Hybrid Encrypted Reversible Data Hiding Using DWT

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Abstract: *With the rapid advancement of communication through Internet, the information exchanged could be tampered intentionally or accidentally through unprivileged access. In the recent years, Reversible Data Hiding (RDH) has become an active research domain in the field of data hiding. In reversible data hiding, at the sender side, the bits which is to be concealed is embedded in the cover file (image) and at the receiver side, the hidden bits of data and the original cover media is extracted without any distortion. Recently researcher focus over image quality ie imperceptibility and robustness of cover image at receiving is need to be improved. Where the PSNR value indicate the visual quality of the image where higher PSNR value lead better image quality. In this paper a hybrid encrypted reversible data hiding scheme has been proposed that embedded the confidential data by adding singular values of the HH band of cover image with encrypted singular values of the confidential data. So main aim of proposed scheme is to need to developed a data hiding scheme which prevent authentication of digital information with maintain higher PSNR ratio also.*

Keywords: Digital image processing, Reversible Data Hiding, DWT, Harr Transform, PSNR

I. INTRODUCTION

The rapid development of digital technologies has improved the means of access to information. These new technologies allow us to store, transfer and manage digital content with less time, less complexity and efficiency. However, the analysis also brings disadvantages, such as confidentiality of digital content. Internet plays an important role in the flow of unauthorized and illegal digital content. This increases the risk of violating confidentiality of digital content of digital content. One way to protect digital content against illegal access and distribution is called reversible data hiding.

Data Hiding is identified as a major technology to achieve copyright protection and multimedia security. Therefore, recent studies in literature include some evident approaches for embedding data into a multimedia element. Because of its useful frequency component separation, the Discrete Wavelet Transform (DWT) is commonly used in Data Hiding schemes.[2] Data Hiding basically is used to protect the matter in an illegal person. To save the legal documents because an unauthorized person access the matter then claims of our document theft. The Data Hiding algorithm incorporates the watermark into the object. The verification algorithm authenticates the object determining both the owner and the integrity of the object [3].

Data hiding techniques can be divided into various categories. The watermarks can be applied in either spatial domain or in the frequency domain. It has been pointed out that frequency domain techniques are more robust than spatial domain techniques. Host and watermark image split into three color components, red, green, & blue [4].

On the other hand the spatial domain Data Hiding schemes have less computational overhead compared to frequency domain schemes. The digital watermarks can be divided as visible watermark and invisible. A visible watermark is a translucent object is overlaid into the primary image and appears visible to a casual viewer on careful inspection. Digital Data Hiding process mostly categorized into three phases

- Embedding
- Distribution
- Extraction or Detection

Furthermore, digital Data Hiding is based on two methods

- Spatial domain based
- Transform domain based

Digital Data Hiding can be done either in spatial domain or frequency domain. Frequency domain methods are more robust in contrast to spatial domain methods and have been used widely. Frequency domain methods are based on transforms such as Fourier Transform (FT) or Fast Fourier Transform (FFT), DCT (Discrete Cosine Transform), and DWT (Discrete Wavelet Transform). We have done an exhaustive survey on Data Hiding methods based on frequency domain and found that DWT based methods are more robust.

Also, the amounts of Data Hiding approaches have been proposed using DWT to watermark medical images. Besides these frequency domain methods, Singular Value Decomposition (SVD) based Data Hiding methods have gained importance. These methods are robust to various attacks - such as compression, noising, and rotation which are intended to destroy the data hiding. Generally, digital Data Hiding techniques must conform to some following requirements.

(1) **Invisibility**: the variance between original multimedia and watermarked must not be noticed by the naked eyes, namely, the feature of cover image multimedia must be good.

(2) **Security**: everybody excepting rightful one cannot be detect Cover image which is unseen in the multimedia. Furthermore, the Data Hiding algorithm must be public, namely, the security of the Data Hiding structure should not construct on attackers who do not know how the system works.

