INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

MULTILEVEL DATA HIDING FOR REVERSIBILITY USING HISTOGRAM SHIFTING

P.H.PAWAR

Computer Department, SGBAU, Amravati, BNCOE, Pusad, INDIA.

Accepted Date:

27/02/2013

Publish Date:

01/04/2013

Keywords

Data Hiding,

Reversible,

Watermarking,

Multilevel,

Pure Payload

Corresponding Author

Mr. P. H. Pawar

Abstract

This paper presents a multilevel reversible data hiding method based on histogram shifting which can recover the original image in lossless way after the hidden data has been extracted from the stego image. It is based on dividing the image into blocks, intensity histogram of each block is generated and shifting the histograms of each image block between its minimum and maximum frequency. Data are then inserted at the pixel level with the largest frequency to maximize data hiding capacity. The peaks (maxima) of the histograms of the image tiles are then relocated to embed the data. The gray values of some pixels are therefore modified. High capacity, high fidelity, reversibility and multiple data insertions are the key requirements of data hiding in images. It is shown how histograms of image blocks of images can be exploited to achieve these requirements. Compared with data hiding method in the whole image, this scheme can result in more capacity improvement with still better image quality, depending on the image content and also improving the levels of data hiding places.

I. Introduction

Development of computer technology and widespread use of internet have driven this world into fast-changing digital place. With digitization of multimedia contents, everybody can access multimedia contents more easily than in analog age. Even if digitization of multimedia contents provides more opportunities to media contents, it also provide easy access paths to copy and distribution of digital contents, because of characteristics of the digital data, represented by 0 and 1. As the copy and distribution of digital contents are widely conducted illegally in internet environment, the copyright holders began to pay attention to copyright protection technologies. Off the technologies that can protect copyright of digital contents, data hiding technology has received keen interests from research communities Data hiding process is to be such that the modifications of the media are imperceptible. For images same as digital watermarking, is the process of embedding information into a digital signal which may be used to verify its authenticity or the identity of its owners. In digital watermarking, it describes methods and technologies that hide information, for example a number or text, in digital media, such as images, video or audio. The embedding takes place by manipulating the content of the digital data, which means the information is not embedded in the frame around the data. The hiding process has this means that the modifications of the pixel values have to be invisible. The signal may be audio, pictures, or video. If the signal is copied, then the information also is carried in copy. Reversible data embedding [7], which is also called lossless data embedding, embeds invisible data (which is called a payload) into a digital image in a reversible fashion. As a basic requirement, the quality degradation on the image after data embedding should be low. An intriguing feature of reversible data embedding is the reversibility, that is, one can remove the embedded data to restore the original image. From the information hiding point of view, reversible data embedding hides some information in a digital image in such a way that an authorized party could decode the hidden information and also restore the image to its original, pristine state. The performance of a reversible data-embedding algorithm can be measured by the following.

1) *Payload capacity limit:* what is the maximal amount of information can be embedded?

2) *Visual quality:* how is the visual quality on the embedded image?

3) *Complexity:* what is the algorithm complexity?

The motivation of reversible data embedding is distortion-free data embedding [1]. Though imperceptible, embedding some data will inevitably change the original content. Even a very slight change in pixel values may not be desirable, especially in sensitive imagery, such as military data and medical data. In such a scenario, every bit of information is important. Any change will affect the intelligence of the image, and the access to the original, raw data is always required. From the application point of view, reversible data embedding can be used as an information carrier. Since the difference between the embedded image and original image is almost imperceptible from human eyes, reversible data embedding could be thought as a covert communication channel. In this paper, we present a high-capacity, high visual quality, low computational complexity and reversible data embedding method for digital images. We divide the image into non-overlapping blocks (e.g.4,16,etc.) and then generating the intensity histogram of each block and with it utilizes maximum point and minimum point to embed the data.

