8 bit grayscale image I, with MxN pixels and watermark Iw.

Output: Watermarked image Iw, the peak point a, the minimum point b, length of watermark and the location map L.

Step 1: Scan the image I and construct it's histogram H(x)Є[0, 255]. In this histogram obtain peak point a and less point b which is equal to (a+n) .

Step 2: Record the position of pixel values whose values lies between point a and b.

Step 3: Scan the cover image I again. Set counter k for length of watermark.

If counter k is less than length of watermark

a. If scanned pixel value lies within a and b, increase it by (n-1) .
b. If pixel value lies above b, then retain pixel values as it is.
c. If pixel values lies below a-(n-2), then also retain that pixel values as it is.
d. Scan the watermark, if scanned value is 1, then increase pixel value of a-(n-2) by (n-1), a-(n-3) by (n-1), a-(n-4) by (n-1)…………a-(n-n) by (n-1). If scanned value of watermark is 0 then do not increase pixel values.

Step 4: Continue step 3 upto end of watermark. If counter k becomes greater than length of watermark, do not change any value upto end of image scanning completes.

Extraction and Restoration: The extraction and restoration procedure is given below.

Input: Watermarked Image Iw , the peak point a, the minimum point b, the location map L and the length of the watermark Iw.

Output: Original 8 bit grayscale image I and the recovered watermark Iw.

Step 1: scan the image in the same order as in the embedding phase.

Step 2: Set counter k=0, k is used to indicate length of watermark. For k is less than length of watermark, go to step 3 else step 4.

Step 3: (a)If image scanned pixel value is a, a-1, a-2,………….(a-(n-2)), extract 0 bit , let k=k+1, and if scanned pixel value is a+1, a+2, a=3,………….a+(n-1) then extract 1 bit, decrease original pixel value by (n-1), and increase counter k=k+1.

(b)If scanned pixel value lies between a and b then subtract (n-1) from the scanned pixel value.(optional).

(c)If pixel value is less than a-(n-2) and greater than b then do not change these values.

Step 4: Continue step 3 upto end of watermark. If counter k becomes greater than length of watermark, do not change any value upto end of image scanning completes.
Step 5: Go to location map L of b-1, b-2……….b-(n-1) and make it b-1, b-2…………..b-(n-1) respectively.

Result Discussion

Result table shows that our modified histogram shifting method gives more PSNR than Hong et. al.(2010) modified histogram method. Our proposed method has 74.3,68.22 and 64.24dB PSNR for forward 1(n-1=1) shifting pixel value, 2(n-1=2) shifting pixel value and 3(n-1=3) shifting pixel value. The Hong et. al.(2010) method gives 64 dB PSNR .

2235, 4249 and 6211 bits becomes available with our proposed 1 pixel value method, 2 pixel values method and 3 pixel values method respectively as a embedding capacity. Hong et. al.(2010) method provides 2235 bits of embedding capacity. This means embedding capacity increases to approximately 2 times 2 pixel value method, 3 times for 3 pixel value method and so on.

Our proposed method shifts 911, 920, 991 pixels while processing forward histogram and 6635 pixels while processing Hong et. al.(2010) histogram. This means our method shifts less number of pixels during processing. As shifting of pixels are less in our proposed method this method can be termed as reduced pixel shifting method. Hence quality of image is very good as compared to Hong et. al.(2010) method[16].

This result is related to 21x21 size of watermark and lena image. As size of watermark changes PSNR, embedding capacity, number of shifting pixels changes and it is depicted in graphs.

The complexity of our method is same as that of Hong et. al.(2010) method[16], as we also scans image twice. The minimum PSNR of this method is 48.13 dB.

Hence we can say that our reduced pixel shifting and forward modified histogram shifting method is more superior than Hong et. al.(2010) method[16].

