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A NOVEL DISCRETE WAVELET TRANSFORM BASED DIGITAL GRAY SCALE IMAGESTEGANOGRAPHY TECHNIQUE

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Abstract: The major target of digial image steganography are inconspicous of the front image and there is no chance to recover the secret image from the stegao image. To face these targets, a novel Discrete Wavelet Transform (DWT) based Digital Image Steganography Technique is proposed. In this given technique, two newideas are introduced. Mainly, the focus point is minimizing the distortion in the cover image and make a good quality stegao image.The first procedure which is related to the secret key computation concept is initiated to build it more rigorous and defiant concerning about steganalysis. The next procedure which is partitioning or blocking comes into play for ensuring the least blurring and variation in the stego iamge as well as cover image.The given technique or approach is applied on five different types of cover images and two secret images.The proposed technique results are very virtous when compared with three most popular steganography techniques in terms of PSNR and CC. Data Hiding metrics are Peak Signal to Noise Ratio (PSNR) and Correlation Coefficient (CC) and in this the proposed technique performs much better than other techniques. There are several types of attacks in digital image steganography which can applied on generated stegao image for checking the quality and robustness of the image. Mainly, The proposed technique tested over the six image processing attacks and the steadiness of the given approach is good . The results in the tables explain the steadiness of the giventechnique under six-image processing attacks. Both stegano-image and extracted secret images possessa much better perceptible quality.

Keywords: Discrete Wavelet Transform, Digital Image Steganography, Image Processing attacks.

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INTRODUCTION

In today's world, Multimedia processing system and internet technologies, an enormous amount of digital data can be dispatched very easily and quickly at very low cost.Using multimedia technologies, The dispatched digital data can be quicklymodified with very low amount of data loss with in few seconds.. However, these modifications may influence the violation of delicate data. Hence, the security of this sensitive data has become an necessary need. To solve the above problem, many techniques and procedures for the consolidation of delicate data have been initiated.

To hide the secret data into carrier data, the process is called Digital steganography and the secret data existence is concealed. There are a lot of carriers available in data hiding, the use of digital image is particular recognized as a carrier data. Digital images can be transferred over very lower bandwidth[3] that's why using it.Mainly, In spatial domain, the intensity value of the cover data or image directly modifies through embedding the secret data.Mostly, Spatial domain procedure is used by the least significant bit (LSB). The other very good and popular spatial domain techniques utilize the contrast, noise insertion etc. [4]. The main advantages of this technique are easy to handle,high speed, analyse and accurate. However, it is very delicate towards digital image processing attacks.

There are three other transformation techniques, namely, DFT, DCT and DWTusing in data hiding. Out of these three, one can apply on the cover image. After that, blocking concept can be implemented on both types of images i.e, cover image and secret image.The secret image is then embedded into cover image. The main advantages of this technique isdiscordprogressive and fixed[4]. The focus of this paper is on transform domain (especially DWT) based steganography technique. It is also worth mentioning that DWT break down the secret image into four sub-bands such as LH, LL, HH and HL bands. Data hiding in three bands (LH, HL and HH) maintains better image quality. There is no need to maintain extra information about embedded data due to self similarity and uniqueness of DWT coefficients [4, 5].

The main benefaction of this approach is to generate a novel DWT based digital image steganography technique. This technique takes advantage of the hide capabilities of DWT to preserve quality of image after generating the stegao image.The blocking concept is to reduce the effect of embedded secret images into cover image. Firstly, Both cover image and secret image are decomposed into small, smallblocksi.e. called blocking. The small blocks of secret image are embedded into small blocks of cover image by using best matching algorithms. And the best matching block address is stored for further computation.It will help in computation of the secret the key.

It includes a general overview on recently developed image steganography techniques followed by proposed digital image steganography technique. The result will be calculated on many cover images and many secret images. Finally, the concluding remarks are presented.

RELATED WORKS

In literature, There are a number of digital image steganography techniques given which shows the image feature extraction and embedding procedure of secret image into cover image. The first one steganography technique is least significant bit (LSB) substitutionwhich is very popular and very well-known, in which embed the secret data into LSB of the pixels[3]. But this technique is not so good due to the performance of the LSB technique in terms of PSNR and the extracted secret digital image from stegao image is not good [10].Abdelwahabb and Hassan [6] technique is different from others, which was applied DWT strategy on both the images. But The technique is not so useful because the extracted image is not the same as the embedded image.Kumar and Kumar [1]decomposed the cover image into different bands and embed thesecret image into different bands and compare the results of all the bands. However, this technique doesn't increase the loading capacity of secret data. Kumar and Kumar [2] defined a new technique in which combined the DCT and DWT into single technique. This is not appropriate due to the loss of data by rounding in it.

