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High Performance Medical Image Compression using 2D Bi-Orthogonal Multiwavelet and Hybrid SPECK - Deflate Algorithm

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Abstract- **Communication of medical diagnostic information became a big challenge for today's researchers. Faster communication of medical information with minimal bandwidth without sacrificing the diagnostic information is necessary. Compressions of medical information prior to transmission help us to achieve the better communication with minimal bandwidth within short time. This paper concentrates on minimizing the transmission bandwidth by compressing the medical information using hybrid algorithm which uses 2D Bi-Orthogonal multiwavelet transform and SPECK – Deflate encoder. The performance of this algorithm is studied with a2D brain images.The subjective and objective quality of the algorithm is comparedalong with existing algorithms in order to study the performance of the proposed algorithm. The qualitative and quantitative analysis is studied and revealed a better compression ratio than traditional compression algorithm.**

Keywords: Angiogram compression, Medical Image compression, Multiwavelet compression, SPECK

I. INTRODUCTION

Medical image compression is a technique in digital image processing to compress the medical images without loss of diagnostic information. The storage of medical images for numerous patients is a big challenge faced by the medical organizations due to its higher storage cost and larger file size. The main goal of this paper is to propose a compression algorithm without compromising the diagnostic information or the quality of the medical information. Compression can be either lossy or lossless but based on the application and information criticality, the algorithm needs to be chosen. For medical information, the lossless or near lossless algorithm needs to be selected due to the presence of critical diagnostic information.

This paper proposes a novel hybrid three stage compression algorithms and evaluates the objective and subjective quality assessment results in order to prove the efficiency of the proposed algorithm. In the recent years, many compression techniques have been proposed for the medical diagnostic information such as MRI, CT images, ECG signals and Ultra scan videos. In the previous work, a compression technique using discrete wavelet transform and hybrid SPIHT deflate algorithm was proposed for medical diagnostic images. On studying the performance, we noted that the reduction in size of 50% was attained with minimal computation time [1]. Somassoundaram et al. presented a compression algorithm using multiwavelet and hybrid SPIHT algorithm for ECG signal with better compression ratio and PSNR [2].Baretta et al proposed a lossy compression technique using DCT to preserve the fine details of the medical diagnostic information [4]. Ho et al proposed a DWT based compression technique for medical diagnostic information using motion compensation prediction to remove the inter frame correlations [5]. They claim that they achieved high quality and high compression ratio when applied to the coronary angiogram sequence. Gibson et al proposed a wavelet based compression technique for the medical diagnostic information in which more number of bits is allocated to the diagnostically significant areas. The coefficients are encoded using 3D- SPIHT algorithm [6][3]. Somassoundaram et al. presented a compression algorithm using multiwavelet hybrid SPECK algorithm for the angiogram sequence which resulted in higher compression ratio and better PSNR [7].

The rest of the paper is organized is as follows. In Section 2, the hybrid three stage algorithms with Multi wavelet – SPECK and Deflate algorithm along with overview of multiwavelet, SPECK algorithm is presented. In Section 3, a brief overview of the quality metrics taken for the assessment is provided. In Section 4, the simulation results and comparative results have been discussed and in Section 5, the paper is concluded.

II. METHODOLOGY

The flow diagram in figure-1 explains the proposed hybrid three stage algorithms with multiwavelet-SPECK and Deflate algorithm. Unlike normal images, medical diagnostic images cannot be processed with all the algorithms due to the presence of significant diagnostic information in it. The medical diagnostic images are pre-processed by using the filters to remove the noise during acquisition. Then multiwavelet transform is applied on the pre-processed image and the coefficients are decomposed using SPECK encoder. The encoded output is compressed using deflate algorithm. The compressed output was greatly reduced in storage space. To restore the medical diagnostic image, the compressed image was decompressed using deflate algorithm and then decoded using the SPECK and inverse multiwavelet transform is applied to it. The reconstructed medical diagnostic image yields a better PSNR and preserves the diagnostic information.

