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A Novel Method of Digital Image Watermarking in Spatial Domain Based on Interpolation

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Abstract: Digital images are very easy to alter, store, publish and this manipulation will lead to serious problems in some applications such as military, medical. The digital documents are easily modifiable, tampered, this property makes it vulnerable to forgery. So the requirement is to produce digital images or documents that are highly unaffected to forgery and easily recoverable. Digital Image Watermarking is a method in which the embedded information cannot easily be recovered. Watermarking methods are classified into two main classes: spatial and frequency based approaches. In spatial domain techniques the watermark is embedded directly into the pixel data. In frequency domain techniques the image data is first converted to frequency domain using transforms such as DWT, DCT, or DFT. The watermark is embedded into the frequency domain coefficients and then the inverse transform is performed to restore the watermark image. This paper presents a new digital watermarking method in spatial domain based on interpolation and compare the result with frequency domain . The results presented in this paper shows that the watermark can be successfully embedded and extracted from an image, without degrading or distorting the original image.

Keywords: DCT, Digital watermarking, DWT, Interpolation, Transform domain, spatial domain.

1. INTRODUCTION

Digital watermarking is the art of hiding of information or data in documents, where the embedded information or data can be extracted to resist copyright violation or to verify the uniqueness of a document which leads to security. Protecting the digital content has become a major issue for content owners and service providers. Image watermarking can be categorized into two types based on type of domain used such as spatial and frequency domain techniques. Frequency domain techniques such as watermarking based on DWT, DCT, or DFT and spatial domain techniques such as LSB and LSB with interpolation are commonly used in recent works. Sudhanshu Suhas Gong e and Ashok A .Ghatol Proposed Combined DWT-DCT Digital Watermarking Technique Used for CTS of Bank [1]. Ki-Hyun Jung and Kee-Young Yoo [2] introduced Data hiding method using image interpolation.

1.1 METHODS OF WATERMARKING

Watermarking can be done by two methods they are spatial domain and transform domain

1.1.1 Spatial Domain Technique

In spatial domain technique, watermarking of cover image is done on the basis of pixel location. The substitution of watermark is done by different methods like LSB, LSB with interpolation. By using this technique we can embed a large watermark image with in small cover image. In this paper we are going to discuss watermarking technique in spatial domain by using interpolation technique

1.1.2. Transform Domain Technique

In this technique, Watermark is embedded into selected mid band frequency co-efficient of transformed image, and then apply the inverse transforms to get watermarked image. The general transforms that are used for watermarking are DCT, Gabor transforms, DWT, SVD, DFT etc. In this paper we are going to discuss a combination of DWT-DCT for watermarking. .

2. WATERMARKING USING COMBINED DWT-DCT TECHIQUE

In this paper, Watermarking is done by changing the selected DWT sub-band coefficients, proceeded by block based DCT on the specified sub-band. The combination of DWT and DCT can yield good results and combat the drawbacks of each other.

The Combined DWT-DCT watermarking algorithm is presented below

2.1. Watermark Embedding Algorithm based on DWT-DCT

The following steps explains the DWT-DCT embedding algorithm

Step1. Apply DWT to original image which decomposes into four sub bands; LL1, HL1, LH1, and HH1.

Step2. Once again apply DWT to HL1 to get another four sub bands LL2, HL2, LH2, and HH2.

Step3. Divide HL2 into 4*4 blocks, apply DCT to each block.

Step4. Convert the watermark image into a vector of zeros and ones.

Step5. Here we are using pn_sequence0 for embedding watermark bit 0 and pn_sequence1 for embedding watermark bit 1. Size of pn_ sequences must be equal to the size of the selected sub-band in step3.

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Step6. Whenever watermark bit is 0, add the pn_sequence0 to the selected mid band coefficient with some gain factor k.

Y=Y+K* pn_sequence0

Where Y is the selected mid-band coefficient and k is the gain factor.

Step7. Whenever watermark bit is 1, add the pn_sequence1 to the selected mid band coefficient with some gain factor k.

Y=Y+K* pn_sequence1

Where Y is the selected mid-band coefficient and k is the gain factor.

Step8. After reception at the receiver applies Inverse DCT to the modified mid-band coefficients preceded by Inverse DWT to get the watermarked image.

