ALPHA BLENDING IMAGE STEGANOGRAPHY USING DISCRETE WAVELET TRANSFORM AND SINGULAR VALUE DECOMPOSITION

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Abstract

Steganography is the methodology to conceal confidential facts and secure information during communication over a network. An image steganography scheme is proposed to conceal one color image deep down the other color image to avoid the visibility of the existence of information. The proposed technique is attributed to the 2D-Discrete Wavelet Transformation (DWT) and Singular Value Decomposition (SVD) schemes in conjunction with the alpha blending technique. The Peak Signal to Noise Ratio (PSNR) of the stego images generated by the designed algorithm is significant. The proposed model is suitable for real-time applications, provides elevated concealing capacity, and proves the protected communication and confidentiality of the Payload Image (PI).

Keywords: Cover Image, Payload Image, DWT, SVD, Steganography, PSNR

1 Introduction

In the era of the fast internet revolutions, different forms of digital communication are used by modern society in daily life to maintain a better lifestyle. The protection of sensitive data is needed for an hour from various attacks. The wide usage of multimedia for interaction through insecure channels is challenging in the network due to the advancement in big data and cloud computing, and information is manipulated on the internet. The focus needs to be on confidentiality and security. The sensitive data transmission through the medium, i.e., the channel, is generally visible to every user connected to that particular channel. This requires real-time information, which needs to be transmitted to provide security. The Various cryptographic techniques to provide information security in the shared medium converts the user specifics into different formats based on a particular mathematical model. However, by visual perception of the enciphered data, someone may comprehend the encrypted content, which leads to unnecessary access to the document by unauthorized users and performs different types of decryptions to retrieve the information [1]. To keep off this issue, the steganography technique has been conceived. The sensitive fact is interposed in the Cover Image (CI) to make it difficult to understand and analyze that something is embedded, which escapes some extent of security attacks.

Srilekha Mukharji et al. [2] manifested the Mid-Position Value (MPV) supported image steganography, progressing masking of the key is examined and Arnold's conversion has been executed on the chosen CI. Barnali and Samir [3] illustrated the Natural Language Processing (NLP) supported text steganography. Liyan Zhu et al. [4] presented robust steganography for

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social networks. Kamaldeep Joshi et al. [5] presented the indicator in CI for the 7th bit of a pixel. Aya Jaradat et al. [6] rendered the image steganography by employing Particle Swarm Optimization (PSO). The proposed technique uses PSO and chaos scheme to embed the guard image to CI effectively. Asmaa Abdelmonem Eyssa et al. [7] presented an image steganography approach to conceal data on wireless communication systems. The target of the methodology is to conceal three-color images in one. To minimize the distortion in the channels, Orthogonal Frequency-Division Multiplexing (OFDM) is used.

Sachin and Rashmi [8] proposed a survey on various steganographic techniques. Sahar A. El Rahman [9] contributed image steganography based on Discrete Cosine Transform (DCT) and Least Significant Bits (LSBs) (1-LSB & 2-LSB). Gandharba Swain [10] presented image steganography adopting Quotient Value Differencing (QVD) and LSB. The CI is converted into 3×3 blocks, the substitution is on two LSBs and QVD is utilized on the outstanding 6 bits. H J Ko et al. [11] proposed the magic cube method along with LSB. The payload information bits are mapped out to a presumed cube, achieving the PSNR of 44 dB. Ying-Qian Zhang et al. [12] proposed the Discrete Hadamard Transform (DHT) and inverse DHT is applied on CI, the personal images are of dimension 512×512. The PSNR is 37.47 dB for the Lena image as CI.

Jingxuan Tan et al. [13] illustrated image steganography using generative adversarial networks with a channel attention mechanism. Inas Jawad Kadhim et al. [14] proposed the Dual-Tree Complex Wavelet Transform (DT-CWT) subband coefficients for embedding. The Average PSNR achieved is 53.7dB. Pranab K Muhuri et al. [15] proposed image steganography upon Integer Wavelet Transformation (IWT) and PSO. The PSNR of the proposed system is 41.15 dB.

