EVALUATION OF CARDIAC GLOBAL FUNCTION USING REDUCED NUMBER OF MR IMAGES

By

Hossam Ahmed Mohammad El-Rewaidy

A Thesis Submitted to the
Faculty of Engineering - Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Biomedical Engineering and Systems

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

Assoc. Prof. Dr. Ahmed S. Fahmy

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Title of Thesis:

Evaluation of the Cardiac Global Function using Reduced Number of MR Images

Key Words:
Cardiac Global Function, Volume Calculation, Surface Reconstruction, Right Ventricle Segmentation, Active Shape Model, Geometric Models, Cardiac Modeling.

Summary:

Evaluating the heart global function from magnetic resonance images is based on estimating a number of functional parameters such as the left ventricular (LV) and right ventricular (RV) volumes, LV and RV masses, ejection fraction, and stroke volume. Estimating these parameters requires: First, accurate segmentation of the main cardiac champers, LV and RV. LV segmentation can be done by many techniques with a plausible performance; However, RV segmentation is still a challenging problem due to the complex shape of the RV, presence trabecular muscles and low tissue-to-blood contrast. Second, accurate calculation of the volumes enclosed by the inner and outer surfaces of the LV and RV chambers. Currently, the volume calculation is achieved through acquisition and segmentation of a large number of short-axis (SAX) cross-sections of the LV and RV, which is time-consuming, expensive and causing patient inconvenience. Unfortunately, reducing the number of the acquired cross-sections results in undersampling the LV surfaces and hence increases the errors of calculating the volume. In this thesis, we propose two packages of novel methods in both RV segmentation and volume calculation from small number of MR slices. In RV segmentation, an Active Shape/Appearance Model (ASM) based system is introduced for accurately segmenting the RV from MR short axial (SAX) images. The RV shape variations are independently modeled using two separate (dual) ASM models in the Bookstein domain. In order to better segment the low contrast regions at the apex, the method is extended for multiple-2D images where the variations of all cardiac levels are incorporated in a single model. For the volume calculation, new method based on fusing the long axial (LAX) and SAX views of the heart is presented. In this method, the LAX contour is used to swipe the SAX contours to fill in the missed LV surface between the SAX slices. Furthermore, novel geometrical models that combine information from SAX and (LAX) views are invented. The results from 25 datasets and 5 CT-based phantom showed that our methods outperform most of the used methods in the literature .

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Dedication

To those persons who inspired me and changed my life for better.

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Nomenclature

2-CH	Two Chambers
4-CH	Four Chambers
AP	Anterior-Posterior direction
ASM	Active Shape Model
CO	Cardiac Output
DCM	Dilated Cardiomyopathy
EDV	End-Diastolic Volume
EF	Ejection Fraction
ESV	End-Systolic Volume
FR	Free Wall
HR	Heart Rate
IHD	Ischemic Heart Diseases
LAX	Long Axial
LR	Left-Right Direction
LV	Left Ventricle
LVM	Left Ventricular Mass
MAD	Mean Absolute Value
MP	Mid-Papillary Muscles
MRI	Magnetic Resonance Imaging
mSimp	Modified Simpson's Method
MV	Mitral Valve
PCA	Principal Component Analysis
PDM	Point Distribution Model
PVE	Partial Volume Effect
RCM	Restrictive Cardiomyopathy