A. Existing Methods: Most of the existing data hiding techniques are not reversible. The well-known least significant bit plane (LSB) based schemes [4] are not lossless owing to bit replacement without "memory". Secondly, Circular interpretation on histogram for reversible watermarking [5] uses modulo 256 addition data hiding scheme, but it also suffers from noise. Thirdly, Distortion-free data embedding for images [6] suggested that the method is suitable for a large amount of data hiding. Still the payload is not large enough for some applications. Specifically , the embedding capacity estimated by authors ranges from 3 to 41 kb for

ISSN: 2319-507X
IJPRET

512x512x8 image & the PSNR of the Marked Image Vs. Original Image is 39 dB. Fourthly, **"**Distortion less data hiding based on Integer Wavelet Transform**" [7]** suggested that the method is suitable for increasing the payload dramatically as ranges from 15 to 94 kb for 512x512x8 grayscale image at the same 24-36 dB a relatively low PSNR of the marked image compared with the original image. This indicates the quality of a marked image is degraded & not satisfies aim at authentication. Fifthly,"Reversible Data Embedding " by Ni et.al[1] is one the most capacity efficient data hiding system while keeping good visual quality for all natural images . But compared to our proposed method, its data hiding capacity is less as well as visual quality of image is low and its computational complexity is also high. The propose method solve these problems.

II .PROPOSED METHOD

The proposed method based on block division is used here to improve the data hiding capacity, the marked image quality and to improve in hiding places of information in the image. The method is explained in a block diagram shown in Figure 1 below.

This technique divides the system into 3 stages as 1) Dividing the original image into non-overlapping 4-tiles. 2) Processing stage and 3) Embedding stage

In first stage, we have to divide the original image into non-overlapping blocks (called as tiles) as shown in following Figure 2 and then apply the steps of processing stage (i.e. generating of intensity histogram for each image tile as shown in Figure 3 and then finding of pair/pairs [1] based on pure payload to each block and embedding stage (i.e. shifting of histogram and embedding hidden data at peak point of histogram generated), considering each tile as a separate image.

A. Embedding algorithm with one pair of maximum and minimum Points

This algorithm [1] uses minimum point as overhead bookkeeping information and is explain in detailed as follows.

For an $M \times N$ image, each pixel grayscale value $x \in$ [0,255].

1. Generate its histogram $H(x)$.

2. In the histogram $H(x)$, find the maximum point $h(a)$ $a \in [0,255]$, and the minimum point

Fig. 1 Block diagram of data embedding using proposed method

3. If the minimum point $h(b) > 0$, recode the coordinate (i, j) of those pixels and the pixel grayscale value b as overhead bookkeeping information). Then set $h(b) = 0$.

4. Without loss of generality, assume $a < b$. Move the whole part of the histogram $H(x)$ with $x \in (a, b)$ to the right by 1 unit. This means that all the pixel grayscale values (satisfying $x \in (a, b)$) are added by 1.

5. Scan the image, once meet the pixel (whose grayscale value is a), check the to-be-embedded bit. If the to-be-embedded bit is "1", the pixel grayscale value is changed to $a + 1$. If the bit is "0", the pixel value remains a.

Now, if the image is partitioned into sub-images, the so-called image tiles, and the histogram shifting is applied to each image tile, not only the below drawbacks are overcome but some additional benefits can be gained.

Drawbacks as

1) If the intensity of the pixels in a region of the maximum and minimum range of the histogram, then their values are also modified.

2) If the minimum frequency of the histogram is non-zero, the coordinates of all the pixels with minimum frequency have to be embedded as side information. This restricts the data hiding capacity of the system.

