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Efficient Image Steganography Using Integer Wavelet Transform

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Abstract: Steganography is the process of transmitting the secret data using a cover carrieras secret information. The carriers used transfer the secret data are images, audios, videos, etc. The proposed method uses Arnold Transformation to scramble the secret image and Integer Wavelet Transform (IWT) to embed the secret image, followed by alpha blending operation. The statistical parameter peak-signal-to-noise-ratio (PSNR) shows better visual quality of stego image than the existing method using Discrete Wavelet Transform (DWT) and Matrix Rotation transformation.

Keywords*:* Steganography, Arnold Transformation, IWT, PSNR, DWT, Matrix Rotation transformation.

I. INTRODUCTION

The word steganography is a Greek word where, stego means ‘covered’ or ‘secret’ and graphy means ‘to write’therefore steganography means “covered or secret writing”.In this process before hiding, the transmitter must select the suitable message carrier and the secret dataalong with the robust password (which is supposed to be known only to the receiver).Image Steganography is the process of embedding the secret image into the cover imageso that the hidden information is invisible to the third party. This can be achieved by two popular schemes [1].

One is Spatial domain that embeds the secret image directly into the image pixels. But if any changes in cover there may be loss of information. Another method is transform domain which is the most robust steganographic systemtoday cover image is transformed into different domain before embedding the secret information into it. Then the cover image is converted back into spatial domain to get thestego-image. Since this method hides secret message in particular areas it appears to be more robust and they are highly resist to the unauthorized detection.

The transformation can be Discrete Cosine transform (DCT), Discrete Wavelet Transform (DWT), Integer Wavelet Transform (IWT) etc.In this paper, Integer Wavelet Transform (IWT) and Arnold Transformation is used to hide the data by scrambling it.

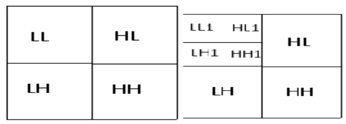
II. EXISTING METHOD

A. DISCRETE WAVELET TRANSFORM

In image processing, the DWT is the technique used to transform the digital image from the spatial domain to the transform domain [3]. It is the process of decomposition of image pixelsinto the low-pass sub band (Li) and high-pass sub band (Hi).

At the level1 decomposition the image pixel are decomposed into four wavelet sub-bands: LL, HL, LH, and HHwhere the LL is the approximate coefficientwhich contains the average value of the image. The most important values of the image lie in this low sub-band., the HL is the horizontal detail, the LH is the vertical detail, and the HH is the diagonal detail of the image.As shown in figure 1(a) the LL sub-band lie at the top-left, HL in the top-right, LH in the bottom-left and HH in the bottom-right part of the wavelet sub-band. Since the quality of the image is decreased while

embedding a message in LL sub-band, the high sub-bands are used which containsthe less important part of the image. Therefore, there won't be any significant damage to the image.
In level2 decomposition,the level1of decomposition is carried out twice, first in horizontal direction, then in the vertical direction. That the LL sub-band is decomposed into LL1, LH1, HL1, HH1 as shown in figure 1(b).



a) Level one decomposition   b) Level two decomposition

Figure1. Decomposition of an Image using DWT

B. MATRIX ROTATION TRANSFORMATION

Matrix Rotation transformation is a process of scrambling the image pixels. In this transform the image pixels are converted into matrix form then this matrix is shuffled, so image pixels are distributed randomly and image break in unidentified pattern. Thus a new matrix is obtained.
Consider a Matrix of (3*3):

$$M = \begin{matrix} 23 & 121 & 197 \\ 109 & 124 & 140 \\ 116 & 127 & 150 \end{matrix}$$

Matrix after Scrambling (3*3):

$$M = \begin{matrix} 124 & 150 & 197 \\ 140 & 121 & 109 \\ 23 & 116 & 127 \end{matrix}$$

III. INTEGER WAVELET TRANSFORM

The Integer Wavelet Transform is an developed technique that maps an integer data set into another integer data [2].In DWT, the used wavelet filters have floating point co-efficient thus when we have to hide the data in their co-efficient due to the truncation of the floating point values there may be loss of hidden information.Thus to avoid floating point precision of the wavelet filters IWT is used. It hides the data in the resolution detail bands (LL, LH, HL, and HH) which is less sensitive to the human visual system. The efficient robust lifting scheme is invariably proposed in IWT to compress and restore the original image without any loss of information.

