Image Steganography Technique Using Daubechies Discrete Wavelet Transform

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Abstract: The world in modern days is being more and more tied up to the use of technology for facilitating day to day tasks. In this regard, information security is turning to be great challenge when sending information from one place to another with the aid of technology. Steganography is one of the techniques for the safe transmission which involves hiding information generally with other information that only the receiver will know. In this research, steganography technique using Daubechies Discrete Wavelet Transform (DWT) is implemented. First the cover image is transformed using Daubechies DWT and secret information is embedded in coefficients of Daubechies DWT which gives stego image. Reverse process is applied to obtain secret information from stego image. The performance of the proposed approach is evaluated using PSNR and MSE. Also analysis is done to find the best sub-band to hide information among different sub-bands of Daubechies DWT.

Keywords: Stego Image; Discrete Wavelet Transform (DWT); Peak Signal to Noise Ratio (PSNR); Mean Square Error (MSE)

1. Introduction

Transmission of information from one place to another always has potential threats of being leaked before it reaches the destination. Especially when one has to transmit secure and confidential message, this risk is always high. To address these threats, people always seek and invent technologies for securely transmitting messages. One of the techniques is information hiding.

There are many techniques of information hiding including cryptography, watermarking and steganography. Cryptography is art of protecting information by transforming or encrypting it into an unreadable format, called cipher text. Only those who possess a secret key can decipher or decrypt the message into plain. Watermarking is a pattern of bits inserted into a digital image, audio or video file that identifies the file's copyright information (author, rights, etc.)

Steganography is an art of covert communication in which a secret message is communicated by hiding it in a cover file, so that the very existence of the secret message is not detectable. The cover file can be image, audio or video; the most commonly being the image files.

Steganography dates back to ancient Greece, where common practices consisted of etching messages in wooden tablets and covering them with wax, and tattooing a shaved messenger's head, letting his hair grow back, and then shaving it again when he arrived at his contact point.

The advantage of steganography over cryptography alone is that the intended secret message does not attract attention to itself as an object of scrutiny. Plainly visible encrypted messages no matter how unbreakable will arouse interest, and may in themselves be incriminating in countries where encryption is illegal. Thus, whereas cryptography is the practice of protecting the contents of a message alone, steganography is concerned with concealing the fact that a secret message is being sent, as well as concealing the contents of the message.

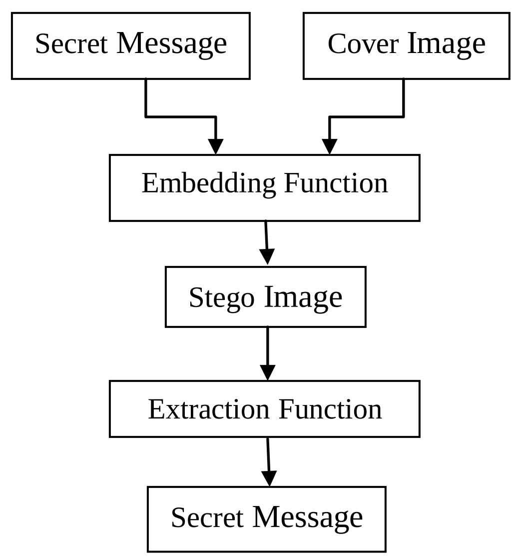


Figure 1: Basic Block Diagram of Steganography

2. Related Theory

A. *Discrete Wavelet Transform*

The wavelet domain is growing up very quickly. Wavelets have been utilized as a powerful tool in many diverse fields, including approximation theory; signal processing, physics, astronomy, and image processing. A wavelet is simply, a small wave which has its energy concentrated in time to give a tool for the analysis of transient, non-stationary or time-varying phenomena. A signal can be better analyzed if expressed as a linear decomposition of sums of products of coefficient and functions. A two-parameter system is constructed such that one has a double sum and coefficient with two indices. The set of coefficients are called the DWT of a signal.

The DWT splits the signal into high and low frequency parts. The high frequency part contains information about the edge components, while the low frequency part is split again into high and low frequency parts which is shown in figure 2 [1].

