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Increasing of Edges Recognition in Cardiac Scintography for Ischemic Patients

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ABSTRACT

The detection of ischemia heart disease was usually scored by a trained nuclear medicine Physician by determining the ischemia location and size subjectively (by eyes). This subjective method will add to the 5% tolerance error, which might compromise the whole process of treatment especially in patients with severe conditions. The aim of this study is to increase the edge recognition in cardiac scintography images in patients with ischemic heart disease using L*a*b* color space and K-means clustering. First, we read the nuclear cardiac images. We then to convert the images form RGB color space to L*a*b* color space. Then we classify the colors in 'a*b*' space using K-means clustering. Then we label every pixel in the Image using the results from K-means. We then create images that segment the cardiac image by colour. Finally, we segment the cardiac image into a separate image. The sample of this study was (146 cases) and they showed increase enhancement. This segmentation technique (automatic scoring) and segmented images was adjudicated by three nuclear medicine physician as being comparable to other segmentation techniques created with manual editing (subjective scoring). This technique showed potentials increasing of detection of the myocardial ischemia rather than conventional one.

Keywords: Cardiac, Segmentation, MatLab, Ischemic patients.

1 Introduction

The heart is the pump responsible for maintaining adequate circulation of oxygenated blood around the vascular network of the body. It is a four-chamber pump, with the right side receiving deoxygenated blood from the body at low pressure and pumping it to the lungs (the pulmonary circulation) and the left side receiving oxygenated blood from the lungs and pumping it at high pressure around the body (the systemic circulation) [1-4]. The myocardium (cardiac muscle) is a specialized form of muscle, consisting of individual cells joined by electrical connections[5][6]. The contraction of each cell is produced by a rise in intracellular calcium concentration leading to spontaneous depolarization, and as each cell is electrically connected to its neighbor, contraction of one cell leads to a wave of depolarization and contraction across the myocardium. This depolarization and contraction of the heart is controlled by a specialized group of cells localized in the sino-atrial node in the right atrium- the

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pacemaker cells [7-9]. These cells generate a rhythmical depolarization, which then spreads out over the atria to the atrio-ventricular node, the atria then contract to push the blood into the ventricles (Tarig Hakim, 2006). The electrical conduction passes via the Atrio-ventricular node to the bundle of His, which divides into right and left branches and then spreads out from the base of the ventricles across the myocardium. This leads to a 'bottom-up' contraction of the ventricles, forcing blood up and out into the pulmonary artery (right) and aorta (left). The atria then re-fill as the myocardium relaxes [10][11].

The 'squeeze' is called systole and normally lasts for about 250 ms (mill second). The relaxation period, when the atria and ventricles re-fill, is called diastole; the time given for diastole depends on the heart rate. The heart needs its own reliable blood supply in order to keep beating; hence it receives the blood via the coronary circulation. There are two main coronary arteries, the left and right coronary arteries, and this branch further to form several major branches (see appendix). The coronary arteries lie in grooves (sulci) running over the surface of the myocardium, covered over by the epicardium, and have many branches which terminate in arterioles supplying the vast capillary network of the myocardium. However these CA frequently susceptible to many disorders and diseases; of either acquired or congenital one [12], such as: (septum patency as congenital and Ischemic and Infarction diseases as acquired), and the focus of this research is to characterize the CA Obstruction and Related Findings in Ischemic Heart Patients Using Cardiac Scintigraphy. Indeed such obstruction could accompany with fatal consequences or morbidities. Radionuclide Scintigraphy during exercise permits accurate assessment of the presence and functional severity of ischemic heart disease. Worldwide the CAO has been as an endemic disease in some countries, such as USA (American Heart Association) [13]. In Sudan, the CAO has been observed increases in some patients with vague etiology, although the main causes mentioned by American Heart Association, was Fats or Embolus in contrast to these causative factors, the CAO patients may have other causes rather than that mention in literature. Therefore the researcher could highlight the co-factors that induce such CAO and further the related consequences [14][15].

2 Materials and Methods

This was experimental study conducted to study segmentation of colour ischemic heart image using colors segmentation filters of MatLab image processing program. The study included all adults patients referred for suspected CAO or Ischemic heart disease in Nuclear medicine department of Elnileen Medical center of Khartoum and Fadil Specialist Hospital.

2.1 Patient's preparations

When the patients referred for heart scintigraphy, the patients asked to stop the medication for 24 hours before the study, as well as Caffeine containing foods or drinks, because it reduced the radiotracer uptake. Also asked for fasting after night till the intravenous injection of the radiopharmaceutical, after the injection time about 15 to 20 minutes the patient asked to eat a fatty meal and chocolate for the good excretion of the gall bladder (it has normal high uptake of the radiotracer).

