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Image Pre-Processing of USG Images by Adjusting Varying Luminance Trend and Applying Morphological Operations on Segmented Image using Thresholding

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Abstract: ***This study discusses analysis of USG images by pre-processing the images for varying luminance by performing morphological operations. Ultrasound images are used to provide information in most of the medical diagnosis. Here we have tried to fix the problem with kidney stone USG images. The image generated by the two-dimensional ultrasound has not been able to provide complete information. Therefore, in order get the form of kidney stone on ultrasound image can be clearly identified with the necessary process of image analysis that can detect the boundaries of objects edges, so that it can differentiate between one object with another object on the ultrasound image. We have used linear model to remove the trend of varying illuminance and applied morphological operations on the same to get more accurate segmented image. It can be used in the ultrasound image segmentation process to obtain the best shape of the object in the image. Based on the available results we can be concluded that the simple linear regression and morphological processing are an appropriate method to fix the varying illuminance and making clearer USG image.***

Keywords: USG, Simple linear regression, Thresholding, Morphological operations, Kidney stone detection

1. Introduction

In today's time medical imaging is the most important domain as the health issues are one of the highest priorities. In medical imaging clear images are constructed of inner structures of the body for different studies and treatments. This helps in giving clear view of the different tissue structures and creates data bank of regular structure and function of the organs to make it easy to recognize the anomalies. There are many other technologies used to record information about the location and function of the body [1]. These techniques have many limitations compared to the methods that produce an image globally for different diagnostic purposes [2]. One of the important advantages of medical imaging is to be producing the image of internal structures of the body without invasive procedures. Due to conversion of the energies arithmetically and logically to signals images were produced [3]. In the present study we have tried to simplify the task of detection of anomaly present in the body through one of the simple and cost-effective modalities i.e., Ultrasound imaging. Before performing actual detection technique, we are first removing noise in the form of luminance which could affect final accuracy of detection. Noise is nothing but random variation of image intensity and visibility as a part of grains in the image. Noise may cause in the image due to effects of behaviour of light or thermal energy of heat present inside the image sensors [4]. It may get generated at the time of capturing or image transmission [6].

Here we have applied two techniques simple linear regression and some morphological operations on kidney stone USG for stone detection. We are also applying threshold to evaluate the image segmentation and can be used to generate binary images from grey scale image. Simple linear regression method is used to remove luminance and morphological operations: erosion and dilation are used to get more clear detection in USG kidney stone image.

2. Literature Survey

In this study author has done comparative study of USG images using B-mode and doppler operator for ovarian mass leisons and found if we use USG with proper operator, it can accurately characterise benign and malignant ovarian lesions [5].

In the study author has used noise removal algorithms for reducing the visibility of noise by using smoothing operation on the entire image without considering areas near contrast boundaries. Further he also added these methods can work fine on low contrast details [6]

As per the study thresholding is a simple but effective tool to separate objects from the background. As many applications of image processing, the grey levels of pixels as a member of the object are significantly different from the grey levels of the pixels belonging to the background [8].

In the study author focuses on different clustering-based thresholding methods and analysing various image pre-processing methods. It also categorizes the image and presented the formulas under a uniform notation. Also, the detailing about Otsu thresholding method considering histogram results are given. As per the result author states that their survey on Otsu thresholding is better [7].

In this study the authors [14] used image processing technique to improve gene expression translation. He has used erosion and dilation to enhance the image. To eliminate some noises the microarray images also undergo a threshold

process. Finally, author concluded by comparing a higher peak signal-to-noise ratio and a lower mean squared error than the Wiener filter, low pass filter, and median filter.

Problem definition
Identifying luminance trend in the USG image and removing the same by using simple linear regression model. Further using morphological operations to simplify the image processing task.

3. Methodology

For present study we selected kidney stone USG images. First, we executed thresholding with single value we didn't get the proper output. After trying for multiple thresholding value, we could get the proper output as there was luminance in image fixed value of threshold was not working. So, we first removed the luminance and then applied thresholding with fixed value. The followedfigure depicts the methodology we have followed.

