Enhancement of Kidney Stone Images using different Filtering Technique

Kirti[1], Sandeep Tayal[2], Ankit Bansal[3] , Bijender Bansal[4] , Monika Goyal[5]

[1]M.Tech Student, Deptt of ECE, VCE, Rohtak
[2]Assistant Professor, Deptt of ECE , VCE , Rohtak
[3] Associate Professor, Deptt of EE , VCE , Rohtak
[4]Associate Professor, Deptt of CSE, VCE, Rohtak
[5]Associate Professor, Vaish Mahila Mahavidalya, Rohtak

Abstract

Kidney-Urine-Belly computed tomography (KUB CT) analysis is an imaging modality that has the potential to enhance kidney stone screening and diagnosis. This study explored the development of a semi-automated program that used image processing techniques and geometry principles to define the boundary, and segmentation of the kidney area, and to enhance kidney stone detection. This can be done by different filtering technique. In our work, we have present ideal, median and Butterworth filter. The performance of these filter is analyzed on the basis of MSE, PSNR,SNR. After analyzing all the parameter it is conclude that Median filters are best fitted for enhancement of kidney stone Images.

Keywords: Renal Calculi, Kidney Stones, MSE (Mean Square Error), PSNR (Peak Signal to Noise Ratio).

I. INTRODUCTION

Kidneys are retroperitoneal organs, located near the middle of the back, just below the rib cage, one on each side of the spine. Every year in both developed and developing countries, many people affected by chronic kidney failure due to diabetes mellitus and hypertension, glomerulonephritis etc. Worldwide research indicates that one out of 10 adults had kidney problems and by 2015 it is estimated that about 36 premature deaths due to kidney disease will happen [2]. Since kidney function impairment can be life threatening, diagnosis of the disorders and diseases in the early stages is crucial. Ultrasound is one of the non-invasive low cost widely used imaging techniques for diagnosing kidney diseases.

Though ultrasound image is adaptable, transferable and comparatively safe, but this type of image often full of acoustic interferences (speckle noise) and artifacts. Speckle is a complex phenomenon, which degrades delectability of target organ and reduces the contrast, resolutions with back-scattered wave appearance which originates from many microscopic diffused reflections. It affects the human ability to identify normal and pathological tissue. Hence, the automatic segmentation of anatomical structures like kidney in ultrasound imagery is a real challenge.

Ultrasound has been a welcome tool for many years to break up kidney stones, but finding the stones still requires radiograph or CT imaging. The accurate diagnosis of a renal stone is dependent on many factors, including the clinical history, the nature of the imaging findings, the experience of the radiologist, and the quality of the examination. A high-quality imaging examination, which is under the control of the radiologist, is essential. We present our technique in the performance of US imaging for the evaluation of kidney stone range and acknowledge that other protocols work equally well. It is expected that these protocols will be modified over time as new equipment becomes available. Ultrasound has been shown to be relatively safe but no imaging method which deposits additional energy into the body should be considered entirely risk free. When the decision to make a diagnostic image is made, the physician should always make a conscious judgment about whether the potential benefits of the imaging procedure are greater than any potential risk. In recent years a great effort of the research in field of medical imaging was focused on kidney stone, renal cavity segmentation. The automatic segmentation has great potential in clinical

medicine by freeing physicians from the burden of manual labeling; whereas only a quantitative measurement allows to track and modeling precisely the kidney disease. Despite the undisputed

The rest of the paper is organized as follows. Section II outlines the complete design of the proposed Filtering Technique. Measured and simulated results of the kidney stone are discussed in Section III. The conclusions are given in Section IV.

II. Filter Techniques :-

1. Ideal Filter :-

Simply cut off all high frequency components that are a specified distance D_0 from the origin of the transform changing the distance changes the behaviour of the filter .The transfer function for the ideal low pass filter can be given as:

$$H(u,v) = \begin{cases} 1 & if\ D(u,v) \leq D_0 \\ 0 & if\ D(u,v) > D_0 \end{cases}$$

where $D(u,v)$ is given as:

$$D(u,v) = \left[(U - \frac{M}{2})^2 + \left(V - \frac{N}{2} \right)^2 \right]^{1/2}$$

