Performance of Digital Image Watermarking using Level-1 DWT

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Abstract: *Digital Image Watermarking is a process of embedding a hidden stream of bit in a file. The file could be an image, audio, video or text. Nowadays, digital image watermarking has many applications such as broadcast monitoring, owner identification, proof of ownership, transaction tracking, content authentication, copy control, device control, and file reconstruction. There are various method of Digital Image Watermarking such as Least Significant Bit (LSB), Singular Value Decomposition (SVD), Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and Discrete wavelet transform (DWT) techniques. In this paper Level-1 Discrete Wavelet Transform (DWT) is used for embedding and extraction of watermark. Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) are measured at different alpha blending coefficients k and q.*

Key Words: *Alpha Blending, Digital Image Watermarking, Discrete Wavelet Transform, Embedding, MSE, PSNR etc.*

1. INTRODUCTION:

A visible or invisible watermark embedded inside the cover image to show authenticity or proof of ownership. The hidden watermark should be inseparable from the cover image, robust enough to resist any manipulations while preserving the image quality. Thus through digital image watermarking, intellectual properties remains accessible while being permanently marked. This approaches use in authenticating ownership claims and protecting proprietary hidden information, discourage unauthorized copying and distribution of images over the internet and ensure a digital picture has not been altered. This paper basically focused on image decomposition using level-1 discrete wavelet transform. The performance of watermarked image and extracted watermark is calculated based on PSNR and MSE with respect to original cover image and original watermark image respectively. Digital watermarking can be basically categorized as: (1) Spatial Domain and (2) Frequency or transform domain

1.1 Spatial Domain: In spatial domain digital watermarking raw data is directly loads into the original image. In this technique watermark appears in any one of the color bands. Following are some useful spatial domain techniques:

Additive watermarking: Most straight forward method for embedding watermark is additive watermarking. In this technique pseudo random noise pattern is added to inserting of image pixels. The noise signal is usually integer or some time floating point numbers. To ensure that the watermark can be detected the noise is generated by a key.

Least Significant Bit (LSB): This is the most popular technique to embed the watermark. This is easy to implement and does not generate serious distortion to the image. It is not very robust against the attacks. The embedding of the watermark is performed by choosing the subnet of image pixel and substituting the LSB of each of the chosen pixel with watermark bits. The watermark may be spread throughout the image or may be in the select location of the image.

1.2 Frequency (Transform) Domain: Frequency domain techniques are most widely used for digital watermarking. The aim of frequency domain technique is to embed the watermark in the spectral coefficients of the image. Following are the commonly used frequency domain techniques.

Discrete Fourier Transform (DFT): DFT transform the continuous function into its frequency components. It is robust against geometric attacks like rotation, scaling, cropping etc. Fourier transforms allows analysis and processing of the signal in its frequency domain by means of analyzing and modifying the coefficients.

Discrete Cosine Transform (DCT): DCT also transform a time domain signal into its frequency domain. DCT only uses the real parts of the DFT coefficients. The JPEG compression technique utilizes this property to separate and remove insignificant high frequency components in image [12].

Discrete Wavelet Transform (DWT): DWT is modern technique frequently used in digital image processing, compression, watermarking etc. The transform is based on small waves called wavelet of varying frequency and limited duration. The wavelet transform decomposes the image into three directions i.e. horizontal, vertical and diagonal.

2. LITERATURE REVIEW:

Akhil Pratap Singh and Agya Mishra (2011) discussed that insertion and extraction of the watermark in the grayscale image is found to be simpler than other transform techniques. They explain the digital watermarking technique on digital images based on discrete wavelet transform by analyzing various values of PSNR's and MSE's.

Malika Narang and Sharda Vashisth (2013) propose the watermarking scheme based on DWT (discrete wavelet transform) which works in transform domain. Watermarking algorithms are divided into two groups based on extraction: Blind and Non-blind watermarking. In blind watermarking extraction does not need original image but in non-blind watermarking original image is needed in watermark extraction. In that paper they use non-blind watermarking.

Anum Javeed Zargar and Ninni Singh (2014) designed the system for digital watermarking, using Discrete wavelet transformation and the wave filter, we have used is HAAR wavelet. This system also provides for an MSE, PSNR, and BER, which determines the robustness of the watermark on the digital image. This is necessary in fragile watermarking as they can be easily removed from the basic image transformation. In such a case imperceptibility present in watermark prevent it from malicious attack.