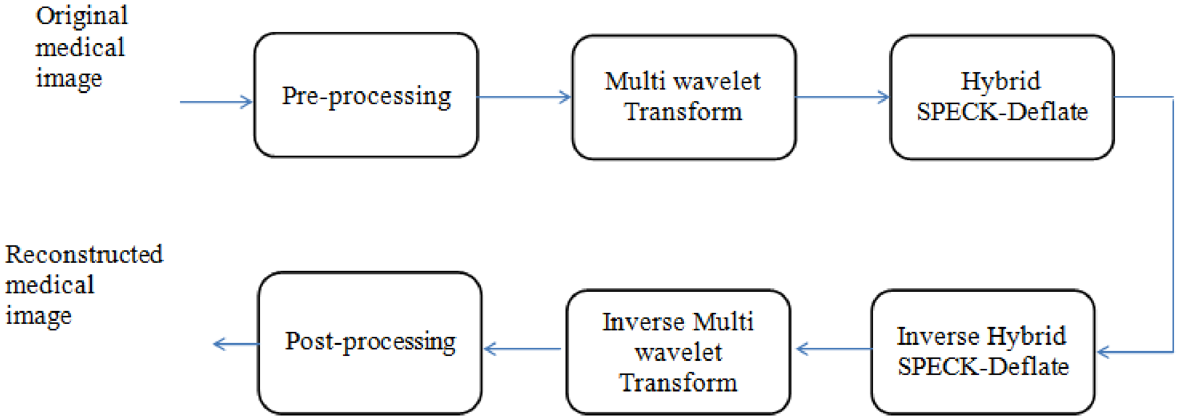

Fig 1. Flow diagram of the proposed algorithm

For better understanding of the proposed algorithm, an overview of multiwavelet transform and SPECK deflate algorithm is better explained in [3].

III. QUALITY METRICS

This paper assesses the objective quality of the hybrid three stage algorithms with multiwavelet – SPECK and deflate algorithm.

Statistical measure based on the Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) is performed for the Objective Quality measure assessment. Structural similarity was also studied in this paper for the Objective Quality measure assessment. The Objective Quality measure assessment metric was calculated as provided below in (1), (2) and (3).

$$MSE = \frac{\sum_i \sum_j (r_{ij} - x_{ij})^2}{M \times N} \quad (1)$$

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (2)$$

Where *r* refers to original image, *x* denotes restored image, M x N is the size of processed image.

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{x,y} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad (3)$$

Where μ_x is the average of *x* given by

$$\mu_x = \frac{1}{N}\sum_{i=1}^{N} x_i,$$

μ_y is the average of *y* given by

$$\mu_y = \frac{1}{N}\sum_{i=1}^{N} y_i,$$

Standard Deviation of *x* given by

$$\sigma_x = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \mu_x)^2}$$

Standard Deviation of y given by

$$\sigma_y = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(y_{i-}\sigma_y)^2}$$

C_1= $(K_1L)^2$, C_2= $(K_2L)^2$ are two variables to stabilize the division with weak denominator; L the dynamic range of the pixel-values (for an 8 bit image it takes from 0 to 255), K_1=0.01 and K_2=0.03 by default.

IV. SIMULATION RESULTS AND DISCUSSION

The efficiency of the algorithm was tested by conducting few experiments. A MATLAB GUI was developed. The performance of the hybrid three stage algorithms with multiwavelet – SPECK and Deflate algorithm was tested with the brain test dataset. Bi-Orthogonal wavelet families have been concentrated for this experiment.

Experiment 1: The proposed algorithm is tested with various brain image database available in Osirix [8]. Objective analysis is carried out to prove the efficiency of algorithm.

TABLE I. Comparison of performance evaluation of various multiwavelet families applied to SPECK encoder for various Brain images of Osirix

Image	Wavelet Family	MSE	PSNR	UIQI	SSIM
IM1	Bih52s	9.73	38.25	0.68665	0.94641
	Bih54s	4.27	41.83	0.73368	0.97240
	Bighm2	0.52	50.91	0.78264	0.99586
IM2	Bih52s	9.85	38.16	0.68297	0.94848
	Bih54s	4.32	41.78	0.72612	0.97341
	Bighm2	0.52	51.00	0.77200	0.99619
IM3	Bih52s	9.71	38.26	0.67720	0.94852
	Bih54s	4.21	41.88	0.71855	0.97412
	Bighm2	0.51	51.06	0.76108	0.99632
IM4	Bih52s	9.84	38.20	0.66691	0.94790
	Bih54s	4.25	41.84	0.70876	0.97386
	Bighm2	0.49	51.19	0.75069	0.99367
IM5	Bih52s	9.96	38.15	0.65939	0.94871
	Bih54s	4.26	41.84	0.69866	0.97429
	Bighm2	0.47	51.36	0.74060	0.99667

From Table I, it is seen that the Bighm2 performs efficiently than the other wavelet families. From Figure 2 – 5, shows the comparison of performance in terms of the objective quality analysis with various multiwavelet families.