Fig. 2 Blocking the cover image

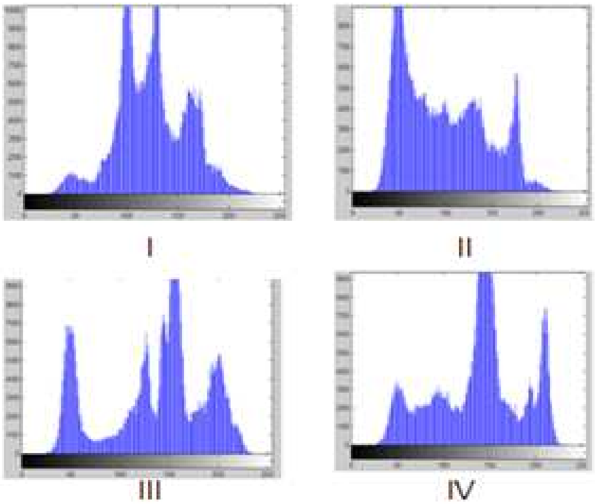


Fig. 3 Histogram of each block

Benefits include

1) High payload

In the shifted-histogram based data hiding method, the maximum number of hidden bits is equal to the maximum frequency of the pixel intensity histogram. When the histograms of the image tiles are considered separately, it is known that the sum of individual maxima is greater than the maximum of the original image intensity histogram. Hence shifted histograms of the image tiles can hide more data.

2) Narrower histogram

Most image tiles have much narrower histogram than that of the whole image. This leads to the important properties for data hiding.

a) In the histogram of the whole image the minimum frequency may not be zero. Hence for reversible data hiding, their positions need to be identified and given as side information, which reduce the data hiding capacity. On the other hand, in the narrower histograms of the image tiles, the minimum frequencies are more likely to be zero. b) Narrower histograms provide the opportunities of selecting the most suitable pairs of peaks-zeros that will increase the quality of the marked images.

c) Individual histogram

Individual histogram makes it possible to distribute the embedded bits among the whole image. This improves the level of hiding places.

The two steps of our embedding of watermark and its detection will be as follows

B. Embedding

1. The image is first divided into N_b non-overlapping image tiles (e.g. N_b=4, 16). The

intensity histogram of each image tile is generated.

2. In each image tile, for a given number of pure payload to be embedded and n (peak, zero) pairs, the pairs are chosen such that the image quality is either maximized (least distances between the chosen pairs).

3. For each of these pairs for each image tile, apply Steps 3-5 described in section II A above. That is, we treat each of these pairs for each image tile as a case of one pair of maximum and minimum points.

The number of image tiles, N_b, number of (peak, zero) pairs n, their positions will be treated as side information that needs to be transmitted to the receiving side for data retrieval.

C. Detection

For the given N_b, and n, the following process is used to extract the secret message from marked image and the lossless recovery of the host image. The process is explained with flow diagram shown in figure 4 and algorithm below.

Firstly, the image is divided into N_b image tiles. Then apply the extraction algorithm [1] presented below to each image tile.

Assume the grayscale value of the maximum point and the minimum points are a and b, respectively. Without loss of generality, assume $a < b$. The marked image is of size $M \times N$, each pixel grayscale value $x \in$ [0, 255].

1. Scan the marked image in the same sequential order as that used in the embedding procedure. If a pixel with its grayscale value $a+1$ is encountered, a bit "1" is extracted. If a pixel with its value a is encountered, a bit "0" is extracted.

2. Scan the image again, for any pixel whose grayscale value $x \in [a, b]$, the pixel value x is subtracted by 1.

3. If there is overhead bookkeeping information found in the extracted data, set the pixel grayscale value (whose coordinate (i, j) is saved in the overhead) as b.

From the step 1, we can able to extract the payload and overhead information. With step 2, histogram comes to its original position, and step 3 set the pixel grayscale value whose coordinate (i, j) is saved in the overhead as b, if there is overhead bookkeeping information found in the extracted data. As, it recovers grayscale value of minimum point, original image is recovered.

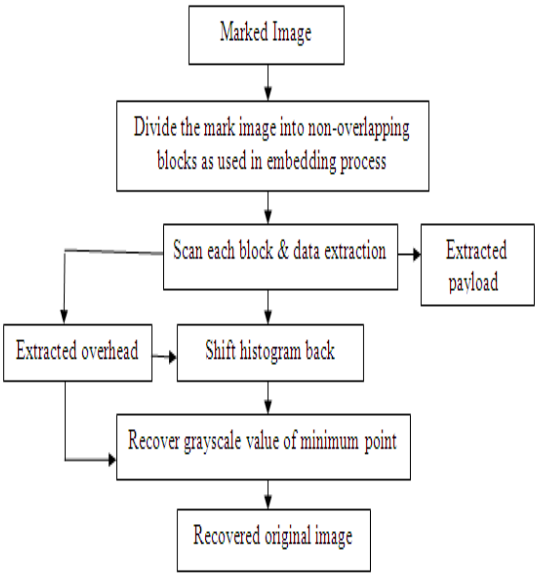


Fig. 4 Block diagram for data extraction algorithm for one pair of maximum and minimum point applying to one tile.

