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SINGULAR VALUE DECOMPOSITION AND ADAPTIVELY SCANNED WAVELET DIFFERENCE REDUCTION BASED IMAGE COMPRESSION

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Abstract: In proposed method, a novel hybrid image codec is proposed which uses singular value decomposition (SVD) and adaptively scanned wavelet difference reduction (ASWDR) technique. The proposed hybrid method retains the advantage of high peak signal to noise ratio (PSNR) value at a particular level of compression. Image is first compressed by SVD to reduce some principal components (PC) which are not significant and then the reconstructed image (using 100 PC) is given as an input to the ASWDR method. In this hybrid method ASWDR is wavelet based compression which gives high compression ratio (CR), region of interest based capability, good perceptual quality and SVD gives high PSNR value. This method is validated over some standard test images and the obtained results are compared with ASWDR, SPIHT and a hybrid technique using both SVD and WDR that exists in literature. The superiority of the proposed method is well justified quantitatively and visually using the aforementioned techniques. The approach obtained a PSNR value equal to 33.07 for lena image at a compression ratio of 64:1.
Keywords: Hybrid image codec; Adaptively scanned wavelet difference reduction; Singular value decomposition; Image compression; Lossy compression.

I. INTRODUCTION

With the increasing demand of computer technologies and its applications, there is a need to store a huge amount of data like images which require large storage space. Handling such huge amount of data not only increases the cost and space of storage but also make the transmission of images a slow process. To overcome these problems of storage and transmission, there is a need to find an efficient compression method which reduces the size of image by eliminating the redundancy without much degradation in the quality and information content of images. In image compression three type of redundancy exists one is statistical, second is psycho visual and last is the coding redundancy [1]. Image compression is done by reducing the number of data bits used to represent the image by using different encoding approaches. Compression of image can be classified into two categories, either lossy compression or lossless compression [2]. In the lossless approach there is no loss of information and reconstructed image is perfectly matched to the original but the *CR* is very less [3]. In the lossy approach of compression, various amount of image information is lost during quantization process and image can’t be reconstructed perfectly but possesses the advantage of high *CR* [4]. Image compression process is applicable in the both spatial as well as frequency domain. In comparison to spatial domain, the frequency domain approach gives better sparse representation of an image. Apart from above approaches there are several transformation methods developed i.e. singular value decomposition(SVD) transform[2], Karhunen and Michel Loeve(KL) transform [3], discrete cosine transform (DCT) [4] and discrete wavelet transform(DWT) [5,6] also exist for image compression. The proposed work is organized as follow: first we explain the proposed image codec methodology, then the details of data set and the experimental results is presented in next section and finally conclusion and future work is given in last section.

II. THE PROPOSED IMAGE CODEC PROCESS

In this paper a hybrid image codec has been designed that uses two methods, firstly the input image is decomposed by SVD and then reconstructed image is further compressed by ASWDR as shown in Fig.1. These both are the lossy image compression techniques. SVD is an algebraic approach to solve matrices. In proposed approach SVD reduces the dimension of the input image to decompose the image into set of three matrices. Among these matrices one matrices represent the eigen values (singular values) also called principle component and rest two are the orthogonal matrix of the image. This eign values matrix are arranged in descending order so only higher order values are significant for image reconstruction[9] and among these eigen values only some of the eign value are significant and they are sufficient to reconstruct the image and rest of these eigen values are discarded. The selection of number of eign values are done by hit and trial method. The plot between PSNR, CR and number of singular values for the SVD method are shown in fig. 3. In proposed method Image is reconstructed using k=100 principal component (PC) at which desired level of CR and PSNR is achieved which are shown in fig.3 and finally this reconstructed image is further compressed by the ASWDR method. ASWDR is used to achieve high CR because SVD gives less CR at very high PSNR values[7]. In ASWDR method, firstly the reconstructed image is wavelet transformed and the wavelet coefficient’s indices are encoded using bit plane encoding process. It uses the wavelet difference reduction process on the index of wavelet transform coefficients in place of coefficient values. By this process compressed bit stream is achieved and to decode the image above steps are reversed. After decoding the important image parameters are calculated i.e. CR, PSNR and MSE are computed. The overall CR of the proposed method is given by multiplication of SVD based CR with the ASWDR based CR [8].

