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Removable Visible Watermarking Using Discrete Fourier Transform

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Abstract: This paper proposes a visible watermarking scheme using Discrete Fourier Transformation and which is reversible with some additional information. In the proposed scheme follows one to one mapping between the DFT coefficient of the cover image and watermark. For the purpose of our scheme the watermark of different size is embedded into the standard test images. Experimental results shows that the watermarked image has good perceptible features and authorised user can recover the original cover image with superior visual quality. The peak signal ratio of the legally recovered image is >50db.
Keywords: Visible Digital image watermarking, Steganography, DFT, Removable watermarking, PSNR, SSIM.

I. INTRODUCTION

In the past few years, the information exchange in the digital world has increased enormously which in turn increased the vulnerability and copyright violation issues of the digital content. In order to counter this kind of threat digital watermark, steganography and cryptography can be considered as the possible solution. Steganography is art and science of hiding information between two parties for the purpose of communication with one another. In steganography if the existence of secret information is revealed, steganography fails [1]. In order to increase the security of communication sometimes steganography is combined with cryptography where in an attacker may be able to extract the message from the cover work but the attacker has to break the encryption code to see the message hidden. Cryptography scramble the cover work or message in such a way that it is meaningless to the other party [2]. If any third party come in hand with the secret key for encryption, they can decrypt the digital content and shared it in the digital media, hence the problem remains the same. Thus digital watermarking can be considered as the only possible solution of for the protection of copyright, ownership and image authentication. Digital watermark is a branch of steganography with different goals, steganography is mainly concerned with concealing the existence of the communication and protecting the embedded data against any modifications that may happen during transmission such as format change or compression on the other hand watermarking hide the information to the cover work and attacker who knows the presence of the watermark may try to alter or removed or destroyed it. Table below shows the comparison between digital watermark, steganography and cryptography [1]:

Table I: Comparision Between Steganography, Cryptography And Watermark

	Steganography	Cryptography	Watermark
Goal	Conceals the existence of the communication	Hide the content of the communication	Protect the embedded content against intentional and unintentional attacks
Perceptibility	Exist	Not Exist	Depend on the scheme/ Application
Embedding Data	Large	Not necessary	Depend on the scheme/ Application
Outputs	Stego-media	Encrypted-media	Watermarked-media
Goals Fails	Existence of message is found out.	Chiper text is Decrypted	Watermarked is destroyed or removed
Challenges	Robustness, Transparency, hiding Capacity	Robustness	Robustness
Key	Depend on the scheme/ Application	Required for encryption/decryption	Depend on the scheme/ Application

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Robustness, imperceptibility and capacity are the three main factor for good digital watermarking scheme. Robustness is define as the ability to resist against any kind of intentional and unintentional attacks on the watermarks. Imperceptibility means there should not any kind of distortion which may decrease the commercial value of the cover work. Capacity means the amount of information that a watermarking system can hide on the cover work. Depending on the Imperceptibility digital watermark can be divided into visible and invisible watermark. Visible watermark is a type of watermarking in which the watermark is perceptible along with the host image. Compare to invisible watermarking in which the watermark such as copyright information is imperceptible in the host image, visible watermarking provide a direct way to resist pirate and copyright [3]. Digital Watermarking can destroy sensitive information of the cover work and the exact retrieval of the cover work is impossible, in some special case watermark may require to be removed so that the original image can be reinstated, such type of watermarking is called reversible watermarking, e.g. If a watermark is embedded in the medical image, a slight modification while inserting the watermark can alter the content of the image and thus a physician may make wrong diagnosis. Reversible watermarking is widely used in the field of medical and military purpose. Hence reversible watermarking is gaining more attention for its increasing used in military and medical purposes. Imperceptibility and capacity are the two main properties in reversible watermarking. Imperceptibility measure the similarity between the original cover work and the watermarked cover data and capacity measures maximum number of information that can be embedded in to the cover work [4].

