A New Approach for Creating Polar Maps of Three-Dimensional Cardiac Perfusion Images

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Abstract

We present a new approach for creating polar maps of three-dimensional cardiac perfusion images. A polar map is a two-dimensional plot of the reconstructed volume from the SPECT study, which provides concise information on myocardial perfusion in a single easily interpretable image. Unlike the traditional approaches, our algorithm is automatic. It relies on image registration techniques to align the patient exam to a previously computed model, avoiding the need of manual intervention by a specialist. Preliminary analysis made by a specialist in nuclear medicine indicates that this new approach is comparable to the gold standard algorithm

1. Introduction

Nuclear medicine images are widely used in the study of patients with coronary artery disease, especially survivors of acute myocardial infarct (AMI). After the AMI, the assessment of the affected area is very important, since it allows the estimation of healthy area and the patient's quantification of risks.

Single photon emission computed tomography (SPECT) studies allow the assessment of heart perfusion, and identification and quantification of reversible and non-reversible affected areas. In the routine of analysis of these studies, the polar map display has been considered a useful tool [1].

A polar map or bull's eye is a two-dimensional image constructed from the SPECT study. The technique for generating these images was originally developed by the Emory University, in Atlanta, U.S.A. In essence, the procedure for constructing a polar map starts from a three-dimensional short axis reconstruction of the SPECT study. Then, the algorithm searches the volume selecting the highest counting points. This way, it asserts that these points belong to the cardiac muscle [2]. Then the Cartesian coordinates of the selected points are transformed into Polar coordinates, and the points plotted into the polar map image.

Polar maps are easily interpretable images, providing information on the perfusion of the whole left ventricle, from apex to base. In a single image, they permit the assessment of relative perfusion of individual walls and analysis of perfusion defects extent. Besides that, the generation of polar maps from SPECT studies allows inter-patient comparisons as well as with normality models [3].

The traditional approach on generation of polar maps involves severely human intervention [4]. For the algorithm to be successful applied on the SPECT study, a specialist needs to point the various regions of the heart. This makes the procedure very inefficient and error prone.

Our approach is to use a model SPECT study, whose regions are previously known. We use image registration techniques to align the patient exam to the model, and then apply the polar map extraction procedure.

2. Methodology

This new approach for generating polar map plots from SPECT studies can be divided in two distinct steps: **registration** and **generation**.

There are several approaches when concerning cardiac image registration. Registration methods based on voxel similarity measures, particularly the intensity difference and correlation methods, are the best-suited techniques for registering images from the same modality, as they assume that pixel values in the registered images are strongly correlated [5].

By using the normalized mutual-information technique, we registered 11 SPECT studies with a model which had pre-established criteria for sample-coordinates searching, which allowed the complete automatization of the process, avoiding the error-prone human-interaction procedure, ending the step called **registration**.

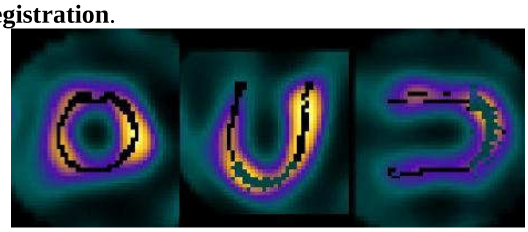

Fig. 1 – Points selected to be plotted in the polar map

In the **generation** step, each frame of the SPECT study was processed: we defined a central point in the short-axis frame of the study, and from this point the algorithm searched the points inside the frame from sectors varying from 0 to 359 degrees, with a step of 1. Each sector was defined by 35 voxels (radius), and the voxel with the highest intensity count from each sector was chosen (Fig. 1), to make sure the perfusion data was correctly selected, due to the constant movement of the heart.

Converting the points that were found by the algorithm in Polar coordinates and plotting them into a bidimensional image of concentric rings ended the **generation** step. Fig. 2 shows the polar map generated from the model and from one patient.

3. Results

We implemented a software tool that applies the proposed technique to generate polar maps from SPECT studies, using the C++ Programming Language, the Visualization Toolkit (VTK) [6] and the Insight Toolkit (ITK) [7]. Preliminary analysis made by a specialist in nuclear medicine and the first results of the selected patients indicate that this new approach is comparable to the gold standard algorithm.

Besides that, it is important to notice that the vast majority of cardiac SPECT image processing softwares are copyrighted, and the studies are processed remotely, forbidding their use. Our software is open source, so it is going to be freely distributable and modifiable.

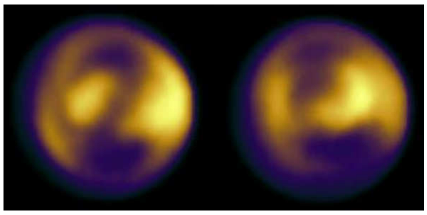

Fig. 2 – Polar map of the model used in the registration step, and from one patient, respectively.

4. Gratefulness

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