In [8], a new steganography approach was proposed which is based on side matching. It totally reserve the quality of a image, which increasesthe capacity of the embedding data. This technique is not prosperous against the image processing attacks and no transfer is used.Narasimmalou et al. [7] gave an most favourable discrete wavelet trasform based steganography technique.They have divide the cover image into bands by applying DWT procedure and some modification had done in the transform coefficients of the divided images.Here also the same problem exists i.e, the extracted secret image from the stegao image is not appropriate and good qualiy.In [5] invented a technique that combines the discrete cosine transform and integer wavelet transform.Munkres' assignment algorithm used in the given technique for embedding the data in frequency domain. However, there is possibility of further optimizing the matching and distribution of secret key bits.`

El-Emam and Al-Zubidy [9] developed a novel algorithm which is using four layers for security to hide anenormous amount of secret image into a cover image. Moreover, it includes adaptive neural network technique i.e, image segmentation However, the major drawback of this algorithm takes more time to produce the results.Ghebleh and Kanso [3] proposed a turbulenttechnique for digital image steganography which is based on lifted discrete wavelet transform with three dimensional chaotic cat map. This approach is very potent, agile and extensible. However, it cannot increase the payload capacity.Baby et al. [10]introduced a new type of data hiding in which multiple color images hide into a single color image by using DWT.N-leveldecomposition is used for above procedure on cover and secret images.By the help of data compression, we can increase the payload capacity.

In this paper, a novel discrete wavelet transform baseddigital image steganography has been developed. There are some reasons for adopting DWT as an underlying technique;mainly its simplicity, easy to implement, and maintenance of better image quality.

PROPOSED TECHNIQUE

The proposed technique is a novel discrete wavelet transform. In this paper, three different secret keys are proposed. This enables the proposed approach to be more potent and protected steganalysis. The cover image and secret image are decomposed by the blocking technique. The reason behind this is that it results in negligible change in the cover image. The proposed approach is based on the DWT technique, which is used to decompose the cover image. The detail coefficient concept of DWT is used to utilize the small variation or change in the cover image during embedding of secret image in these coefficients.

The proposed techniquehaving two phases: embedding phase (secret image into cover image) and extraction phase (secret image from stegao image). The details of these phases are depicted as follows.

Embedding Phase

The process of embedding phase shows in the *Figure 1*. In the embedding phase, take the two images i.e, the cover image (I) and the secret image (S), decomposed into four sub-images such as coefficients of approximation (ICA), coefficients of horizontal (ICH), coefficients of vertical (ICV), and coefficients of diagona (ICD), SCA, SCH, SCV and SCD using DWT. These sub-images are divided into non-overlapping blocks. The blocks of SCA are attached with blocks of ICA using root mean square method. Then, compute the difference blocks to each block of ICA with the each block of SCA.After that replace the difference block with best matched block coefficients of ICH, ICV or ICD. The inverse $DWT\left(IDWT\right)$ is applied on ICA and modified detail coefficients $\left(ICH,\ ICV,\ and\ ICD\right)$ to get Stegano Image (I'). The process is as follows:

1. The cover image $\left(I\right)$ and the secret image $\left(S\right)$ decomposed into four sub-images $\left(ICA,\ ICH,\ ICV,\ ICD\right)$ and $\left(SCA,\ SCH,\ SCV,\ SCD\right)$ respectively using DWT.

