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A Novel Approach for Data Hiding using Reversible Texture Synthesis Based on Ridgelet Transform

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***Abstract*— The main objective of this project is to develop a novel approach for hiding the data through Steganography. In Steganography, the secret message is to embedded into the image and then this embedded image is used for further sending purpose. This Steganography technique is used to protect the secret message from the eavesdroppers. First the cover image is divided into blocks and then the prediction algorithm is applied to each block to find the blocks which contains the texture information. The prediction error helps to find out the texture blocks. These blocks only used to embed the secret message for providing high visual perception. Not only that in this paper multilayer security is also included. Before embed the secret message the encryption technique is applied and then the encrypted message is collapsed for avoiding attacks.**

The embedding process is done on the ridgelet transform. It increases the payload and the quality of the embedded image. The ridgelet transform is applied on the detected blocks and then normalization process is applied and then the collapsed secret image bit is fused with the ridgelet normalized ridgelet coefficients. Finally the inverse ridgelet transform and denormalization is applied to get the embedded image. In extracting these process is done in reverse manner. This novel scheme provides the high embedding capacity. Not only that this process provides high recovery rate also because of using ridgelet. So the recovered image is exactly same as the original source texture. From the experimental results is performs better than the using of other transform for embedding.

Keywords—Block Dividing; Prediction;Prediction Error;Ridgelet Transform; Embedding Process;Extraction Process;Fusion;Stego Image

I. INTRODUCTION

Computer technology and the Internet are rapidly developing and are becoming more and more widely used as a means of distributing digital content. With the rapid growth of Internet and digital media techniques in recent years multimedia such as images, videos and audios can be easily copied, altered are destroyed. So the protection of ownership of multimedia data has to be provided.

Steganography is the practice of concealing a file, message, image, or video within another file, message, image, or video. The first recorded use of the term was in 1499 by Johannes Trithemius in his Steganographic, a treatise on cryptography and steganography, disguised as a book on magic. Generally, the hidden messages appear to be (or be part of) something else: images, articles, shopping lists, or some other cover text. For example, the hidden message may be in invisible ink between the visible lines of a private letter. Some implementations of steganography that lack a shared secret are forms of security through obscurity, whereas key-dependent steganographic schemes adhere to Kerckhoffs's principle.

The advantage of steganography over cryptography alone is that the intended secret message does not attract attention to itself as an object of scrutiny. Plainly visible encrypted messages—no matter how unbreakable—arouse interest, and may in themselves be incriminating in countries where encryption is illegal. Thus, whereas cryptography is the practice of protecting the contents of a message alone, steganography is concerned with concealing the fact that a secret message is being sent, as well as concealing the contents of the message.

Steganography includes the concealment of information within computer files. In digital steganography, electronic communications may include steganographic coding inside of a transport layer, such as a document file, image file, program or protocol. Media files are ideal for steganographic transmission because of their large size. For example, a sender might start with an innocuous image file and adjust the color of every 100th pixel to correspond to a letter in the alphabet, a change so subtle that someone not specifically looking for it is unlikely to notice it.

A many research works have been carried out on LSB based Steganography. Different researchers employed different techniques for the purpose of hiding secret data in a cover image. Following are the few related works carried out by various research groups. Some of the major techniques used in the field of Image Steganography are mentioned below. Some trivial algorithms utilizing the techniques are also listed.

Babita Ahuja[1] and, Manpreet Kaur have presented LSB based steganography algorithm with high data hiding capacity, as four LSB's are used to hide data, high confidentiality as distortions which can cause suspicions for the intruders, are removed through filtering techniques and two level high security is applied.

Chang-Chu Chen[2] and Chin-Chen Chang have proposed that data hiding scheme is a modification of the LSB-based steganography using the rule of reflected gray code. The embedding ability and distortion level of our novel method are similar to those of the simple LSB substitution scheme. The difference is that the LSBs of stego-image are not always the same as the secret bits while the simple LSB substitution keeps them equally.

Chin-Chen Chang[3] proposed a scheme embeds a larger-sized secret image while maintaining acceptable image quality of the stego-image and also improved image hiding scheme for grayscale images based on wet paper coding.

