A Survey on Recent Reversible Watermarking Techniques

A. Jemila Rani

Lecturer (Senior Grade), Department of Electronics and Communication Engineering Kamaraj Polytechnic College Pazhavilai-629501, Kanyakumari District, Tamilnadu, India *Email-Id: jemilarani@rediffmail.com*

Abstract- Watermarking is a technique to protect the copyright of digital media such as image, text, music and movie. Reversible watermarking is a technique in which watermark can be removed to completely restore the original image. Reversible watermarking of digital content allows full extraction of the watermark along with the complete restoration of the original image. For the last few years, reversible watermarking techniques are gaining popularity due to its applications in important and sensitive areas like military communication, healthcare, and law-enforcement. Due to the rapid evolution of reversible watermarking techniques, a latest review of recent research in this field is highly desirable. In this survey, the performances of different latest reversible watermarking techniques are discussed on the basis of various characteristics of watermarking.

Keywords – Watermarking, Reversible Watermarking, Copyright, Restoration.

1. INTRODUCTION

During the past two decades, the improvement of data compression performance and the increasing bandwidth of internet make the digital images, video, and audio more easily duplicated and broadcast. In addition, more and more people would like to share their creative digital works, e.g. digital images, videos, and audios on Internet. Therefore, copyright protection and ownership declaration of the digital works have become very important. To protect the digital works against piracy, digital watermarking provides a potential solution.

Digital image watermarking is a process that embeds a watermark into a digital image to form a watermarked image. Digital watermarking methods for images are usually categorized into two types: invisible and visible. Invisible type aims to embed copyright information imperceptibly into host media such that in cases of copyright infringements, the hidden information can be retrieved to identify the ownership of the protected host. It is important for the watermarked image to be resistant to common image operations to ensure that the hidden information is still retrievable after such alterations.

Methods of visible watermarking type on the other hand, yield visible watermarks which are generally clearly visible after common operations are applied. In addition, visible watermarks convey ownership information directly on the media and can deter attempts of copyright violations.

Another way of classification is blind and nonblind watermarking systems. In non-blind watermarking systems, the detector requires either the original image or some information about the original image. However, in blind watermarking systems, there is no need of original or any information about the original image.

Image watermarking techniques can be categorized into spatial watermarking and spectral watermarking techniques. Spatial watermarks are created in the spatial domain of the image and are embedded directly into the pixels of the image. Spatial watermarks are destroyed by image processing operations. Spectral watermarks are incorporated into image's transform coefficients. That is, the transform coefficients of the image are used in creating and embedding the watermark. The associated watermarking techniques are called frequency domain techniques. Examples of transforms include Discrete Cosine Transform (DCT), The Wavelet Transform (DWT) and The Fast Fourier Transform (FFT). Frequency domain techniques can resist intentional and unintentional attacks and watermark extraction can be done effectively.

Reversible Watermarking (RW) methods are used to embed watermarks, e.g., secret information, into digital media while preserving high intactness and good fidelity of host media. It plays an important role in protecting copyright and content of digital media for sensitive applications, e.g., medical and military images. Robust Reversible Watermarking (RRW) is a challenging task. RRW recovers original image as well as resist intentional and unintentional attacks and extract watermark successfully.

Due to the rapid evolution of reversible watermarking techniques, a latest review of recent research in this field is highly desirable. In this paper, the performances of different latest reversible watermarking techniques are discussed on the basis of various characteristics of watermarking.

This paper is organized as follows: Section II gives a survey on recent reversible watermarking techniques. Section III lists out the commercial applications of reversible watermarking techniques. Section IV summarizes and concludes this paper.

2. SURVEY ON RECENT REVERSIBLE WATERMARKING TECHNIQUES

This chapter gives a literature survey on the performances of different latest reversible watermarking techniques.

Kim Sao Nguyen et al. [9] described a new histogram shifting-based reversible watermarking method. Most of the methods available in the literature need to use simultaneously the watermarked image and some imagedependent side information to restore the watermark and the original image. But this method can do above restorations without any auxiliary information. Such methods are called free from side information. This combines LSB-embedding and histogram shifting (HS). The original image is parted into two domains: the first one, consisting of a few pixels, is used for hiding auxiliary information by LSB-inserting, while the second one, comprising the other pixels is used for embedding the watermark by histogram shifting. In comparison to a few known free from side information methods, this method has higher embedding capacity and lower computational complexity. In addition, the solution obtained can easily be used to make almost other histogram shifting based reversible watermarking methods become free from side information.