II. LITERATURE SURVEY REVERSIBLE WATERMARKING

Barton (1994) [5] in his invention introduced method for authenticating information provided by the user in which he embeds an authentication data to digital data using a digital signature which is a compressed version of the digital block. Both the signature and additional data are embedded into the digital block by replacing predetermined bit within the block. Mohanty et al (1999) [6] propose dual watermarking scheme in which a visible watermark is first inserted and then an invisible watermark is added to visible watermarked cover image. For visible watermark insertion they divide both the watermark and cover image into block of equal size then mean and variance of each block was computed. Using this mean and variance they calculated the scaling and embedding factor for watermark insertion. For invisible watermark insertion they perform logical EX-ORed between the bit planes and binary watermark. Honsinger et al (2001) [7] were first one to propose the reversible watermarking for images. In which they utilized modulo 256 addition for embedding the hash value of the cover work to the cover image. If the watermark is the hash of the original image, he cross checked extracted watermark with the hash calculated for the watermarked image then subtract the watermark pattern to get the original cover image. Due to modulo 256 addition the watermark suffer from salt and pepper artefact. Macq (2000) [8] modified the patch work algorithm and modulo 256 addition to achieve the reversible watermarking. This also suffer the same problem encounter by Honsinger et al. (2001) [7]. Later Vleeschouwer et al. (2003) [9] developed a scheme using a circular interpretation of bijective transformation of the histogram for the block used as a patch work to reduce the salt and pepper artefact. In this the luminance value of the cover image are uniformly distributed in circle and pixel value are equivalent from the transformation point of view. Fridich et al. (2002) [10] also proposed a reversible watermarking scheme which make involve compressing the least significant bit of the cover image and image hash is added this and finally the outcome is encrypted and is added to the original image by replacing it with this encrypted bit plane. Celik et al (2002) [11] proposed high capacity, low distortion reversible watermarking scheme using generalized LSB modification and lossless image compression algorithm context-based adaptive lossless image coding (CALIC) in their methods. Tian (2003) [12] increase the capacity of watermark using difference expansion of pair of pixels. This scheme embed one bit of data to every pair of pixels. The location of pairs in which the data is embedded is compressed and included in the payload. Alattar (2003) [13] expanded the Tian algorithm instead of using two pair of pixels to hide 1 bit information, he used three pixels to hide two bits of information with every spatial and cross spectral triplet's pixel to increase the hiding capacity. A triplet is 1x3 vector which are chosen from the pixel value of the coloured image. In his scheme he considered two kind of triplet one is spatial triplet which is a three pixel value chosen from three different location within the same colour component chosen in predetermined order and cross spectral triplet is also a pixels values chosen from three different colour components according to predetermined order. Later on Alattar (2004) [14] extended his algorithm to hide two bits of information with every quad of pixels. A quad is a 1x4 vector formed from four pixel values chosen from four different locations within the same colour component according to a predetermined order. Later Lin et al. (2008) [15] improve the Tian (2003) method without using the location map used for extracting the original image. The difference between a pair of pixels is recorded by the relation of pixels neighbouring the pair of pixels. Ni et al (2006) [16] proposed a histogram shifting based reversible data hiding scheme in which they utilised the zero and peak value of image histogram to hide the data by slightly modifying the grayscale pixels. They assume zero point to the grayscale value which no pixel in the given image assumes and a peak point corresponds to