2.2 Imaging scanning technique:

After 45 min to 1 hour after the injection the patient entered to the gamma camera for imaging, and asked to pick out his/her upper clothes and lie supine in the imaging table to fix the ECG electrodes on his upper right side near Rt. Clavicle, Lt. Clavicle and Lt. lower thoracic vertebrae. Then the computer already set on the gated SPECT for the rest hear study, and the machine started the acquisition form the RAO (-45 degree) to LPO (135 degree), step and shoot technique till the acquisition finished. Then the processing of the acquired study by SPECT protocol for obtaining the serial images of sliced heart (Coronal, Sagittal and Transverse cuts), as well as bollar map and Ejection fraction of the heart and any available information if interested on A4 paper with a colored scale. For the Stress heart Scintigraphy used the same process that of Rest study in addition to using treadmill as exercise for elevating the heart rate or Pharmacological agent (Persantin) as stress action after the heart reaches his maximum effort then the radiopharmaceutical should be injected, then all process as same as the Rest study.

For nuclear cardiology images, each image scanned using digitizer scanner then treated by using image processing technique (MatLab), where the segmentation was studied. The scanned images were saved in PNG and 600 dpi file format to preserve the quality of the image. We used Color-Based Segmentation Using K-Means Clustering Algorithm to enhance the cardiac images. The steps of segmentation were shown in the Fig. 1 as below:

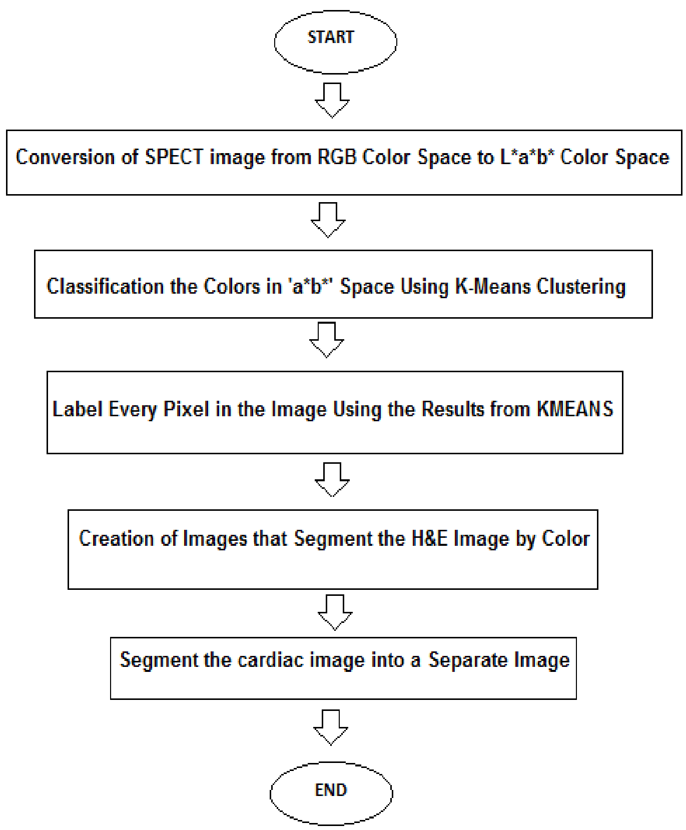

Figure 1. Steps of Colour-Based Segmentation Using K-Means Clustering

3 The results

This was experimental study conducted to study segmentation of colour ischemic heart image using colours segmentation filters of MatLab image processing program. The sample of this study was 146 patients with different age distribution and body mass index. For the group of patients where age distribution was measured, 1.2 % of patients were within the 20-29 years age range, 5 % of patients were within the 30-39 years age range, 16 % of patients were within the 40-49 years age range, 35 % of patients were within the 50-59 years age range, 34.6 % of patients were within the 60-69years age range, 7 % of patients were within the 60-69 years age range and 1.2 % of patients were within the 80-89 years age range Figure 2 and Figure 3.