In this way, the original image can be recovered without any distortion for each of these pairs for each image tile. Treat each of these pairs for each image tile of maximum and minimum points a and b, respectively. The marked image is of size M x N, each pixel grayscale value $x \in$ [0, 255].

III. EXPERIMENTAL RESULTS AND ANALYSIS

We have tested the performance of the proposed method for 4 image tiles of different size and format commonly used test images, texture images, medical images, aerial images and coral images. Here, results are discuss and analysis for test images only. The original image sizes shown in figure.5 were 512$\times$ 512 pixels with 8 bit resolution.Table1 summarizes the results of Lena image (image1 of Figure 5) tiles , with respect to that of whole image .As the table shows, tiled images have higher data hiding capability and still do have a better watermarked image quality. By using four tiles the overall capacity is 16,464 bits/whole image, which is almost more extra payload compared to using the whole image and average marked image quality of 47.33 dB, or 0.015 dB improvement in quality. The number of peak-zero pairs can vary from one tile to another and they can be arranged such that for instance, the watermarked image quality is uniform across the whole image.

TABLE I- MAXIMUM CAPACITY AND MARKED QUALITY OF WHOLE AND 4TILES OF LENA IMAGE (IMAGE1 OF FIGURE 5).

Image	**Whole image**	**4 tiles image**			
		Tile1	Tile2	Tile3	Tile4
Capacity	5488	4116	4116	4116	4116
		16464			
PSNR	46.79	49.67	50.07	45.72	45.77
		47.33			

image1 image2 image3

image4 image5 image6

Fig. 5 Six original test images

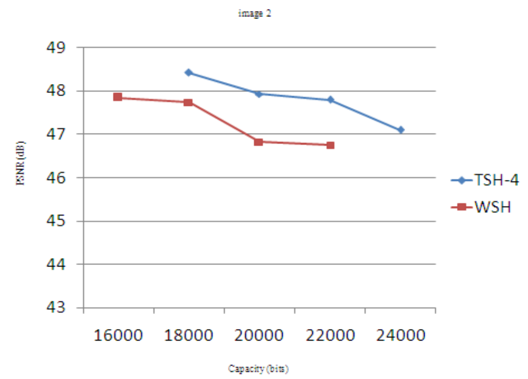
Table 2 shows the maximum payload and the quality of 6 various test images which are shown in Figure5, under shifted histogram of whole (WSH), 4-tile(TSH-4).In each experiment, data were embedded at the full capacity of each image, without use of any priority in image tiles, their spectral density or number of peak-zero pairs. The first column shows the image used and the maximum payload of the whole image and 4-tile images are respectively depicted in columns, 2, 3. The watermarked quality of each method is shown in columns 4 and5. As in all cases quality can be traded for capacity.

Finally, the percentage of increase in payload for 4 tile images over the whole image, are respectively shown in columns 6.

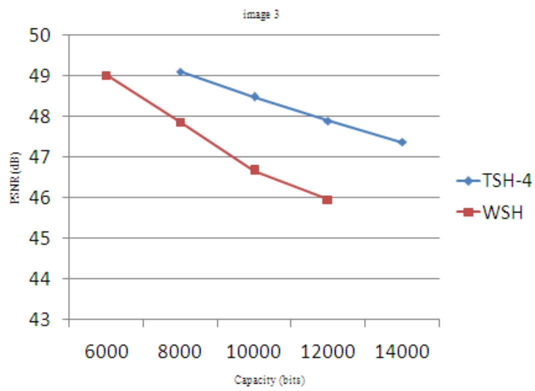
The graphs shown in Figure 6 states that the proposed method not only improves the data-hiding capacity but also improves the marked image quality over whole image. Figure 7 shows that the individual histograms make it possible to distribute the embedded bits among the whole image instead at particular place in WSH. This improves the level of hiding places as well as level of security in images. Table 2 also indicates that 5%-200% capacity improvement with still better image quality, depending on the image content. In all improving the marked image quality, while maintaining high data embedding capability as well as levels of hiding places.

