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A REVIEW AND ANALYSIS OF DIFFERENT REVERSIBLE DATA HIDING TECHNIQUES

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Abstract

Data hiding is an emerging research field since the internet is utilized today for data communication but is insufficiently safe to communicate highly sensitive information. Data is embedded into digital media as part of the data hiding process for security. In some specialized applications such as medical, military, and legal, even slight distortions in digital images can cause false alarms. Reversible Data Hiding (RDH) is the process which allows the original data to be recovered fully with no loss of information, and is thus an active research direction in this area. Different RDH techniques are widely used from image recognition to medical image processing to vector reconstruction in CAD. In this paper several reversible data hiding techniques are reviewed. Different techniques like Block Prechecking, Difference based Fibonacci Transform, Block-Wise Histogram Shifting, Code Division Multiplexing, Progressive Recovery, Distributed Source Encoding, Histogram Modification and MSBs Integration, block-wise multi-predictor were reviewed in this paper. The results of different reversible data hiding techniques are analysed by using the previous methods.

Keywords: Reversible Data Hiding (RDH), Data Extraction, Data Embedding Encryption, Stream Cipher.

1. Introduction

Internet came into existence, to exchange important data among researchers throughout the world. The Internet has a vast amount of digital data information available, with the rapid advancement of information technology. A growing number of digital images are being sent over insecure communication channels, such as the internet. As a result, any plan to handle medical diagnosis, military, and quality assurance images must be secured. Based on these images, the decisions made could change such manipulations.

The users exchange secret data using internet, due to the intruders or attackers the internet is not safe. Thus, the confidentiality and security of the data became very important. In order to address this issue, the data hiding technique was developed, whereby the secret data is concealed within a cover object with as little degradation as possible. This prevents the intruder from discovering the existence of secret information within the cover object.

The process of embedding the data into the cover image or video with a minimum amount of distortion or error to the original cover image or video is called data hiding. Two kinds of data concealment techniques are reversible and irreversible data hiding. The covered image can often be recovered in reversible, but the original cover cannot be recovered in irreversible. The primary objective of this could be to incorporate some confidential and sensitive information into a carrier by modifying certain parts for protection copyright or covert communication.

Data-hiding is the procedure of concealing information in any media. By changing the image pixel values, additional information can be added to a digital image. In most of cases distortion will be experienced by the cover media due to the altering of the pixel values during data hiding. Even after the extraction of secret data the distortion cannot be recovered. In few applications, to illustrate medical analysis and law authorization, it's important to show media back to the original kind once the retrieval of the information for legal contemplations. In different applications, for example, remote detecting, therapeutic picture sharing, multimedia media file administration, picture trans-coding and high-vitality particle physical experimental examination, the distortion is not tolerable. Figure 1 represents the working of reversible data hiding.

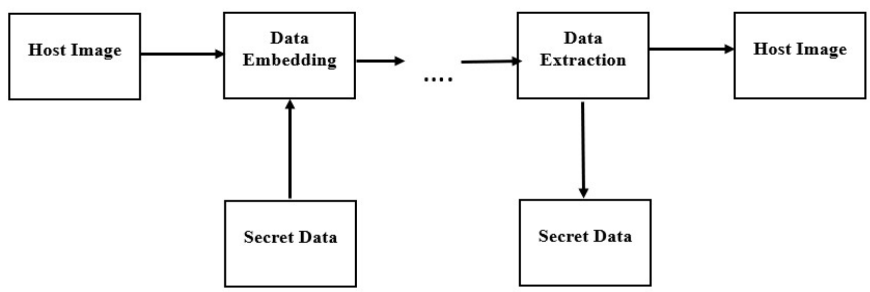

Figure 1: Working of Reversible Data Hiding

Reversible Data Hiding (RDH) includes embedding information into media in a very manner that takes into thought the recovery of the inserted information and additionally the first media [1]. RDH joins different methods to guarantee the reversibility. Its practicality is principally because of the lossless compressibility of regular pictures. RDH [2] is a current research direction in this area because it allows the original data to be fully recovered with no loss of information. Many RDH approaches have been applied widely since the development of the reversible data hiding algorithm. These techniques include picture validation, medical image processing, cloud data coloring, vector restoration in CAD, and more.