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the grayscale value which the maximum number of pixels. In this scheme the pixels is modified at most by 1. In this scheme the number of bits that can be embedded into an image equals to the number of pixels which are associated with the peak point. Hu et al (2006) [17] proposed a key based removable watermarking scheme using DWT (discrete wavelet transform). The DWT coefficients of the watermark used for embedding are selected by a key. The pixel-wise varying parameters of the embedded are calculated from those unchanged coefficients. Another key based watermarking scheme is propose by Tsai and Chang (2007) [18] in which use the key to compromise between robustness and transparency. The key used is a random variable with discrete normal distribution. Yang et al (2008) [19] proposed a removable visible watermarking using DCT. The visible watermark was removable using secret key. In this they divided watermark image into block of 16x16 and the pre-processed watermarked is obtain by multiplying each DCT block and a key based matrix. The scaling and embedding factor is determined using HVS modal in which making greater scaling factor in the midluminance areas and shrinking its value at darker and brighter components and HVS is less sensitive to the changes made texture region, they use low value for scaling factor in the texture region. The texture features of both the host image and original watermark into account in order to better adapt to HVS characteristics. Thodi and Rodriguez (2007) [20] combine difference expansion and histogram shifting to achieved reversibility of watermark. They also introduce prediction error expansion to achieved higher data embedding capacity as it better exploit local correlations within neighbouring pixels and the derived prediction error histogram are sharply distributed. Lee et al. (2007) [21] proposed a reversible watermarking is proposed in which they divide the image into no overlapping blocks and watermark is embedded into the high DWT coefficient of each block. They use integer to integer wavelet transform achieve reversibility. Integer to integer wavelet transform maps integers to integers and does not cause any loss of information through forward and inverse transforms. The watermark payload content both the message and side information used for the construction of the original image.Tsai and Lin (2008) [22] proposed dual watermarking scheme in which they embed a visible and semi fragile watermark on a cover image using HVS model. In HVS model they collaborate Contrast sensitive Function (CSF) and Noise visible function (NVF) for noise reduction in the visibility threshold of HVS in DWT domain. CSF and NVF also determine the optimal watermark region in the cover image as they characterized the local and global image properties and identifies texture and edge of the cover image. Tai et al. (2009) [23] proposed a histogram based reversible data hiding scheme in they found out the histogram modification technique does not work well when an image has an equal histogram, they histogram modification technique by considering the differences between adjacent pixels instead of simple pixel value to hide the data and modified the histogram. They used a binary tree structure to solve the problem of interacting between several pairs of peak point to recipient. Tsai (2009) [24] proposed a watermarking scheme based on Content and Contrast aware, in which they utilize the local characteristic of the host and watermark image of discrete wavelet transform (DWT) to obtain the optimal watermark location and strength at the embedding stage which result in higher PSNR in watermarked image. Ying Yang et al. (2009) [25], proposed a lossless visible watermarking scheme in which the strength of the watermark adaptively varies to different areas of the host image based on the HVS and cover image data. To get the original image from the watermarked image, a recovery packet data embedded in the watermarked region of the image. To improve the packet less severe the scheme make used of compression and no original image were required to restore the original image. The scheme also use pixel prediction method to construct approximate cover work. Li et al. (2010) [26] proposed a reversible data hiding scheme using difference in adjacent pixels. They first scans the cover image and employs the pixel-difference function to calculate the difference between each current pixel and the next pixel. Then, Adjacent Pixel difference generates the histogram of the transformed image, which is called the difference sequence. Adjacent Pixel difference selects the first pair of a peak point and its closest zero point. Given a peak point, both sides of the peak point have a zero point that is closest to the peak point Farrugia (2010) [27] proposed a reversible watermarking scheme in which they embed the watermarking in the Region of Interest of the host image and information regarding the retrieval of the original host image is embedding the quantized transform making used of Reversible Contrast Mapping. In order prevent the loss of information during compression, the residual information packet is embedded in the lower frequency transform domain. The residual information is calculated based on the compressed host image Qin et al. (2013) [28] proposed a fragile watermarking using vector quantization and image inpainting. Vector quantization and inpainting, are integrated in the generation of recovery-bits for each classified cover image block. The watermark used in this scheme consist of an authenticating bit for tamper localization and recovery bit for image recovery. The watermark is embedded into the cover image using LSB to produce the watermarked image. Hsu et al (2014) [29] proposed a reversible watermarking scheme in which a binary image is added to the gray-scale image. The visible watermark is simply achieved by modifying the pixel value of the cover image and can be distinguished by human. To recover the original image they simply add watermark data into the stego image by making used of reversible stenographic approach. Zeng and Wu (2010)[30], proposed visible watermarking scheme which make used of HVS Model in which they calculate the scaling and embedding factor depend on both host and watermark such as luminance and texture sensitivity. Then the

