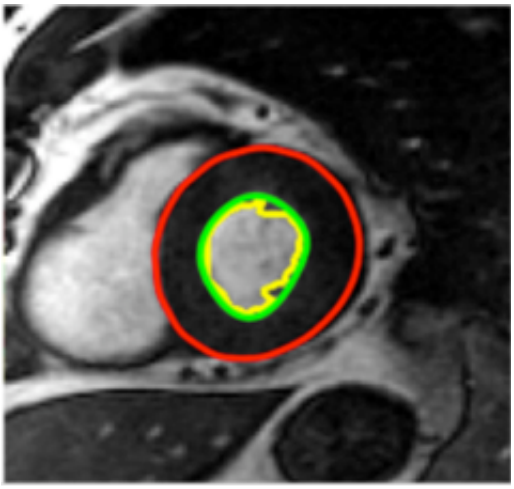
Cardiac MR Left Ventricle Segmentation Challenge



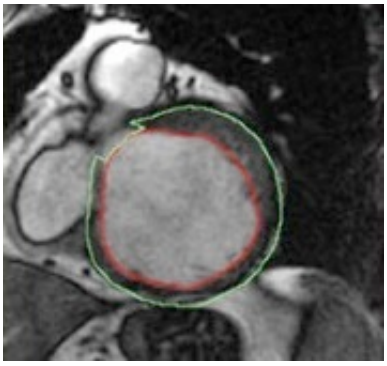
Overview

Welcome to the Cardiac MR left ventricle (LV) segmentation challenge's website. The challenge is part of MICCAI 2009's **3D Segmentation Challenge for Clinical Applications** (visit website)**.** In the challenge, participants enter their best software algorithm to find LV contours automatically, with little or no user intervention. The goal of this contest is to compare state-of-the-art LV segmentation methods by providing an evaluation system and a database of cardiac cine MR images and expert contours freely available on the internet for research purposes. The database will contain 45 cine-MRI images from a range of patients and pathology, together with the manual segmentations determined by an experienced cardiologist on the end-diastolic (ED) and end-systolic (ES) phases. The data will be provided by Sunnybrook Health Sciences Centre.

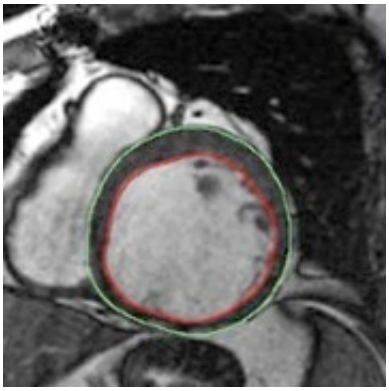
To find out more about the contest, explore Motivation, Data and Evaluation above. To enter the contest go to Register.

Motivation

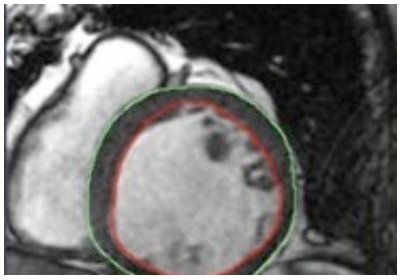
The motivation of the context is to quantitatively analyze global and regional cardiac function from cine magnetic resonance (MR) images, clinical parameters such as ejection fraction (EF), left ventricle myocardium mass (MM), and stroke volume (SV) are required. Calculations of these parameters depend upon accurate delineation of endocardial and epicardial contours of the left ventricle (LV). Manual delineation is time-consuming and tedious and has high inter-observer variability. Thus, fully automatic LV segmentation is desirable.



The automatic segmentation of the LV in cine MR typically faces four challenges: 1) the overlap between the intensity distributions within the cardiac regions; 2) the lack of edge information; 3) the shape variability of the endocardial and epicardial contours across slices and phases; and 4) the inter-subject variability of these factors. A number of methods have been proposed for (semi-) automatic LV segmentation, including using a probability atlas [1], dynamic programming [2-3], fuzzy clustering [4], a deformable model [5], an active appearance model [6], a variational and level set [7-10], graph cuts [11-12] and an image-driven approach [13]. For a complete review of recent literature describing cardiac segmentation techniques, see [14]. Although the segmentation results have improved, accurate LV segmentation is still acknowledged as a difficult problem.



The goals of this contest are to compare LV segmentation methods by providing an evaluation system, and a database of images and expert contours. Comparing segmentation results across research studies can be difficult due to unspecified differences in the method or implementation of evaluation metrics. This contest will provide open-source code for contour evaluation. Furthermore, the database will provide a set of images such that confounding segmentation differences due to image quality or pathology could be eliminated.



