Image Compression Using Hybrid SVD-WDR and SVD-ASWDR: A comparative analysis

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Abstract: In this paper new image compression techniques are presented by using existing techniques such as Singular value decomposition, wavelet difference reduction (WDR) and Adaptive wavelet difference reduction (ASWDR). The SVD has been taken as a standard technique to hybrid with WDR and ASWDR. Firstly SVD is combined with WDR (SVD-WDR) and after that it is combined with its advance version that is ASWDR (SVD-ASWDR) in order to achieve better image quality and higher compression rate. These two techniques are implemented or tested on several images and results are compared in terms of PSNR, MSE and CR.

Key Words: Compression rate (CR), Peak signal to noise ratio (PSNR), Mean square error (MSE), Joint photographic expert group (JPEG2000), Singular value decomposition (SVD), Wavelet Difference Reduction (WDR).

Introduction:

One of the applications of DIP is transmission and encoding. The very first image that was transmitted over the wire was from London to New York through the medium of a submarine cable. The picture that was evacuated took three hours to grasp from one place to another. Now just imagine that today we are canny to see live video feed, or live CCTV footage from one continent to another in addition with just a lag of seconds. It means that a lot of work has been done in this field. This field does not only focus on transmission or storage but also on encoding. The important focus and aim of image compression is to reduce irrelevance and redundant pixels of the image data in contemplation of being able to store and transmit data in an efficient form. Image compression minimizes the size in bytes of a graphics file without reducing the quality of the image to an unsatisfactory level. The reduction in file size permits more images to be stored in a low amount of disk or memory space. It also reduces the time required for images to be posted over the Internet or downloaded from web pages.

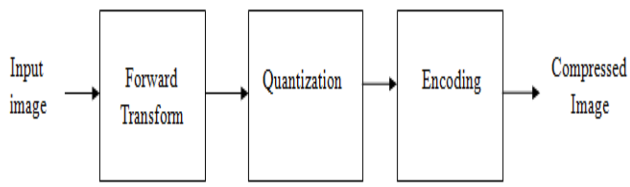

Fig. 1 Basic model of Image compression

The image compression is of two types that is lossy image compression and lossless image compression. Lossless and lossy compression are terms that specify whether or not, in the compression of a file, all original data can be recovered when the file is uncompressed. SVD is an efficient technique that offers very high quality of image but low compression rate. Here SVD is combined with WDR and ASWDR which are wavelet difference based technique and offer high compression rate. These proposed techniques are compared with each other in terms of PSNR and MSE.

Overview of SVD, WDR and ASWDR:

A. Singular value decomposition

As we know an image is a matrix of numbers whose elements are intensity values of corresponding pixels of an image. SVD is used to decompose a matrix into further three matrices that are U, Σ and V where U and V are orthogonal and Σ is diagonal matrix. By simple applying SVD we can't compress the image. After applying SVD we retain some singular values that are stored at the diagonal matrix in descending order. It is considered that the very first singular value contains the largest amount of information and as we go in descending the subsequent singular values contain the reducing information. Thus the lower singular values contain minimum or negligible amount of information, so we can ignore these values compression rate.

$$A_{m\times n} = U_{m\times m}\Sigma_{m\times n}(V_{n\times n})^T \quad (1)$$

$A_{m\times n}$ is the image matrix and $(V_{n\times n})^T$ means transpose of V matrix.

$$\Sigma_{m\times n} = \begin{bmatrix} \Sigma_{p\times q} & 0 \\ 0 & \dots \end{bmatrix} \quad p \le m \text{ and } q \le n \quad (2)$$

As $\bar{\Sigma}$ has low number of rows and columns as compare to Σ so some column of U and V are need to reduce for the matrix multiplication for reconstructing the image.

$$U_{m\times m}=[U_{m\times p} \;\; U_{m\times (m-p)}] \text{ and}$$

$$V_{n\times n}= [\, \bar{V}_{n\times q} V_{n\times (n-q)} \,] \quad (3)$$

Hence the reconstructed matrix can be obtained by:

$$A_{m\times n}= \bar{U}_{m\times p}\bar{\Sigma}_{p\times q}(\bar{V}_{n\times q})^T \quad (4)$$