Vajiheh Sabeti et al. [16] proposed a wavelet-based steganography method in accordance with the Genetic Algorithm (GA) to produce high-quality Stego Image (SI). Guru Vimal Kumar Murugan et al. [17] exhibited image steganography in virtue of Haar DWT for a secured and safe transaction, DWT has more advantages than DCT and the PSNR achieved is 53.77 dB**.** Hanaa A. Abdallah et al. [18] introduced the technique to conceal the information in the orthogonal matrix of the SVD and the PSNR is 12.44 dB. Reham A. El-Shahed et al. [19] proposed the multiple resolutions Stationary Wavelet Transform (SWT) and SVD to hide the secret information in a video.

B. Lakshmi Sirisha et al. [20] offered the method employing SVD and DWT.SVD is applied on the LL band of the payload to get U, S, and V matrices. Zhu et al. [21] presented SVD-IWT-based image steganography. The information hiding is performed in the low-frequency components and GA is used. Durafe & Patidar [22] used the DWT-SVD and IWT-SVD combinations to analyze the effect on imperceptibility. R J Mstafa et al. [23] proposed a DWT and DCT-based video steganographic scheme employing Multiple Object Tracking (MOT). A. Nevriyanto et al. [24] imparted image steganography by means of DWT and SVD for text as payload. X. Han et al. [25] proposed an image encryption scheme for embedding Electronic Patient Records (EPR) information. Elhoseny et al. [26] furnished the Advanced Encryption Standard (AES) and RSA, succeeded by a steganography technique employing DWT. The test images are taken from [27, 28].

In this paper, image steganography using DWT and SVD supplementary to alpha blending techniques is proposed. The DWT and SVD schemes and alpha blending are combined to get an effective image steganography algorithm.

2. Related Works

2.1 Discrete Wavelet Transformation (DWT)

DWT is used to compress the respective input image. Out of four sub-band coefficients, only LL band coefficients are considered, which can also be viewed as the compressive version of the input image. For simpler implementation, the two-dimensional Haar DWT is used in this case where the 2×2 Haar transform equation is considered to maintain the regional details [1] which is given in equation (1) as

$$H_2 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \times \begin{bmatrix} a & b \\ c & d \end{bmatrix} \tag{1}$$

Here, a, b, c, and d → 2×2 input image sub-matrix.

The four sub-band equations [29] can be rewritten as

$$Y_{LL} = \frac{a+b+c+d}{\sqrt{2}} \tag{2}$$

$$Y_{LH} = \frac{(b+d)-(a+c)}{\sqrt{2}} \tag{3}$$

$$Y_{HL} = \frac{(c+d)-(b+a)}{\sqrt{2}} \tag{4}$$

$$Y_{HH} = \frac{(a+d)-(b+c)}{\sqrt{2}} \tag{5}$$

Likewise, to get IDWT, the transpose of the input matrix present in equation (1) is employed. The architectural diagram of the DWT-IDWT [31] is shown in Figure 4.

