Steganography

Name: Suvajit Roy
College, Department Name: RCCIIT CSE
Email-id: suvajitroy60@gmail.com

Name: Swayamdeepto Paul
College, Department Name: RCCIIT CSE
Email-id: pswayamdeepta1@gmail.com

Name: Gunjan Nandy
College, Department Name: RCCIIT CSE
Email-id: gunjan.nandy1@gmail.com

Abstract — this paper introduces an algorithm of digital watermarking based on Least Significant Bit (LSB), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). According to the characters of human vision, in this algorithm, the information of digital watermarking which has been discrete Cosine transformed, is put into the high frequency band of the image which has been wavelet transformed. Then distills the digital watermarking with the help of the original image and the watermarking image. The simulation results show that this algorithm is invisible and has good robustness for some common image processing operations.

Keywords — digital watermarking; least significant bit (LSB), discrete cosine transform (DCT); discrete wavelet transform (DWT); peak signal to noise ratio (PSNR), mean square error (MSE), high frequency band, streak block, python 3.

I. INTRODUCTION

[2] With the redundancy of the medium as image and voice, digital watermarking technology is to use the digital embedding method to hide the watermarking information into the digital products of image, visible and video. Seen form the field of signal process, the watermarking signal being embedded into carrier is as a feeble signal to add into a strong background. As long as the intensity of watermarking is lower than the contrast restriction of human visible system (HVS) or the apperceive restriction of human audio system (HAS), the watermarking signal won't be felt by HVS or HAS. With the characters and important application, digital watermarking technology has been got more and more attention. In the future the main development of digital watermarking is like this: copyright protection, pirate tracking, copying protection, image authentication, cover-up communication, classification control of digital watermarking video and so on. And the common characters of digital watermarking is: insensitivity, secrecy, robustness and insurance. According to the different partitions, watermark can be parted in different types like these: significant watermark and the insignificant; the visible and the invisible; the brittle and the steady; the spatial domain watermark and the transformed domain watermark; the blind, the semi blind and the non-blind. One another partition is carrier and there are image watermark, audio watermark, video watermark, text watermark and so on.

The current classical algorithm contains spatial domain algorithm and transformed domain algorithm. With the spatial domain algorithm, the embedding and the distilling of watermarking are finished in spatial domain, by amending directly or comparing the gray-level value or color value. The classical spatial domain algorithms including several ways as follow: the least significant bit (LSB), Patchwork method with streak block mapped coding, the method based on district intersecting and so on. Then the main current transformed domain algorithms are spread spectrum, DCT transformation method and DWT transform method.

This paper introduces an algorithm of digital watermarking based on Least Significant Bit (LSB), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). The watermarking image will be discrete Cosine transformed at first. Because these DCT modulus contain the low frequency information of watermarking image, as long as these information do not lose or lose little then the watermarking image can be renewed well. This enhance the robustness and concealment. The host image I is decomposed through DWT transform, then choose the appreciate wavelet modulus in the high frequency level. The watermarking information are embedding into the corresponding position. Make the whole image IDWT transformed and get the watermarked image I'. The watermarking distilling is quite the contrary.

[7] We have used Python 3.6.1 for making the project. We used PIL for Spatial domain transformations like LSB and OpenCV for Frequency domain transformations like DCT and DWT implementations. We are hiding text inside a carrier image and make that stego to be decoded later and get the hidden text back. We stored MSE and PSNR (db.) for LSB, DCT, DWT and stored them in an excel spreadsheet.

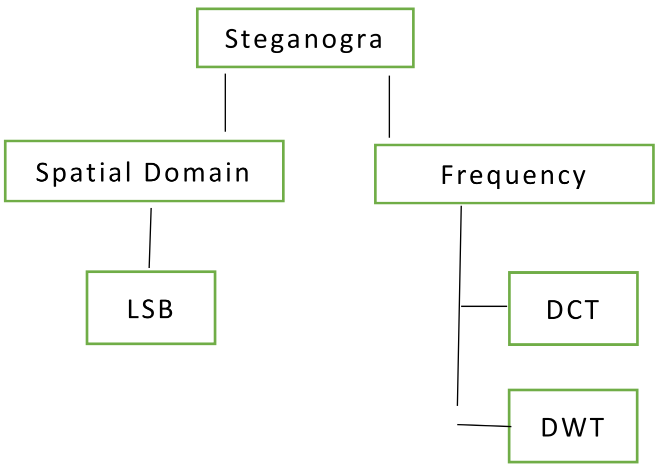

Figure: Types of Image watermarking [7]

