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# Performance Evaluation of Digital Image Watermarking Using Level 3 DWT

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This is the age of digital communication where digital data is used mostly for processing and distribution. It can be easily access by multimedia device and can produce it to the multiple copies of the digital data. It is now necessary to protect the data from piracy. Digital image watermarking is a process in which ownership data can be hided in multimedia data, this ownership data can be extracted later on to prove the authentication of owner. This paper uses level three discrete wavelet transform for digital image watermarking and evaluates the performance of watermarked image based on Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE) and Structural Similarity Index Metric (SSIM).

**Keywords:** Watermarking; Discrete wavelet transform, Embedding, alphablending, PSNR, MSE, SSIM.

## 1. INTRODUCTION

Digital image watermarking uses to hide the copyright information of owner into the digital data using specified algorithm. The information that is to be embedded may be signature, some text, important images, author's serial number, password, company logo etc. This information is embedded into the digital data which may be image, audio or video. This embedded data is transmitted and at receiver end the original information is recovered by applying the same algorithm. In this way data can be authenticate and identify the owner.

There are two methods to hide the watermark in the digital data they are:

(a) Visible and (b) invisible.

In visible watermarking watermark is visible to the user when it is inserted to the image, whereas in invisible watermarking, the logo is transparent to the user, they are insensible and they do not change the visual of the image.

Watermarking technique can also be categorized as:

(a) blind and (b) non-blind.

In blind watermarking technique original image is not necessary when watermark is extracted form watermarked image; while in non-blind watermarking original image is necessary when watermark is recovered from the watermarked image.

There are some basic qualities of watermarking:

**(i)** **Robustness**: It is defined as ability to survival of watermark from various attacks. Since the data is passed through different types of operations. The quality of watermark must be unaffected in these conditions.

**(ii)** **Imperceptibility**: This shows the ability of watermark such that it cannot be seen by human eyes. The watermark can be accessed only by particular operations on it.

**(iii)** **Security**: It is the ability of watermark so that any unauthorized user can access it. It can be access only by authorized user.

**(iv)** **Capacity**: It is the amount of information that watermark can imbed into original image. It can also refers the amount of secret information that is present in watermarked image.

**(v)** **Computational cost**: computation cost depends on type of method which is used for watermarking. If the watermrking method is simple, contains simple algorithm, require limited software and hardware, the computation cost will be low. On the other hand if the watermarking method is complex, contains complex algorithm and require more software and hardware, the computational cost will be higher.

## 2 THREE LEVEL DISCRETE WAVELET TRANSFORM

Discrete Wavelet Transform (DWT) is multi-resolution description of the image. In this method decoding is processed sequentially from a low resolution value to high resolution value. The DWT splits the original image

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into high frequency and low frequency sub parts. The high frequency part tells the information about vertical and horizontal edge components. The low frequency part splits again into high frequency and low frequency sub parts. The high frequency sub part contains edge information, and it is used for watermarking because human eye is less sensitive to changes in edges.

In level-3 DWT, original image is decomposed first in vertical direction then in horizontal direction. After decomposition the first level, original image is converted into four sub-bands LL1, LH1, HL1, and HH1. LL1 is low resolution sub-band while LH1, HL1 and HH1 are high frequency sub-bands. For level-2 decomposition low frequency sub band LL1 is used as input. To perform level-2 decomposition, DWT is applied to LL1 band. After level-2 decomposition LL1 is converted into four sub-bands LL2, LH2, HL2 and HH2. LL2 is low frequency sub-band which is used as input for level-3 decomposition. For level-3 decomposition, the DWT is applied to LL2 band. After decomposition LL2 is converted into four sub-bands LL3, LH3, HL3 and HH3. In this way after level three decomposition total 10 sub-bands are present. Sub-band LL3 is lowest frequency sub-band and LH1, HL1 and HH1 are highest frequency sub-bands. The level-3 DWT decomposition is shown in Fig.1.

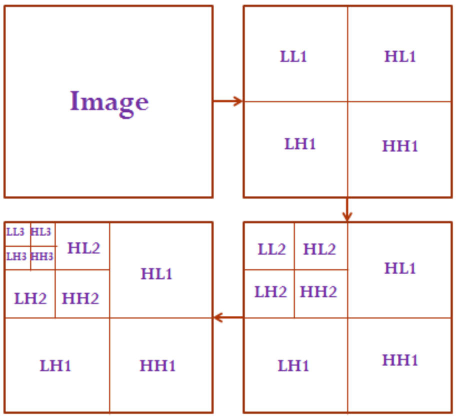


**Fig 1: Level 3 DWT decomposition**

The proposed algorithm is basically divided into two parts, watermark embedding and watermark extraction.