(3) **Efficiency**: in order to be implemented efficiently, the Data hiding algorithm must have decent performing efficacy, and it does not need original multimedia to extract the Hidden data.
(4) **Robustness**: after the embedded multimedia is processed by the digital signal processing (such as filtering, compressing, cropping, sharpening, blurring, etc.), the watermark still can be extracted when the feature of the multimedia is suitable.

II. RELATED WORK

Data hiding [5] is a security technique used to conceal secret information into digital media. Reversible data hiding can guarantee that the secret message can be extracted correctly and that the cover image can be reconstructed exactly. In this paper, author presented our design of a new reversible data hiding scheme, which is based on Sudoku reference matrix and can enhance the performance of some reversible data hiding schemes for image interpolation. In [6] author proposes a reversible data hiding scheme that enables an adjustable amount of information to be embedded in JPEG images based on padding strategy.

The proposed embedding algorithm only modifies, in a subtle manner, an adjustable number of zero-valued quantized DCT coefficients to embed the message. Hence, compared with a state-of-the-art based on histogram shifting, the proposed scheme has a relatively low distortion to the host images. A scheme of reversible data hiding [7] in encrypted image (RDH-EI) with high embedding capacity is proposed in this paper. First, cover image is transformed to the quantized discrete cosine transform (DCT) coefficients, which are reformed and encrypted to generate the encrypted image. Reversible data hiding [8] in encrypted images has attracted considerable attention from the communities of privacy security and protection.

The success of the previous methods in this area has shown that a superior performance can be achieved by exploiting the redundancy within the image. Specifically, because the pixels in the local structures (like patches or regions) have a strong similarity, they can be heavily compressed, thus resulting in a large hiding room. In this paper, to better explore the correlation between neighbor pixels, author propose to consider the patch-level sparse representation when hiding the secret data. The widely used sparse coding technique has demonstrated that a patch can be linearly represented by some atoms in an over-complete dictionary. As the sparse coding is an approximation solution, the leading residual errors are encoded and self-embedded within the cover image.

Histogram shifting (HS) [9] embedding as a typical reversible data hiding scheme is widely investigated due to its high quality of stego-image. For HS-based embedding, the selected side information, i.e., peak and zero bins, usually greatly affects the rate and distortion performance of the stego-image. Due to the massive solution space and burden in distortion computation, conventional HS-based schemes utilize some empirical criterion to determine that side information, which generally could not lead to a globally optimal solution for reversible embedding. In this paper, based on the developed rate and distortion model, the problem of HS-based multiple embedding is formulated as the one of rate and distortion optimization.

Two key propositions are then derived to facilitate the fast computation of distortion due to multiple shifting and narrow down the solution space, respectively. It is clear from the survey that the image quality imperceptibility and robustness of cover image at receiving is needed to be improved. Where the PSNR value indicate the visual quality of the image where higher PSNR value lead better image quality.

So main research gap need to developed a data hiding scheme which prevent authentication of digital information with maintain higher PSNR ratio also. The embedding algorithm is robust against common image processing operations. It is concluded that the embedding and extraction of the proposed algorithm is well optimized, robust and show an improvement over other similar reported methods.

III. PROPOSED REVERSIBLE DATA HIDING SCHEME

In this paper, a hybrid encrypted reversible data hiding (HERDH) scheme has been proposed. HERDH employed Digital Wavelet Transform (HAAR transformation) with Singular value decomposition of HH band. Proposed HERDH initially applied DWT transformation over cover image (C_I) and decompose it into four frequency sub band namely LL, HL, LH and HH.

The proposed techniques use the DWT transformation scheme for the reversible data hiding. Which decomposes the cover image (C_I) in four components, namely, LL, HL, LH and HH, where the first letter corresponds with frequency offset of the row either low or high and second latter refer to filter applied to the columns.

The lowest resolution level LL refer to approximate part of the Cover image whereas rest three refer to detail parts and give the vertical high (LH), horizontal high (HL) and high (HH) frequencies. In the proposed algorithm, confidential data is embedded into the host image by modifying the high frequency coefficients band i.e. HH sub band. Proposed reversible data hiding scheme is based mutually on both DWT and SVD with encryption as explain in algorithm Reversible Data Hiding Procedure.