Debnath Bhattacharyya[4] security model is proposed which imposes the concept of secrecy over privacy for text messages. The proposed model combines cryptography, steganography and along with an extra layer of security has been imposed in between them.

Gaetan Le Guelvoit[5] proposed a work which deals with public- key Steganography in presence of passive warden. The main aim is to hide the secret information within cover documents without giving the warden any clue and without any preliminary secret key sharing. This work explores the use of trellis coded quantization technique to design more efficient public key scheme.

Giuseppe Mastronardi[6] have studied the effects of Steganography in different image formats (BMP, GIF, JPEG and DWT) and proposed two different approaches for lossless and loss image. They are based on the creation of an "adhoc" palette for BMP and GIF images.

Jan Kodovsky[7] and Jessica Fridrich worked out the specific design principles and elements of steganographic schemes for the JPEG format and their security. The detect ability is evaluated experimentally using a state of art blind steganalyser.

Jaya[8] have converted the secret image into a meaningful mosaic image of the same size as of secret image and looks like a preselected target image with the contrast difference. The secret image transmission is controlled by a secret key which is encrypted into secret image and no one can access the content of the target image, unless, they have the decrypting. The information required for recovering the secret image is embedded into the created mosaic image by a lossless data hiding scheme using a key. The efficiency of the image recovered after transmission is also calculated and to check the performance of the method.

Jen Lai[9] have proposed four types of mosaic images. The mosaic images including crystallization mosaic, ancient mosaic, photo-mosaic, and puzzle image mosaic. A fast greedy search algorithm is proposed to find a similar tile image in the secret image to fit into each block in the target image. The information of the tile image fitting sequence is embedded into randomly-selected pixels in the created mosaic image by a lossless LSB replacement scheme using a secret key; without the key, the secret image cannot be recovered. Color images, is also extended to create gray scale mosaic images which are useful for hiding text-type gray scale document images. The results improved the feasibility of this method.

Lisa M. Marvel[14] and Charles T.Retter have presented a method of embedding information within digital images, called Spread Spectrum Image Steganography (SSIS). SSIS conceals a message of substantial length with in digital images while maintaining the original image size and dynamic range. A hidden message can be recovered using the appropriate keys without any knowledge of the original image.

Liu Tong[15] and Qiu Zheng-Ding have proposed a Quantization-based Steganography scheme. In this method the secret message is hidden in every chrominance component of a color image and the hiding capacity is higher than that of the popular Steganography software. Since the Quantization-based hiding method is free from the interference and simulation results the hidden message can be extracted at low BER and our scheme is robust to common attacks.

Mahdavi.M[16] have presented a steganalysis method for the LSB replacement. The method is based on the changes that occur in histogram of an image after the embedding of data. It is less complex and more accurate than the RS steganalytic method for the images which are acquired directly from scanner without any compression. The RS method needs to count the number of regular and singular groups twice and also require LSB flipping for the whole image. This method has better average and variance of error comparing to RS steganalytic method.

Merlin[17] have proposed mosaic image creation and secret image recovery. In mosaic image creation, fitting the tile images of the secret image into the target blocks then transforming the color characteristic of tile image and rotating each tile image into a direction with the minimum RMSE value with respect to its corresponding target block and embedding relevant information into the created mosaic image for future recovery of the secret image. In the secret image recovery, extracting the embedded information for secret image recovery from the mosaic image, then reverse transforming the color characteristic of each tile image and reverse rotating each tile image into a direction with respect to its corresponding target block and recovering the secret image using the extracted information.

Mohammad Ali Bani Younes[18] and Aman Jantan have proposed a steganographic approach for data hiding. This approach uses the least significant bits (LSB) insertion to hide data within encrypted image data. The binary representation of the data is used to overwrite the LSB of each byte within the encrypted image randomly. The hidden data will be used to enable the receiver to reconstruct the same secret transformation table after extracting it and hence the original image can be reproduced by the inverse of the transformation and encryption processes.