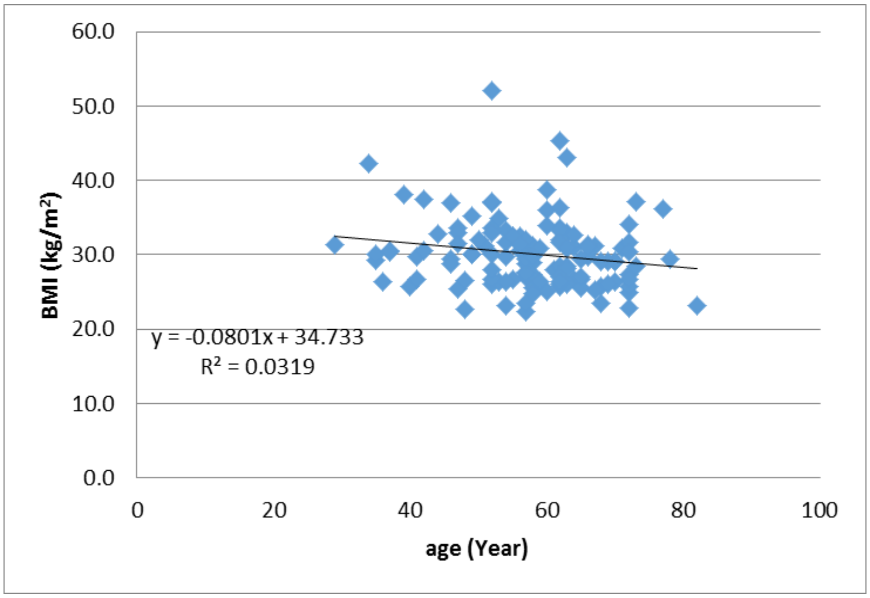

Figure 2. Correlation between age of patient and BMI

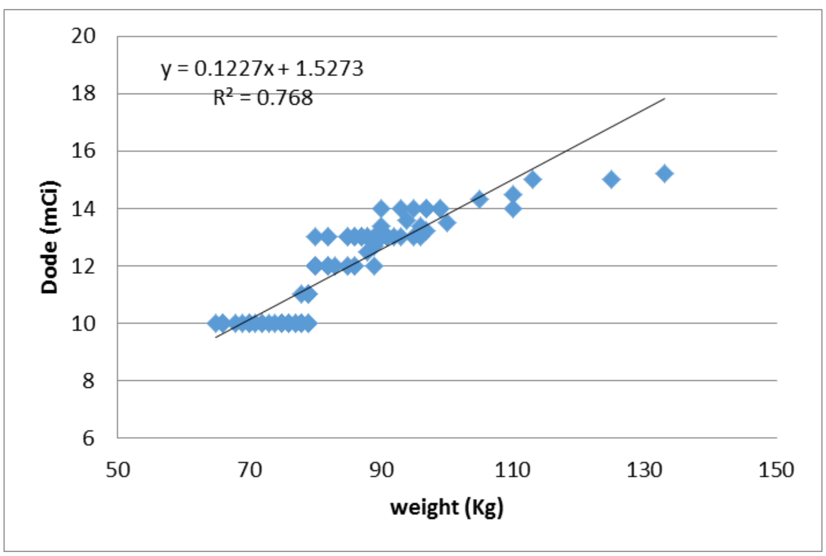

Figure 3. Correlation between the body weight (Kg.) and radiation dose (mCi) of study

In this study firstly, I read in SPECT image with extension PNG, which is a colour ischemic heart image. This colour method helps nuclear medicine physician or cardiologist distinguish different heart tissue types Figure 4.