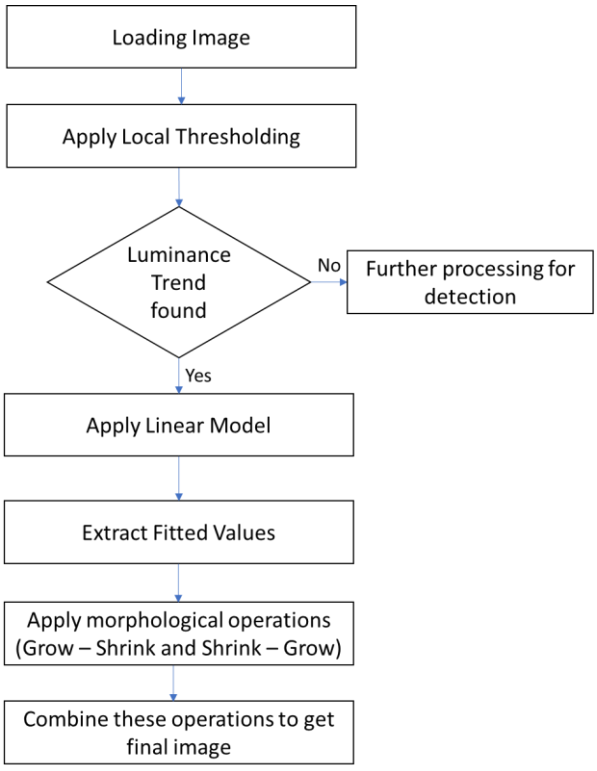


Figure 1: Steps of image pre-processing of USG images

We have applied linear model and grey thresholding technique on kidney stone image to simplify further processing of kidney stone detection. Both the techniques are implemented in R programming.

Simple linear regression: Simple linear regression is used to evaluate the relationship between two quantitative variables. Here the formula for a simple linear regression [9]:

$$y = \beta_0 + \beta_1 X + \epsilon \quad \text{Eq. 1}$$

Here, y is the predicted value of the dependent variable, B_0 is the intercept, the predicted value of y when the x is 0, B_1 is the regression coefficient, x is the independent variable, e is the error of the estimate. Linear regression finds the best fit line through the data. It finds the regression coefficient i.e. B_1which minimizes the total error (e) of the model.

Gray Thresholding:
Basically, thresholding is to define a range of brightness value in the original image. After thatitselects the pixels within the range which are belonging to the range of foreground and then removes all other pixels to the background [10]. After processing we get a binary image [11]. Following is the formula for thresholding for grey level pixel.

$$g(x,y) = \begin{cases} 0, & f(x,y) < T, \\ 1, & f(x,y) \geq T \end{cases} \quad \text{Eq.2}$$

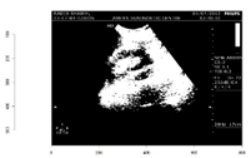
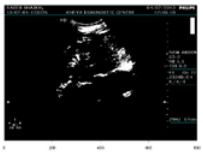
Here, T is the threshold value, f (x, y) is the original pixel value and g (x, y) are the resulted pixel value after thresholding the image. Eq. 1 denotes 0 and 1 as output values, which gives the result as a true binary image. Eq.1 can be presented by Table 1. as mappings of input to output grey level [12].

In image processing the basic operations of morphological processing are erosion and dilation. The erosion shrinks the foreground structures, and the dilation enlarges them. The performance of both operations depends on their structuring element shape. In this study, the erosion and dilation operations are performed on segmented USG kidney stone image to get the clearer segmentation [13].

4. Results and Discussion

In the present study firstly, we applied thresholding with four different threshold values viz. 80, 85, 90 and95. We have got following results:

Table 1: Thresholding with four different values

Threshold value: 80	Threshold value: 85	Threshold value: 90	Threshold value: 95
			

We extracted fitted values to remove the luminance trend in the image. The output is as shown below:

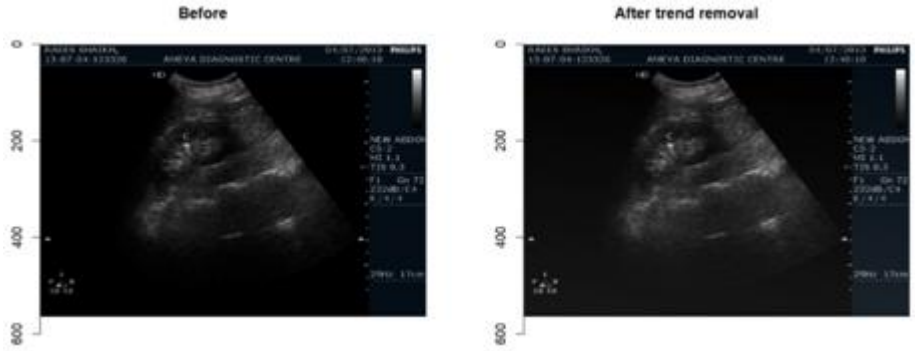


Figure 2: Before and after removal of luminance trend

We also executed histogram to observe the difference after removal of luminance trend

