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Reversible Watermarking based on Histogram Shifting Modification:A Review

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Abstract: *When we talk about the data communication or exchange of information from sender to receiver, the major concern is DATA. This (data) being of high importance, prone to various kinds of attacks. In order to protect it, data hiding techniques are used. Some of the data hiding techniques available are digital watermarking, steganography, etc. By digital watermarking, data is hidden in any type of multimedia like images, audio, etc. Watermarking is one of the major solution to provide authenticity and copyright protection to the digital data. But watermarking causes damage to the cover signal (signal in which data are embedding), therefore recovery of the original cover signal is not possible at the receiving end, which is not tolerable in many fields like medical, military, etc. To reduce the degradation in the watermarked signal "Reversible watermarking techniques" are used. In reversible watermarking original cover signal and the message are retrieved with fewer errors. Reversible data hiding techniques are also known as the Lossless data hiding techniques. This technique is getting high importance day by day because of some fields like military, medical, etc. This paper describes the various reversible watermarking techniques which are already existing.*

Index Terms: *Reversible watermarking, Histogram shifting, Authentication.*

I. Introduction:

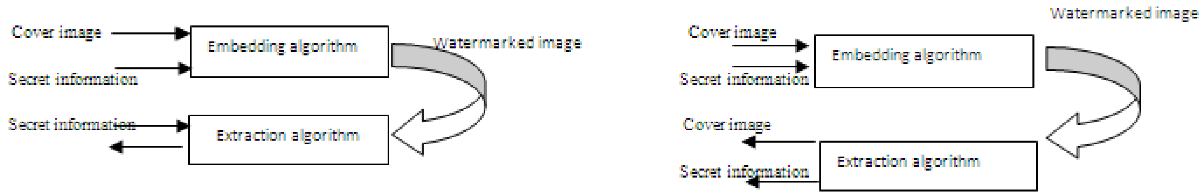
Watermarking is a data hiding technique. In watermarking data is hidden in the noise tolerant signal like image, audio, video, etc. Watermarking is similar to steganography, what separates them is their goal. The main difference between the watermarking and steganography is, in steganography the intermediates did not know that data is hidden inside the signal, but in watermarking intermediates knows very well that there is something valuable information inside the signal but they cannot modify the information in any manner[9]. Watermarking can be of two types visible or Invisible. In visible watermarking the logo is present on the signal, by seeing the signal one can easily identify that this signal belongs to which organization and in invisible watermarking one cannot identify the difference between the watermarked signal or in the original signal with the naked eyes. Fig [1] shows the types of watermarking. In watermarking information is embedded into the cover signal so there will be some degradation in the cover signal so the recovery of the original signal is not possible at the receiving end and these types of degradation is not tolerable in some fields like military, army, etc., according to the signal they have to take decisions, if the signal is distorted then they might make wrong perception. To recover the cover image at the receiver end "reversible watermarking" is used. Cover signal and the watermark is retrieved at the receiver end without any error or with fewer errors in reversible watermarking. Fig [2] shows the block diagram of the conventional watermarking and reversible watermarking.

i) Cover image ii) Watermarked image

a) Visible watermarking b) Invisible watermarking

Fig [1]

Watermarking scheme can be of various types like[7], robust, fragile and semi fragile. Robust techniques can handle all types of attacks, so these techniques can be used in the copyright protection. Fragile techniques cannot tolerate attacks.



a) Conventional watermarking b) Reversible watermarking

Fig. 2

In fragile techniques the signal becomes useless after some modification, so it is used in authentication purpose. Semi fragile techniques are those who lie between robust and fragile techniques. The main goal of watermarking is that no one can change the data in between, when the transmission is going on. Watermarking mainly depends on the two things [9], the first thing is embedding capacity and the second thing is the imperceptibility. Embedding capacity means that how much amount of data we can insert into the cover signal and imperceptibility means there should not be any difference between the cover signal and the watermarked signal which can't be easily recognized with human eyes. The property of watermarking is: image fidelity, robustness, effectiveness, and payload size.This paper is divided into three parts. Part A describes the application of watermarking, part B describes the existing work and limitation and in part C conclusion is there.

