An Improved Hadamard-Coiflets Transform for Image Compression with Arithmetic Coding

Priyatosh Halder

***Abstract*— Recently the growths of the digital imaging applications have increased the need of various image compression techniques. To remove the redundant information from the image the image compression is used. With the help of image compression we can store the essential information of the image so that the storage size, the time and bandwidth of transmission get reduce. Recently the research on image compression techniques inspired us to propose Hadamard-Coiflets transform with arithmetic coding to increase the visual quality of image. The improved Hadamard-Coiflets transform with arithmetic coding is good techniques of compression and can able to give higher PSNR value as compared to various existing methods. Here the Hadamard-Coiflets transform is applice first and then on each block of the low frequency subband and split all values from each transformed block followed by applying arithmetic coding for image compression.**

***Index Terms*— Image Compression, Hadamard-Coiflets Transform and Arithmetic Coding.**

I. INTRODUCTION

Recently an important issue is created regarding the image transmission and storing due to increase the image related applications. The transmission and storage of image require considerable amount of bandwidth and space. The image compression addresses these problems. To represent an image it reduces the required bit rates. So, in the age of digital communication, the image compression takes an important role in the field of research.

Over the last few decades, a greater improvement has been made in image compression because of demand for storage and transmission of visual information. As personal computer having the capability to represent the sophisticated pictures as a digital image people started to find out the way of efficient representation of these images for efficient transmission and low disc storages. There are two types of approaches of image compression: predictive approach and transformation approach. In the field of transformation approach various types of transform method is used. Widely the image compression is divided into two types: lossless compression techniques and lossy compression techniques [1]. In lossless compression we can able to recover the original images. It gives low compression ratio. In case of lossy compression, the redundant information which is not perceptible by the human eyes is removed. Here after decompression we can't recover the original image. As it gives higher compression ratio, in various applications it is preferred. Mostly the transformation approach is used in case of lossy image compression.

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Initially, in case of transform coding method, the DCT [2] was the popular transform for image compression because it can able to give the optimal performance and easily implementable. There are various algorithms such as for still images JPEG [3] and for videos MPEG [4] based on the DCT. As it applied on the blocked image it is not possible to eliminate the correlation across the block boundary. Using the wavelet transform [5] this demerit can be overcome. The wavelet transform gives the time and frequency analysis of data and it is applied on the whole image of without blocking it. In case of the image compression, the transform, quantization, modeling, ordering and entropy encoding are the main stages. The existing research shows that for a successful algorithm of image compression the modeling and ordering takes an important role. In this paper we have proposed a new algorithm based on a novel scheme of modeling and ordering in the wavelet domain pixels classification [6].

It is seen that there has been various attempts to design the next generation image coding techniques. Recently, various image compress such as EZW [7], EBCOT [8], JPEG 2000 [9], GW [10] and SPHIT [11] image coding method has been introduced. The paper can be organized in the following ways: section II it is discussed the review of literature. And in section III my proposed method based on Hadamard-Coiflets transform with arithmetic coding is explained. Section IV deals the simulation results and it comparison with the various existing methods. And finally, in section V it is shared the conclusion and future work.

II. REVIEW OF LITERATURE

Marc Antonini et al. in [12] described that the image compression is now essential for applications such as transmission and storage in data bases. This paper proposed a new scheme for image compression taking into account psychovisual features both in the space and frequency domains; this new method involves two steps. First, it is used a wavelet transform in order to obtain a set of biorthogonal subclasses of images; the original image is decomposed at different scales using pyramidal algorithm architecture. The decomposition is along the vertical and horizontal directions and maintains constant the number of pixels required to describe the image. Second, according to Shannon's rate distortion theory, the wavelet coefficients are vector quantized using a multi-resolution codebook. Furthermore, to encode the wavelet coefficients, it proposed a noise shaping bit allocation procedure which assumes that details at high resolution are less visible to the human eye. Finally, in order to allow the receiver to recognize a picture as quickly as possible at minimum cost, it is presented a progressive transmission scheme.

