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Analysis of Diverse Reversible Watermarking Methods in Image Processing

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Abstract

Watermarking is the current area of research in Image Processing. Since, there would be need that the data may be image, text, video and so on transferred via internet to be more secure and helps to hide something within the data. To make them secure and extract the hidden information as much as possible the watermarking is used. General watermarking only authenticates and extracts the data but not recognize the data similar to original for that purpose Reversible Watermarking is used it not only authenticates the data but also Checks the extracted data similar to the real/original data bit by bit and pixel by pixel. This paper gives the analysis of different watermarking methods used in various fields.

Keywords- Reversible Watermarking, Histogram Shifting, Expansion Embedding.

Introduction

Reversible Watermarking is the better way to transfer the data safely with the hidden information. The need to hide the information is far above the ground nowadays because of the insecurity but watermarking provides security and Reversible Watermarking provides security along with the accurate original image [3]. It can be used in many fields like Medical Clinical Atlas, Healthcare Applications, Electronic Patient Records and Reliability in Medical Images [5], [8], [2], [4].

In reversible watermarking, embed a watermark in a digital image I [3], and obtain the watermarked image I'. Before sending it to the content authenticator, the image I' might or might not have been tampered by some intentional or unintentional attack. If the authenticator finds that no tampering happened in I', i.e., I' is authentic, then the authenticator can remove the watermark from I' to restore the original image, which results in a new image I''. By definition of reversible watermark, the restored image I'' will be exactly the same as the original image I, pixel by pixel, bit by bit.

The different methods in reversible watermarking methods are reversible watermarking using difference expansion [3], wavelet transform [6], wavelet and sorting [7], expansion embedding [10], histogram modification [12], sorting and prediction [14], Haar wavelet transform [15], histogram shifting, sorting and prediction [16], prediction-based [19]. Out of these methods the most commonly used method is that the reversible watermarking using Difference Embedding by Jue Tian [3]. All the research papers definitely compare the results with the Jue Tian method which was the basic for reversible watermarking methods. The reversible watermarking has huge use in Medical and Military Applications for example Electronic Clinical Atlas, Electronic Patient Records, Healthcare and patent like Apparatus for embedding authentication embedding within digital data [1].

Methodology

The Reversible Watermarking (RW) follows the same method as the general watermarking in addition to that it verifies the extracted image is similar to the original image. Some general features [9] of reversible watermarking are

1). Robust:

The reversible watermarking should be robust to ensure the lossless data though the embedded data is high. That means the watermark capability will be high and can't be fragile even in the case of compression. Robustness is the difficult

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property to achieve completely and successfully in reversible watermarking.

2). Imperceptibility/Invisibility:

The invisibility indicates the intruder can't know that the image is watermarked and this enables the reversible watermarking an efficient one.

3). High Payload and Embedded Data:

The main feature is that the RW should be capable of processing high payload then only it is possible to embed large number of bits i.e. hide more number of bits in an image. The RW methods are classified according to the process of embedding/hiding the bits

4). Capacity (cbpp):

The capacity to hide the data in the pixels is measured in terms of capacity of bits per pixel ***(cbpp).*** The higher the cbpp rate the higher the ability to hide the data.

5). PSNR:

The PSNR is the peak signal to noise ratio and it implies the ratio of signal and noise. The higher the ratio of PSNR, lower the noise because the signal and noise are inversely proportional to each other.

Steps involved in the RW:

The sequences of steps involved in the RW are,

i. Embedding Watermark to Original Image
ii. Publish the Watermarked Image.
iii. Extract the Watermark and the Original Image using Watermark Scheme.
iv. Verify the Original Image with the Watermarked Image.

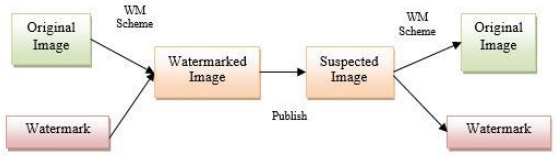

Fig 1.Semantic Diagram of Reversible Watermarking

i. Embedding Watermark to Original Image:

The original image and the watermark kept separately, with the help of watermark (WM) scheme the WM is inserted into the Image. The WM can be inserted in different ways and different schemes. The basic method is to hide the data/information within the bit and pixel selected. The number bits needed to hide the information is based on the WM scheme used.

