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Analysis of Varying Least Significant Bits DCT and Spatial Domain Stegnography

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Abstract- Stegnography is a historical technique adopted for data security. Various techniques has been developed and adopted for the implementation of Stegnography. This paper focuses on Stegnography in DCT domain. It presents the statistical analysis of hiding capacity, the qualitative metrics used for the analysis of stego image for **different combinations of least** significant bits replacement, in DCT domain as well as Spatial domain are MSE, SNR and PSNR. Healthier results of MSE, SNR, PSNR and Stego image are observed with significant data hiding capacity achieved. A comparative analysis of spatial domain and DCT domain Stegnography is also made proving DCT a better domain for Stegnography practices at same hiding capacity level.

Keywords: Image Stegnography, DCT Stegnography, *Image Processing, Information Security, LSB, VLSB*

1. INTRODUCTION

Stegnography is a method of secure data exchange between the trusted end users. The information is hidden in a cover file i.e. audio, video, image, in such a mechanism that any unintended party is unaware of the existence of information in cover file. Both spatial and transform domain are used to implement Stegnography. Techniques like least significant bits (LSB) Stegnography, 4LSB Stegnography and VLSB Stegnography were adopted for implementing Stegnography in spatial domain (Raja, *et al.,* 2005), (Khan, *et al.,* 2013). (Walia, *et al.,* 2010). The VLSB proved to be the most power full one among the spatial domain Stegnography techniques (Khan, *et al.,* 2013).

Stegnography is also implemented in transform domain using Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (Raja, *et al.,* 2005), (Bhattacharyya, *et al.,* 2010). Song, *et al.,* 2012). e.g. concealing encrypted message using DCT domain (Chhikara, *et al.,* 2012) data hiding in image in DWT domain, using pixel position method (PPM) (Bhattacharyya, *et al.,* 2010) and adaptive DCT based mode 4 Stegnography (Qi, *et al.,* 2005), All these implemented techniques of transform domain basically hide the permanent data in the LSB of the transform coefficient.

The main objective of this paper is to use the variable least significant bits (VLSB) of DCT coefficients for data hiding and the net effect has been find out on stego image for which Signal-to-noise ratio (SNR), peak signal-to-noise ratio (PSNR) and mean square error (MSE), of various number of LSB used for hiding of data. At the end a comparison of various numbers of least significant bits replacement in this approach is done with various number of least significant bits substitution in the spatial domain.

2. QUALITY MEASURING PARAMETERS

The analysis of stego image is done by both qualitatively via observation and quantitatively via the numerical values of MSE, PSNR and SNR. Hiding capacity and key size for each combination is also calculated to measure the strength of the algorithm. Following are the expressions for calculating **the MSE, SNR and PSNR** (Gonzalez, *et al.,* 2002). Khayam, 2003)

$$MSE = \frac{1}{R*C}\sum_{i=1}^{R}\sum_{j=1}^{C}\left[Cov(i,j) - Stego(i,j))\right]^2$$

$$SNR = 10*\log_{10}\left[\frac{\sum_{i=1}^{R}\sum_{j=1}^{C}\left[Cov(i,j)\right]^2}{\sum_{i=1}^{R}\sum_{j=1}^{C}\left[Cov(i,j) - Stego(I,j)\right]^2}\right]$$

$$PSNR = 10*\log_{10}\left[\frac{255^2}{MSE}\right]$$

3. IMPLEMENTATION

To hide the data in the least significant bits of DCT coefficients, first the Discrete Cosine Transform is applied on the image and the DCT coefficient are

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calculated. In this context the cover image pixels are divided in blocks [Pij] of pixels i.e. size of 8×8 blocks 14 and DCT has been applied on that block and corresponding block [Dij] of DCT coefficients is obtained. **(Fig.1).**