II. LEAST SIGNIFICANT BIT TRANSFORM

[6] The least significant bit (in other words, the 8th bit) of some or all of the bytes inside an image is changed to a bit of the secret message. Digital images are mainly of three types:

i. 8 bit images

ii. 24 bit images

iii. 32 bit images

In 24 bit images we can embed three bits of information in each pixel, one in each LSB position of the three eight bit values. Increasing or decreasing the value by changing the LSB does not change the appearance of the image; much so the resultant stego image looks almost same as the cover image. In 8 bit images, one bit of information can be hidden.

The hidden image is extracted from the stego-image by applying the reverse process. If the LSB of the pixel value of cover image C(i,j) is equal to the message bit m of secret massage to be embedded, C(i,j) remain unchanged; if not, set the LSB of C(i, j) to m. The message embedding procedure is given below

S(i,j) = C(i,j) - 1, if LSB(C(i,j)) = 1 and m = 0

S(i.j) = C(i,j), if LSB(C(i,j)) = m

S(i,j) = C(i,j) + 1, if LSB(C(i,j)) = 0 and m = 1

Where LSB(C(i, j)) stands for the LSB of cover image C(i,j) and m is the next message bit to be embedded. S(i,j) is the stego image. As we already know each pixel is made up of three bytes consisting of either a 1 or a 0.

For example, suppose one can hide a message in three pixels of an image (24-bit colours). Suppose the original 3 pixels are:

(11101010 11101000 11001011)

(01100110 11001010 11101000)

(11001001 00100101 11101001)

A steganographic program could hide the letter "J" which has a position 74 into ASCII character set and have a binary representation "01001010", by altering the channel bits of pixels.

(11101010 11101001 11001010)

(01100110 11001011 11101000)

(11001001 00100100 11101001)

In this case, only four bits needed to be changed to insert the character successfully. The resulting changes that are made to the least significant bits are too small to be recognized by the human eye, so the message is effectively hidden. The advantage of LSB embedding is its simplicity and many techniques use these methods. LSB embedding also allows high perceptual transparency.

III. DISCRETE COSINE TRANSFORM

[1] DCT coefficients are used for JPEG compression. It separates the image into different parts of importance. It transforms a signal or image from the spatial domain to the frequency domain. It separates the image into high, middle and low frequency components. In low frequency sub-band, much of the signal energy lies at low frequency which contains most important visual parts of the image, while in high frequency sub-band, high frequency components of the image are usually removed through compression and noise attacks. So the secret message is embedded by modifying the coefficients of the middle frequency sub-band, so that the visibility of the image is not affected.

With the character of discrete Fourier transform (DFT), discrete cosine transform (DCT) turn over the image edge to make the image transformed into the form of even function. It's one of the most common linear transformations in digital signal process technology. Two-dimensional discrete cosine transform (2D-DCT) is defined as

$$F(jk)=a(j)a(k)\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} f(mn)cos\left[\frac{(2m+1)j\pi}{2N}\right]cos\left[\frac{(2n+1)k\pi}{2N}\right] \quad (1)$$

The corresponding inverse transformation (Whether 2DIDCT) is defined as

$$f(mn)=\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} a(j)a(k)F(jk)cos\left[\frac{(2m+1)j\pi}{2N}\right]cos\left[\frac{(2n+1)k\pi}{2N}\right] \quad (2)$$

The 2D-DCT can not only concentrate the main information of original image into the smallest low frequency coefficient, but also it can cause the image blocking effect being the smallest, which can realize the good compromise between the information centralizing and the computing complication. So it obtains the wide-spreading application in the compression coding.

IV. DISCRETE WAVELET TRANSFORM

[1] Wavelet transform is a time domain localized analysis method with the window's size fixed and form convertible. There is quite good time differentiated rate in high frequency part of signals DWT transformed. Also there is quite good frequency differentiated rate in its low frequency

part. It can distill the information from signal effectively.