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It is shown that the wavelet transform is particularly well adapted to progressive transmission. Iren Valova et al. in [13] represented that a general algorithm for decomposition and compression of grayscale images. The decomposition can be expressed as a functional relation between the original image and the Hadamard waveforms. The dynamic adaptive clustering procedure incorporates potential functions as a similarity measure for clustering as well as a reclustering phase. The latter is a multi-iteration, convergent procedure which divides the inputs into non-overlapping clusters. These two techniques allow us to efficiently store and transmit a class of half-tone medical images such as magnetic resonance imaging (MRI) of the human brain. Due to the redundant image structure of MRI, obtained after the decomposition and clustering, almost half of the image can be omitted all together. Naturally, the compression rates for this specific type of grayscale image are increased greatly. A run-length coding is performed in order to compress further the retained information from the first two steps. Although all the techniques applied are simple, they represent an efficient way to compress grayscale images. The algorithm exhibits a performance which is competitive and often outperforming some of the methods reported in the literature.

Sonja Grgic et al. in [14] explained a set of wavelet functions (wavelets) for implementation in a still image compression system and to highlight the benefit of this transform relating to today’s methods. The paper discusses important features of wavelet transform in compression of still images, including the extent to which the quality of image is degraded by the process of wavelet compression and decompression. Image quality is measured objectively, using peak signal-to-noise ratio or picture quality scale, and subjectively, using perceived image quality. The effects of different wavelet functions, image contents and compression ratios are assessed. A comparison with a discrete-cosine-transform-based compression system is given. Our results provide a good reference for application developers to choose a good wavelet compression system for their application.

Arthur Petrosian et al. in [15] elaborated that there is no future for telemedicine without signal compression. In fact the very idea of sending X-rays and other medical images and information electronically could not have brought up without advances in compression technology over the past two decades. Leading compression standards, such as JPEG/ MPEG [4] and those based on Hadamard matrix 121, have been successfully implemented in numerous signal/ image coding/decoding applications ranging from satellites to medical imaging. On the other hand, ever-increasing requirements in signal recognition and transmission, particularly related to telemedicine, have challenged the researchers to develop new compression techniques better suited for each practical situation. The wavelet technology emerged as one of the most promising tools in that direction. Both wavelet and Hadamard transform based algorithms provide excellent quality biomedical signal reconstruction at high compression ratios and can be implemented in real-time on existing microprocessors. The objective of this study is to construct hybrid Hadamard-wavelet transforms and to develop corresponding optimal zonal sampling methods with the use of such transforms. The designed hybrid transforms can be useful in various specific signal processing applications where combining properties of Hadamard and wavelet transforms may be of particular benefit.

Sunil Malviya et al. in [16] represented that with the increasing demand of storage and transmission of digital images, image compression is now become an essential applications for storage and transmission. This paper proposes a new scheme for image compression using DWT (Discrete Wavelet Transform) taking into account sub-band features in the frequency domains. Method involves two steps firstly a two levels discrete wavelet transforms on selected input image. The original image is decomposed at different 8x8 blocks, after that apply 2D-Walsh-Wavelet Transform (WWT) on each 8x8 block of the low frequency sub-band. Firstly dividing each sub-band by a factor and then apply Arithmetic Coding on each sub-band independently. Transform each 8x8 block from LL2, and then divide each block 8x8 separated into; DC value and compressed by Arithmetic coding.

Dong Liu et al. in [17] explained that the image compression utilizing visual redundancy is investigated. Inspired by recent advancements in image inpainting techniques, we propose an image compression framework towards visual quality rather than pixel-wise fidelity. In this framework, an original image is analyzed at the encoder side so that portions of the image are intentionally and automatically skipped. Instead, some information is extracted from these skipped regions and delivered to the decoder as assistant information in the compressed fashion. The delivered assistant information plays a key role in the proposed framework because it guides image inpainting to accurately restore these regions at the decoder side. Moreover, to fully take advantage of the assistant information, a compression-oriented edge-based inpainting algorithm is proposed for image restoration, integrating pixel-wise structure propagation and patch-wise texture synthesis. It is also constructed a practical system to verify the effectiveness of the compression approach in which edge map serves as assistant information and the edge extraction and region removal approaches are developed accordingly. Evaluations have been made in comparison with baseline JPEG and standard MPEG-4 AVC/H.264 intra-picture coding. Experimental results show that our system achieves up to 44% and 33% bits-savings, respectively, at similar visual quality levels. Here the proposed framework is a promising exploration towards future image and video compression.

After reviewing the various presented image compression methods a techniques which come in my mind that is Hadamard-Coiflets transform with arithmetic coding to fill up the missing techniques.

III. PROPOSED METHOD

Here our proposed method for image compression are summarizing as the following steps:

1. Choose an input image.

2. Select the Coiflets which is used for compression.

3. From the standard parameter set select the quantization factor parameters, which is denoted by Q1 and Q2.

4. Set compression ratio factor (CRF) from range 1-10.

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5. Apply the Hadamard-Coiflets transform and then use the arithmetic coding to compress the image.