Neil F. Johnson[19] and Sushil Jajodia have provided several characteristics in information hiding methods to identify the existence of a hidden messages and also identify the hidden information. The images are reviewed manually for hidden messages and steganographic tool to automate the process. The developed tool is to test robustness of information hiding techniques in images such as warping, cropping rotating and blurring.

Por.L.Y[20] have proposed a combination of three different LSB insertion algorithms on GIF image through stegcure system. The unique feature about the stegcure is being able to integrate three algorithms in one Steganography system. By implementing public key infrastructure, unauthorized user is forbidden from intercepting the transmission of the covert data during a communication because the stego key is only known by the sender and the receiver.

Raja[21] have proposed a novel image adaptive stegnographic technique in the integer wavelet transform domain called as the Robust Image Adaptive Steganography using Integer Wavelet Transform. According to information theoretic prescriptions for parallel

Gaussian models of images, data should be hidden in low and mid frequencies ranges of the host image, which have large energies.

Ruisong Ye[22] have proposed a chaos-based image encryption scheme with an efficient permutation-diffusion structure. In the permutation process, a multimodal skew tent map is utilized to generate one chaotic orbit used to permute the image pixel positions, while in the diffusion process, another two multimodal skew tent maps are employed to yield two pseudo-random grey value sequences for designing a two-way diffusion process. attack. The proposed image encryption scheme is highly secure and to its large key space and robust permutation-diffusion mechanism.

Shilpa P.Hivrale[23] have presented various statistical measures and PMF based method of detection. It uses the frequency count of the pixel intensities in the image to test for the detection of stego image or not. Here LSB embedding technique is used.

Shrutin Sarwate[24] have proposed a securely transfer using reversible Color transformation method.The secret image to be transmitted into a meaningful mosaic tile image with the same size which looks like another image which was preselected as the target image. The process of transformation is done with the help of some relevant information that is embedded andonly with the help of this embedded information can a person losslessly recover the transmitted secret image from the mosaic tile image. The result is the mosaic tile image, which consists of the tile fragments of an input secret image which has color characteristics same as that of another target image selected from the database.

In this paper first the cover image is divided into blocks and then the prediction algorithm is applied to each block to find the blocks which contains the texture information. The prediction error helps to find out the texture blocks. These blocks only used to embed the secret message for providing high visual perception. Not only that in this paper multilayer security is also included. Before embed the secret message the encryption technique is applied and then the encrypted message is collapsed for avoiding attacks. In this paper the embedding process is done on the Ridgelet transform. It increases the payload and the quality of the embedded image. The Ridgelet transform is applied on the detected blocks and then normalization process is applied and then the collapsed secret image bit is fused with the Ridgelet normalized Ridgelet coefficients. Finally the inverse Ridgelet transform and denormalization is applied

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to get the embedded image. In extracting these process is done in reverse manner.

The remainder of this paper is organized as follows. The embedding and extraction process are discussed in Section II. Section III describes the experimental results and performance evaluation of the proposed method. Finally, Section VI concludes the paper.

II. PROPOSED METHOD

In this project first the cover image is divided into blocks and then the prediction algorithm is applied to each block to find the blocks. Which contains the texture information. The prediction error helps to find out the texture blocks. These blocks only used to embed the secret message for providing high visual perception. Not only that in this paper multilayer security is also included. Before embed the secret message the encryption technique is applied and then the encrypted message is collapsed for avoiding attacks. In this paper the embedding process is done on the ridgelet transform. It increases the payload and the quality of the embedded image. The ridgelet transform is applied on the detected blocks and then normalization process is applied and then the collapsed secret image bit is fused with the ridgelet normalized ridgelet coefficients. Finally the inverse ridgelet transform and denormalization is applied to get the embedded image. In extracting these process is done in reverse manner.

This method produces high quality images, high PSNR value and low quality error.This method can apply both color and gray image.It low distortion and high recovery rate.It provides high capacity and low distortion.

