International Journal of Scientific and Technical Advancements

ISSN: 2454-1532

Effect of Singular Value Interpolation on the quality of Ultrasound Images

Santoresh Kumar[1], Priti Rajput[2], Jyoti Lalotra[3], Tinni Sawhney[4]
[1]Departmentof Computer Sciences, MIET, Jammu, J&K, India-181122
[2]Department of Electronics, University of Jammu, Jammu, J&K, India-180006
[3]Department of Electrical Engineering, IECS, Jammu, J&K, India-181206
[4]Department of ECE, MBSCET, Jammu, J&K, India-181206
Email address: [1]pritijamwal@outlook.com

Abstract— The proper diagnosis of diseases results in treatment of the same in a perfect way. Ultrasound imaging which is a means to see what's happening inside the body solves the mystery of disorders/infections in the body. The universe around us is surrounded by different noises, some controllable and some behind our control. A small noise inside the diagnosis can route the investigations in a wrong way. In this research, ultrasound images are treated with different noises of varying noise level and the images so obtained are then treated with singular value decomposition method. The quality of the images before and after processing through SVD technique is compared qualitatively and quantitatively.

Keywords—Digital images; enhancement; ultrasound; singular value decompostion; noises.

I. Introduction

Digital image processing is an interesting and widely spread area of research finding its application in every field of technology surrounding us [1-3]. Digital camera is the primary means of obtaining digital images of the real world. The images so obtained are processed through various computer algorithms and techniques to filter out noises in the images which coined the term digital image processing [3-5]. The images of the 3D world are captured using camera when light reflected by the object is captured by the camera and is converted into 2D image hence result in image formation. This image is digitized by signal processing and then is handled by digital image processing [6-10].

Fig. 1. Editing image.

Fig. 1 shows that an image is captured by a camera and has been sent to digital system to remove all the other details and just focus on the image of Kalpana Chawla. The other methods of obtaining digital images are by using animation techniques where computer graphics is taken help to frame images [11-14].

There are numerous applications of digital image processing. Sitting in one part of the universe and seeing live what's happening in the other part is a simple application of DIP [15] [16]. The space research projects which gives us clear cut picture of the universe above us is nothing but DIP application [15], [17]. Keeping the world secure by keeping an eye on them by CCTV's is DIP. A number of criminal cases are solved with the help of this wonderful application of DIP [18]. Security system developed using iris recognition or finger prints recognition of heart beat scan is the wonderful application of DIP. Videos can be edited and specific information is derived through DIP [19], [20]. It is impossible to have surveillance on each part of the universe manually. Drones which are put to seek information are an imaging application of technology assisted by DIP [21], [22]. When a fire broke out in dense forest, the information is passed through satellites in the form of images to controlling authorities so that an action should be taken upon [23]. No human being has yet visited Mars or Jupiter, but the probability of having signs of life is there. It is the DIP which enables the researcher to draw conclusions about the planets far away from us [15].

The disease which affects our internal body parts was not easily diagnosed in the past. It was totally a work of predictions and analysing the symptoms which sometimes went wrong and finally worked against the patient. Medical imaging helps the doctor to diagnose the diseases inside the body. Images inside the body are captured using MRI, CT scan and Ultrasound [24], [25]. Out of this ultrasound is safer and is and easy tool of diagnosing the diseased part inside the body. The working of ultrasound is similar to sonar which works on the principle of echo [26]. In ultrasound technique, an ultrasound probe, a monitor and a gel (chemical) is used to take the images of the internal organs. The gel is applied on the skin above the body part that is to be analysed. The ultrasound probe which is a transducer/electric instrument meant for conversion of energy transmitted high frequency sound waves. The sound energy goes deep into the body and is reflected by the internal body parts. The reflected energy is collected by the probe and is transferred to the computer. Software is there which calculates the amount of reflected energy and the delay it takes to get the energy reflected. The specified computer software works upon to convert the data received into a two dimensional image. The higher frequencies

Santoresh Kumari, Priti Rajput and Jyoti Lalotra, “Effect of singular value interpolation on the quality of ultrasound images”, *Journal of Scientific and Technical Advancements*, Volume 1, Issue 3, pp. 101-104, 2015.

displays softer tissues, muscles, neonatal brains and comparatively lower frequencies display deeper body organs such as liver, pancreas, gall bladder etc.[17], [27], [28]. The images obtained through ultrasound are not very clear so various enhancement techniques are worked upon to obtain more clarified information that will help the pathologist with more accurate results and thus help in the doctor and patient [17], [28]. Different enhancement techniques are purposed by different researchers to enhance the quality of digital images. Enhancement techniques for non- uniform and uniform dark images were used to grab more information from the darker areas [17], [29], [30]. Aura transformation which is basically used for analysis and synthesis of texture is worked upon ultrasound images [28].