Ravi K Sheth and Dr. V V Nath (2016) suggested a new secured digital watermarking technique that can be used for the data validation. This method is secure and efficient. The secured digital watermark is added by the hybrid method for which they have used combination of discrete cosine transform (DCT) and discrete wavelet transform (DWT) methods along with cryptographic technique (Arnold Transform). This technique provides strong robustness and perception transparency to the watermarked image and original image against different kind of attacks like cropping, noise and scaling. They found that DCT-DWT method is superior to LSB and DCT methods. Hence it can be safely concluded that the suggested technique of DCT-DWT provides stronger robustness and perception transparency to the watermarked image and original image against different kind of attacks like noise, cropping and scaling.

Hina Lala (2017) implement digital image watermarking technique based on discrete wavelet transform using alpha blending technique. This technique embeds visible watermark into the cover image. The cover image is required in the extraction process. The quality of recovered watermark image and watermarked image is depends on the scaling factors k and q.

Meeta Malonia and Surendra Kumar Agarwal (2016) embedded the watermark into the 1-level high-high, high-low, and low-high sub-band of cover image using Arithmetic Progression technique. The sub-band which has the smallest average is to be embedded first. After that, the watermarked image is projected to several attacks like median filtering, JPEG compression, Gaussian low-pass filtering, shearing, cropping, rotation etc.

3. PROPOSED METHODOLOGY:

Discrete Wavelet Transform (DWT) gives a multi resolution representation of the image. This representation provides a simple framework for interpreting the image formation. The DWT analyses the signal at multiple resolution. When we apply the DWT to an image, it divides the image into two quadrants, i.e. high frequency quadrant and low frequency quadrant [6]. This process repeats until the signal has been entirely decomposed. If we apply level-1 DWT on two-dimensional image, it divides it into four parts as shown below [13]:

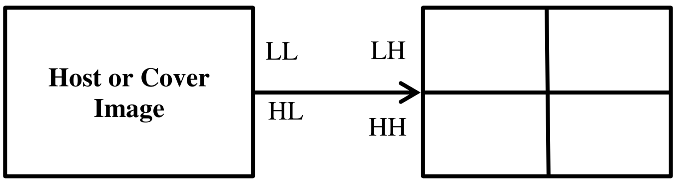


Figure 1: Level-1 DWT Decomposition

LL: it consist the low frequency details of the original image, we can say approximation of image lies in this part.
LH: It consist vertical details of the original image.
HL: It consist horizontal details of the original image
HH: It consist high frequency details of the original image [13].
Since we know that the details of the original image lies in low frequency coefficient. The watermark embeds in low frequency coefficient.

3.1 Watermark Embedding

To hide personal data into cover image in perceptual visible manner, cover image is decomposed into four components i.e. low frequency approximation, low frequency vertical, low frequency horizontal and high frequency diagonal as shown in figure 2. The same procedure is applied on the watermark image which is to be imbedded into cover image. Now alpha blending technique is used for inserting watermark in cover image. In this decomposed cover and watermark images are multiplied by particular scaling factor and are added. The alpha blending formula for embedding the watermark in cover image is given as below:

$$WMI = k \times LL + q \times WM \qquad (1)$$

Where WMI = Watermarked Image
LL = Low frequency approximation of cover image obtained by level-1 DWT
WM = Low frequency approximation of watermark image obtained by level-1 DWT
k and q = scaling factors

After embedding the watermark Image on cover image inverse DWT is applied to the watermarked image coefficient to generate the final secure watermarked image.

3.2 Watermark Extraction

To extract watermark image from watermarked image level-1 DWT is applied to both watermarked image and cover image which decomposed the image in sub-bands as shown in figure 3. After that the watermark is recovered from the watermarked image by using the formula of the alpha blending given below:

$$\boldsymbol{RW} = \frac{\boldsymbol{WMI - k \times LL}}{\boldsymbol{q}} \qquad (2)$$

Where RW = Recovered Watermark
WMI = Watermarked Image
LL = Low frequency approximation of cover image obtained by level-1 DWT
K, q = Scaling Factors

After extraction process, Inverse discrete wavelet transform is applied to the watermark image coefficient to generate the final watermark extracted image [17].