2. Each of $ICA,\ SCA,\ SCH,\ SCV,\ and\ SCD$ are divided into blocks of 4×4 pixels and can be represented as:

$$SCA=\left\{BSA_i,\ 1\le i\le SA_n\right\}$$

$$ICA=\left\{BIA_j,\ 1\le j\le IA_n\right\}$$

$$ICH=\left\{BIH_k,\ 1\le k\le IH_n\right\}$$

$$ICV=\left\{BIV_l,\ 1\le l\le IV_n\right\}$$

$$ICD=\left\{BID_p,\ 1\le p\le ID_n\right\}$$

where BSA_i represents i^{th} block in SCA. BIA_j designates j^{th} block in ICA. BIH_k, BIV_l, and BID_p represent k^{th} block in ICH, l^{th} block in ICV and p^{th} block in ICD

3. For each block BSA_i in SCA, the best matched block BIA_j using $(RMSE)$. The first secret key $K1$ introduced.

4. Find the difference block DB_i as follows

$$DB_i = BSA_i - \left(\min_{1 \le j \le IA_n} BIA_j \right)$$

5. $$Bt_{CH} = \min_{1 \le k \le IH_n} \left(RMSE\left(DB_i, BIH_k \right) \right)$$

$$Bt_{CV} = \min_{1 \le l \le IV_n} \left(RMSE\left(DB_i, BIV_l \right) \right)$$

$$Bt_{CD} = \min_{1 \le p \le ID_n} \left(RMSE\left(DB_i, BID_p \right) \right)$$

6. Replace DB_i with either Bt_{CH}, Bt_{CV}, or Bt_{CD} which is best matched. The secret keys $K2$, $K3$ and $K4$ introduced.

$$DB_i \leftarrow min\left\{ Bt_{CH}, Bt_{CV}, BT_{CD} \right\}$$

7. *Steps 3 to 6* will repeat until all secret image difference blocks are embedded into cover image ICH, ICV, and ICD blocks.

