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Performance Analysis Between Haar and Daubechies Discrete Wavelet Transform in Digital Watermarking

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Abstract

In this paper, the cover image is embedded with watermark image and from the watermarked image and the watermark image has been extracted by using haar and daubechies discrete wavelet transform based digital watermarking by using MATLAB Simulation software and also performance of these watermarking has been evaluated using different performance metrics they are mean square error (MSE), peak signal to noise ratio (PSNR), structural similarity index measure (SSIM) and correlation coefficient (CRC). In the simulation result, we found that daubechies wavelet transform give better performance over haar wavelet transform in terms of PSNR, MSE, SSIM and CRC..

Keywords: *haar discrete wavelet transform, daubechies discrete wavelet transform, watermark image.*

1. INTRODUCTION

With advancements in digital communication technology and the growth of computer power and storage, the difficulties in ensuring individuals' privacy become increasingly challenging. The degrees to which individuals appreciate privacy differ from one person to another. Various methods have been investigated and developed to protect personal privacy [1].

Watermarking is a technology that provides data security, authentication and integrity and also provides copyright protection for digital media. Watermarking process mainly consists of two modules, watermark embedding module and watermark extraction and detection module. The main focus of watermarking technology is to embed secret information or signal into digital images, video and audio etc. After embedding the information is detected and extracted and extracted information reveals real identity of media or owner [2]. Digital watermarking is the act of hiding a message related to a digital signal (i.e. an image, song, video) within the signal itself. It is a concept closely related to steganography, in that they both hide a message inside a digital signal. However, what separates them is their goal. Watermarking tries to hide a message related to the actual content of the digital signal, while in steganography the digital signal has no relation to the message, and it is merely used as a cover to hide its existence [3]. This paper is organized as follows, description of haar and daubechies discrete wavelet transform is presented in Section II and simulation results are described in

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Section III. Finally, conclusion is stated in Section IV.

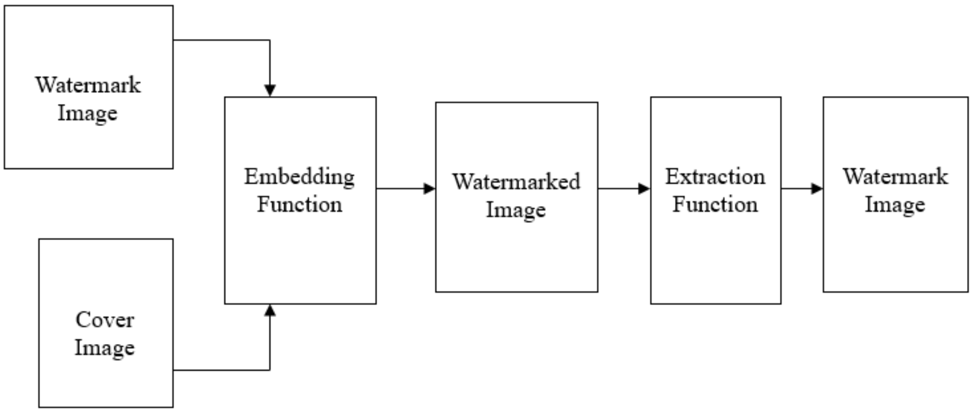

Figure 1. Basic block diagram of digital watermarking.

2. HAAR AND DAUBECHIES DISCRETE WAVELET TRANSFORM

There are various techniques in implementing digital watermarking. These techniques are commonly categorized in terms of working domain i.e. spatial domain or transform domain. In spatial domain, pixel luminance and chrominance values are modified to embed the watermark for example Least Significant Bit (LSB), correlation based and patchwork techniques. While in transform domain, the media content undergoes mathematical transformation before watermark embedding is done for example using Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) [4] However, DWT has been used more frequently in digital image watermarking due to its time/frequency decomposition characteristics, which resemble to the theoretical models of the human visual system.

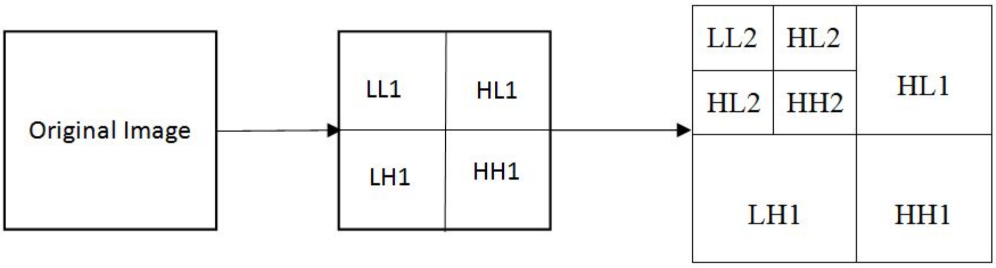

Figure 1. DWT decomposition of the image.