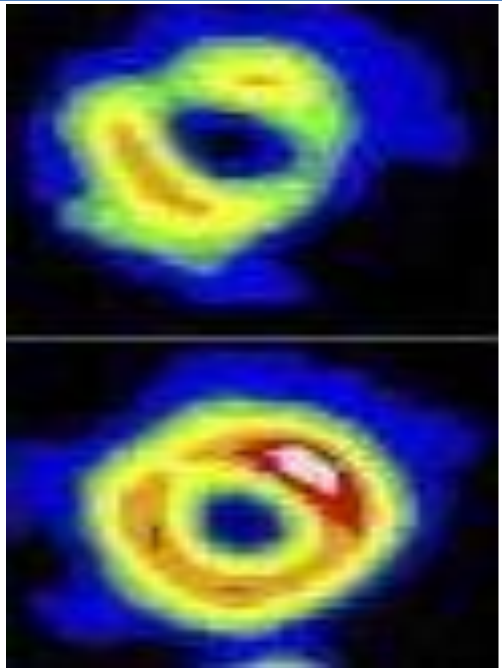

Figure 4. Original cardiac images

Many colours can notice in the cardiac image if one ignore variations in brightness. There are three colors: white, blue, and pink. It is easily to distinguish these colors from one another easily. The L*a*b* color space (also known as CIELAB or CIE L*a*b*) enables us to quantify these visual differences. The L*a*b* color space is derived from the CIE XYZ tristimulus values. The L*a*b* space consists of a luminosity layer 'L*', chromaticity-layer 'a*' indicating where color falls along the red-green axis, and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis. All of the color information is in the 'a*' and 'b*' layers. We measured the difference between two colors using the Euclidean distance metric. In this study we converted the image to L*a*b* color space using makecform and applycform (forward transformation). The RGB or CMYK values first need to be transformed to a specific absolute color space, such as sRGB or Adobe RGB. This adjustment will be device dependent, but the resulting data from the transform will be device independent, allowing data to be transformed to the CIE 1931 color space and then transformed intoL*a*b*.The L* coordinate ranges from 0 to 100. The possible range of a* and b* coordinates is independent of the colour space that one is converting from, since the conversion below uses X and Y which come from RGB.

The forward transformation

$$L^* = 116\left({}^{Y}/_{Y_n}\right) - 16 \tag{1}$$

$$a^* = 500\left[f\left({}^{X}/_{X_n}\right) - f\left({}^{Y}/_{Y_n}\right)\right] \tag{2}$$

$$b^* = 200\left[f\left({}^{Y}/_{Y_n}\right) - f\left({}^{Z}/_{Z_n}\right)\right] \tag{3}$$

Where,

$$f(t) = \begin{cases} t^{1/3} & if t > \left(\frac{6}{29}\right)^3 \\ \frac{1}{3}\left(\frac{29}{6}\right)^2 t + \frac{4}{29} & otherwise \end{cases} \quad (4)$$

Where X_n ,Y_n and Zn are the CIE XYZ tristiulus values of the reference white point. The devision of the f function into two domains was done to prevent an infinite slope at t=0. was assumed to be linear below some t = t0, and was assumed to match the $t^{1/3}$ part of the function at t0 in both value and slope as shown in Fig.5.

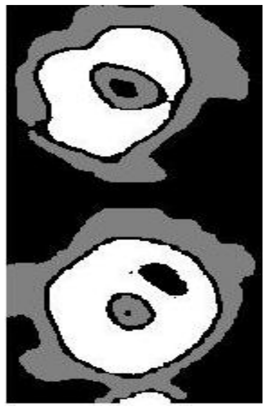

Figure 5. Image labelled by cluster index

We used K-means clustering in order to treat each object as having a location in space. It found partitions such that objects within each cluster are as close to each other as possible, and as far from objects in other clusters as possible. We specified the number of clusters to be partitioned to 3 and a distance metric to quantify how close two tissues in cardiac scintography to each other. Since the color information exists in the 'a*b*' space,the objects are pixels with 'a*' and 'b*' values. Use kmeans to cluster the objects into three clusters using the Euclidean distance metric as shown in Fig.6.

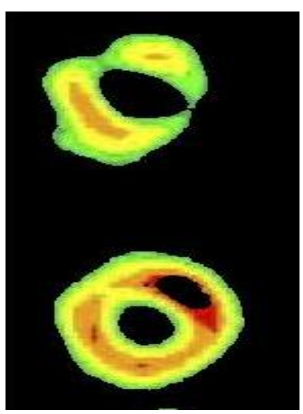

Figure 6. Cardiac image in cluster 1 Kmeans algorithm

For every structure in our input (cardiac images), kmeans returned an index corresponding to a cluster. The cluster_center output from kmeans would be used later in the demo. Every pixel was label in the image with its cluster_index Fig.7.

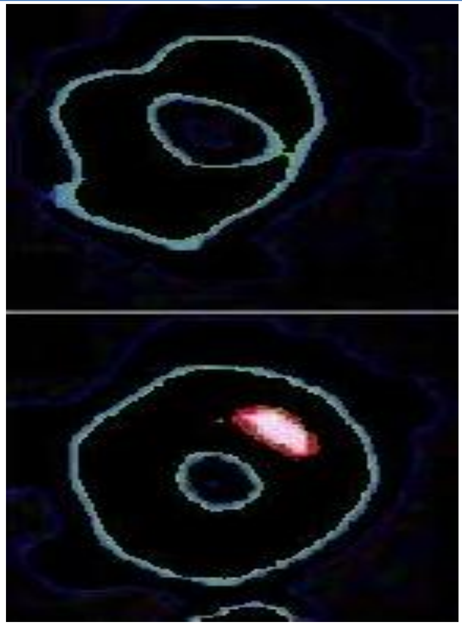

Figure 7. Cardiac image in cluster 2 Kmeans algorithm

Using pixel_labels, I separate stuctures in cardiac images by color, which would result in three images Fig.8.