8. Apply the inverse DWT to the ICA and the modified sub-images ICH, ICV, and ICD to obtain the stegano-image I'.

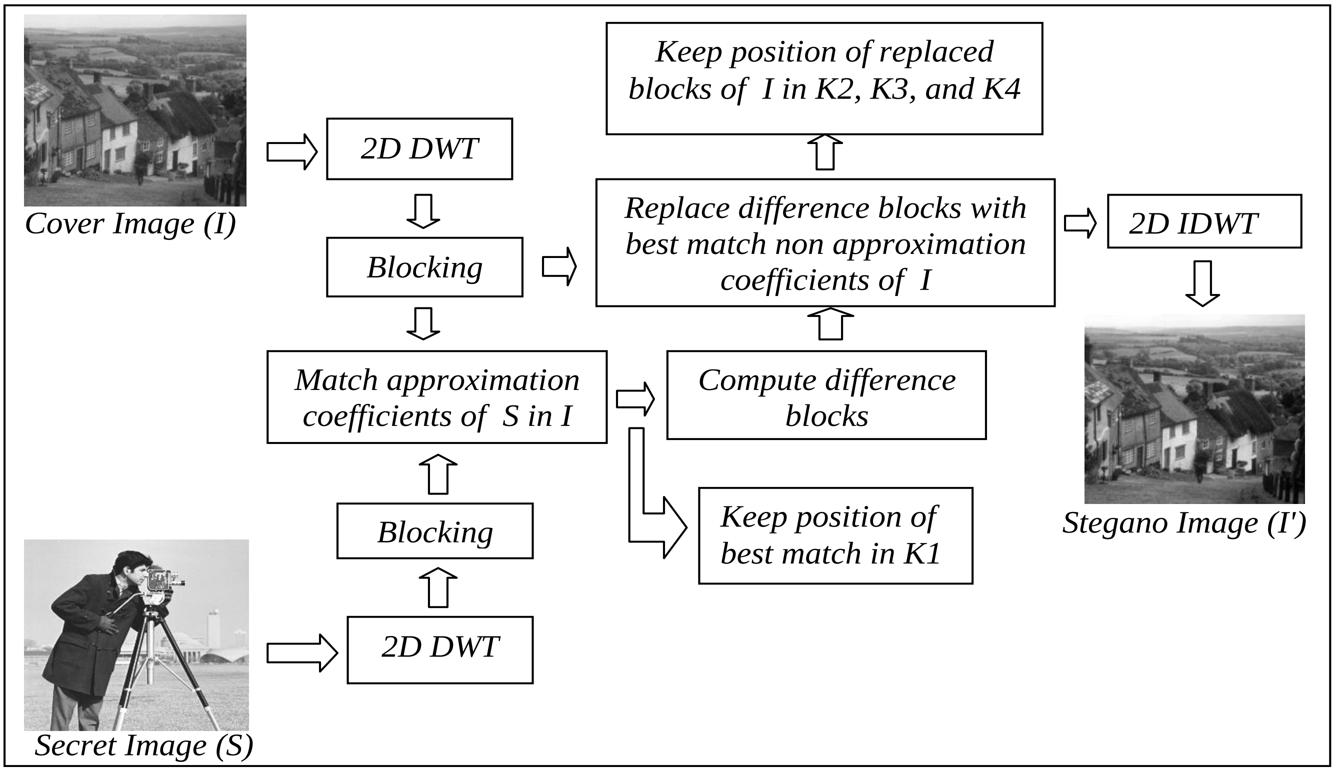


Figure 1.*Proposed Embedding Procedure*

Extraction Phase

The process of extraction phase shows in *Figure 2*. The difference and best matched blocks generates the secret image of ICA'. The extracting procedure is asfollows:

1. Decompose Stegano-image I' into four sub-images (ICA', ICH', ICV', ICD') using DWT.

2. Each of $ICA', ICH', ICV', and\ ICD'$ represented as:

$$ICA' = \{BIA'_j, 1 \le j \le IA_n\}$$

$$ICH' = \{BIH'_k, 1 \le k \le IH_n\}$$

$$ICV' = \{BIV'_l, 1 \le l \le IV_n\}$$

$$ICD' = \{BID'_p, 1 \le p \le ID_n\}$$

3. Extract the best matched block BIA'_j from sub-image ICA' using the first secret key $K1$. The secret keys $K2$, $K3$, and $K4$ are used to extract difference blocks DB'_i from sub-images ICH', ICV', and ICD'. The secret block BSA_i is computed as:

$$BSA_i = BIA'_j - DB'_i$$

4. Repeat *Step 2* until all the secret blocks are extracted.

5. Allocate each of sub-images SCH, SCV, and SCD as zeros and apply $IDWT$ to obtain the embedded secret image.

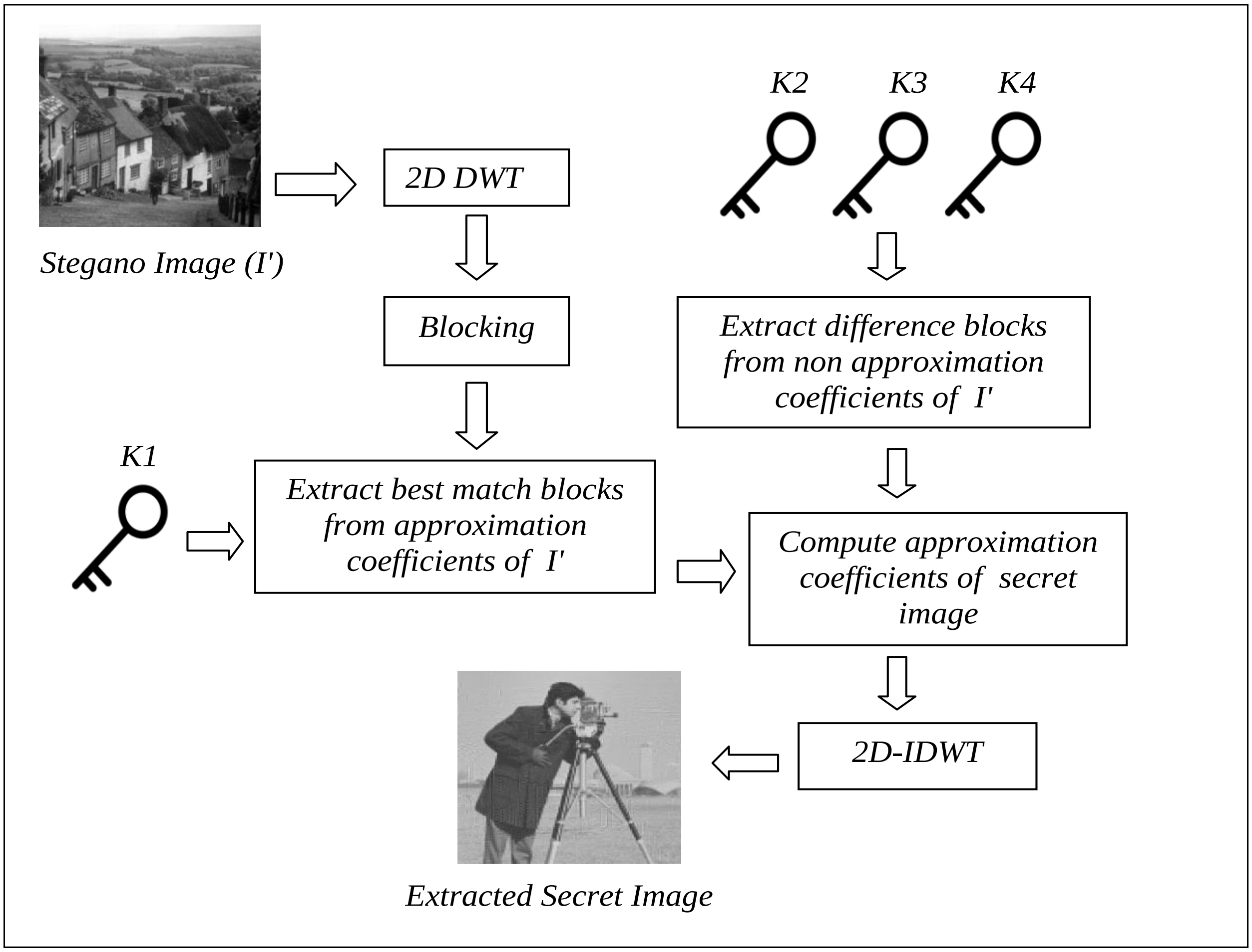


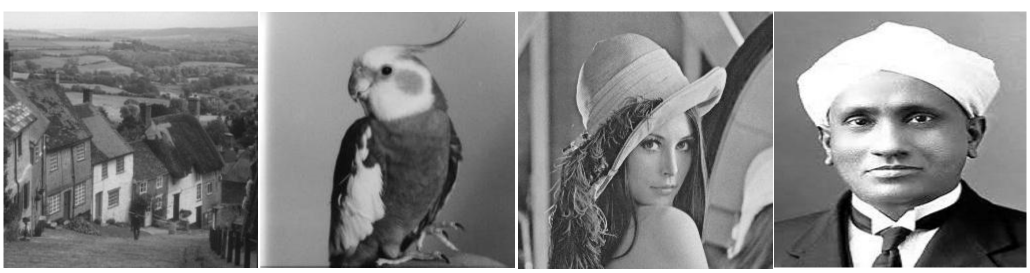
Figure 2.*Proposed Extraction Procedure*

PERFORMANCEEVALUATION

In this section, Performance will be evaluated on the basis of many experiements whatever done on different images.The results will compared with the other popular techniques and find the best results of proposed technique.

Performances Metrics and Digital Images

Take the four different images as cover image, namely,*Goldhill*, *Bird*, *Lena*, and *Raman* and two secret images: *Camerman* and *Baboon.* The different sizes of images includes for evaluation. The sizes are 256×256, 128×128, 64×64. Figure 3 shows the all cover images with same size. Figure 4 shows the all secret images with same size. The results in terms of PSNR or CC of new proposed technique is compared with other popular steganography techniques such as Least Significant Bit (LSB) [6], Discrete Wavelet Transform based steganography technique (DWS) [9], and DCT_DWT based steganography technique (DCWS) [4]. In terms of performance metrics, PSNR and CC used for comparison.



(i) (ii) (iii) (iv)

Figure 3. *Original Cover Images* (i) *Goldhill* (ii) *Bird* (iii) *Lena* (iv) *Raman.*

(i) (ii)

Figure 4. *Original Secret Images* (i) *Cameraman* (ii) *Baboon.*

The PSNR is used to measure imperceptibility. It is an important parameter for evaluation of steganographic techniques. Mathematical notation is :

$$\text{PSNR}=10\times\log_{10}\left(\frac{255\times 255}{MSE}\right) \tag{1}$$

Here,

$$\text{MSE}=\frac{1}{M\times N}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(I_{i,j}-I'_{i,j}\right)^2 \tag{2}$$

where $I_{i,j}$ shows the value of intensity of original cover image (or secret image), $I'_{i,j}$ shows the value of intensity of stegano image (or extracted secret image). The size of image is $M\times N$. The PSNR value is directly proportional to the quality of the image i.e, imperceptibility.