Step 5 consists of the following:

5.1 Two levels Discrete Coiflets Transform.

5.2 Apply 2D Hadamard Transform on each 8x8 block of low frequency sub-band.

5.3 Split all values form each transformed block 8x8.

5.4 Compress each sub-band by using the Arithmetic coding, the first part of Hadamard-Coiflets compression steps for high frequency, domains, and then second part of the Hadamard-Coiflets compression steps for low frequency.

6. The output image is obtained by the compression.

The flow chart of our proposed method is given below:

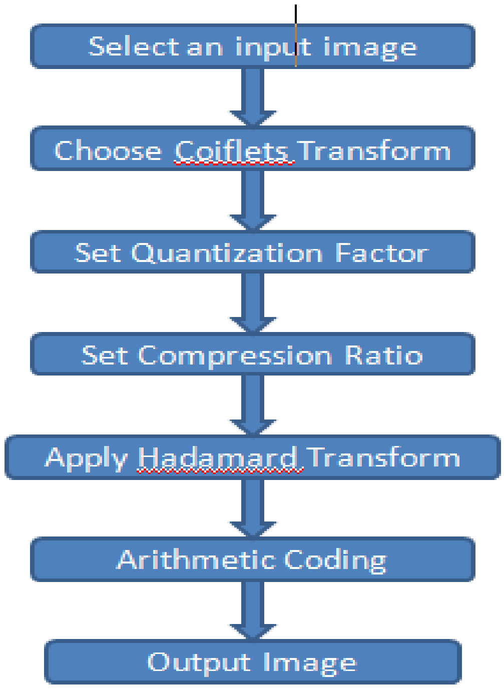

Fig -1: Flow chart of proposed method

IV. RESULTS AND ANALYSIS

As a test images it three classic images are selected here: Lena image, Barbara image and Mandrill image. The size of the each classic image is 512x512. The test images are shown in the figure 2.

Fig -2: Test Images

The proposed method is applied the above three classic images. Using Coif5 wavelets the image compression is done. Here the value of quantization factor Q1, Q2 and compression ratio factor (CRF) is chosen as 0.02, 0.02 and 2 respectively. After getting the output results it is compared with the results of the existing methods GW, EZW, SPHIT, EBCOT and JPEG 2000. For analysis the results, the PSNR value is chosen here.

Table -1: Comparison of PSNR of proposed method with the different existing method

Methods	PSNR (in db)		
	LENA	**BARBARA**	**MANDRILL**
GW	31.39	32.84	30.20
EZW	30.38	28.54	32.23
SPHIT	29.30	30.32	30.90
EBCOT	28.58	29.36	31.96
JPEG 2000	29.58	30.96	31.90
Proposed Method	**32.99**	**33.52**	**32.39**

Table -1 shows the result of comparison of PSNR value of Lena image, Barbara image and Mandrill image of different existing methods such as with the proposed algorithm.

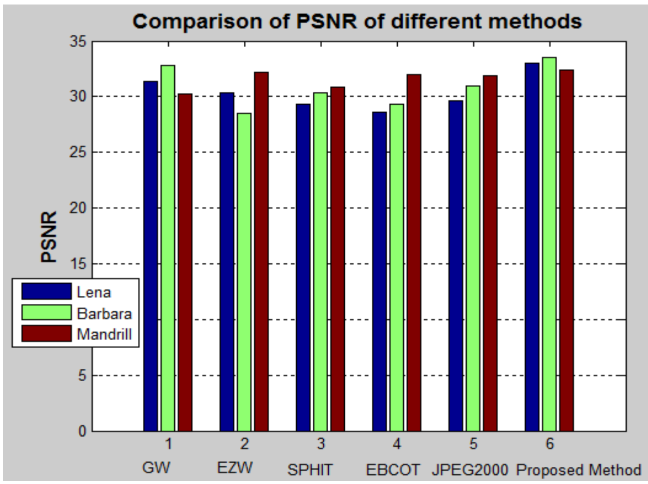

Fig -3: Comparison of PSNR of different method

It is seen from the above fig -3 and table -1 that the proposed method has able to reduce the false counting effects and blocking artifacts significantly which occurs during the image reconstruction. According to the table-1 it is seen that the proposed method gives the PSNR value 32.99 dB, 33.52 dB and 32.39 dB for the Lena image, Barbara image and Mandrill image respectively.

