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Performance analysis of SPIHT codec on medical images using DWT and IWT

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***Abstract* -** Image compression in medical image processing is a most significant technique which reduces the burden of storage and transmission time over the network with less degradation in the visual quality and without information loss. Image compression techniques are used to reduce the volume of data for effective storage and transmission. They are classified into lossy compression and lossless compression. In this work, Magnetic Resonance Imaging (MRI) of brain and Computer Tomography (CT) of lung images are used for analyzing compression. The images are compressed using Discrete Wavelet Transform (DWT)-Set Partitioning In Hierarchical Trees (SPIHT) and Integer Wavelet Transform (IWT)-SPIHT with three wavelets such as Haar, Sym4 and Coif1. DWT is used for lossy compression and IWT is used for lossless compression of images. The performance metrics such as Peak signal-to-noise ratio (PSNR), Bit Per Pixel (BPP) and Mean square error (MSE) are measured for lung and brain images. The comparative analyses for SPIHT with DWT and IWT are calculated based on the performance of wavelet. The dataset has been collected from various scan centers.

Keywords:- Compression, SPIHT, DWT, IWT, BPP, PSNR, MSE

I. INTRODUCTION

Digital images are used in life applications such as television, satellite, CT, X-Ray and MRI. These images have high resolution, large size and also contain redundancy and irrelevancy information. For transmission of these images it requires large bandwidth and transmission time. Digital image compression is a method of image data reduction to save storage space. Images must be compressed before transmitting the image.

The main challenges faced by medical industry are to store images, maintain the databases of patient images and transmitting the image through the network. For this purpose the compression of images is necessary. Compression is categorized into lossy and lossless compression. Lossless Compression is important in the field of medical image processing. In this work, the compressions of two medical image modalities such as CT and MRI are analyzed. SPIHT is a wavelet based image compression technique. In this work three wavelets such as Haar, Sym4 and Coif1 are applied in DWT-SPIHT and IWT-SPIHT for compression of images.DWT is a mathematical tool for decomposing an image. It does not change the information content present in the signal. IWT is used for lossless compression. Coefficients of this transform are represented by finite precision numbers and this allows for lossless coding [9].

The following paper is ordered as follows: Section I contains the introduction of medical image processing, compression method and datasets, Section II contain the related work of compression method SPIHT and discussed the transform methods such as DWT and IWT, Section III explain the methodology with flowchart, Section IV describes results and discussion, Section V shows the comparative analysis of SPIHT-DWT and SPIHT-IWT with three wavelets such as Haar, Sym4 and COIF1, Section VI describes the conclusion of SPIHT-DWT and SPIHT-IWT.

II. RELATED WORK

Panjavarnam.B and P.T.V.Bhuvaneswari discussed the performance analysis of SPIHT algorithm for biomedical image transmission. It increases the effective use of available spectrum for image transmission over Long Term Evolution (LTE) networks. The wavelet based SPIHT algorithm is employed to compress the medical images without compromising on the image quality. The metrics PSNR, MSE, CR are evaluated [7].

Rania Boujelbene,Yousra Ben Jemaa and Mourad Zribi described an efficient codec for image compression. It is based on an optimal spline wavelet transform and an improved SPIHT algorithm. A comparative study with existing works using the polynomial spline based transform and the bi-orthogonal 9/7 which is frequently used in image compression is done [8].

T.Vijayakumar and S Ramachandran analyzed the performance of DWT-SPIHT algorithm for medical image compression with uniform aspect ratio. It analyses various wavelet filters and SPIHT encoding techniques in compression and decompression of medical images. Various DWT filters are experimented to select the right type of filters for compressing and decompressing the images without sacrificing on the quality. Bi-orthogonal (Bior) and Daubechies (DB) achieve PSNR in the range of 45dB to 52dB for lossless compression [17].