[3] The Haar DWT is applied in this technique. A 2-dimensional Haar DWT consists of two operations: One is the horizontal operation and the other is the vertical operation. Detailed procedures of a 2D Haar DWT are described below:

Step 1: Scan pixels from left to right in the horizontal direction. Then, perform the addition and subtraction operations on neighbouring pixels. Store the sum on the left and the difference on the right as illustrated in figure 5. Repeat this operation until all the rows are processed. The pixel sums represent the low frequency part (denoted as symbol L) while the pixel differences represent the high frequency part of the original image (denoted as symbol H).

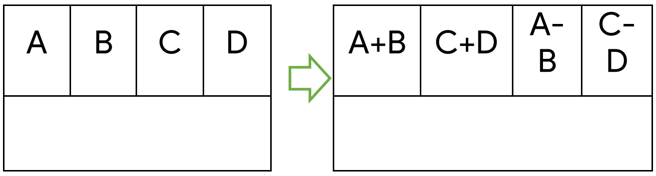

Figure: The horizontal operation on first row [3]

Step 2: Scan pixels from top to bottom in vertical direction. Perform the addition and subtraction operations on neighbouring pixels and then store the sum on the top and the difference on the bottom as illustrated in Figure 6. Repeat this operation until all the columns are processed. Finally, 4 sub-bands denoted as LL, HL, LH, and HH obtained. The LL sub-band is the low frequency portion and hence looks very similar to the original image. The whole procedure described is called the first order 2D Haar DWT.

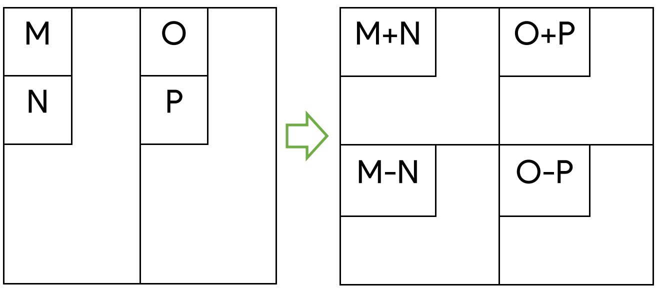

Figure: The vertical operation [3]

[1] The basic idea of discrete wavelet transform (DWT) in image process is to multi-differentiated decompose the image into sub-image of different spatial domain and independent frequency district. Then transform the coefficient of sub-image. After the original image has been DWT transformed, it is decomposed into 4 frequency districts which is one low-frequency district (LL) and three high-frequency districts (LH,HL,HH). If the information of low-frequency district is DWT transformed, the sub-level frequency district information will be obtained. A two-dimensional image after three-time DWT decomposed can be shown as Fig Where, L represents low-pass filter, H represents high-pass filter. An original image can be decomposed of frequency districts of HL1, LH1, and HH1. The low-frequency district information also can be decomposed into sub-level frequency district information of LL2, HL2, LH2 and HH2. By doing this the original image can be decomposed for n level wavelet transformation.

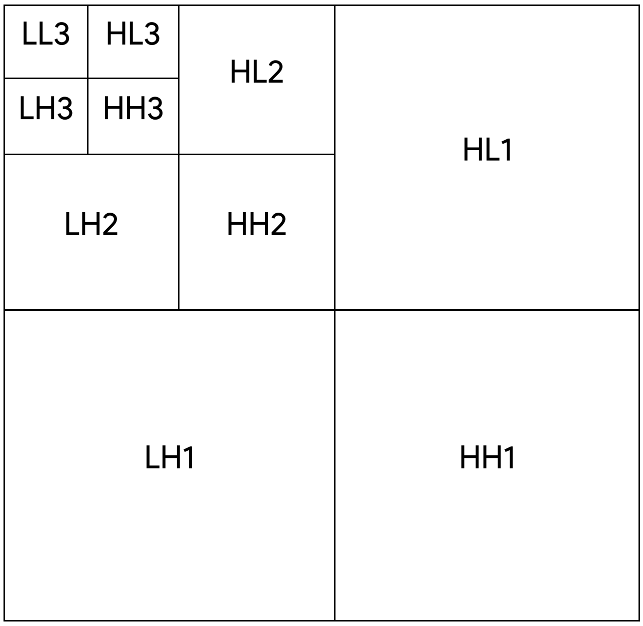

Figure: DWT transformation [1]

The information of low frequency district is an image close to the original image. Most signal information of original image is in this frequency district. The frequency districts of LH, HL and HH respectively represents the level detail, the upright detail and the diagonal detail of the original image.