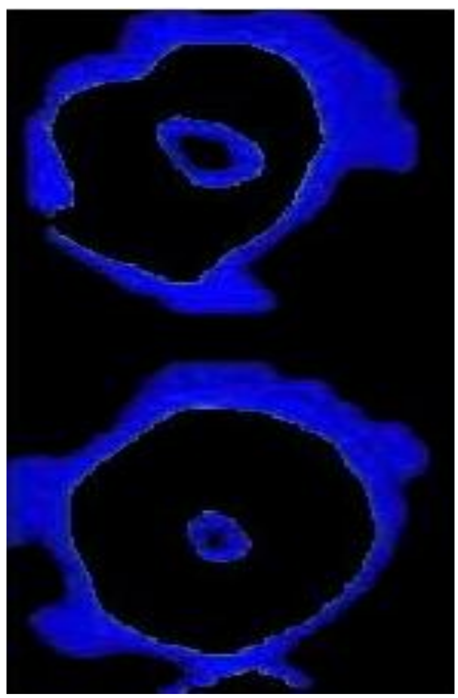

Figure 8. Cardiac image in cluster 3 Kmeans algorithm

There were dark and light color strutures in one of the clusters. I separated dark blue from light blue using the 'L*' layer in the L*a*b* color space. We recalled that the 'L*' layer contains the brightness values of each color. Then I found the cluster that contained the blue objects. We extracted the brightness values of the pixels in this cluster and threshold them using im2bw. I programmatically determined the index of the cluster containing the blue objects because kmeans would return the same cluster_idx value every time. I could do this using the cluster_center value, which contains the mean 'a*' and 'b*' value for each cluster. The blue cluster has the smallest cluster_center value (determined experimentally). Finally, I used the mask is_light_blue to label which pixels belong to the cardiac structure. Then I displayed the blue color in a separate image Fig.9.

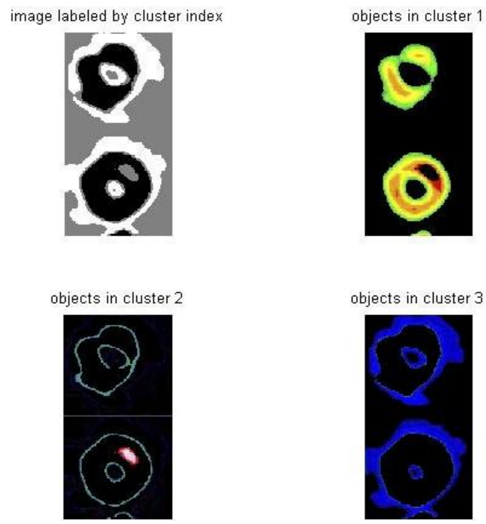

Figure 9. Segmentation of the cardiac images into a Separate Image

4 Conclusion

The common co-factors associated with the CAO include: Wight, Height, Instant Foods (Jungle meals), Smoking, which contribute in occurrence or severity of the Ischemic disease. Concerning the Age there was strong relation with Myocardial Ischemia in a relation with CAO, which is more manifested in oldest Age group found to be most severe than the descending other Age groups representing as mild or moderate. Concerning the BMI there was very strong inverse relation in having the Ischemia in association with CAO with a description of severe, moderate and mild. Segmentation used to identify the object of image that we are interested. The nuclear cardiology has become a common way to study myocardial disorders. Most images that created cardiac images were not completely clear and some had high signal noise ratio, which affected myocardial borders detection. The main objective of this research was to increase of edges recognition in cardiac scintigraphy for ischemic patients. In addition to detect the border of entire heart using segmentation, filter technique. These techniques help in preservation of the image's overall look, detected of small and low contrast details in the diagnostic content of the image, and highlighted the role of using image-processing technique in nuclear medicine. The result of edge detection now closely matches the original in-memory result comparing with others studies using different segmentation techniques. So conclusion of this paper that colour segmentation using K-means tools are best tools to detect heart and it structure which is very beneficial special in patients with ischemic heart disease. The detection of the noise is a complex procedure, which is difficult to detect by naked eye so that image analysis should perform by using powerful image processing. A colour K-means segmentation Algorithm of heart is proposed in myocardial heart study. Proposed method is able to determine the heart boundaries accurately. It is able to segment heart and improves radiological analysis and diagnosis.

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