A Comparative Study of Binarisation of Ultrasound Images

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ABSTRACT
The ultrasound imaging is one of most trustful tool to diagnosis the abnormities in kidney. The urinary tract infection is major problem rise due to presence of stones in the kidneys. Automatic detection of region of stone is a challenging task as ultrasound image suffers with speckle noise which is coherent in nature. The present research is aimed to test various binarisation algorithms and conduct statistical analyzes to find the algorithm best suitable for the binarisation of ultrasound images. A comparative study is conducted on clinical and synthetic ultrasound images. The binarisation algorithms are classified into two broad categories namely global and local thresholding. The study included binarisation algorithms such as Otsu's binarisation algorithm under global binarisation, whereas, Souvola's binarisation, Niblack's Binarisation, Bernsen's Binarisation, Morphological binarisation and adaptive binarisation are considered for analysis under local binarisation. These algorithms are tested on 50 ultrasound images collected from ultrasound centres. The statistical metrics considered for testing are Visual Observation and PSNR (Peak signal to noise ratio). The statistical analysis revels that presence of speck is the major hindrance in the segmentation of ultrasound images. Among the tested algorithms, adaptive binarisation and morphological operations based binarisation have shown better results. The speckle noise needs to be suppressed keeping the fine detail like edge information while separating the background from region of interest.

Keywords
Binarization, Global Binarisation, Local Binarisation, Segmentation, Ultrasound Images, Speckle Noise

1. INTRODUCTION
Ultrasound scanning is one of the most frequently used diagnosis process to detect abnormalities in kidneys. It is used to identifying the shape and structure of human anatomy, especially in case of kidney scanning. One of the most common diseases is urinary tract infection (UTI) and root cause is presence of renal stones. The presence of renal stones effect the function of kidney and leads to abnormality in kidney function and abdomen pain. Early detection of stone in kidney can avoid complication of UTI. The ultrasound is considered as the preliminary diagnosis tool to detect the size and location of stones in the kidney. It is popular among the physician due to its non invasive nature, radiation free and low cost of scanning. The ultrasound imaging is real time system which generates images of inner tissues of kidney by propagating ultrasound waves of frequency between 1 to 15 Mhz. It is based on pulse echo approach in which a probe is placed on the area to be analyzed. The ultrasound waves travel through the tissues and reflected back to generate images. Generally, the analysis of ultrasound images is carried out manually by the physician with simple image processing options. The various efforts have carried out to provide automation of detection of abnormalities in the kidney scanning. The present study is also an attempt to analysis various binarisation algorithms used for segmentation of ultrasound images. The segmentation is used to segment the ultrasound images for analysis of shape and size of kidney, detection of stone, ulcers and lesion. The ultrasound image suffers with speckle noise which is inherited in nature and hinders the automatic segmentation process [1]. Presence of speckle not only degrades the visual quality but it makes difficult to find the edge information [2]. The binarisation algorithm is considered as one of the method to segment the images into background and foreground. The present study is an attempt to analyze the various algorithms to binarise of Ultrasound images.

2. BINARISATION TECHNIQUES FOR ULTRASOUND IMAGES
Binarisation is the process which is used to classify image pixels into two groups i.e. background and foreground. The various approaches are available in literature [9-12] to binarise document, camera captured images. The binarisation techniques are classified into global and local binarisation [3]. In global binarisation, single threshold value is used to binaries the whole image whereas local threshold algorithms used multiple threshold values to segment the different regions. The example of global binarisation has been seen in Otsu's binarisation and Kapur's binarisation, whereas, Savala's binarisation, Niblack's Binarisation, Bernsen's Binarisation are examples of local binarisation methods [4]. The major issue with binarisation is to find the threshold value which can segment the image into two well defined regions while preserving the region of interest. The following Techniques have been conserved for study.

1. Otsu's Binarisation Technique
2. Niblack's Binarization Technique
3. Sauvola's Binarization Technique
4. Wolf's Binarization Technique
5. Adaptive Binarization Technique

In present study is aimed for searching for an algorithm which can revere the region of interest i.e. kidney region where stone may be present and suppress the background. The presence of speckle is another problem that hinders the segmentation process. The speckle intermixed with object region and deformed the edge information leads to region overloads.

2.1 Otsu's Binarization Technique:
It is a global binarization method. It assumes that the image to be threshold [6] contains two groups of pixels (e.g.

foreground and background) and calculates the optimum threshold value to separating those two groups so that their intra-class variation is minimal. Where intra-class variance is calculated as

$\sigma 2\omega(t)=\omega 1(t)\sigma 21(t)+\omega 2(t)\sigma 22(t)$

The Otsu's algorithm is not satisfactory performance in uneven illumination and is not real-time implementation.

2.2 Niblack's Binarization Technique

Niblack's algorithm is a local thresholding method based on the calculation of the local mean and local standard deviation [5]. In this method, the averaged grey level of a neighbourhood of a given point is used to set a threshold for that point. The threshold is decided by the formula:

$T(x, y) = m(x, y) + k \cdot s(x, y)$

Where, m(x, y) and s(x, y) are the average of a local area and standard deviation values, respectively. Drawback of this method is a considerable sensitivity to window size and the persistence of background noise in the output image .The improved Niblack's method uses parameters k and R to reduce its sensitivity to noise.