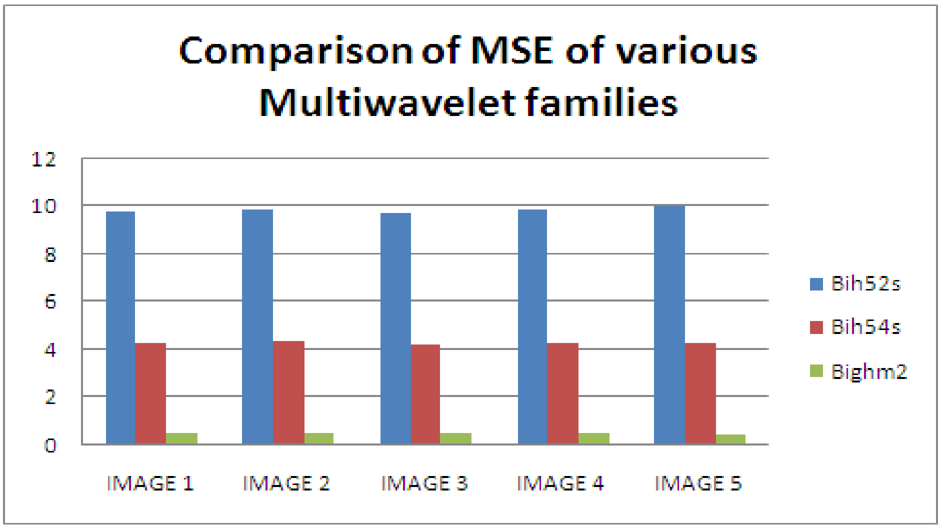

Fig 2 Comparison of MSE of proposed algorithm with various Multiwavelet families.

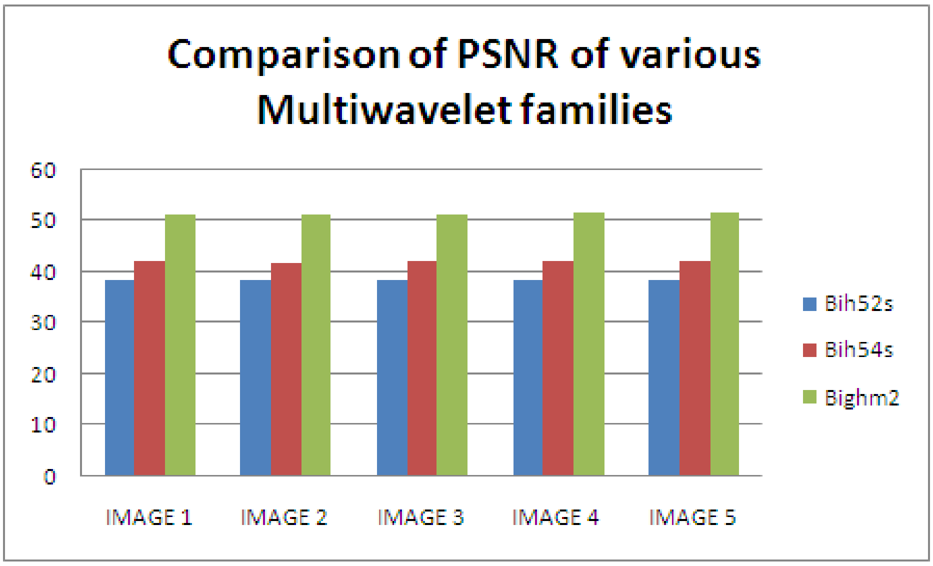

Fig 3.Comparison of PSNR of proposed algorithm with various Multiwavelet families.

