Enhanced Image Steganographic Technique Based on Discrete Wavelet Transform and Histogram Shifting

J.Stephy, V.Subramaniyaswamy

***Abstract:** A excessive need on digital information in the current years increases the need to shield its secrecy. High capacity, imperceptibility and lossless hiding method in digital images have been proposed in this paper. However, Cryptographic techniques are used as a better solution for securing the data but in nature the encrypted data attracts the attackers. In order to overcome the issues found in security data hiding techniques are found to be an alternative solution. Hiding data based on wavelet transforms helps in maintaining visual quality of an image. Discrete Haar Wavelet Transform (DHWT) is used to convert an image into wavelet coefficients. The data is embedded in medical images and standard images based on Histogram Shifting. This technique uses pixel difference in cover image and peak point belongs to histogram is selected to protect the information which increases the hiding capacity. The experimental results shows good imperceptibility and hiding capacity compared to other existing data hiding techniques.*

***Keywords:** Reversible data hiding, Discrete Haar Wavelet Transform, Histogram shifting, Peak signal to noise ratio, Capacity*

I. INTRODUCTION

In recent years the demand on digital information has increased significantly which leads to high requirement on security of digital information and there is high security needed in the applications such as military and medical applications. Generally secret information is protected using cryptography and data hiding techniques. Cryptography is used for security which converts the secret message into unreadable form which seeks the attention of adversary. Therefore data hiding techniques are used which hides the secret message to its corresponding cover image and the data embedded image that is Stego-image has been received at the users destination in which the intended user get back the original image and the message using extraction algorithms.

Steganography is defined as hiding the digital information in unsuspicious medium [2]. Images are the highly used source since images are easy to find and can deal with distortion compared to other mediums used in steganography. There are many techniques which hide secret message in images; they are classified according to the way of hiding. There are three important properties need to be satisfied for good data hiding technique which are imperceptibility, high Capacity and robustness. When these properties are satisfied the performance of algorithm is more efficient. Data hiding techniques are categorized as spatial domain techniques and transform domain techniques. The method of spatial domain embeds the data immediately in image pixels, but in transform domain techniques embed the message into wavelet coefficients which increases the quality of respective image. Transform domain techniques are discovered mainly get over robustness and imperceptibility troubles in LSB technique which is a spatial domain technique generally transform techniques hide the data in the region which is less sensitive to human visual system which increase the robustness. In transform domain techniques Discrete Wavelet Transform (DWT) enhances the image quality. Histogram modification is the reversible data hiding (RDH) technique proposed to insert the digital information in histogram bins of the respective image. This technique is mainly used for performing low distortion while inserting the data but it does not results high embedding capacity , hence histogram shifting based on adjacent pixel difference found to be an effective way of increasing the hiding capacity. The embedding is done by shifting the histogram values and data is embedded using adjacent pixel differences. The peak point in histogram is selected to insert the message. Hiding capacity is proved in basis of peak points of histogram of the image and this technique also increases visual quality of an image and this technique also controls overflow and underflow problems. The flow of the paper planned as: Section 2 explains in detail about literature survey; Section 3 explains about the proposed data hiding methodology which involves data embedding and data extraction; Section 4 describes about experiment results compared with existing techniques; Section 5 summarizes the paper with future work.

II. RELATED WORK

Reversible Data Hiding (RDH) is the most required technique which receiving more attention from research communities [1][3]. There are vast number of techniques to hide the data, among all of them there are many efficient techniques which hides information which increases capacity, robustness and imperceptibility as these three are the main properties of Data Hiding. Spatial domain techniques are used as the basic technique used for data embedding, spatial domain technique uses Least Significant Bit (LSB)

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substitution to protect private data with using cover images by directly changing the LSBs of input image with the bits of the data. Optimal Pixel Adjustment process (OPAP) for data hiding which is applied to gain high capacity whereas these technique is not fully reversible due to its need of memory for replacement of LSBs [11].

In transform domain techniques, the commonly used transform method is Discrete Cosine Transform (DCT). [19] presents a technique using DCT. Here, the image is divided into 8 into 8 blocks and the message is embedded in each block of DCT which provides high quality of image and maintains robustness but the hiding capacity is poor since insertion of data done in each block which only embeds small data and when coefficients of DCTs are not selected properly it leads to visual degradation to image quality[17].