Bhagya Raju V1, K. Jaya Sankar2, C. D. Naidu analyzed Multispectral Image Compression with Discrete Wavelet Transformed Improved SPIHT using various Wavelets.It deals with DWT and Improved SPIHT algorithm for various existing discrete wavelets. The proposed algorithm, a lossy multispectral image compression method yields better performance results for PSNR, MSE, CR, ENTROPY(H), SSIM and CC [3].

Marco Grangetto, Enrico Magli, Maurizio Martina, and Gabriella Olmo presented optimization and implementation of the IWT for image coding. It deals with the implementation of image transform coding algorithm based on IWT. The criteria are proposed for the selection of optimal factorizations of the wavelet filter polyphase matrix to be employed within the lifting scheme. The obtained results lead to IWT implementations with very satisfactory lossless and lossy compression performance [20].

III METHODOLOGY

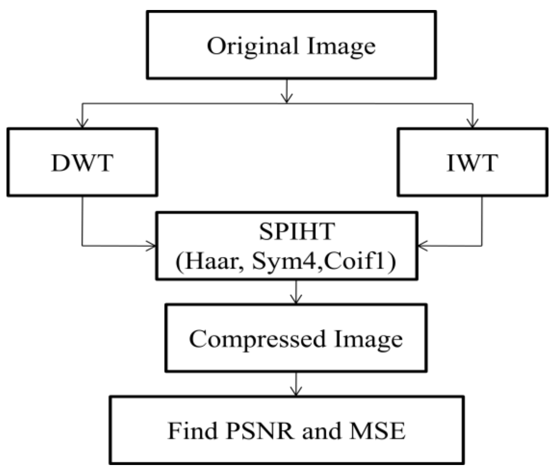

Figure 1. DWT-SPIHT and IWT-SPIHT compression methodology

The input image is first transformed using DWT and IWT into multiple decomposition levels which produces different sub bands. Then, the sub bands are encoded using SPIHT algorithm. The encoded bit stream is transmitted and at the receiver, it is decoded using inverse SPIHT algorithm. After inverse SPIHT, inverse DWT and IWT is performed on the obtained 2D sub bands. The decompressed image is used in the computation of MSE and PSNR in comparison with the original image. Figure 1 shows the DWT-SPIHT and IWT-SPIHT based compression methodology.

DWT (Discrete Wavelet Transform):

Wavelet transform decomposes a signal into a set of basis functions. These basis functions are called wavelets. Wavelets are obtained from a single prototype wavelet called mother wavelet by dilations and shifting. The DWT is a highly efficient and flexible method for sub band decomposition of signals. The 2D-DWT is nowadays established as a key operation in image processing. It is a multi-resolution analysis and it decomposes images into wavelet coefficients and scaling function. In DWT, signal energy concentrates to specific wavelet coefficients. This characteristic is useful for compressing images.

IWT (Integer Wavelet Transform):

The reason for choosing IWT over DWT is that IWT maps the integer data set to another integer dataset whereas DWT converts the floating point values to integer by truncation process. Truncation results in the loss of data. When the input data is in the form of an integer, perfect reconstruction is possible while applying an inverse transform. IWT is used for lossless compression. Finite precision numbers are used to represent the transform coefficients, and this allows for truly lossless coding. Image can be reconstructed without any loss because all the coefficients are integers and can be stored without rounding off errors. IWT is implemented using the lifting scheme [10].

SPIHT (Set Partitioning In Hierarchical Trees):
SPIHT is the one of the most powerful wavelet based image compression algorithm. The basic steps of the SPIHT algorithm are partial ordering by magnitude of the wavelet coefficients according to their significance. Significance information in SPIHT algorithm is stored in three data dependent ordered lists: a List of Insignificant Pixels (LIP), a List of Insignificant Sets (LIS), and a List of Significant Pixels (LSP).