In this research we are using singular value decomposition to refine the ultrasound images interfered with various noises of differing levels. The singular value decomposition (SVD) plays an important role in matrix theory. In the linear algebra the SVD is a factorization of a real or complex matrix analogous to the digonalization of symmetric using a basis of eigenvectors. SVD is a stable and effective technique to split the system into a set of linearly independent components, each of them bearing own energy contribution. SVD is a numerical technique used to diagonalize matrices in numerical analysis. SVD is a matrix factorization technique which takes a rectangular matrix defined as A where A is an *m x n* matrix in which the *m* rows represents the users, and the *n* columns represents the items. The SVD state that [33].

$$A_{mxn} = U_{mxm} S_{mxn} V^T_{nxn}, \text{ where } U^TU = I_{mxm}\ V^TV = I_{nxn}$$

Where the columns of U are the left singular vectors; S (the same dimensions as *A*) has singular values and is diagonal; and V^T has rows that are the right singular vectors. Calculating the SVD consists of finding the Eigenvalues and Eigenvectors of AA^T and A^TA. The Eigenvectors of A^TA make up the columns of V, the Eigenvectors of AA^T make up the columns of U. Also, the singular values in S are square roots of Eigenvalues from AA^T or A^TA. The singular values are the diagonal entries of the S matrix and are arranged in descending order. The singular values are always real numbers. If the matrix A is a real matrix, then U and V are also real. Matrix S is a diagonal matrix having only *r* nonzero entries, which makes the effective dimensions of U, S and V matrices $m \times r$, $r \times r$, and $r \times n$, respectively. The diagonal entries ($s_1, s_2, \ldots s_r$) of *S* have the property that $s_i > 0$ and $s_1 \geq s_2 \geq \ldots \geq s_r$.. SVD is powerful and reliable orthogonal matrix decomposition method. Due to SVD conceptual and stability reasons, it becomes more popular in signal processing area [31], [32]. SVD is an attractive algebraic transform for image processing [34]. Other application of SVD is made for separation of image data and noise subspaces using SVD. The SVD characterized the signal and noise subspace eigen modes. Because the noise has much lower power compared with the signal, the eigen modes corresponding to the dominant singular values. SVD is applied also for detection of faint stars, noise removing, continuum subtraction of spectral lines for radio-astronomical images, and automatic image classification [35]. In previous year ago SVD was also investigate for water marking. For dimension reduction and data processing of principal component analysis (PCA) technique is used [36]. SVD and PCA are common techniques for analysis of multivariate data into fewer dimensions while retaining important information. SVD and PCA have many applications such as Image processing and compression, Immunology, Small-angle scattering etc.

II. METHODOLOGY

The ultrasound image of liver is taken from an internet source and converted into grayscale image and processed through SVD. Singular values are extracted out of the grayscale matrix. This singular matrix is treated with polynomial equation of different orders. Here, we have treated it with order varying from 1 to 50. Root mean square value for different orders w.r.t. the SVD matrix is calculated. The image is reconstructed for different orders and all the total set of 51 images are compared manually. Fig. 3 shows the ultrasound of the liver of an adult female patient. Images show a large (8 cms) rounded, hyperechoic, non-calcific mass in the right lobe of liver. There is a reasonable amount of acoustic enhancement posterior to the lesion.

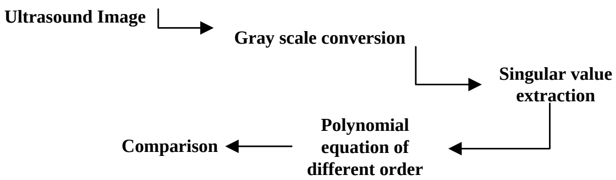

Fig. 2. Steps of the experiment.