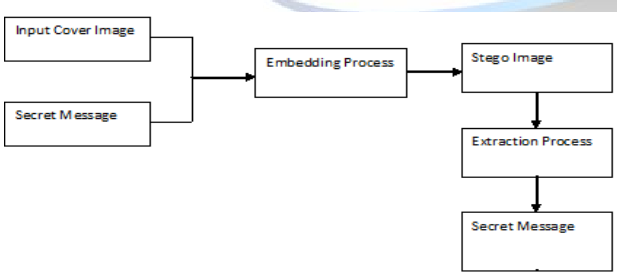

Fig.1Overall Block Diagram

The proposed method contains two main modules. They are embedding and extraction. In embedding process the cover image and the secret message is given as the input. And the stego image is produced as the output. In extraction process the stego image is given as the input image and the secret message is produced as the output.

1. Embedding Process

The embedding process is used to produce the stego image. To do this first the cover image is divided into blocks and then the prediction algorithm is applied to each block to find the blocks which contains the texture information. The prediction error helps to find out the texture blocks. These blocks only used to embed the secret message for providing high visual perception. Then these blocks are collapsed for providing additional security.

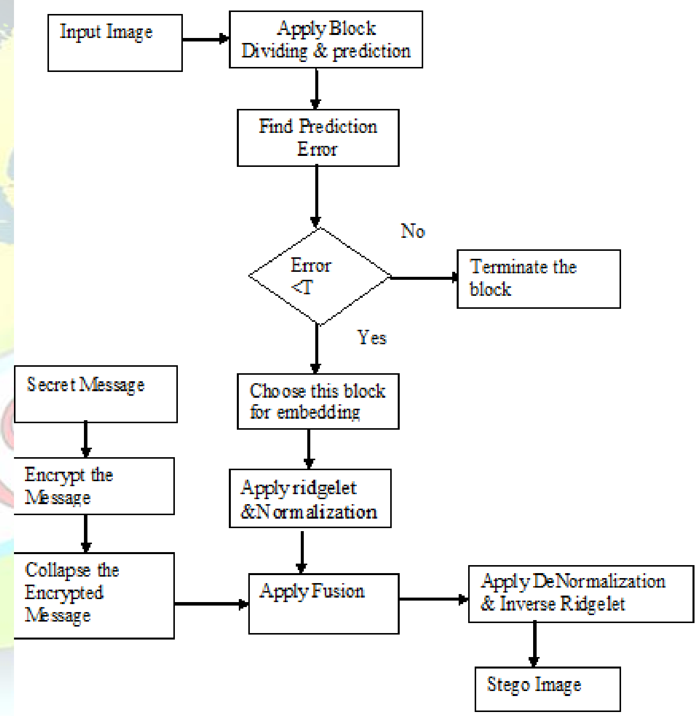

Fig 2.Embedding Process

The secret message is encrypted using the encryption technique is applied to produce multilayer security and then the encrypted message is collapsed for avoiding attacks. Christo Ananth et al. [10] proposed a system in which OWT extracts wavelet features which give a good separation of different patterns. Moreover the proposed algorithm uses morphological operators for effective segmentation. From the qualitative and quantitative results, it is concluded that our proposed method has improved segmentation quality and it is reliable, fast and can be used with reduced computational complexity than direct applications of Histogram Clustering. The main advantage of this method is the use of single parameter and also very faster. While comparing with five color spaces, segmentation scheme produces results noticeably better in RGB color space compared to all other color spaces.

2. Block Dividing

This is the first step of the embedding process. The original cover image sized $M \times N$ as I, and it is divided into the non-overlapping $n \times n$ blocks. For simplicity, assume that M and N can be divided by n with no remainder. Denote all k divided blocks in raster scanning order as $B_{i,j}$, where $k = M \times N / n2$, $i = 1, 2, \ldots, M/n$, and $j = 1, 2, \ldots, N/n$.

3. Prediction and Prediction Error

After block dividing the next step is to find the texture information block. To identify this the interpolation method is used. For do this take the current processing block as $B_{x,y}$ and its left blocks are $B_{x,y-1}$ and upper blocks $B_{x-1,y}$, respectively. To find the average value of these two blocks and calculate the difference value of interpolated blocks and the current processing blocks. Then compare the difference value with the threshold value. If the difference value is greater than the threshold value the block contains the structure information so eliminate these blocks. Otherwise the block contains the texture information. These blocks are considered as the embedding blocks.