IV RESULTS AND DISCUSSION

In this section, the results of DWT-SPIHT and IWT-SPIHT for medical image compression are discussed. Table 1 shows the PSNR value for MRI brain image using DWT and SPIHT using three wavelets such as Haar, Sym4 and Coif1. Table 2 shows the MSE value for MRI brain image using DWT and SPIHT using three wavelets such as Haar, Sym4 and Coif1. Table 3 shows the PSNR value for MRI brain image using IWT and SPIHT using three wavelets such as Haar, Sym4 and Coif1. Table 4 shows the MSE value for MRI brain image using IWT and SPIHT using three wavelets such as Haar, Sym4 and Coif1. Table 5 shows the performance metric of PSNR value for CT lung image using DWT and SPIHT using three wavelets such as Haar, Sym4 and Coif1. Table 6 shows the MSE value for CT lung image using DWT and SPIHT using three wavelets such as Haar, Sym4 and Coif1. Table 7 shows the PSNR value for CT lung image using IWT and SPIHT using three wavelets such as Haar, Sym4 and Coif1. Table 8 shows the MSE value for CT lung image using IWT and SPIHT using three wavelets such as Haar, Sym4 and Coif1. The simulation is done using MATLAB. The performance metric is evaluated on grayscale MRI brain image and CT lung image.

Table 1. PSNR value for brain image using DWT and SPIHT

BPP	HAAR	SYM4	COIF1
	SPIHT+DWT		
	PSNR	***PSNR***	***PSNR***
0.25	36.82	43.26	40.92
0.50	40.52	48.97	45.71
0.75	43.57	52.49	49.01
1.00	46.20	54.75	51.69
1.25	48.16	54.86	53.64
1.50	50.22	54.88	53.82
1.75	51.88	55.25	54.14
2.00	53.41	55.88	54.56

Table 2. MSE value for brain image using DWT and SPIHT

BPP	HAAR	SYM4	COIF1
	SPIHT+DWT		
	MSE	***MSE***	***MSE***
0.25	3.68	1.75	2.29
0.50	2.40	0.91	1.32
0.75	1.69	0.61	0.90
1.00	1.25	0.47	0.66
1.25	1.00	0.46	0.53
1.50	0.79	0.44	0.52
1.75	0.65	0.30	0.50
2.00	0.54	0.25	0.48

Table 3. PSNR value for brain image using IWT and SPIHT

BPP	HAAR	SYM4	COIF1
	SPIHT+IWT		
	PSNR	***PSNR***	***PSNR***
0.25	36.88	33.31	39.01
0.50	41.52	36.60	43.24
0.75	44.55	36.67	46.37
1.00	47.25	36.77	50.88
1.25	48.98	36.88	52.64
1.50	52.20	37.75	53.01
1.75	53.56	38.75	54.87
2.00	56.45	39.88	53.88

Table 4. MSE value for brain image using IWT and SPIHT

BPP	HAAR	SYM4	COIF1
	SPIHT+IWT		
	MSE	***MSE***	***MSE***
0.25	3.41	5.51	3.64
0.50	2.26	3.77	2.95
0.75	1.60	3.70	1.88
1.00	1.24	3.41	1.98
1.25	0.98	3.10	1.56
1.50	0.50	2.10	0.98
1.75	0.45	1.75	0.78
2.00	0.35	1.61	0.54

Table 5. PSNR value for lung image using DWT and SPIHT

BPP	HAAR	SYM4	COIF1
	SPIHT+DWT		
	PSNR	***PSNR***	***PSNR***
0.25	36.61	42.88	42.55
0.50	40.32	47.99	47.12
0.75	43.37	51.53	51.12
1.00	46.14	54.78	54.5

1.25	48.10	54.65	54.25
1.50	50.28	54.98	53.24
1.75	51.87	55.78	55.47
2.00	53.43	56.99	55.89