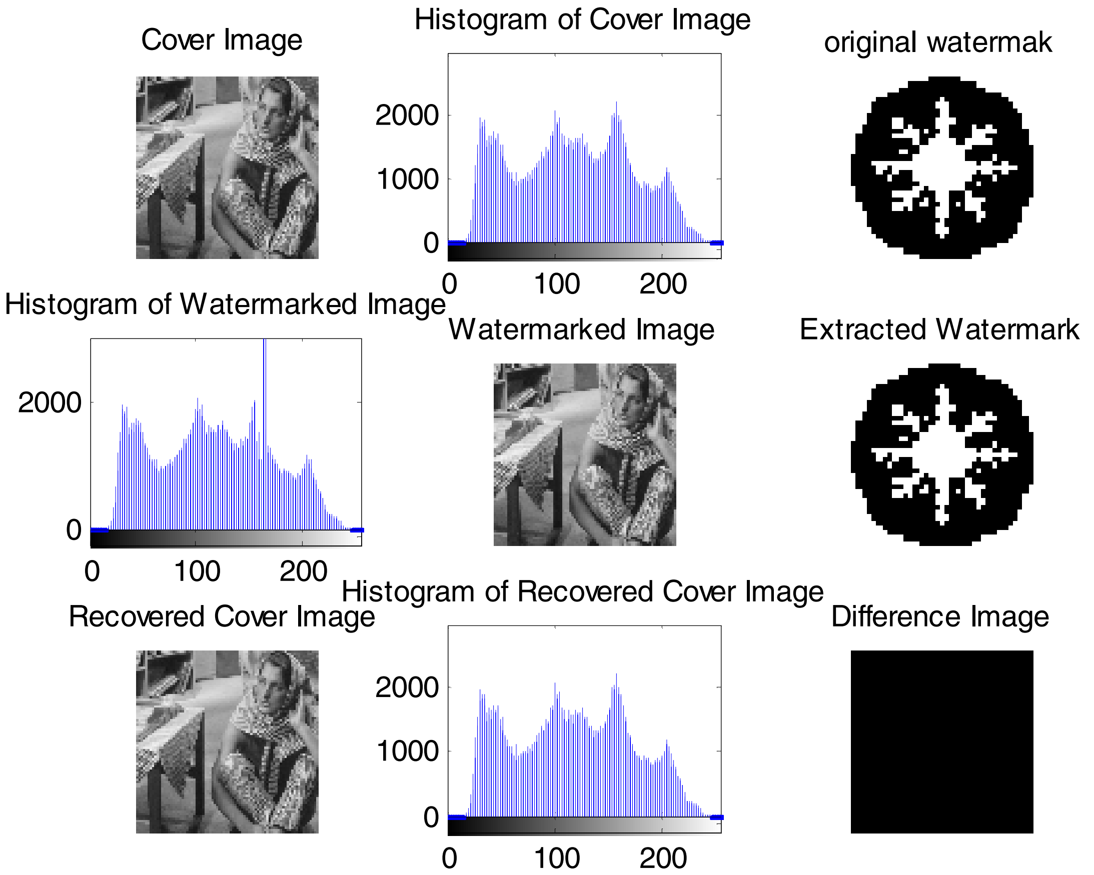
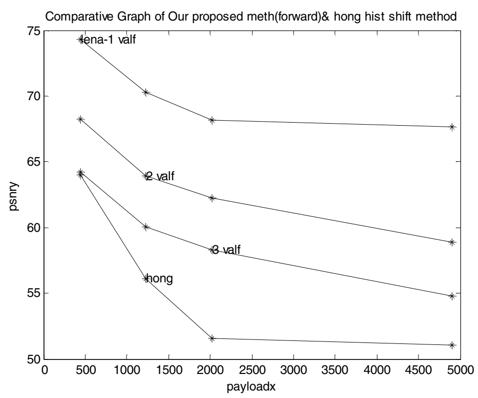
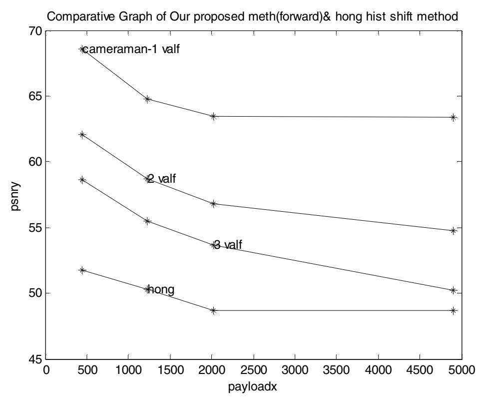
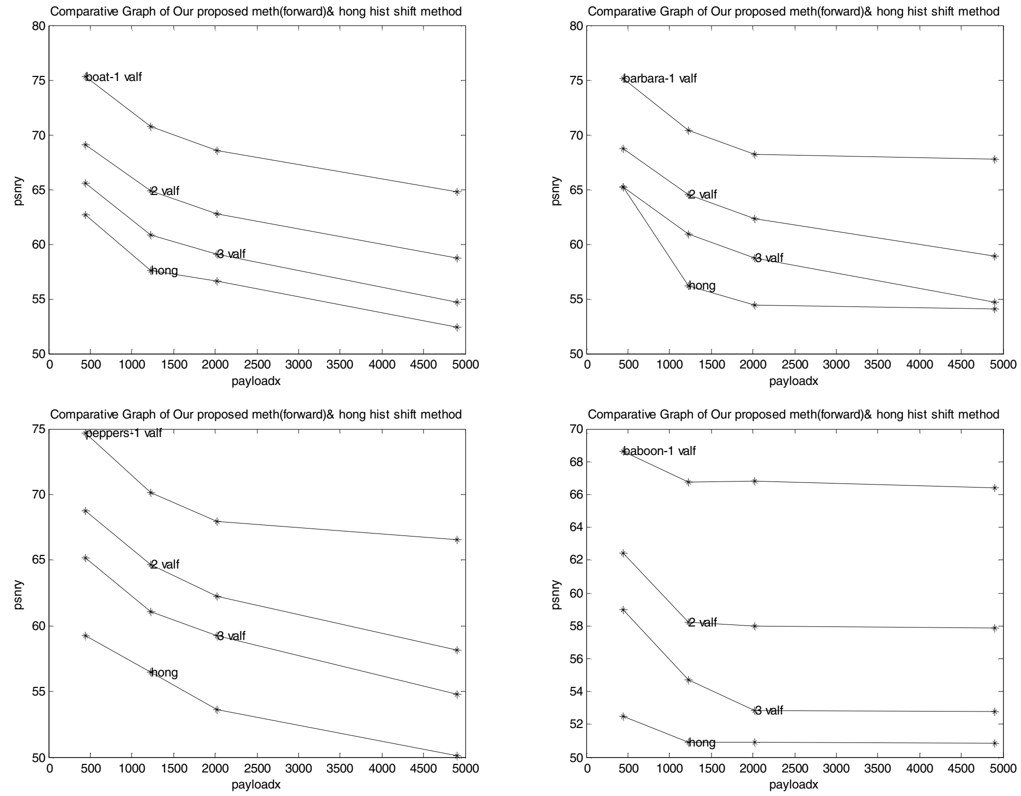