4. Multilayer Security

In this paper the multilayer security is provided. To do this the blocks which are used detected as the embedding blocks are collapsed. And the secret image is also encrypted and it also collapsed to provide more security.

5.Embedding on Ridgelet Transform

After collapse the blocks then apply the ridgelet transform on it. Before apply the ridgelet transform the normalization process is applied. After applying the ridgelet transform and then the encrypted secret bit is fused with the ridgelet transform. Finally the inverse ridgelet transform to get the stego image.

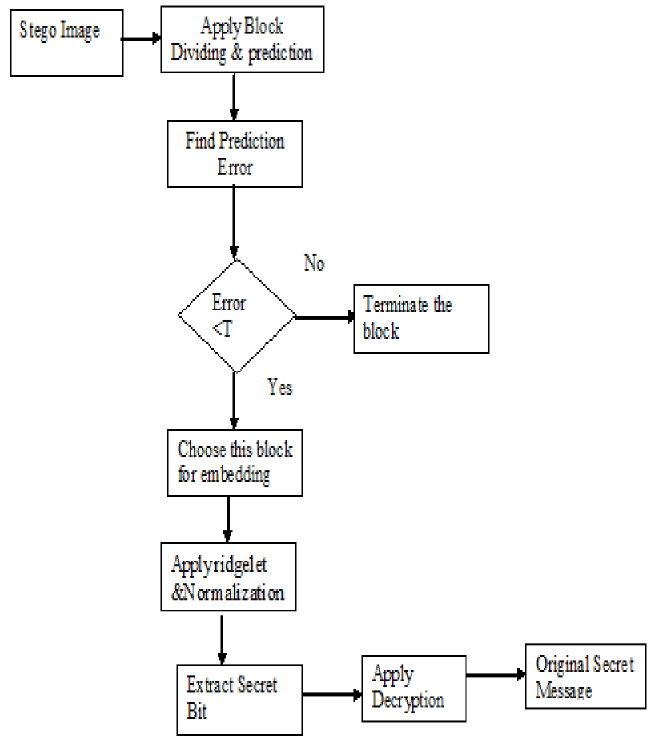

Fig 3. Extraction Process

6.Extraction Process

The extraction process is used to get the original secret message from the stego image. To do this first the stego image is divided into blocks and then the prediction algorithm is applied to each block to find the blocks which contains the texture information. The prediction error helps to find out the texture blocks. These blocks only used to extract the secret message for providing high visual perception. Then these blocks are collapsed for providing additional security. After that the ridgelet transform is applied on the detected blocks and then normalization process is applied and then extract the secret image bit. Finally these message bit is decrypted to get the original secret message.

The overall algorithm of the proposed method is described below.

1. First get the cover image as input.
2. And then divide the image into non overlapping blocks.
3. Apply the prediction on to each block.

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4. And then calculate the prediction error from the original and predicted blocks.
5. Compare these error value with the threshold to find out the texture information of these blocks.
6. If the error value is greater than the threshold the block is terminated because it contains structure information.
7. Otherwise the block is considered as the embedding blocks because it contains the texture information.
8. And then these blocks are collapsed to provide the additional security.
9. And then get the secret message which is to be embedded.
10. Apply the encryption on to the secret message to provide the multilayer security.
11. And then these encrypted messages are collapsed.
12. Finally apply the ridgelet transform on to the selected blocks and then apply the fusion.
13. Apply the inverse ridgelet transform and block combining to produce the stego image.
14. In stego image apply the step 2-8 steps.
15. And then apply the steps ridgelet transform and perform defusion to extract the secret message.