Initially, DWT decomposes the host image into four frequency sub-bands namely LL, HL, LH, and HH band. LL band deals with approximate details, HL band deals with horizontal details, LH gives vertical details and HH band contain diagonal details of the image. HERDH use HH band to embed the confidential data since it haves the finer details about image energy. In this way embedded data hiding will not influence the perceptual fidelity of cover image as explain in algorithm Reversible Data Hiding Procedure.

Hiding Phase

In hiding phase of proposed scheme use HH band of cover image (C_I) to hide confidential data (CD_I). In HH band, spectrum of frequency is very high and report minimum

distortion due to noise. Proposed scheme initially encrypt CD_I then add SVD of encrypted CD_I with SVD of HH band of C_I as encrypted SVD. Encrypted SVD then superimpose over HH band of DWT (C_I) after applying inverse SVD operation. Finally apply inverse DWT to generate embedded cover image (EC_I).

The proposed scheme confidential data is embedded by adding singular values of the HH band of cover image with encrypted singular values of the confidential data as explain in algorithm Reversible Data Hiding Procedure.

Algorithm (Reversible Data Hiding Procedure)

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Step 1:- Apply encryption over confidential data image (CD_I)

$$ECD_I = encrypt(CD_I) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.1$$

Step 2:- Apply SVD over confidential data image (ECD_I)

$$SVD(ECD_I) = U_{ECD\,I} * S_{ECD\,I} * V^T_{ECD\,I} \ldots\ldots\ldots\ldots 1.2$$

Where, $S_{ECD\,I}$ Singular value co-efficient are rounded to the nearest integer

Step 4:- Decompose the cover image into four sub-bands with different wavelength by using DWT Haar wavelet transformation

$$C_I = LL, HL, LH, HH \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.3$$

Step 5:- Apply SVD over HH band of cover image.

$$Cover_I^{HH} = U_{HH} * S_{HH} * V^T_{HH} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.4$$

Step 6:- Add the singular values of the HH band with the encoded singular values of the confidential data image.

$$SVD(Embedded\ C_{image}^{HH}) = U_{HH} * S_C^{ECD} * V^T_{HH} \ldots\ldots\ldots\ldots\ldots 1.5$$

Step 7:- Apply inverse SVD to produce the Haar transform of embedded data hiding cover image.

Step 8:- Apply inverse DWT to produce the embedded data hiding cover image

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Selection of cover image is such a manner that its singular values lies within the given range and energy of the singular values of CD_I will be approximately equal to the energy of the singular values of the HH band. Hence the replacement of the singular values will not affect perceptual quality of image and the energy content of HH band.

Extraction Phase

In Extracting proposed scheme use to apply DWT over embedded image (ECI) to get HH band where confidential data (CDI) is hided as explain in algorithm Reversible Data extraction Procedure.

Algorithm (Reversible Data Extraction Procedure)

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Step 1:- Decompose the embedded cover image into four sub-bands with different wavelength by using DWT Haar wavelet transformation

$$EC_I = LL, HL, LH, HH \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5.6$$

Step 2:- Apply SVD over HH band of embedded cover image.

$$Embedded\ Cover_I^{HH} = U_{HH} * S_C^{ECD} * V^T_{HH} \ldots\ldots\ldots\ldots\ldots 5.7$$

Step 3:- Subtract the singular values of the HH band of cover image and embedded cover image that return SVD matrix of ECD_I

$$SVD(Embedded\ CD_{image}) = U_{ECD} * S_{ECD} * V^T_{ECD} \ldots\ldots\ldots 5.8$$

Step 4:- Apply Inverse SVD over$SVD(Encrypted\ CD_{image})$

$$Encrypted\ CD_{image} = U_{ECD} * S_{ECD} * V^T_{ECD} \ldots\ldots\ldots\ldots\ldots\ldots 5.9$$

Where, S_{ECD} Singular value co-efficient are rounded to the nearest integer

Step 5:- Apply decryption over confidential encrypted confidential data image (ECD_I) and get confidential data image.

$$CD_I = decrypt(ECD_I) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5.10$$

Step 6:- Apply Inverse SVD over$SVD(Embedded\ C_{image})$

$$Embedded\ C_{image} = U_C * S_C * V^T_C \ldots\ldots\ldots\ldots\ldots\ldots\ldots 5.11$$

Where-

S_C Singular value co-efficient are rounded to the nearest integer

Step 7:- Apply inverse DWT to produce the original Host image.