Discrete Haar Wavelet Transform is the transform technique used in hiding data which is proposed by [6, 8, 27, 28]. In this papers DHWT is used in data embedding where the message gets embedded after quantization of DWT coefficients. This method is obtained from DCT method. This method maintains visual quality and capacity. Integer Haar wavelet Transform (IHWT) for high quality steganography using modulus function[5]. Here IHWT is derived from DWT, this method transforms integer wavelet coefficients from value of pixel and reconstructs them from wavelet coefficients. It uses modulus function to embed messages which produces high quality images [7, 9, 10]. Data Hiding using Histogram modification is the method where the private data is inserted in the image by shifting the image histogram. [13] proposed a technique using histogram modification based on binary tree structure in order to defeat underflow and overflow problems while embedding the data.

Embedding data based on histogram [12,14,15] based on finding adjacent pixel differences instead of directly embedding into pixels to improve the performance and embedding capacity it also prevents overflow and underflow problems. The proposed algorithm overcomes the problems of spatial domain technique such as robustness and imperceptibility by using transform domain techniques like Integer Haar wavelet Transform (IHWT) and histogram Modification. By using these techniques it provides high quality images, imperceptibility and results less distortion.

III. PROPOSED DATA HIDING TECHNIQUE

Proposed method briefly discusses about Discrete Haar Wavelet Transform (DHWT) and Histogram Shifting. Histogram Shifting mainly performs embedding process and extraction process. Embedding data into wavelet coefficients results in high quality image. This technique produces four sub bands, as eyes of human are very responsive to low frequency band, the message is embedded in all remaining three higher frequency sub bands. Laplacian Pyramid is used as the second level decomposition after getting wavelet coefficients by applying DHWT. Here the decomposed image is utilized for embedding the data using Histogram Shifting after getting adjacent pixel differences. This algorithm sets a range by calculating peak and zero point of an image histogram and data is embedded by shifting the histogram.
To reconstruct the image Inverse Discrete Haar Wavelet Transform (IDHWT) is applied which transforms the pixel values and reconstructs them from wavelet coefficients. The reconstructed image is used for extracting the data.

A. Discrete Haar Wavelet Transform (DHWT)

Discrete Haar Wavelet Transform is used to reconstruct the image efficiently by transforming pixel value and get back the image from corresponding wavelet coefficients. DHWT which is represented by Discrete wavelets decomposes to create sub bands such as (LL,HL,LH,HH) , whereas important values presents in low sub bands so embedding the data in LL band cause degradation in image quality by creating distortions. Therefore, the data is embedded in other three sub bands. DHWT converts the image into 2x2 blocks which is the matrix represents 2x2 group of pixels in image, where let $I_{i,j}$ in matrix which indicates the pixels in image with row i and column j from the input image. DHWT transforms pixels into wavelet coefficients.

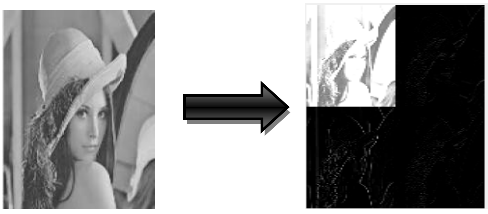


Fig.1: Example of DWT Transformation

B. Laplacian Pyramid

Laplacian pyramid performs decomposing the original image where the image is decomposed into low pass and high pass bands. Laplacian pyramid obtained from Gaussian pyramid in which each band consists of difference between two adjacent low pass images of Gaussian pyramid. This pyramid saves each levels difference images of blurred versions which is mainly used in image compression. It reduces noise better than wavelet transform which is used for second level decomposition. It also reduces large number of excess data from Gaussian pyramid and band pass filtered images is obtained.

C. Histogram Shifting

Histogram Shifting performs embedding the secret data where the data is inserted by relocating the histograms. As a first step the histogram is created for the resultant image, in that histogram peak and zero point is determined to fix the embedding area. Those area between peak point and zero point is fixed as the range which is threshold (T_L,T_R),for shifting the histogram and embedding the data. Let P implies the peak and Z implies the zero point of histogram. The range lies in between [P, Z] is relocated to right by 1 and the point zero is leaved as P+1. If pixel value P is met, consider the bit of message embedded is 1, then the pixel is raised by 1. If it is zero no value is changed. The amount of data's are equal to pixels located within the peak of histogram. The data in image is extracted by inverting the embedding process[16].