Wavelet Domain is a promising domain for watermark embedding. Wavelet refers to small waves. Discrete wavelet transformation is based on small waves of limited duration and varying frequency. This is a frequency domain technique in which firstly cover image is transformed into frequency domain and then its frequency coefficients are modified in accordance with the transformed coefficients of the watermark and watermarked image is obtained which is very much robust. DWT decomposed image hierarchically, providing both spatial and frequency description of the image. It decomposes an image in basically three spatial directions i.e. horizontal, vertical and diagonal in result separating into four different components namely LL, LH, HL and HH. Here first letter refers to applying either low pass frequency operation or high pass frequency operations to the rows and the second refers to the filter applied to the columns of the cover image. LL level is the lowest resolution level which consist of the approximation part of the cover image and rest three levels i.e., LH, HL, HH give the detailed information of the cover image. DWT decomposition of image shown in Figure 2.

2.1 Haar Discrete Wavelet Transform

Haar is the simplest and very fast wavelet transform. Haar matrix is sequentially ordered. Inma thematics, the Haar wavelet is a sequence of rescaled ―square-shaped functions. The wavelet theorems are most popular methods of image processing, de-noising and compression. Considering that the Haar functions are the simplest wavelets, these forms are used in many methods of discrete image transforms and processing. The Haar wavelet transform has a number of advantages such as it is conceptually fast, simple, memory efficient, since it can be calculated in place without a temporary array.

The Haar wavelet also has limitations. In generating each of averages for the next level and each set of coefficients, the Haar transform performs an average and difference on a pair of values. Then the algorithm shifts over by two values and calculates another average and difference on the next pair. The high frequency coefficient spectrum should reflect all high frequency changes. The Haar window is only two elements wide. If a big change takes place from an even value to an odd value, the change will not be reflected in the high frequency coefficients.

In the process of watermark embedding, a watermark image is embedded in the cover image. In order to embed a watermark in an image Haar wavelet is used as mother wavelet.

2.2 Daubechies Discrete Wavelet Transform

Daubechies wavelets are the most popular wavelets. They represent the foundations of wavelet signal processing and are used in various applications. These are also called Maxflat wavelets as their frequency responses have maximum flatness at frequencies 0 and π [12].