In this paper the review on different RDH techniques is presented. Based on the previous approaches, a thorough analysis of reversible data hiding techniques is suggested. The results consist of the comparison of different methods on reversible data hiding.

2. Related Work

Aziz F et al. [3] illustrates a unique method for reversible data hiding that takes advantages of an image's textures and patterns. Rather than calculating the difference between neighbouring pixels, this method searches in the image for the pattern that had the possibility of maximum embedding capacity. This method aims to increase the marked image embedding capability while also improving its visual quality. High embedding capability was another benefit it offered that transferred pattern images for applications. In order to maximize the embedding capability, this method intermediate step produces a transformed image that can be utilized in conjunction with other difference-based techniques. They extracted the data from the marked image in one step and embedded it in another. For embedding of the data in the input image, it needs to generate index map by taking the values from 1 to width-1 to δ. Prior to calculating the embedding capability, compute the index map. The maximum capacity of δ should be chosen as the value. The input images columns are changed using the index map, which has the largest capacity. The resulting image then has a different arrangement of columns than the original image. For the index mapped transformed image, the difference matrix is computed. The peak intensity is employed to shift the histogram in order to create space for the data embedded. In difference image the message is embedded with histogram shifting that has the value 1. Finally, the image that is transformed has the data which us embedded in image is known as marked Image. During extraction process marked image is converted to transformed image by reverse process. To create the altered image, the difference image with histogram shifting is computed.

V.M. Manikandan et al. [4] proposed a technique to embed data on the image blocks that does not consists of any random textures. This method has a new encryption scheme to lower the bit error rate by utilizing block prechecking. Because of the changes to pixel values in medical images are not taken into account and can result in incorrect diagnoses, this scheme is an impulse to use RDH in medical image transmission. The purpose of this scheme is to encrypt data using three distinct encryption keys. The process of block-wise encryption for the image block is done by the sender. A secret message bit that must be embedded determines how many pseudorandom bytes are chosen to encrypt a particular image block. Three bits can be simultaneously embedded in a single block of the secret message using this method as opposed to other approaches that only allow for the embedding of one bit. Therefore, a 9*9 pixel image block can contain three bits embedded in it. A few predetermined rules are utilized to create the pseudo random streams of nine bytes. By using Pseudo random bytes and XOR operations embedding is done in data in blocks of an images. This method makes use of trained Support vector machine for both image recovery and extraction of data. It is done by considering some different features of SVM. The data will be retrieved and the image restored by XORing the image blocks with pseudo random bytes. This is best suitable for medical images as it does not embed any data in random textures compared to other methods. This also ensures very low bit error rate.

Panchikkil et al. [5] proposed a method using the Fibonacci transform to hide the data in encrypted images. To conceal data in encrypted images, an ensemble learning technique combined with the Fibonacci transform is utilized. The image that is encrypted is split into non-overlapping blocks of images, taking into account one-by-one blocks, in order to hide the data. The encrypted image pixel intensities are created so that they cannot be changed while the image is being hidden. The RDH scheme is implemented using a well-known method called the Fibonacci transform image scrambling algorithm. By making images undecipherable and unreadable image scrambling provides security to image data as compared to other methods. It emits the correlation that is present between neighbouring pixels. Through simple matrix transformations, the pixel locations are modified in scrambling of Fibonacci transforms. For image recovery and hidden information extraction, models of machine learning like Support

Vector Machine, Convolutional Neural Network and K-Nearest Neighbor are utilized. A lossless recovery of many of the 210 unique images from the USC-SIPI image database can be ensured by this scheme, in contrast to other methods and algorithms. It provides a bit error rate of 0, a peak signal-to-noise ratio of ∞, and a structural similarity index of 1.