D. Embedding Process

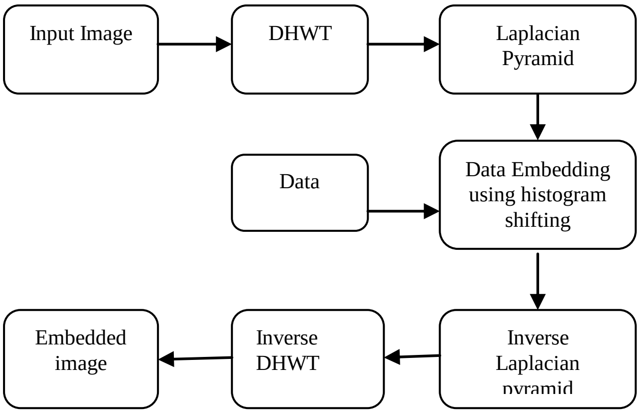


Fig.2: Representation of proposed embedding method using histogram shifting

The procedures followed in embedding algorithm as represented in above block diagram is described in following steps:

Step 1: Examine the cover image

Step 2: Perform DHWT on examined cover image for getting wavelet coefficients and sub bands such as (LL,LH,HL,HH)

Step 3: Perform Laplacian pyramid to the resultant image gained by processing with DHWT, Laplacian pyramid decomposes the image after the first level decomposition done by wavelet transform.

Step 4: Generate Histogram of an image

Step 5: Scan the image using zig-zag scan. Consider the image I_p where it defines the grayscale value of an host image, $0 \leq p \leq N-1$ which implies the pixel values from 0 to 255. Let D be the data.

Step 6: Calculate the difference d_i of adjacent pixels between I_{p-1} and I_p, let p=0 when it is I_p otherwise $I_{p-1} - I_p$

Step 7: Determine peak P and zero Z points of an image histogram

Step 8: Scan the wavelet image in reverse order, when the value of difference pixels is greater than peak point P, the pixel value is shifted by 3 and if the difference value d_i is equal to peak of histogram, the grayscale value of pixel I_p is modified with respect to the data D.

The above steps discusses about the embedding procedure of data by calculating the peak and zero point and by determining the difference of pixels adjacent to it. Embedding the data using wavelet coefficients and histogram shifting the hiding capacity is increased and also increases image visual quality.

E. Extraction Process

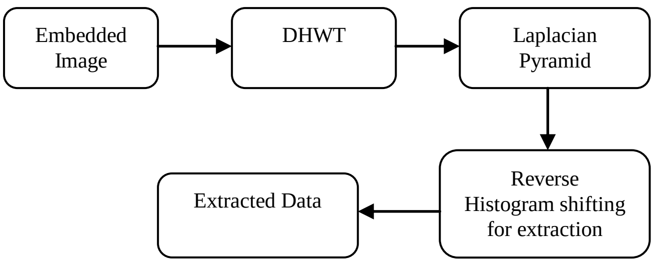


Fig.3: Representation of Proposed Extraction Procedure using Histogram Shifting

The procedures followed in Extraction algorithm as represented in above block diagram are explained below

Step 1: Examine the embedded stego-image

Step 2: Apply DHWT in embedded image for reverse process

Step 3: Laplacian pyramid is applied in wavelet coefficients to extract the levels of pyramid in order to embed the data.

Step 4: Scan the image in zig-zag order

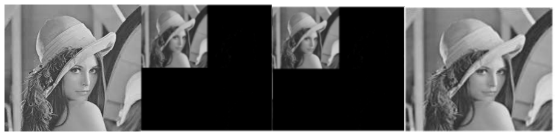
Step 5: Now extract the image using the reverse histogram process which is the reverse procedure of data embedding

Step 6: Here when the pixel value P+1 is encountered, the bit of message "1" is extracted by decreasing the value as 1.

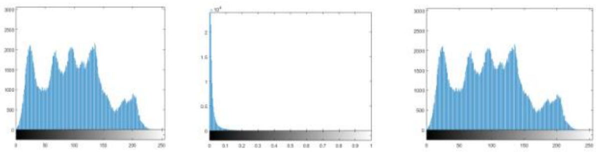
Step 7: When pixel value P is met, the message bit "0" is extracted

Step 8: When data is extracted, [P+2, Z] is relocated to left by 1. The steps are continued till all messages are extracted.