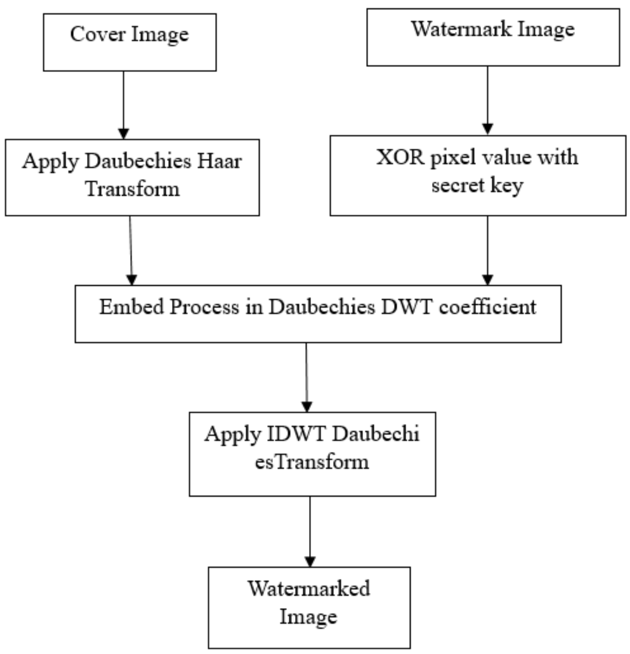

Figure 3. Embedding process in daubechies wavelet transform

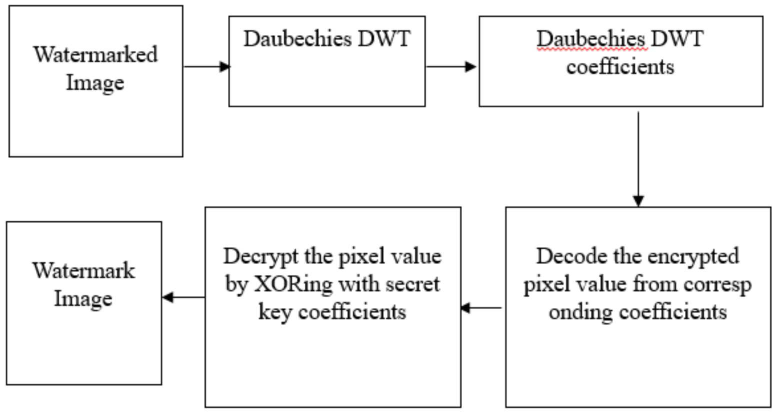

Figure 4. Extracting process in daubechies wavelet transform

The Daubechies wavelet transforms are defined in the same way as the Haar wavelet transform by computing running averages and differences via scalar products with scaling signals and wavelets the only difference between them consists in how these scaling signals and wavelets are defined. For the Daubechies wavelet transforms, the scaling signals and wavelets have slightly longer supports, i.e., they produce averages and differences using just a few more values from the signal. This slight change, however, provides a tremendous improvement in the capabilities of these new transforms. The names of the Daubechies family wavelets are written dbN, where N is the order, and db the "surname" of the wavelet. db1 is same as Haar wavelet, generally these are considered as same wavelet.

In the process of watermark embedding, an watermark image is embedded in the cover image. In order to embed a watermark in an image Daubechies wavelet is used as mother wavelet. The watermark embedding and extraction process using Daubechies wavelet transform is as illustrated in following block diagram 3.

3. SIMULATION RESULT

For the implementation of the proposed work, i.e. to study the comparative analysis of Haar and Daubechies DWT, RGB color image of size 512x512 were used as cover image and 128x128, 64*64 image are used as watermark image and implemented on MATLAB 2013a. Here, as the watermark image size must be 25% less than that of Cover image, thus watermark image of image size 128x128 and 64x64 are used as watermark image. The standard RGB cover images considered are Lena, Peppers, Baboon, Canvas, Pollen etc. and Watermark images are Android icon, Flag of Nepal, NCIT logo etc. as shown below.

The experiments are performed on MATLAB 2013a platform on various cover images with the number of watermark image for both Haar and Daubechies DWT based digital watermarking. The details regarding experimental study is as described below:

In this experiment Lenna image is considered as cover image and Andoid icon as watermark image (128*128), Daubechies DWT gives the results as shown in Figure 5.

It was found that

For Watermark image, MSE = 899.5375; PSNR = 18.5906

Similarly, for cover and watermarked image,

MSE = 95.3803; PSNR = 28.3362

SSIM = 0.8545; CRC = 0.8545

And when LENNA is considered as cover image and ANDROID ICON as watermark image, Haar DWT gives the following result.

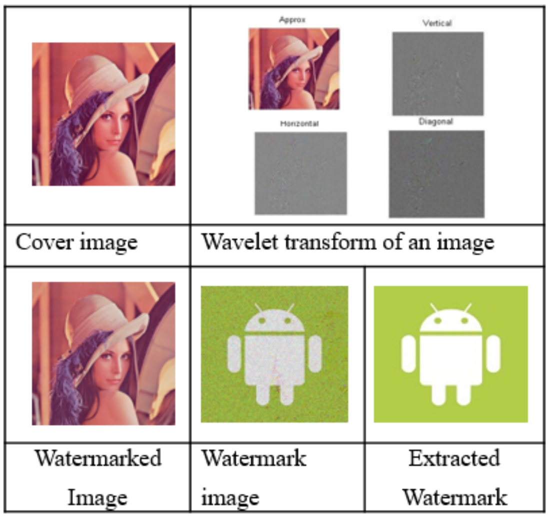

Figure 4. Daubechies DWT of Lenna with Andriod icon as watermark.

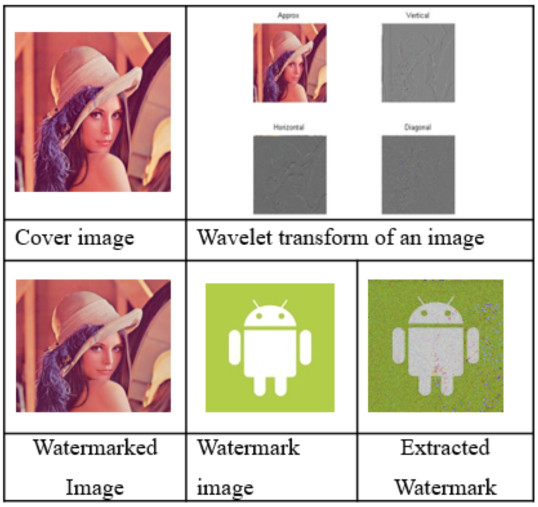

Figure 5. Haar DWT of Lenna with Andriod icon as watermark.