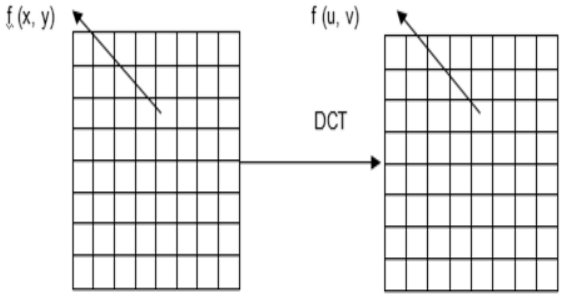

Figure 1: Obtained DCT co-efficient from Image pixels

A substitution mechanism is used for hiding the data in the coefficients after the calculation of DCT coefficients. In this mechanism, In the least significant bit of every coefficient of DCT, a data is hidden in it. After the completion of data hiding procedure the inverse DCT is obtained from the customized coefficients in order to acquire Stego Image. The entire course of action is explained via block diagram given in **(Fig.2).**

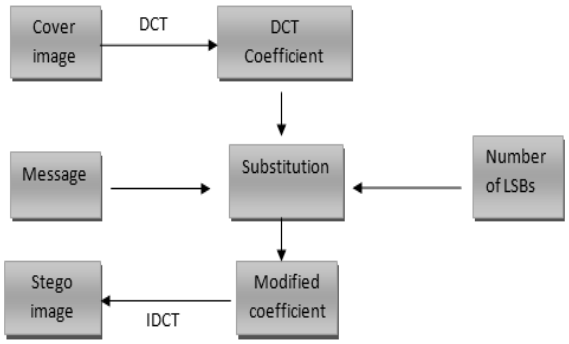

Figure 2: DCT Stegnography Mechanism

4. RESULTS OF DCT DOMAIN

For the implementation of stegnography in DCT domain, data hiding is done in the LSB of DCT coefficients of the cover image shown below in fig. 3. Data is hidden in 1 LSB (i.e. 1st LSB), 2 LSBs (i.e. 1st and 2nd LSB), 3 LSBs (i.e. 1st, 2nd and 3rd LSB), 4 LSBs (i.e. from 1st to 4th LSB), 5 LSBs (i.e. from 1st to 5th LSB) and so on, a stego image is acquired for each of the experimental combination of least significant bits. The Stego images of 1LSBs, 2LSBs, 3LSBs, 4LSBs and 5LSBs as given in **(Fig. 4, a, b, c, d and e),** the 6LSBs and higher combination create lots of distortion in Stego images and are not worth to shown here. Then the metrics for analysis i.e. MSE, PSNR, SNR and hiding capacity are computed for each combination as well. The results of each of the above mentioned parameter is given in **(Table 1).** The analysis of Capacity, MSE, SNR and PSNR verses no. of LSBs is given in pictorial form as shown in **(Fig. 5, 6, 7 and 8)** respectively.

Figure 3: Cover Image

Fig. 4: Stego Images of DCT Stegnography for various LSBs a) 1LSB, b) 2LSBs, c) 3LSBs, d) 4LSBs, e) 5LSBs

Table 1: Capacity, MSE, SNR & PSNR verses No. of LSB in DCT

SNO	NO of LSBs	Capacity	MSE	PSNR	SNR
1	1	12.50	0.3364	52.8625	28.7971
2	2	25.00	0.9054	48.5623	24.4969
3	3	37.50	3.1563	43.1390	19.0736
4	4	50.00	11.9074	37.3726	13.3072
5	5	62.50	26.3579	33.9217	9.8563
6	6	75.00	57.9710	30.4987	6.4333
7	7	87.50	67.3131	29.8498	5.7844
8	8	100.00	91.4440	28.5193	4.4539

The results given in table 1 shows a direct relationship of number of LSB and hiding capacity, MSE however shows inverse relationship of number of LSB with SNR and PSNR i.e. as the number of LSB increases the hiding capacity and mean square error are also increased while SNR and PSNR are decreased. There is another dramatic change in MSE occurs at 6LSBs and higher combination substitution and a significant change is observed Stego image is observed for these combinations.