B. Wavelet difference reduction

The wavelet difference reduction (WDR) is wavelet base technique which can be lossy or lossless. Here in our proposed work we have used lossy WDR. First the Discrete Wavelet transform (DWT) is applied to the given image followed by bit plane encoding. The bit planer encoding consists of five phase as shown in the Fig. 2. At the initialization stage, an initial threshold T_o is chosen such that the value of T_o is greater than all the transform values and atleast one transform value has a magnitude of $T_o/2$ .After the initialization stage, the threshold $T=T_k - 1$ is updated to $T=T_k$, where $T_k=T_k-1/2$. At the significant pass stage, new stage occurs

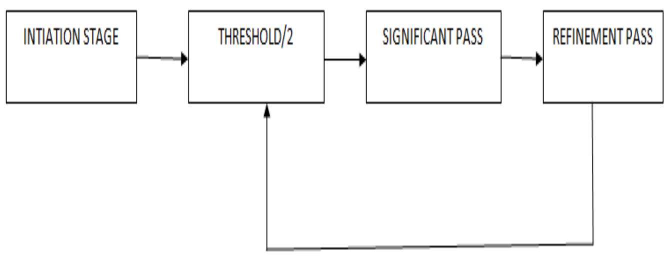

Fig. 2 WDR

Which satisfy $T<|w(i)|<2T$ are identified. By using alter reduction method, their index values are encoded [3]. This is the phenomenon of SVD technique.

For example consider threshold values as $T1$=13, with significant values $w(2)$ =36, $w(5)$=−62, $w(9)$=32 and $w(19)$=63. The indices are 2, 5, 8, and 19 but instead of working with indices WDR will work with their difference such as 3, 4, and 10. The first number is considered as the index and the successive are considered as the number of steps to be followed to reach to the next index. In refinement pass the errors are refined by quantization. In order to reconstruct the image all these steps are inversed by using inverse wavelet transform (IWT).

C. Adaptive scanned Wavelet difference reduction

ASWDR is one of the leading enhanced image compression algorithm proposed by Walker (2000; 2001). This technique does focus to get better the subjective qualities of compressed images and improve the results of image quality and compression ratio. ASWDR algorithm is a simple adaptation of the Wavelet Difference Reduction (WDR) algorithm. WDR algorithm uses a hard and fast ordering of the locations of wavelet coefficients, so ASWDR method uses a various order which does focus to adapt itself to specific image qualities. The ASWDR adjusts the scanning order therefore as to predict positions of recent significant values. ASWDR dynamically adapts to the locations of edge details in an image by using specific scanning order, and this increases the declaration of these edges in ASWDR compressed images. So, ASWDR shows better qualities, especially at low bit rates, than WDR. ASWDR is simply a modification of WDR to achieve higher image quality and compression rate and it leads to better results than WDR.

Proposed work: As we have mentioned earlier the proposed techniques are hybridization of the SVD and WDR and ASWDR techniques. The image is first compressed using SVD-WDR and then same image is compressed with SVD-ASWDR technique as shown in fig 3. After calculating the results with the specified parameters, they are compared and it is analysed that SVD-ASWDR performs better than SVD-WDR in terms of quality and compression ratio.

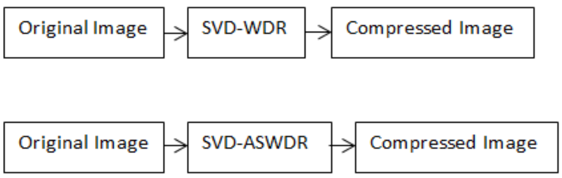

Fig. 3 Methodology of proposed work

In next section we are going to discuss the experimental results and will compare the results with several state-of-the-art techniques.