### 2.1 Watermark Embedding

For embedding the watermark into host image, we first apply level three DWT on host image. It decomposes the host image into four sub-images which contains 3 details and 1 approximation. The approximation looks like as original image. Similarly level three DWT is applied to the watermark image. Watermark is also decomposes into four sub images as host image. Haar wavelet is used for the decomposition of host image and watermark. Approximation part of host image and watermark are embedded, for this alpha blending is used. In this technique the approximation components of the host image and the watermark are multiplied by two different scaling factors and they are added to give the watermarked image. Since the watermark embedded in low frequency approximation Component of the host image so it is perceptible in nature or visible. Watermarked image can be obtained by following alpha blending formula:

$$W\_I3 = k*(LL3) + q*(WW3) \quad (1)$$

Where
WW3 = low frequency approximation of watermark,
LL3 = low frequency approximation of host image,
W_I3 = low frequency approximation of watermarked image,
k and q = Scaling factors
After embedding the watermark on host image inverse DWT is applied to the watermarked image W_I3 to generate the final secure watermarked image.

### 2.2 Watermark Extraction

For recovering the watermark from watermarked image first apply level three DWT to watermarked image and host image. DWT decomposes the watermarked image and host image into sub-images. For recovering the watermark approximation sub part of host image is multiplied by scaling factor and it is subtracted from watermarked image. For this alpha blending extraction technique is used. Watermark is recovered by the following alpha blending formula:

$$R\_W3 = (W\_I3 - k*LL3)/q \quad (2)$$

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Where
R_W3 = Low frequency approximation of recovered watermark,
LL3 = Low frequency approximation of the host image, W_I3 = Low frequency approximation of watermarked image.
k and q = Scaling factors
After extraction process, final watermark can be obtained by applying inverse DWT on low frequency approximation of watermark image.

The performance of watermarked image and extracted watermark are measured based on value of Mean Square Error (MSE), Peak Signal to Nose Ratio (PSNR) and Structural Similarity Index Metric (SSIM) of the images.

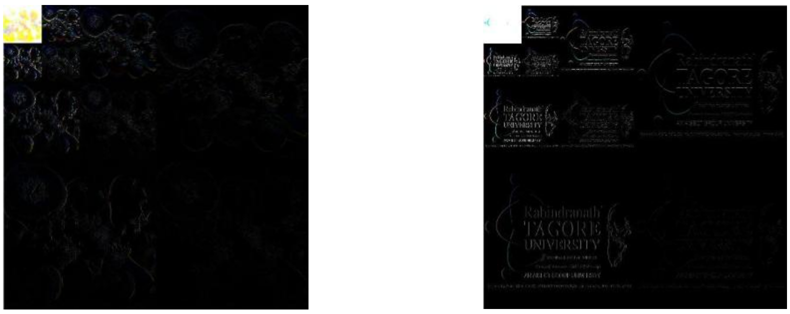
- Mean Square error is defined as the average squared difference between host image and watermarked image.
- Peak Signal to Noise Ratio is used to measure the similarity between the host image and the watermarked image.

## 3 EXPERIMENT RESULT

Experiment is done on MATLAB R2013a, in this process fruits image (fruits.jpg) is taken as host image and the logo of the Rabindranath Tagore University Bhopal (RNTU.jpg) is taken as watermark as shown in figure 2a and 2b respectively. The size of host image is 512 x 512 and the watermark is resized with host image. Since the alpha blending technique is used here which adds the low frequency contents of the two image hence both images must be of same size.
The host image and watermark are converted into three level discrete wavelet transform (DWT). Three level DWT of host image and watermark is shown in figure 3a and 3b respectively.


**(a) Cover Image** **(b) Watermark**

**Figure 2: Original cover image and watermark**



**(a) Cover Image** **(b) Watermark**

**Figure 3: Level-3 Decomposition of Cover Image and Watermark**

Approximation sub-band is of level three DWT of host image and watermark is used for embedding the watermark into the host image. This is done using alpha blending formula. The value of scaling factor q is varied from 1.0 to 0.0001 by keeping the value of scaling factor k constant to 0.99. The watermarked images found for various value of q are shown in the figure 4.