It was found that,
For Watermark image, MSE = 2.2980e+03; PSNR = 14.5173
Similarly, for Cover and watermarked image,
MSE = 384.0539; PSNR = 22.2869
SSIM = 0.7683; CRC = 0.7683

When NCIT is considered as watermark image (Watermark Image size: 128*128), Daubechies and Haar DWT gives the following result.

Table 1. Calculated performance parameter when NCIT is a watermark image.

Cover Image	Haar DWT			
	MSE	PSNR	SSIM	CRC
Lenna	527.4238	20.9092	0.7290	0.7290
Baboon	717.1212	19.5749	0.5552	0.5552
Pepper	306.0197	23.2733	0.6578	0.6578
Canvas	1.0080e+03	18.0960	0.5419	0.5419
Pollen	1.0502e+03	17.9179	0.7065	0.7065
WiFi	3.2052e+03	13.0722	0.4979	0.4978
House	2.3608e+03	14.4002	0.4953	0.4953
Linkedin	4.3588e+03	11.7372	0.4449	0.4449
Icon	1.0885e+03	17.7624	0.5680	0.5680
Chrome	3.1099e+03	13.2033	0.4564	0.4563
Color	1.0131e+03	18.0745	0.5623	0.5623
Process Icon	3.5346e+03	12.6474	0.4503	0.4503
pens	826.6590	18.9575	0.5622	0.5621
pinguin	729.5404	19.5003	0.8597	0.8597
flowers	486.4910	21.2601	0.7826	0.7825

Cover Image	Daubechies DWT			
	MSE	PSNR	SSIM	CRC
Lenna	179.4586	25.5912	0.8074	0.8074
Baboon	599.5849	20.3523	0.6199	0.6199
Pepper	199.2694	25.1364	0.7108	0.7107
Canvas	375.5991	22.3836	0.7384	0.7383
Pollen	1.0389e+03	17.9652	0.7435	0.7435
WiFi	1.7360e+03	15.7354	0.5078	0.5077
House	1.9460e+03	15.2395	0.5432	0.5431
Linkedin	2.9618e+03	13.4153	0.5170	0.5170
Icon	862.4516	18.7735	0.6371	0.6370
Chrome	2.9415e+03	13.4451	0.5062	0.5062
Color	993.6883	18.1583	0.5686	0.5686
Process Icon	2.4955e+03	14.1592	0.5206	0.5205
pens	578.4330	20.5083	0.6864	0.6864
pinguin	581.2461	20.4872	0.8993	0.8992

flowers	292.1611	23.4746	0.8610	0.8610

Table I, shows the MSE, PSNR value for Cover image and Watermarked image and SSIM, CRC for Watermark and Extracted Watermark Image when NCIT is used as watermark image. It shows that less value of MSE and thus more the PSNR for Daubechies DWT as compared to Haar DWT. Also higher value of SSIM and CRC shows that extracted watermark image is similar and compatible to original watermark image.

Also, the comparative study of PSNR and SSIM value for Watermark and Extracted Watermark image for Daubechies and Haar DWT is illustrated in Figures 7 and 8 respectively.

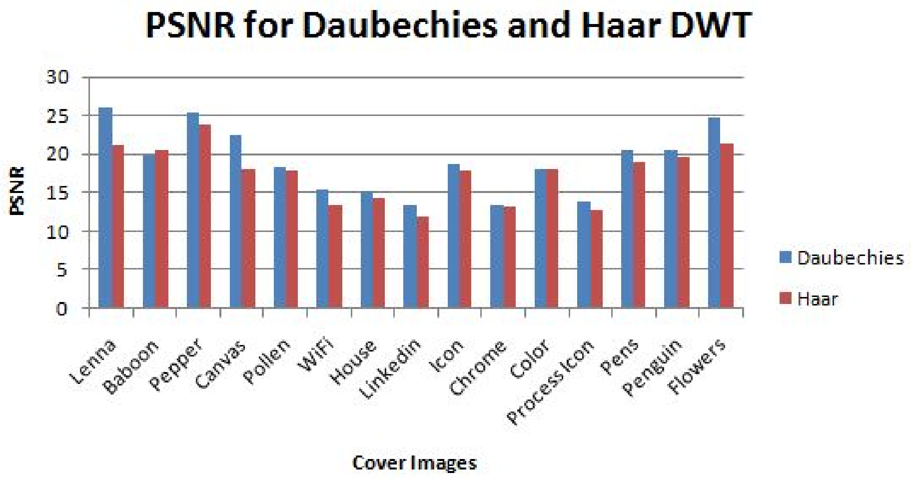

Figure 7. Bar Diagram showing PSNR and SSIM value for Daubechies DWT with NCIT as Watermark image.