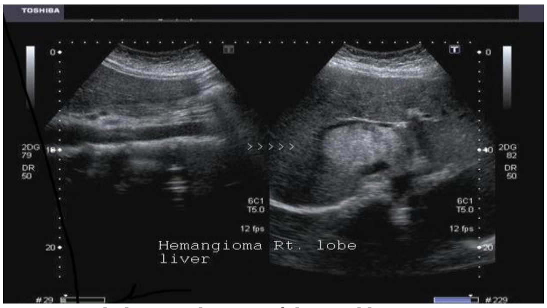

Fig. 3. Unprocessed ultrasound image of diseased liver.

Fig. 4 to Fig. 7 shows the processed image at an order of 5, 10, 15, 20 shows enhancement in quality with increasing orders.

Fig. 4. Order 5 ultrasound image.

Santoresh Kumari, Priti Rajput and Jyoti Lalotra, "Effect of singular value interpolation on the quality of ultrasound images", *Journal of Scientific and Technical Advancements*, Volume 1, Issue 3, pp. 101-104, 2015.

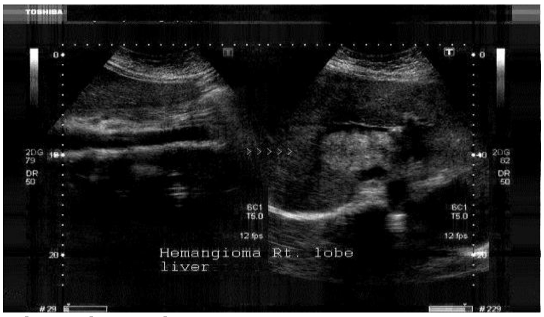

Fig. 5. Order 10 ultrasound image.

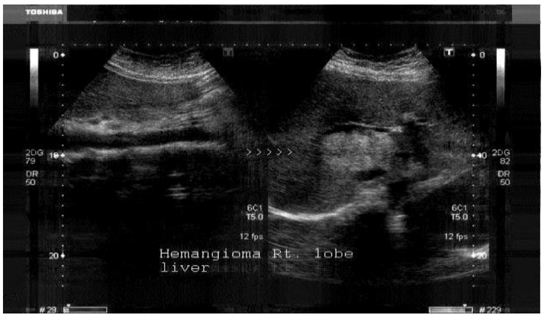

Fig. 6. Order 15 ultrasound image.

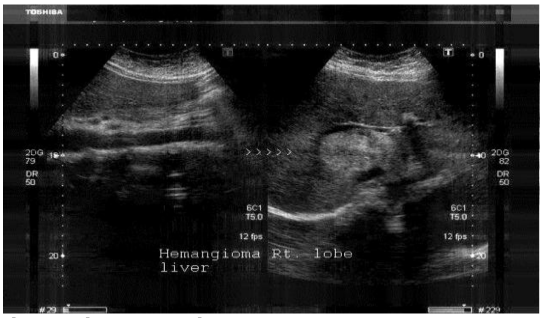

Fig. 7. Ultrasound image at order 20.

Fig. 8 shows the zigzag pattern of root mean square error w.r.t. the original image at different orders.

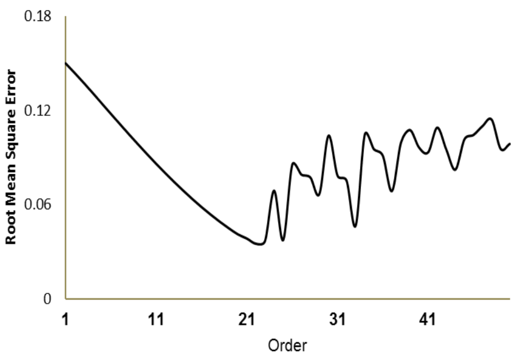

Fig. 8. Order verses Root Mean Square Error.

III. Results

After processing the images, the results were obtained. The maximum value of root mean square value at order 1 is 15.004% as provided in Fig. 9 and minimum value of root mean square at order 22 is 3.5174% as shown in Fig. 10.

Fig. 9. Processed image at order 1.