According to the character of HVS, human eyes is sensitive to the change of smooth district of image, but not sensitive to the tiny change of edge, profile and streak. Therefore, it's hard to conscious that putting the watermarking signal into the big amplitude coefficient of high-frequency band of the image DWT transformed. Then it can carry more watermarking signal and has good concealing effect.

V. Error Calculation

[5]The following two error metrics are used in the performance analysis.

A. Mean Square Error (MSE):

It is defined as the square of error between cover image and the stego image. The distortion in the image can be measured using MSE.

$$MSE = \frac{1}{MN}\sum_{j=1}^{M}\sum_{k=1}^{N}(x_{j,k} - x'_{j,k})^2$$

M and N are the number of rows and column in the input image.

B. Peak Signal to Noise Ratio (PSNR):

It is the ratio of the maximum signal to noise in the stego image.

$$PSNR = 10\ log\frac{(2^n - 1)^2}{MSE}$$

$$PSNR = 10\ log\frac{(255)^2}{MSE}$$

PSNR is measured in decibels (dB). PSNR is a good measure for comparing restoration results for the same image.

VI. Performance Analysis

Method	LSB	DCT	DWT
Invisibility	Low	High	High
Payload Capacity	High	Medium	Low
Robustness	Low	Medium	High
PSNR	High	Medium	Low
MSE	Low	Medium	high

Table: Parameters Analysis of Steganography Methods [3]

[3] The watermark is embedded in the DWT and DCT domain of an image in a multi-resolution way. In the DWT domain, an original image and watermark are transformed into wavelet domain and then watermark is embedded. The DCT scheme also employs visual masking to guarantee that the embedded watermark is invisible and to maximize the robustness of the hidden data.

In the decoding phase, once the watermark is extracted from the watermarked image, certain performance measures such as peak signal to mean noise ratio (PSNR) and correlation are calculated. Different types of attacks have been applied to the watermarked image to test the robustness of the applied technique and for each case, PSNR and correlation are calculated. Even though DWT method gives better results when compared to DCT, performances of both methods are good.

Our DWT implementation is incomplete for now and we have kept it for future work. From what we have implemented till now, we can draw the tables attached below.

Our project implementation shows the result for Lenna image:

For Lenna.png	MSE	PSNR
Original vs LSB	0.168922	55.85393
Original vs DCT	1.8888	45.55556

Table: Comparison of MSE and PSNR

Above table shows the MSE and PSNR for original cover image with after LSB and DCT transformation.

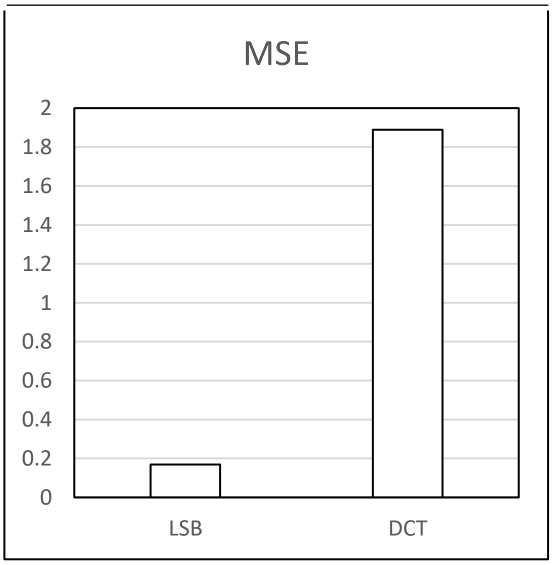

Chart: MSE comparison

The above chart shows the MSE for LSB and DCT. Mean Square Error for DCT is quite higher than LSB, but payload capacity, and robustness is greater in DCT than of LSB.

