# Watermark Logo in Digital Image using DWT

Amol R. Madane, K T. Talele and M. M. Shah

*Abstract:* **This paper gives the idea of the method digital image watermarking algorithm which is new popular topic for research. The Discrete wavelet is the tool used for digital image watermarking. Wavelet transform has been applied widely in watermarking research as its excellent multi-resolution analysis property. The watermark logo is embedded based on the frequency coefficients of the discrete wavelet transform. The detailed wavelet coefficients of low frequency band of the host image are altered by the watermark logo. The algorithm has been tested under the presence of attacks like Jpeg compression, bit planer reduction, cropping, warping etc. The watermark logo is inserted in the host image in frequency domain which gets spread over the whole part of the host image in time domain.**

*Keywords:* **Discrete wavelet transform, gray scale image, cropping, warping.**

## I. INTRODUCTION

Digital watermarking allows to add a layer of protection to images by identifying copyright ownership and delivering a tracking capability that monitors and reports where images are being used i.e. it is a method of hiding information into a host image. Digital watermarking technique can provide copyright protection for digital data [1], [12], [13], [14].

Digital watermarking is a covert security feature for identity documents that enables trusted authentication of host image like the image of PAN card and other IDs.

Watermarking involves the transformation of a digital artifact into another token of the same type. Watermarking is done at the object-level. Almost all watermarking methods, which have been proposed today, can provide robust and secret watermark and against various attacks such as filtering, data compression, warping, cropping etc. The watermark is robust and secret due to the owner keeps the algorithm private [6].

Traditionally due to the limited processing abilities in analog media, manipulation of images has been a tedious task with only low quality results being realized without prohibitively expensive professional equipment. But today it is a 'digital era'. Digital objects may be copied, manipulated or converted easily without any control. The achievements during the last decades by both image processing techniques and telecommunication network have facilitated the current explosion of applications that considerably simplify the acquisition, representation, storage and distribution of images in digital format. All these advances have also made it possible to produce digital data with the greatest ease. The advancement of digitized media is creating pressing need to prove authenticity of personal documents and research work.

Digital watermarking technology is emerging as a solution to a broad class of challenges. There has been great interest in applying watermark to digital multimedia data for copyright protection, image authentication and proof of ownership etc [9]. Image watermarking is finding more and more support as a possible solution for the protection of intellectual property rights.

Any watermark signal is associated (one by one) with an integer number (or a set of integer numbers) which is the watermark key. This key is used to produce, embed and detect a watermark. The key is private and characterizes exclusively the legal owner of the digital product. The number of available keys is enormous [10]. Each watermark must correspond to a unique key. It thus serves to identify the owner of the watermarked image.

## II. PROBLEM DEFINATION

Digital water marking is hiding information into a host image in perceptually invisible way [2], [7]. A more precise explanation of it is as shown in figure 1.

$$WM(x,y)=H(x,y)+W(x,y)$$

Where, $H(x,y)$ = host image,
$WM(x,y)$ = watermarked image,
$W(x,y)$ = watermark (logo)

The error between $H(x,y)$ and $WM(x,y)$ should be minimum. It is noted that, for watermark embedding, the normalization is applied with respect to the original image, while, for watermark extraction, it is applied with respect to the watermarked image. Thus, it is important to design the watermark signal so that it has minimal effect on the normalized image.

## III. PROPOSED SYSTEM

The purpose of proposed project is to hide personal information into a cover image in perceptually invisible manner. To achieve this, a mathematical tool Wavelet transform is selected [3], [4], [8]. Following are the steps to hide a grayscale image (watermark) into cover image.