Kamil Khudhair et al. [6] proposed a pixel value that attain a distribution which is obtained from the cover image. Dynamic block-wise reversible data embedding method is utilized to improvise the embedding capability, to provide better visual quality, and also provide the security. At the beginning of process by using cover image, pixel histogram is drawn for that image. The 256-bit key is determined by processing the histogram, which divides the cover image into blocks of four. Blocks of the cover image are divided, and for each block, a histogram bin is plotted. Each blocks contrast is calculated, and the resultant contrast value determines the frame histogram characteristics, such as its high, low, or normal contrast. The predefined contrast properties should be used to modify the histogram peak value. It will identify the direction of peak value of histogram. Then 1-bit LSB technique is utilized to embed the data after conditions of contrast have been selected. Depending on the contrast values, the histogram is shifted to the right or left of the pixel value. It is shifted to right if the contrast is low and shifted to left if the contrast value is high and the bins of histogram are distributed in the middle if the contrast is normal. Thus, by using the contrast variations this method provides lesser variability. It provides the better histogram-shifting compared to other methods.

Ma, Bin et al. [7] proposed RDH scheme based on CDM algorithm. The different orthogonal spreading sequences are utilized to denote cover data and after that cover data is embedded into image that is covered. Adopting the Warsh Hadamard matrix, a new technique for generating orthogonal spreading sequences, allows data to be embedded overlappingly without interfering with one another. To increase the embedding capability, multilevel data embedding technique is used. Spreading sequences for most of the elements are cancelled manually when they are overlappingly embedded. That causes low level image distortion even with a high embedding capacity. Although a location map is not necessary to locate embedding positions, pseudo bits are added during the embedding process. On both ends, the distribution of the image histogram is contracting to address the overflow/underflow problem

Z. Qian et al. [8] proposed a technique based on progressive recovery to enhance and provide a high embedding rate. This method involves three parties: the recipient uses the decryption key to retrieve the image, the content owner encrypts the original image, and the data hider conceals data in the encrypted image. The content owner utilises AES and an encryption key to encrypt the original image during the process of encryption. The process of data embedding involves the data hider embedding the additional information into an encrypted image. The encrypted image is divided into three sets by data hider. Each set of images contains the message embedded in it, and the recipient receives the image containing the extra data. The recipient must have decryption key to recover the data and image loselessely. Extraction of data is done by two methods. The image can be recovered approximately if receiver has only decryption key. If the recipient has both encryption and decryption keys the recovery of the original image can be done loselessely. If receiver has both keys, then by using progressive recovery the data can be extracted from divided images separately. Though by using progressive recovery it will provide better results compared to other techniques.

X. Zhang et al. [9] proposed distributed source coding to create a unique scheme for Reversible data hiding. This technique seeks to increase the payload capacity for encrypted image embedding. The original image is encrypted by content owner by utilizing stream cipher method. Distributed source coding provides the extra or spare room needed to encode secret data, which is the inspiration behind Slepian-wolf source encoding. The chosen bits from the stream-cipher image are encoded using low density parity check (LDPS) codes. By using two keys during data extraction, it is possible to recover both the hidden data and the original image. On the receiving end, all hidden data can be extracted using the embedding key. Approximately, the original image can be recovered with a high-quality encryption key. The hidden data and the image can be recovered perfectly if both the keys are available. The proposed technique is compared with existing vacating room after encryption method, it provides method which substantially increases the payload. It achieves a high embedding payload and better image reconstruction quality by the sender without requiring the room to be reserved.

Mohammadi et al. [10] proposed some concepts for reversible data hiding in plain images, like prediction error and histogram modification, which use encrypted images to hide data reversibly. Stream cipher may be utilized to encrypt the original image. In order to vacate room for data bits to be embedded, the most important bits of encrypted pixels are integrated. Separable vacating room after encryption is proposed. In image encryption, by utilizing exclusive OR bitwise of the original image the encryption is achieved. The embedding of data bits consists of integration, vacating room, data embedment, disintegration and foaming marked sources. During data extraction and recovery, by using data hiders secret key, error-free data can be extracted and by using owners secret key lossless reconstruction of original image can be accomplished. Predictors are used to reduce the risk failure in original image retrieval and to maximise the embedding capability.

Li, Q et al. [11] proposed a block-wise multi-predictor technique for RDH in encrypted images. To take advantage of full spatial correlation, a block-wise multi predictor scheme applies 16 prediction models in blocks of natural images. A block prediction performance was measured by a function. When the block size is set to 8 by 8, this method can strike a balance between performance and the size of the prediction map. The residuals in the blocks are closed to zero or small integers after multi-predictor prediction. By using the improved Huffman coding technique, the prediction model map and prediction error image are compressed, freeing up more space for embedding data. During encryption process block permutation, compression and pixel modulation is carried out for original images and the information is embedded in encrypted image by using key. By using both keys image is extracted as well as the original image is recovered. Higher embedding capacity, total reversibility, and image restoration are all achieved by this method.