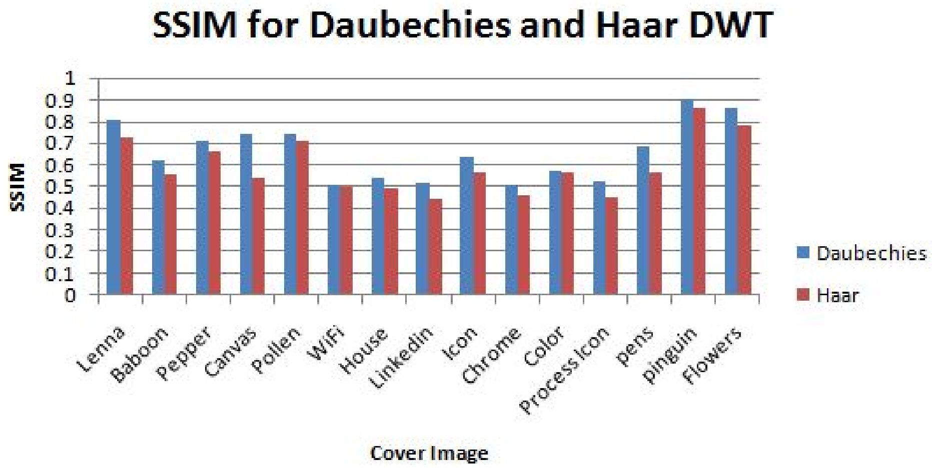

Figure 8. Bar Diagram showing PSNR and SSIM value for Haar DWT with NCIT as Watermark image.

When NCIT is considered as watermark image (Watermark Image size: 64*64), Daubechies and Haar DWT gives the following result.

Table II. Calculated performance parameter when NCIT is a watermark image.

Cover Image	Haar DWT			
	MSE	PSNR	SSIM	CRC
Lenna	521.3383	20.9596	0.8598	0.8595
Baboon	678.0034	19.8185	0.5124	0.5123
Pepper	301.3346	23.3403	0.6667	0.6665
Canvas	1.0047e+03	18.1106	0.5360	0.5359
Pollen	1.0435e+03	17.9460	0.8810	0.8807
WiFi	2.9802e+03	13.3883	0.5425	0.5424
House	2.3808e+03	14.3635	0.8495	0.8492
Linkedin	4.1136e+03	11.9886	0.4582	0.4581
Icon	1.0833e+03	17.7833	0.5861	0.5860
Chrome	3.1015e+03	13.2151	0.4622	0.4621
Color	995.1558	18.1519	0.5659	0.5658
Process Icon	3.3696e+03	12.8551	0.4653	0.4652
Pens	822.8506	18.9776	0.8274	0.8272
Penguin	716.6878	19.5775	0.9939	0.9936
Flowers	479.1923	21.3257	0.8983	0.8981

Cover Image	Daubechies DWT			
	MSE	PSNR	SSIM	CRC
Lenna	172.3496	25.7667	0.8794	0.8791
Baboon	589.2058	20.4281	0.5856	0.5855
Pepper	189.3973	25.3571	0.7277	0.7275
Canvas	369.3508	22.4564	0.7941	0.7939
Pollen	909.0486	18.5449	0.8531	0.8529
WiFi	1.7734e+03	15.6427	0.5430	0.5429
House	1.9423e+03	15.2476	0.6429	0.6428
Linkedin	2.8850e+03	13.5293	0.6891	0.6890
Icon	856.5244	18.8034	0.8556	0.8554
Chrome	2.9371e+03	13.4516	0.5201	0.5200
Color	989.6663	18.1759	0.5682	0.5681

Process Icon	2.4889e+03	14.1708	0.5459	0.5457
Pens	573.0132	20.5492	0.8672	0.8670
Penguin	584.0002	20.4667	0.9187	0.9184
Flowers	304.5672	23.2940	0.8808	0.8805

Table II shows the MSE, PSNR value for Cover image and Watermarked image and SSIM, CRC for Watermark and Extracted Watermark Image when Flag of Nepal is used as watermark image. It shows that less value of MSE and thus more the PSNR for Daubechies DWT as compared to Haar DWT. Also higher value of SSIM and CRC shows that extracted watermark image is similar and compatible to original watermark image. Also, the comparative study of PSNR and SSIM value for Watermark and Extracted Watermark image for Daubechies and Haar DWT is shown in Figures 9 and 10.