The procedure of this above process is the process invert to the embedding procedure which is discussed in above steps. The image is applied to wavelet transforms to get the reverse and histogram shifting is done reversely to extract the embedded message which gives high image quality.



a) Input Image b) DHWT performed image c) Image after data d)Reconstructed Image



e) Histogram of cover image f) Histogram of difference pixels g) Histogram of stego image

Fig.4: Entire Implementation using Lena Image

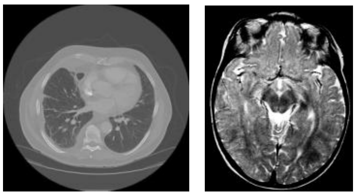
IV. EXPERIMENT RESULTS

This section described about the proposed method with comparisons of various other techniques and proposed method was implemented in MATLAB R2016b. The images used are CT and MRI in DICOM images and Lena, Baboon, Cameraman, Plane and Boats in standard images for examination of proposed method and the image size used is 512x512.

a) Baboon b) Lena

c) Plane d) Boats e) Cameraman

Fig.5: Standard grayscale images used for experiments in proposed Data Hiding Technique



f) CT Image g) MRI Image

Fig.6: Medical Images used for experiments in proposed Data Hiding Technique

Stego Image Quality:

The image quality is higher when it has lower distortion which is occurred because of inserting the message. To calculate quality or imperceptibility of embedded data Peak Signal to noise ratio (PSNR) is determined.

$$\text{PSNR} = 10\log_{10}\frac{255x255}{MSE}$$

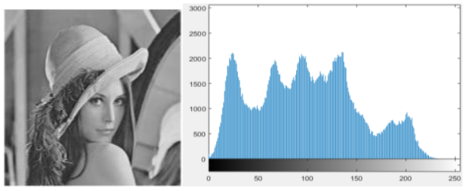
Whereas, MSE stands for mean square error which denotes both value of pixel of cover image and value of embedded image which is represented as

$$\text{MSE} = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(q(x,y) - q'(x,y))^2$$

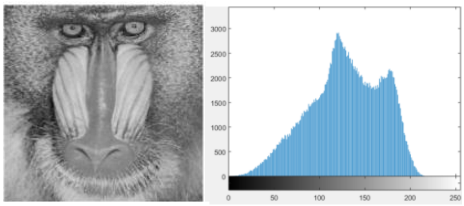
Payload Capacity:

Payload capacity defined as the quantity of data concealed in cover image without distortion and decreasing the value of an image quality. The data hiding techniques proves that embedding large amount of data will not disturb the stego-image quality. Using wavelet transform and embedding the data by histogram shifting helps to maintain the image quality without degradation. The PSNR and hiding capacity is calculated in each image.

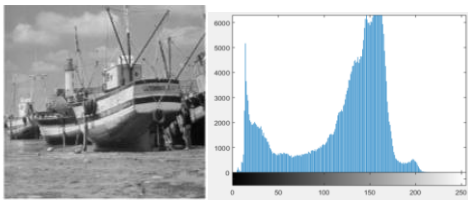
Fig 7 represents the embedded images with respect to its histogram and fig 8 represents the PSNR values of different images. The randomly generated data is embedded in each image. Each medical and standard image is embedded with 25% payload and PSNR and Hiding Capacity is calculated and compared with the existing techniques. The images used for experiment is represented in Fig 5 and 6.



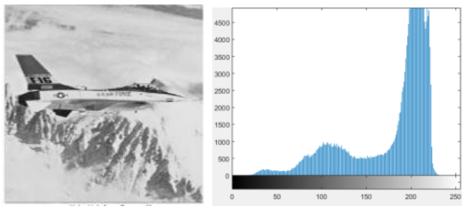
a) Lena Stego-Image , PSNR= 42.47 b) Histogram of stego Lena



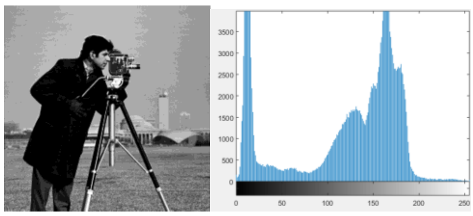
c) baboon Stego-Image PSNR=41.13 d) Histogram of Stego Baboon