A. LIFTING SCHEME

Lifting scheme is used to separate the odd and even coefficients. It consists of forward operation and reverse operation.Forward operation hasthe split step that divides the data set into odd and even elements. Next in predict step the odd values are predicted from the even elements that the difference between the approximation and the actual data replaces the odd elements of the data set. Finally in update step replaces the even elements with an average. This process results in a smoother output image of the wavelet transformas shown in figure.2.

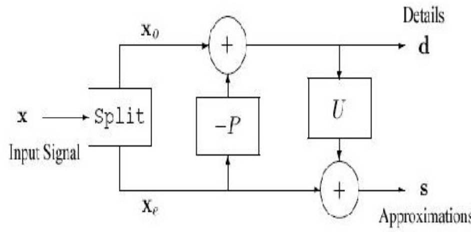


Figure 2. Forward operation

The Reverse lifting scheme the update phase follows the predict phase in which the reversing of the forward operation is done. Then predict step is followed by a merge step that combines the odd and even elements back into a single data stream as shown infigure.3.

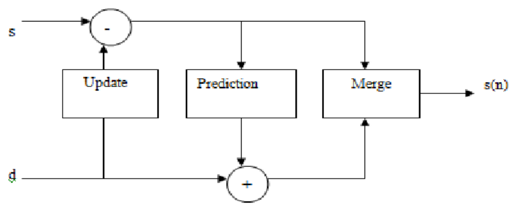


Figure 3.Reverse operation

Due to this the LL sub-band of IWT transform appears to be similar with a smaller scale of the original image while in the case of DWT the resulting LL sub-band is slightly distorted.

IV. ARNOLD TRANSFORMATION

Arnold transformationwas proposed by V.J.Arnold. It is also known as cropping transformation. When this transformation is applied on the matrix form of the image, it becomes "chaotic". After this a new matrix is obtained. The Arnold Transform is given by.

$$\begin{bmatrix} i' \\ j' \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} i \\ j \end{bmatrix} \text{(Mod N)}$$

This transformation can be done repeatedly along with the private key for encoding and decoding the secret image. This makes this method more secure.

V. ALPHA BLENDING

Alpha blending is the blending technique that combines two input images together to get a stego-image. In this technique the decomposed components of the cover image and the secret image are added after multiplying thescaling factor to it. It can be accomplished by blending eachpixel from the secret image with the corresponding pixel in the cover image.

The equation for executing alpha blending is,

Stego Image = k*(LL3) +q*(Secret Image)

Where k and q are scaling factors.

The blending factor used in the blended image is called the "alpha." Value of alpha determines the level of mixing.

VI. PROPOSED METHOD

A. ENCODING PROCESS

In **encoding Process**, the Arnold transformation is applied on the secret image to get the scrambled secret image. Then level 1and level 2 of Integer Wavelet Transform (IWT)is applied on the cover image and scrambled secret image respectively. Then their coefficients are alpha blended. Finally IIWT is applied on the alpha blended image to get the stego-image as shown in Figure.4.