Theother well-known similarity measure is Correlation Coefficient (*CC*). The mathematical representation of CC is given below [19]:

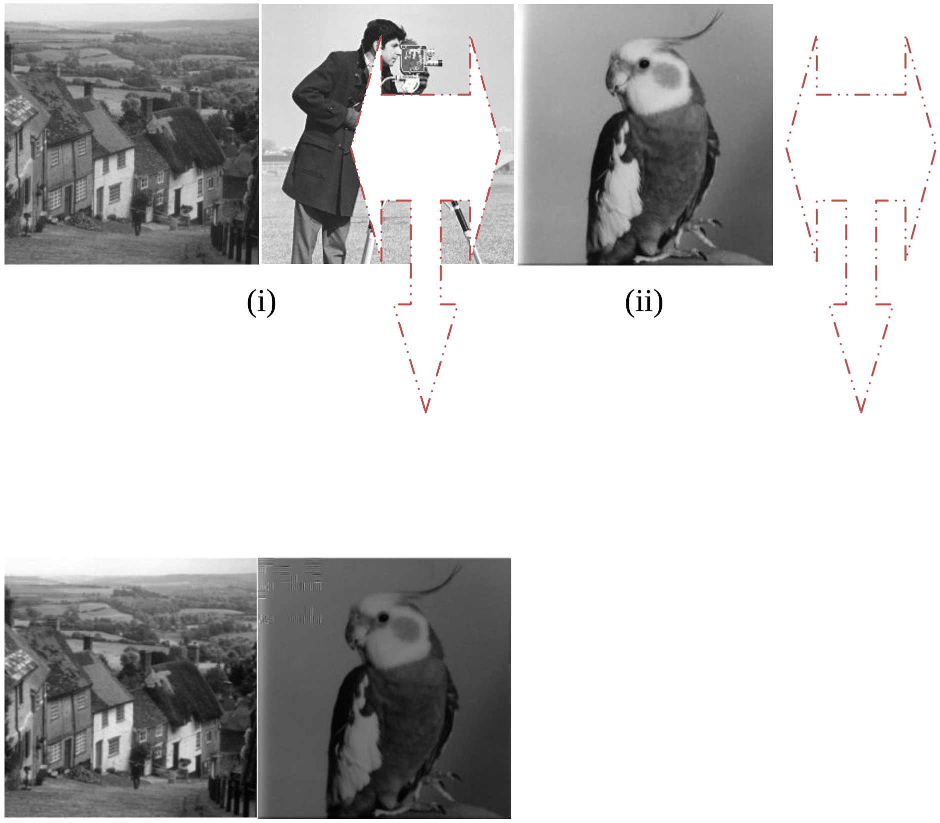
$$CC=\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left(I_{i,j}-\bar{I}\right)\left(I'_{i,j}-\bar{I}'\right)}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}\left(I_{i,j}-\bar{I}\right)^2}\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}\left(I'_{i,j}-\bar{I}'\right)^2}} \tag{3}$$

where $\bar{I}$ and $\bar{I}'$ are mean of original and stegano/extracted secret image. If the original and steagno/extracted secret image are highly correlated, this results in higher value of *CC*.

Results and Discussion

The *Cameraman* image was embedded into four cover images namely, *Lena*, *Goldhill*, *Bird*, and *Raman* . Similarly, we embedded *Baboon* image into *Goldhill*, *Bird*, *Lena*, and *Raman*images.*Figure* 3 represents the process of embedding of *Cameraman*as a secret image. The stegano images are much better image quality than other techniques stegano images. *Figure* 4 represents the process of embedding of *Baboon* as a secret image. The quality of stegano images are much better and negligible change shown inthe used cover images.