A) Application Of Watermarking [10]:

- **Broadcast monitoring**: this is the responsibility of the agencies that their commercials are getting that much air time for that they have paid. Watermarking can be used for that purpose.
- **Authentication:** watermarking can be used in the place of copyright, to identify the owner of the digital work like audio, video, etc, also be used to identify the owner of the particular multimedia.
- **Transaction tracking:** watermark is embedded in the digital work, that can be used to record more than one transaction take place in the history of a copy of this work.
- **Copyrights:** This application of the watermarking prevents illegal copying of the multimedia or the essential information. In this application some information is embedded into the multimedia by that the multimedia will become watermarked multimedia, if any one use that data by saying that this belongs to him, that will easily catch.

B) Existing Work And Limitation:

This paper describes reversible histogram based data hiding techniques and its developments since 2001. The first reversible watermarking approach is proposed in 2001 by Vleeschouwer et al. [1] in this paper Image is divided into several blocks of neighboring pixels. Then, each block is split into two parts, and corresponding histograms are calculated. A bin (interval) is shifted accordance with the value of watermark bit. If the bit is '1', shift the lowest bin to the highest one, and downgrade other bins. And if the bit is '0', then upgrade each bin and shift the highest bin to the lowest bin. High distortion is introduced in the watermarked image because of the shifting. Then in 2003 they improve their work by introducing the bijective transformation [2]. Other techniques are described as follows:

i) Z. NI. APPROACH

In 2006 one reversible watermarking technique is presented by Zhincheng Ni[3]. In this approach, before embedding they have recorded three peaks and zero points from the histogram of the cover image, the pixel between those points goes under modification. But there is a limitation on the embedding capacity.

Embedding Process:

A) Algorithm for embedding with One Pair of Maximum and Minimum Points: For an N*N image.

1) H(z) be the histogram of the image z.

2) Maximum point h (x) x € [0,255] and the minimum point zero h (y) y € [0,255] is selected from the histogram H (z).

3) If the minimum point h(y)>0 , recode the co-ordinate *(i, j)* of those pixels and the pixel Grayscale value b as over head information then set h(y)=0 .

4) Without loss of assuming generality x<y. Move the whole part of the histogram H(z) with z €[x, y] to the right by 1 unit. This means that all the pixel grayscale values (satisfying x € [x, y]) are added by 1.

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

B) Actual Data Embedding Capacity (Pure Payload):

Data embedding capacity, is calculated by the following formula:

C=h(x)-O

Where, O denotes the amount of data overhead information.

C) Multiple Pairs of Maximum and Minimum Points Embedding Algorithm:

For an image containing the gray scale value z€ [0,255].

1) Calculate histogram H(z) of the given image .
2) In the histogram, find three minimum points, h(y1), h(y2), h(y3). Such that y1<y2<y3.
3) In the intervals (0,y1) and(y3,255) , find the two maximum point h(x1), h(x3) respectively, Such that x1€[0,b1], x3€[b3,255].
4) Find two maximum points in each intervalof (y1, y2), (y2, y3). Suppose they are h(x12), h(x21), y1<x12<x21<y2 and h(x23), h(x32), y2<x23<x32<y3 respectively.
5) Find a point with larger histogram value in each of the inteval ((h (x1), h (x12)), (h (x21), h (x23)), and (h (x32), h (x3)), respectively. Suppose they are h(x1), h(x23),h(x3) respectively.
6) Then (h (x1), h (y1)), (h (x23), h (y2)), (h (x3), h (y3)) are the three pairs of maximum and minimum points. For each and every pair, apply Steps 3-5 described in the above section.

ii) Chia-Chen Lin's Method:

Then to improve the capacity of the Ni's method in 2008 Lin et al [4] presents a multilevel reversible watermarking technique. In this technique, the difference image is calculated by taking the difference between the two neighboring pixels of the cover image. The cover image is divided into the non overlapping blocks; a difference block corresponding to each block is calculated, for embedding data histogram modification techniques is applied to each block. But the overhead information is high in this technique because there is the need to store the peak value of each block. Fig 3 shows the flow diagram of the Lin's method.

Histogram generation phase:

For increasing the hiding capacity, an image is generated, called a difference image before the hiding phase. For a grayscale image $H(x, y)$ $P\times Q$ pixels in size, a difference image $D(x, y)$, $P\times(Q-1)$ pixels in size can be generated from the original image H by using the following formula:

$D(x,y) = |H(x, y) - H(x, y + 1)|$ .... (1)

$0\le x\le P - 1,\ 0\le y\le Q - 2$

Here $|\cdot|$ is the absolute value operation.