The main feature to be noted in this process is that the quality of image should not be degraded and the inserted WM should not be visible to others. The Imperceptibility feature makes the RM to be used efficiently. The resultant image will be the watermarked image.

ii. Publish the Watermarked Image:

The Watermarked image is published along the path to the authenticator with the help of either symmetric key algorithm or Asymmetric key algorithm key. In symmetric key algorithm, both at the sender and the receiver uses the same secret key that is either public key or private key. In asymmetric key algorithm the sender and receiver utilizes the different key at sender and receiver.

iii. Extract the Watermark and the Original Image using Watermark Scheme:

After publishing the watermarked image to the authenticator, there is a need to extract the watermark from the image. It not only used to extract the image but also used for the authentication purpose. Its main purpose is for authentication and the watermark is removed with the help of RW schemes. Section 3, provides the various reversible schemes, methods and applications

iv. Verify the Original Image with the Watermarked Image:

After extracting the watermark from the image, it is verified that the extracted image is same as bit by bit and pixel by pixel. This verification is done by using the various WM schemes. The main feature of RW is that the extracted image will be same as original image bit by bit.

Analysis of Various RW Methods

The different RW methods that to be analyzed are:

A. Difference Expansion
B. Expansion Embedding
C. Wavelet Transform
D. Wavelet and Sorting
E. Dynamic Prediction Error Based
F. Interpolation Technique
G. Histogram, Sorting and Prediction

A. Difference Expansion:

The RW can be achieved using the redundancy property of the digital images and this helps for large embedding capacity and provides low distortion in image quality. The differences between the neighboring pixels are calculated and some of them are selected for the difference expansion i.e. message, data hidden in those difference values.

The reversible integer transform is used to transfer the values of the original image to reversible values. After transferring into the reversible values, the changeable difference values are identified. Then the

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identified values of bits are expanded /changed to embed the data.

General Process:

The algorithm used in this Difference Expansion was Data Embedding Algorithm. There are six Steps in the Algorithm, they are

1. ***Calculating the difference Values:***
   The Image must be grouped into the pixels and the nearest pixels are called neighboring pixels. The pair of pixels is formed according to the neighboring pixels or with computed difference value
2. ***Partitioning the difference values into Four Sets:***
   The pair of pixels is used to form four disjoint sets named EZ, EN, CN and NC with the difference values h $\{h_1, h_2, h_3 \ldots h_n\}$.
   EZ- contains all Expandable (h=0 and h= -1).
   EN- contains all Non-Expandable (h not € EZ).
   CN- contains all Changeable (h not € (EZ U EN)).
   NC- contains all Non-Changeable (h).
3. ***Creating a Location Map:***
   The location map is created according to the sets that are partitioned based on the difference values. The difference values in EZ are selected and the EN is divided into EN1 and EN2. EZ U EN1 the value 1 is assigned to the location map and EN2 U CN U NC the value 0 is assigned to the location map with the difference value set h.
4. ***Collecting original LSB values:***
   The original LSB bits are collected according to values assigned to the location map.
5. ***Data embedding by Replacement:***
   The location map is embedded along with the original LSB and Payload. Payload contributes the authentication Hash
6. ***Inverse Integer Transform:***
   The Inverse Integer Transform is used to transform the reversible values into the original integer values.

Experimental Results and the Future Enhancement:

The images used in this paper are Common Lena image because it contains all the RGB values. The results obtained were compared with other related methods and this method performs well. The Future enhancement of this work may be considerable for the color images.

B. Expansion Embedding:

The Expansion Embedding used by Tian [3] enables efficient method but the method suffers large distortion in low embedding capacity and low capacity control. To avoid these demerits this method uses histogram shifting technique. The method uses two differences, they are

Expandable Difference:

The difference that obtained by satisfying the expandability condition.

Changeable Difference:

The difference that obtained by satisfying the expandability condition.

General Process:

The algorithm has two methods, they are

1. ***Histogram Shifting & Overflow Map***:
   The image is divided into differences, values, expandable and changeable locations. In the receiver, differences between the values are calculated and the changeable locations are identified.
2. ***Histogram shifting & Flag bits:***
   The data was embedded within the feature element along the bits and the bits are named as flag bits. The bits should posses the modifiability property and the property indicates the capable of measuring the differences where the modification undergone.

Experimental Results and Future Work:

The Histogram Shifting technique was used in this method to avoid the drawbacks in the Tian's [3] method stated as low embedding capacity and lack of capacity control. The future work may be the histogram shifting will be combined with the Prediction-Error method.

C. Wavelet Transform:

The IWT indicates the Integer Wavelet Transform which uses the integer coefficient values transformed to the original values without loss. The methods used in this paper were Wavelet Decomposition, Histogram Alteration and Threshold Embedding.

General Process:

The algorithm involves three methods/process, they are

Wavelet Decomposition:

The wavelet decomposition was done with the help of frequency bands (higher and lower). This causes the overflow and underflow.