I. Finally apply the decryption and decollapse to get the original secret message.EXPRIMENTAL RESULTS

A. Experimental Images

Experiments were conducted on a group of color images to verify the effectiveness of the proposed scheme. For the experimental purpose several type of cover images are taken. Some of these images , i.e., Lena, Barbara, Babbon, Peppers, Sailboat, and Tiffany, are shown in Figure 4. The sizes of the divided non-overlapping image blocks are set to 4 × 4, i.e., n = 4 for the experiments

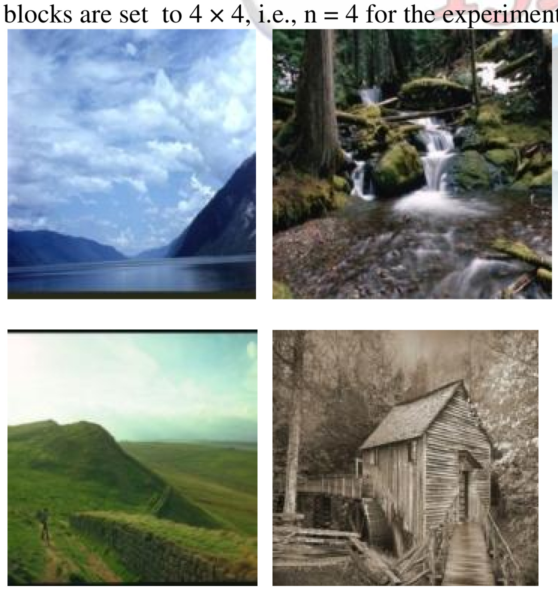

Fig 4. Experimental Images

B.Performance Analysis

To evaluate the performance of the steganography techniques several performance metrics are available. This paper uses the PSNR,SSIM, MSE and RMSE to analyses the performance.

(i) Peak Signal-to-Noise-Ratio

The peak signal-to-noise ratio (PSNR) is used to evaluate the quality between the stego image and the original image. The PSNR formula is defined as follows:

$$\mathrm{PSNR} = 10 \times \log 10 \frac{255 \times 255}{\frac{1}{H \times W} \sum_{x=0}^{H-1} \sum_{y=0}^{W-1} [f(x,y) - g(x,y)]^2} \mathrm{dB}$$

where H and W are the height and width of the image, respectively; and f(x,y) and g(x,y) are the grey levels located at coordinate (x,y) of the original image and attacked image, respectively.

Methods	PSNR
LSB	32.58
DCT	36.24
DFT	40.56
DWT	45.64
Proposed	54.42

(ii) Structural Similarity Index Metric

The structural similarity index is a method for measuring the similarity between the stego image and the original image.

$$\mathrm{SSIM}\,(y, \hat{y}) = \frac{\left(2_{\mu_y \mu_{\hat{y}}} + c_1\right)(2\sigma_{y\hat{y}} + c_2)}{\left(\mu_y^2 + \mu_{\hat{y}}^2 + c_1\right)(\sigma_y^2 + \sigma_{\hat{y}}^2 + c_2)}$$

where, $\hat{Y}$ is the stego image, the Y is the original image, μ is the mean and the is the variance.

(iii) Mean Square Error

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The mean square error (MSE) is used to evaluate the difference between a stego image and the original image. The MSE can be calculated by

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(\widehat{Y}_i - Y_i)^2$$

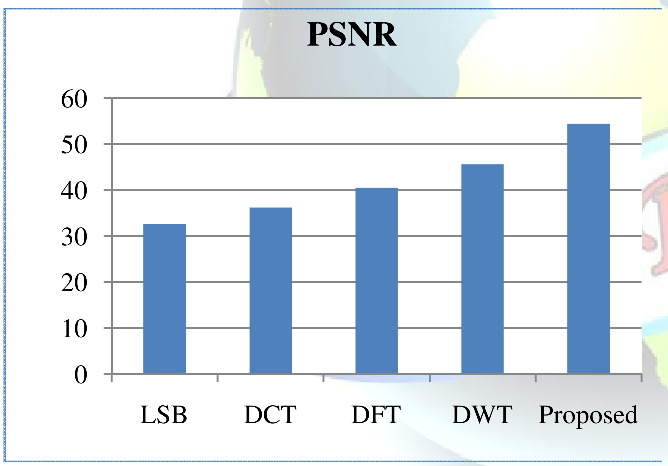
where, $\widehat{Y}$ is the stego image and the Y is the original image.