Data hiding phase:

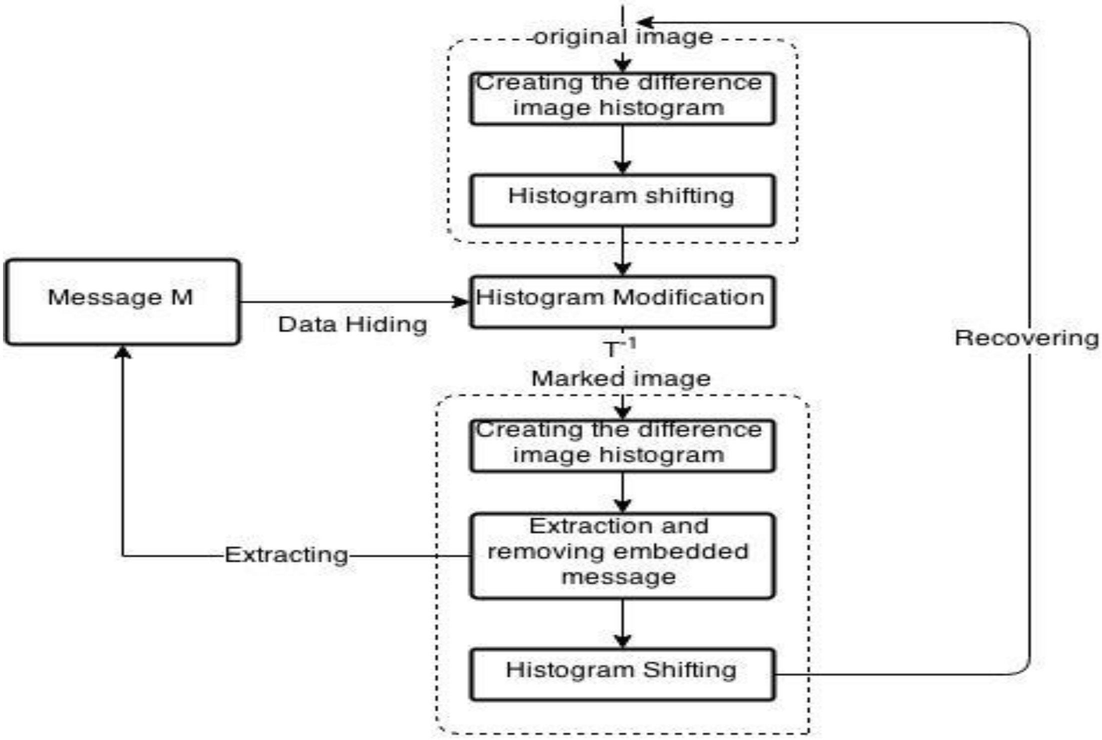
The hiding phase of this technique can be divided into five steps as follows.

Step 1: The cover image is divided into multiple number of non overlapping blocks $A\times B$ in size. A difference image $D_b(x,y)$ of size $A\times(B-1)$ is generated for each block by using following formula:

$D_b(x,y) = |H_b(x,y) - H_b(x, y + 1)|$ ....(2)

$0\le x\le A - 1,\ 0\le y\le B - 2,\ 0\le b\le (M \times N)/(A \times B) - 1$

Step 2: Calculate the histogram of the difference image D_b and the peak point P_b is recorded for each and every block.



Flow chart of Lin's method
Fig [3]

Step 3: If the pixel value of block *b* is larger than the peak point P_b of block *b*, change the pixel value of block *b* is incremented by 1. Otherwise, the pixel value remains unchanged. The modification will be done as follows:

$$D'_b(x, y) = \begin{cases} Db(x,y) + 1 & \text{if } Db(x,y) > Pb, \\ Db(x,y) & \text{otherwise} \end{cases} \qquad \text{......................} (3)$$

For $0 \le x \le A - 1$, $0 \le y \le B - 2$,
And $0 \le b \le (M \times N)/(A \times B) - 1$
Where *Pb* is the maximum point of block *b*.