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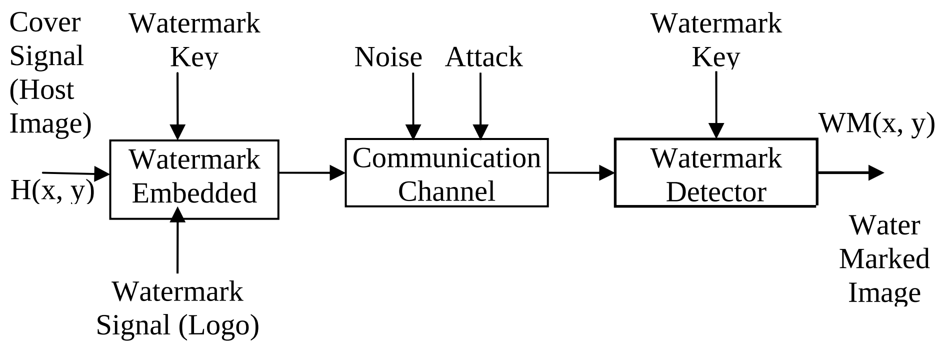



Fig 1: Basic Block Diagram of Digital Image Processing

*A. Algorithm*

a) Consider any gray scale image having size 512 X 512 as a host image. If size of host image is not 512 X 512 then make it 512 X 512.

b) Decompose the host image by using discrete wavelet transform. Store the first level approximation coefficients i.e. $LL_1$, horizontal coefficient $LH_1$, vertical coefficient $HL_1$, diagonal coefficient $HH_1$ as first level watermark key coefficients of host image.

c) Approximation coefficient of first level is $LL_1$ which is further decomposed into new coefficients i.e. $LL_2$, horizontal coefficient $LH_2$, vertical coefficient $HL_2$, diagonal coefficient $HH_2$ as second level watermark key coefficients of host image.

d) Consider the gray scale image having size 128 X 128 as a watermark logo. If size of watermark logo is not 128 X 128 then make it 128 X 128.

e) Reduce the intensity value of $LL_2$ part of host image to half and store it in another variable ($LL_2$mod), since it is used as a watermark keys while extraction of watermark logo. Reduce the intensity values of watermark logo to half. This is used to maintain the value of pixels within range after addition of watermark logo.

f) Add the watermark logo in $LL_2$ part of host image pixel by pixel.

g) Perform the two level inverse discrete wavelet transform of host image by using approximation coefficients of host image to find the Visible Watermark Image having size 512X512.

h) Find the mean square error (MSE) and peak signal to noise ratio (PSNR) in between the original host image and visible watermark image by using the related formulae as these are the important performance parameters.

i) Find the correlation coefficient (CC) in between the original host image and visible watermark image as a next performance parameter.

## IV. ATTACKS

An important requirement of watermarking scheme is robustness. However it is important to note that the level of robustness required varies with respect to the application in hand [6].

In today's world, images are sent on internet as well as in transmission from one point to another; in such case, some noise is added to the images. Some of the time attacks on images may be deliberate also to misuse it. Following sections cover different types of attacks and detect logo for each case. Comparative study of logo detection under various attacks is done.

*A. Filtering*

Median filtering up to order 9X9 can be used. And presence of logo can be detected by using the extraction procedure [6], [10]. The median filtered watermarked image and detected logo are as shown in figure 2. These are the steps which are used to find the watermark image and extracted watermark logo from median filtered watermark image.

a) Consider the watermark image as host image or input image having size 512 X 512. Pass the watermark image through median filter having various orders (like 3 X 3, 5 X 5, 7 X 7, 9 X 9 etc) to get the median filtered watermark image.

b) Initially, the mask size is 3X3 to get better median filtered watermark image.

c) Decompose the median filtered watermark image by using discrete wavelet transform. Then we will get the first level approximation coefficients i.e. $LL_1$, horizontal coefficient $LH_1$, vertical coefficient $HL_1$, diagonal coefficient $HH_1$ as first level watermark key coefficients of median filtered watermark image.

d) Approximation coefficient of first level is $LL_1$ which is further decomposed into new coefficients i.e. $LL_2$, horizontal coefficient $LH_2$, vertical coefficient $HL_2$, diagonal coefficient $HH_2$ as second level watermark key coefficients of median filtered watermark image..

e) Extract the logo as per the procedure of given algorithm to find the median filtered extracted logo from median filtered watermark image. Gray scale median filtered extracted watermark logo is obtained which is perceptually equal to original watermark logo

(a) (b)

CORRELATION COEFFICIENTS = 0.9580

Figure 2: a) Median filtered watermarked image (Size: 512x512). b) Detected logo. (Size: 128x128) for median filter of mask size (3 X 3).