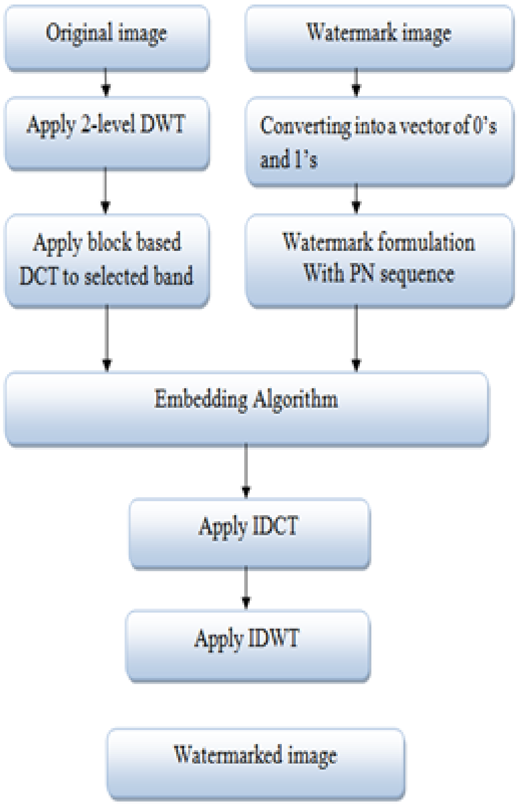

Figure 1: Watermark Embedding Algorithm

2.2. Watermark Extracting Algorithm Based on DWT-DCT

This method is a blind detection algorithm, so does not need the original image for extraction. The following steps explains DWT-DCT extraction algorithm

Step1. Select watermarked image, decompose the image into four sub bands which are non-overlapping such as LLI, LH1, HL l, and HH1on applying DWT.

Step2. Again decompose the sub-band HL l into four bands LL2, LH2, HL2, and HH2 and HL2 band is selected.

Step 3. HL2 sub-band is further divided into 4x 4 non overlapping blocks and DCT is applied to each block

Step4. Middle band frequency coefficients from each block of DCT transformed image are extracted from selected sub-division band of HL2.

Step5. The pseudorandom sequences which were used in watermark embedding process are loaded**.**

Step6. The correlation between the middle band frequency coefficients is calculated for each block in the band of HL2.

Step7. If the correlation value is greater than or equal to pn_sequence0 then the extracted bit is considered as 0 otherwise considered as 1.

Step8. Reconstruct the watermark image by using extracted watermark bits .

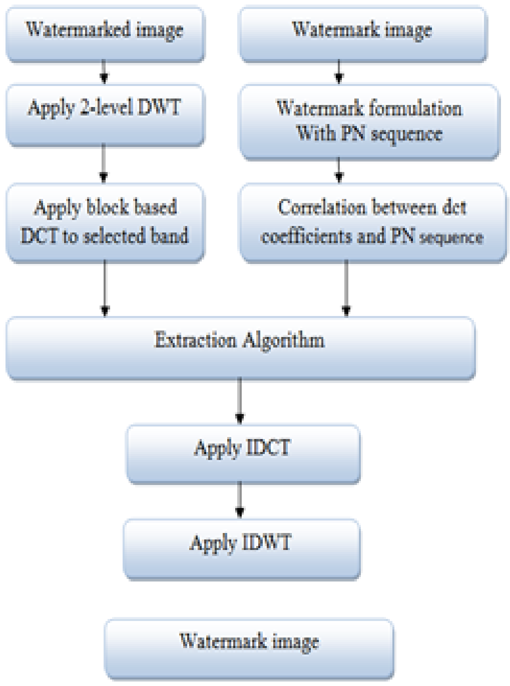

Figure 2: Watermark Extracting Algorithm

3. WATERMARKING IN SPATIAL DOMAIN BYUSING INTERPOLATION

In the transform domain technique watermark size is low compared to the cover image. In spatial domain technique by using interpolation high watermark size is embedded into low cover image.. In this paper we propose a novel method of bit stream hiding into the image using interpolation.

3.1 WATERMARK EMBEDDING PROCESS

Step1. Original image is divided into multiples of 2x2 blocks.

Step2. Each 2x2 block is converted into 3x3 blocks using interpolation.

Step3. Logarithmic values of these new elements are taken and stored in a variable. These values are used for the selection of length of watermark bits to be chosen.

Step4. Now the key should be added.

Step5. Bit stream of watermark chosen according to log values and calculate equivalent decimal values.

Step6. The decimal values of those bit streams are added with the new elements of 3x3 blocks.