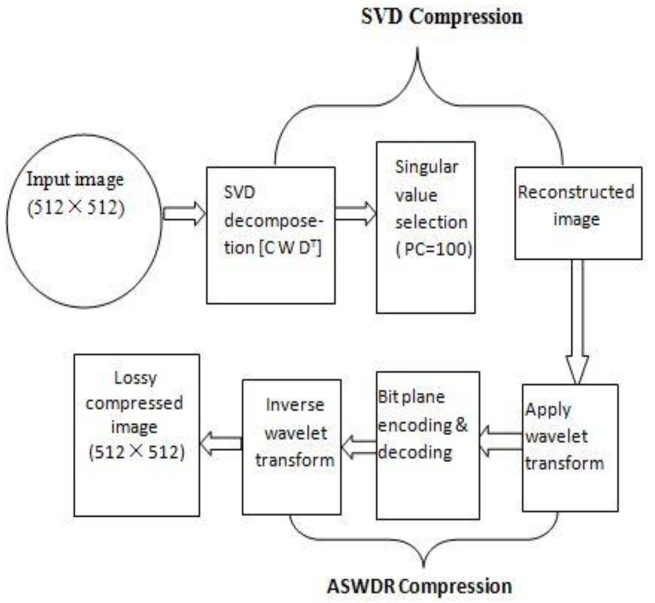


Fig.1 Block diagram of the proposed codec

III. RESULTS AND DISCUSSIONS

Set of images used in proposed method

The proposed codec applied over the different standard test images like Lena, Goldhill, Barbara, Airfield images acquired from internet repository [10]. This codec is implemented in MATLAB R2015a platform. All of the image having dimensions are 512×512, and bit depth was equal to *8* in matlab supported format(.tif).

Evaluation Metrics

The quantitative evolution parameters used for the proposed method are as follows-

Compression Ratio (CR): *CR* of an image is defined by the ratio of bits required to constitute given input image to the compressed image and is given as,

$$Compression\ Ratio = \frac{\text{Size of input Image}}{\text{Size of compressed Image}} \tag{1}$$

Peak signal to noise ratio (PSNR) **:**.

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

$$\text{Where, MSE} = \frac{\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}(I_{i\times j} - \hat{I}_{i\times j})^2}{m \times n}$$

$I_{i\times j}$ is the input image and $\hat{I}_{i\times j}$ is the reconstructed image

And *m*, *n* are the rows and columns of the input image respectively.

Experimental results and discussion on performance of proposed method

This lossy image codec is applied over different set of test images. The experiment results are shown in Table I, II and III. These tables provide the values of *PSNR* at a fixed value of compression (*CR*). Last column of tables shows the %age improvement of proposed method with respect to Rufai et al. [8].

Table [1] PSNR values in dB at the CR 64:1

Image/ Method	Walker JS. ASWDR	Said *et al.* SPIHT	Rufai *et al.* [8]	Proposed	Percentage Improved (%) w.r.t. [8]
Lena	30.48	30.61	1.88	33.07	3.732
Goldhill	27.25	27.37	3.98	34.78	2.354
Barbara	23.97	23.22	7.77	29.07	4.681
Airfield	22.20	22.41	7.65	28.92	4.593

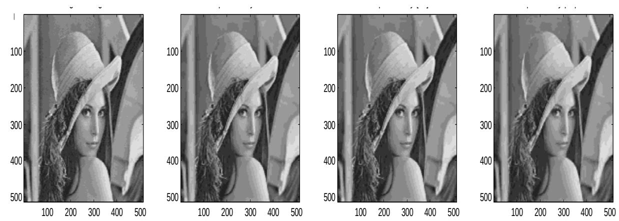
Table [2] PSNR values in dB at the CR 32:1

Image/ Method	Rufai *et al* ASWDR	Said *et al.* SPIHT	Rufai *et al* .[8]	Proposed	Percentage Improved (%) w.r.t. [8]
Lena	33.44	33.51	6.78	37.97	3.249
Goldhill	30.15	30.17	6.62	37.79	3.194
Barbara	27.07	26.92	30.67	32.07	4.564
Airfield	25.50	25.46	30.45	31.79	4.400

Table [3] PSNR values in dB at the CR 16:1

Image /Method	Walker JS. ASWDR	Said *et al.* SPIHT	Ruufai et al. [8]	Proposed	Percentage Improved (%) w.r.t. [8]
Lena	36.52	36.77	9.58	40.81	3.107
Goldhill	32.62	32.66	7.85	38.98	2.985
Barbara	30.74	30.82	3.57	35.12	4.617
Airfield	28.03	28.05	2.45	33.89	4.437

To validate the subjective quality which is the indication of visualization of image by human eyes is given in Fig. (2). This fig.2 show the lena image and compressed image using ASWDR, SPIHT, Rufai *et al.*[8] and proposed technique. It is seen that the proposed codec provides the best subjective quality of image than the existing method.