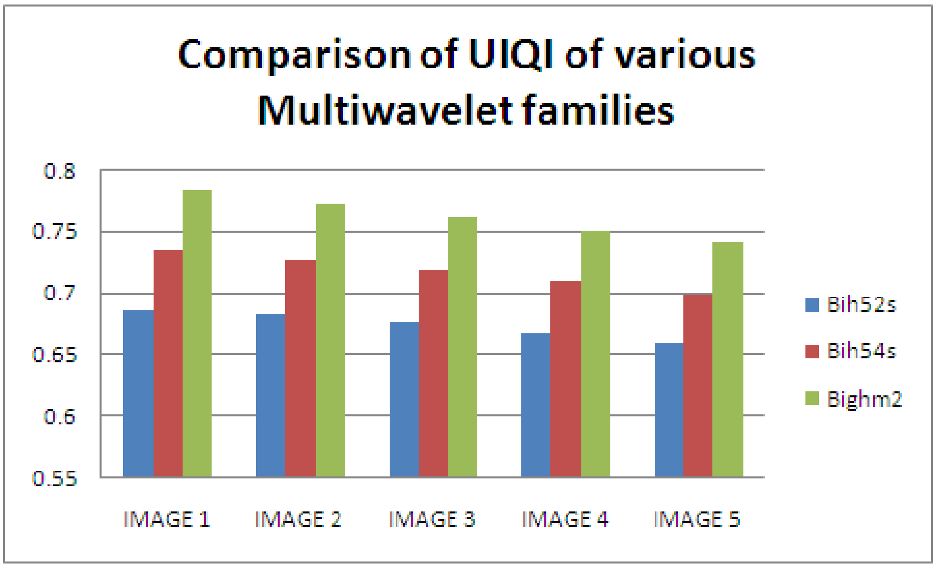

Fig 4.Comparison of UIQI of proposed algorithm with various Multiwavelet families.

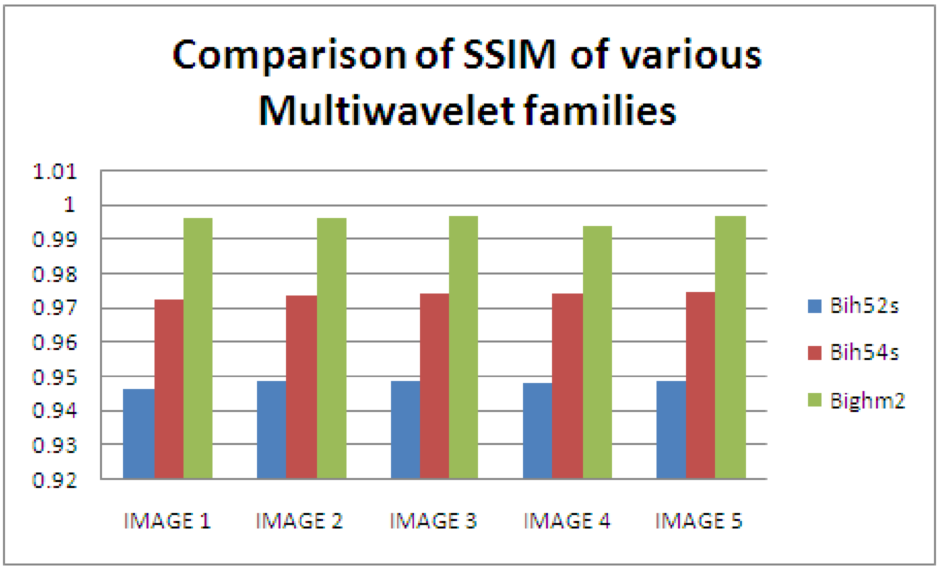

Fig 5 Comparison of SSIM of proposed algorithm with various Multiwavelet families.

Experiment 2: The proposed algorithm is compared with previous literatures for the Brain images taken for the study.

TABLE II.Comparison of performance evaluation of various multiwavelet families applied to SPECK encoder for various Brain images of Osirix

Image	Wavelet Family	MSE	PSNR
IM1	Multiwavelet + SPIHT	9.608	28.30
	Proposed Algorithm	0.52	50.91
IM2	Multiwavelet + SPIHT	10.092	28.09
	Proposed Algorithm	0.52	51.00
IM3	Multiwavelet + SPIHT	9.928	28.16
	Proposed Algorithm	0.51	51.06
IM4	Multiwavelet + SPIHT	10.038	28.11
	Proposed Algorithm	0.49	51.19
IM5	Multiwavelet + SPIHT	10.27	28.01
	Proposed Algorithm	0.47	51.36

From Table II, the proposed algorithm performs efficiently than the existing algorithm by providing better PSNR. Figure 6-7 shows the performance interms of PSNR and MSE of the proposed algorithm is better than the existing algorithm.