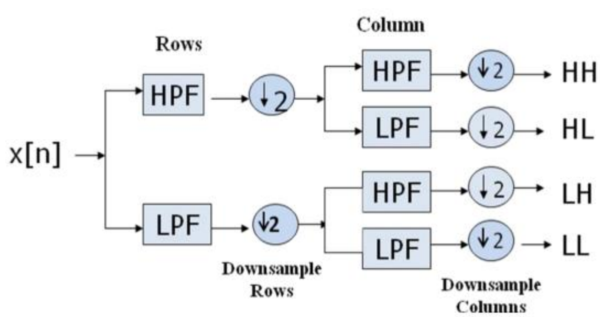


Figure 2: Block Diagram of 1-Step 2-D DWT

The high frequency components are usually used for steganography since the human eye is less sensitive to changes in edges [2]. In two dimensional applications, for each level of decompositions, we first perform the DWT in the vertical direction, followed by the DWT in the horizontal direction. As we can see in figure 3 [2], after the first level of decomposition, there are four sub-bands: LL, LH, HL and HH.

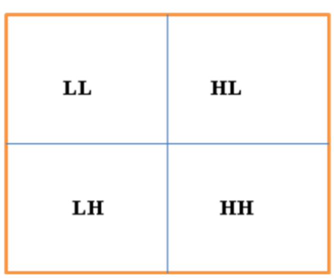


Figure 3: First level wavelet Decomposition

B. *Haar Wavelet*

Haar wavelet is one of the oldest and simplest wavelet. It is also the symmetric wavelet. In discrete form Haar wavelets are related to a mathematical operation called the Haar transform. The Haar transform works as a prototype for all other wavelet transforms. In mathematics, the Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. Wavelet analysis is homogeneous to Fourier analysis in that it allows a target function over an interval to be represented in terms of an orthonormal function basis. It represents the same wavelet as Daubechies db1. 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.

C. *Daubechies Wavelet*

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. 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.

D. *Peak Signal to Noise Ratio (PSNR)*

It is the measure of reconstruction of the transformed image. This metric is used for discriminating between the cover and stego image which is given by equation 1 [13].

$$PSNR = 10log_{10}255^2/MSE \qquad (1)$$

E. *Mean Square Error (MSE)*

It is one of the most frequently used quality measurement technique followed by PSNR. The MSE can be defined as the measure of average of the squares of the difference between the intensities of the stego image and the cover image. It is popularly used because of the mathematical tractability it offers. It is represented in equation 2 [13].

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\ \sum_{j=1}^{N}\left(f(i,j) - f'(i,j)\right)^2 \quad (2)$$

F. *Cover Image*

It is defined as the original image into which the required secret message is embedded. It is also termed as innocent image or host image. The secret message should be embedded in such a manner that there are no significant changes in the statistical properties of the cover image. Good cover images range from gray scale image to colored image in uncompressed format.

G. *Stego image*

It is the final image obtained after embedding the secret information (in a form of image, text, audio etc.) into a given cover image. It should have similar statistical properties to that of the cover image.

3. Related Works

There are many steganography techniques which are capable of hiding data within an image. These techniques can be classified into two categories based on their algorithms: (1) spatial domain based techniques; (2) transform domain based techniques. The spatial domain based steganography technique use either the LSB or Bit Plane Complexity Segmentation algorithm. The most widely used technique to hide data is the usage of the LSB [5]. The existing techniques are mainly based on LSB (Least Significant Bit) where LSBs of the cover file are directly changed with message bits. S. M Karim et al. [6] has proposed a LSB technique for RGB true color image by enhancing the existing LSB substitution techniques to improve the security level of hidden information. LSB matching image steganography and edge adaptive scheme was proposed which can select the embedding regions according to the size of secret message and the difference between two consecutive pixels in the cover image. In [7] designing of robust and secure image steganography based on LSB insertion and RSA encryption technique has been used.

M. A. Ahmed et al. [8] proposed a method in which a message hidden inside an image by using the Least Significant Bit technique and after creation of the hidden message, the image will pass it in hash function to obtain hashing value using the MD5 technique. In [9] a hash based approach proposed for secure keyless steganography in lossless RGB images that an improved steganography approach for hiding text messages in lossless RGB images.

Transform domain techniques embed secret information in a transform space of the signal means the process of embedding data in the frequency domain of a signal to make them more robust to attack such as adding noise, compression, cropping, some image processing etc[10]. Many transform domain variations exist. One method is to use the Discrete Cosine Transformation (DCT) as a vehicle to embed information in image. Another method would be the use of wavelet transforms. Advantages of transform domain include higher level of robustness against simple statistical analysis.