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watermark is embedded into the cover image by adjusting the scaling and embedding factor. Samee and Gotzee (2013) [31] proposed a reversible and blind watermarking scheme using CDMA. The removal of watermark doesn't required the original watermark. In this scheme, they first make sequence of the watermark using some sequencing code and perform DCT on the cover image and some frequency coefficient is selecting and using the sequenced watermark is added to select frequency co-efficient. For the removal of the watermark at the end user, watermarked image transform using DCT and they selected the same frequency co-efficient and finding out the co-relation between the selected co-efficient and sequencing code, which is provided a key, the watermark obtain. The extracted watermark is again process with sequencing code and subtracted from the selected coefficient and they perform inverse transform it to obtain the original image. Zhang (2012) [32] proposed encryption based data hiding scheme which is made up of encryption data embedding and data recovery phased. Encryption phase consist encrypting an uncompressed image using an encryption key and to hide the data in the encrypted image, they compressed the LSB using a data hiding key to create a sparse space to accommodate additional data. Using Encryption key and data hiding key the original cover image can be restored. Using only the data hiding key, end users may not be able to retrieve the original image. Li et al. (2013) [33] proposed a histogram based reversible data hiding scheme by considering each pixel-pair and its context, a sequence consisting of pairs of difference values is computed. Then, a two-dimensional difference-histogram is generated by counting the frequency of the resulting difference-pairs. Finally, reversible data embedding is implemented according to a specifically designed DPM. Wang et al. (2013) [34] proposed a watermarking scheme using Standard Deviation and two watermark. One watermark is for tamper detection and another for restoration of the original image. In this scheme they divide the original image into block and using standard deviation they classified the blocks into different category. They perform DCT on each block and quantized coefficient is used to encode to different bits using according to category they belong and is then encrypted to add the recovery watermark into the host image along with the authenticating bit. The recovery bit is the compressed form of the original host and this is referred for the reconstruction of the original image. Zhang et al. (2015) [35] proposed a watermarking scheme which involved bitwise exclusive OR operation and the black pixel of the watermark which correspond to part of the encrypted data is changed to embed the visible watermark along with some additional information was also embedded for data recovery. In the receiver end the decryption will lead to the watermarked image and decryption-extraction will lead to the recovery of the original plain text image (plain text is an ordinary readable text before encryption and after decryption).

III. PROPOSED METHOD

We present DFT based visible watermarking scheme which is reversible. The scheme follow one to one mapping of the DFT components of the cover image as well as the watermark image. The watermark may be of different dimension and we are able to achieve a visible watermark pattern. The equation of watermark embedding is given by

$$I' = I + \alpha W \qquad (1)$$

Where I' is the watermarked image, I is the host image, α is user define constant known as embedding factor, and W is the binary watermark. In order to remove a watermark from the watermark image we can define an equation using the above equation

$$I = I' - \alpha W \qquad (2)$$

In our scheme we required the original watermark and embedding factor for retrieving the original cover image. The details step of the watermarking scheme is given below:

Input: cover image I_c, watermark W

Output: watermarked cover image I_w.

Step 1: we perform the DFT transform for I_c and W to get I_{DFT} and w_{DFT}.

Step 2: we resize the W into different dimension 512X512, 256X256, 128X126 and 64X64.

Step 3: we increase the co-efficient of W by embedding factor α and it is added to the coefficient of I_c to get new DFT component of I_c.

Step 4: Performing the inverse DFT to get the watermarked image.

Visible watermark extracting algorithm

Input: watermarked image Iw, watermark W.

Output: Original cover image Ic.

Step 1: We read both the Iw and W.

Step 2: We divide the original image into blocks depending on the size of the watermark.

Step 3: The watermark is resize according to the block defined.

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Step 3: We perform DFT on both watermarked image and watermark the get DFT components. Step 4: We used the embedding factor α which is passed a key to the authorised users and perform one to all multiplication with the watermark image.
Step 5: The new derived watermark is subtracted from DFT component of the watermarked image.
Step 6: Inverse DFT is perform to get the un-watermarked original image.