The following table will give the detail information about the variation of mask size with the PSNR, MSE, and CC.

Table 1: variation of PSNR, MSE, CC with mask size

| MASK SIZE | PSNR | MSE | CC |
|---|---|---|---|
| 3X3 | 36.6585 | 0.0440 | 0.9352 |
| 5X5 | 33.1679 | 0.0984 | 0.9104 |
| 7X7 | 31.1841 | 0.1553 | 0.8912 |
| 9X9 | 29.8906 | 0.2092 | 0.8845 |

From the table, we can conclude that, the better recovery is possible when mask size is small as possible.

*B. Compression*

Using different type of lossy compression schemes like biplane reduction and JPEG compression. We tried to compress the watermarked image. Logo is successfully detected from the decompressed image. These are the steps which are used to find the watermark image and extracted watermark logo from Jpeg compressed watermark image. Figure 3 shows the Jpeg compressed watermark image for quality factor Q-20 and detected logo for quality factor 20%.

(a) (b)

CORRELATION COEFFICIENTS=0.9746

Figure 3: a) Jpeg compressed watermarked image (Q-20) (size: 512x512). b) Detected logo. (Size: 128x128) for jpeg compression of quality factor 20 %

a) Consider the watermark image as host image or input image having size 512 X 512. Find the JPEG compressed watermark image for different quality factor which is varying from 20 to 70 to get JPEG compressed watermark image.
b) Decompose the JPEG compressed watermark image by using discrete wavelet transform. Then we will get the first level approximation coefficients i.e. $LL_1$, horizontal coefficient $LH_1$, vertical coefficient $HL_1$, diagonal coefficient $HH_1$ as first level watermark key coefficients of JPEG compressed watermark image.
c) Approximation coefficient of first level is $LL_1$ which is further decomposed into new coefficients i.e. $LL_2$, horizontal coefficient $LH_2$, vertical coefficient $HL_2$, diagonal coefficient $HH_2$ as second level watermark key coefficients of JPEG compressed watermark image.
d) Extract the logo as per the procedure of given algorithm to find the JPEG compressed extracted logo from JPEG compressed watermark image. Gray scale JPEG compress extracted watermark logo is obtained which is perceptually equal to original watermark logo.

In this case, the variation of quality factor is also possible. The following table will give the basic idea about the variation of quality factor with PSNR, MSE, and CC.

Table 2: variation of PSNR, MSE, CC with Quality factor

| QUALITY FACTOR | PSNR | MSE | CC |
|---|---|---|---|
| 20% | 167.8259 | 3.2606e-015 | 0.9389 |
| 30% | 171.3026 | 3.2605e-015 | 0.9412 |
| 40% | 177.8367 | 3.2603e-015 | 0.9443 |
| 50% | 184.7078 | 3.2601e-015 | 0.9475 |
| 60% | 189.2158 | 3.2597e-015 | 0.9511 |
| 70% | 190.3924 | 3.2592e-015 | 0.9585 |

From the above table, it is clear that there is effect of change in quality factor on the watermark image and extracted watermark logo.

Experimental results show that logo is perfectly detected in all two compression cases. However logo detected from wavelet decompressed image is of superior quality [6]. The Jpeg compressed watermarked image and detected logo are as shown in figure 3. The bit planer watermarked image and detected logo are as shown in figure 4.

(a) (b)

MSE= 0.0272, PSNR = 38.7561, CORRELATION COEFFICIENTS=0.9494

Figure 4: a) Bit planer reduced watermarked image (size: 512x512). b) Detected logo. (Size: 128*128) for bit planer compression.

