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Ultrasound Image Compression Using SVD and Evaluation of Image Characteristics

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ABSTRACT: Digital images are in general stored in memories, preprocessed, transmitted and reprocessed for final applications. The quantum of binary data to be handled by an image processor is enormous. The problem of how one stores and transmits a digital image has been a topic of research for more than 40 years and was initially driven by military applications. Image compression techniques have been developed to reduce the size of image. Wavelet transform and singular value decomposition (SVD) are very powerful techniques for image compression. These are lossy moment preserving quantization method for compressing digital gray-level images. Their advantages are simplicity, fault tolerance, the relatively high compression efficiency and good image quality of the decoded image.

KEYWORDS: Compression, SVD, PSNR, SNR, RMSE.

I.INTRODUCTION

Medical imaging has had a great impact on the diagnosis of diseases and surgical orchestrating. However, imaging contrivances perpetuate to engender more data per patient, often 1000 images or ~500 MB. These data need long-term storage and efficient transmission. Current compression schemes engender high compression rates if loss of quality is affordable. However, medicine cannot afford any deficiency in diagnostically paramount regions.

Entropy and Redundancy: In most authentic-world images, the gray values of adjacent pixels are highly correlated. This designates that a great deal of information about the gray value of a pixel could be obtained by inspecting its neighbors. Ergo, a substantial amount of redundant information is available in these images. A quantification of the information content of an image is the entropy (Lynch, 1985). It expresses the minimum number of bits compulsory for the representation of an image without any loss of information. The entropy is an ecumenical measure of the correlation between gray values of neighboring pixels. For an n-bit image with M gray levels (M = Zn), the entropy H can be computed as

$$H = -\sum_{i=0}^{M} p(g_i)\log_2 p(g_i)$$

where $p(g_i)$ is the percentage of occurrence of each gray value, which can be obtained from the image histogram. Most data sources, including digital images, have non-uniform gray value distributions. If these distributions were uniform, the entropy would have a maximum at [4]

$$H_{\max} = \log_2 M$$

where M is the number of gray levels. Because real images seldom have uniform probability distributions, their entropies always less than H.

Compression Ratio: The general compression ratio ΔC is defined as the ratio of the no. of bytes of the original image before compression and the no of bytes of the compressed image .The maximum compression ratio ΔC_{max} that can be achieved without any loss of information is defined as follows

$$\Delta C_{\max} = (\log_2 M)/H$$

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For digital image we reach the maximum compression ratio when the image coding results in bit-per-pixel rates equal to entropy. To achieve the maximum ratio we first need to eliminate or reduce the correlations between pixels, and then to code these pixels as efficiently as possible [5]. Several techniques have been developed to compress digital images. In this research paper SVD technique is used to compress ultrasound images and various characteristics parameters are computed.

II.SINGULA VALUE DECOMPOSITION

It In the linear algebra is a factorization of a rectangular real or complex matrix analogous to the digonalization of symmetric or Hermitian square matrices using a basis of eigenvectors. SVD is a stable and an effective method to split the system into a set of linearly independent components, each of them bearing own energy contribution [1, 3]. A digital Image X of size M x N, with M≥N, can be represented by its SVD as follows

$$[X]M = M[U][S].M[V]N$$
$$U = [U_1, U_2, ..., U_M]$$
$$V = [V_1, V_2, ...V_N]$$

where *U* is an $M \times M$ orthogonal matrix, *V* is an $N \times N$ orthogonal matrix, and *S* is an $M \times N$ matrix with the diagonal elements represents the singular values, S_i of *X*. Using the subscript T to denote the transpose of the matrix. The columns of the orthogonal matrix U are called the left singular vectors, and the columns of the orthogonal matrix V are called the right singular vectors. The left singular vectors (LSCs) of *X* are eigenvectors of *XXT* and the right singular vectors (RSCs) of *X* are eigenvectors of *XTX*. Each singular value (*SV*) specifies the luminance of an image layer while the corresponding pair of singular vectors (*SCs*) specifies the geometry of the image [13]. *U* and *V* are unitary orthogonal matrices (the sum of squares of each column is unity and all the columns are uncorrelated) and S is a diagonal matrix (only the leading diagonal has non-zero values) of decreasing singular values. The singular value of each eigen image is simply its 2-norm. Because SVD maximizes the largest singular values, the first eigen image is the pattern that accounts for the greatest amount of the variance-covariance structure.

III.METHODOLOGY

In In order to proceed with the research work image processing toolbox is used. The work is divided into two major parts. Images used in the research work are shown in Fig. 1. In the first part SVD technique is used with various compression ratios (algorithm shown in Fig. 2) and in second part various image characteristics parameters are computed.