Table 6. MSE value for lung image using DWT and SPIHT

BPP	**HAAR**	**SYM4**	**COIF1**
	SPIHT+DWT		
	MSE	***MSE***	***MSE***
0.25	3.77	1.90	1.98
0.50	2.46	1.02	1.05
0.75	1.73	0.68	0.71
1.00	1.26	0.48	0.53
1.25	1.00	0.47	0.49
1.50	0.78	0.44	0.46
1.75	0.65	0.30	0.43
2.00	0.54	0.20	0.41

Table 7. PSNR value for lung image using IWT and SPIHT

BPP	**HAAR**	**SYM4**	**COIF1**
	SPIHT+IWT		
	PSNR	***PSNR***	***PSNR***
0.25	38.72	32.53	40.45
0.50	40.82	32.72	45.76
0.75	43.71	35.49	47.88
1.00	46.85	35.50	50.68
1.25	49.76	35.51	52.08
1.50	50.49	37.70	53.47
1.75	53.24	38.12	53.88
2.00	54.99	39.25	56.42

Table 8. MSE value for lung image using IWT and SPIHT

BPP	**HAAR**	**SYM4**	**COIF1**
	SPIHT+IWT		
	MSE	***MSE***	***MSE***
0.25	2.95	6.02	3.40
0.50	2.06	5.90	2.60
0.75	1.98	4.29	2.35
1.00	1.16	4.28	1.86
1.25	0.83	3.56	1.66
1.50	0.74	3.32	1.44
1.75	0.50	3.20	1.37
2.00	0.36	2.20	1.26

V. COMPARATIVE ANALYSIS

The comparative analyses are performed using DWT-SPIHT and IWT-SPIHT with three wavelets such as Haar, Sym4 and Coif1. The results are obtained on gray scale CT lung and MRI brain image. The Performance metrics such as BPP, PSNR and MSE are measured for each image. Figures 2 to 9 show the comparative analysis of DWT-SPIHT and IWT-SPIHT.

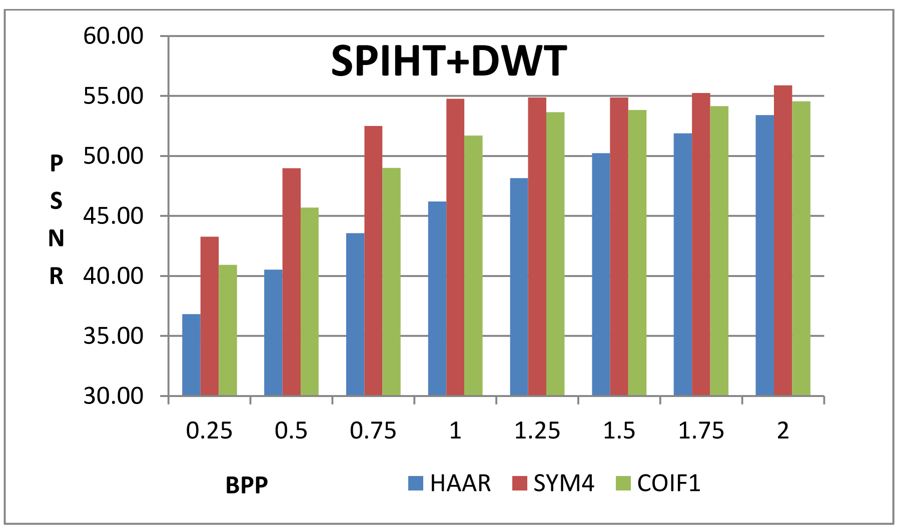

Figure 2. Comparative Analysis of PSNR for brain image using DWT and SPIHT with three wavelet filter