(iv) Root Mean Square Error
The Root Mean Square Error (RMSE) is a frequently used measure of the difference between stego image values and the original image values.

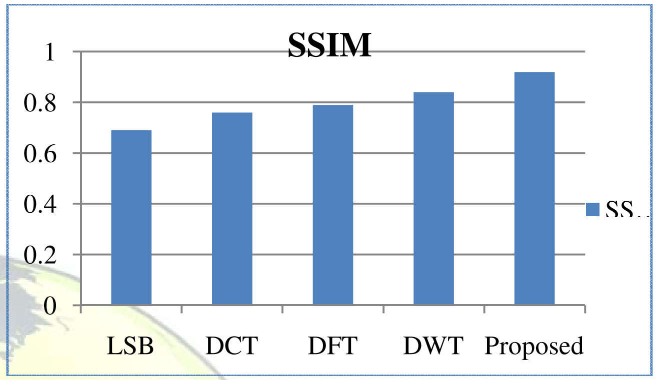
$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(\widehat{Y}_i - Y_i)^2}{n}}$$

where $\widehat{Y}$ is stego image and Y is original image

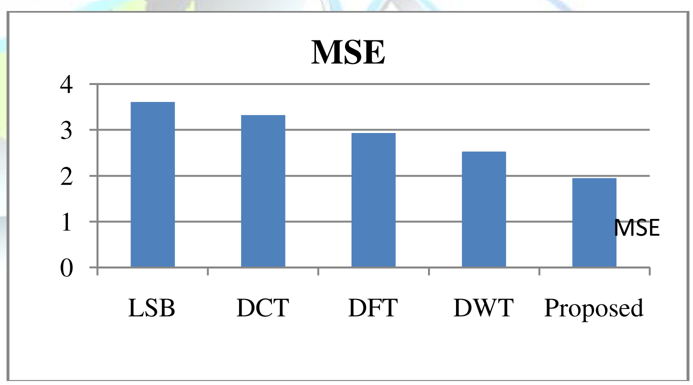
.



Methods	SSIM
LSB	0.69
DCT	0.76
DFT	0.79
DWT	0.84
Proposed	0.92



Methods	MSE
LSB	3.61
DCT	3.32
DFT	2.93
DWT	2.53
Proposed	1.95



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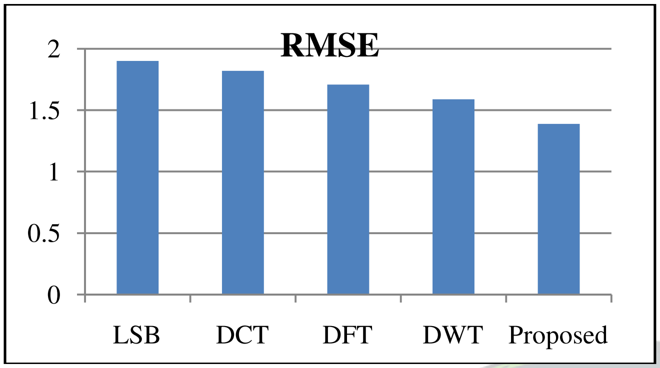

Methods	RMSE
LSB	1.9
DCT	1.82
DFT	1.71
DWT	1.59
Proposed	*1.39*

IV. CONCLUSION

In this project a novel approach for hiding is proposed. In the novel approach the prediction algorithm is applied to find the texture information. The prediction error is also applied to find out the texture blocks. In this paper multilayer security is also included. Before embed the secret message the encryption technique is applied and then the encrypted message is collapsed for avoiding attacks. In this paper the embedding process is done on the ridgelet transform. It increases the payload and the quality of the embedded image.

The ridgelet transform is applied on the detected blocks and then normalization process is applied and then the collapsed secret image bit is fused with the ridgelet normalized ridgelet coefficients. Experimental results shows that the proposed method performs better than the existing approaches.

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