*C. Warping*

Image warping is an attack where part of the image is expanded and part of image is compressed keeping overall dimensions same as original image [6].

a) Consider the watermark image as host image or input image having size 512 X 512. Coefficients of some part of the image are altered in such a way that liquidification of image takes place. Some part of image gets expanded by repeating rows or columns or somewhere wave type image is created i.e. warped watermark image.
b) To warp the watermark image, there are so many software's like adobe Photoshop. By changing the pressure of brush, size of brush, we can vary the quantity and quality of warping (Liquidification).
c) Decompose the warped watermark image by using discrete wavelet transform. Then we will get the first level approximation coefficients i.e. $LL_1$, horizontal coefficient $LH_1$, vertical coefficient $HL_1$, diagonal coefficient $HH_1$ as first level watermark key coefficients of warped watermark image.
d) Approximation coefficient of first level is $LL_1$ which is further decomposed into new coefficients i.e. $LL_2$, horizontal coefficient $LH_2$, vertical coefficient $HL_2$, diagonal coefficient $HH_2$ as second level watermark key coefficients of warped watermark image.
e) Extract the logo as per the procedure of given algorithm to find the warped extracted watermark logo from remixed watermark image. Gray scale warped extracted watermark logo is obtained which is perceptually equal to original watermark logo.

Image warping attacks on all the images and algorithm detects logo successfully along with alterations made to image. In figure 5, warped watermarked image and detected logo are shown satisfactorily.

(a) (b)

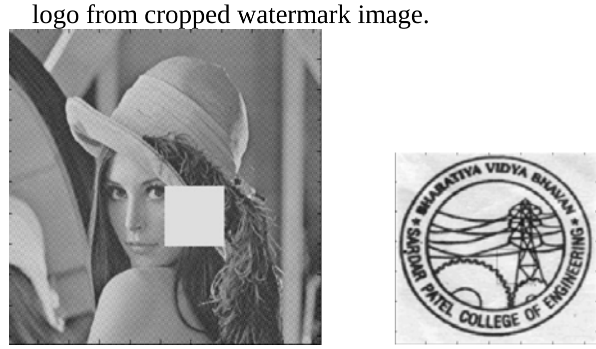
MSE = 0.1805, PSNR = 73.6201, CORRELATION COEFFICIENTS=0.8172

Figure 5: a) Warping of watermarked Lena image (Size: 512x512). b) Detected logo. (Size: 128x128) for warping.

*D. Cropping*

Lena image is the image where face of image is cropped. All the pixel values of particular part are made 255. So if some hidden information is there in that particular part then it will be lost. On one hand image is corrupted and at the same time lost of confidential information also take place. In this situation algorithm detects cropped region very evidently along with usual detection of logo. For experimental verification, face of Lena image is cropped as shown in figure 7.

a) Consider the watermark image as host image or input image having size 512 X 512. Crop the watermark image by making the value of the respective pixel to zero.
b) Decompose the cropped watermark image by using discrete wavelet transform. Then we will get the first level approximation coefficients i.e. $LL_1$, horizontal coefficient $LH_1$, vertical coefficient $HL_1$, diagonal coefficient $HH_1$ as first level watermark key coefficients of cropped watermark image.
c) Approximation coefficient of first level is $LL_1$ which is further decomposed into new coefficients i.e. $LL_2$, horizontal coefficient $LH_2$, vertical coefficient $HL_2$, diagonal coefficient $HH_2$ as second level watermark key coefficients of cropped watermark image.
d) Extract the logo as per the procedure of given algorithm to find the cropped extracted watermark logo from cropped watermark image.




(a) (b)

MSE = 0.0025, PSNR = 113.1899, CORRELATION COEFFICIENTS=0.9743

Figure 6: a) Cropping of watermarked Lena image (Size: 512x512). b) Detected logo. (Size: 128x128) for cropping.

*E. Fading*

Fading is the phenomenon in which the actual value of pixel is changed by means of addition of some noise.

a) Consider the watermark image as host image or input image having size 512 X 512. Each pixel value of watermark image is altered by using the mathematical operation like addition, subtraction, multiplication, division to get the faded watermark image.
b) Decompose the faded watermark image by using discrete wavelet transform. Then we will get the first level approximation coefficients i.e. $LL_1$, horizontal coefficient $LH_1$, vertical coefficient $HL_1$, diagonal coefficient $HH_1$ as first level watermark key coefficients of faded watermark image.
c) Approximation coefficient of first level is $LL_1$ which is further decomposed into new coefficients i.e. $LL_2$, horizontal coefficient $LH_2$, vertical coefficient $HL_2$, diagonal coefficient $HH_2$ as second level watermark key coefficients of faded watermark image.
d) Extract the logo as per the procedure of given algorithm to find the extracted watermark logo which is affected due to fading from faded watermark image. Gray scale extracted watermark logo which is affected due to fading is obtained which is perceptually equal to original watermark logo.