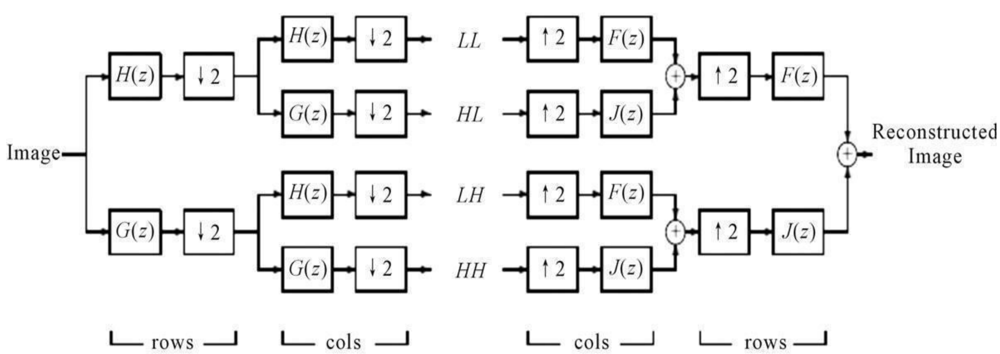

Figure 4: DWT-IDWT Diagram

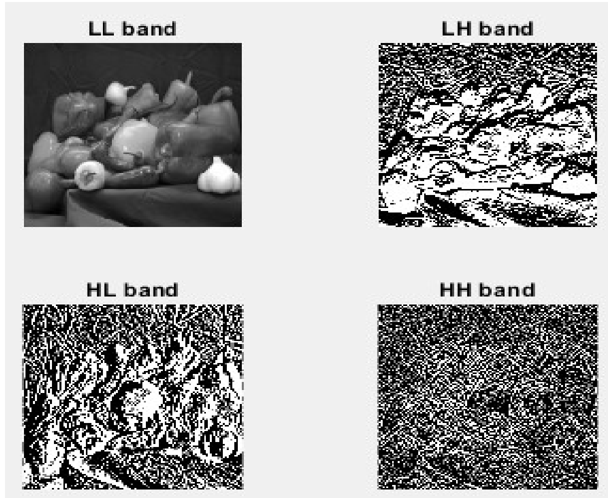

Figure 5: DWT Subbands

2.2 Alpha Blending

The alpha blending technique is used to combine two images to generate composite images. In the case of the color image, each plane's pixel values are merged separately, and then the resultant image is constructed from those planes. The ‘L’ values decide the transparency of the hidden image over the CI. Normally the ‘L’ value varies from 0.0 to 1.0 where 0.0 gives fully transparent behavior and 1.0 gives fully opaque color. The equation used for embedding two images through alpha blending [32] is given in equation (6) as

$$WMI = (1 - L) \times LL_{cover} + L \times LL_{hidden} \quad (6)$$

Where WMI → LL band of watermarked images.

LLcover → LL band of the cover image.

LLhidden → LL band of payload image.

To recover the hidden image from the generated composite image, the alpha de-blending equation [14] is used, which is given in equation (7) as

$$W = \frac{WMI - LL_{cover}}{L} \quad (7)$$

2.3 Singular Value Decomposition (SVD)

SVD is used in various image processing applications for the extraction of features [33]. It decomposes the image into a number of optimal matrices depending upon maximum energy values which helps to divide the overall image into a set of linearly dependent components with isolated energy contribution. The SVD of a given matrix generates three consequent matrixes [34]. The input digital image of m*n size can be represented as

$$A = U \times S \times V^T \quad (8)$$

Where U→ m x n matrix of the orthonormal eigenvectors of $A*A^T$

VT → Transpose of n x m matrix consist of the orthonormal eigenvector of $A*A^T$

S → n x n diagonal matrix of the singular values, the square root of the eigenvalues of $A*A^T$.

3. The Proposed Model

The proposed model consists of preprocessing, stego image generation and payload image retrieval. The details of each procedure will be described in the following subsections.

3.1 Preprocessing

The test image cannot be used directly for processing. For proper analysis, it must be preprocessed, which makes it suitable for computer processing [29]. In this case, the resize and color plane conversions present in MATLAB [30] are used for preprocessing. The resize technique converts the image into a standard size (512×512) and the color plane conversion technique separates different color planes namely red, green, and blue planes, respectively from the composite color. Such color decomposition is shown in Figure 3.

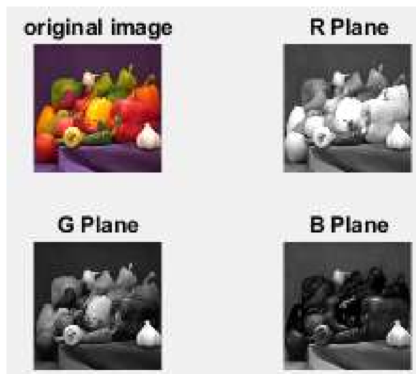

Figure 3: Color Components of an Image

3.2 Stego Image Generation

The flowchart of the stego image generation is depicted in Figure 1. In the stego image generation stage, in this, the color components of the CI and Payload are separated and then fed to different DWT blocks. In the LL band, the output of the DWT block is fed to separate SVD blocks, which generate three components, namely U, S, and V components. Among those components, the 'S' coefficient of the corresponding blocks is fed to the alpha blending block, which merges two images. The resultant coefficient and remaining coefficients are then merged using the Merge and Concatenation block. By means of the IDWT block, the hidden payload image is reconstructed.