The result is obtained for different value of scaling factor q for k=0.99. The watermarked image for different value of scaling factor is shown in figure and the perception of extracted watermark for different scaling factor is approximately same as shown in figure 5. The various values of PSNR, MSE and SSIM for

watermarked image and extracted watermark for different value of scaling factor are shown in table 1. The result shows that as the value of q decreases mean square error (MSE) of watermarked image decreases while peak signal to noise ratio (PSNR)and Structural Similarity Index Metric (SSIM) of watermarked image increases. It is also seen that by decreasing the value of q the MSE of extracted watermark increases while PSNR of extracted watermark decreases. The SSIM for extracted watermark remain constant for entire range of scaling factor q. Fork=0.99 best value of PSNR for watermarked image is obtained for q=0.005.
The graph between scaling factor q and various parameters such as PSNR, MSE and SSIM for watermarked image and extracted watermark using level-3 DWT are shown in figure 6 and 7 respectively.

| | | | | | |
|---|---|---|---|---|---|
| **k=0.99,q=1.0** | **k=0.99,q =0.5** | **k=0.99, q=0.1** | **k=0.99, q=0.01** | **k=0.99, q=0.005** | **k=0.99, q=0.001** |

**Figure 4:Watermarked Image using Level-3 DWT**

**Table 1: Experiment Result using Level-3 DWT**

| **k** | **q** | **MSE of Watermarked Image** | **PSNR of Watermarked Image** | **SSIM between Cover and watermar-ked Image** | **MSE of Extracted Watermark** | **PSNR of Extracted Watermark** | **SSIM between Watermark and extracted watermark** | **Remark** |
|---|---|---|---|---|---|---|---|---|
| 0.99 | 1.0 | 0.3438 | 52.7681 | 0.2848 | 2.1290e-30 | 344.8490 | 1.0000 | |
| 0.99 | 0.5 | 0.1556 | 56.2100 | 0.8496 | 3.1176e-30 | 343.1927 | 1.0000 | |
| 0.99 | 0.1 | 0.0072 | 69.5356 | 0.9970 | 1.9169e-29 | 335.3048 | 1.0000 | |
| 0.99 | 0.05 | 0.0017 | 75.9298 | 0.9993 | 5.8958e-29 | 330.4254 | 1.0000 | |
| 0.99 | 0.01 | 2.8463e-05 | 93.5881 | 1.0000 | 1.1711e-27 | 317.4449 | 1.0000 | |
| 0.99 | 0.005 | 6.4389e-06 | 100.0427 | 1.0000 | 4.5912e-27 | 311.5115 | 1.0000 | Best Result |
| 0.99 | 0.001 | 1.8123e-05 | 95.5486 | 1.0000 | 1.1152e-25 | 297.6573 | 1.0000 | |
| 0.99 | 0.0005 | 2.1415e-05 | 94.8237 | 1.0000 | 4.4481e-25 | 291.6490 | 1.0000 | |
| 0.99 | 0.0001 | 2.4341e-05 | 94.2674 | 1.0000 | 1.1092e-23 | 277.6806 | 1.0000 | |

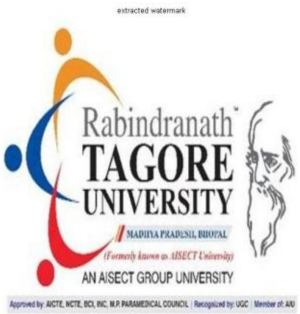



**Figure 5: Extracted Watermark using Level-3 DWT**

Table 1 shows that for level-3 DWT Structural Similarity Index Metric (SSIM) between original image and watermarked image is increasing for q=1.0 to 0.05, and for lower value of q similarity measure is 1. This shows that original cover image and watermarked image are similar for q less or equal to 0.01. Table 1 also shows that similarity measure for original watermark and extracted watermark is 1 for all value of q.

