Automatic Quantification of Epicardial and Thoracic Adipose Tissue from Cardiac CT Scan Images

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Abstract*— Cardiac fat depots are correlated with the cardiac diseases.The major fat depots in the heart are epicardial and thoracic adipose tissue.The increase in epicardial and thoracic fat volume causes various diseases such as metabolic syndrome,coronary atherosclerosis,etc.It is essential to estimate the epicardial fat and thoracic fat. There are different imaging and assessing techniques for adipose tissue quantification.These adipose tissues can be quantified automatically or manually from the CT and MRI cardiac scans.The quantification of the EAT and TAT requires segmentation of these fats by various segmentation methods and then they are quantified.This project proposes the fully automatic segmentation of the epicardial and thoracic adipose tissues from the cardiac CT scan images employing the fuzzy c-means segmentation algorithm and quantification of fat volume from the segmented fat region.The FCM segmentation algorithm is used for the segmentation process by means of clustering which segments the epicardial fat and paracardial adipose tissue from the input image.The segmented epicardial and paracardial fat region are then used for the quantification process which provides the epicardial and thoracic fat volume.The thoracic fat is the combination of the epicardial and paracardial fat.This proposed system is implemented by using the matlabcode.The proposed system is simple,fully automatic and produces accurate results.

***Keywords*—epicardial adipose tissue,paracardial adipose tissue,computed tomography,thoracic adipose tissue**

I. INTRODUCTION

Cardiovascular disease is one of the prominent reason for the death in human beings worldwide.The cardiovascular disease is mainly caused by the increased thickness of the adipose tissues in the heart.Obesity also causes many heart diseases.Cardiac adipose tissue includes three distinct fat depots:They are

- Epicardial adipose tissue.
- Myocardial fat.
- Pericardial adipose tissue.

Myocardial fat is described as the triglyceride depots inward cardiomyocytes.Epicardial fat was defined as adipose tissue confined by the visceral pericardium, inclusive of fat straightway bordering the coronary arteries.The Thoracic fat was defined as all adipose tissue within the chest at the heart level,confined by the rear limit of the heart and over the diaphragm, with the same cranial and caudal boundaries defined for epicardial fat.The pericardium layer is present between the epicardial and paracardialfat.In health,cardiac fat depots play defending and regulatory role.The potential interactions between epicardial and myocardium tissues can take place in the absence of fascia.Epicardial fat acts as a buffer for acquiring and releasing the free fatty acids (FFAs) when required in order to avert lipotoxicity or to support myocardium with energy. As an endocrine organ,the pro- and anti-inflammatory adipocytokines are produced by the epicardial adipose tissue.However,the cardiac adipose tissue plays a important role in the diabetes mellitus development.Increase in epicardial fat depots develops large amount of inflammatory mediators, FFAs,adiponectin, which outcomes in defective metabolism of glucose and diabetes mellitus.The epicardial fat volume visceral layer relies upon location, with greatest centralization along the coronary arteries and in the atrioventricular and interventricular canals. Epicardial fat is not segregated from the heart muscle by a fascia and the blood supply from the coronary arteries is shared by the epicardialfat.Pericardial fat is the fat placed between visceral and parietal pericardium.The pericardial fat also encloses the pericardium.The blood from non-coronary sources,along with the pericardiophrenicartery is received by the pericardial fat.

II. RELATED WORK

There are different methods for the quantification of cardiac fat depots.They are manual,semi-automatic and fully automatic method.The semi-automatic method is used in [1] for determining the association of various thoracic fat depots with the occurrence and extension of coronary artery plaque and circulating biomarkers.The epicardial adipose tissue volume was calculated by using the semi-automatic software in [2] for comparing the characteristics of the epicardial fat measured with the coronary calcium score and CT coronary angiography.The epicardial,extrapericardial and intrathoracic fat volumes were estimated by using the semi-automatic method in [3].The epicardial adipose tissue were quantified by using the manual method in [4].From the non-contrast coronary calcium computed tomography scans,the pericardial and thoracic fat volumes were quantified using automatic method in [5].The bidimensional and volumetric epicardial adipose tissue quantification reproducibility on cardiac CT were compared by automatic method in [6] and estimated their correlation with the coronary artery disease continuation.The volume of epicardial and thoracic adipose tissues were estimated from non-contrast computed

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tomography using automatic method in [7] for assessing the interscan recreatibility.The automatic pericardium segmentation and epicardial fat quantification were performed in [8].The epicardial adipose tissue were quantified automatically in [9].The performance of the automated software tool and manual method for EAT quantification were assessed in [10].

III. CARDIAC FAT IMAGING METHODS

The volume of epicardial and thoracic adipose tissues can be quantitatively measured from the different types of the non-invasive imaging models namely CT and MRI are viable and occupy a analytic part in cardiovascular risk assessment.