(a) (b) (c) (d)

Fig.2 (a) Original 'lena' image, and Compressed image at CR 16:1 using different method of compression (b) SPIHT (c) Rufai et al.[8]. (d) Proposed method

Loss of the information between original and the compressed image is mathematically calculated by *MSE* (mean square error). From the experiment, it is also observed that by increasing the *CR* the *PSNR* decreases (Fig.4).

The relationship between *PSNR* values(in dB) and *CR* with respect to the different number of singular values(PC) used in the proposed method for the lena image of size 512 × 512 is shown in fig.3.

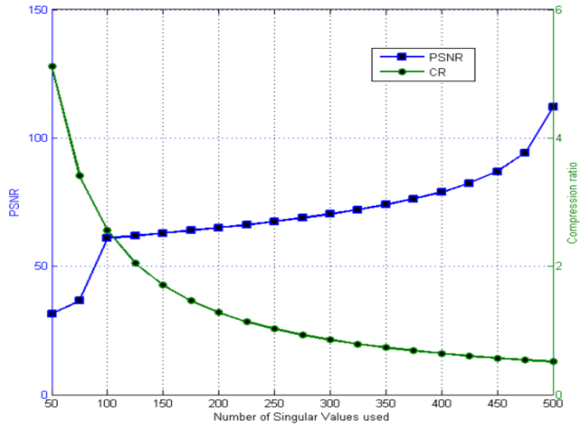


Fig.3 Graph showing the relationship between PSNR, CR and number of singular values for the SVD method in case of 'Lena' image

The relationship between *PSNR* and *CR* for 'Barbra' image is shown in Fig.4. This plot shows that proposed method give highest value of PSNR at particular of compression when comparing to the state of art techniques.

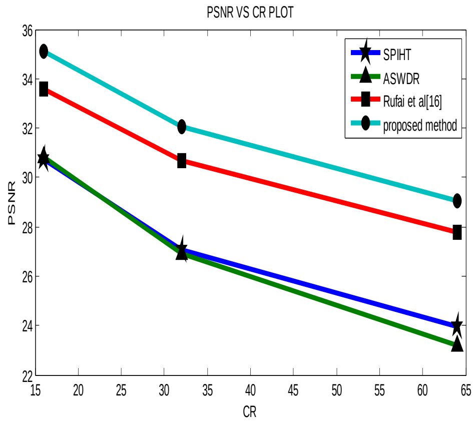


Fig.4 Comparison of PSNR(dB) vs CR for different technique in case of 'Barbra' image

IV. CONCLUSION

In the proposed work a new hybrid codec is projected. From the experimental investigation at different *CR* values it shows that this method of compression give the higher *PSNR* value and also good visual effect when compared to existing state of art techniques. The *CR* of the proposed method is calculated by multiplication of SVD based *CR* with the ASWDR based *CR*. The subjective and quantitative results proved the superiority of this codec. Significantly the average percentage improvement is 3.73, 10.98 and 7.83 in comparison to the existing state of art works at *CR* value equal to 64:1.

REFERENCES

[1] Gonzalez, R.C., Woods, R.E.: 'Digital image processing' (Prentice-Hall, 2008, 3rd edn.).

[2] Kalman, D.: 'Singularly Valuable Decomposition: The SVD of a Matrix'Coll. Math. J., 1998, 27, (01), pp. 2–23.

[3] Hladnik, A.: 'Image compression and face recognition : Two image processing applications of Principal component analysis'Int. Circ. Graph. Educ. Res., 2013, 6, pp. 56–61.

[4] Ahmed, N., Natarajan, T., Rao, K.: 'Discrete cosine transform'IEEE Trans. CJour, 1974, 100, (01), pp. 90–93.

[5] Said, A., Pearlman, W.A.: 'A new, fast, and efficient image codec based on set partitioning in hierarchical trees'IEEE Trans. Circuits Syst. Video Technol., 1996, 6, (3), pp. 243–250.

[6] Wells, R.O.: 'Embedded Image Coding Using Wavelet Difference Reduction', in Topiwala, P.N. (Ed.): 'Wavelet Image and Video Compression' (Springer US, 1998), pp. 289–301.

[7] Walker, J.S., Nguyen, T.Q.: 'Adaptive scanning methods for wavelet difference reduction in Lossy Image Compression'Int. Conf. Image Process., 2000, pp. 182–185.

[8] Rufai, A.M., Anbarjafari, G., Demirel, H.: 'Lossy image compression using singular value decomposition and wavelet difference reduction.'Digit. Signal Process., 2014, 24,(01), pp. 117–123.

[9] Greenberg, M.: 'Differential equations and linear algebra,' In (Prentice-Hall, 2001, 1st edn.).

[10] Website http://www.image.cityu.edu.hk/ imagedb/ and Website ftp://ipl.rpi.edu/pub/ image/ still/usc/gray/, accessed August 2015