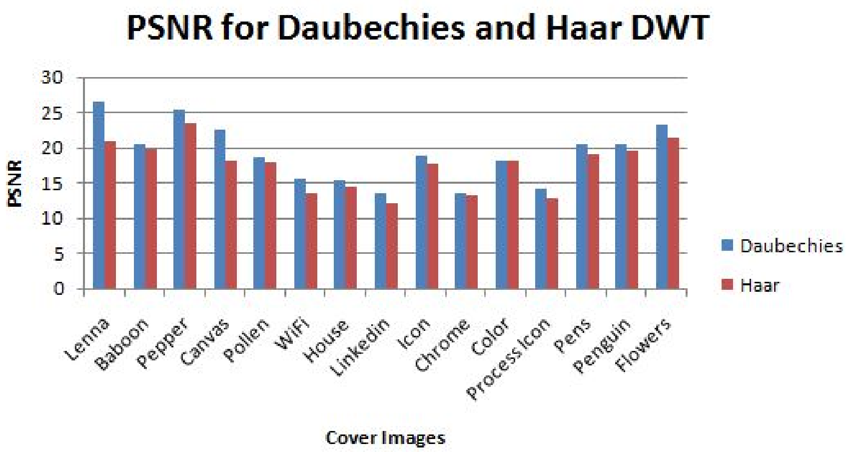

Figure 9. Bar Diagram showing PSNR and SSIM value for Daubechies DWT with NCIT as Watermark image.

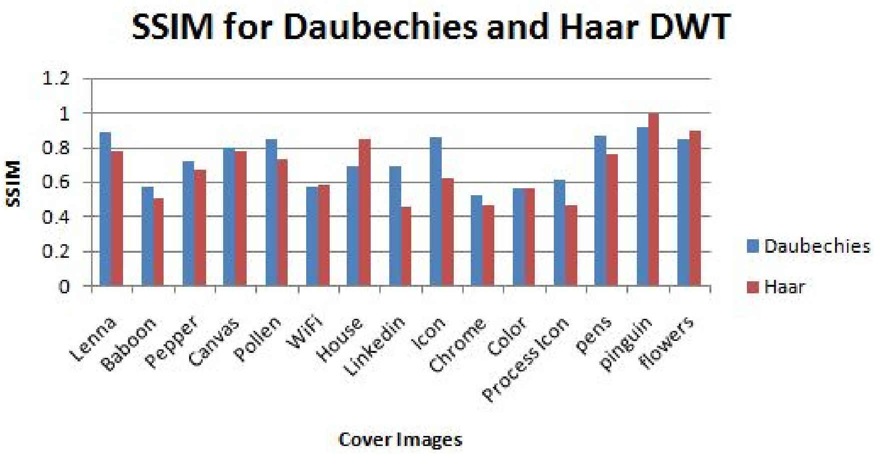

Figure 10. Fig. 10. Bar Diagram showing PSNR and SSIM value for Haar DWT with Robot as Watermark image.

4. Conclusion

This paper, mainly focused on invisible watermarking that provides a comprehensive and robust algorithm that embeds and extracts watermark image effectively. The Wavelet transform of various Cover images with different watermark image has been performed and to evaluate the performance of the Haar and Daubechies DWT based digital watermarking, performance metrics: MSE, PSNR, SSIM and CRC were calculated. The above experiments show that Daubechies DWT gives less MSE and thus more PSNR compared to Haar DWT. With the higher value of PSNR that defines the imperceptibility so we can say that the cover image and watermarked image are visually same. In terms of SSIM and CRC, Daubechies DWT have larger value, shows the high similarity between the original watermark and extracted watermark than that of Haar DWT. By human visual system it seems that Daubechies gave best result. Also it has been observed that performance metrics for 64*64 is better than 128*128 watermark image which shows that less the image size better the performance. Thus it can be concluded that performance of Daubechies DWT is better than Haar DWT in digital watermarking.

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