TABLE II- MAXIMUM CAPACITY & MARKED QUALITY OF WHOLE AND 4 TILES OF GENERALLY USED IMAGES

Image	**Pure payload**		**PSNR of marked images (dB)**		**% change in increase in capacity**
	WSH	TSH-4	WSH	TSH-4	
image 1	5488	16464	46.79	47.33	200
image 2	16168	18288	47.83	48.41	12
image 3	8776	11136	47.30	48.15	30
Image 4	59982	62982	45.56	45.63	05
Image 5	20000	22500	45.98	46.29	12.5
Image 6	14312	22272	46.19	46.29	50

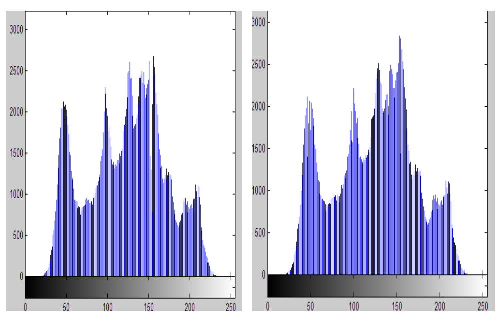


(a)



(b)

Fig 6 PSNR versus capacity of two tiled images (a) image 2 (b) image 3



(a) (b)

Fig 7 (a) Histogram of embed image by WSH (b) Histogram of embed image by TSH-4

IV .Conclusions

We have shown that data-hiding based on the shifted histogram is better to be applied to image tiles than the image itself. This not only improves the data-hiding capacity, but also improves the marked image quality. Improvement in payload capacity is due to the fact that sum of the peaks of the individual pixel intensity histogram is greater than the single peak of the image histogram itself and the individual histograms are much narrower and sharper than the histogram of the image itself, creating more possibility for zeros, it helps in the coordinates of all the pixels with minimum frequency have not to be embedded; it also helps in increasing the data hiding capacity, as well as making distances between the peaks zeros, such that data can be free from disturbance. As a result, less displacement between pairs of maximum point and minimum point, it improves the quality of an image. Finally individual histograms make it possible to distribute the embedded bits among the image. This improves the level of hiding places and as equally pure payload to each tile of image, for low embedding rate also it is useful to distribute the embedded bits among the whole image. This results in more robustness of system.

References

1. Zhicheng Ni , Yun-Qing Shi, Nirwan Ansari, and Wei Su,"Reversible Data Embedding",*IEEE Transactions on Circuits and Systems for Video Technology,* vol.16, no.3, 2006.

2. Wen-Chung Kuo , Po-Yu Lai and Lih-Chyau Wuu,"Adaptive Reversible

3. Data Hiding Based on Histogram",*10th IEEE International Conference on Intelligent Systems Design and Applications*, pp.1376-1381, 2010.

4. Shiuh-Jeng Wang, Chi-Yao Weng, Dushyant Goyal, "Multilevel Data Hiding for Embedding Reversibility Upon Improving Histogram Shifting", *IEEE*, pp.137-141, 2010.

5. M. M. Yeung and F. C. Mintzer, "Invisible watermarking for image verification,"

Electron. Image., vol. 7, no. 3, pp. 578–591, 1998.

6. C. De Vleeschouwer, J. F. Delaigle, and B. Macq, "Circular interpretation on histogram for reversible watermarking," in *IEEE International Multimedia Signal Processing Workshop,* France, pp. 345–350, 2001.

7. M. Goljan, J. Fridrich, and R. Du, "Distortion-free data embedding," in *Proceeding. 4th Information. Hiding Workshop*, Pittsburgh, PA, pp. 27–41.

8. G. Xuan, J. Zhu, J. Chen, Y. Q. Shi, Z. Ni, and W. Su, "Distortionless data hiding based on integer wavelet transform," *IEE Electron. Letters*, vol.38, no. 25, pp. 1646– 1648, 2002.