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SEMI-AUTOMATION OF RENAL REGION OF INTEREST IN RENOGRAPHY IMAGES BY THRESHOLDING AND EDGE DETECTION*

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Abstract. In the survey of the activity of the kidneys by nuclear medical imaging, determining the region of interest (ROI) by the operator is an important factor. The current study aimed to obtain an automatic method to determine the ROI of kidney to reduce the error of manual method of the operator. In this survey, the equations obtained through the thresholding method are performed to semi-automation of ROI drawing. For the left kidney the threshold is 1.03 times the mean count of left kidney and for the right kidney, the good threshold is 1.08 times the mean court of the right kidney with correlation coefficient 0.95.

Key words: thresholding, renography, region of interest.

1. INTRODUCTION

To investigate the activity of the kidneys in diagnosis of renal diseases, nuclear medical images are the most common methods. By gamma camera-based methods, there is no need for blood or urination sample to survey the activity of the kidneys [1]. Today, besides the quality investigation of nuclear medical images by the aid of recorded counts by gamma camera, the quantity survey is done [2]. In this method, imaging is taken after preparing the patient and putting the detector in posterior condition, various images of the patient's kidneys are taken. Normally, the imaging is done in two stages. In the first stage, images are recorded to survey the blood distribution to the kidney, the time duration if each image being 1–2

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seconds. The second stage images that are recorded to investigate the kidney performance have a time duration of 10-30 seconds.

After the end of imaging for each of the kidneys, a time-activity curve (Renogram) is assembled. Renograms indicate the balance between radioactivity matter entrance to kidney (purification) and its exit from the kidney (emptying in urinary bladder). The main way to provide Renogram curve is the correct diagnosis of the kidney edges. The mistake of kidney edges diagnosis can lose count or adding the background counts. However, the nuclear medical images have low signal to noise ratio, thus kidney edges in these images are not detected well. To remove this problem, it is required to add a combination of images that are the sum of some primary images to improve signal to noise ratio. Determining the border of the kidneys is achieved by manually plotting a line around the kidneys or ROI. But this method to determine the kidneys border is error prone because count gradient changes around the kidneys are not detected well by the human eye. This causes a user not to be able to draw two similar ROIs on an image in processing replication. Drawing ROI by different users is considerably different [3–6]. The importance of these differences depends upon the interpretation method of Renogram. These errors cause considerable differences in quality interpretation that is the consideration of the physician to the images not the Renogram but considerable err or are ca used in quantity interpretation. It should be considered that in consecutive imaging, the negative or positive changes in the disease are not diagnosed in quality interpretation and the interpretation should be done by the indices extracted from Renogram curve. The indices such as relative activity of two kidneys, kidneys output and time passing of radioactivity matter from Parenchyma tissue are considerably affected by such errors.

One solution to remove this problem and reduction of error is ROI drawing as semi-automatic. By this method, we can minimize the error dependency of ROI drawing to operators. The current study aimed to obtain the relationship between a good threshold with the mean count of each kidney.

2. METHOD

In the current study, 20 series of renography images size 128*128 were applied. These images were divided into high relative count density and low relative count density. The first group included 10 image series with count collection time in each image 10s and maximum relative count 10–30. In this group, the combinational image to draw ROI was obtained by adding 12 first images in time duration 0–120s. The second group was consisted of 10 images with collection time of each count in each image of 60s and maximum relative count was 100–1000. In the second group, the combined image was the sum of two initial images (two initial minutes). The study was performed using the MATLAB (7.6.0) software.

Reference ROIs were drawn by a specialized medical physician for each series of the images manually on the combined image. For each kidney, the count of ROI was 1 inside it and it was zero outside of it. The binary image was applied as reference to compare with the semi-automatic methods (Fig. 1).

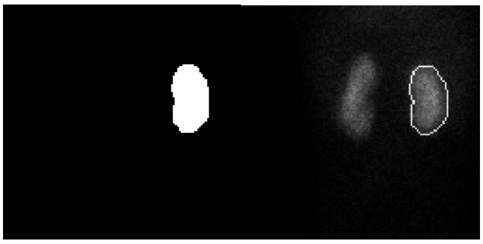

Fig. 1 – Left , ROI around the right kidney determined by the physician, right binary reference image.

To eliminate the error of the counting of other organs of the body such as liver in neighborhood of the kidney and as the kidney size depends upon the gender, height and weight, a rectangle box including the kidneys was determined for each kidney separately. To achieve this box in the right, left, up and down of each kidney, the outermost pixel of the kidney was determined in the image and the kidney confinement box was drawn. To be ensured of the full placement of the kidney in this box, based on its 128×128 size, the images were added as symmetrical, 10 pixels were added to the length and width of the rectangle. Then, the maximum value and mean of the count of each kidney were determined separately (Fig. 2).

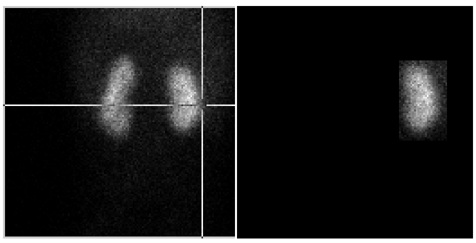

Fig. 2 – Left, the first click of the operator, right output image of the border for right kidney.

