International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-1 Issue-2, June 2012

Reversible Watermarking: A comparative Study

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Abstract: ***Considering the age of reversible watermarking which is just a decade to count, it has fetched enormous attention of researchers to boast of. Due to many researches in this field, it has become very difficult to judge an algorithm for a specific application. So a definite need arises to compare these algorithms on some criteria. In this paper, we present a comprehensive and competitive study of three basic algorithms which are reversible watermarking using data compression, Tian's difference expansion and histogram bin shifting. We have compared these algorithms based on criteria like PSNR, embedding capacity and processing time.***

Keywords: Reversible Watermarking, Compression, difference expansion, histogram bin shifting, PSNR, embedding capacity, processing time

I. INTRODUCTION

Reversible watermarking has found a huge surge of experimentation in its domain in past decade as the need of recovering the original work image after extracting the watermark arises in various applications like military and hospitals. In traditional watermarking techniques, our main concern is to embed and recover the watermark with minimum loss. The quality of original work image we get after extraction is highly degraded and not restorable. But in applications like medical images, in which superior quality of image is needed, we cannot use these algorithms. medical images, some prerequisite information about the patient is watermarked in it while transmitting and at reception we need to have both, the original image and that information to be recovered lossless. This type of result is achievable by making use of any reversible watermarking algorithm. But we need to know out of a pool of algorithms which one of them is best suited for an image in hand. Our attempt here is to study three basic algorithms and compare them on the basis of embedding capacity, PSNR and processing time.

The techniques we have studied here are Tian's difference expansion, histogram bin shifting and data hiding using Integer Wavelet Transform.

II. TIAN'S DIFFERENCE EXPANSION

Revised Manuscript Received on 30 June 2012.

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This scheme usually generates some small values to represent the features of the original image. Then, we expand (enlarge) the generated values to embed the bits of watermark information. The watermark information is usually embedded in the LSB parts of the expanded values. Then the watermarked image is reconstructed by using the modified values. The algorithms steps are:

1. Take two adjacent pixel values x and y.
2. Find difference and average values of pixels.

$$a = \frac{x+y}{2} \qquad (1)$$

$$d = x - y \qquad (2)$$

3. Then we expand d into its binary form and add watermark bit w right after most significant bit to get d'.
4. Reconstruct the image using a and d', we get the watermarked image.[2]

The similar process is required to be followed for the lossless recovery of the Original Image and the watermark.

III. HISTOGRAM BIN SHIFTING

The former two types of reversible watermarking are not robust under image processing and distortions. In order to enhance the robustness of the reversible watermarking, the embedding target is replaced by the histogram of a block. We introduce the Ni et al.'s scheme to work out the concept of this type. The algorithm steps are:

1. Scan the cover image and construct its histogram
2. The gray value for which the histogram is highest is denoted the peak point a and the gray value for which the histogram is lowest is denoted by the minimum point b.
3. If $H_i(b)=0$, then b is called a zero point. For simplicity, we assume a<b
4. Scan the image and record the positions of those pixel values to b and place them into the location map L
5. Shift the histogram $H_i(x)$, $x \in (a, b)$ to the right to vacate the histogram bin at a+1
6. Extract a data bit s from secret data S. Scan the image once more.
7. If the scanned pixel value is a and the data bit to be embedded is 1, then set the pixel value to a+1.
8. If the data bit to be embedded is 0, no change has to be done on the scanned pixel.[3]

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The similar process is required to be followed for the lossless recovery of the Original Image and the watermark.

IV. DISTORTIONLESS DATA HIDING ALGORITHM BASED ON INTEGER WAVELET TRANSFORM:

This is a distortionless image data hiding algorithm based on integer wavelet transform that can invert the stego-image into the original image without any distortion after the hidden data are extracted. This algorithm hides data into one (or more) middle bit-plane(s) of the integer wavelet transform coefficients in the middle and high frequency sub bands. It can embed much more data and also satisfy the imperceptibility requirement.

The embedding process for the algorithm is as described below:

1. Read the Original Image
2. Perform Integer Wavelet Transform of the Original Image
3. Construct binary Images from the 5th bit of CH, CV and CD
4. Compress the data in the 5th bit plane of CH, CV and CD by arithmetic encoding
5. Read the watermark and reshape it for insertion
6. Find the length of all the bit planes and the watermark to form the header
7. Insert the header, compressed data and watermark into the Image
8. Perform Inverse Integer Wavelet Transform to get the Watermarked Image.[4]

The similar process is required to be followed for the lossless recovery of the Original Image and the watermark.

V. RESULTS

We have compared above techniques based on PSNR and Embedding Capacity both because if we increase the embedding capacity the PSNR gets reduced and vice versa. So we have to maintain an optimum balance between them to get a satisfactory result. A good technique should have high PSNR as well as high Embedding Capacity

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Figure 1(a): Original Image

Figure 1(b): Watermarked Image

Figure 1(c): Recovered Original Image

Figures 1(a-e): Distortionless Data Hiding Algorithm Based on Integer Wavelet Transform

Figure 2(a): Original Image

Figure 2(b): Watermarked Image

Figure 2(c): Recovered Original Image

Figure 2(a-c): Tian's Difference Expansion

Figure 3(a): Original Image

Figure 3(b): Watermarked Image

Figure 3(c): Recovered Original Image

Table 1: Comparative Table of Techniques

	Data compression in Transform Domain	Difference expansion	Histogram bin shifting
Schemes	Xuan et al.	Tian	Ni et al.
Total embedding (bpp)	0.750488	0.5	0.0221
Watermark embedding (bpp)	0.257103	0.467865	0.0221
Overall Time Complexity (seconds)	61.449792	50.996732	5.932329
PSNR (dB)	35.151581	34.634949	65.3745
Robustness	Low	Low	Moderate

VI. CONCLUSION

This study has introduced a number of techniques for the reversible watermarking of digital images, as well as touching on the limitations and possibilities of each. Although only the very surface of the field was scratched, it was still enough to draw several conclusions about digital reversible watermarking techniques.

We particularly classified the existing reversible watermarking techniques into three types to work out the features of reversible watermarking techniques. The three types are analyzed and compared based on PSNR, Embedding Capacity and Processing Time to introduce the current status of reversible watermarking techniques.

In the techniques by applying data compression in the transform domain, a proper choice of transform and compression method is important. The existing techniques belonging to this type are not robust because it uses compression technique for embedding. The difference expansion method has moderate embedding capacity because most of the bits available for embedding are used for saving header information and location map. This method is also weak in robustness because the destroyed location map will cause mismatching. In histogram bin shifting method we require a secured communication channel to transmit some extra information which is required to restore the image. Reversible watermarking schemes are still in development and have dramatically potential possibilities. From this paper, we hope to provide an overall introduction of reversible watermarking, and give a proper cause to commence the research in this fascinating area.

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