Step7. This process is repeated for every 2*2 block until the watermark bits are embedded into the original image. Thus watermarked image is formed.

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Watermark embedding flow graph

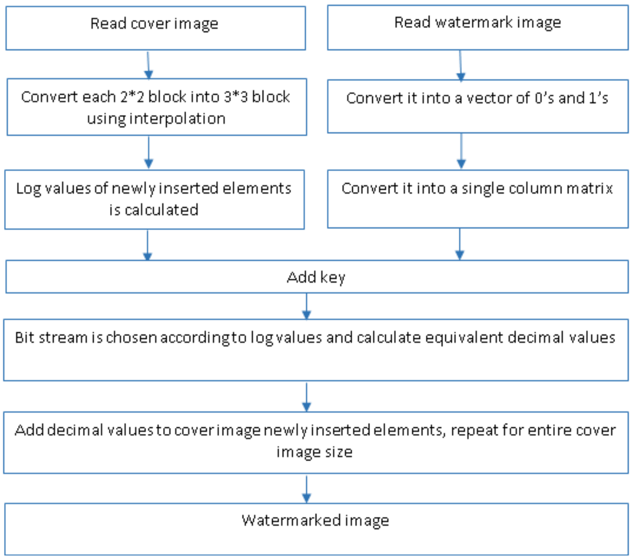

Figure 3: Watermark Embedding Algorithm

3.2 WATERMARK EXTRACTION PROCESS

Step1. Watermarked image is divided into 3*3 blocks.
Step2. Convert the original 3*3 blocks by using interpolation method.
Step3. The difference between the original 3*3 block and watermarked 3*3 blocks gives the decimal value of the watermark bit stream.
Step4. From the decimal value convert it into binary and store in a vector.
Step5. After completion of all blocks reshapes the vector to a matrix form which will give the watermark image.

Watermark extraction flow graph

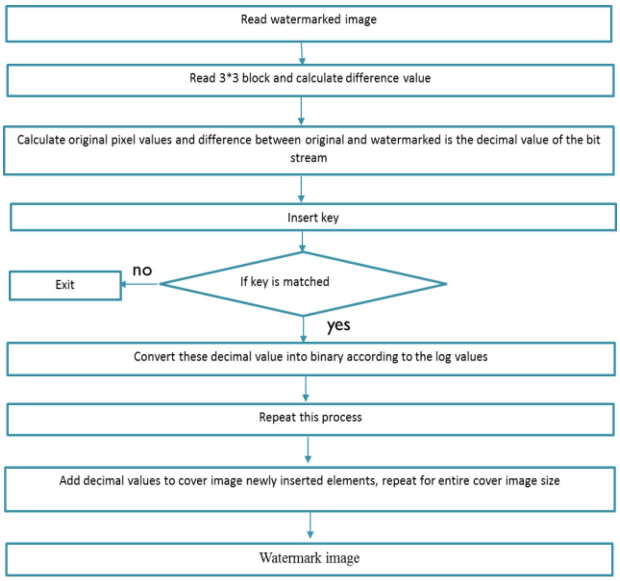

Figure 4: Watermark extraction process

4. RESULTS AND DISCUSSIONS

In DWT-DCT for 256*256 cover image only 32*32 watermark size is embedded ,which is very low .To overcome this draw back we are using spatial domain watermarking by using interpolation.

By using interpolation technique original image of size 264*264 is interpolated to a size of 396*396.
Watermark image of size 370*370 is embedded in the interpolated image (of size 396*396) of original image (of size 264*264). Here Embedded capacity is 132343.By using the extraction algorithm we can successfully recover the watermark, original image.

The simulation results obtained by implementing the proposed watermarking algorithm in spatial domain based on interpolation and compare the results with transform domain. Experiments have been carried out with various host images to evaluate the efficiency and embedded capacity of the proposed method.