e) Boats Stego-Image PSNR=45.50 f) Histogram of Stego Boats



g) Plane Stego-Image PSNR=43.23 h) Histogram of Stego Plane



i) Cameraman Stego-Image PSNR=44.23 j) Histogram of Stego Cameraman

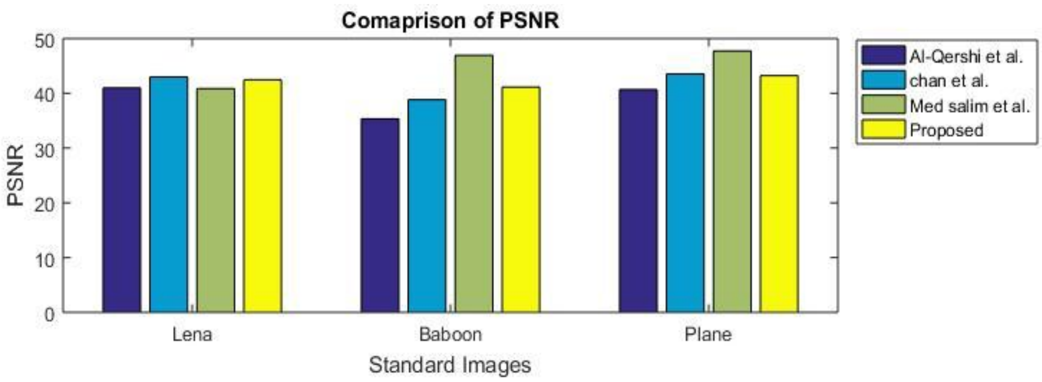
Fig.7: Data embedded Stego-images and their corresponding histograms

Table 1: Performance of proposed work evaluated with existing techniques for standard images

	Test Images	Parameters	Al-Qershi et al.	Chan et al.	Med Salim Bouhlel et al.	Proposed Technique
Standard images	Lena	HC(bits) PSNR	52,428 41.58	50,686 43.46	19600 40.85	52,728 42.47
	Baboon	HC(bits) PSNR	26,214 35.33	11,564 38.84	3969 45.96	49,776 41.13
	Plane	HC(bits) PSNR	52,428 40.68	44,003 43.56	- 47.74	52,728 43.23
	Boats	HC(bits) PSNR	- -	31,719 38.34	- -	52,728 45.50
	Cameraman	HC(bits) PSNR	- -	- -	7225	49,776 44.23

Table 2: Comparison of capacity and PSNR for medical images

	Images	Parameters	Bee Ee khoo et al.	Sunita Dhavale et al.	Josan et al.	Proposed
Medical images	CT Image	HC(%)	25%	2534	25%	25%
		PSNR	36.88	44.65	43.64	43.95
	MRI Image	HC(%)	25%	2098	25%	25%
		PSNR	42.38	47.14	42.35	44.41



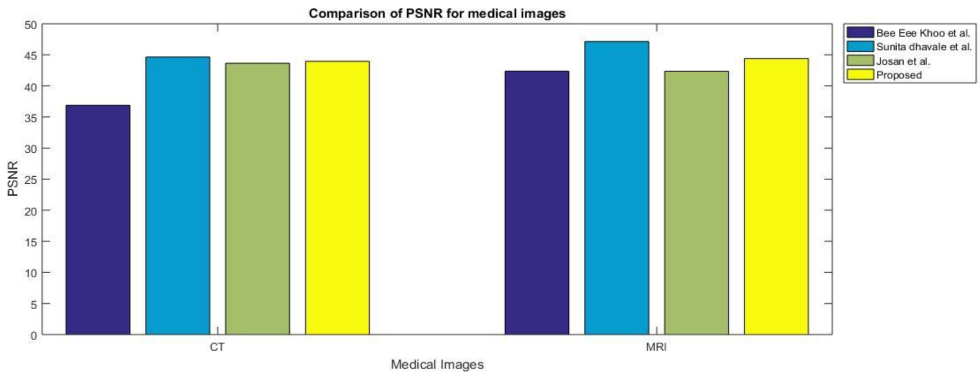


Fig. 8: Represents the performance of different standard and medical images with their corresponding PSNR values.

In the proposed technique certain parameters have picked to improve the capacity and imperceptibility of embedded stego images. Table 1 and table 2 compares the proposed technique to various other techniques which shows the better capacity and PSNR compared to other technique for standard image and medical images. For future work more images can be examined to get the specific hiding capacity of different images.

V. CONCLUSION

The data hiding technique is proposed using Histogram Shifting (HS) and Discrete Haar Wavelet Transform (DHWT), using the properties of this field to hide the data. This algorithm is effective with respect to image quality and capacity by hiding the data in wavelet and hiding data using difference with adjacent pixels. Laplacian is used to hold large amount of payload. DHWT is the efficient technique which protects various number of bits in every wavelet coefficient with respect to capacity to improve hiding capacity without degradation of image quality. The proposed technique made changes to increase the capacity and imperceptibility of medical images and standard images after the data is embedded. The results demonstrate the proposed technique in which it increases the quality and imperceptibility.

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