EXPERIMENTAL RESULTS AND DISCUSSION

The proposed method has been simulated using MATLAB and tested on different image of dimension of 512x512. We added the watermark of different dimension to test the PSNR achievable in reference to the watermarked area and embedded bit per pixels. Two parameter, Peak Signal to Noise Ratio, Structural Similarity (SSIM) index, were used to evaluate the effectiveness of the presented scheme. The PSNR is utilized to find is utilized to find the fidelity of the image while inserting the watermarked image and it's given by the equation below [38]:

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[I(i,j) - I'(i,j)]^2 \qquad (3)$$

The PSNR in db is defined as

$$PSNR = 10log_{10}\left(\frac{MAX_I^2}{MSE}\right) \qquad (4)$$

Where I and I' are the original and watermarked image respectively of size MXN, and MSE is known as Mean square error. And MAX_I is Maximum possible pixel value of the original image.

Structural Similarity (SSIM) index compute the quality valuation based on three terms namely the luminance, the contrast and the structural term. The overall index is a multiplicative combination of tree terms [42]

$$SSIM(x,y) = [l(x,y)]^{\alpha}.[c(x,y)]^{\beta}.[s(x,y)]^{\gamma} \qquad (5)$$

Where

$$l(x,y) = \frac{2\mu_x\mu_y + c_1}{\mu_x^2 + \mu_y^2 + c_1} \qquad (6)$$

$$c(x,y) = \frac{2\sigma_x\sigma_y + c_2}{\sigma_x^2 + \sigma_y^2 + c_2} \qquad (7)$$

$$s(x,y) = \frac{\sigma_{xy} + c_3}{\sigma_x\sigma_y + c_3} \qquad (8)$$

Where μ_x, μ_y, σ_x,σ_y, and σ_{xy} are the local means, standard deviations, and cross-covariance for images x, y. If $\alpha = \beta = \gamma = 1$ (the default for Exponents), and $C_3 = C_2/2$ (default selection of C_3) the index simplifies to:

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \qquad (9)$$

The test image and watermarked used are shown in the figure below:

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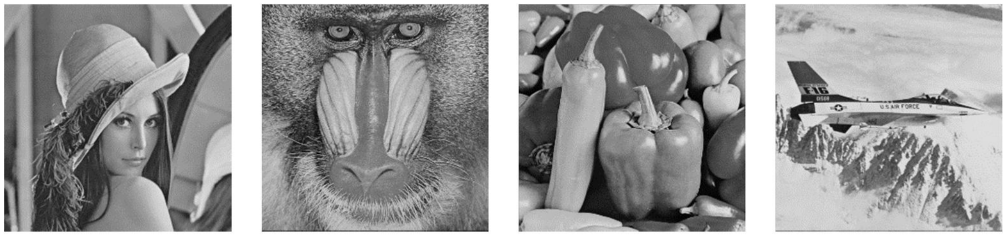

Figure 1: Cover Images used.

Figure 2: Binary Watermark Image used

We set the embedding factor α to 0.15 and embedded the watermark of different size into this cover images. The watermarked image are shown in the figure below:

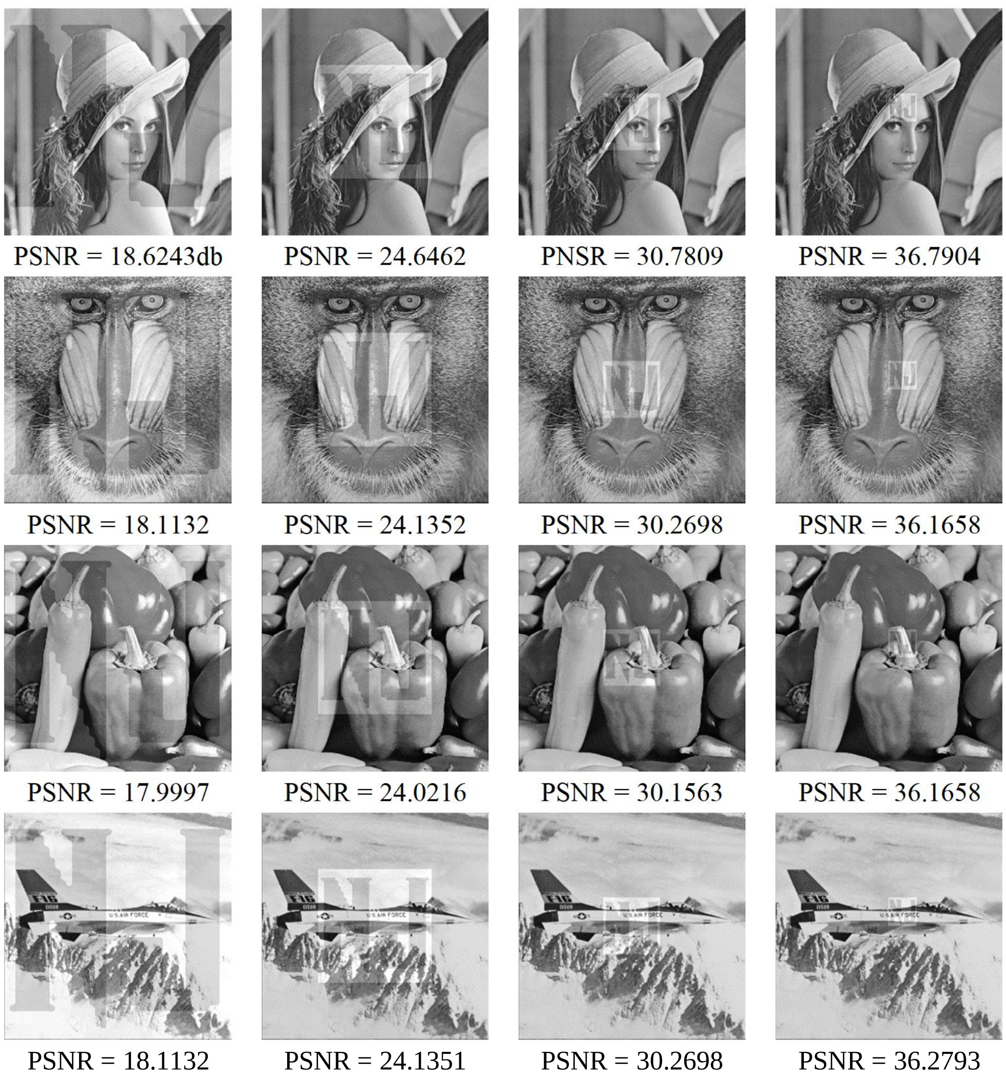

Figure 3: host Images after insertion of visible watermark which is of different size

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We got an average PSNR of 27.71045 db, 27.171 db, 27.08585 db and 27.19935 db for Lena, Baboon, Pepper, and Jet cover image respectively after the insertion of watermark.

