Bit Position based Qualitative and Quantitative Analysis of DCT and Spatial Domain Stegnography

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Abstract

This paper statistically analyze the effect of each bit position on Stego Image and its contribution towards signal to noise ratio (SNR) and peak signal to noise ratio (PSNR) in Image Stegnography using Discrete Cosine Transform. To statistically analyze SNR and PSNR the information is hidden in each least significant bit position of Discrete Cosine Transform (DCT) coefficients one by one and SNR and PSNR are calculated for each bit position of DCT coefficients. A comparison with the effect of each bit position on Stego Image and its contribution towards signal to noise ratio (SNR) and peak signal to noise ratio (PSNR) of Spatial domain Image Stegnography is also made and presented.

Keywords: *Stegnography, Steganalysis, Discrete Cosine Transform.*

1. Introduction

Stegnography is a technique of hidden and secrete writing, the information are hidden in cover media (text, audio, image, video) in both spatial (LSB, VLSB) [1, 2, 3] and transform (DCT, DWT) domain [1]. In spatial domain LSB and VLSB [3, 4] are the most fashionable methods of Stegnography [5]. In transform domain Stegnography has been implemented using Discrete Wavelet Transform (DWT) [6] and Discrete Cosine Transform (DCT) e.g. adaptive DCT based mode 4 Stegnography [8], pseudo-code algorithm [6] and compression [7].

In all previously implemented techniques a specific region/coefficients of the DCT are targeted and data/information are hidden in the least significant bits of specific DCT coefficients. This paper specifically deals with LSB Stegnography using DCT. The main aim of this paper is to find and analyze the effect and contribution of each bit position on SNR and PSNR of Stego image in DCT domain and also to make a comparison with the effect and contribution of each bit position on SNR and PSNR of Stego image in spatial domain.

2. Data Hiding in DCT Domain

In Discrete Cosine Image data is divided into square blocks e.g. 8×8 of pixels and is transformed to a block of same size of DCT coefficients by using the expression given below [13].

$$f(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{M-1} F(x,y)\cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)v\pi}{2M}\right]$$

A block/matrix of DCT coefficient [dij] is obtained for a block of pixels [bij] as shown in figure 1. The data/information that needed to hidden is embedded in these DCT coefficients [dij] by rewriting DCT coefficients using substation mechanism [9, 10].

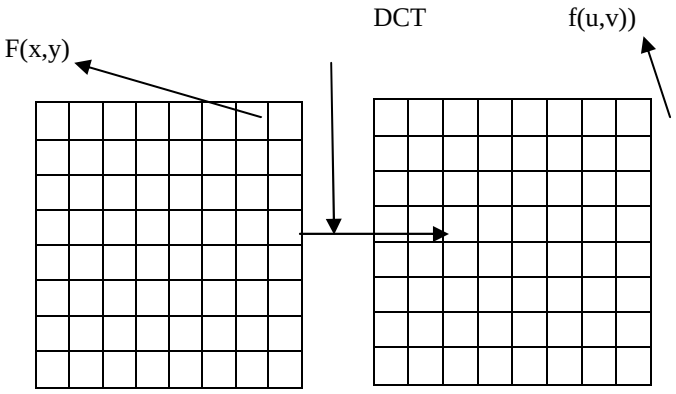


Fig. 1: Image Pixels conversion to DCT coefficient

To make the bit position wise analysis of SNR and PSNR of Stegnography in DCT the information is hidden in 1st, 2nd position and so on.

To implement Stegnography using Discrete Cosine Transform, the cover image, as shown in figure 3(a), is

converted in from spatial domain to transform domain by applying DCT. An array of DCT coefficients of same size as that of cover image is obtained. The data is hidden in a specific bit (1st, 2nd…so on) of each DCT coefficient using substitution process. To get Stego image, after hiding the data/information, the inverse DCT of the modified coefficient is taken. The whole process is given in figure 2.