$T(x, y) = m(x, y) \cdot [1+k\cdot (1-s(x, y)/R)]$, Where, k and R are empirical constants.

2.3 Sauvola's Binarization Technique

Sauvola's binarization technique is window¬ based, which calculates a local threshold for each image pixel at (x, y) by using the intensity of pixels within a small window W (x, y). Here, the window of size N x N pixels with (x, y) as centre except at the edge pixels of the image frame is considered [6]. The threshold T (x, y) is computed using the following formula:

$T(x, y) = M(1 + k (SD/R - 1))]$, Where M is the mean of gray values in the considered window W (x, y), SD is the standard deviation of the gray levels, R is the dynamic range of the variance(Standard Deviation), k is a constant (0 to1).

2.4 Wolf's Binarization Technique:

Wolf's Binarization technique is implemented by calculating stranded deviation and mean within local window and over whole image [7]. The sliding window is placed over each pixel of the image and neighboring pixels values are considered for calculating m (mean) and S (standard deviation). The following equation is used to find the threshold over local window.

$T_{wolf}=(1-K)*m+K*M+K*S/R(m-M)$,

Where, k=0.5(Fixed), M- Minimum Gray value, m-mean local, m-mean global, S-Standard Deviation local, R Standard Global.

3. ANALYSIS AND CONCLUSION

The presence of speckle in ultrasound images degrades the visual quality. The denoising are used to suppress the noise in the images. These algorithms are task specific in nature. The present study is aimed to evaluate various algorithm in order to enhance the visual quality of kidney ultrasound images. The well-known algorithms such as Otsu's local thresholding, Niblack, Sauvola, wolf and adaptive are considered for analysis. These algorithms are tested on clinical ultrasound images. Table1 shows PSNR(Peak Signal to Noise Ratio) value of denoised images. The statistical parameter, PSNR is used which can be defined as the ratio of peak signal power to average noise power [8]. It can be calculated as

$PSNR= 10\log 10\ 2552*MN/ \Sigma i\ \Sigma j(x(i,j)-y(i,j))^2$

Table1: Display PSNR values of denoise US images

Image Ref.	Otsu	Niblack	Sauvola	Wolf	Adaptive
1	5.16	12.88	13.58	5.59	26.10
2	7.852	11.23	12.76	8.39	19.06
3	5.194	4.197	14.97	4.89	25.95

Higher the value of PSNR better the results of denoising algorithm. Table2 shows reference image and visual results.

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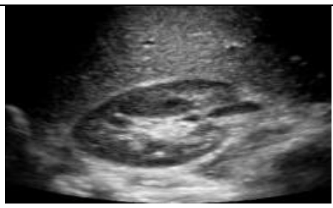
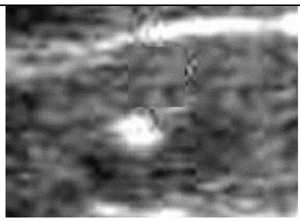
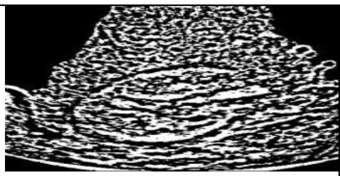
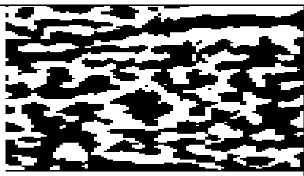
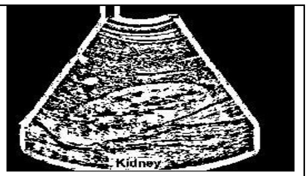
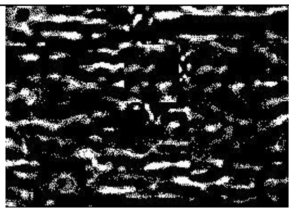
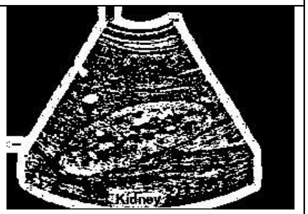
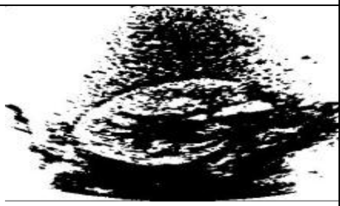
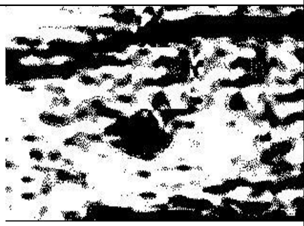
Table2: Comparison of various Binarisation Algorithms

Method/Ref.No			
1.Otsu's Binarisation			

2.Niblack's Binarisation			
3.Sauvola's Binarisation			
4.Wolf's Binarisation			
5.Adaptive Binarisation			

PSNR looks at how many pixels in the image differ from Ground truth image values and find quantity of the pixels. Higher the value of PSNR indicates better result. The statistical analysis shows adaptive binarisation and Sauvola's binarisation are better in terms of enhancing the visual quality of the ultrasound images. The present study is limited with implementation and testing of few well known algorithms but there is need to develop dynamic local thresholding method. All these method studied need to optimize to enhance the visual quality and preserve the vital information in the images.

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