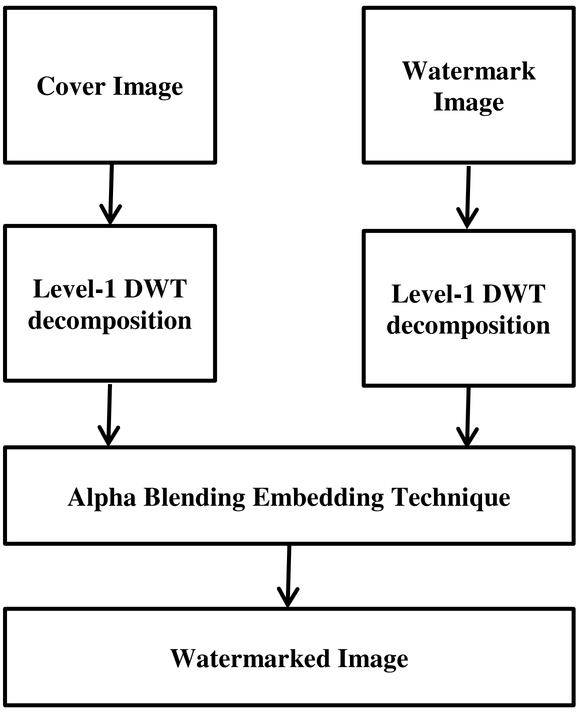


Figure 2: Watermark embedding

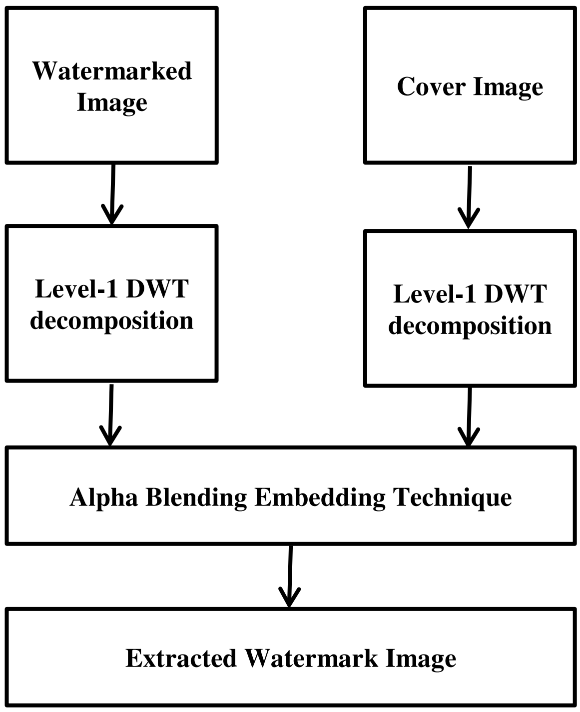


Figure 3: Watermark extraction

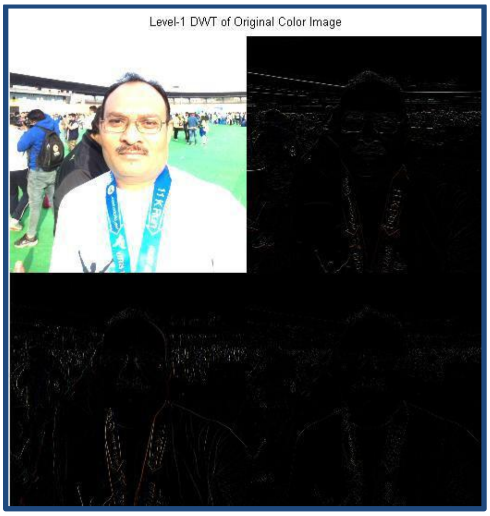
4. RESULT AND DISCUSSION:

In proposed technique image of a man is used as host or cover image and AISECT university logo is used as watermark. Cover is 512X512 colour image as shown in figure 4a. Watermark is colour image resize with cover image as shown in figure 4b.

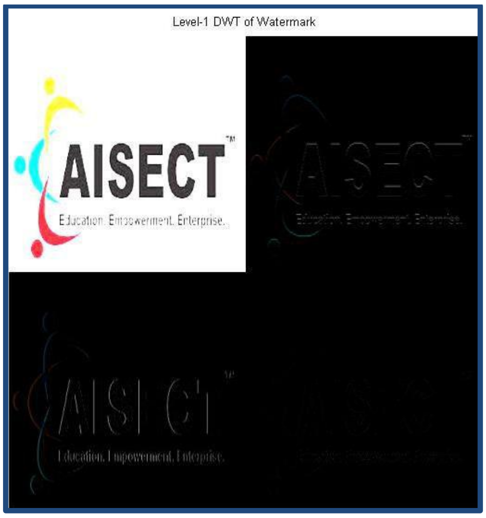
Figure 4a: Original Cover image

Figure 4b: Watermark

Cover image and watermark are decomposed with level-1 DWT as shown figure 5.