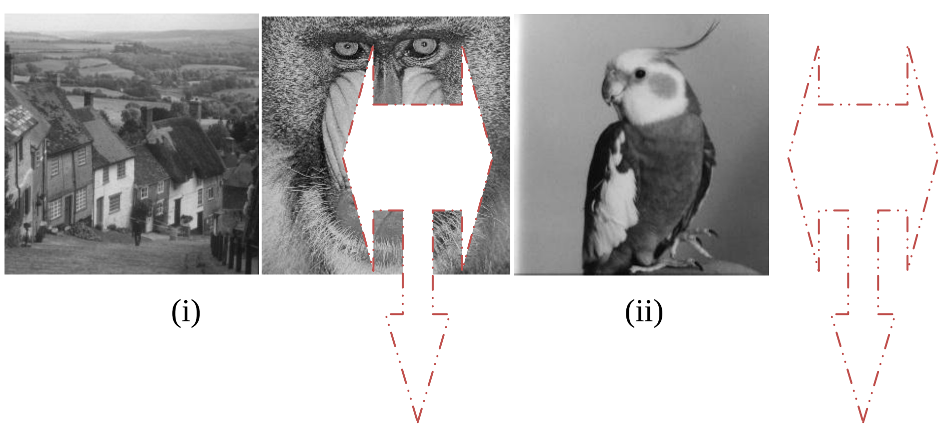
Tables 1 and Table 3 characterizethe *PSNR*value of stegano images after embedding .Table 2 and Table 4 represents the PSNR value of extracted secret images.



(i) (ii) (iv)

(iii) (v)

Figure 5.(i) *Cover Goldhill Image* (ii) *Secret Cameraman Image* (iii) *Stegano Goldhill Image after embedding Cameraman* (iv) *Cover Bird Image* (v) *Stegano Bird Image after embedding Cameraman.*



(i) (ii) (iv)

(iii) (v)

Figure 6.(i) *Cover Goldhill Image* (ii) *Secret Baboon Image* (iii) *Stegano Goldhill Image after embedding Baboon* (iv) *Cover Bird Image* (v) *Stegano Bird Image after embedding Baboon.*

Table 1. PSNR of Stegano Images after embedding Cameraman as Secret Image

Cover Images	*Algorithms*			
	LSB	***DWS***	***DCWS***	***Proposed Approach***
Goldhill	11.16	31.86	41.84	**43.22**
Bird	12.91	32.37	42.45	**45.12**
Lena	09.66	31.86	41.93	**44.84**
Raman	12.91	32.37	42.45	**45.23**

Table 2. PSNR of Extracted Cameraman as Secret Image

Cover Images	*Algorithms*			
	LSB	***DWS***	***DCWS***	***Proposed Approach***
Goldhill	12.14	30.89	40.23	**45.12**
Bird	10.67	31.24	41.56	**44.20**
Lena	10.76	32.56	41.67	**42.73**
Raman	13.47	33.45	40.34	**42.49**

Table 3. PSNR of Stegano Images after embedding Baboon as Secret Image

Cover Images	*Algorithms*			
	LSB	***DWS***	***DCWS***	***Proposed Approach***
Goldhill	11.16	31.86	41.84	**44.98**
Bird	12.91	32.37	42.45	**43.60**
Lena	09.66	31.86	41.93	**42.87**
Raman	12.91	32.37	42.45	**43.36**

Table 4. PSNR of Extracted Baboon as Secret Image

Cover Images	*Algorithms*			
	LSB	***DWS***	***DCWS***	***Proposed Approach***
Goldhill	11.16	31.86	41.84	**42.98**
Bird	12.91	32.37	42.45	**42.49**
Lena	09.66	31.86	41.93	**42.46**
Raman	12.91	32.37	42.15	**42.38**

The another performance metrics correlation coefficient (*CC*) calculated for stegano images after applying the embedding process shown in Tables 5 and 7. Tables 6 and Table 8 illustrates the values of *CC*for extractedsecret images.

Table 5. Correlation Coefficient of Stegano Images after embedding Cameraman as Secret Image

Cover Images	*Algorithms*			
	LSB	***DWS***	***DCWS***	***Proposed Approach***
Goldhill	0.7069	0.8595	0.9578	**0.9993**
Bird	0.7913	0.8669	0.9429	**0.9677**
Lena	0.6868	0.8487	0.8999	**0.9174**
Raman	0.6753	0.8599	0.9162	**0.9378**

Table 6. Correlation Coefficient of Extracted Cameraman as Secret Image

Cover Images	*Algorithms*			
	LSB	***DWS***	***DCWS***	***Proposed Approach***
Goldhill	0.9594	0.9523	0.9500	**0.9718**
Bird	0.9422	0.9479	0.9495	**0.9527**
Lena	0.9287	0.9388	0.9489	**0.9624**
Raman	0.9298	0.9458	0.9512	**0.9576**