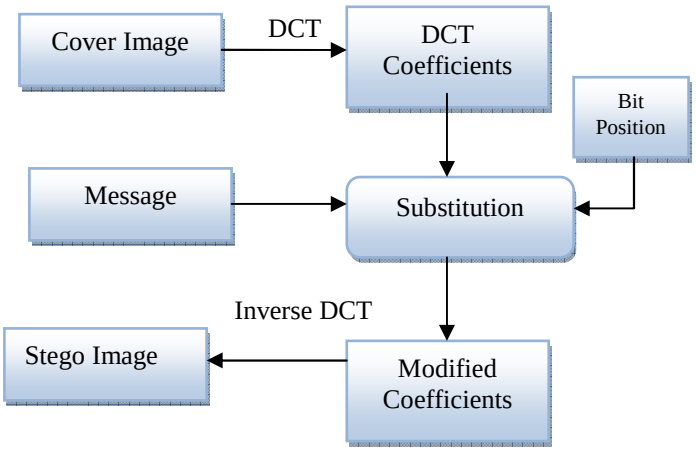
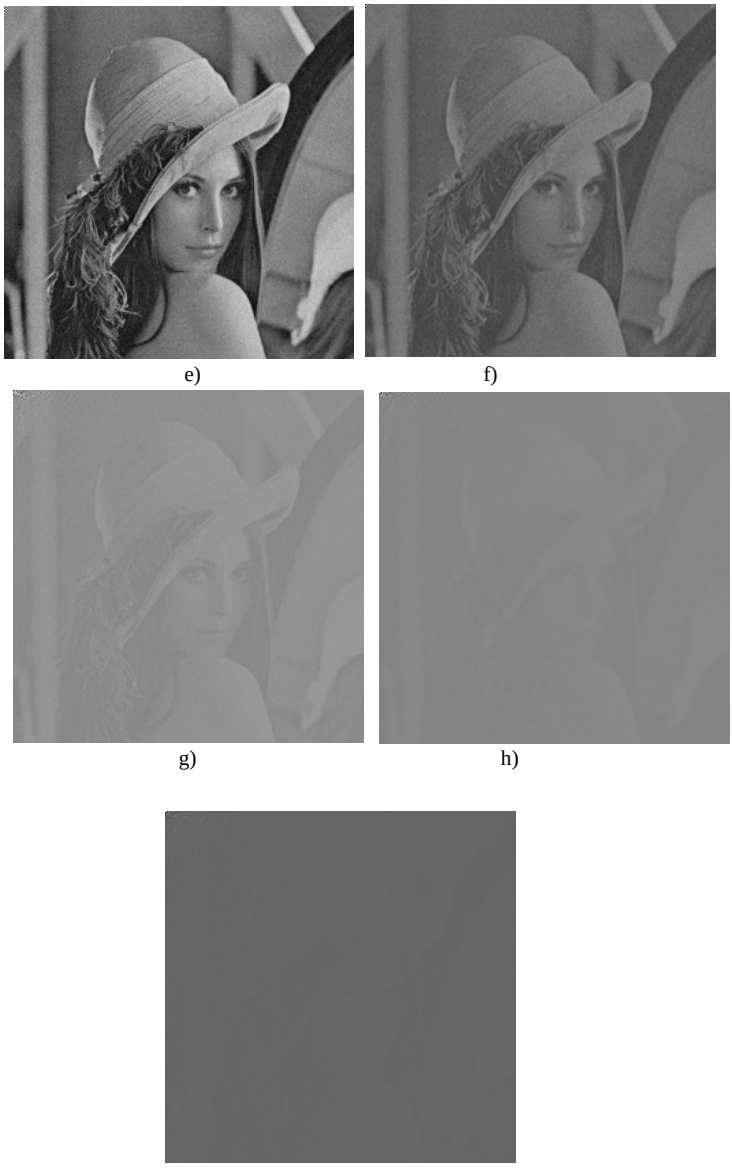


Figure 2: Block diagram of Position wise DCT Stegnography

The Stego images are obtained for 1st bit position, 2nd bit position and so on. And the results are analyzed both qualitatively and quantitatively. The qualitative analysis is made directly by observing the cover image and the Stego images as shown in figure 3 (a, b, c, e, f, g, h and i).

a) b)

c) d)



e) f) g) h)

i)

Fig. 3: Stego Images of DCT Stegnography for specific bit position; a) Cover Image, b) 1st Bit position c) 2nd Bit position d) 3rd Bit position) e) 4th Bit position f) 5th Bit position g) 6th Bit position h) 7th Bit position i) 8th Bit position

While the quantitative analysis is made by calculating signal to noise ratio (SNR) given in expression (2) [3, 4, 11] and peak signal to noise ratio (PSNR) given in expression (3) [3, 4, 11] of the Stego images for each bit position as given in table 1.

$$SNR = -10Log\left[\frac{sum((Coverimage - Stegoimage)^2}{sum((Coverimage)^2)}\right]^{-1} db \quad (2)$$

$$PSNR = -10Log\left[Mean((Coverimage - Stegoimage)^2)\right] db \quad (3)$$

And the variation in SNR and PSNR with varying bit position is presented in the graphical form in figure 4 and figure 5 respectively.