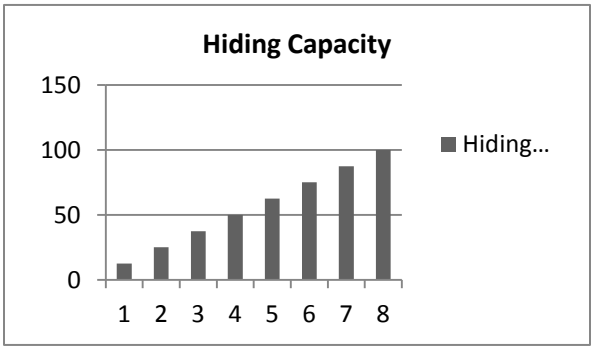

Fig. 5: Hiding Capacity verses no. of LSBs in DCT Stegnography

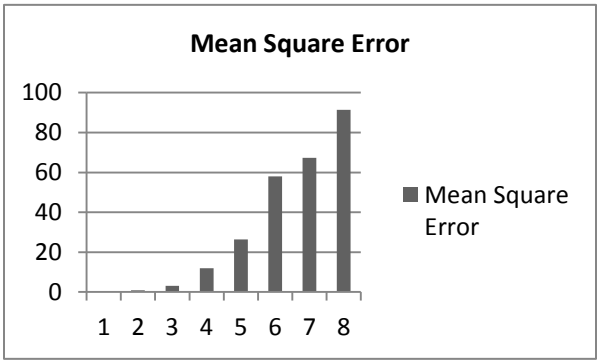

Fig. 6: Mean Square Error (MSE) verses no. of Least Significant Bits (LSBs) in DCT Stegnography

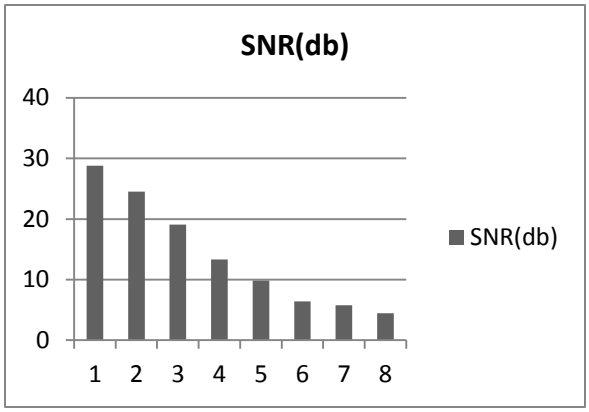

Fig. 7: SNR verses various numbers of LSBs in DCT Stegnography

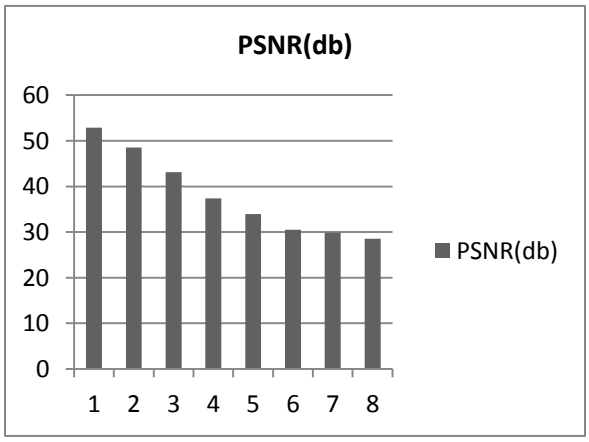

Fig. 8: PSNR verses various numbers of LSBs in DCT Stegnography

5. RESULTS OF SPATIAL DOMAIN

In order to make the comparison of Spatial domain and DCT domain stegnography the data is also hidden is cover image in spatial domain, directly targeting the least significant bits of cover images' pixels. Data is hidden in 1LSB (i.e. 1st LSB), 2LSBs (i.e. 1st and 2nd LSB), 3LSBs (i.e. 1st, 2nd and 3rd LSB), 4LSBs (i.e. 1st, 2nd, 3rd and 4th LSB) and so on and Stego image is obtained for each of the experimental combination of least significant bits. The Stego images of 1LSB, 2LSBs, 3LSBs and 4LSBs are shown in figure 9 (a, b, c and d). The rest higher combinations create significant distortion and are not shown here. Just like the calculation of MSE, SNR, PSNR and hiding capacity of DCT domain, the same qualitative measuring parameters are also computed for every combination of LSB in spatial domain as well. The values of quality measuring parameters are listed in **(Table 2)**. The analysis of Capacity, MSE, SNR and PSNR verses no. of LSBs is given in graphical form as shown in **(Fig 10, 11, 12 and 13)** respectively.