Figure 5: Cover Image of size 264*264

Watermarking by interpolation

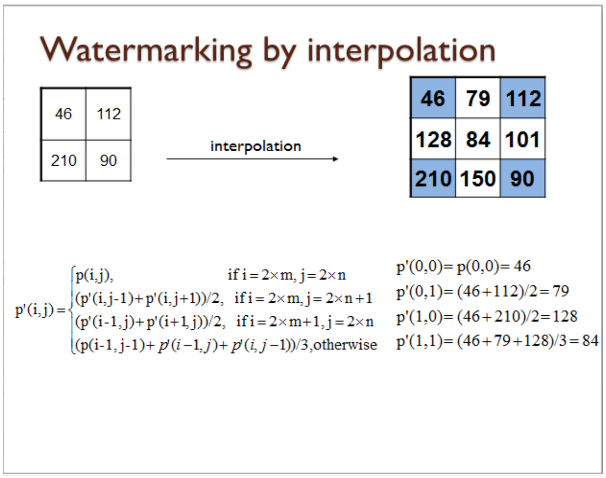

Figure 6: Interpolation process

Figure 7: Interpolated image of size 396*396

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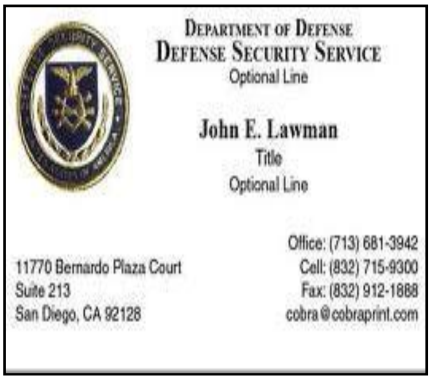

Figure 8: Original Watermark of size 370*370

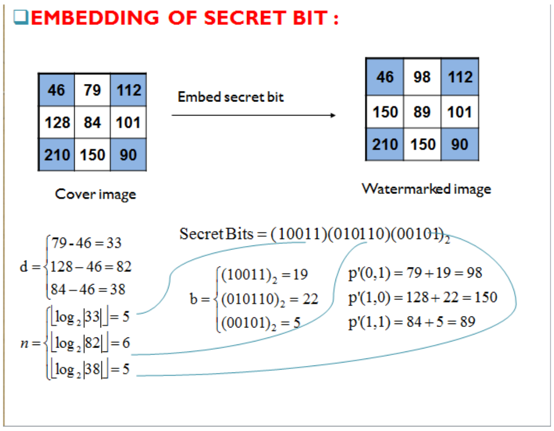

Figure 9: Embedding of Secret Bits

Figure 10: Watermarked Image

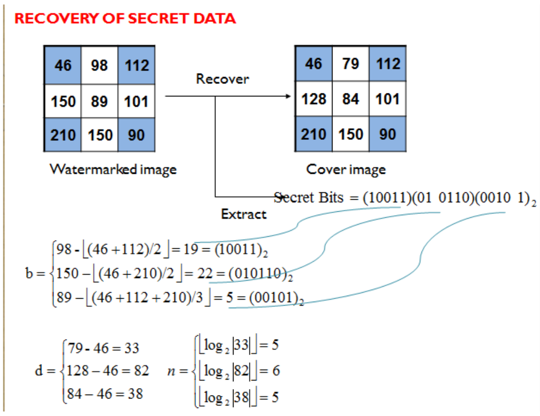

Figure 11: Recovery of secret data

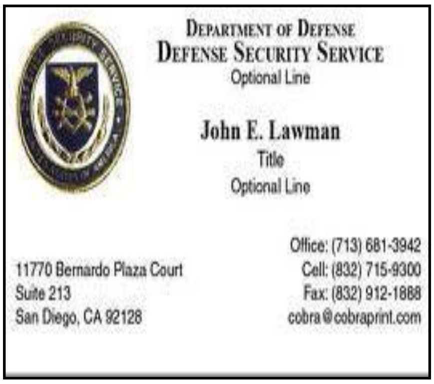

Figure 12: Recovered Watermark image

Figure 13: Recovered original image

Fig 5 is the cover image of size 264*264. Fig 6 explains the interpolation process for the cover image to convert it into a size of 396*396. Fig 7 is the interpolated image of Fig 5. Fig 8 is the watermark of size 370*370 is used in this example.

The process of introduction of key (secret message) is presented in Fig9. Fig.10 is Watermarked image. After transmission and reception of watermarked with secret key image the recovery process of original watermark begins with the recovery of secret bits as shown in Fig 11 by following algorithm presented in section 3.2 .

The recovered watermark image and cover image are shown in Fig's 12 & 13 respectively.

The performance is compared using standard parameters, namely PSNR ,SSIM, NCC, Embedded capacity. The obtained PSNR and Embedded Capacity values are higher than the combined DWT-DCT algorithm. Generally in defense or military applications, the amount of information exchanged has to be kept secret so this algorithm is best suitable in such cases.