In second part various image characteristic parameters such as signal to noise ratio (SNR), peak signal to noise ratio (PSNR), root mean square error (RMSE), and mean absolute error (MAE) are estimated for compressed image with respect to original image. Four set of algorithms are designed to compute these parameters. Compressed image degrade the quality of the image which needed to be investigated. Root mean square error (RMSE) corresponds to pixels in the reference image I_r and the fused image I_f. If the reference image and fused image are alike give the RMSE value equal to zero and it will increase when the dissimilarity increases between the reference and fused image

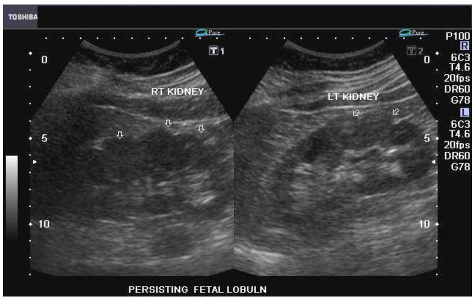

Fig. 1 Ultrasound image used in research work.

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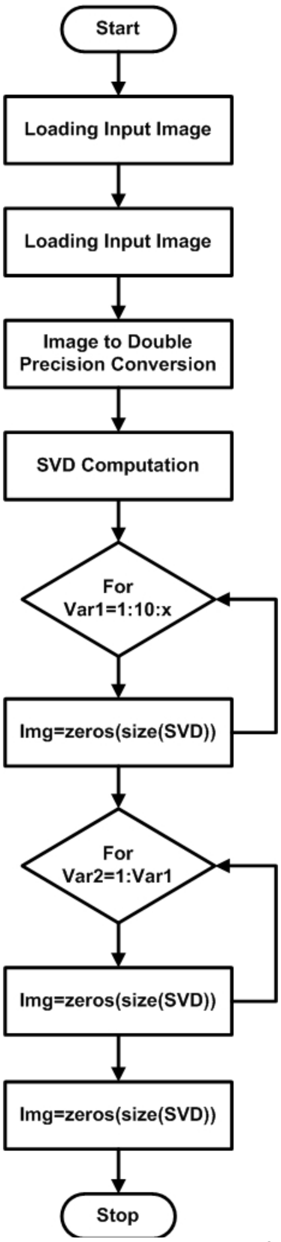

Fig. 2. Flow chart For SVD transformation.

IV.RESULTS

SVD is one of the most useful tools of linear algebra for image compression. SVD is a factorization and approximation technique which effectively reduces any matrix into a smaller invertible and square matrix. In this experiment SVD matrix is formed with five iterations and the compressed image is compared with original image to compute image characteristics parameters. Figure 3 to 7 shows the compressed ultrasound image with various ratio of SVD matrix. The computed value of image characteristics parameters i.e. PSNR, SNR, RMSE, and MSE are given Table 1.

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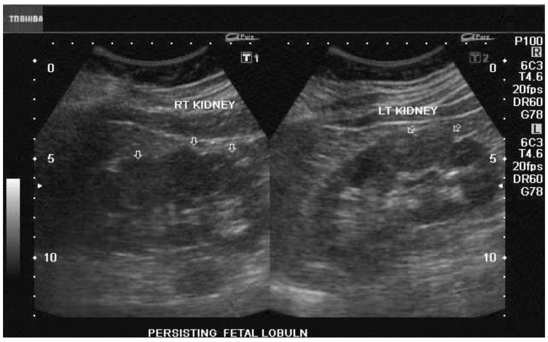

Fig. 3 Compressed image with SVD matrix 1:100:size(original image)/2.

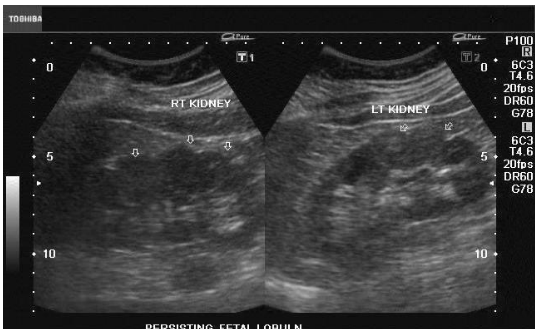

Fig. 4 Compressed image with SVD matrix 1:120:size(original image)/2.

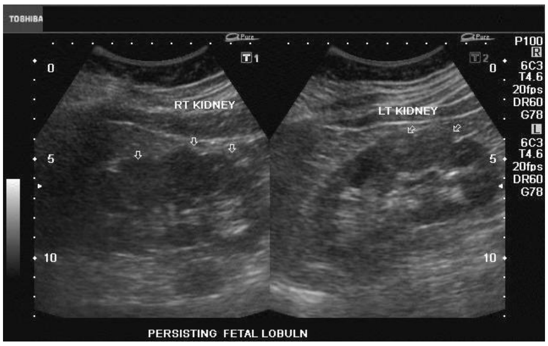

Fig. 5 Compressed image with SVD matrix 1:140:size(original image)/2.

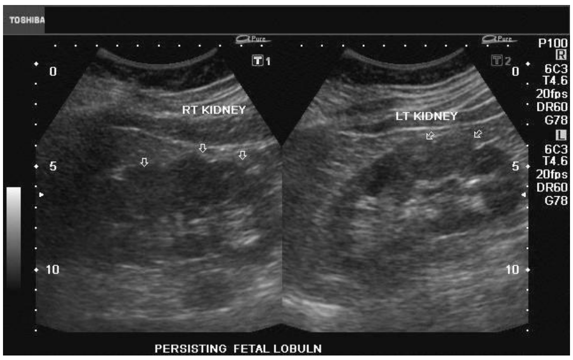

Fig. 6 Compressed image with SVD matrix 1:160:size(original image)/2.