A. Measurement From CT

For the cardiac fat measurement,the accurate imaging method is the Computed Tomography(CT).The immense spatial resolution and temporal resolution of CT delivers exact epicardial adipose tissue and pericardial adipose tissue volumes quantification independently.The Computed Tomography(CT) have precise fat attenuation values.With the help of this ,the fat that is exist above the heart is readily detected by the chest CT or cardiac CT.The steps required for the epicardial and thoracic fat volume quantification are heart limit identification and the tracing of pericardium and inner thoracic cavity which can be performed by the manual or semi-automatic.The unremarkable fat attenuation values are adapted to describe the attenuation of fat by CT.The attenuation range of (–30, –190) Hounsfield Units is adapted for non-contrast CT.The Fat voxels inward of this attenuation range enclosed by the visceral pericardium are categorized as epicardial fat and surrounded by the inner thoracic cavity are categorized as thoracic fat.The exposure of radiation and comparatively high cost are the drawbacks of Computed Tomography(CT).

B. Measurement From MRI And Ultrasound

The epicardial adipose tissue thickness can be calculated through the transthoracic echocardiography.As a consequence of the fact that the right ventricle can be acquired from long and short axis prospects and owing the foremost adipose tissue thickness, the epicardial fat calculation are commonly executed on the right ventricle free wall. Some current studies have used cardiac magnetic reasonance imaging as a equipment to estimate the epicardial adipose tissue. Similar to CT, with MRI the contours of the epicardial adipose tissue are traced on short axis slices and adipose tissue voxels are included to estimate the epicardial fat volume.For the purpose of the volumetric approach,the inter-observer variability and inter-observer reproducibility are greater with MRI comparing with the measurement of the thickness of epicardial adipose tissue.The MRI do not utilize ionizing radiation, but it has some disadvantages such as high cost and adipose tissue manual image evaluation takes more time.These are the limitations of MRI.

IV. METHODOLOGY

In our project,the quantification of the cardiac fat depots particularly the epicardial adipose tissue and paracardial adipose tissue from the cardiac CT scan images were proposed.The unification of the paracardial and epicardial fat is the thoracic fat.The quantification of the adipose tissue plays important role in the heart diseases and obesity.There are various methods for the quantification of cardiac fat depots.They are manual method,semi-automated method and fully automated method.Our proposed system uses the fully automated method.Inorder to quantify the cardiac fat,it is necessary to segment the fat region.For the segmentation process,there are several methods.The Image segmentation is the approach of separating an image into several segments.This is usually inured to determine objects and other appropriate data in digital images.From the segmented image,the fat regions are classified and then their volumes are identified.The steps involved in the automatic segmentation and quantification of epicardial fat and thoracic adipose tissue is given in the below figure 1.

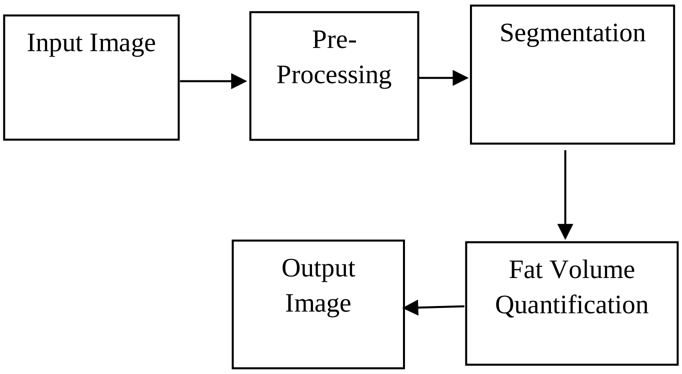

Figure.1.Block Diagram

The input image is the CT scan two dimensional cardiac images.These images are processed for the segmentation and quantification of the epicardial and extra pericardial fat.The thoracic adipose tissue is the unification of the epicardial and extra pericardial adipose tissue.The input image undergoes preprocessing in order to convert the colour image such as rgb image into the grey image.The preprocessing step also removes the unwanted noise and distortion in the input image.

A. Segmentation

Data clustering is the technique by which the large datasets are categorized into clusters of smaller groups of similar data.In the medical imaging field,the Fuzzy c-means (FCM) clustering algorithm plays the major role and it is often utilized.It is an unsupervised approach and does not require any training of the data.Medical image segmentation is the process of segmenting the obvious anatomical textures from the given medicinal images.The Fuzzy C-means (FCM) is a approach of grouping where single section of the data belongs to more than one clusters.From the fuzzy set theory,fuzzy logic is obtained as the multi-valued logic.FCM is generally utilized for the segmentation of the soft tissues such as brain tissue.The Fuzzy C-Means segmentation algorithm is proposed for the cardiac CT scan image segmentation in this paper.