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Apply SVD over HH band to get decompose singular value that also contain singular value of encrypted confidential data as explain in algorithm Reversible Data extraction Procedure. As SVD of HH band of Cover Image is being shared among sender and receiver before communication, extracting phase use this SVD value to subtract from SVD of received Image. After subtracting extracting phase get SVD value of encrypted confidential data and apply inverse operation to get confidential data CD_I.

IV. RESULT ANALYSIS

The proposed works has tested on the different images of size 512x512. All These images are colored. Here the images

are used called baboon, LENA and pepper. The data hiding image has also the same size as the host image. To simulate the proposed work the implementation has done in MATLAB. The execution has been done on the i3 processor with 4 GB RAM and 500 GB HDD. This calculation has been gathering by the computer program. There is a various testing images has been used. Some of them have been shown here with their results.

As shown in table 1 PSNR of existing technique for all the available data set describes in figure 1 is less than 50%. Where the PSNR value indicate the visual quality of the image where higher PSNR value lead better image quality.

Table 1: PSNR

Images	Existing	Proposed
Fishing Boat	49.86	58.17416
Barbara	49.76	51.717238
Lena	49.99	70.631805
Pirate	49.77	53.805407

The graph of PSNR is shown in Figure 1. As the graph shows that there are some images has been used for as input. This input and the generated output image has been used for calculating the PSNR. Graph also shows the proposed approach shows the batter results.

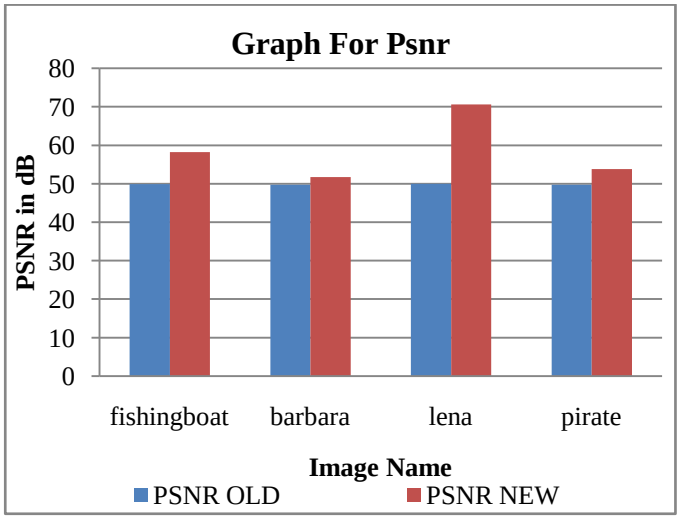

Figure 1: Graph for PSNR

V. Conclusion

With the rapid advancement of communication through Internet, the information exchanged could be tampered intentionally or accidentally through unprivileged access. In the recent years, Reversible Data Hiding (RDH) has become an active research domain in the field of data hiding. In reversible data hiding, at the sender side, the bits which is to be concealed is embedded in the cover file (image) and at the receiver side, the hidden bits of data and the original cover media is extracted without any distortion. RDH is also referred as invertible or lossless data hiding.

In this paper, a hybrid encrypted reversible data hiding (HERDH) scheme has been proposed. HERDH employed Digital Wavelet Transform (HAAR transformation) with Singular value decomposition of HH band. Proposed HERDH initially applied DWT transformation over cover image (CI) and decompose it into four frequency sub band namely LL, HL, LH and HH. The proposed algorithm is robust against common image processing operations. It is concluded that the embedding and extraction of the proposed algorithm is well optimized, robust and show an improvement over other similar reported methods.

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