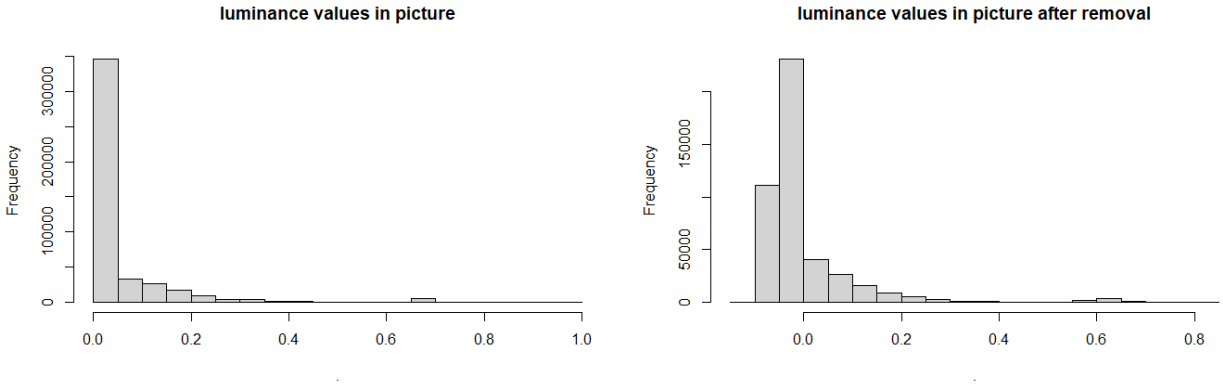


Figure 3: Luminance values in original image **Figure 4:** Luminance values after removal

It is now easier to threshold the image. So, we executed thresholding technique with four different threshold values: 80, 85, 90 and 95 again. The result is shown as below:

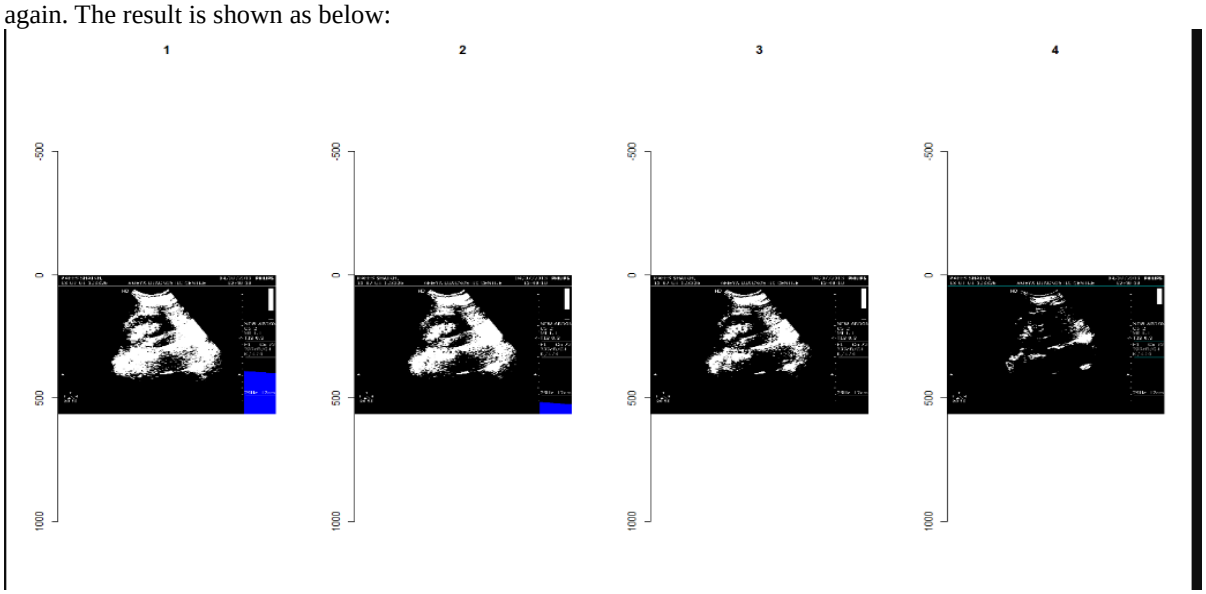


Figure 5: Thresholding results with four different values viz. 80, 85, 90 and 95

Further we applied Morphological operations on pixsets. We selected thresholding value as 95%. After applying we get following image

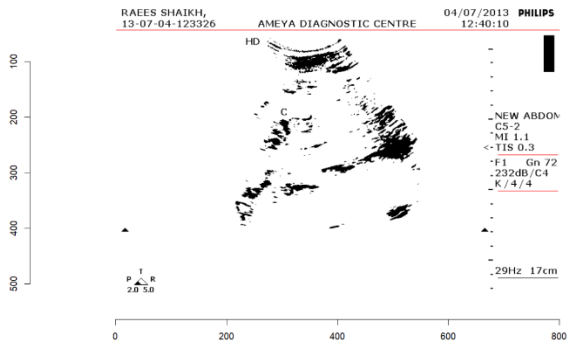


Figure 6: Thresholding pixsets with 95%

To make use of many convenience functions we converted black and white image to "pixset" object. In the image above, the pixels in white define the pixset. "grow" a morphological dilation enlarges a pixset and "shrink" shrinks it. "shrink" removes all the isolated dots. "grow" and "shrink" are not inverse operations indeed, if we combine "shrink" followed by "grow", we can clean up pixsets. Following figure depicts the same"

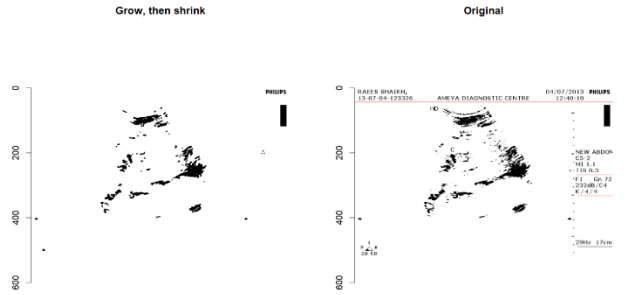


Figure 7: Grow then shrink operation

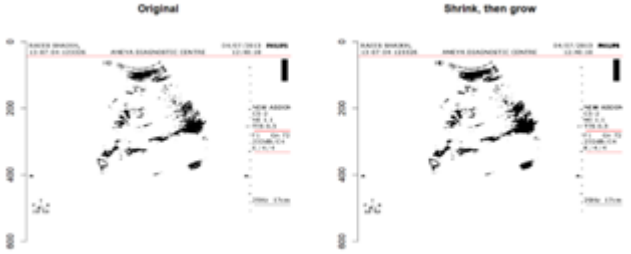


Figure 8: Shrink then Grow operation

Combining both the operations Grow and Shrink then Shrink and Grow we get a good, outlined USG kidney stone image.

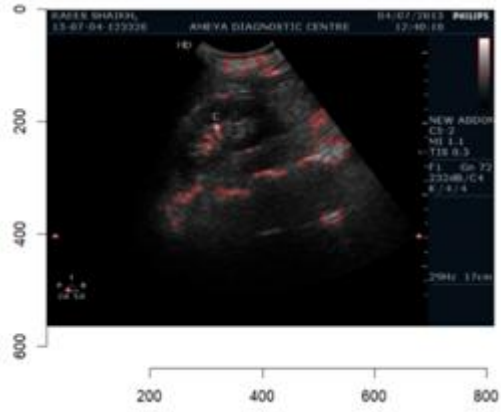


Figure 9: USG kidney stone image after performing erosion and dilation both

5. Conclusion

In our above study on USG kidney stone image pre-processing, we found firstly Linear model eliminate the unwanted luminance trend from the image by retaining only useful information and secondly morphological operations really shown a good performance on segmented image. Thus, we conclude that Simple linear regression is one of the methods of Linear model and morphological operations considered to be a good technique to simplify the further processing of an image and to get the more accurate result.

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