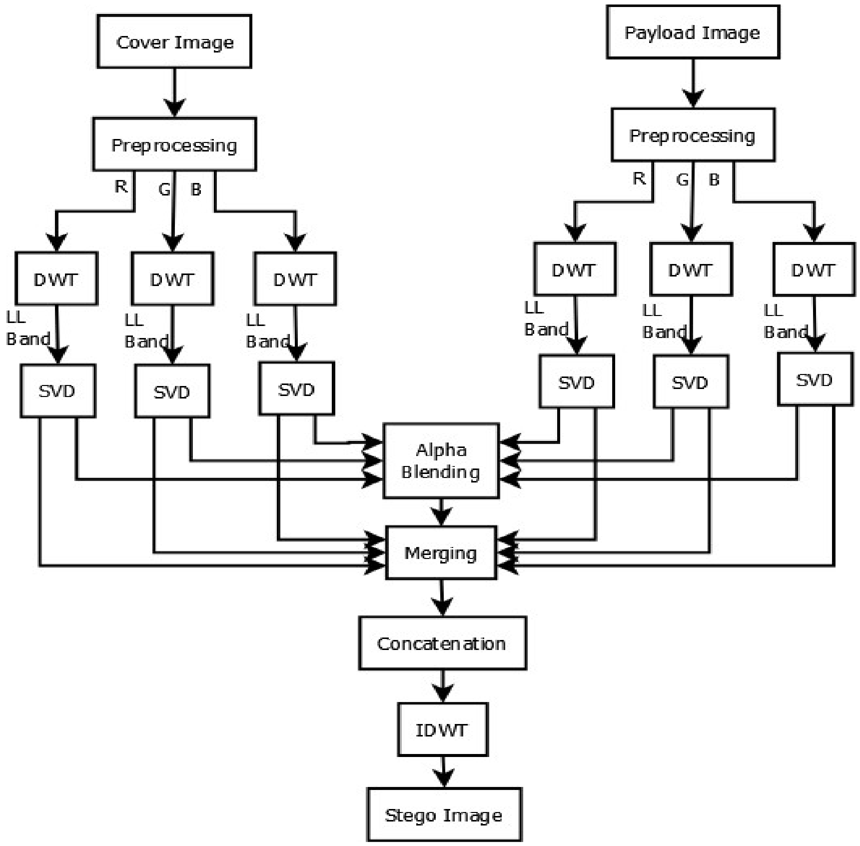

Figure 1: Stego Image Generation

3.3 Payload Image Retrieval

The flowchart of the payload image retrieval is depicted in Figure 2. Likewise, the payload image retrieval is the inverse of the SI generation, as shown in Figure 2.

The Merging and Concatenation blocks are used to generate the color image from the separate color components.

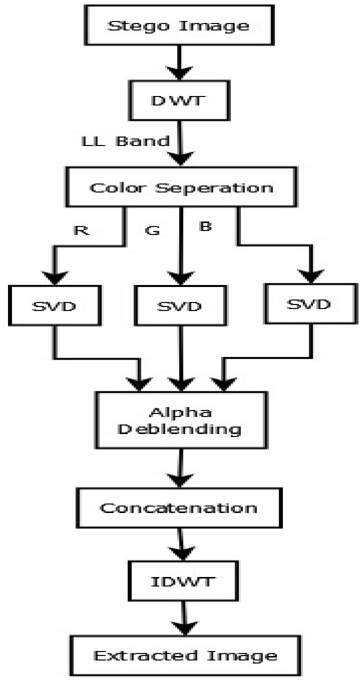

Figure 2: Payload Image Retrieval

4. Simulation Result

The schemed algorithm is experimented with using MATLAB [35] where the MATLAB coding [30] is utilized. The performance of the proposed algorithms using standard images [36] is shown in Figures 6 to Figure 8.