Teleradiology enables medical images to be transferred over the computer networks for many purposes including clinical interpretation, diagnosis, archive, etc. In telemedicine, medical images can be manipulated while transferring. In addition, medical information security requirements are specified by the legislative rules, and concerned entities must adhere to them. Ali Sharifara et al, [10] designed a novel medical image watermarking scheme for medical images, which embeds watermark and patient information in medical images. The scheme is proposed to preserve the visual integrity of medical images, which must not be compromised by watermarking. This scheme used compression method to increase the size of watermark and also encryption to increase the security of medical images. Moreover, the current method combines image and text data as a watermark and then embeds data to RONI part of medical images.

order improve the robustness, In to imperceptibility, and anti-malicious extraction capability of reversible image watermarking, Zhengwei Zhang et al [11] designed an adaptive reversible image watermarking algorithm based on IWT and level set. Firstly, the stable edge profile is extracted by using the Laplace operator and the level set methods. Secondly, the unit circle in the stable edge profile is determined. Finally, the inscribed square area of the determinate unit circle is divided into nonoverlapping blocks. Each sub-block is performed by IWT, and the HVS is used to embed the watermark adaptively.

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The results showed that the algorithm has good invisibility and can resist various attacks. The algorithm not only has strong robustness against geometric attacks and conventional signal processing attacks but also can losslessly recover the original image.

This algorithm needs to consume a certain amount of time with using the level set idea to find a stable edge profile. How to further reduce the running time under the premise of ensuring the algorithm with high performance will be the next step to study.

To improve the visual quality and the embedding rate of the existing reversible image watermarking algorithm, Zhengwei Zhang et al. [12] et al. designed an improved reversible image watermarking algorithm based on difference expansion. First, the watermark information is divided into groups, and the information value of each group is calculated. The watermark group number and the corresponding carrier image block number are mapped, and the corresponding coefficient position of each corresponding carrier block is identified according to the value of the watermark information in each group. Second, the identified location map is compressed and embedded in the original image through the difference expansion. Through circular searching the suitable pixel position, the embedding rate can be effectively improved without sacrificing any visual quality. The experimental results show that this algorithm not only has high embedding rate but also has a high visual quality and can achieve full recovery of the original image. Compared with other algorithms, the main contribution of the proposed reversible image watermarking algorithm is to improve the watermark ER in the premise of maintaining a better visual quality. The experimental results show that the proposed method has a great improvement in the quality of the watermarked image, which can effectively alleviate the contradiction between the quality of the watermarked image and the amount of embedded data. Original host image after extracting the watermark information without distortion restoration can be used in high demanding fields such as military intelligence, medical records, and legal argumentation.

Namita Tiwari et al. [13] presented an active research domain of digital data hiding techniques. The lossless compressibility decides the reversibility of RDH images. They discussed eight RDH techniques, to which the G-LSB of early compression based scheme gives a fine scalability and the recent lossless compression based scheme minimizes the embedding distortion. The difference expansion scheme gives a higher embedding capacity with low distortion. The adaptive embedding strategies improve the reversible embedding performance by taking into account the properties of local image such as sorting and embedding-location selection. It perhaps can be integrated into many RDH methods to obtain an improved performance. Histogram shifting is an actively explored topic in RDH. For getting a performance enhancement, instead of using the spatial domain embedding, the transform domain embedding makes a large difference.

PVO based methods give a good quality of stego-image by accurately predicting the values and then ordering the pixel values. The characteristics of different PVO methods: IPVO, PVO-K, PPVO and Wang's method were discussed. The PPVO gives a higher embedding size of 9 bits for a 4×4 block. The future work in PVO based RDH techniques include, improving the embedding size. Code division multiplexing gives high embedding capability with low level of distortion. The future work involves elimination of the errors caused in the decoding stage due to malicious attacks. Interpolation technique gives a high image factor without compromising with the embedding size. Optimal weight based prediction achieves a good payload-distortion performance. The future work could explore a better performance by making the estimation errors close to zero, and combining this scheme with different data images. The buyer-seller protocol successfully resolves the conspiracy problem. The future work could include the exploration in elimination of the buyer's assistance to resolve the dispute in piracy.