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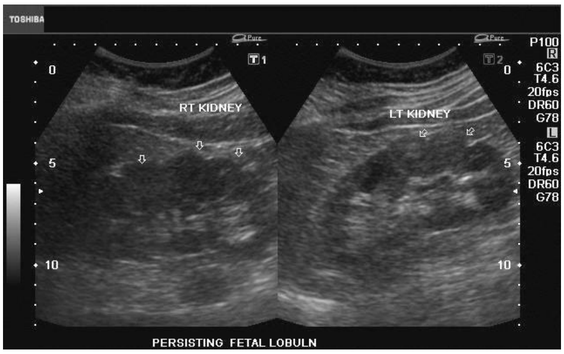

Fig. 7 Compressed image with SVD matrix 1:180:size(original image)/2.

Table 1. Computed image characteristic of compressed image using SVD.

SVD Matrix 1:x:size (I_m)	PSNR (dB)	SNR(dB)	RMSE	MSE
x=100	34.63	-0.029	0.021	0.0004
x=120	36.50	-0.018	0.017	0.0003
x=140	37.99	-0.012	0.014	0.0002
x=160	39.49	-0.008	0.011	0.0001
x=180	41.17	-0.005	0.009	0.00008

It can be observed from the computed image parameters that as the step size of SVD matrix is increased higher value of PSNR is obtained, which means the compressed image retains the major information content with respect to the original ultrasound image. The graphical representations of image parameters are also done. Figure 8 and 9 shows the PSNR and RMSE of the compressed image with increasing order of the step size in SVD matrix.

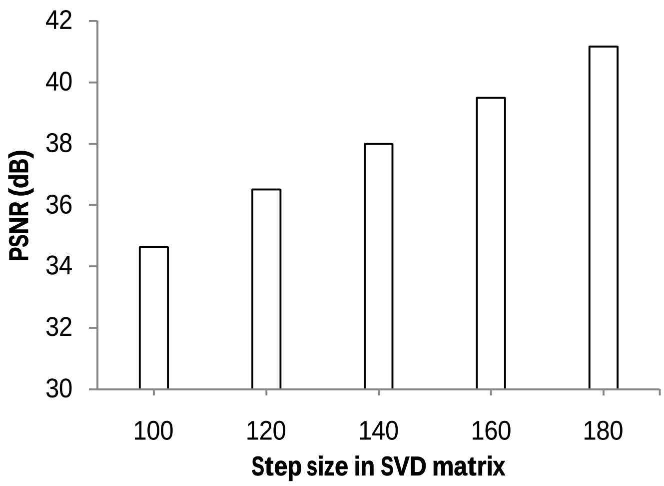

Fig. 8 PSNR (dB) of compressed image.

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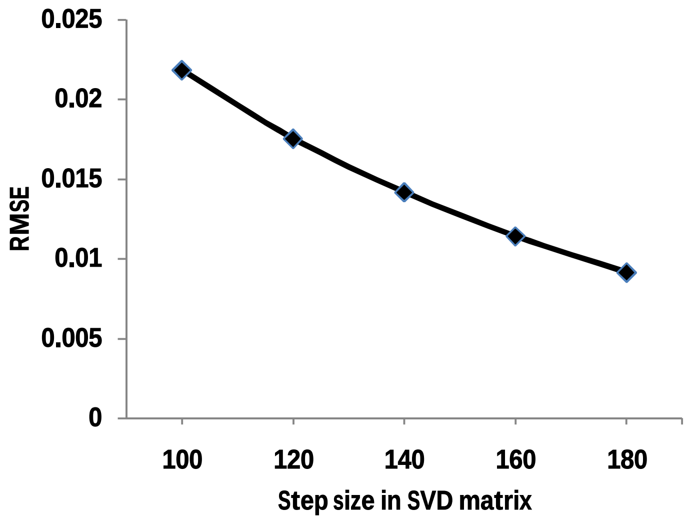

Fig. 9 RMSE of compressed image.

VI.CONCLUSION

Thus Biomedical image processing is a very broad field; it covers biomedical signal gathering, image forming, picture processing, and image display to medical diagnosis based on features extracted from images. SVD and wavelet are apparently elegant and efficient time-domain compression technique. In this research work ultrasound images are compressed using SVD and wavelet methods. In the first experiment SVD based algorithms are designed with various compression rates of $1{:}x{:}size(I_m)$ where x ranges from 100 to 180 and I_m image matrix. The image quality parameters are estimated and it is observed that PSNR values increases as x is increased having minimum and maximum values 34.6381 dB and 41.1722 dB respectively. Similarly, minimum and maximum SNR of the compressed image is -0.02944 dB and -0.00515 dB respectively. Also RMSE and MSE values of compressed image with respect to original image comes out to be 0.02184 and 0.00048 for x = 100 and 0.00915 and 0.00008 for x = 180.

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