Histogram alteration:

The Histogram was adjusted to avoid overflow and underflow. The efficient histogram adjustment referred from [16].

Threshold Embedding:

By default, the threshold value was set and the embedding rules were applied according to the

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IWT coefficients corresponding to the smaller, larger and equal values of the Threshold.

Experimental Results & Future Work:

The results obtained perform well compared to the others and avoids the underflow, overflow with the help of threshold embedding. The future enhancement may be the multi-level embedding.

D. Wavelet & Sorting:

In the wavelet and sorting embed the large amount of data with the help of least bit prediction and Tian's [3] improved expansion embedding [10].

General Process:

The algorithm involves LSB prediction and the Improved Difference Expansion.

LSB Prediction:

The LSB method modifies only the least bit method and this result in less distortion.

Improved Difference Expansion:

The main problem in the Tian method was choosing the set of locations and overhead costs. The drawbacks can be removed using the technique Haar Transform [4].

Experimental Results & Future Enhancement:

The results obtained perform due to the combination of the wavelet and sorting. The future work may contribute to the color images.

E. Histogram Modification:

Histogram Modification is the method of either equalizing or modifying pixel levels of histogram. For gray-Scale images the histogram values produced will be only two values black and white. For color images the histogram values are produced based in three level in terms of Red, Green, Blue.

In the histogram modification, values in the histogram of the image changed and the data embedded where the histogram values changed.

General Process:

The general process involves the Histogram Equalization, Histogram Specification, and Gray-Level Grouping

Histogram Equalization:

The Histogram in the image is equalized according to the property of better image quality. The data can be hidden in the place of equalization of histogram.

Histogram Specification:

In the histogram specification the bit planes are shifted to embed the data with the help of bit plane slicing. It divides the bits into the eight planes according to the bits of the pixel.

Gray –Level Grouping:

It groups the gray level histogram bins to hide the data and groups are distributed iteratively

F. Dynamic Prediction Error Based:

The prediction error method [18] uses the error predicting method to understand the quality of the extracted image from the watermark. The main drawback in this prediction error was it can't well in all kinds of image.

But in [19], a new method named dynamic prediction error based was proposed. This method outperforms in predicting error in all kinds of images

General Process:

The general process consists of finding neighbors and predicting errors

Finding Neighbors:

The image transformed to the pixel format and after selecting the random pixel the neighbors of the random pixels are identified.

Predicting Errors:

The errors are predicted with the help of the neighbor pixels. Since the data embedded within the neighbor pixel after finding the error between the pixel with the help of algorithm [19] dynamically the original image extracted exactly.

Experimental Results & Future Enhancement:

The results perform better when compared to other due to the Dynamic error prediction and the future work corresponds to the Videos.

G. Interpolation Technique:

The interpolation technique is the method that takes the random sample points from the image and performs the operations to increase the image quality [17].

General Process:

The general process involves Statiscal and Deterministic process

Statistical:

In this method it approximates the value by minimizing the estimation error and the result produced involves the samples not repeated. This method is inefficient in some applications

Deterministic:

In this method, it assumes some certain variability between the sample points and the linearity property is followed. This method performs well in almost all applications.

Experimental Results & Future Enhancement:

The results are good due to the deterministic interpolation technique but the future work may be combined with some other methods.

H. Histogram, Sorting & Prediction:

The combination of the histogram, sorting and prediction results well when compared all existing and it is shown in the Table 1.There is no

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need to describe the methods since, a detailed description about the histogram, sorting and the prediction have been already given above, The future enhancement of this combines method may involves in the application of Medical Imaging, Military Applications and Video Processing also.

Table 1. Comparision of various RW methods in terms of bpp(bits per pixel) and PSNR

Methods	bpp	PSNR	Images Used
Difference Expansion	0.15	44.20	Lena
Expansion Embedding	0.22	46.72	Lena
Wavelet Transform	0.17	37.46	Lena
Wavelet and sorting	0.25	45.00	Lena
Histogram Modification	0.14	48.2	Lena
Prediction-based	0.19	47.67	Medical and Lena
Interpolation Technique	0.21	46	Lena
Histogram, Sorting, Prediction	0.12	60.34	Medical

Conclusion

The reversible watermarking expanded the area of research application in the medical and military fields. There are many methods involved in RW and this analysis some of them important. From the Analysis, it is clear that all the reversible methods must perform better separately and also have some drawbacks. It is also understandable from the Table and graph, if the methods are combined it produces good and best results compared to others. The aim of this analysis is to establish the various RW schemes and used as the combination depends on the applications.

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