Table 1: SNR and PSNR of DCT Stegnography vs. Bit Position

S. No.	*Position*	*Capacity (%)*	*SNR(db)*	*PSNR(db)*
1	1st Bit	12.5002	28.8482	4.7828
2	2nd Bit	12.5002	23.7195	-0.3459
3	3rd Bit	12.5002	17.9933	-6.0721
4	4th Bit	12.5002	12.2312	-11.8342
5	5th Bit	12.5002	7.5639	-16.5015
6	6th Bit	12.5002	5.3927	-18.6727
7	7th Bit	12.5002	4.1712	-19.8942
8	8th Bit	12.5002	3.6367	-20.4287

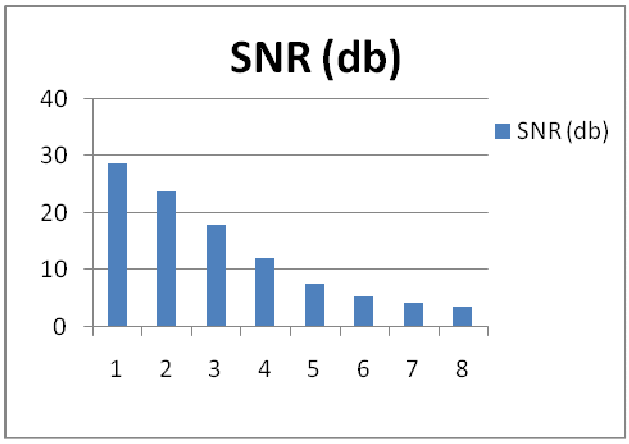


Fig. 4: SNR vs Bit Position in DCT Stegnography

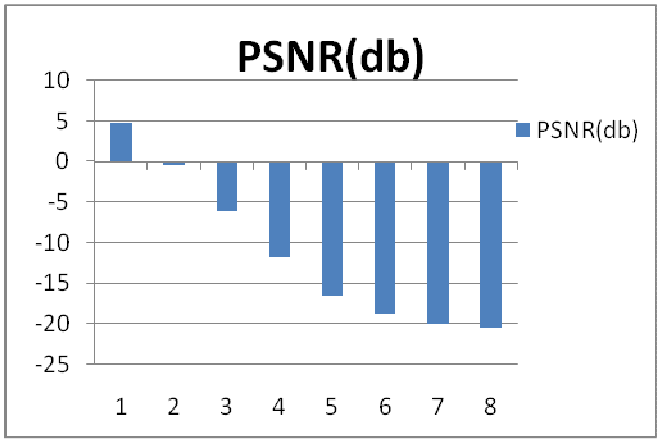


Fig. 5: PSNR vs Bit Position in DCT Stegnography

3. Stegnography in Spatial Domain

In the spatial domain information/data is hidden directly pixels of the cover image. Data is embedded in a specific bit position (1st, 2nd, and so on) in each pixel of the cover image and the Stego image is obtained for each bit position as shown in figure 6.