Snehamol et al. [14] described another type of reversible image watermarking. In this paper, it mainly explicit the reversible of image watermarking by using the histogram shape method and wavelet reconstruction. In the transmitter section, it manly explicit the watermark embedding. Here a Gaussian low pass filtering is applicable to the host image. The Gaussian filter is used to smoothen images and avoid noise. The Gaussian filters are used in image processing method because they have a property for the support in the time domain, is equal to the support in frequency domain also. Here it mainly uses the Gaussian low pass filtering. The basics of filtered operations is called low-pass method. A low-pass filtered method is also called as blurring or smoothing filter techniques, averages out immediate changes in intensity. The simplest lowpass filtering method just calculates the average of the pixel and all of the eight immediate neighbors. After that we are constructing a histogram from the filtered image in relation with the grey levels by using a key. Then we are propose to build a safe band between the selected and non selected pixel groups needed for robustness. After that a watermark bit is inserting in to the selected groups. Here HFCM is also implementing to compensate the defects of Gaussian filtering to get the robustness. After embedding the watermarks the filtered image undergoes through the compression and encoding process. For the compression uses the SPIHT(set partition in hierarchical trees) after that it undergoes through the RS(reed Solomon) encoder algorithm followed by arithmetic encoding. Then we have to obtain the final watermarked image. At the recovery and enhancement section the final watermarked image from the embedding section undergoes different attacks during transmission. After the attacks undergo through the watermarked image, we have to receive a image at the recovery section. In the receiver side image it again apply the Gaussian low pass filtering method and the histogram is constructed. After comparing both the histograms and using the key it can extract the message. In the decoding section it need to recover the host image too. For that the receiver sided image is decompressed by using arithmetic decoding, RS decoding (Reed- Solomon) and followed by SPIHT(set partition in hierarchical trees) wavelet decompression method. Hence it obtains the original host image. Now the host image will be contrast enhancement by applying histogram equalization method.

Harish R et al. [15] designed a robust and semiblind reversible watermarking (RRW) technique for digital data. The primary commitment of this work is that it permits recuperation of a watermarked advanced information even in the wake of being subjected to pernicious assaults. RRW is additionally assessed through assault investigation where the watermark is distinguished with greatest interpreting precision in various situations. RRW can recoup both the inserted watermark with unique advanced information. RRW outflanks from every one of them on various execution merits.

Chengyou Wang et al. [16] introduces a robust image watermarking algorithm working in the wavelet domain, embedding the watermark information into the third level low frequency coefficients after the three-level discrete wavelet transform (DWT) and singular value decomposition (SVD). Additionally, to improve the robustness to geometric attacks, the affine-scale-invariant feature transform (ASIFT) is applied to obtain feature points which are invariant to geometric attacks. Then, features of acquired points between the watermarked image and the received image are used to realize the resynchronization to improve the robustness. This algorithm achieves great balance between robustness and imperceptibility, and is robust against geometric attacks, JPEG compression, noise addition, cropping, median filters, and so on. This paper can be implemented in special cases for military operations, hospital documents etc.

Plenoptic images are highly demanded for 3D representation of broad scenes. Contrary to the images captured by conventional cameras, plenoptic images carry a considerable amount of angular information, which is very appealing for 3D reconstruction and display of the scene. Plenoptic images are gaining increasing importance in areas like medical imaging, manufacturing control, metrology, or even entertainment business. Thus, the adaptation and refinement of watermarking techniques to plenoptic images is a matter of raising interest. A. Ansari et al. [17] proposed a new method for plenoptic image watermarking. A secret key is used to specify the location of logo insertion. Employing discrete cosine transform (DCT) and singular value decomposition (SVD), a robust feature is extracted to carry the watermark. The Peak Signal to Noise Ratio (PSNR) of the watermarked image is always higher than 54.75 dB which is by far more than enough for Human Visual System (HVS) to discriminate the watermarked image. The proposed method is fully reversible and, if no attack occurs, the embedded logo can be extracted perfectly even with the lowest figures of watermark strength. Even if enormous attacks occur, such as Gaussian noise, JPEG compression and median filtering, this method exhibits

significant robustness, demonstrated by promising bit error rate (BER) performance.