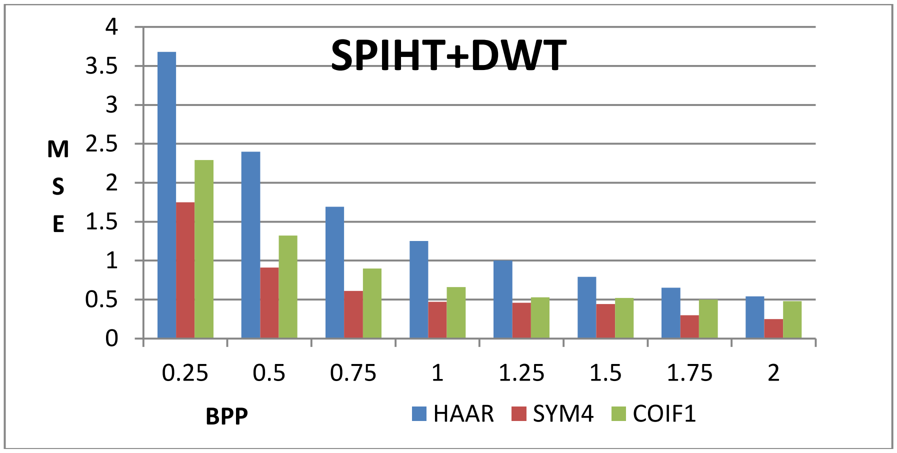

Figure 3. Comparative Analysis of MSE for brain image using DWT and SPIHT with three wavelet filter

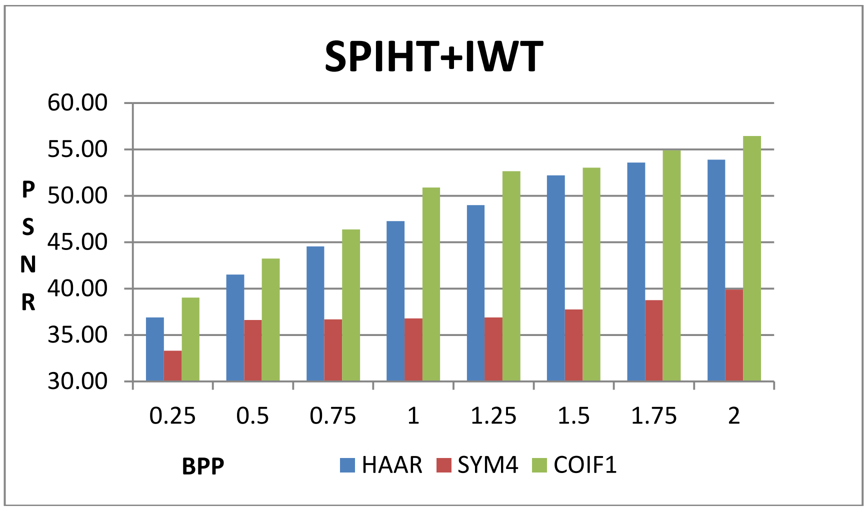

Figure 4. Comparative Analysis of PSNR for brain image using IWT and SPIHT with three wavelet filter

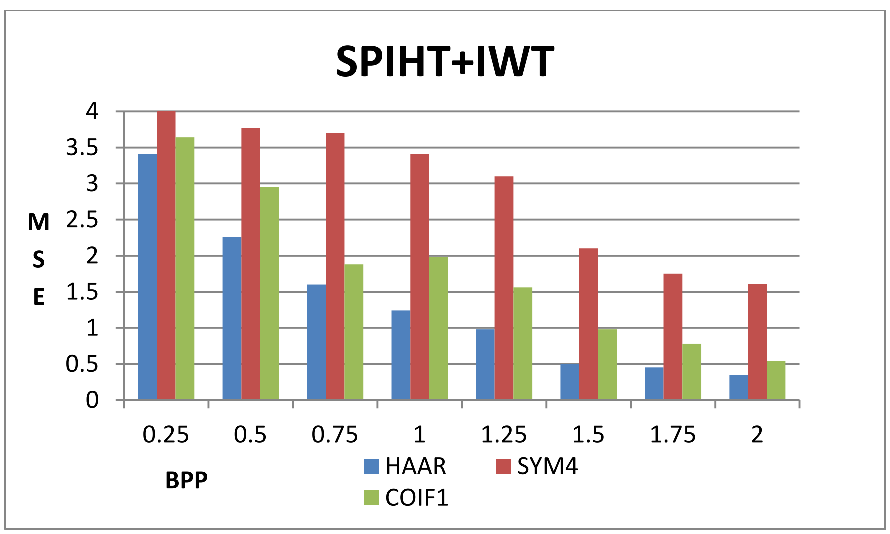

Figure 5. Comparative Analysis of MSE for brain image using IWT and SPIHT with three wavelet filter