Results and Discussion: As it was told earlier the proposed techniques are tested on various image samples. Table 1 is showing the quantitative comparison between the both proposed techniques, SVD-WDR and SVD-ASWDR in terms of PSNR for compression ratio of 20:1.To compare the proposed hybrid SVD-WDR and SVD-ASWDR techniques with different compression ratios Tables 1 and 2 are with compression ratio of 20:1 and 40:1 respectively are prepared. All the images used are 512 × 512 with 8-bit grey-scale representation. In order to ensure consistency, the same test images used in [3] were used. As the PSNR values written in table 1 and table 2 show that SVD-ASWDR outperforms the SVD-WDR technique. The reason for the high gain in PSNR values is due to the fact that SVD compression serves as a 'booster' as it compresses the image without ample loss in quality and therefore boosting the overall compression when ASWDR compression is applied. The SSIM values show that the SVD-ASWDR outperforms SVD-WDR. In general, the quantitative and qualitative results show that the proposed hybrid SVD-ASWDR is an outstanding technique with high performance even at high compression ratios (40:1).

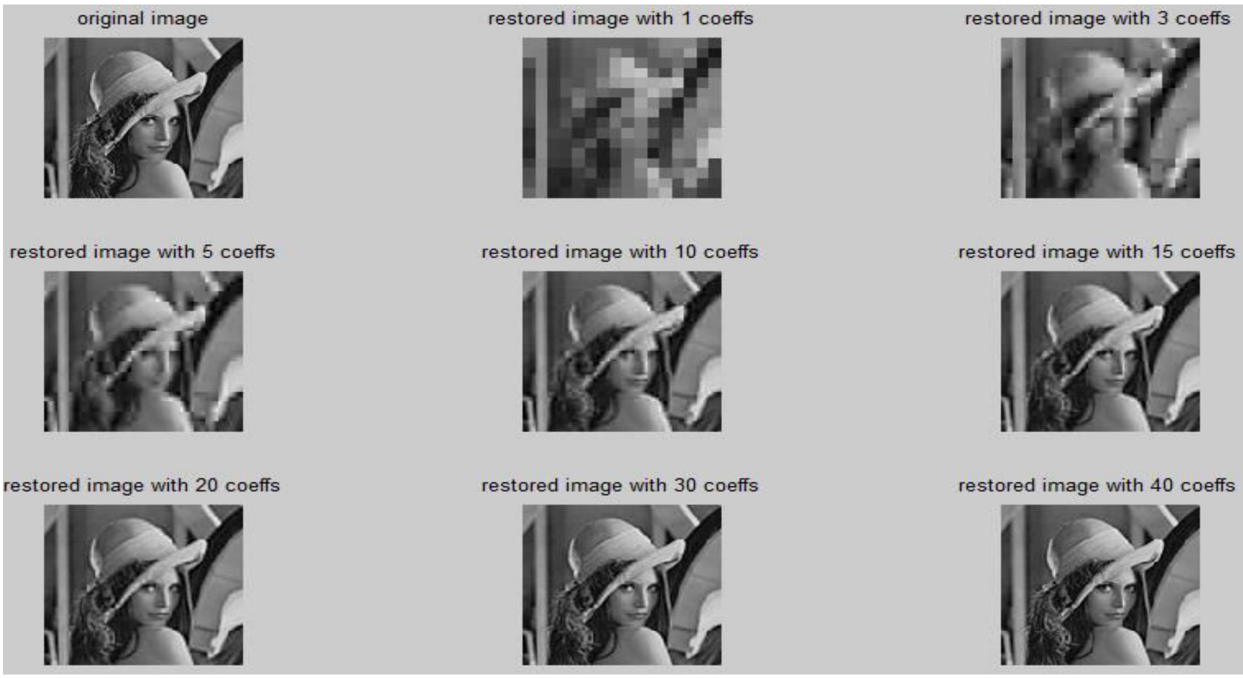

Fig. 4 Compression with SVD-WDR

Fig. 5 Compression with SVD-WDR

Table 1 Comparison table at 20:1

Parameters	Image/method	SVD-WDR	SVD-ASWDR
PSNR **SSIM**	Bridge.tif	22.33 0.477	22.71 0.479
PSNR **SSIM**	Chess.tif	22.80 0.680	23.82 0.690
PSNR **SSIM**	Roots.jpg	22.80 0.561	22.82 0.571
PSNR **SSIM**	Football.tif	26.89 0.699	26.96 0.710
PSNR **SSIM**	Cameraman.tif	22.91 0.651	22.98 0.676