JSteg sequentially replaces the LSB of the non-zero quantized DCT coefficients with secret message bits whereas in JPHide the quantized DCT coefficients are not selected sequentially but selected randomly by a pseudo-random number generator [10]. F5 comes after a series of F3 and F4 [11]. F5 steganographic algorithm was introduced by Westfield and it embeds message bits into randomly chosen DCT coefficients. The F5 algorithm employs matrix embedding that minimizes the necessary number of changes to hide a message of certain length .

The discrete wavelet transform (DWT) method is favored over the DCT method in steganography because DWT provides better image resolution at various levels. DWT converts spatial domain information to the frequency domain information and it clearly partitions the high-frequency and low-frequency information on a pixel by pixel basis [12]. Wavelets are mathematical functions that divide data into frequency components, which makes them ideal for image compression. Haar wavelet transform is the widely used wavelet transform due to the simplicity in implementation [13].

4. Methodology

A. *Algorithm for Embedding Process*

1. Get cover image and secret image.
2. Calculate daubechies wavelet transform of the cover image.
3. Embed the pixel values of secret image into the wavelet coefficients. This is done in following method.
    i. Select any two bands (i.e. HL/HH or LH/HH or HL/LH).
    ii. Get the secret information (image).
    iii. Get lower four bits of secret information and embed into the lower

four bits of wavelet coefficients of one of the band selected.
    iv. Get higher four bits of secret information and embed into the lower four bits of wavelet coefficients of other band selected.
4. Calculate inverse daubechies wavelet transform.
5. Stego image is generated.

B. *Algorithm for Extracting Process*

1. Get stego image.
2. Calculate daubechies wavelet transform of the stego image.
3. Obtain the coefficients of the selected band where the pixel value of secret image is hidden.
4. Extract the pixel values of secret image from wavelet coefficients. The extraction is done in following method.
    i. Get coefficients from one of the selected bands of wavelet.
    ii. Obtain lower four bits of the coefficients.
    iii. Get coefficients from other selected bands of wavelet.
    iv. Obtain lower four bits of the coefficients.
    v. Combine this four bits with the four bits obtained in (ii) by making this four bits as higher bits and other four bits as lower bits.
5. Secret image is generated.

5. Experiment and Evaluation

A. Simulation Parameters

- Coding Platform: Matlab
- Cover and Secret Image: 8-bit grayscale
- Cover Image size: 512 X 512
- Secret Image size: 128 X 128

B. Comparison of different bands of Daubechies wavelet transform for embedding secret image

5 different secret images and 30 different cover images are taken and secret image is embedded in different combination of bands (horizontal/diagonal, vertical/diagonal and vertical/horizontal) and performance is evaluated in terms of mean square error (MSE) and peak signal to noise ratio (PSNR).

Table 1: Calculation of MSE and PSNR at different bands with roses.jpg as secret image

Cover Image	roses (Secret Image)					
	horizontal/diagonal		vertical/diagonal		vertical/horizontal	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
lina1	227.0067	24.57042	223.0057	24.64764	630.069	20.13692
image11	2538.8	14.08452	2664.4	13.87481	3065.9	13.26522
image2	1111	17.67366	1124.1	17.62275	2683.4	13.84395
test	405.8065	22.04761	424.1797	21.8553	6196	10.20969
chess	208.5411	24.93889	223.9547	24.6292	300.5876	23.35109
aaa	193.5825	25.26214	171.9372	25.77711	439.0814	21.70535
aa	189.594	25.35256	201.1265	25.09611	1219.4	17.26934
drae	553.144	20.70242	594.3964	20.39004	812.5802	19.03214
test1	198.9744	25.14283	200.0817	25.11873	373.3772	22.40933
noise	217.6369	24.75348	219.5092	24.71628	5544.2	10.69241
highpass	204.1147	25.03206	214.7119	24.81224	830.8343	18.93566
rose	176.1932	25.67091	178.9166	25.6043	1030.4	18.00075
image12	180.6531	25.56235	178.3638	25.61774	638.3116	20.08048
image14	4141.2	11.95954	4149.4	11.95095	4573	11.52879
image16	423.2897	21.86443	446.4719	21.63286	1866.3	15.42099
image17	165.3695	25.94625	171.9332	25.77721	169.64	25.83552
image20	190.9529	25.32154	202.0372	25.07649	1430.8	16.57501
image21	225.8375	24.59284	238.2367	24.36072	336.1237	22.86581
image24	1878	15.39385	1884.6	15.37861	2192.2	14.722
image30	177.3276	25.64304	190.3532	25.3352	568.7062	20.58192
image31	2049.4	15.01454	2105.1	14.89808	2427.5	14.27921
image32	640.2269	20.06746	721.5757	19.54798	2463.6	14.2151
image33	359.5592	22.5731	363.8241	22.52189	701.0541	19.67329
image34	209.3379	24.92232	221.3373	24.68026	266.7036	23.87051
image36	193.166	25.2715	227.5934	24.55921	1400	16.66952
image37	435.712	21.73881	496.0349	21.17568	4825.6	11.29529
image39	186.1259	25.43274	190.2888	25.33667	203.76	25.03961
image40	235.5389	24.41018	227.8763	24.55381	1681.1	15.87487
image26	1730.1	15.75009	1898.6	15.34647	2248.8	14.6113
moon	232.7104	24.46265	252.3342	24.11104	985.8918	18.19251