V. CONCLUSION AND FUTURE WORK

To analyze the signals the wavelet transform is a powerful tool. Among the various applications of the wavelet transform; one is image compression.

For image compression the Coiflets transform is simple and effective algorithm as compared to other algorithms such as GW, EZW, SPHIT, EBCOT and JPEG 2000. Here the quality of compressed image is also maintained. In this paper it is presented an image compression framework that adopts Coiflets with Hadamard transform to remove the redundancy from images. Hence an improved image compression algorithm is proposed with this correspondence. It is capable to restore the removed regions for good visual quality. This new method can also reduced the blocking artifacts and false contouring significantly. As a future work it can be extended the quality of the picture with the increasing compressed ratio factor. Also in near future by using different type of compression techniques and different transforms as well as using different discrete wavelet with our method better results we can expect.

REFERENCES

1. M.A. Losada, G. Tohumouglu, D. Fraile and A. Artes, "Multi-iteration wavelet zerotree coding for image compression", Sci. Signal Process., vol. 80 pp. 1281-1287, 2000.
2. N. Jayant, J. Johnston and R. Safranek, "Signal compression based on models of human perception", Proc. IEEE, vol. 81, no. 10, pp. 1385-1422, Oct. 1993.
3. A. Skodras, C. Christopoulos, and T. Ebrahimi, "The JPEG2000 still image compression standard," IEEE Signal Process. Mag., vol. 18, pp. 36–58, Sep. 2001.
4. MPEG-2video, ITU-T-Recommendation H.262-ISO/IEC 13818-2, Jan. 1995.
5. Ronald A. DeVore, Bjorn Jawerth and Bradley J. Lucier, "Image Compression Through Wavelet Transform Coding", IEEE Transactions on Information Theory, Vol. 38. No. 2, March 1992.
6. D. Taubman, E. Ordentlich, M.Weinberger, G. Seroussi, I. Ueno, and F. Ono, "Embedded block coding in JPEG2000," in Proc. Int. Conf. Image Processing, vol. 2, 2000, pp. 33–36.
7. J. M. Shapiro, "Embedded image coding using zerotrees of wavelet coefficients," *IEEE Trans. Signal Process.*, vol. 41, no. 12, pp. 3445–3462, Dec. 1993.
8. S. Servetto, K. Ramchandran, and M. Orchard, "Image coding based on a morphological representation of wavelet data," *IEEE Trans. Image Processing*, vol. 8, pp. 1161–1173, Sept. 1999.
9. A. Criminisi, P. Pérez, and K. Toyama, "Region filling and object removal by exemplar-based image inpainting," *IEEE Trans. Image Process*., vol. 13, no. 9, pp. 1200–1212, Sep. 2004.
10. D. Alani, A. Averbuch, and S. Dekel, "Image coding with geometric wavelets," *IEEE Trans. Image Process*., vol. 16, no. 1, pp. 69–77, Jan. 2007.
11. A. Said and W. A. Pearlman, "A new, fast and efficient image codec based on set portioning in hierarchical trees," *IEEE Trans. Circuits Syst. Video Technol*., vol. 6, no. 3, pp. 243–250, Jun. 1996.
12. Marc Antonini, Michel Barlaud, *Member*, Pierre Mathieu, and Ingrid Daubechies, "Image Coding Using Wavelet Transform", IEEE Transactions on Image Processing, Vol. I , No *2*. April 1992.
13. Iren Valova and Yukio Kosugi, "Hadamard-Based Image Decomposition and Compression", IEEE Transactions on Information Technology in Biomedicine, Vol. 4, No. 4, December 2000.
14. Sonja Grgic, Mislav Grgic and Branka Zovko-Cihlar, "Performance Analysis of Image Compression Using Wavelets", IEEE Transactions On Industrial Electronics, Vol. 48, No. 3, June 2001.
15. Arthur Petrosian, "New Classes of Hybrid Hadamard-Wavelet Transforms for Signal-Image Processing", Proceeaings of the Second Jam EMES BMES Conference Houston TX. JSA - Oclooer 23-26, 2002.
16. Sunil Malviya ,Neelesh Gupta and Vibhanshu Shirvastava, " 2D-Discrete Walsh Wavelet Transform for Image Compression with Arithmetic Coding", 4th ICCCNT-2013.
17. Dong Liu, Xiaoyan Sun, Feng Wu, Shipeng Li and Ya-Qin Zhang, "Image Compression With Edge-Based Inpainting", IEEE Transactions on Circuits and Systems for Video Technology, Vol. 17, No. 10, October 2007.

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