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EDGE DETECTION IN CARDIAC NUCLEAR IMAGES

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ABSTRACT

Nuclear imaging with positron emission tomography (PET) and single photon emission tomography (SPECT) enables visualizing the functional details of the organs. Cardiac nuclear imaging plays a critical role in the diagnosis of coronary artery diseases. One of the objectives of image processing is to improve the pictorial information of the image for human interpretation. A major step in image interpretation is to segment the region of interest from its background. A fundamental tool for image segmentation is edge detection. In this paper an attempt is made to study the performance of different edge detection techniques and their effect on cardiac nuclear images. Henceforth, the method which yielded the best results is extended and applied on color cardiac nuclear images.

KEYWORDS: Cardiac Nuclear Imaging, Edge Detection, Segmentation

INTRODUCTION

Cardiac nuclear imaging provides pictures of the distribution of blood flow to the heart muscle. Coronary artery disease is caused by the accumulation of plaques in the walls of arteries that supply blood to the myocardium. This creates stenosis in the coronary arteries which impairs blood flow to the myocardium. Myocardial perfusion imaging is the most accurate test available for assessing the impact of these plaques on the blood flow to the heart [1]. To evaluate the cardiac functioning, two sets of cardiac scans are performed, one while the patient is at rest and the other, after engaging the patient in physical exercise (commonly known as stress test). The images obtained at stress are then compared with the images obtained at rest to detect any blockages of the coronary arteries. As a preprocessing step to this analysis the region of interest can be segmented out and these segmented portions can be compared. Image segmentation is carried out to classify an image into several regions according to the feature of the image. According to the techniques employed segmentation methods can be classified into region based segmentation and edge based segmentation. Edge detection is a part of edge based segmentation methods. Different edge detection techniques are available. In this paper an attempt is made to review the common edge detection techniques and to find their effect on cardiac stress and rest images. Then the method which best suits is extended to ycbcr color space and obtained the result.

COMMON EDGE DETECTION TECHNIQUES

In an image, an edge occurs when there is a discontinuity in the intensity function between neighboring pixels. Using this assumption if the derivative of the intensity value is taken across the image and if the point at which maximum derivative occurs is found out, the edges could be located. So discontinuities can be detected by using first order and second order derivatives. The first order derivative of choice in image processing is the gradient [2]. The gradient of a 2D function f(x,y) is defined as the vector given in equation (1).

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \tag{1}$$

The magnitude of this vector is given by equation (2)

$$\nabla f = \left[G_x^{\ 2} + G_y^{\ 2}\right]^{1/2} \tag{2}$$

To simplify computation this value is approximated by omitting the square root operation as shown in equation (3).

$$\nabla f \approx G_x^{\ 2} + G_y^{\ 2} \tag{3}$$

Using absolute values results in equation (4)

$$\nabla f \approx |G_x| + |G_y| \tag{4}$$

Many edge detection techniques are available in literature [2]. Sobel edge detection, Canny edge detection, Robert edge detection and Prewitt edge detection are reviewed in this section. To analyze cardiac nuclear images it is better to work with color images. But the above mentioned edge detection techniques are defined for gray scale images. So the original cardiac nuclear images are first converted into gray scale images and then the operations are performed.

SOBEL EDGE DETECTION METHOD

The Sobel edge detection method [2, 3] which was introduced by Sobel in 1970, uses Sobel approximation to the derivative to find edges. It uses gradient method, which detects the edges by looking for the maximum and minimum in the first derivative of the image. The Sobel operator masks are given in equation (5).

$$x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \tag{5}$$

PREWITT EDGE DETECTION METHOD

The Prewitt edge detection method [2] is used to estimate the magnitude and orientation of the edges. It also uses gradient method. It uses a 3x3 neighborhood pixels edge gradient operator described by the masks given in equation (6).

$$x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} y = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \tag{6}$$

ROBERT EDGE DETECTION METHOD

A 2D spatial gradient measurement is performed by the Robert operator [2] and it emphasizes regions of high spatial frequency that correspond to edges. The Roberts edge detection operator masks are as given in equation (7).

$$x = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} y = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \tag{7}$$

CANNY EDGE DETECTION METHOD

Canny edge detection algorithm [2,4] was created by John Canny and it outperforms many of the newer edge detection algorithms. The Canny edge detection algorithm consists of the following steps:

- Smoothing
- Finding gradients
- Non-maximum suppression
- Double thresholding
- Edge tracking by hysteresis.

PROPOSED METHOD

The cardiac nuclear image is read in terms of one luminance and two chrominance components because this models human perception of color more closely than the standard RGB model. The conversion formula is given in equation (8). From this representation the luminance component is separated out.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112.000 \\ 112.000 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (8)$$

The edge detection operations are carried out on the luminance component. Then the image is converted back to RGB color space.

EXPERIMENTAL RESULTS

The relative performance of various edge detection techniques is presented in this section. The techniques were implemented using MATLAB and tested with a portion of the cardiac stress rest image. The original image is given in Figure 1, its gray scale version is given in Figure 2 and the images obtained by using common edge detection techniques are given in Figure 3, Figure 4, Figure 5 and Figure 6. The image obtained by the proposed method is given in Figure 7.

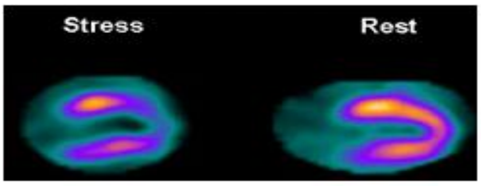

Figure 1: Cardiac Nuclear Stress Rest Image

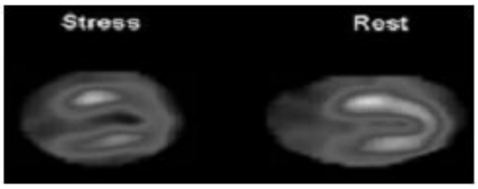

Figure 2: Corresponding Gray Scale Image

Figure 3: Sobel Edge Detection

Figure 4: Prewitt Edge Detection

Figure 5: Robert Edge Detection

Figure 6: Canny Edge Detection

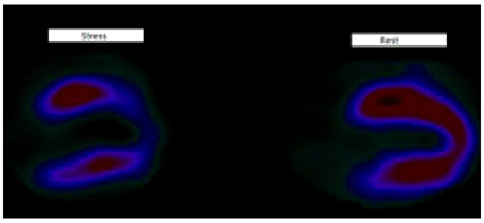

Figure 7: Proposed Method

DISCUSSIONS

Edge detection methods investigated so far are further assessed by comparing the quality of the edge maps. The evidence for the best edge detector is judged by studying the edge maps relative to each other through statistical evaluation [5]. Table 1 gives the relative frequencies of occurrence of edge pixels in the different edge detector outputs. The prewitts operator reports the higher detected edge pixels. Upon this evaluation, prewitts edge detection method was employed to characterize edges in color cardiac nuclear images in ycbcr color space. The result is given in Figure 7.

Table 1: Relative Frequencies of Detected Edges

Operator	Sobel	Prewitt	Roberts	Canny
Sobel	1	3.6684	1.0092	1.8051
Prewitt	0.2726	1	0.2751	0.4921
Roberts	0.9908	3.6348	1	1.7886
Canny	0.5540	2.0322	0.5591	1

CONCLUSIONS

In this paper an attempt is made to observe the effect of the edge detection techniques based on discontinuity intensity levels on cardiac nuclear images. From the results, the prewitt operator gives the better output for these types of images. Then the edge detection technique using prewitt operator is extended to color space and obtained a visually appreciable output.

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