In table 1, out of 30 tests, 26 give less mean square error and hence more peak signal to noise ratio in horizontal/diagonal band and 4 give less mean square error in vertical/diagonal band.

Table 2: Calculation of MSE and PSNR at different bands with house1.jpg as secret image

Cover Image	house1 (Secret Image)					
	horizontal/diagonal		vertical/diagonal		vertical/horizontal	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
lina1	224.3099	24.622319	263.9912	23.915	618.1324	20.21999
image11	284.4663	23.590495	351.2156	22.675	456.9362	21.53225
image2	643.054	20.048329	615.2386	20.24	1086.9	17.76891
test	451.5289	21.583948	752.8693	19.364	1298.4	16.99672
chess	321.5059	23.058914	353.2876	22.65	259.099	23.99615
aaa	216.0289	24.785685	267.5063	23.857	213.7628	24.83148
aa	289.7525	23.510532	301.6014	23.336	650.0114	20.00159
drae	677.1614	19.823882	874.7213	18.712	1099.5	17.71885
test1	233.6724	24.444729	233.1108	24.455	338.2643	22.83824
noise	241.8947	24.29454	450.332	21.595	779.9642	19.21006
highpass	223.6788	24.634555	196.6776	25.193	306.6747	23.26402
rose	335.9387	22.868203	339.3306	22.825	652.0356	19.98809
image12	197.0387	25.185288	211.3	24.882	479.2419	21.32526
image14	915.4968	18.514235	1100.6	17.715	4616	11.48815
image16	489.2836	21.235197	484.0939	21.282	1283.6	17.04651
image17	242.9184	24.276199	258.9008	23.999	256.997	24.03152
image20	205.7913	24.996534	205.7495	24.997	438.126	21.71481
image21	187.6199	25.398015	413.787	21.963	265.3393	23.89279
image24	256.1647	24.045611	247.5874	24.194	343.243	22.77479
image30	200.5266	25.109084	206.3627	24.984	540.0852	20.80618
image31	851.8571	18.827136	975.4838	18.239	987.8709	18.1838
image32	483.0316	21.291048	337.7449	22.845	705.2938	19.6471
image33	288.7723	23.525248	201.3334	25.092	370.319	22.44504
image34	400.1071	22.109041	210.0988	24.907	327.0353	22.98486
image36	209.5191	24.918567	201.5491	25.087	412.2944	21.97873
image37	264.9592	23.899014	377.5391	22.361	1418.5	16.61251
image39	313.3872	23.169991	320.5284	23.072	298.7421	23.37784
image40	354.2698	22.637462	206.912	24.973	928.6486	18.45229
image26	302.6871	23.320864	335.7319	22.871	443.2863	21.66396
moon	366.0989	22.494819	345.3344	22.748	406.8639	22.03631

In table 2, out of 30 tests, 16 give less mean square error and hence more peak signal to noise ratio in horizontal/diagonal band, 12 give less mean square error in vertical/diagonal band and 2 in vertical/horizontal band.