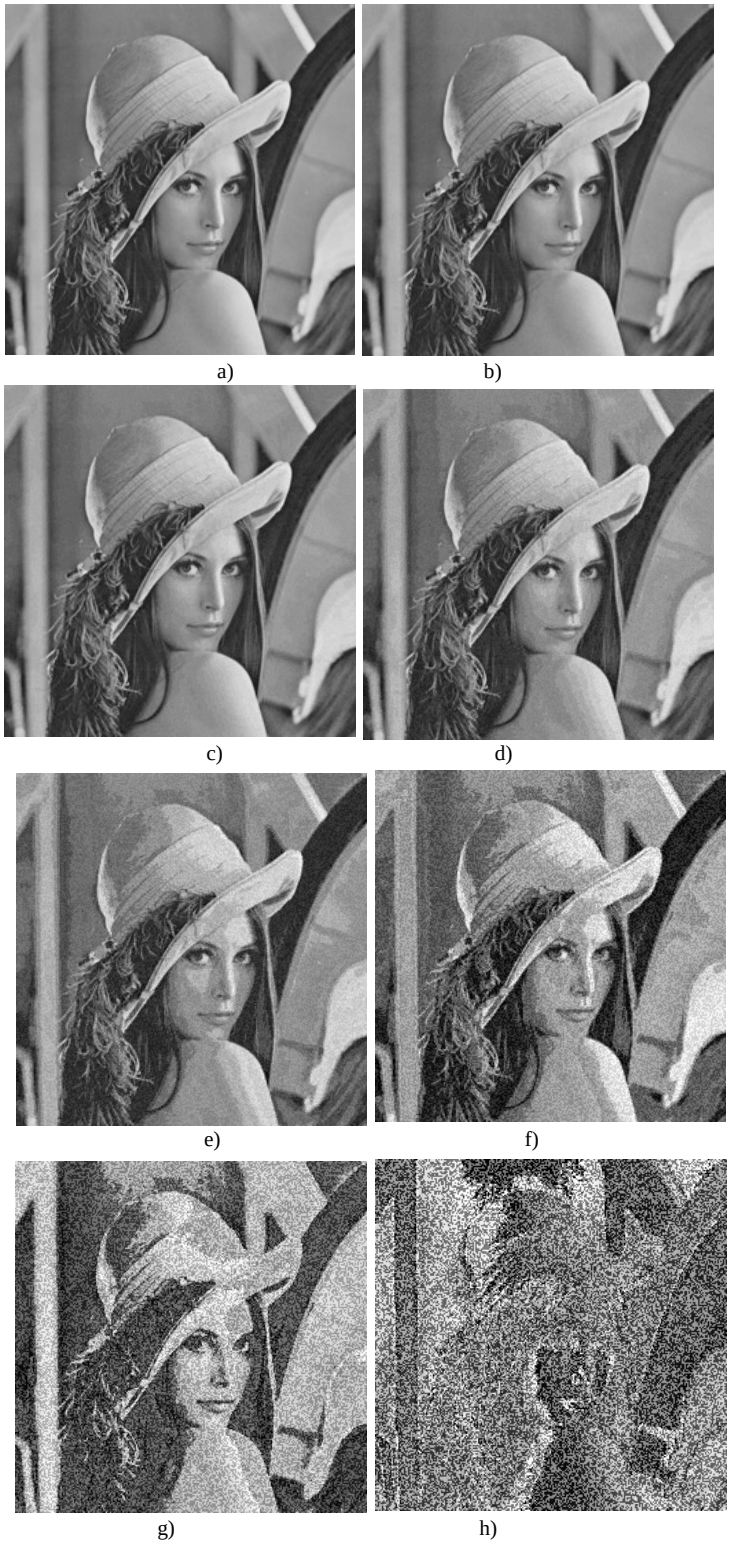


Fig. 6: Stego Images of Spatial domain Stegnography for specific bit position; a) 1st Bit position b) 2nd Bit position c) 3rd Bit position d) 4th Bit position e) 5th Bit position f) 6th Bit position g) 7th Bit position h) 8th Bit position

The qualitative analysis is made directly by observing the Stego images and the quantitative analysis is made on the basis of SNR and PSNR as given by expression 2 and 3 respectively and are given in table 2. And the variation in SNR and PSNR with varying bit position in spatial domain is presented in the graphical form in figure 7 and figure 8 respectively.

Table 2: Bit SNR and PSNR of Spatial Stegnography vs. Bit Position

S. No.	*Position*	*Capacity (%)*	*SNR(db)*	*PSNR(db)*
1	1st Bit	12.5002	30.1342	6.0688
2	2nd Bit	12.5002	24.0282	-0.0372
3	3rd Bit	12.5002	18.1205	-5.9449
4	4th Bit	12.5002	12.0878	-11.9776
5	5th Bit	12.5002	6.9984	-17.0670
6	6th Bit	12.5002	6.7729	-18.0527
7	7th Bit	12.5002	6.0127	-18.0925
8	8th Bit	12.5002	5.9413	-18.1241