(a) (b)

(c) (d)

Fig. 9: Stego Images of spatial domain Stegnography for various LSBs a) 1LSB, b) 2LSBs, c) 3LSBs, d) 4LSBs

Table 2: Obtained capacity, MSE, PSNR, SNR of spatial domain respectively vs. Bit Position

SNO	No. f LSBs	Capacity	MSE	PSNR	SNR
1	1	12.50	0.2336	54.4456	30.3802
2	2	25.00	0.8483	48.8455	24.7801
3	3	37.50	3.2437	43.0204	18.9550
4	4	50.00	13.2054	36.9233	12.8579
5	5	62.50	46.0658	31.4970	7.4316
6	6	75.00	80.9797	29.0470	4.9816
7	7	87.50	87.8704	28.6924	4.6270
8	8	100.00	107.2062	27.8286	3.7632

The spatial domain results also shows the same trend of increase in hiding capacity and MSE and decrease in SNR and PSNR but in spatial domain the error is much larger than DCT domain results for 5LSBs and higher. In DCT domain 26.36 db and 47.97 db mean square error (MSE) is observed for 5LSBs and 6LSBsa respectively while in spatial domain 46.06 db MSE is observed for 5LSBs which is almost equal to 6LSBs MSE in DCT domain. So the spatial domain Stegnography creates more distortion and error than DCT Stegnography for the hiding data.