Table 3: Calculation of MSE and PSNR at different bands with sec.jpg as secret image

Cover Image	sec (Secret Image)					
	horizontal/diagonal		vertical/diagonal		vertical/horizontal	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
lina1	336.0264	22.86707	232.3139	24.47	522.2986	20.95161
image11	1227.2	17.24165	1714.1	15.79	3075.7	13.25136
image2	832.741	18.9257	877.9965	18.696	1518.4	16.31694
test	330.733	22.93603	514.2712	21.019	1801.6	15.57422
chess	280.5366	23.65091	301.1914	23.342	492.1562	21.20977
aaa	262.0065	23.94768	264.8839	23.9	406.468	22.04054
aa	301.1351	23.34319	320.6244	23.071	760.0464	19.3224
drae	799.9365	19.10025	875.1922	18.71	1053.4	17.90487
test1	356.9564	22.60465	398.4433	22.127	436.6625	21.72934
noise	417.676	21.92241	414.0279	21.961	1405	16.65404
highpass	318.0975	23.1052	339.6024	22.821	324.6218	23.01703
rose	295.3685	23.42716	296.3103	23.413	593.2756	20.39824
image12	270.9931	23.80122	331.6098	22.925	708.8446	19.62529
image14	5214.7	10.95851	5160.8	11.004	6497.4	10.00341
image16	421.5468	21.88235	448.6499	21.612	1499.9	16.37018
image17	249.9127	24.15292	261.0217	23.964	492.8276	21.20385
image20	252.2028	24.1133	377.8871	22.357	812.4347	19.03292
image21	342.4185	22.78523	327.759	22.975	596.8591	20.37209
image24	2050.6	15.01199	1898.5	15.347	2187.5	14.73132
image30	290.1818	23.5041	295.2054	23.43	378.3547	22.35181
image31	1304.9	16.97503	1151.8	17.517	1411.7	16.63338
image32	421.9924	21.87776	405.8443	22.047	1282.8	17.04921
image33	413.2877	21.96828	414.5646	21.955	611.6548	20.26574
image34	327.9899	22.9722	327.2231	22.982	374.7996	22.39281
image36	323.9753	23.02568	349.3306	22.698	724.4454	19.53075
image37	580.8964	20.48982	527.8282	20.906	1722.3	15.76972
image39	306.4636	23.26701	299.2375	23.371	520.231	20.96884
image40	349.5421	22.69581	379.8043	22.335	1066.8	17.84997
image26	2270.1	14.57035	3006.2	13.351	3295.5	12.95159
moon	418.1559	21.91742	408.3144	22.021	584.6746	20.46166

In table 3, 19 give less mean square error and hence more peak signal to noise ratio in horizontal/diagonal band and 11 give less mean square error in vertical/diagonal band.

Table 4: Calculation of MSE and PSNR at different bands with imm.jpg as secret image

Cover Image	imm (Secret Image)					
	horizontal/diagonal		vertical/diagonal		vertical/horizontal	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
lina1	227.0067	24.57042	223.0057	24.64764	630.069	20.13692
image11	2538.8	14.08452	2664.4	13.87481	3065.9	13.26522
image2	1111	17.67366	1124.1	17.62275	2683.4	13.84395
test	405.8065	22.04761	424.1797	21.8553	6196	10.20969
chess	208.5411	24.93889	223.9547	24.6292	300.5876	23.35109
aaa	193.5825	25.26214	171.9372	25.77711	439.0814	21.70535
aa	189.594	25.35256	201.1265	25.09611	1219.4	17.26934
drae	553.144	20.70242	594.3964	20.39004	812.5802	19.03214
test1	198.9744	25.14283	200.0817	25.11873	373.3772	22.40933
noise	217.6369	24.75348	219.5092	24.71628	5544.2	10.69241
highpass	204.1147	25.03206	214.7119	24.81224	830.8343	18.93566
rose	176.1932	25.67091	178.9166	25.6043	1030.4	18.00075
image12	180.6531	25.56235	178.3638	25.61774	638.3116	20.08048
image14	4141.2	11.95954	4149.4	11.95095	4573	11.52879
image16	423.2897	21.86443	446.4719	21.63286	1866.3	15.42099
image17	165.3695	25.94625	171.9332	25.77721	169.64	25.83552
image20	190.9529	25.32154	202.0372	25.07649	1430.8	16.57501
image21	225.8375	24.59284	238.2367	24.36072	336.1237	22.86581
image24	1878	15.39385	1884.6	15.37861	2192.2	14.722
image30	177.3276	25.64304	190.3532	25.3352	568.7062	20.58192
image31	2049.4	15.01454	2105.1	14.89808	2427.5	14.27921
image32	640.2269	20.06746	721.5757	19.54798	2463.6	14.2151
image33	359.5592	22.5731	363.8241	22.52189	701.0541	19.67329
image34	209.3379	24.92232	221.3373	24.68026	266.7036	23.87051
image36	193.166	25.2715	227.5934	24.55921	1400	16.66952
image37	435.712	21.73881	496.0349	21.17568	4825.6	11.29529
image39	186.1259	25.43274	190.2888	25.33667	203.76	25.03961
image40	235.5389	24.41018	227.8763	24.55381	1681.1	15.87487
image26	1730.1	15.75009	1898.6	15.34647	2248.8	14.6113
moon	232.7104	24.46265	252.3342	24.11104	985.8918	18.19251