(a) (b)

MSE1 = 8.3821e-016, PSNR = 400.3338, CORRELATION COEFFICIENTS=0.9740

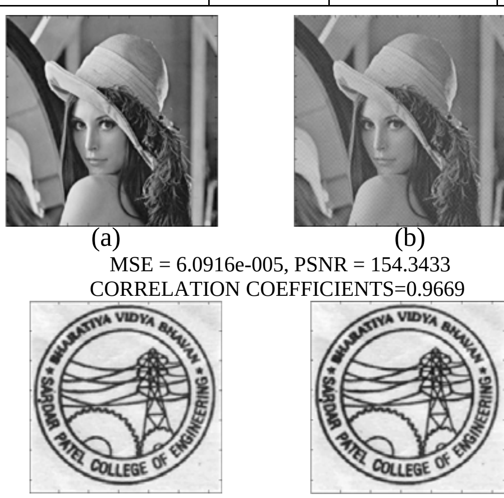
Figure 7: (a) fading of watermarked Lena image. (Size: 512x512). b) Detected logo (Size: 128x128) for fading.

## V. RESULT DISCUSSION

The performance of our proposed watermarking scheme is evaluated by using the different host images. The simulations are performed in the MATLAB7 software environment [2]. The following table will give the basic idea about the variation of performance parameters with different host image.

Table 3: Variation of PSNR, MSE, and CC for the different host images

| INPUT IMAGE | PSNR | MSE | CC |
|---|---|---|---|
| LENA | 66.6475 | 6.0916e-005 | 0.9601 |
| BRAIN (Medical Image) | 66.6105 | 6.0916e-005 | 0.9552 |
| FINGER PRINT | 66.1520 | 6.0916e-005 | 0.9457 |
| PAN CARD | 66.3972 | 6.0916e-005 | 0.9537 |
| RESEARCH PAPER | 66.6294 | 6.0916e-005 | 0.9575 |



(a) (b)

MSE = 6.0916e-005, PSNR = 154.3433
CORRELATION COEFFICIENTS=0.9669

(c) (d)

MSE = 0, PSNR = Inf,
CORRELATION COEFFICIENTS= 0.9835

Figure 8: (a) Original Lena (b) watermarked Lena, (c) Original logo, (d) Recovered logo.

Original grayscale images of 512 X 512 size are selected and grey scale logo of size 128 X 128 is inserted into the images in non perceptible manner according to the algorithm explained which is specially designed for insertion of gray scale logo in a cover image. Images are selected very carefully. LENA is a standard image for comparing strength of algorithm [3]. Figure 8 shows the watermarked 'LENA' along with original 'LENA' and original logo along with recovered logo.

Table 4: comparative study for different extracted watermarked logos.

| ATTACKS | PSNR (dB) | MSE | Normalized correlation coefficients (r) |
|---|---|---|---|
| **Filtering** | 117.7690 | 0.0046 | 0.9580 |
| **Jpeg Compression** | 400.4804 | 8.2602e-016 | 0.9746 |
| **Bit Planer Reduction Compression** | 115.1392 | 0.0027 | 0.9520 |
| **Warping** | 73.6201 | 0.1805 | 0.8172 |
| **Cropping** | 113.1899 | 0.0025 | 0.9743 |
| **Fading** | 400.3338 | 8.3821e-016 | 0.9740 |

The imperceptibility of a watermark is measured by the watermarked image quality in terms of *Peak-Signal-to-Noise Ratio* (PSNR) (in dB) [2]. The robustness performance of watermark extraction is evaluated by *normalized correlation coefficient*, *r*, of the extracted watermark A and the original watermark B.

$$\gamma = \frac{\sum_m \sum_n \left(A(m,n) - \bar{A}\right)\left(B(m,n) - \bar{B}\right)}{\sqrt{\left(\sum_m \sum_n \left(A(m,n) - \bar{A}\right)^2 \sum_m \sum_n \left(B(m,n) - \bar{B}\right)^2\right)}}$$

Where A and B respectively, the normalized original and extracted watermark by subtracting its corresponding means value. The magnitude range of r is [0, 1], and the unity holds if the extracted image perfectly matches the original one.