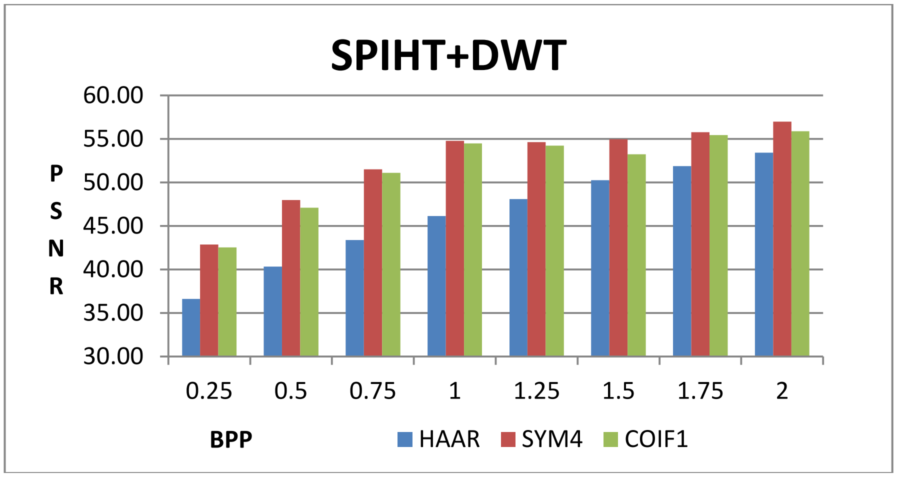

Figure 6. Comparative Analysis of PSNR for lung image using DWT and SPIHT with three wavelet filter

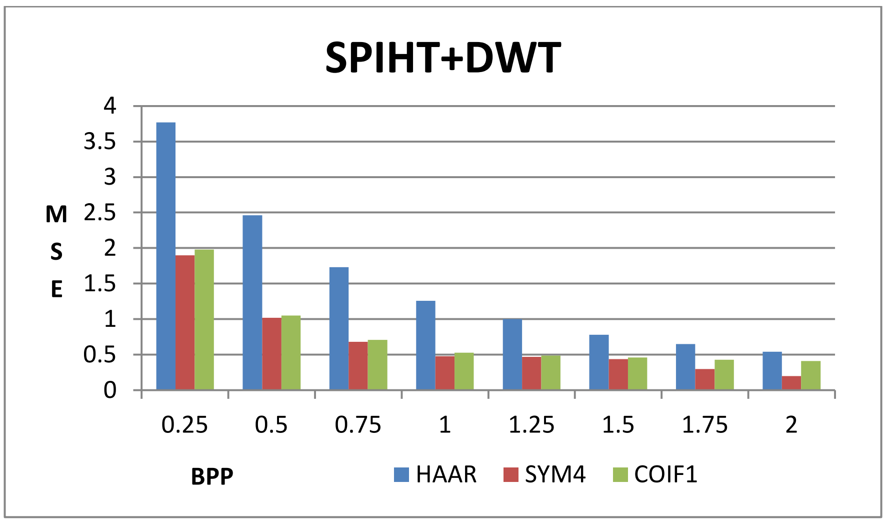

Figure 7. Comparative Analysis of MSE for lung image using DWT and SPIHT with three wavelet filter