In table 4, out of 30 tests, 20 give less mean square error and hence more peak signal to noise ratio in horizontal/diagonal band and 10 give less mean square error in vertical/diagonal band.

Table 5: Calculation of MSE and PSNR at different bands with secr.jpg as secret image

Cover Image	secr (Secret Image)					
	horizontal/diagonal		vertical/diagonal		vertical/horizontal	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
lina1	247.3735	24.197272	262.3742	23.942	390.0919	22.21913
image11	1491.1	16.395736	1600.6	16.088	1953.1	15.22356
image2	1277.2	17.068215	1260.3	17.126	2677.2	13.854
test	245.6612	24.227438	257.4182	24.024	2755.2	13.72927
chess	193.5219	25.263502	195.8959	25.211	204.7261	25.01907
aaa	234.8042	24.423745	244.9876	24.239	244.9091	24.24075
aa	240.9103	24.31225	280.5471	23.651	810.886	19.04121
drae	615.5201	20.238381	627.1213	20.157	907.0526	18.55448
test1	257.7365	24.019044	256.7739	24.035	368.0475	22.47176
noise	252.9445	24.100551	287.3444	23.547	2946	13.43848
highpass	218.6307	24.733692	191.5765	25.307	374.4696	22.39664
rose	204.9199	25.014962	194.2748	25.247	668.5211	19.87965
image12	207.4206	24.962285	208.5787	24.938	565.6366	20.60543
image14	3236	13.030718	3238.3	13.028	4096.2	12.00699
image16	494.5818	21.188422	472.5336	21.386	1422.3	16.60089
image17	196.8328	25.189829	201.6071	25.086	199.4324	25.13285
image20	252.1632	24.113987	270.4713	23.81	1128.9	17.60425
image21	245.9616	24.222131	244.8299	24.242	359.9957	22.56783
image24	1481.9	16.422615	1355.6	16.809	1677.1	15.88521
image30	191.5515	25.307948	215.6621	24.793	309.0566	23.23042
image31	1719.1	15.777792	1669.9	15.904	1983.9	15.15561
image32	544.9973	20.76686	592.963	20.401	1773	15.64372
image33	355.4284	22.623282	341.4385	22.798	661.1539	19.92778
image34	192.3648	25.289548	220.2045	24.703	201.5913	25.08609
image36	267.0773	23.864434	237.471	24.375	948.8707	18.35873
image37	422.3401	21.87418	416.7313	21.932	2898	13.50982
image39	223.5789	24.636495	219.702	24.712	242.4744	24.28414
image40	240.4617	24.320344	265.5273	23.89	1173.4	17.43634
image26	1065.5	17.855269	1522.3	16.306	2099.1	14.91047
moon	289.8643	23.508856	271.9287	23.786	412.925	21.97209

In table 5, out of 30 tests 17 give less mean square error and hence more peak signal to noise ratio in horizontal/diagonal band and 13 give less mean square error in vertical/diagonal band.

In above five tables, out of 150 tests, 98 give less mean square error in horizontal/diagonal band, 50 give less mean square error in vertical/diagonal band and 2 give less mean square error in vertical/horizontal band. Horizontal/diagonal band has slightly more images with less mean square error and vertical/diagonal band also contains significant number of images with less mean square error. Hence, it can be concluded that diagonal band contains less information of an original image and can be used to embed the secret information with less distortion in original image.

