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RESEARCH ARTICLE

An Assessment of PSNR for Reversible Watermarking Techniques

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Abstract— Reversible watermarking gets enormous attention from researchers in past decade as the need of recovering the original work image after extracting the watermark arises in various applications like military and hospitals. Due to many researches in this field, there are various techniques are available. So to choose which one is the best technique, a definite need arises to compare those techniques on some criteria like PSNR and Embedding Capacity. In this paper, we present a comparative analysis of three basic robust techniques, which are Least Significant Bit (LSB), Difference Expansion (DE) and Reversible Contrast Mapping (RCM) technique.

Keywords— Reversible watermarking, difference expansion (DE), least significant bit (LSB), reversible contrast mapping (RCM), PSNR (Peak Signal to Noise ratio), Embedding Capacity

I. INTRODUCTION

Reversible watermarking is a novel category of watermarking schemes. It not only provides the protection of the copyright by embedding the assigned watermark into the original image but also can recover the original image from the suspected image. The retrieved watermark can be used to determine the ownership by comparing the retrieved watermark with the assigned one. This feature is suitable for some important media, such as medical and military images, because these kinds of media do not allow any losses. This type of result is achievable by making use of any reversible watermarking techniques. But we need to know out of a pool of techniques which one of them is best suited for an image in hand. Our attempt here is to study three basic robust techniques and compare them on the basis of PSNR and Embedding Capacity. The techniques we have studied here are Tian's difference expansion, mapping and LSB (Least significant bit) technique.

Reversible watermarking schemes have to be robust against the intentional or the unintentional attacks, and should be imperceptible to avoid the attraction of attacks and value lost. Therefore, the reversible watermarking also has to satisfy all requirements of the conventional watermarking such as robustness, imperceptibility and readily embedding and retrieving. Reversible watermarking is also useful in remote sensing, multimedia archive management, etc. The robustness of the watermarked images against attacks has been verified on the parameters of PSNR (Peak Signal to Noise Ratio), MSE (Mean

Square Error) and SNR (Signal to Noise Ratio) which show that the resulting quality of combination watermarking method is good than other techniques.

II. RELATED WORK AND PROBLEM IDENTIFICATION

Over the past few years a number of research papers about reversible watermarks have been produced. Reversible watermarking restores the original image without any distortion. This feature is suitable for some important media, such as medical and military images, because these kinds of media do not allow any losses**.** Reversible Watermarking algorithms are based on lossless compression. Different techniques are used for reversible e.g. Histogram Shifting (HS), Difference Expansion (DE), Reversible Contrast Mapping (RCM), Prediction Error Expansion (PEE), Integer Transform, Least Significant Bit (LSB), Interpolation Technique and Wavelet Transforms.

Zhicheng Ni et.al [1] proposed a Histogram shifting (HS) based reversible data hiding. This technique can be achieved efficiently high capacity and low distortion of an image. Jen-Bang Feng et.al [2] defined the purpose of reversible watermarking, reflecting recent progress, and provide some research issues for the future. Thodi and Rodriguez [3] proposed a PEE technique. PEE is an improvement of DE technique with the superior correlating abilities of a predictor, resulting in a higher data-embedding capacity than with DE, Histogram modification framework and it significantly adds the number of feature elements that expanded for data embedding.

Dinu Coltuc et.al [5] proposed a very fast watermarking by reversible contrast mapping (RCM). It provides high data embedding bit-rate at a very low mathematical complexity. Yongjian Hu et.al [6] proposed a difference-expansion (DE)-based reversible data hiding which is a new embedding scheme that helps to construct an efficient payload-dependent overflow location map. Difference Expansion (DE) reversibly embeds a bit in the difference number. It can be Increase the magnitude of difference.

