A System for Computer Assisted Analysis of Ventriculograms

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Abstract - **Left Ventricle (LV) volume and contractile abnormalities can be important manifestations of coronary artery deseases. Cineangiography is used extensively to visualize the LV and may provide quantitative information about its performance.**

In routine clinical practice the cineangiograms are, in many laboratories, assessed visualy, which results in significant inter and intra observer variation. For this reason the quantification of the left ventricle function is desirable. We have developed a system for the semi-automated quantitative analysis of the LV to help cardiologists in routine clinical practice and research. It was developed on a MS-DOS platform, with image processing hardware and a graphical user interface. A report is produced for each patient including graphics of the results and patient data. This system is currently instaled at Centro Hospitar de Gaia to be tested.

Sumário - **As anormalidades de volume e contracção do ventrículo esquerdo (VE), podem ser manifestações importantes da doença coronária. A cineangiografia é usada extensivamente para visualizar o VE e pode fornecer informação quantitativa sobre o seu desempenho.**

Em prática clínica de rotina os cineangiogramas são, em muitos laboratórios, inspeccionados visualmente o que resulta em significativa variabilidade intra e inter-observador sendo desejável quantificar a função ventricular. Foi desenvolvido um sistema para a análise semi-automática quantitativa da função do VE que se pretende que seja uma ferramenta útil ao cardiologista na análise dos ventriculogramas na clínica de rotina e na investigação. Este sistema é baseado numa plataforma MS-DOS com hardware de processamento de imagem e uma interface gráfica com o utilizador. No fim da análise correspondente a cada paciente é produzido um relatório que inclui dados do paciente e resultados sobre a forma gráfica. Este sistema está instalado no Centro Hospitalar de Gaia com a finalidade de ser testado.

I. INTRODUCTION*

Left Ventricle (LV) volume and contractile abnormalities can be important manifestations of coronary artery deseases. Cineangiography is used extensively tovisualize the LV and may provide quantitative information about its performance.

LV cineangiography is a technique that allows the visualization of the LV silhouette along the cardiac cycle after the injection of a contrast product and using X-rays. These images contain a great deal of information which is difficult to apreend by visual inspection. In routine clinical practice, in many laboratories, the cineangiograms are still assessed visualy which results in significant inter and intra-variation, that is why the quantification of LV performance is desirable. A great number of methods of quantifying this performance have been proposed, but there is no consensus on the best method[1]. Because it is important to have the possibility to use more than one method and since the LV quantification, using any of these methods, is too time consuming to perform manually on a routine basis, some semi or fully automated systems for the quantitative analysis of the LV cineangiograms have been developed [1,2,3,4].

II. SYSTEM OVERVIEW

Our system was developed to help cardiologists in routine clinical practice and research. It is a new version, more friendly and complete, of a previously developed system [4], based on a MS-DOS platform with image processing hardware and a graphical interface. We shall describe the system in further detail in the next sections.

A. System Configuration

The LV cineangiographic images are currently recorded at the catheterization Laboratory of the Centro Hospitalar de Gaia using a video tape recorder but, in the near future, we will have access to digital images directly from a DSA (Digital Subtraction Angiography) system.

The system is based on a MS-DOS platform with image processing hardware (a commercial frame grabber with A/D flash converter, a frame buffer of 512x512x12bits, input and output Look Up Tables that allow some real time image processing and three D/A converters for pseudo-colour display) and a video colour monitor (figure 1).

Software was developed mostly in C, however some routines to handle the frame grabber were written in Assembly. It is modular and open, allowing the adition of any new functionality.