Table 7. Correlation Coefficient of Stegano Images after embedding Baboon as Secret Image

Cover Images	*Algorithms*			
	LSB	***DWS***	***DCWS***	***Proposed Approach***
Goldhill	0.7527	0.8259	0.9345	**0.9981**
Bird	0.7908	0.8476	0.9352	**0.9917**
Lena	0.7596	0.8263	0.8965	**0.9174**
Raman	0.7668	0.8369	0.9159	**0.9652**

Table 8. Correlation Coefficient of Extracted Baboon as Secret Image

Cover Images	*Algorithms*			
	LSB	***DWS***	***DCWS***	***Proposed Approach***
Goldhill	0.7845	0.7900	0.8178	**0.8268**
Bird	0.7988	0.8008	0.8199	**0.8270**
Lena	0.8078	0.8211	0.8207	**0.8476**
Raman	0.7988	0.8175	0.8234	**0.8364**

Performance Evaluation Under Different Image Processing Attacks

The performance of proposed technique is also tested over somedigital image processing attacks such as *Gamma Correction,Sharping*, *HistogramEqualization,GaussianNoise,Rotation and Transform*.Table 9 and Table 10 shows the results.

Table 9. PSNR of Stegano Images and Extracted Cameraman as Secret Image Under Different Attacks

Image After Attack	Algorithms	Image Processing Attacks					
		Sharpening	Histogram Equalization	Gamma Correction	Gaussian Noise	Transform	Rotation
Stegano-Goldhill	*Proposed*	**27.65**	**41.68**	**32.31**	**41.69**	**41.46**	**37.37**
	DCWS	11.95	16.51	25.54	18.69	12.61	24.87
Stegano-Bird	*Proposed*	**34.34**	**42.72**	**31.63**	**42.73**	**40.66**	**37.01**
	DCWS	29.78	18.94	18.37	31.76	26.63	29.87
Stegano-Lena	*Proposed*	**37.62**	**44.12**	**31.92**	**45.23**	**41.42**	**37.26**
	DCWS	13.65	16.25	19.89	40.48	11.78	25.37
Stegano-Raman	*Proposed*	**35.82**	**42.56**	**34.87**	**44.76**	**40.67**	**38.23**
	DCWS	31.64	30.06	20.19	18.66	38.66	32.38
Extracted-Cameraman	*Proposed*	**27.66**	**41.68**	**32.31**	**41.68**	**41.45**	**37.38**
	DCWS	17.10	13.26	12.44	19.50	38.92	37.27

Table 10. PSNR of Stegano Images and Extracted Baboon as Secret Image Under Different Attacks

Image After Attack	Algorithms	Image Processing Attacks					
		Sharpening	Histogram Equalization	Gamma Correction	Gaussian Noise	Transform	Rotation
Stegano-Goldhill	*Proposed*	**28.33**	**41.68**	**32.31**	**41.69**	**41.46**	**37.39**
	DCWS	11.90	16.56	25.59	18.76	12.63	24.78
Stegano-Bird	*Proposed*	**28.69**	**42.69**	**31.61**	**42.69**	**40.61**	**36.79**

	DCWS	24.78	23.94	19.39	32.79	28.63	29.73
Stegano-Lena	*Proposed*	**30.13**	**43.26**	**31.59**	**42.94**	**40.84**	**36.58**
	DCWS	15.62	17.52	19.78	38.43	13.76	23.32
Stegano-Raman	*Proposed*	**36.21**	**42.61**	**30.51**	**44.27**	**41.82**	**40.53**
	DCWS	29.66	28.08	22.16	26.64	38.27	33.47
Extracted-Baboon	*Proposed*	**37.40**	**42.43**	**35.92**	**42.44**	**42.34**	**35.59**
	DCWS	26.48	32.76	32.67	37.89	36.56	28.78

CONCLUSIONS

A novel Discrete Wavelet Transform based digital image steganography approach has been proposed. Mainly, two novel concepts, computation of secret key and blocking phase applied on the proposed technique. The blocking uses the minimum deviation concept. Detail coefficient and minimum error matching criteria helps to compute the secret key. The performance of the proposed technique is much better than other techniques in terms of *PSNR*and correlation coefficient. Stegano image and the extracted secret image quality is very good and extracted secret image looks like the original secret image. Good visual quality provides by the newly secret key criterion.

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