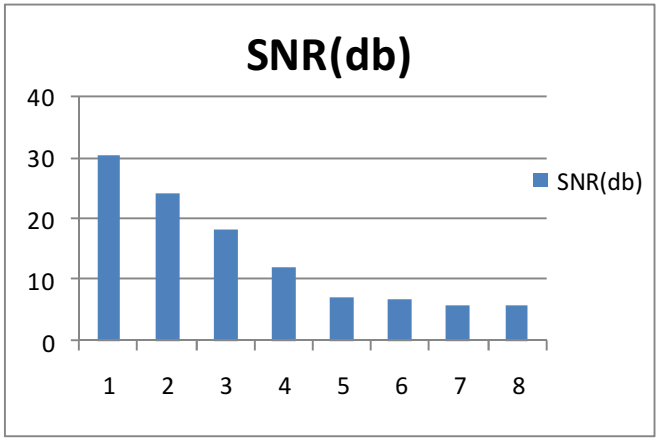


Fig. 7: SNR vs Bit Position in Spatial domain Stegnography

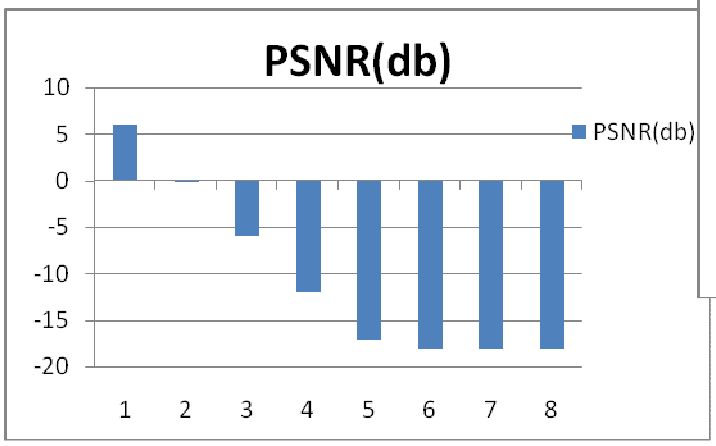


Fig. 8: PSNR vs Bit Position in Spatial domain Stegnography

4. Comparison of DCT and Spatial Domain Stegnography

The quantitative analysis of SNR and PSNR of both DCT and Spatial domain shows that the mentioned parameters decrease with increasing bit position but the SNR and PSNR of Spatial is higher than that of DCT for the same bit position as shown in figure 9 and figure 10. But as the Stegnography more concern with the visibility of distortion in the Stego image so the qualitative analysis is more important than quantitative, because more the information are unperceivable much better the technique used is. The qualitative analysis of Stego images of both DCT domain and Spatial domain Stegnography shows the visible distortion in the Stego image increase with increasing bit position but the distortion is DCT domain is less severe than the spatial domain for the same bit position. In DCT domain the contrast of the Stego image is affected and in spatial domain the distortion appears in the form of noise. The distortion in DCT domain insignificant up to 4th bit position and the distortion become significant for 5th and higher bit position substitution in DCT coefficients while in Spatial domain there is significant distortion for 4th and higher bit position substitution image pixels.

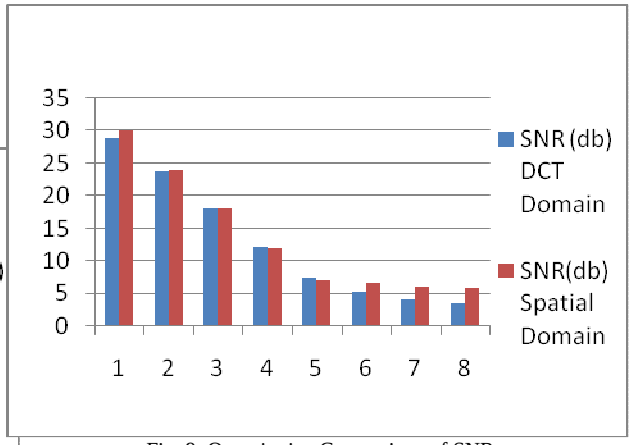


Fig. 9: Quantitative Comparison of SNR

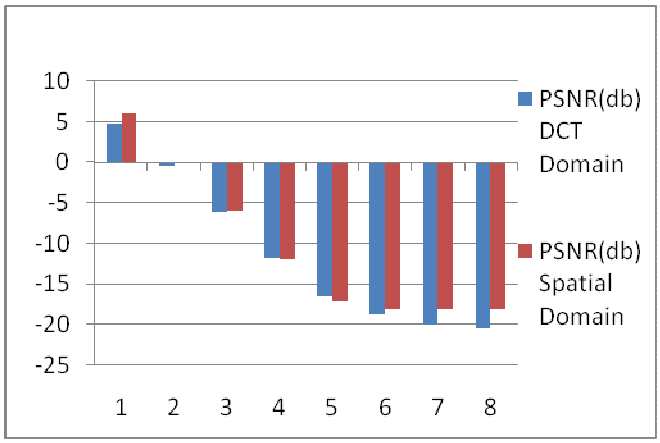


Fig. 10: Quantitative Comparison of PSNR

5. Conclusions

The Analyzing the qualitative and quantitative results of spatial domain and DCT domain results it has been observed that the SNR and PSNR decreases with increasing bit position in both domains and the Stego image become distorted correspondingly. In DCT the contrast of Stego image decreases while in spatial domain the distortion appear in the form of noise in the Stego image. The DCT produces a better quality results as compared to spatial domain for the same bit position.

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