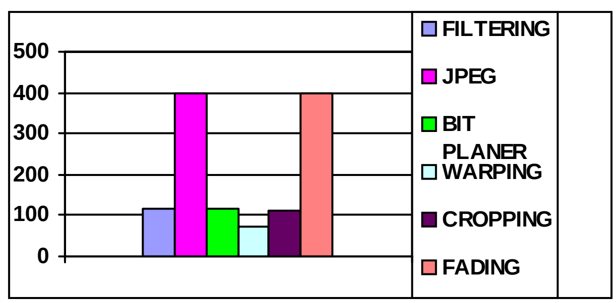



Figure 9: Graph of PSNR.

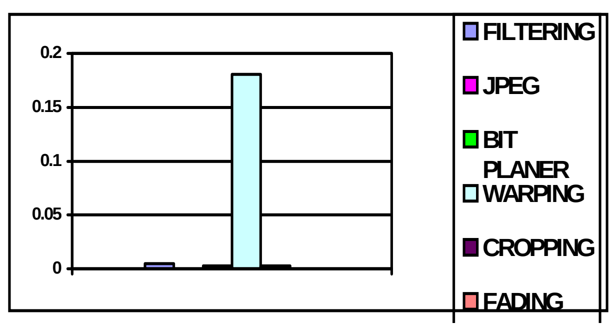



Figure 10: Graph of MSE.

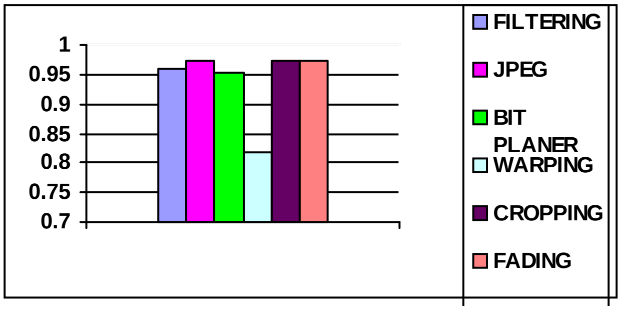



Figure 11: Graph of normalized correlation coefficients (r).

Table-1,figure 9, figure 10, figure 11 graph shows mean square error (MSE), PSNR values, normalized correlation coefficients (r) [2] for different extracted logos respectively. The value of image MSE is very low; PSNR and normalized correlation coefficients (r) are sufficiently high. So this algorithm has created minimum disturbance to host image and perceptually both the images are alike. Lena image gives better result than any other images. Extracted logo from Jpeg Compressed watermarked image has highest PSNR and normalized correlation coefficients (r) and extracted logo from warped watermarked image has minimum PSNR and normalized correlation coefficients among all.

## VI. CONCLUSION

We have designed the system for digital image watermarking with a given gray scale logo using a secret key. The system also provides for a MSE, PSNR and normalized correlation coefficient (r) that determine the robustness of the logo in the digital image. This is necessary in the case of fragile watermarks as they can be easily removed by basic image transformations. In such a case the imperceptibility of the watermark helps protect it from malicious attacks.

The robust watermark is embedded in the wavelet coefficients of LL band of the image to strengthen the watermark and against various attacks such filtering, data compressing, and other malicious modification etc. The developed system also detects and extracts an embedded watermark from a digital image.

The given system provides the good results against the attacks like Filtering, Jpeg compression, and bit planer reduction, warping, cropping, and fading. Out of these, system gives best result against Jpeg compression and worst against warping.

## VII. ACKNOWLEDGMENT

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