H. Zhang et al. [12] proposed an efficient method to conceal the data into JPEG images without needing to first decompress them. The methods work on entropy coded and quantized DCT coefficients directly. Very few changes will be necessary for the JPEG bit stream. Without seeing entire JPEG data, the bit streams are processed efficiently on-the-fly. By treating each DCT block as an integer and proposing a few selected DCT coefficients, this technique altered the in a reversible manner. The JPEG compressed stream quantization table and quantized DCT coefficients are the only things that the technique addresses. JPEG stream in a DCT coefficients is organized into MCUs, it consists a number of blocks without waiting for the end of the data. Real-time processing of JPEG streams is possible, and both embedding and detection can be finished in a single pass. Table 1 represents the comparative study of different methods for RDH.

Table 1: Overview of different RDH Techniques.

Author	**Year**	**Technique**	**Objective**	**Metrics**	**Remarks**
Furqan Aziz, Taeeb Ahmad	2020	Difference based technique	To maximise the embedding capability, to increase the visual quality	PSNR	Pixel Difference Histogram (PDH) the proposed technique is validated through Stegoanalysis, and the results show that the marked images produced by the suggested method are undetectable by PDH analysis.
V.M. Manikandanan, Bini A. A	2020	Block Prechecking	To recover all the image blocks Perfectly	BER ER	The intricacy of image recovery or data bit extraction errors were not taken into consideration when the data bits were embedded.
Shaiju Panchikkil, Siva Priya Vegesana	2023	Fibonacci Transform	To ensure a lossless recovery	PSNR SSIM BER	Hiding the data while maintaining the encrypted pixel intensities unchanged
Samar Kamil Khudhair, Monalisa Sahu	2023	Block-Wise Histogram Shifting	Improved visual quality and better embedding capacity	PSNR, ER SSIM and Q	To improve the quality and embedding capability of stego images, it is suggested to use RDH based on dynamic blocks and histogram shifting

Bin Ma, Yun Q. Shi	2016	Code Division Multiplexing	To reconstruct the original image, to provide large embedding capacity	PSNR, ER SSIM	The data can be embedded overlappingly without interfering with one another by creating orthogonal spreading sequences with the Walsh Hadamard matrix.
Zhenxing Qian, Xinpeng Zhang	2016	Progressive Recovery	Large embedding rate, to recover the image loselessely	PSNR, ER	In comparison to state-of-the-art RDH-EI techniques, RDH-EI offers a better prediction method based on progressive recovery for estimating the LSB-layers of the image using three rounds.
Zhenxing Qian, Xinpeng Zhang	2015	Distributed Source Encoding	To enhance the encrypted image embedding payload capacity	PSNR	With distributed source decoding, the recipient can precisely restore the original image if they possess both the encryption and embedding keys.
Ammar Mohammadi, Mohammad Ali Akhaee	2023	Histogram Modification and MSBs Integration	Error-free data extraction, reduce the failure risk in the original image retrieval	PSNR	To make room for embedding data bits, the most significant bit (MSB) of the encrypted pixels is integrated.
Huiqi Zhang, Lin Li, Qingyan Li	2021	Block-wise multi-predictor	For embedding secret data and restore the	PSNR, ER SSIM	To reduce the size of the prediction model map and prediction error, a better

			original image losslessly		Huffman coding technique is utilised

3.Conclusion

Reversible data hiding technique recovers the original image without any distortion after the extraction of data. This review paper analysed different methods of reversible data hiding. This review article often goes with several RDH subjects like difference-based technique, Block Prechecking, Fibonacci Transform, Block-Wise Histogram Shifting, Code Division Multiplexing, Progressive Recovery, Distributed Source Encoding, Histogram Modification and MSBs Integration, block-wise multi-predictor. The above methods have several advantages and disadvantages. The above techniques provide better embedding capacity, lossless data recovery and also extraction of carrier image without any error. All of the previously mentioned approaches were enhanced and implemented in order to produce better results in terms of capacity, perceptibility, robustness, and most importantly security.

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