Step 4: The pixels having a grayscale value the same as peak point P_b can be modified as follows to hide embedded message bit *m* in difference image D'_b :

$$D''_b(x, y) = \begin{cases} D'_b(x,y) + m & \text{if } D'_b(x,y) = Pb, \\ D'_b(x, y) & \text{otherwise,} \end{cases} \qquad \text{........................} (4)$$

For $0 \le x \le A - 1$, $0 \le y \le B - 2$,
And $0 \le b \le (M \times N)/(A \times B) - 1$
Where P_b is the maximum point of block *b*, and $m \in \{0, 1\}$.

Step 5: Original image and hidden difference image is used to construct the marked image by performing the inverse transformation T^{-1}. The inverse operation is applied on the first two pixel of each row. The procedure is as follow:

$$S_b(x, 0) = \begin{cases} H_b(x, 0) & \text{if } H_b(x, 0) > H_b(x, 1), \\ H_b(x, 1) + D''_b(x, 0) & \text{otherwise,} \end{cases} \qquad S_b(x, 1) = \begin{cases} H_b(x, 0) + D''_b(x, 0) & \text{if } H_b(x,0) \le H_b(x,1), \\ H_b(x, 1) & \text{otherwise,} \end{cases} \qquad \text{..................}(5)$$

For $0 \le x \le A - 1$, $0 \le b \le (M \times N)/(A \times B) - 1$.

For any residual pixels, the inverse operation is defined as

$$S_b(x,y) = \begin{cases} S_b(x, y-1) + D''_b(x, y-1) & \text{If } H_b(x, y-1) \leq H_b(x, y), \\ S_b(x, y-1) - D'_b(x, y-1) & \text{otherwise,} \end{cases} \quad \ldots\ldots\ldots\ldots\ldots(6)$$

For $0 \leq x \leq A-1,\ 2 \leq y \leq B-2,\ 0 \leq b \leq (M \times N)/(A \times B) - 1$

Extracting the information phase:
In this process, the embedded message is extracted and reverses the marked image to its original. The extracting and reversing process is as follows.
Step 1: Divide the received marked image into blocks $A \times B$ in size. Generate the difference image $SD_b(x, y)$ of block b from the received marked image by using the following formula:

$$SD_b(x,y) = |S_b(x,y) - S_b(x, y+1)|, \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

For $0 \leq x \leq A-1,\ 0 \leq y \leq B-2,\ 0 \leq b \leq (M \times N)/(A \times B) - 1$

Step 2: Perform the embedded message extracting on the difference image $SDb(x,y)$ of block b by using the following rule:

$$m = \begin{cases} 0 & \text{if } SD_b(x,y) = Pb, \\ 1 & \text{if } SD_b(x,y) = Pb + 1, \end{cases} \quad \ldots\ldots\ldots\ldots\ldots (8)$$

For $0 \leq x \leq A-1$, $0 \leq y \leq B-2$, And $0 \leq y \leq (M \times N)/(A \times B) - 1$. Where P_b is the received maximum point of block b.

iii) Piyu Tsai's Method

In 2009 one more technique for data hiding through histogram shifting is proposed by Tsai et al [5]. This scheme works on the neighboring similarity of pixels in the medical image to improve the histogram-based reversible data hiding. Provide a higher hiding capacity while keeping the good quality of the embedded image is the goal of the proposed technique.

Embedding procedure:

While exploring the similarity between neighboring pixel, the cover signal is divided into multiple number of blocks of n*n pixels. Center pixel is selected as the basic pixel for prediction from each block. To generate prediction errors, pixels in each block are processed by the technique called linear prediction technique, the prediction errors are also called as the residual values. By taking the difference between the each pixel and the basic pixel these residual values are calculated. After processing all the blocks is finished, the residual image is generated. The size of residual image and the cover image is same. On the basis of the occurrences of residual value corresponds to these non basic pixels of the cover image, the residual histogram is generated. Fig 4 shows the flow diagram of the embedding procedure.

The histogram is of the cover image has two parts: first one is a Non Negative Histogram (NNH) and the second one is a Negative Histogram (NH). Secret data are embedded into the residual histogram. A group of peak and zero points are selected from NNH and NH. Let S is the size of secret data and the maximum hiding capacity derived from NNH and NH is greater than S, it indicates that there is enough space for hiding the secret data. Otherwise more number of peak and zero points are searched in NNH and NH histogram.