Table 1 presents the comparison of embedding capacity, PSNR and MSC between proposed spatial domain interpolation method with that of standard existing DWT , DCT transform method. There is a limitation of watermark size in DWT- DCT whereas that limitation is not there in spatial domain interpolation method. It is seen from table 1 with cover image size say 128*128, with watermark of 8*8 the PSNR is 39.23, in DWT-DCT method.

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Parametric Evaluation

Table 1: Comparision of PSNR and Embedded Capacity in Transform and Spatial domain.

Cover image size	DWT-DCT				SPATIAL(proposed)			
	Watermark size	MSE	PSNR	Embedded Capacity	Watermark size	MSE	PSNR	Embedded Capacity
32*32	**2*2**	2.9e+003	26.46	4	**54*54**	534.80	53.60	2894
64*64	**4*4**	1.2e+003	35.32	16	**101*101**	299.33	59.32	10016
128*128	**8*8**	608.25	39.23	64	**187*187**	205.72	63.04	34856
256*256	**16*16**	336.43	46.25	256	**384*384**	136.69	67.43	124885
512*512	**32*32**	193.70	55.36	1024	**676*676**	102.98	70.26	456681

For the same cover image the watermark in spatial domain method chosen is 187*187 and corresponding PSNR is 63.04. In DWT-DCT method the maximum possible size of watermark size is 8*8 whereas in the proposed method the maximum possible watermark size is 187*187 for the same cover image of 128*128. There is an improvement of embedding capacity by 546 times.

Table 2: For same original image size but different watermark sizes.

COVER IMAGE SIZE	WATERMARK SIZE	MSE	PSNR	SSIM	NCC
264*264	370*370	0.0011	68.3252	0.9501	0.99
264*264	380*380	0.0020	62.278	0.9998	0.9897
264*264	400*400	0.0085	47.647	0.994	0.9552
264*264	500*500	0.0390	32.454	0.9971	0.7806

Table 2 presents along with PSNR, SSIM and NCC for the same cover image with different watermark images. As the watermark image size increases PSNR is reducing and SSIM and NCC is almost same. As the watermark size increases gradually, after certain watermark size PSNR value started to decrease. So the watermark image size to be embedded depends on Embedded Capacity.

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Table 3: For same original but different watermark images with same size.

Input name	Watermark name	MSE	PSNR	NCC	SSIM	Embedded capacity	type
Flowers	Defense1	131.6345	67.7197	1	1	132343	jpeg
Flowers	Defense2	134.6382	67.4941	1	1	132343	png
Flowers	Defense3	132.4946	67.6546	0.9943	0.999	132343	jpeg
Flowers	Defense4	137.4256	67.2892	0.9564	1	132343	jpeg
Flowers	Defense5	118.4105	68.7784	0.9969	0.999	132343	jpeg
Flowers	Defense6	130.6767	67.7927	1	1	132343	png
Flowers	Defense7	123.9011	68.3252	0.9501	0.999	132343	png

Table 3 shows the different watermark images of defense 1 to defense 7. With same cover image, there is no much change in PSNR, NCC and SSIM. Also we find that the embedded capacity remains same for different watermark images of same size. This indicates that for different watermark images of same size there is no effect on PSNR