PSNR **SSIM**	X-ray.tif	29.99 0.916	30.75 0.989
PSNR **SSIM**	Watch.tif	27.29 0.786	27.89 0.789
PSNR **SSIM**	Strom.tif	22.80 0.561	27.92 0.625
PSNR **SSIM**	Lena.tif	26.89 0.699	29.91 0.777
PSNR **SSIM**	Jockey.tif	22.91 0.651	28.93 0.743
Average PSNR **SSIM**	Total Images (10)	21.71 0.633	27.71 0.689

Table 2: Comparison Table at 40:1

Parameters	Image/method	SVD-WDR	SVD-ASWDR
PSNR **SSIM**	Bridge.tif	27.02 0.698	32.98 0.721
PSNR **SSIM**	Chess.tif	32.36 0.787	33.54 0.811
PSNR **SSIM**	Roots.jpg	29.01 0.786	33.20 0.779
PSNR **SSIM**	Football.tif	32.18 0.898	32.86 0.991
PSNR **SSIM**	Cameraman.tif	28.24 0.877	31.18 0.899
PSNR **SSIM**	X-ray.tif	30.05 0.766	30.89 0.779
PSNR **SSIM**	Watch.tif	31.38 0.855	32.81 0.899
PSNR **SSIM**	Strom.tif	32.18 0.856	33.65 0.886
PSNR **SSIM**	Lena.tif	35.99 0.890	33.22 0.901
PSNR **SSIM**	Jockey.tif	32.07 0.779	33.22 0.819
Average PSNR **SSIM**	Total Images (10)	31.12 0.811	32.75 0.899

Conclusion: In this paper, we have proposed two new techniques by combining existing techniques that is SVD, WDR and ASWDR. SVD-ASWDR technique leads to better compression rate and image quality as compare to SVD-WDR. We have compared the results of hybrid SVD-WDR technique with SVD-ASWDR and the results are showing superiority over SVD-WDR.

References:

1. Kaur M., Kaur N., "A Literature Survey On Lossless Image Compression," Proc. Of IEEE, Signal Processing and Communication, Vol. 4, pp. 360-365, March 2015.
2. Pascual J.M., Mora H., Guilló A.F., López J.A., "Adjustable Compression Methods for Still jpeg Images," Proc. Of IEEE, Signal Processing, Vol. 32, pp. 16-32, March 2015.
3. Rufai A.M., Anbarjafari G., Demirel H., "Lossy Image Compression Using Singular Value Decomposition and Wavelet Difference Reduction," Elsevier, Digital Signal Processing, Vol. 24, pp. 117-123, Jan. 2014.
4. Rufai A.M., G. Anbarjafari, H. Demirel, "Lossy Medical Image Compression using Huffman coding and singular value decomposition," Proc. Of IEEE, Signal Processing and Communications, Vol. 5, pp. 1-4, 2013.

5. S.P Raja., "Image Compression using WDR & ASWDR Techniques with different Wavelet Codecs" ACEEE, Signal Processing, Vol. 01,pp. 136-139, 2011.
6. Vaish A. and Kumar M., "WDR coding based Image Compression technique using PCA," Proc. of IEEE, Signal Processing, Vol. 2, pp.123-127, 2013.
7. Dhawan S., "A Review of Image Compression and Comparison of its Algorithms," International Journal of Electronics & Communication Technology, Signal Processing, Vol. 2, pp. 143-147, 2011.
8. Khan U., " wavelet based image compression using Different techniques: a comparative study" International Journal of Electronics & Communication Technology, Signal Processing, Vol. 3, pp. 144-149, 2014.