Let s_d called as a bit of secret data and each residual value in the peak point is employed to carry one bit secret data. If s_d =1, no changes needed to be done in the residual values, otherwise the residual value is decremented to one or shifted to left by the amount of 1. The one who did not lie between the ranges of maximum or minimum points no modifications are applied to that value. When secret data are embedding is done, the residual embedded image is generated. The reverse linear prediction technique is applied to the residual embedded image to generate an embedded image.

To provide the best quality of embedded images, the absolute distance between the original residual values and modified values is at most 1. Therefore, the absolute distance between one pixel in the cover image and its corresponding pixel in the embedded image is at most 1.

Extraction procedure:

Fig 5 shows the flow diagram of the extraction procedure of Tsai's method. In this technique, once the maximum and minimum point pair and embedded image are received, then the extraction procedure can be started. Linear prediction technique is applied to embedded images, according to that the residual embedded image is obtained. The resultant image is now checked. There are two different ways:

1) If pixel x of the residual embedded image is not lying in the maximum and minimum points, the pixel is skipped and the pixel value remains for image reconstruction.

Otherwise, there can be three cases:

1) If x is at maximum point, secret data valued at 1 is extracted and the value of x is unchanged.
2) If the absolute difference between x and the maximum point is 1, secret data value 0 is extracted and the value of x is replaced by the value of the maximum point.
3) The remaining pixels are shifted closer to peak point by 1 and no secret data is extracted. After that, the embedded secret data are extracted from the embedded image. On performing the linear prediction technique to the embedded image the original image can be recovered.

iv) Narawade's Method:

In 2012 Narawade et al. [6] Presented a different technique for the histogram shifting. In the technique firstly the cover image is scanned, then histogram of the cover image is calculated, according to the histogram the maximum and minimum points are calculated, and according to the maximum and minimum points, location map is calculated. But there is the limitation in this approach that the cover image is calculated twice..

Embedding procedure:

Step 1: Scan the cover image I and create its histogram H(x), x € [0, 255]. In its histogram obtain maximum and minimum point x, y respectively, such that y=x-1.

Step 2: The pixel values those lies between the maximum and minimum point are recorded.

Step 3: Scan the cover image I again. Set the counter k to the length of watermark. If counter k is less than length of watermark then check the following:

(a) If scanned pixel value lies between x, y, then pixel value is decremented by 1.
(b) If a pixel value is below 'y', then Pixel value will not get changed.
(c) If pixel values are above 'x' then Pixel value will not get changed.
(d) Scan the watermarked image, if scanned

Value is 0, then decrease the pixel value of x by 1. If scanned pixel value of watermark is 1, then do not change pixel value.

Step 4: Continue step 3 up to end of watermark. If counter k becomes greater than the length of watermarked image, and stop the procedure.

Extraction procedure:

Step 1: Watermarked image is scanned in the same order as in the Embedding phase.

Step 2: Set counter k to 0, k is used to indicate the length of watermarked image. If k is less than the length of watermarked image, go to step 3 else step 4.

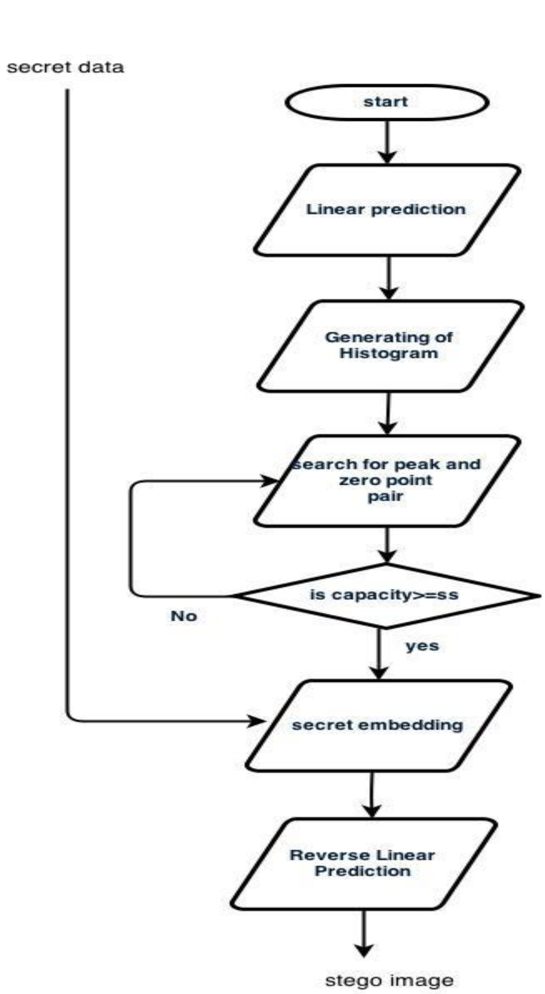
Step 3: Scan the image and check the following