Cover Image



Watermark

Figure 5: Level-1 decomposition of cover image and watermark

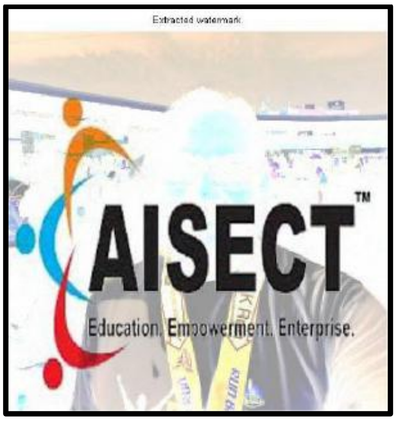
After decomposing cover and watermark images are embedded using alpha blending techniques. Watermarked image is then obtained for different values of scaling factors are shown in figure 6a-d.

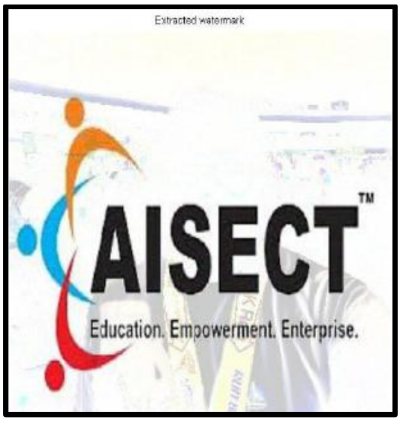
Figure 6a: k=0.98, q=0.5

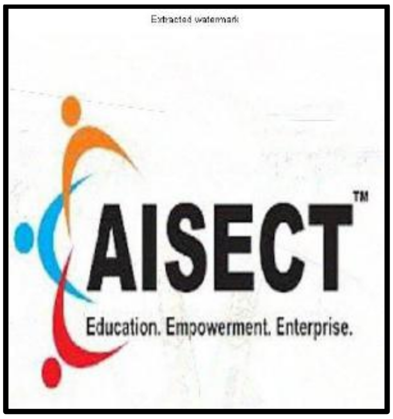
Figure 6b: k=0.98, q=0.1

Figure 6c: k=0.98, q=0.05 Figure 6d: k=0.98, q=0.01

Watermark is extracted using alpha blending technique for different values of scaling factors as shown in figure 7a-d.







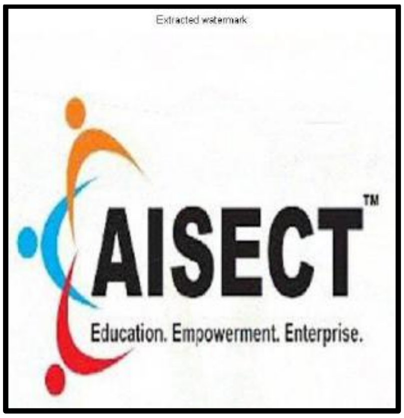


Figure 7c: k=0.5, q=0.5 Figure 7d: k=0.4, q=0.5

Mean square error (MSE) and Peak Signal to Noise Ratio (PSNR) of watermarked image for different value of alpha blending constant k and q are shown in table 1. It is clear from table that for k=0.98 and q=0.01 the MSE is minimum and PSNR is maximum.

Table 1: MSE and PSNR for Watermarked Image

k	**q**	**MSE of Watermarked Image**	**PSNR of Watermarked Image**
0.98	0.5	$6.739x10^{3}$	9.844

0.98	0.1	396.387	22.149
0.98	0.05	91.307	28.526
0.98	0.01	19.402	35.252
0.98	0.005	22.387	34.252
0.98	0.001	26.795	33.850

Mean square error (MSE) and Peak Signal to Noise Ratio (PSNR) of extracted watermark for different value of alpha blending constant k and q are shown in table 2. It is clear from table that for k=0.4 and q=0.5 the MSE is minimum and constant while and PSNR is maximum and constant.

Table 2: MSE and PSNR for Extracted Watermark

k	q	MSE of Extracted Watermark	PSNR of Extracted Watermark
0.7	0.5	5.504×10^4	0.7237
0.6	0.5	5.501×10^4	0.7261
0.5	0.5	5.500×10^4	0.7270
0.4	0.5	5.500×10^4	0.7271
0.3	0.5	5.500×10^4	0.7271
0.2	0.5	5.500×10^4	0.7271

5. CONCLUSION:

The experiment result obtained for watermarked image is by keeping the value of k constant (k=0.98) and varying the value of q. The result shows that by decreasing the value of q the quality of watermarked image improves. The best watermarked image is obtained for k=0.98 and q=0.01. The result obtained for extracted watermark is by keeping the value of q constant (q=0.5) and varying the value of k. The result shows that by decreasing the value of k the quality of extracted watermark gets improved. The best extracted watermark is obtained for k=0.4 and q=0.5.

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