Roberto Caldelli et.al [7] proposed a complete review and classification of reversible watermarking techniques which are subdivided into two main categories: Fragile and Semi-fragile or Robust. Navnath Narawade et.al [9] proposed a complete review of reversible watermarking with different techniques based upon the embedding capacity, PSNR and processing time. Gurpreet Kaur et.al [12] implementing an LSB technique on image watermarking using text and image which is based on different parameters like Standard deviation, Entropy and Mean.

In previous works, there are various techniques are available for reversible watermarking. The challenge was to find which one is the best method robust to noise; a definite need arises to compare those techniques on some criteria like PSNR and Embedding Capacity. In traditional reversible watermarking techniques, our main concern is to embed and recover the watermark and also restore the original image with minimum distortion. The robustness, imperceptibility, higher embedding capacity, effectiveness, payload capacity, visual quality and the security are the basic criterion of the reversible watermarking.

III.METHODOLOGY

The main objective of the reversible data hiding method for encrypted images is that we are able to embed data in encrypted images and then to decrypt the image and to rebuild the original image by removing the hidden data. Here we choose three basic robust techniques for reversible watermarking and compare them on parameter like PSNR and Embedding Capacity.

A. LEAST SIGNIFICANT BIT (LSB)

The LSB technique works by replacing some of the information in a given pixel with information from the data in the image. While it is possible to embed data into an image on any bit-plane, LSB embedding is performed on the least significant bit(s). Proposed LSB (Least significant bit) technique selects an image as cover image. Then it selects the secret information either it can be text or an image. After selecting both cover and message information it calculates the set parameters (Standard Deviation or Mean). Then it finds the highest value and uses it to hide the information in the LSB (Least significant bit) of an image. PSNR and Embedding Capacity are calculated to compare the results with the existing approaches. The steps followed in LSB image watermarking are:

1. Select cover image.
2. Select information type for secret data as image or text.
3. Convert image pixels into binary values.
4. Hide the information using the parameter (Standard deviation or Mean) that results in high value.
5. Repeat the steps until image or text is hidden in image.

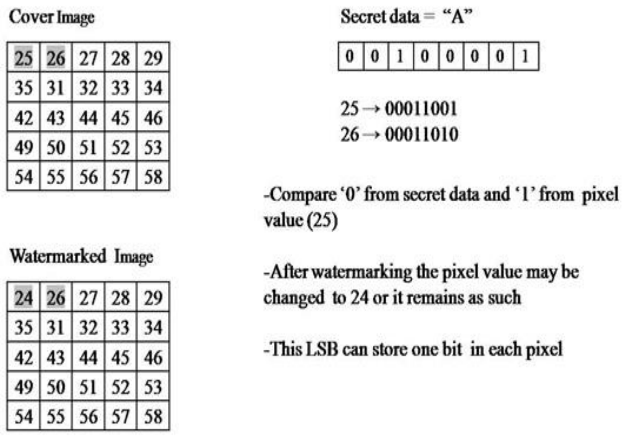

Fig. 4.1: An example of 1-bit LSB

For example, Figure 4.1 shows the 1-bit LSB. In Figure 4.1, LSB can store 1-bit in each pixel. If the cover image size is 256 x 256 pixel image, it can thus store a total amount of 65,536 bits or 8,192 bytes of embedded data

B. TIAN'S DIFFRENCE EXPANSION

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 watermark image is reconstructed by using the modified values. The 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 most significant bit to get 'd'.
4. Reconstructed the image using 'a' and 'd', we get the watermarked image.

The similar process is required to be followed for the lossless recovery of the original image and the watermark. PSNR and Embedding Capacity are calculated to compare the results with the existing approaches.