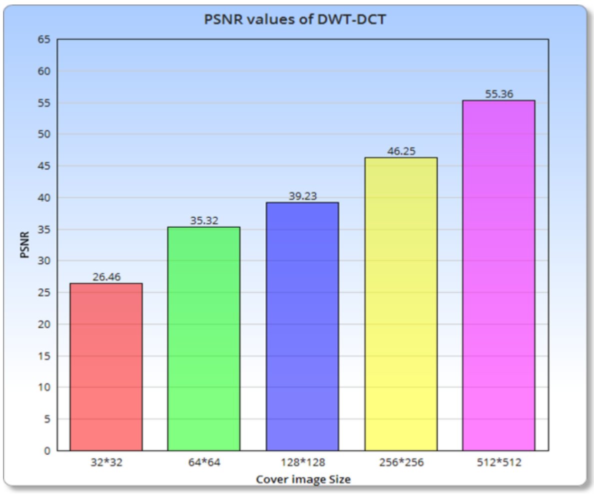

Figure 14: PSNR verses cover image of different sizes in DWT-DCT method

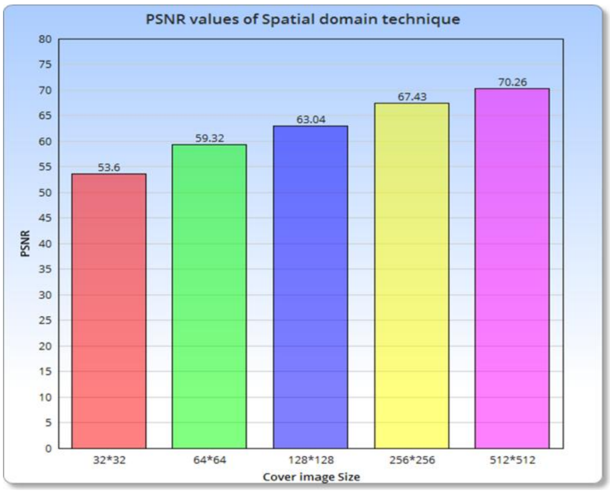

Figure 15: PSNR verses cover image of different sizes in proposed spatial domain interpolation method.

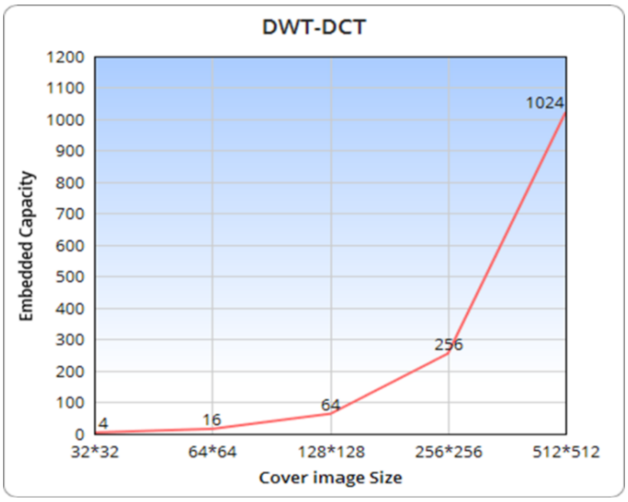

Figure 16: Embedded capacity verses cover image of different sizes in DWT-DCT method.

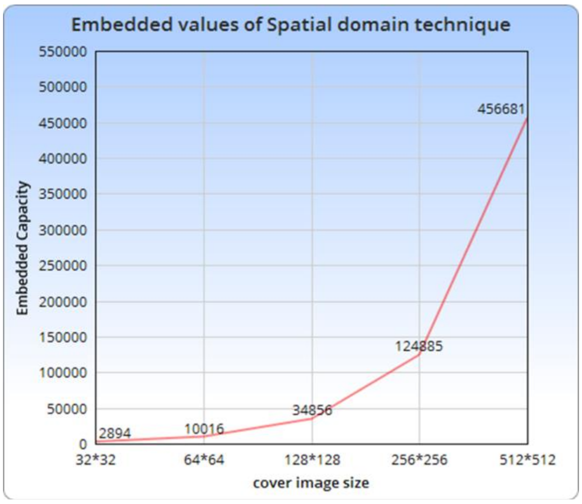

Figure 17: Embedded capacity verses cover image of different sizes in proposed spatial domain interpolation method.

The graphical representation of PSNR with respect to different sizes of cover images is presented in Fig. 14 & 15 for both DWT-DCT method and proposed method. It clearly shows that proposed method is superior. The embedded capacity is depicted graphically for both methods with respect to cover image sizes as shown in Fig. 16 & 17

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5. CONCLUSION

The proposed method which is based on spatial domain using interpolation has been studied and compared the results with transform domain method.. From table 1 it is clear that the spatial domain method successfully embeds bigger size watermark image into smaller size cover image. From Table 2 as the watermark size increases gradually, after certain watermark size PSNR value started to decrease. So it states that the high watermark image has some limitations on size beyond some particular value.

Table 3 explains the performance parameters for different watermark images, this method is independent of watermark image data, and thus we can prove that though the watermark image is changing the PSNR value obtained is same. The obtained PSNR and SSIM value shows that the extracted watermark is same as input watermark. Generally in defense applications the amount of information exchanged has to be kept secret so this algorithm is best suitable in such cases.

The proposed method clearly demonstrates that the size of watermark with respect to cover image is not on obstacle. Hence large amount of information can be transmitted with encryption especially for defense applications.

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BIOGRAPHIES

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