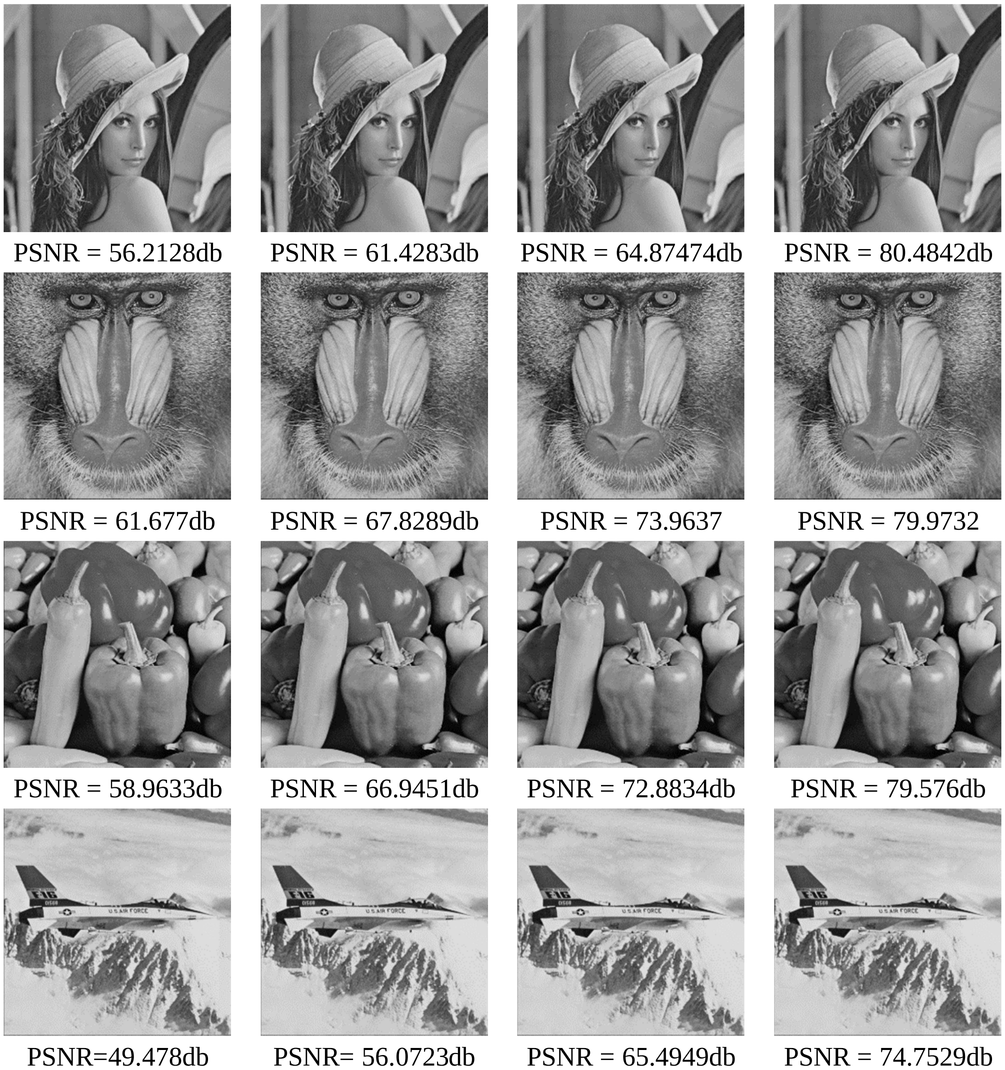

Figure 4: Recovered image and their corresponding PSNR value

Figure above shows the results of original image after the removal of watermark. We can see that, recovery process has no loss of information while retrieving the cover image. The PSNR value of the reconstructed image is also shown.

We use Structural similarity index to validate the originality of the recover watermark. The SSIM value of both the watermarked image and recovered image is shown in the table below.

Table II: SSIM value of the watermarked image and Recovered cover image.

Image Name	Watermark size	SSIM(Watermarked Image)	SSIM(Recovered image)
Lena	512X512	0.9302	0.9998
Lena	256X256	0.9678	1
Lena	128X128	0.9857	1
Lena	64X64	0.9933	1
Baboon	512X512	0.9567	1
Baboon	256X256	0.9745	1
Baboon	128X128	0.9848	1

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Baboon	64X64	0.9931	1
Pepper	512X512	0.9231	0.9999
Pepper	256X256	0.9607	1
Pepper	128X128	0.9849	1
Pepper	64X64	0.9943	1
Jet	512X512	0.9456	0.9992
Jet	256X256	0.9679	0.9998
Jet	128X128	0.9874	1
Jet	64X64	0.9945	1

The SSIM value is 1 in most of the recovered image which implies that the recovered image is identical. The SSIM index is a decimal value between -1 and 1, the value 1 is only achievable in the case of two identical data.

IV. CONCLUSION

We propose a removable watermarking scheme in which a visible watermark is embedded into the cover image and it can be removed from the cover image provided some additional information. The scheme achieve all the desire condition of lossless data hiding scheme and its effectiveness then some of the scheme already proposed earlier. We also found out that the size of watermark and place of the watermark placement on the host image plays an important role for achieving a valid PSNR. This scheme can be extended to embed one or multiple small-sized watermarks into the arbitrary regions of the cover-image so that the degrees of the visibility of the cover-image as well as the difficulty of removing watermarks are increased. The proposed scheme is in preliminary stage, future work we will concentrate on the area of watermark and make a less imperceptible visible watermark which is removable using different visual masking methods.