C. REVERSIBLE CONRAST MAPPING (RCM)

In this, we discuss a reversible watermarking scheme that achieves high-capacity data embedding without any additional data compression stage. The scheme is based on the reversible contrast mapping (RCM), a simple integer transform defined on pairs of pixels. RCM is perfectly invertible, even if the least significant bits (LSBs) of the transformed pixels are lost. The data space occupied by the LSBs is suitable for data hiding. The basic RCM watermarking scheme was introduced in which a modified version that allows robustness against cropping is proposed. The control of distortions introduced by the watermarking is investigated as well. The mathematical complexity of the RCM watermarking is further analysed, and a very low cost implementation is proposed. Finally, the RCM scheme is compared with Tian's difference expansion scheme with respect to the bit-rate hiding capacity and to the mathematical complexity. It is shown that the RCM scheme provides almost similar embedding bit-rates when compared to the difference expansion approach, but it has a considerably lower mathematical complexity.

Marking: The marking proceeds as follows:
1. Partition the entire image into pairs of pixels (for instance, on rows, on columns, or on any space filling curve)
2. For each pair
a) If and if it is not composed of odd pixel values, transform the pair using the (1), set the LSB of to "1," and consider the LSB of as available for data embedding.
b) If and if it is composed of odd pixel values, set the LSB of to "0," and consider the LSB of as available for data embedding.
c) If , set the LSB of to "0," and save the true value.

3. Mark the image by simple overwriting the bits of the watermark.

A different marking procedure is proposed in which a map of transformed pairs and the sequence of LSBs for all non transformed pairs are first collected. Then, the entire image LSB plane is overwritten by the payload and by the collected bit sequences. The slightly modified procedure proposed in this letter provides robustness against cropping. The location map of the entire image is replaced by the LSB of the first pixel of each pair showing if the pair was transformed or not. Let us further consider that the saved LSB of a non transformed pair is embedded into the available LSB of the closest transformed pair. Thus, all the information needed to recover any original pixel pair is embedded into the pair itself or very close to it. In the case of cropping, except for the borders where some errors may appear, the original pixels of the cropped image are exactly recovered together with the embedded payload. For pixel pairing on row or column direction, there are no problems of synchronization. Some control codes should be inserted in the payload to validate watermark integrity.

Detection and Original Recovery: Watermark extraction and exact recovery of the original image is performed as follows:
1. Partition the entire image into pairs of pixels.
2. For each pair
a) If the LSB is "1," extract the LSB of and store it into the detected watermark sequence, set the LSBs of, to "0," and recover the original pair by inverse transform.
b) If the LSB of is "0" and the pair with the LSBs set to "1" belongs to , extract the LSB of , store it into the detected watermark sequence, and restore the original pair as with the LSBs set to "1".
c) If the LSB of is "0" and the pair with the LSBs set to "1" does not belong to, the original pair is recovered by replacing the LSB of with the corresponding true value extracted from the watermark

sequence. PSNR and Embedding Capacity are calculated to compare the results with the existing approaches.

D. PSNR and MSE

The simplest, oldest and most widely used technique to quantify image/video signal quality is the mean squared error (MSE). Mathematically it is defined as:

$$\text{MSE} = \frac{1}{\text{MN}} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (u - v)^2$$

Where, two images u and v having size M×N, one of them is the noisy (watermarked) approximation of the other (original) one.

Peak-signal-to noise-ratio (PSNR) is used to quantify the visual distortion made by watermarking process as well as different attack operations. Mathematically for an 8 bit gray scale image it is defined as:

$$\text{PSNR} = 10 \log_{10} \left(\frac{255^2}{\text{MSE}} \right)$$

Where: 255 is the maximum possible pixel of the image. Here for 8 bit image, it is 255.

IV. EXPECTED RESULT

We are expecting that the PSNR value is high for the best method from existing techniques because a good technique should have high PSNR as well as high embedding capacity.

V. CONCLUSIONS

This paper has introduced a number of techniques for reversible watermarking of digital images, as well as touching on the limitations and possibilities of each. We particularly classified the existing reversible watermarking technique into three types of work out the features of reversible watermarking techniques. The three types are analysed and compared based on PSNR and other parameters to find the best technique for reversible watermarking.

From this paper, we hope to provide an overall introduction of reversible watermarking and its schemes, which are still in development and have dramatically potential possibilities.

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