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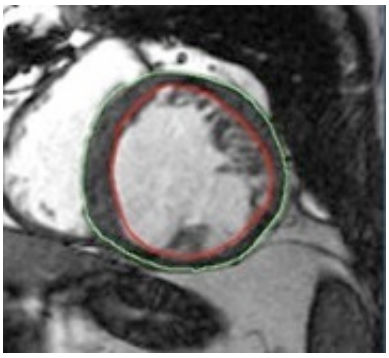
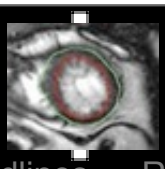
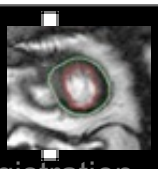
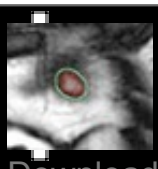


MICCAI

LV Segmentation Challenge

Data

In our institution we have collected 45 cardiac cine-MR datasets with expert contours, as part of the clinical routine. Cine steady state free precession (SSFP) MR short axis (SAX) images were obtained with a 1.5T GE Signa MRI. All the images were obtained during 10-15 second breath-holds with a temporal resolution of 20 cardiac phases over the heart cycle, and scanned from the ED phase. Six to 12 SAX images were obtained from the atrioventricular ring to the apex (thickness=8mm, gap=8mm, FOV=320mm320mm, matrix= 256256). In these SAX MR acquisitions, endocardial and epicardial contours were drawn by an experienced cardiologist in all slices at ED and ES phases, following the convention of including papillary muscles and endocardial trabeculations in the ventricular cavity. All the contours were confirmed by another cardiologist. The manual segmentations will be used as the ground truth for evaluation purposes.

All the data will be in anonymized DICOM format following HIPAA regulations, and permission for the described open database has already been granted by our institution's ethics review board. The imaging data will be provided without any pre-processing after reconstruction, as it is typically presented to physicians for analysis. The datasets will be randomly divided into three groups: 15 for training, 15 for testing and 15 for the on-line contest. Teams registered with a letter of intent can download both the training and testing datasets from the workshop website. The training datasets are provided for participants to optimize their algorithms, which have both images and ground truth segmentation contours. The testing datasets are presented to blinded participants, in that the data will not include ground truth segmentations. Participants will send in their segmentation results in standard format based on the testing datasets for evaluation by a given deadline. The evaluation results are then sent back to the participants for preparation of their workshop papers. The on-line test datasets will be released before the start of the on-line competition during the MICCAI conference. Segmentation results on these datasets are required to be submitted in three hours for evaluation. All submitted segmentation results will be assessed using an evaluation software, which can also be downloaded from the workshop website for teams registered with a letter of intent. Qualitative results will be provided only for the testing results, not the on-line portion of the contest. The evaluation methods will be described in the next section.

Evaluation Methods

Three types of left ventricle segmentation techniques are accepted for this competition, including fully automatic, semi-automatic and interactive techniques, provided that the manual steps are entirely preceding an automatic stage. The performance of the segmentation algorithm is evaluated from both quantitative and qualitative points of view. In order to quantitatively evaluate the detected endocardial and epicardial contours of the ED and ES phases of all slices several measures were assessed, as described below.

Automatic Evaluation Methods

Average perpendicular distance: The average perpendicular distance measures the distance from the automatically segmented contour to the corresponding manually drawn expert contour, averaged over all contour points. A high value implies that the two contours do not match closely.

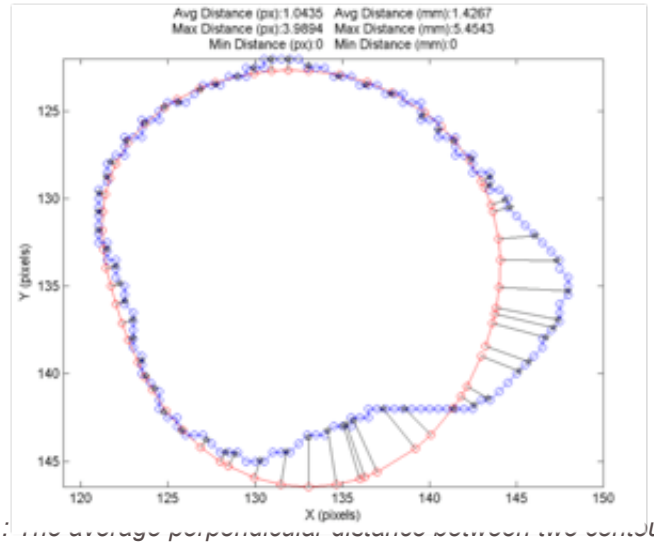


Fig. 1: The average perpendicular distance between two contours

Dice metric: The Dice metric [1]

$$DM = 2A_{am}(A_a + A_m)^{-1}$$

is a measure of contour overlap utilizing the contour areas automatically segmented (A_a), manually segmented (A_m), and their intersection (A_{am}). *DM* is always between 0 and 1, with higher *DM* indicating better match between automatic and manual segmentations.

Clinical parameters: Left ventricle ejection fractions (EF) and left ventricle Left Ventricular Mass (LVM) are critical parameters for cardiac diagnosis. The EF and LVM determined by the manual and automatic methods will be compared by Bland-Altman plot analysis separately.

Visual (Manual) Evaluation Method

Visual Assessment: An experienced cardiologist will rate the segmentation results from testing datasets on a visually-based 4-point scale, for each of the following:

1. Accuracy of the contours delineating the LV papillary muscles and trabeculations, suitable for LV Mass calculation; and
2. Accuracy of the LV myocardial contours, suitable for EF calculation.

Evaluation Methods for On-Line Contest Only

Manual steps: Number of manual steps (e.g. key presses or mouse clicks) required to initialize the automatic segmentation stage, if any.

Computation time: The average computation time to complete the ES and ED segmentations on all slices for the automatic stage of the procedure.

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