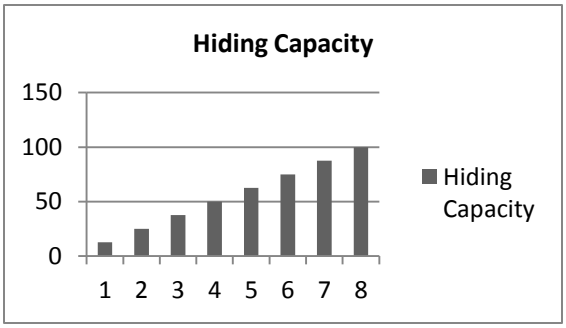

Fig. 10: Hiding Capacity of various LSBs in spatial domain

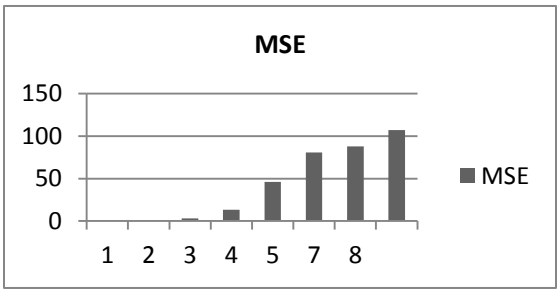

Fig. 11: MSE of various LSBs in spatial domain

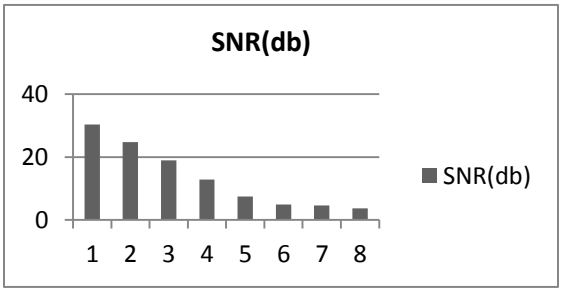

Fig. 12: SNR of various LSBs in spatial domain

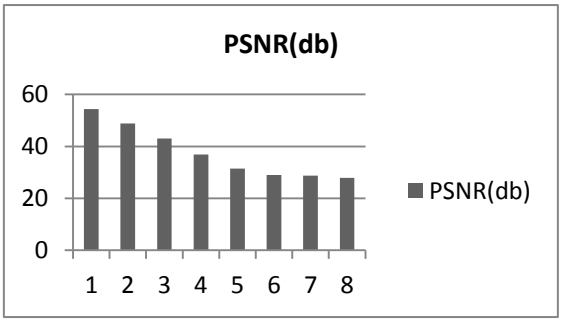

Fig. 13: PSNR of various LSBs in spatial domain

6. COMPARISON OF SPATIAL DOMAIN STEGNOGRAPHY AND DCT STEGNOGRAPHY

The analysis that is done via quality metrics of Stego images shows that the DCT Stegnography generates much fine results with less distortion rather than the spatial domain Stegnography keeping the hiding capacity constant. That can visibly be experiential by investigative.

The statistical results of MSE, SNR and PSNR shows that DCT Stegnography results much smaller MSE than Spatial domain results. For example the spatial domain Stegnography generate 46.06 db mean square error at hiding capacity of 62.5% while DCT Stegnography create 26.36 db mean square error at the same hiding capacity level which is almost 8 time less. Likewise the PSNR and SNR of DCT domain Stegnography are as well better than that of spatial domain Stegnography for the same data hiding capacity spatially at higher capacity level. The comparison of spatial domain and DCT domain stegnography has been done by using MSE, SNR and PSNR and presented mutually in **(Fig. 14, 15 and 16)** respectively.

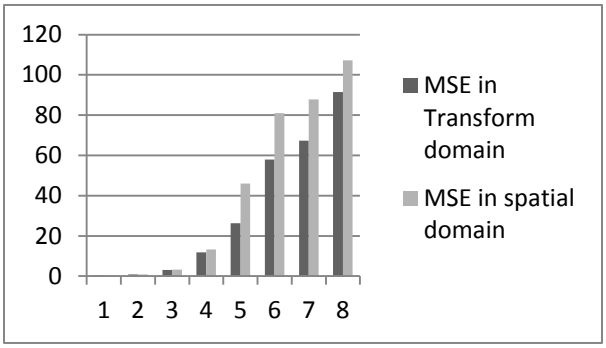

Fig. 14: Quantitative Comparison of MSE

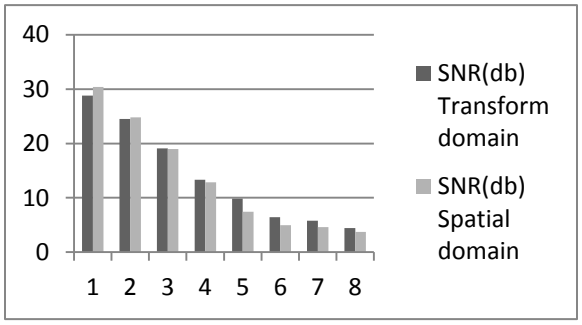

Fig. 15: Quantitative Comparison of SNR

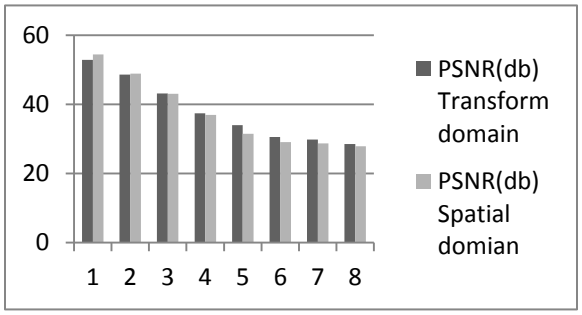

Fig. 16: Quantitative Comparison of PSNR

7. CONCLUSION

In conclusion there is a trade of between the hiding capacity and the distortion in stego image. As the hiding capacity increases the MSE increase however the PSNR and SNR decrease in both DCT and spatial domain. But DCT domain is more powerful and can be used to hide more data with less distortion in comparison with spatial domain.

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