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The FCM algorithm is unbiased fuzzy groupings and does not need any training of the data.The traditional clustering algorithm determines the hard separation of the designated dataset depending on the convinced measures that estimate the uprightness of the separation. By the method of the hard separation ,every data corresponds to completely single group of segregation.In contrast,soft groupings determines the soft separation of the specified dataset and the datum corresponds to more than one clusters.The kind of the soft clustering is the one that assures the point x membership degree in all clusters addition to one,that is,

$$\sum_j \mu_{c_{j(x_i)}} = 1 \quad \forall x_i \in X \tag{1}$$

The prominent Fuzzy C-Means algorithm is the fuzzy clustering which generates the inhibited soft separation. For the purpose of generating such a constrained soft separation, the hard c-means objective function J_1 were elongated in dual ways.They are,membership degree of fuzzy in the cluster is introduced in the expression of formula and the extra criterion m is used as the exponent of weight in membership of fuzzy. The extensive objective function is indicated by Jm which is given as follows,

$$J_{m(P,V)} = \sum_{i=1}^{k} \sum_{x_k \in X} (\mu_{C_i}(x_k))^m \|x_k - v_i\|^2 \tag{2}$$

where,the fuzzy partition is denoted by Pand the given dataset is indicated by X .The fuzzy partition is generated by C1, C2, ….., Ck and k denotes count of the groupings.The partial membership degree of cluster influence the grouping result were estimated by the parameter m which is a weight. In contrast to the hard c-means,the fcm algorithm looks for the membership function which deprecates J_m.The restrained fuzzy separation such as C1, C2, …..,Ck can be unbiased function local minimum Jm as long as the following constraints are met:

$$\mu_{c_i}(x) = \frac{1}{\sum_{j=1}^{k} \left(\frac{\|x - v_i\|^2}{\|x - v_j\|^2} \right)^{\frac{1}{m-1}}} \tag{3}$$

$1 \leq i \leq k$, $x \in X$

$$v_i = \frac{\sum_{x \in x} \mu_{c_i}(x)^m x}{\sum_{x \in X}^{n} \mu_{c_i}(x)^m} \quad 1 \leq i \leq k \tag{4}$$

The Fuzzy c-means segmentation algorithm assures for the converge for m is greater then one. It determines the objective function Jm local minimum.The outcome of employing the fuzzy c-means to the specified dataset not only rely on the option of parameter m and c, in addition to the preference of the primary pattern.

After applying the fuzzy c-means algorthim, the segmentated image is obtained.The segmented image consists of the epicardial segmented region which is represented in red colour and extra pericardial segmented region which is represented in green region.Then these segmented fat regions are used for the quantification process.

B. Fat Volume Quantification

The fat regions that are segmented from the cardiac CT scan image are then utilized for the quantification approach for estimating the volume of the epicardial and paracardial fat**.**The epicardial and extra pericardial fat volumes are quantified by using the five parameters.They are area,minoraxis,majoraxis,orientation and perimeter of the fat regions.With the help of these parameters,the volume of the epicardial and extra pericardial fat regions were obtained. Unification of the epicardial and extra pericardial fat volumes are the thoracic fat volume.This the output of the given input image.

V. RESULT AND DISCUSSION

The input image is the cardiac CT scan image.The image taken is a fat contained image.The output image is the segmented output of the given input image.In this segmented image,red colour region indicates the epicardial fat region and the green colour region indicates the paracardial fat region.This segmentation is obtained by using the fuzzy c-means algorithm. This image is used as input for the segmentation and quantification process.The epicardial fat is the fat that is located inside the pericardium layer and the paracardial fat is the fat that is located outside the pericardium layer.The input and output image is given in the figure 2 below.

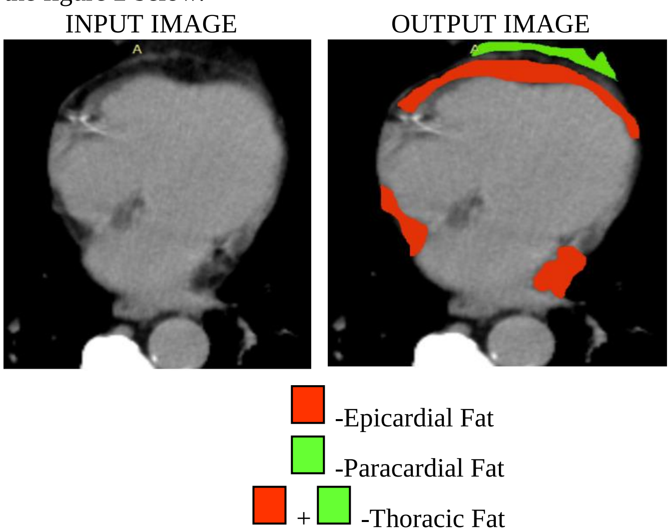

Figure.2.Input And Output Image

The Segmentation of the epicardial and thoracic adipose tissue using the fuzzy c means segmentation algorithm and the fat volume quantification from cardiac CT scan images were implemented successfully in the matlab code.The thoracic adipose tissue is the unification of epicardial and paracardial fat.The result produced by this proposed system is accurate and easy to understand.The proposed system is the fully automated system and the complexity is less.

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