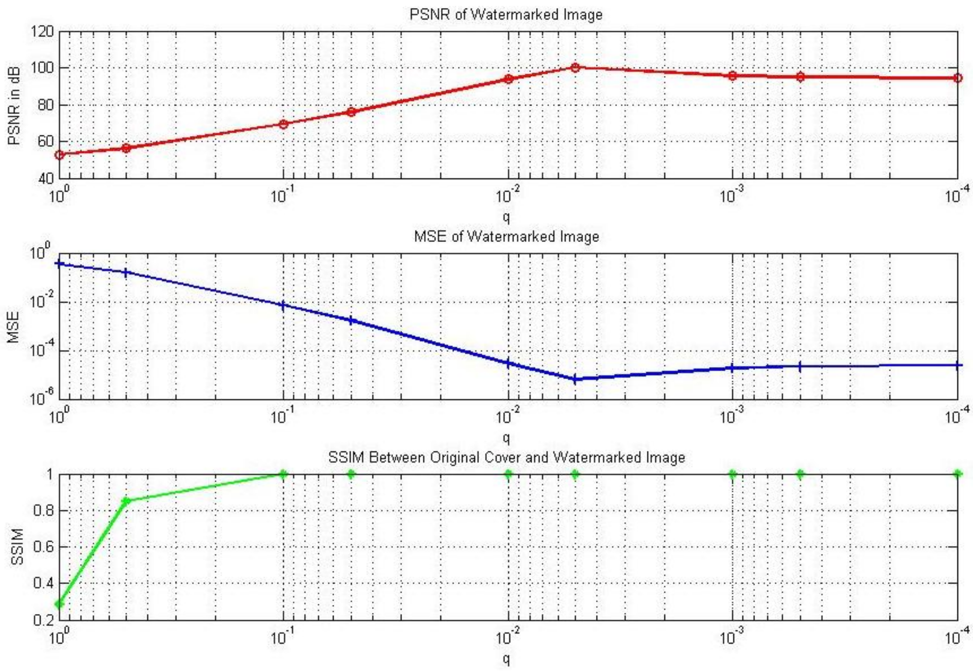



**Figure 6: PSNR, MSE, SSIM and q of watermarked image using Level-3 DWT**

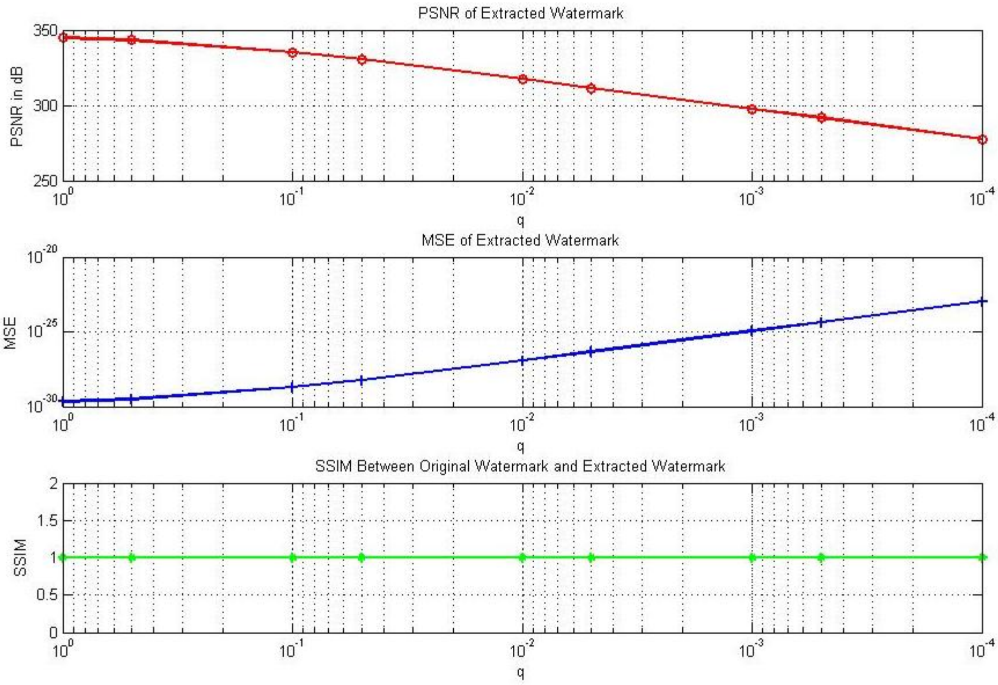



**Figure 7: PSNR, MSE, SSIM and q of watermarked image using Level-3 DWT**

## 4 Conclusion

The result shows that as the value of q decreases the quality as well as PSNR of watermarked image improved. The best result is obtained for q=0.005 as shown in the table1. At this value PSNR of watermarked image is maximum and MSE is minimum. The SSIM between original cover or host image and watermarked image is for q=0.01 or lower. The result also shows that the SSIM between original watermark and extracted watermark is constant for all the value.

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