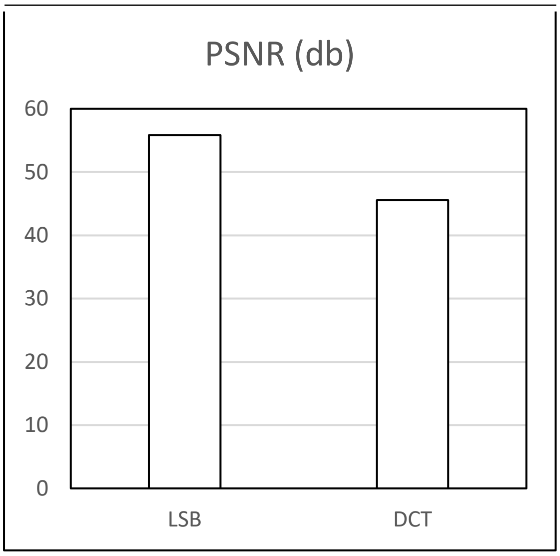

Chart: PSNR comparison

The previous chart shows the PSNR for LSB and DCT. Peak Signal to Noise Ratio for LSB is quite higher than DCT. Greater the PSNR, lesser the noise in the image. Like if we take 2 identical image and calculate MSE and PSNR, MSE becomes 0, and as PSNR is inversely proportional to MSE, the PSNR becomes infinite.

VII. Conclusion

This paper discusses in detail about the LSB, DCT, and DWT algorithms on steganography application. The LSB, DCT, and DWT algorithms are implemented for steganography application. In this experiment, performance analysis of LSB and DCT methods are successfully completed and experimental results are discussed. We have kept the DWT implementation for future work. The MSE and PSNR values are compared for the LSB and DCT algorithms. The PSNR value shows the quality of image after embedding the data. From the experiment results it is observed that the PSNR of DCT is high as compared to the other two algorithms. Thus, the experiment concludes the DCT algorithm is more suitable for the steganography application compared to the LSB and the DWT based algorithms.

Acknowledgement

Firstly, we would like to express our sincere gratitude to our advisor Associate Professor Mr. Harinandan Tunga and Technical Assistant Mrs. Priya Sen for the continuous support of our image watermarking and steganography related micro project, for their patience, motivation, access to the laboratory and research facilities and their immense knowledge. Their guidance helped us in all the time of micro project and writing of this project thesis. We could not have imagined having a better advisor and mentor for our micro project.

Without their precious support it would not be possible for us to conduct this micro project.

References

[1] Mei Jiansheng, Li Sukang and Tan Xiaomei, "A Digital Watermarking Algorithm Based On DCT and DWT" -Nanchang Institute of Technology, Nanchang, China

[2] Thottempudi Pardhu, Bhaskara Rao Perli "Digital Image Watermarking in Frequency Domain" - International Conference on Communication and Signal Processing, April 6-8, 2016, India.

[3] Saravanan Chandran, Koushik Bhattacharyya, "Performance Analysis of LSB, DCT, and DWT for Digital Watermarking Application using Steganography" - International Conference on Electrical, Electronics, Signals, Communication and Optimization (EESCO) - 2015.

[4] Gurmeet Kaurand Aarti Kochhar, "A Steganography Implementation based on LSB & DCT", "International Journal for Science and Emerging, Technologies with Latest Trends" 4(1), ISSN No. (Online):2250-3641, ISSN No. (Print): 2277-8136, 35-41 (2012).

[5] Zakir khan, "What is the PSNR ratio value for steganography image?", available at the following link: https://www.researchgate.net/post/What_is_the_PSNR_ratio_value_for_steganography_image

[6] Krasimir Kordov and Borislav Stoyanov, "Least Significant Bit Steganography using Hitzl-Zele Chaotic Map", - INTL JOURNAL OF ELECTRONICS AND TELECOMMUNICATIONS, 2017, VOL. 63, NO. 4, PP. 417–422

[7] Neivin Mathew, Robyn Rintjema and Steven Kalapos, "Comparison of Image Steganography Techniques (DCT vs LSB)" -