250 different thresholds at duration 1–2.5 were considered in 1/100 difference on images (first and second group). The pixels more than the threshold value were 1 and less than threshold value were 0. For each thresholded image dice similarity coefficient) DSC) and error to binary model of manual method of the medical physician were calculated separately for the left and right kidney. These values were obtained by the following definitions:

$$\text{Error} = \frac{\text{The difference of count of binary images of manual method and thresholded images} \times 100}{\text{count value in manual method}}$$

$$\text{DSC} = \frac{\text{the common counting between manual binary images and thresholded} \times 2}{\text{counting in binary image of manual method} + \text{count in binary threshold image}}$$

In the previous studies, comparing the images from the semi-automatic method with the reference image, quality method high, good, average and weak [7]. In this study, the quantity comparison is based on the above definitions to be independent of relativity. Based on the defined equations, it is expected that optimal threshold is the one in which the error is minimum and DSC is maximum.

In order that in the final equations in the entire maximum interval of relative count of the images provided by the hospitals (with radiotracers, imaging protocols and different reading of the images), the closest correct answer is shown, the entire images were multiplied by transfer coefficient. This coefficient was defined for maximum transfer of relative count of various images to 100–1000. The maximum interval of the counting of the first group with low count density was transferred to the maximum count of the second group with high count density.

$$\text{Transfer coefficient} = \frac{1100}{\text{the lowest maximum counting} + \text{the highest counting maximum}}$$

3. RESULT

In thresholding method on 20 patients, DSC and error minimum value were obtained in common threshold. To determine the good threshold, a fraction was defined in which the numerator is the error and denominator is DSC. The optimal threshold is the one making this fraction minimum. For two groups of the images, optimal threshold equations obtained by maximum count and counting mean of left and right kidney were obtained separately. These equations after applying transfer coefficient on images were achieved. Fig. 3 shows good threshold value in mean count of left kidney and Fig. 4 shows the same results after applying transfer coefficient on the images.

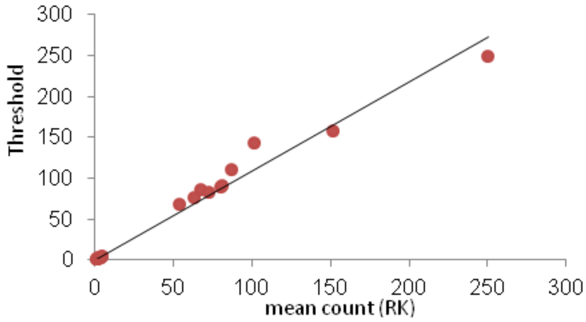

Fig. 3 – The optimal threshold obtained in mean count for right kidney for 20 images.

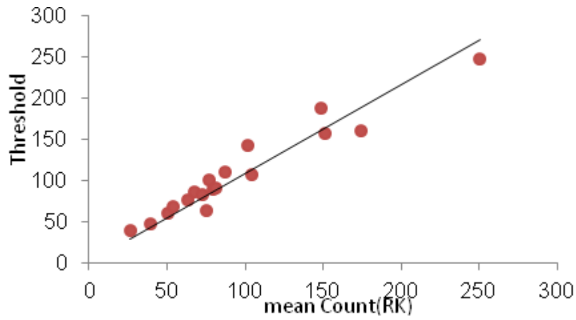

Fig. 4 – The optimal threshold obtained in mean count for right kidney for 20 images.

After applying transfer coefficient:

Fig. 5. The thresholded image for right kidney by semi-automatic method
in mean count by applying transfer coefficient.

4. DISCUSSION AND CONCLUSION

In determining the ROI of the kidneys in Renography images to survey the activity of the kidneys and plotting Renogram curve, we can apply semi-automatic thresholding methods. Due to reducing the error from the noise in nuclear medical images, expressing the optimal threshold equations in mean count is more suitable than expressing this equation in maximum count.

In separated investigations, two types of images with high maximum count and low maximum count, the optimal threshold equations were obtained in count mean separately. These two relations separate ROI of the kidneys well as semi-automatic in the images. In simultaneous investigation of 20 images, the equations for one type can separate the ROI well. To remove this problem, a unit equation was obtained after applying transfer coefficient on the images. Finally, we can report an optimal threshold for the right kidney as 1.03 as its mean count and for the left kidney as 1.08 as its mean count with correlation coefficient 0.95.

As drawing the ROI manually only on the image of the sum of frames of two first minutes and by semi-automation of this trend, for both two minutes of the frames, separate ROI is achieved. As on the initial frames in which the kidneys have the greatest ROI, rectangle box is separated and is copied on the remaining of the frames. For each frame, the mean count of the kidney is obtained and ROI automatic is drawn. Thus, the extra count is prevented in drawing Renogram and the patient movement correction is done. In some clinical investigations, it is required to separated the image in which radiotracer enters the renal pelvis and is isolated of the series of the images in order not to affect Renogram curve. Thus, this is important in determining ROI semi-automation on whole frames. This trend should go where renal pelvis receive radiotracer.

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