Root mean square value shows a linear decrease up to order 22 after that it fluctuates showing a zig-zag pattern. The images were compared manually and it was observed that the contrast and brightness increases with increasing decreasing mean square error. The quality of the image is inversely related to the root mean square error.

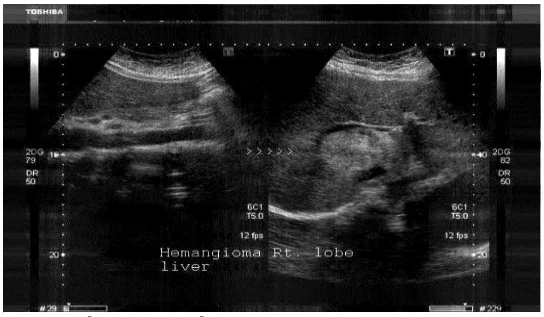

Fig. 10. Processed image at order 22.

IV. Conclusion

The investigation shows that the quality of processed ultrasound image increases with increasing order. At minimum root mean square the clarity is maximum. The manipulation of root mean square error will give better results. The time required process the quality of images is less. To enhance the images by manipulating root mean square error is in future prospectus.

References

[1] B. Jähne, *Digital Image Processing*, 2002.
[2] W. K. Pratt, *Digital Image Processing*, Jan. 2007.
[3] M. Goldberg, “Digital image processing of remotely sensed imagery,” *Digital Image Processing*, vol. 77, pp. 383–437, 1981.
[4] A. Rosenfeld, “Digital image processing and recognition,” *Digitale Bildverarbeitung Digital Image Processing*, vol. 8, pp. 1–11, 1977.
[5] K. Hartmann, “Adaptive noise reduction filtering on moving scanned-electron microscope images,” *IEEE Sixteenth Saraga Colloquium on Digital and Analogue Filters and Filtering Systems*, 1996.
[6] J. Tarrant, “Camera menus,” *Understanding Digital Cameras*, pp. 32–53, 2006.
[7] J. Gerlach, Choosing your digital camera, Digital Nature Photography, pp. 27–43, 2007.
[8] P. Rajput, S. Kumari, S. Arya, and P. Lehana, “Effect of diurnal changes on the quality of digital images,” *Physical Review & Research International*, vol. 3, no. 4, pp. 556–567, 2013.

Santoresh Kumari, Priti Rajput and Jyoti Lalotra, “Effect of singular value interpolation on the quality of ultrasound images”, *Journal of Scientific and Technical Advancements*, Volume 1, Issue 3, pp. 101-104, 2015.