(a) If scanned pixel value is 'x', bit 1 is

Extracted. If the scanned value is x-1, extract 0 bits, and increase counter k=k+1.

(b) If the scanned value lies between x and y then add '1' in the scanned pixel value.

(c) If a pixel value is greater than 'x' and lesser than 'y' then do not change these values.



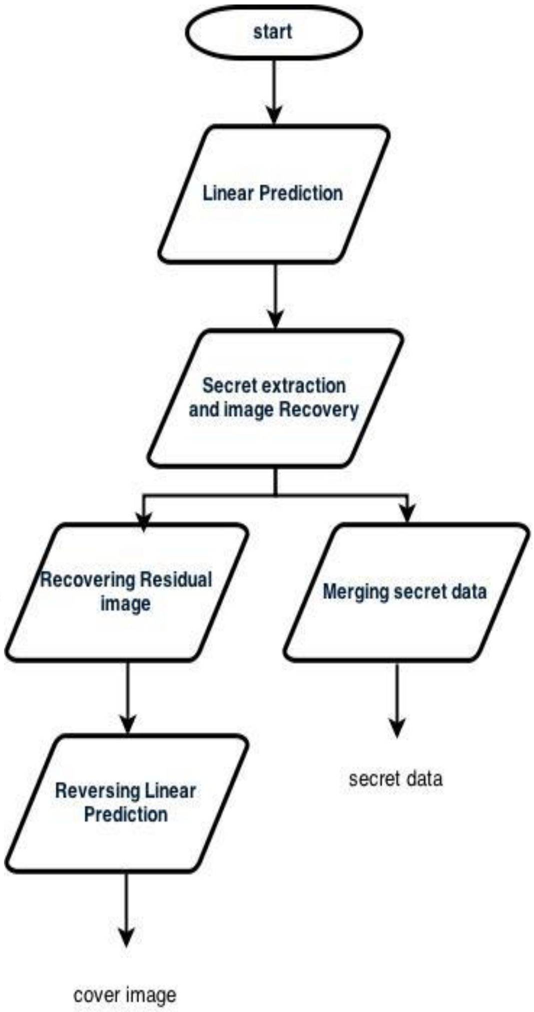


Fig .4 Embedding procedure of Tsai Method **Fig. 5** Extraction procedure of Tsai Method

Step 4: Continue step 3 up to end of watermarked image. . If counter k becomes greater than the length of watermarked image, and stop the procedure.
Step 5: Go to location map L of y+1, and make it y+1.

C) Conclusion:

In this paper the existing histogram based watermarking techniques are discussed, and shows the result (Table 1) of different techniques. The results which are shown in the table are based on the embedding capacity and PSNR value, as PSNR value and embedding capacity are the important parameter of the watermarking. The result shows below are of the different type of images, on that images the existing techniques are applied. The PSNR value of the Narawade method is very high i.e. approx 77dB, this method is applicable for the cartoon images only. The embedding capacity of this method is 170671 bits. This survey shows that the embedding technique of the Ni's method is very low, and the PSNR level is satisfactory. In future there is the scope to increase the embedding capacity of the Ni's method.

Methods	Ni's scheme	Chia chen sheme	Tsai's method
PSNR (dB) Lena	48.0	30	50.59
Capacity (Bits)	5469	308474	52322
PSNR (dB) Baboon	48.21	30.4	51.03
Capacity (Bits)	5421	161118	18410
PSNR (dB) Boat	48.247	30.4	47.6
Capacity (Bits)	7301	307193	5351030

Table 1. The performance of the histogram based data hiding schemes[8]

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