The ideal filtered image with different frequency range as shown in fig 1.
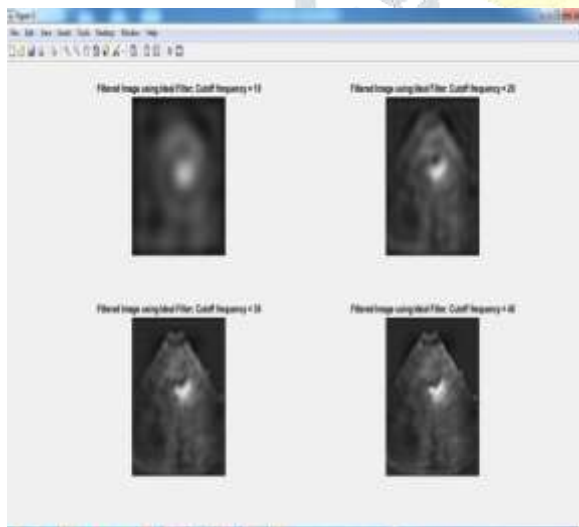

Fig 1. Filtered Image using Ideal Filter with different cutoff Frequency

2. Median Filter :-

Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges. It is particularly effective at removing 'salt and pepper' type noise. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighbouring pixels. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image 2 pixel, over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value.

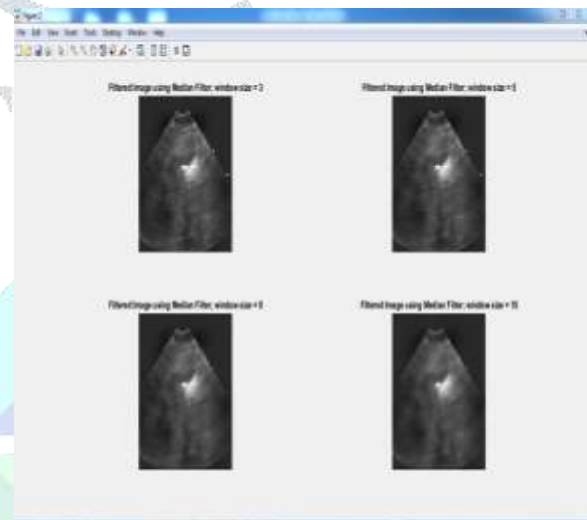The median filtered image with different window techniques as shown in fig 2.

Fig 2. Filtered Image using Median Filter with different Window Size.

3. Butterworth Filter :-

The butterworth filter has a maximally flat response, i.e., no pass band ripple and roll-off of minus 20db per pole. Another name for it is "flat maximally magnitude" filters at the frequency of $\Omega = 0$, as the first 2N - 1 derivatives of the transfer function when $\Omega = 0$ are equal to zero. [4]. The Butterworth filters achieve its flatness at the expense of a relatively wide transition region from passband to stopband with average transient characteristics. This filter is completely defined mathematically by two parameters i.e. cut off frequency and number of poles. Compared to chebyshev filter, the phase linearity of buttorworth filter is better. In other words, the group delay (derivative of phase with respect to frequency) is more constant with respect to frequency. This means that the waveform distortion of the butterworth filter is lower.

This Butterworth filters have the following characteristics

i)The magnitude response is nearly constant (equal to 1) at lower frequencies. That means pass band is maximally flat   .
ii)The response is monotonically decreasing from the specified cut off frequencies. The maximum gain occurs at Ω= 0 and it is |H(0)|= 1.   iii)Half power frequency, or 3db down frequency, that corresponds to the specified cut off frequencies.

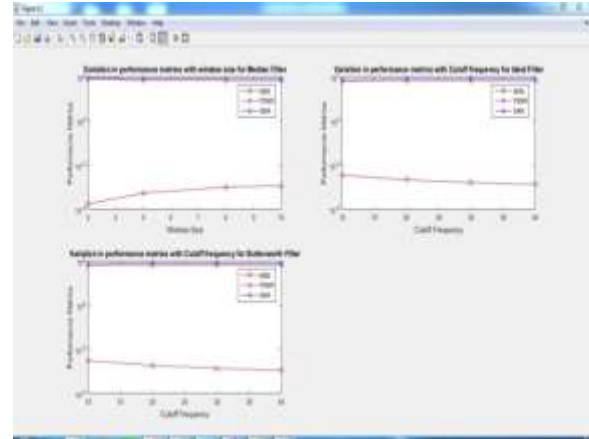The butterworth filtered image with different frequency range as shown in fig 1.