[9] P. Rajput, S. Kumari, S. Arya, and P. Lehana, "Effect of contrast and brightness on digital images under outdoor conditions," *Advances in Research*, vol. 2, no. 5, pp. 266–278, 2014.
[10] P. Rajput, S. Kumari, S. Arya, and P. Lehana, "Qualitative and quantitative analysis of non-uniform dark images," *Advances in Image and Video Processing*, vol. 2, no. 1, pp. 23–34, 2014.
[11] O. O. L. Martinez, "Criteria for Defining Animation: A Revision of the Definition of Animation in the Advent of Digital Moving Images," *Animation*, vol. 10, no. 1, pp. 42–57, Feb. 2015.
[12] N. Grammalidis, G. Goussis, G. Troufakos, and M. G. Strintzis, "Estimating body animation parameters from depth images using analysis by synthesis," *Proceedings Second International Workshop on Digital and Computational Video*, 2001.
[13] D. Mclean, S. Brown, and K. Bellamy, "Digital images and animation in PowerPoint," *Journal of Visual Communication in Medicine*, vol. 26, no. 4, pp. 174–177, Jan. 2003.
[14] D. James, Animation, Crafting Digital Media, pp. 123–146, 2009.
[15] C. G. Eze, "Satellite remote sensing technology in spatial modeling process: technique and procedures," *International Journal of Science andTechnology*, vol. 2, no. 5, pp. 309–315, 2012.
[16] G. Nagy, "Digital image-processing activities in remote sensing for earth resources," *Proceedings of the IEEE,* vol. 60, no. 10, pp. 1177–1200, 1972.
[17] P. Lehana, P. Rajput, S. Kumari, and S. Arya, "Effect of enhancement technique on nonuniform and uniform ultrasound images," *Journal of Computational Engineering,* vol. 2015, 2015.
[18] V. Damjanovski, Networking in CCTV, CCTV, pp. 410–477, 2014.
[19] M. Foracchia, E. Grisan, and A. Ruggeri, "Detection of optic disc in retinal images by means of a geometrical model of vessel structure," *IEEE Transactions on Medical Imaging*, vol. 23, no. 10, pp. 1189–1195, 2004.
[20] N. R. Syambas and U. H. Purwanto, "Image processing and face detection analysis on face verification based on the age stages," *in Proceedings of the 7th International Conference on Telecommunication Systems, Services, and Applications (TSSA '12)*, pp. 289–293, October 2012.
[21] R. Schneiderman, "Unmanned drones are flying high in the military/aerospace sector [special reports]," *IEEE Signal Processing Magazine*, vol. 29, no. 1, pp. 8–11, Jan. 2012.
[22] J. Zulaika, "Drones, witches and other flying objects: the force of fantasy in US counterterrorism," *Critical Studies on Terrorism*, vol. 5, no. 1, pp. 51–68, Apr. 2012.
[23] E. K. Forkuo and A. Frimpong, "Analysis of forest cover change detection," *International Journal of Remote Sensing Applicaions*, vol. 2, no. 4, pp. 82–92, 2012.
[24] P. Kozlowski, Magnetic Resonance Imaging, Medical Imaging, pp. 221–284, Mar. 2009.
[25] P. Suetens, *Fundamentals of Medical Imaging*, 2009.
[26] R. Pinkel, M. Merrifield, J. Smith, and H. Ramm, "Advances in doppler sonar technology," *Proceedings of the IEEE Fifth Working Conference on Current Measurement*, 1995.
[27] H. Edwards, "Echoes," *Ultrasound*, vol. 23, no. 1, pp. 70–71, Feb. 2015.
[28] S. Arya, S. Khan, D. Kumar, M. Dutta, and P. Lehana, "Image enhancement technique on ultrasound images using aura transformation," *International Journal in Foundations of Computer Science & Technology*, vol. 2, no. 3, pp. 1–10, 2012.
[29] S. Erkanli and Z. Rahman, "A wavelet based enhancement technique for non-uniform and uniform-dark images," *10th International Conference on Intelligent Systems Design and Applications*, Nov. 2010.
[30] K. Hasikin and N. A. M. Isa, "Fuzzy image enhancement for low contrast and non-uniform illumination images," *IEEE International Conference on Signal and Image Processing Applications*, Oct. 2013.
[31] H. C. Andrews and C. L. Patterson, "Singular value decompositions and digital image processing," *IEEE Trans. on Acoustics, Speech, and Signal Processing*, vol. ASSP-24, pp. 26–53, 1976.
[32] J. L. Kamm, "SVD-based methods for signal and image restoration," PhD Thesis, 1998.
[33] J. Lia, C. Wangb, M. Lia, and PanGuo, "An image quality assessment algorithm on the basis of edge information and singular value decomposition," *International Journal of Signal Processing, Image Processing and Pattern Recognition*, vol.8, no.6, pp. 283-288, 2015.
[34] R. A. Sadek, "SVD based image processing applications: state of the art, contributions and research challenges," *International Journal of Advanced Computer Science and Applications (IJACSA)*, vol. 3, no. 7, pp. 26-34, 2012.
[35] V. Kolev, K. Tsvetkova, and M. Tsvetkov, "Singular value decomposition of images from scanned photographic plates,'' *Proceedings of the VII Bulgarian-Serbian Astronomical Conference (VII BSAC) Chepelare*, Bulgaria, no. 11, pp. 187-200, 2012.
[36] B. Kour, R. Singh, P. Lehana, and P. Rajput, "Effect of singular value decomposition based processing on speech perception,'' *International Journal on Natural Language Computing (IJNLC)*, vol. 2, no.1, pp. 9-16, 2013.

Santoresh Kumari, Priti Rajput and Jyoti Lalotra, "Effect of singular value interpolation on the quality of ultrasound images", *Journal of Scientific and Technical Advancements*, Volume 1, Issue 3, pp. 101-104, 2015.