C. Comparison of Haar and Daubechies Wavelet Transform

Five different secret images and 20 different cover images are taken and performance of Haar and Daubechies wavelet transform is compared on these images in terms of mean square error.

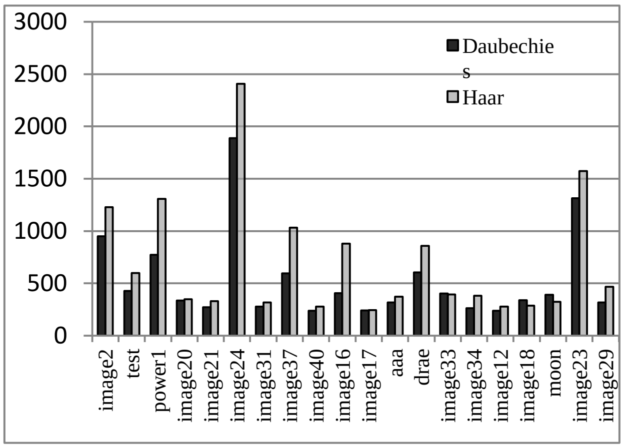


Figure 4: MSE of different images with Daubechies and Haar wavelet transform (Secret Image: imm.jpg)

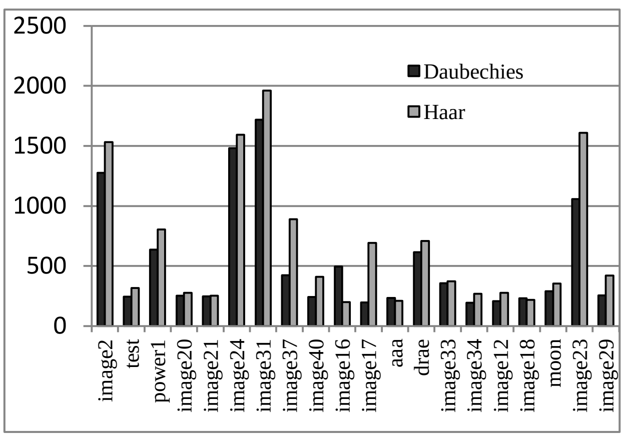


Figure 5: MSE of different images with Daubechies and Haar wavelet transform (Secret Image: secr.jpg)

In figure 4, there are 17 cover images out of 20 images where the mean square error of Daubechies wavelet transform is less than Haar wavelet transform. In figure 5, there are 17 cover images out of 20 images where the mean square error of Daubechies wavelet transform is less than Haar wavelet transform.

In figure 6, there are 19 cover images out of 20 images where the mean square error of Daubechies wavelet transform is less than Haar wavelet transform.

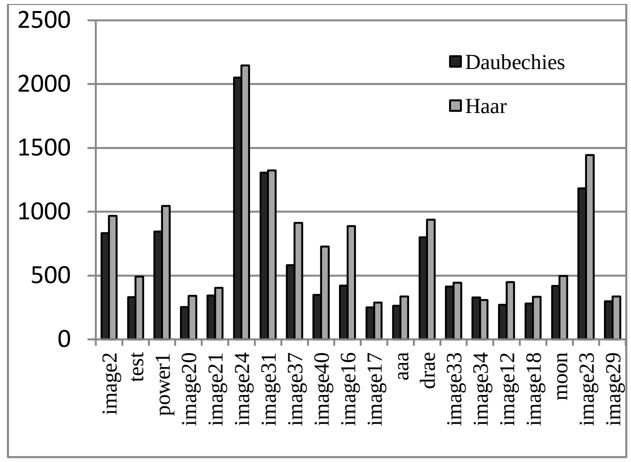


Figure 6: MSE of different images with Daubechies and Haar wavelet transform (Secret Image: sec.jpg)

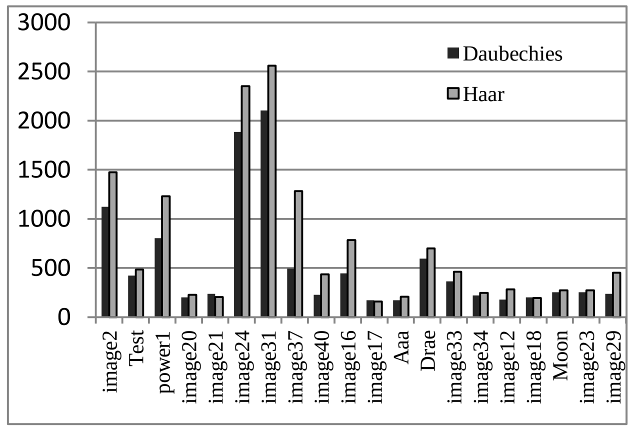


Figure 7: MSE of different images with Daubechies and Haar wavelet transform (Secret Image: roses.jpg)

In figure 7, there are 17 cover images out of 20 images where the mean square error of Daubechies wavelet transform is less than Haar wavelet transform.