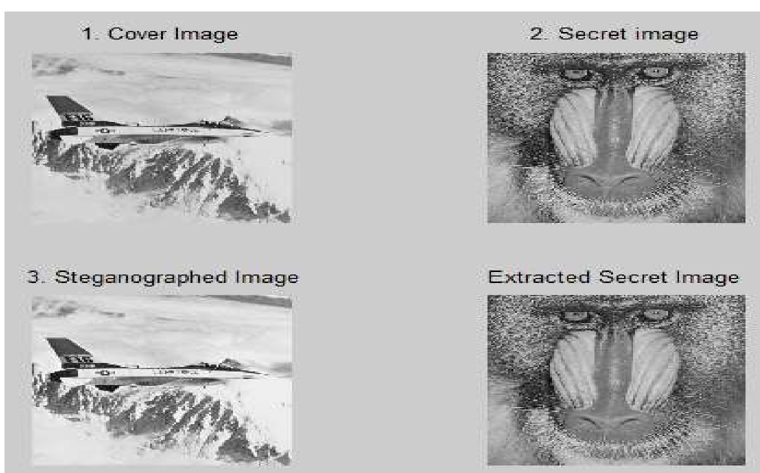

Figure 6: Test Result

Figure 7: Test Result

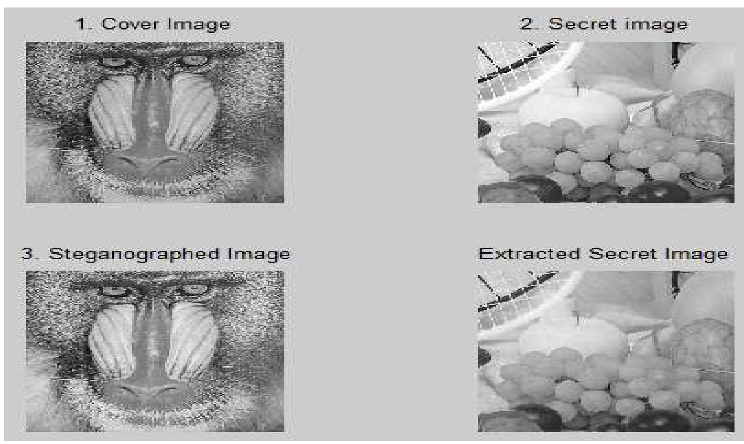

Figure 8: Test Result

4.1 Performance Analysis

To evaluate how well the algorithm performs, the PSNR and MSE equations [1, 30 39, and 40] are used. The PSNR and MSE for the test images are tabulated in table 1. From table 1, it can be seen that the PSNR value of the SI is significantly higher and corresponding MSE values are low, which confirms that the schemed algorithm is effective.

Table 1: Result

COVER IMAGE	PAYLOAD	PSNR	MSE
Airplane	Baboon	62.1442	0.1992
Baboon	Fruits	61.4883	0.2148
Lena	Peppers	69.4471	0.0859
Peppers	Airplane	63.5258	0.1699
Cat	Girl	72.2132	0.0625
Monarch	Fruits	74.0167	0.0508
Sails	Tulips	56.3829	0.3867
Tulips	Monarch	61.6477	0.2109

Hessain	Tissue	66.4684	0.1211
Pears	Fabric	55.3112	0.4375
Fabric	Pears	58.2883	0.3105
Peppers	Fruits	67.6683	0.1055
Airplane	Lena	64.2544	0.1563
Archichare	Baboon	55.4677	0.4297
Pool	Fruits	61.3318	0.2188
Archichare	Airplane	56.0811	0.4004
Burger	Balls	65.0497	0.1426
Horse	Baboon	58.5096	0.3027
San Diego	Oakland	67.3524	0.1094

4.2 Comparison with Existing Techniques

The maximum PSNR values of the schemed methodology with the current [6, 37, 38] are compared in table 2, from which it is evident that the proposed algorithm is able to generate better maximum PSNR values than existing ones. This proves that the presented algorithm is more effective than the existing one in retaining the CI characteristic.

Table 2: PSNR value Comparison

Authors	**Techniques**	**PSNR (dB)**
Aya Jaradat et al. [6]	Chaotic PSO	68.51
P. K. Muhuri et al. [37]	IWT and PSO	50.63
A. H. Mohsin et al. [38]	PSO	58.78
Proposed System	DWT and SVD algorithm	74.01

5. Conclusion and Future Scope

The DWT and SVD technique in association with the alpha blending schemes are utilized to build the robust image steganography algorithm, which is implemented on the MATLAB tool. The SI generation and Payload retrieval are implemented in this paper. The PSNR values are measured and which shows that the proposed algorithm proffers secured communication. Future research may combine techniques like DTCWT, Curvelet Transform, Local Binary Pattern (LBP), Local Directional Pattern (LDP), and Local optimum orientated Pattern (LOOP).

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