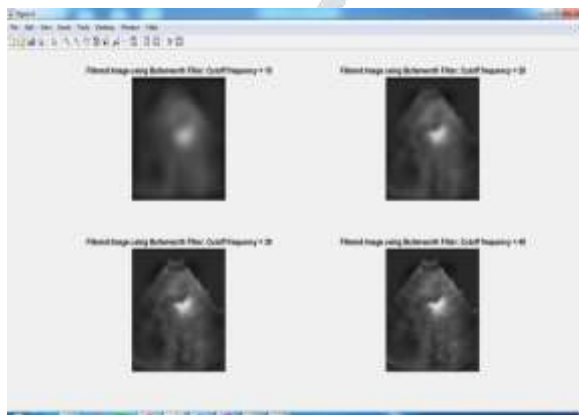**Fig 4. Performance Metrics of different Filters**

III.   Comparative Analysis

In this section, comparative of three filtering technique is shown in tabular form. Return loss and bandwidth is compared in table 1.

Fig 3. Filtered Image using Butterworth Filter with different Frequency.

III. Performance Parameter

There are three performance parameter to measure restored image. Image restoration research aims to restored image to from a blurred and noisy image. A widely used measure of reconstructed image fidelity for an N * *M* size image is the mean square error (MSE) and is given by

$$MSE = \frac{1}{MN}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}\left|f(i,j) - \hat{f}(i,j)\right|^2$$

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

Table 1.Comparative analysis of different Filter.

Sr. No	Para meter	Cut-off Freque ncy	MSE	PSNR	SNR
1.		10	0.00339	72.82892	63.44691
2.		20	0.00211	74.88745	65.50545
3.	Ideal Filter	30	0.00153	76.19105	66.80905
4.		40	0.001289	77.02801	67.64601
5.		3	0.00017	85.82815	76.44614
6.	Medi an Filter	5	0.00052	80.96916	71.58715
7.		8	0.000984	78.20292	68.82091
8.		10	0.001123	77.62873	68.24673
9.		10	0.003016	73.33667	63.95466
10.		20	0.001825	75.51922	66.13722
11.	Butter worth Filter	30	0.001356	76.80767	67.42567
12		40	0.001086	77.77396	68.39195

IV. Conclusion

After Analyzing, it is found that ideal filter has low value of PSNR with high MSE and Simulated PSNR is 76.80767 with MSE 0.001086 db .These results show that Median filter is best filtering method for enhancement of kidney stone image .

References

[1] Nilar Thein , Kazuhiko Hamamoto, Hanung Adi Nugroho "A comparison of three preprocessing techniques for kidney stone segmentation in CT scan images "11th Biomedical Engineering International Conference (BMEiCON) , pp 78-86 , July 2018.

[2] S. Hu , F. Yan, M. Griffa , R. Kaufman G. Anton A. Maier C. Riess "Towards Quantification Of Kidney Stones Using X-Ray Dark-Field Tomography " IEEE 14th International Symposium on Biomedical Imaging (ISBI 2017) , PP 77-88 , 2017.

[3] Nuhad A. Malalla, Pengfei Sun, Ying Chen, Michael E. Lipkin, Glenn M. Preminger "C-arm Technique with Distance Driven for Nephrolithiasis and Kidney Stones Detection: Preliminary Study" IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI) , pp 147-156 , July 2016.

[4] Pallavi Vaish, R Bharath, P Rajalakshmi, U. B. Desai "Smartphone Based Automatic Abnormality Detection of Kidney in Ultrasound Images" 18th International Conference on e-Health Networking, Applications and Services, pp 417-425 , Nov 2016.

[5]Tanzila Rahman, Mohammad Shorif Uddin "Speckle Noise Reduction and Segmentation of Kidney Regions From Ultrasound Image" *IEEE , (pp 99-106),May 2014* .

[6] K.Vishwanath , R. Gunasundari "Design and analysis performance of Kidney Stone Detection from Ultrasound Image by Level Set Segmentation and ANN Classification" *International Conference on Advances in Computing, Communications and Informatics,(pp 407 – 414) , Aug 201*

[7]S. Asadi, H. Hassanpour, and A. Pouyan, "Texture based image enhancement using gamma correction," *Middle-East Journal of Scientific Research*, vol. 6, no. 6, pp. 569-574, 2010.