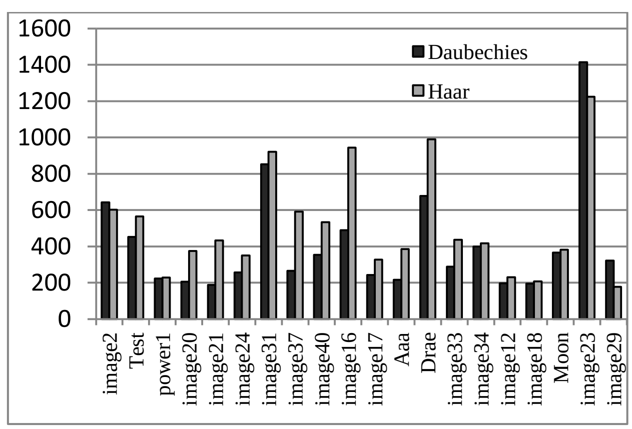


Figure 8: MSE of different images with Daubechies and Haar wavelet transform (Secret Image: house1.jpg)

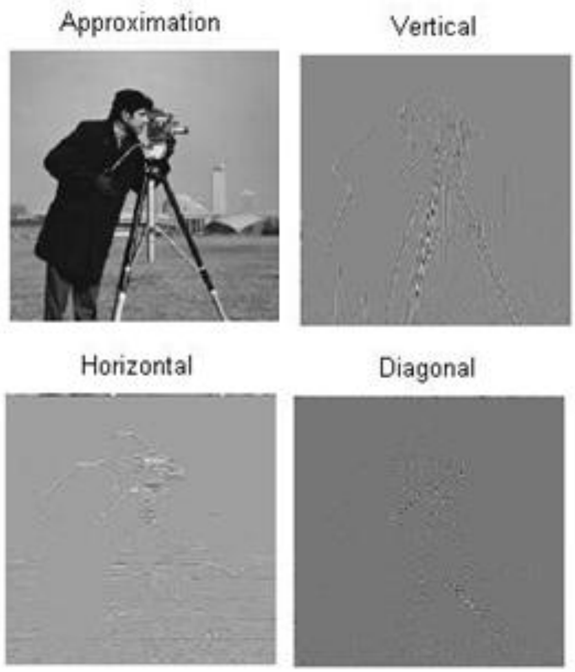
In figure 8, there are 17 cover images out of 20 images where the mean square error of Daubechies wavelet transform is less than Haar wavelet transform.

In above 5 cases, a total of 87 out of 100 tests give less mean square error in Daubechies wavelet transform than Haar wavelet transform. Hence it can be concluded that Daubechies wavelet transform gives better quality of secret image extracted from stego image.

D. Daubechies Wavelet Transform of some images

(a)

(b)



(c)

(d)

(e)

Figure 9: (a) Cover Image (image12) (b) Stego Image (c) Wavelet Transform of an image (d) Original Secret Image (e) Extracted Secret Image

5. Conclusion and Future Works

In steganography, secret information is to be embedded in such a way that it doesn't make significant change to cover file. In this research, Daubechies discrete wavelet transform technique is used to embed the secret information and different tests have been performed. Different results show that diagonal band of wavelet transform carries less information of original image and hence coefficients of this band can be used to embed the secret information without much change to an original image. Instead of taking single band, embedding secret information in combination of bands such as vertical/diagonal or horizontal/diagonal band gives better result in terms of MSE.

Also the performance of Daubechies DWT and Haar DWT is evaluated in terms of PSNR and MSE. Different tests show that Daubechies DWT gives less MSE and hence more PSNR compared to Haar DWT.

In future, same tests can be done for color image and better embedding algorithm can be used to improve the performance.

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