* Trabalho realizado no âmbito da disciplina de projecto

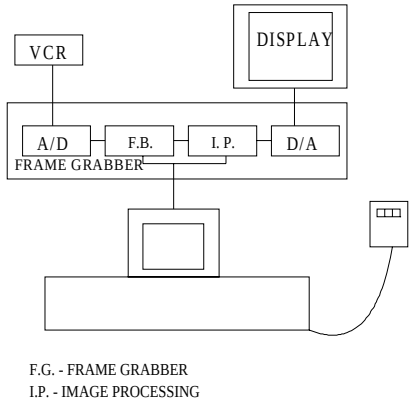

Figure 1- The system is based on a MS-DOS platform with image processing hardware, video tape recorder, a mouse and a video monitor

B. Functionality

This system offers the user the following functionality:

i)- Image acquisistion, calibration and interest zone definition;

ii)- Image enhancement (histogram modification and pseudo-colour);

iii)- Manual and semi-automated contour detection and edition;

iv)- contour processing according to several methods of quantitative analysis of LV performance;

v)- Image, contour and results archive;

vi)- Final report including patient data, images and analysis results presented as graphics.

C. User Interface

The main goal of this user interface is to assure that it can be used by clinicians who don't need to have previous experience with computer systems. Considering the users' profile and the nature of the task they will have to perform using this system, we chose to use menus as main dialog style. The interface is iconic and offers on line help to the user as well as protection against many possible wrong entries. Warnings and error messages are produced whenever necessary. Some features that must be available everywhere can be invoqued also using function keys.

D. Image acquisition and calibration

Images are digitized using a spatial resolution of 254x254, considered to be adequate for LV cineangiograms [1] and a tonal resolution of 256 grey levels (8 bits), which leaves the other 4 bits to graphic overlays.

Until now no distortion correction is done. A calibration factor is obtained from a grid of known step filmed at the begining of the catheterization procedure. Assuming that the existing distortion is zero near the centre of the images and using the four central nodes it is possible to generate an undistorted grid. Each set of nodes defining corresponding areas in both grids (distorted and undistorted) allow to compute a distortion transformation for each of these areas. Using these transformations and grey level interpolation it is possible to generate an undistorted image. These transformations are computed only once and can be used for all cineangiograms of each patient. Currently we are testing and evaluating several procedures and techniques.

E. Image preprocessing

The preprocessing techniques implemented are pseudo-colour and histogram operations. These techniques were used to produce images of enhanced 'quality' from the user's point of view, since in this system the user must validate (and correct if necessary) all detected contours. These histogram operations are performed only over an interest zone previously defined (by the user using the mouse) and have no effect on the contour detection algorithms.

E. Contour detection

After acquiring the images, defining the interest zone, and having some preprocessing if necessary, the user can detect the LV contours manually (using the mouse) or choose a contour detection algorithm. In the first version of this systrem [4] two types of algorithms were available: i)- 'one image algorithms' which detect the LV contour on the current image using the information contained in this image and information introduced interactively by the user

ii)- intermediate contour detection algorithms- which use the information contained in the current image along with information from the contours previously detected on images corresponding to the same patient.

All these algorithms needed an interest zone and now we are developing new algorithms which do not use an interest zone.

F. Contour processing: global and regional parameters

After detecting all the contours corresponding to a patient (the minimum number is 2: end-systolic and end-diastolic) it is possible to compute global and

regional parameters that characterize the LV performance during contraction. The global parameters computed are volume, corresponding to each detected contour (using Chapman's model), and ejection fraction [4] defined as:

$$EF = \frac{Volume(end\text{-}diast) - Volume(end\text{-}syst)}{Volume(end\text{-}diast)}$$

The computation of regional parameters, regional ejection fraction or regional wall contractility is done using three different models for the left ventricle contraction:

i)- Standford Model [6]
ii)- Slager Model[1]
iii)- Centerline Model[7]

G. Report

After completing the analysis, the user can produce a printed report including patient data, images and graphical results of the models. This report is generated in POSTSCRIPT language.

III. DISCUSSION

This system is instaled at the Catatherization Laboratory of Centro Hospitalar de Gaia to be tested in clinical routine. The new contour detection algorithms have to be validated and we have to define which is the mostconvenient distortion correction procedure. In the near future it will be possible to obtain images directly from a DSA system, in which case the overall procedure is simpler since we have already digital images.

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