[8] V. Caselles, F. Catte, T. Coll, and F. Dibos, "A geometric model for active contours in image processing," *Numerische Mathematik*, vol. 66, no. 1, pp. 1-31, 1993.

[9] R. Malladi, J. A. Sethian, and B. C. Vemuri, "Shape modelling with propagation," *A Level Set Approach. Trans. of Pattern Analysis and Machine Intelligence*, vol. 17, no. 2, pp. 158-175, Feb. 1995.

[10] A. Rosenfeld and A. C. Kak, *Digital Picture Processing*, 2nd ed., Academic Press, 1982, ch. 10.

[11] E. R. Davies, *Machine Vision: Theory, Algorithms and Practicalities*, 4th ed., Academic Press, 1990, ch. 2, pp. 18-37 and ch. 4, pp. 83-97.

[12] D. Vernon, *Machine Vision. Automated Visual Inspection and Robot Vision*, Prentice-Hall, 1991, ch. 4, pp. 49-50 and ch. 5, pp. 86-90.

[13] J. Serra, *Image Analysis and Mathematical Morphology*, London: Academic Press, 1982, ch. 1, pp. 3-20 and ch. 2, pp. 50-59.

[14] L. Shapiro and G. Stockman, *Computer Vision*, 1st ed., Prentice Hall, Jan. 2001, ch. 3, pp. 63-97.

[15] R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer, Sep. 2010, ch. 3, pp. 122-132.

[16] A. Ruina and R. Pratap, *Introduction to Statics and Dynamics*, Oxford University Press, 2002, ch. 2, pp. 71-85 and ch. 3, pp. 138-152.

[17] J. Kolomaznik, "Fast segmentation of kidneys in CT images," presented at the WDS '10 Proceedings of Contributed Papers, 2010, Part I, pp. 70-75.

[18] D. Y. Kim and J. W. Park, "Computer-Aided detection of kidney tumor on abdominal computed tomography scans," *Acta Radiologica*, vol. 45, no. 7, pp. 791-795, 2004.

[19] D. T. Lin, C. C. Lei, and S. W. Hung, "Computer-Aided kidney segmentation on abdominal CT images," *IEEE Trans. on Information Technology in Biomedicine*, vol. 10, no. 1, pp. 59-65, Jan. 2006.

[20] A. Madabhushi, N. Dimitris, Mctaxas, "Combining low-high-level and empirical domain knowledge for automated segmentation of ultrasonic breast lesions", in IEEE Trans. On Medical Imaging, vol. 22, no. 2, pp. 155-169,Dec 2003

[21] O. G. Cula and K. J. Dana, "3D texture recognition using bidirectional feature histograms", Int. J. Comput. Vis., vol. 59, (2004), pp. 33-60.

[22] C. Schmid, "Weakly supervised learning of visual models and its application to content-based retrieval", Int. J. Comput. Vis., vol. 56, (2004), pp. 7-16.

[23] M. Varma and A. Zisserman, "A statistical approach to texture classification from single images", Int. J. Comput. Vis., vol. 62, (2005), pp. 61-81.

[24] B. Caputo, E. Hayman and P. Mallikarjuna, "Class-specific material categorization", Proceedings of the International Conference on Computer Vision, vol. 2, (2005), pp. 1597-1604,Dec2005.

[25] Yap, M.H., Ewe, H.T., Region of interest (ROI) detection in ultrasound breast images. In: Proceedings of MMU International Symposium on Information and Communications Technologies (M2USIC).

Cyberjaya, Malaysia: Multimedia University,5–8,Dec2005   [26] M. M. Fernandes, C. A. Lopez, "An approach for contour detection of human kidneys from ultrasound images using Markov random fields and active contour", in Medical Image Analysis,pp.1-23,Dec2005 [27]Bommanna Raja, Madheswaran and Thyagarajah," A General Segmentation Scheme for Contouring Kidney Region in Ultrasound Kidney Images using Improved Higher Order Spline Interpolation", International Journal of Biological and Life Sciences, Vol. 2, No. 2, pp. 81-88, 2006.