Accepted Manuscript

Automated recognition of the pericardium contour on processed CT images using genetic algorithms

É.O. Rodrigues, L.O. Rodrigues, L.S.N. Oliveira, A. Conci, P. Liatsis

PII: S0010-4825(17)30135-X

DOI: 10.1016/j.compbiomed.2017.05.013

Reference: CBM 2668

To appear in: *Computers in Biology and Medicine*

Received Date: 4 February 2017

Revised Date: 11 May 2017

Accepted Date: 12 May 2017

Please cite this article as: É.O. Rodrigues, L.O. Rodrigues, L.S.N. Oliveira, A. Conci, P. Liatsis, Automated recognition of the pericardium contour on processed CT images using genetic algorithms, *Computers in Biology and Medicine* (2017), doi: 10.1016/j.compbiomed.2017.05.013.

Automated Recognition of the Pericardium Contour on Processed CT Images Using Genetic Algorithms

É. O. Rodrigues*, L. O. Rodrigues†, L. S. N. Oliveira‡, A. Conci§ and P. Liatsis¶
*§Department of Computer Science, †School of Pharmacy, ‡School of Nursing, Universidade Federal Fluminense, Niterói - Rio de Janeiro - Brazil
¶Department of Electrical and Computer Engineering, Khalifa University of Science and Technology, Petroleum Institute, PO BOX 2533, Abu Dhabi - United Arab Emirates
erickr@id.uff.br*, lucasor@id.uff.br†, larissasno@id.uff.br*, aconci@ic.uff.br* and pliatsis@pi.ac.ae¶

***Abstract*—This work proposes the use of Genetic Algorithms (GA) in tracing and recognizing the pericardium contour of the human heart using Computed Tomography (CT) images. We assume that each slice of the pericardium can be modelled by an ellipse, the parameters of which need to be optimally determined. An optimal ellipse would be one that closely follows the pericardium contour and, consequently, separates appropriately the epicardial and mediastinal fats of the human heart. Tracing and automatically identifying the pericardium contour aids in medical diagnosis. Usually, this process is done manually or not done at all due to the effort required. Besides, detecting the pericardium may improve previously proposed automated methodologies that separate the two types of fat associated to the human heart. Quantification of these fats provides important health risk marker information, as they are associated with the development of certain cardiovascular pathologies. Finally, we conclude that GA offers satisfiable solutions in a feasible amount of processing time.**

***Keywords*-Genetic algorithm; metaheuristic; erpicardium; epicardial; pericardium; human heart; adipose tissue; image segmentation; ellipse tracing; computed tomography**

I. Introduction

An increasing demand for medical diagnosis support systems has been observed jointly with increases in computing power in recent years. These systems speed up the tedious and meticulous manual analysis done by physicians or technicians on patients' medical data, where, in many cases, a huge amount of data requires processing and, therefore, the data supporting diagnosis may lack precision and suffer noticeable inter- and intra-observer variation.

Cardiac epicardial and mediastinal fats are correlated to several cardiovascular risk factors [1]. At present, three imaging modalities appear suitable for quantification of these adipose tissues, namely Magnetic Resonance Imaging (MRI), Echocardiography and Computed Tomography. Each of these modalities has been used in several works in the literature [2, 3, 4]. However, Computed Tomography provides a more accurate evaluation of fat tissues due to its higher spatial resolution compared to ultrasound and MRI. In addition, CT is widely used for computing the coronary calcium score.

In this work, we propose a simple yet robust method to automatically identify the pericardium contour of processed cardiac CT images. The pericardium appears as an elliptical object in the CT images of the axial-plane. Given images of the ground truth in [5], we are able to delineate the pericardium layer and separate the epicardial from the mediastinal fats. The proposed methodology is based on determining the parameters of an ellipse using Genetic or Evolutionary algorithms.

The methodology proposed in this work can (1) improve processing time for the automated segmentation of the fats. In a previous work [5], we proposed a method that automatically segments the epicardial and mediastinal fats on CT images using machine learning. However, this processing can take up to 1.8 hours for a single patient, which corresponds to segmenting a total of 44 images on average. Instead, a single image can be processed by the previously proposed methodology. Next, the pericardium can be delineated and, thereafter, the traced ellipse can be propagated to the remaining 43 images, speeding up segmentation time considerably. The quantification of the epicardial fat can be performed by counting the amount of voxels inside the propagated ellipse. Furthermore, the method proposed in this work also (2) improves the visualization of the pericardium in the processed images of [5] and could also improve the accuracy of the obtained segmentation by disregarding incorrectly segmented epicardial fat.

II. Literature Review

The pericardium is a fibroserous sac that contains the human heart. It is composed of three concentric layers: (1) the parietal layer, (2) the serous pericardium and (3) the fibrous pericardium, from the inner surface of the heart to the outermost layer, respectively. The pericardium separates two types of adipose tissues that are tightly associated to the human heart. The fat enclosed by the percardium is usually called epicardial fat, whilst the outer fat is usually called mediastinal or pericardial fat [5].

A significant amount of studies correlate cardiovascular risk factors or conditions such as atherosclerosis [6, 7, 8], myocardial infarction [9], diastolic filling [10], atrial fibrillation and ablation outcome [11], carotid stiffness [12], etc [1, 9, 13, 14, 15], to the epicardial fat volume. Furthermore, the progression of coronary artery calcification is associated to the epicardial fat volume, as suggested by previous works [9, 16]. Chen et al. [17] associate high coronary artery calcium score to a higher general cancer incidence.