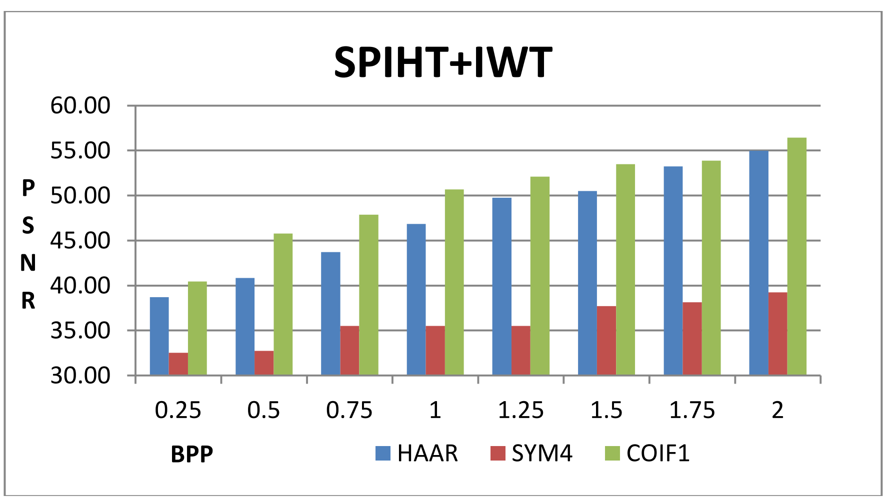

Figure 8. Comparative Analysis of PSNR for lung image using IWT and SPIHT with three wavelet filter

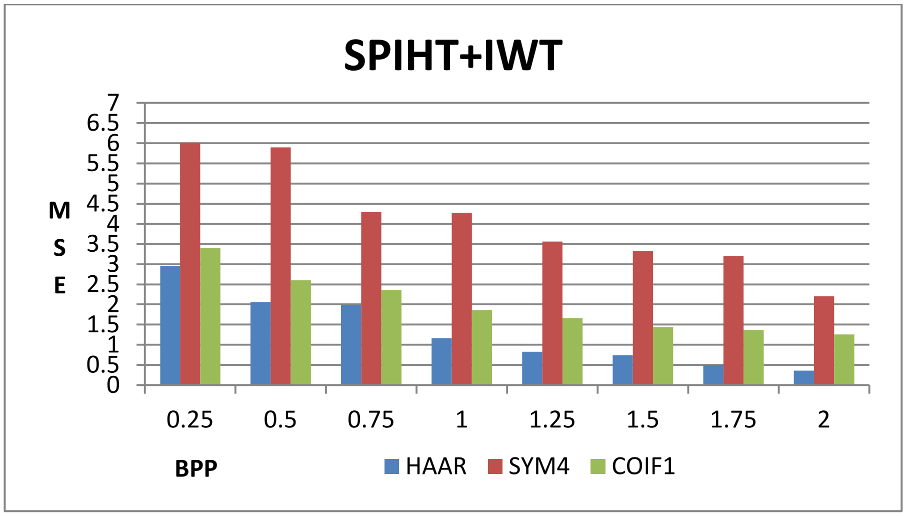

Figure 9. Comparative Analysis of MSE for lung image using IWT and SPIHT with three wavelet filter

VI. CONCLUSION AND FUTURE SCOPE

In medical image processing, image compression is very significant. The percentage of loss of data provides improper diagnosing the patient. In this work, the performance of the SPIHT technique is analyzed with DWT and IWT. Also, three wavelets namely as Haar, Sym4, and Coif1 are analyzed on gray scale CT lung image and MRI brain image. PSNR is the most commonly used measure to find the image quality. To increase the PSNR value the image has to be compressed without any loss of quality in the original image. From the analysis, the PSNR is increased while using sym4 wavelet filter in SPIHT+DWT for brain and lung images. Using Coif1 wavelet filter in SPIHT+IWT for brain and lung images gives high PSNR value. It is concluded from the results that coif1 and sym4 wavelets give high PSNR value using SPIHT+DWT and SPIHT+IWT. In future, an efficient compression technique will be used and compared over a large data set of images and also on video files.

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