B. BLOCK DIAGRAM

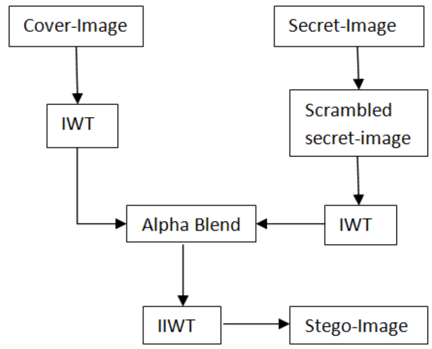


Figure 4. Block diagram of encoding process

C. ALGORITHM FOR ENCODING PROCESS

Step 1: Get the cover image and the secret image .
Step 2: Apply a 2-D level 1ofIWT to the cover image.
Step 3:Apply Arnold transformation on the secret image to obtain the scrambled secret image.
Step 4: Apply a 2-D level 2 of IWT to the scrambled image.
Step 5: Extract the approximation coefficient and detail coefficients of level 1 2-D IWT of the cover image.
Step 6: Extract the approximation coefficients and detail coefficients of level 1 2-D IWT of the scrambled image.
Step 7: Apply Alpha Blending operation on the cover imageand the scrambled image.
Step 8: Perform 2-D IIWT to obtain the stego-image.

D. DECODING PROCESS

The **decoding process** is the inverse process of the encoding process. The IWT applied on the stego-image and known cover image. Then alpha blending is performed on both images and Inverse Integer Wavelet Transform (IIWT) is applied on Alpha blended image to get the scrambled secret image. Finally, inverse Arnold transformation is performed to recover the original secret image is shown on Figure.5.

E.BLOCK DIAGRAM

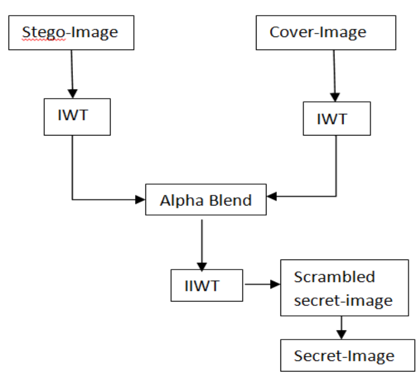


Figure 5. Block diagram of decoding process

F. ALGORITHM FOR DECODING PROCESS

Step 1: Apply 2-D level 1 ofIWT on the stego-image and the cover image .
Step 2: Apply Alpha blending operation on stego-image and cover image.
Step 3: Separate the wavelet coefficients and apply IIWT to get the scrambled secret image.
Step 4: Perform the inverse Arnold transformation on image SS to get the original secret image.

VII. PERFORMANCE ANALYSIS AND EXPERIMENTAL RESULTS

The performance of the proposed and existing method is evaluated by implementing it using MATLAB R2014a. And the performance is analysed by comparing the cover image and the stego-image in terms of PSNR.

A. Mean Square Error (MSE)

MSE is a measure of difference between the estimator and what is estimated.It represents the difference between the original cover image (M x N) and the stego image (M x N).

$$\text{MSE}= 1/MN[\sum_{i=1}^{n}(y - y1)^2]$$

where,
y– Real cover image
y1 -stego image x'

B. Peak Signal Noise Ratio (PSNR)

It is the measure of amount of noise present in the image. Its unit is decibel (dB). PSNR is genarally used to measure the quality of reconstructed image. When the PSNR value is high it indicates that the image quality is good.

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

C. *EXPERIMENTAL RESULTS*

Cover image	Secret image	Existing PSNR	Proposed PSNR
Goldhill.png 512x512	Fruits.png 512x512	29.89 dB	33.79 dB
Peppers.png 512x512	Barbara.png 512x512	28.23 dB	42.56 dB

VIII. CONCLUSION

In this paper, a new algorithmfor hiding image data using Integer Wavelet Transform combined with Arnold Transform for scrambling the secret image is proposed. The stego-image of the proposed method looks perfectly similar to the original image and has high PSNR value. Hence, the detection of the secret information is difficult. From the experimental results, it can be concluded that the proposed technique using IWT gives better quality of the stego image when compared with the existing Discrete Wavelet Transform method.

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