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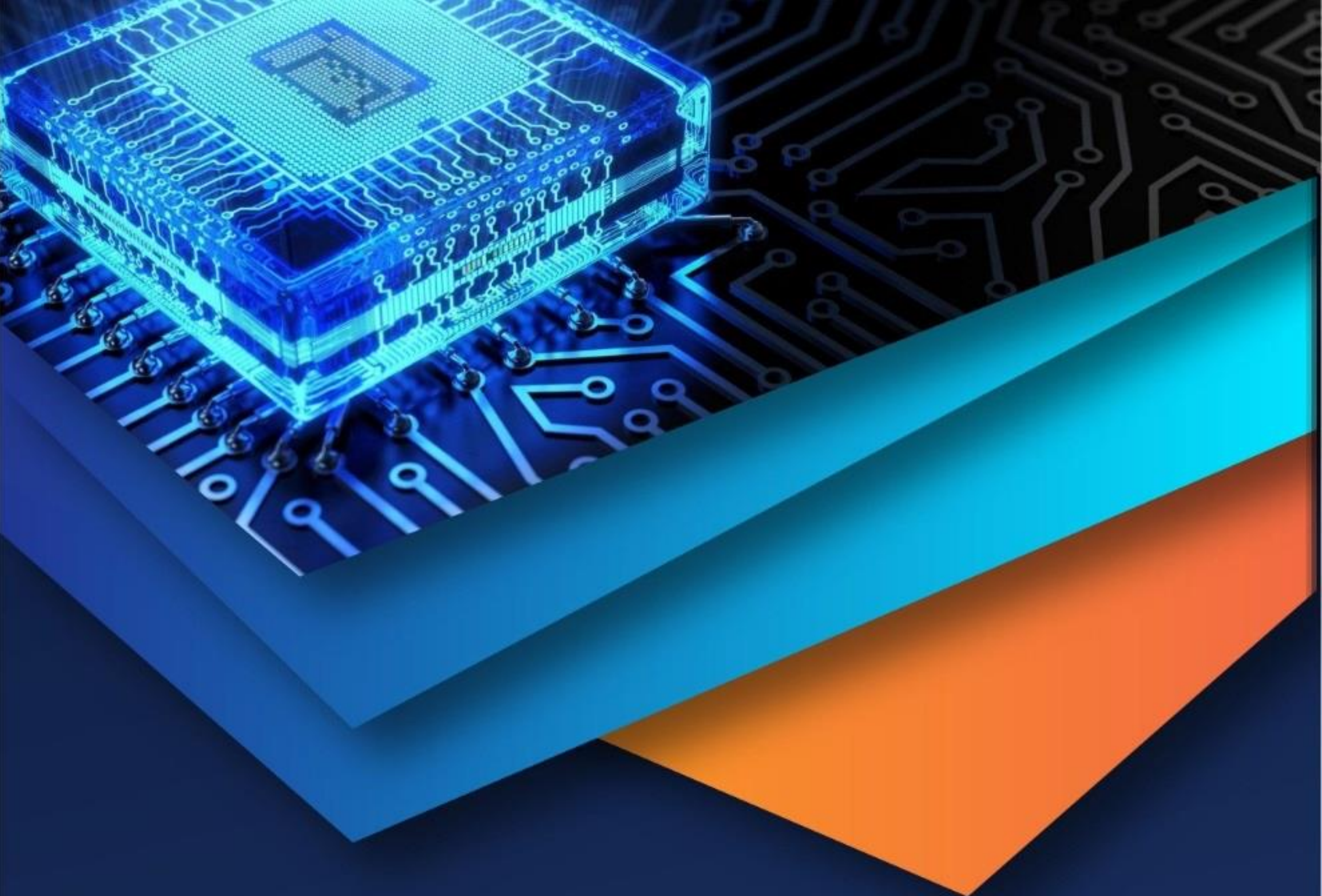

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