Figure 1: Above figure shows (a)cover image(b) Histogram(c)Original watermark(d)Histogram of original watermark(e)Watermarked image(f)Extracted Watermark(g)Recovered image(h)Histogram of recovered image(i)Difference between original and recovered image







Graph 1: Above comparative graph shows PSNR Vs payloadfor(a)Lena(b)Cameraman(c)Boat(d)Barbara(e)Peppers(f)Baboon

Conclusion and Future Scope

In this paper we have presented forward modified histogram shifting method. Our proposed method has better PSNR and embedding capacity than Hong and Lin et. al.(2010) method with same computational cost[16]. This has been compared in a graph .

Generally PSNR and Embedding Capacity, are inversely proportional to each other. But our proposed method gives better PSNR and embedding capacity than a Hong et. al.(2010) method [16]. Our proposed method increases (n-1) times embedding capacity than Hong et. al.(2010) method. The PSNR of our method is more than Hong et. al.(2010) method. As shifting of pixels are reduced in our method, quality of our method is higher.

Above graphs also shows that our forward method gives better PSNR than our backward method.

Our forward improved histogram shifting method significantly increases PSNR, embedding capacity with reduced shifting of pixels. The complexity of our method is same as that of Hong et. al.(2010) method, as our method also scans image twice.

Handling of distortion still remains a difficult task. More robust system will also significantly lead the area. Secure reversible watermarking with any attack may be a dream and a challenging field in near future.

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