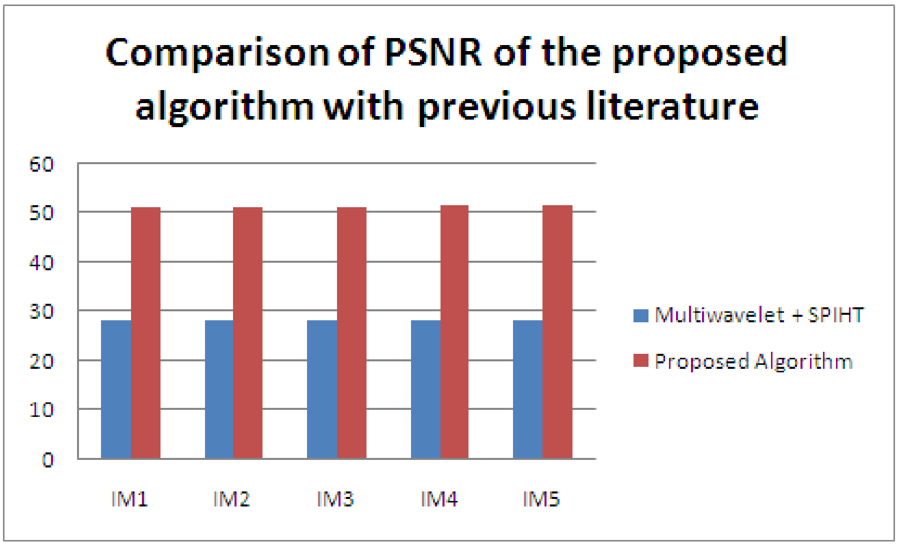

Fig 6 Comparison of PSNR of proposed algorithm with previous literature.

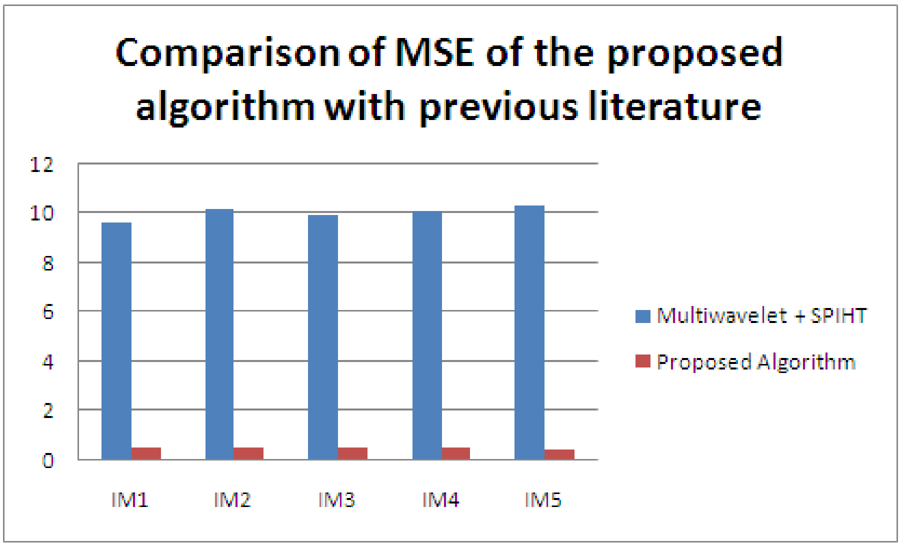

Fig 7 Comparison of MSE of proposed algorithm with previous literature.

V. CONCLUSION

In this paper, an efficient compression technique using Multiwavelet transform and Hybrid SPECK deflate algorithm has been presented for the 2D medical diagnostic images. The main goal is to achieve low transmission cost and reduction in storage space required for the medical diagnostic information with better quality. Objective assessment is performed on the proposed algorithm to ensure the better performance of the proposed algorithm compared to existing algorithms. This research will further more focus on the reduction of computation time of the proposed algorithm.

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