Chetna Sharma et al. [18] proposed a new reversible watermarking algorithm based on adaptive prediction-error expansion which can recover original image after extracting the hidden data. Embedding capacity of such algorithms depend on the prediction accuracy of the predictor. The method can embed secret data into 3×3 image block order by exploiting the pixel redundancy within each block. An interesting feature of randomization is that it provides improved image parameters i.e. Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). In this proposed method of reversible watermarking the proposed method gives much better results in terms of PSNR, MSE and Embedding Capacity.

Prediction error expansion (PEE) is state of the art technique for RW. Performance of PEE methods depends on the predictor's ability to accurately estimate image pixels. Muhammad Ishtiaq et al. [19] presented a novel Diamond-Mean (D-Mean) prediction mechanism. The D-Mean predictor uses only D-4 neighbors of a pixel, i.e. pixels located at {east, west, north, south}. In the estimation process, apart from edge presence, its orientation and sensitivity is also taken into account. In experimental evaluations, the D-Mean predictor outperforms currently in use MED (median edge detector) and GAP (gradient adjusted predictor) predictors. For, standard test images of Lena, Airplane, Barbara and Baboon, an average improvement of 51.79 for mean squared PE and an average improvement of 0.4 for error-entropy than MED/GAP are observed. Payload vs imperceptibility comparison of the method shows promising results.

Most artists are reluctant to apply undesirable modifications to their original work even when the extent of change is small. In addition, they want to protect their work by marking their ownership. Many digital technologies developed for legitimate digital content distribution via the Internet utilize algorithms involving lossy features. To minimize the likelihood of incurring such features, Junkyu Park et al. [] proposed a high-quality reversible watermarking method for lossless image compression of PNG images. In this method, robustness against undesired external attacks is considered for real-world usage. The data to be hidden are binary, comprising zeros and ones, and the cover image is in the compressed PNG format with a size of 512×512 or 256×256 . This algorithm is based on a constraint difference expansion (DE) algorithm and discrete wavelet transforms (DWTs) with Haar filters for achieving both reversibility and robustness. Simulation results show the superior performance of this method in terms of the high visual quality of stego-images, high data embedding capacity, and low computational complexity. Peak signal-tonoise ratio (PSNR) is used for comparing the cover and stego-images. The PSNR values of all the experimental images are approximately 60-70 dB on an average. The embedding capacity differs from image to image because the maximum capacity is embedded by applying a discriminant to ensure that overflow/underflow does not occur in an image. For the 512×512 size, the smallest capacity is approximately 60 bits. To measure the degree of robustness, they used the survival-ratio (SVR), which calculates the proportion of surviving bits after attacks. The result shows that this algorithm is robust against various attacks within a specific range.

3. COMMERTIAL APPLICATIONS

Authentication: A digital signature can be embedded as a watermark in a work. An advantage of this arrangement is for legacy systems. There has been concern because embedding a signature alters the work .

Military Application: Many images used to target certain location (longitude and latitude of target is embedded) should be reversible. In this case watermark is just to authenticate the target.

Medical Applications: Many medical images that need to send to a doctor should be embedded with history of patient. This history of patient may be in text format. Here original image should be completely reversible to take a decision by a doctor.

4. CONCLUSION AND FUTURE SCOPE

In this paper ,the current literatures on reversible watermarking is surveyed which is a recent hot topic of research. The discussion is carried out based on PSNR and Embedding Capacity, both, because if we increase the embedding capacity the PSNR gets reduced and vice versa. So an optimum balance between them is to be maintained to get a satisfactory result. A good technique should have PSNR as well as high Embedding Capacity. Reversible image watermarking algorithms still exist such as reversible image watermarking performance (especially the robustness) needs to be further improved, and poor ability of anti-attack in legal geometric problems should be solved and potential application fields of reversible image watermarking also need to be further widened. Secure reversible watermarking with any attack may be a dream and a challenging field in near future.

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Author



A.Jemila Rani obtained B.E. in Electronics and Communication Engineering from Kamaraj Madurai University, Madurai, Tamilnadu, India and M.E. in Applied Electronics in 2011 from Anna University, Tirunelveli, Tamilnadu, India. She is a Lecturer (Senior Grade) in the Department of

Electronics and Communication Engineering at Kamaraj Polytechnic College, Pazhavilai, Tamilnadu, India. She has a teaching experience of 26 years. Her interesting area is Image Processing.