RV Segmentation using Point-to-Point Correspondence

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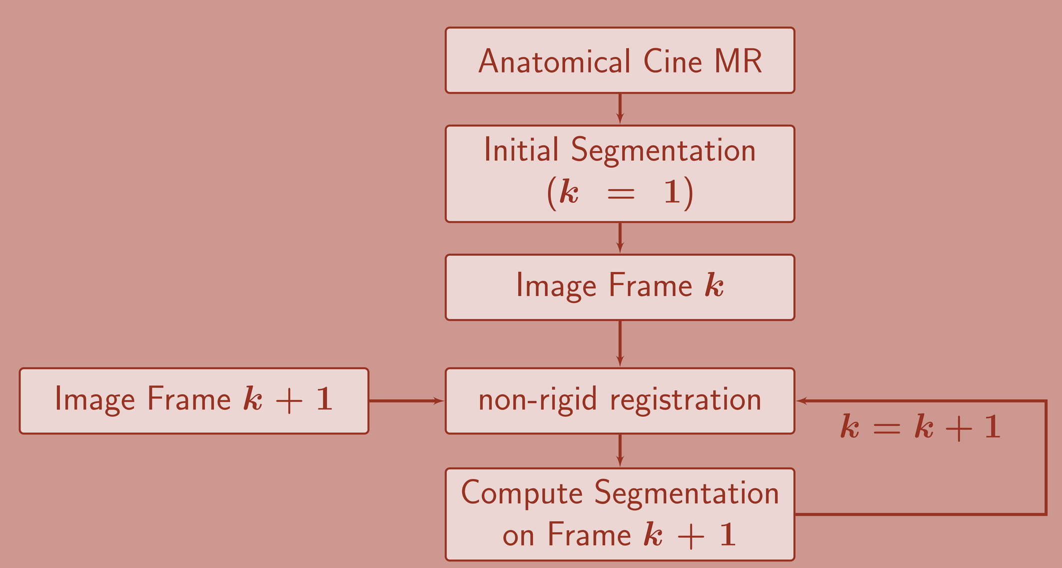
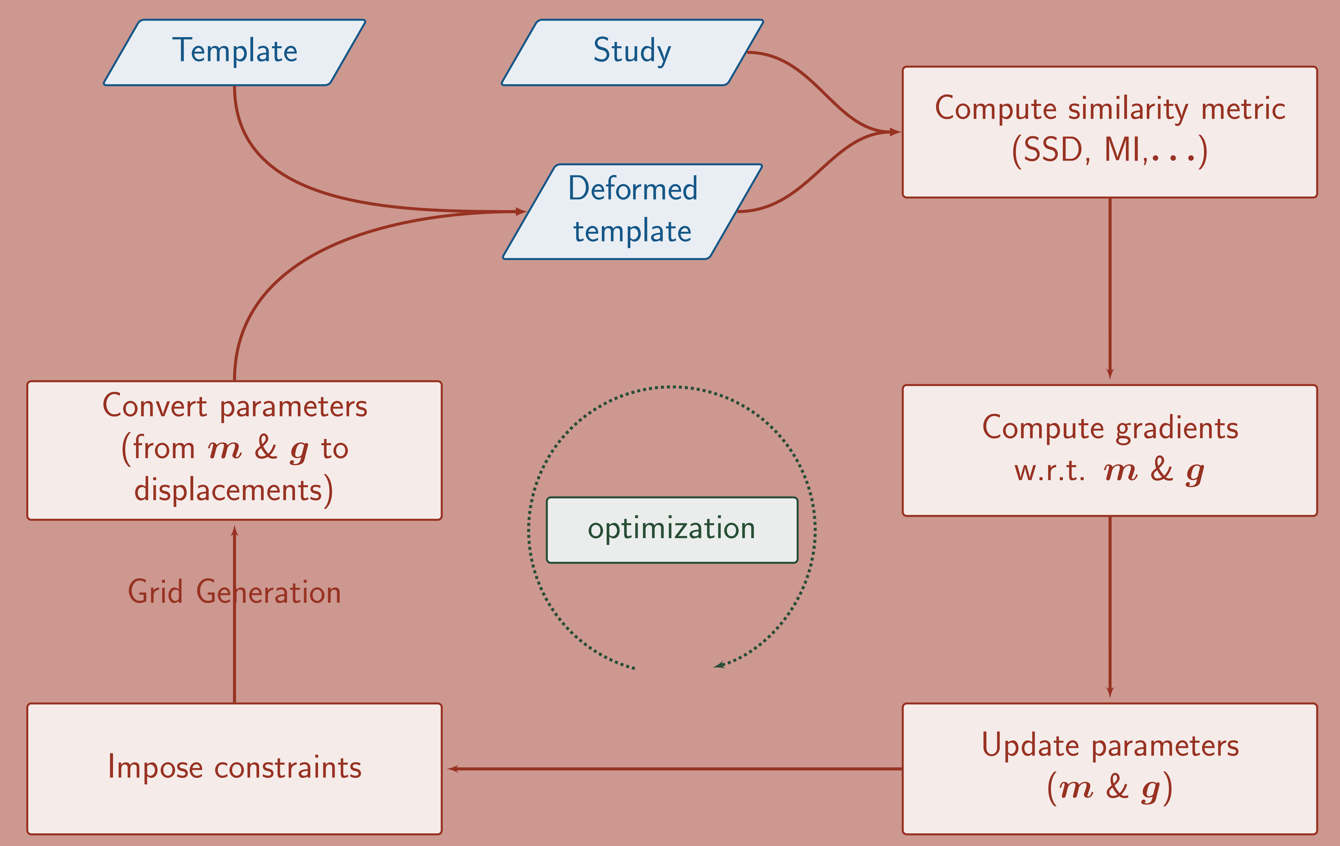
Introduction

- This study presents an approach to the segmentation of the right ventricle (RV) from a sequence of cardiac magnetic resonance (MR) images.
- Automatic delineation of the RV is difficult because of its complex morphology, thin and ill-defined borders, and the photometric similarities between the connected cardiac regions such as papillary muscles and heart wall.
- Further, geometric/photometric models are hard to build from a finite training set because of the significant differences in size, shape, and intensity between subjects.
- In this study, we propose to use a non-rigid registration method [1] developed recently to obtain the point correspondence in a sequence of cine MR images.
- Given the segmentation on the first frame, the proposed method segments both endocardial and epicardial borders of the RV using the obtained point correspondence, and relaxes the need of a training set.
- The proposed method is evaluated quantitatively on common data set by comparison with manual segmentation, which demonstrated competitive results in comparison with recent methods.

The proposed method



Diffeomorphic Nonrigid Registration

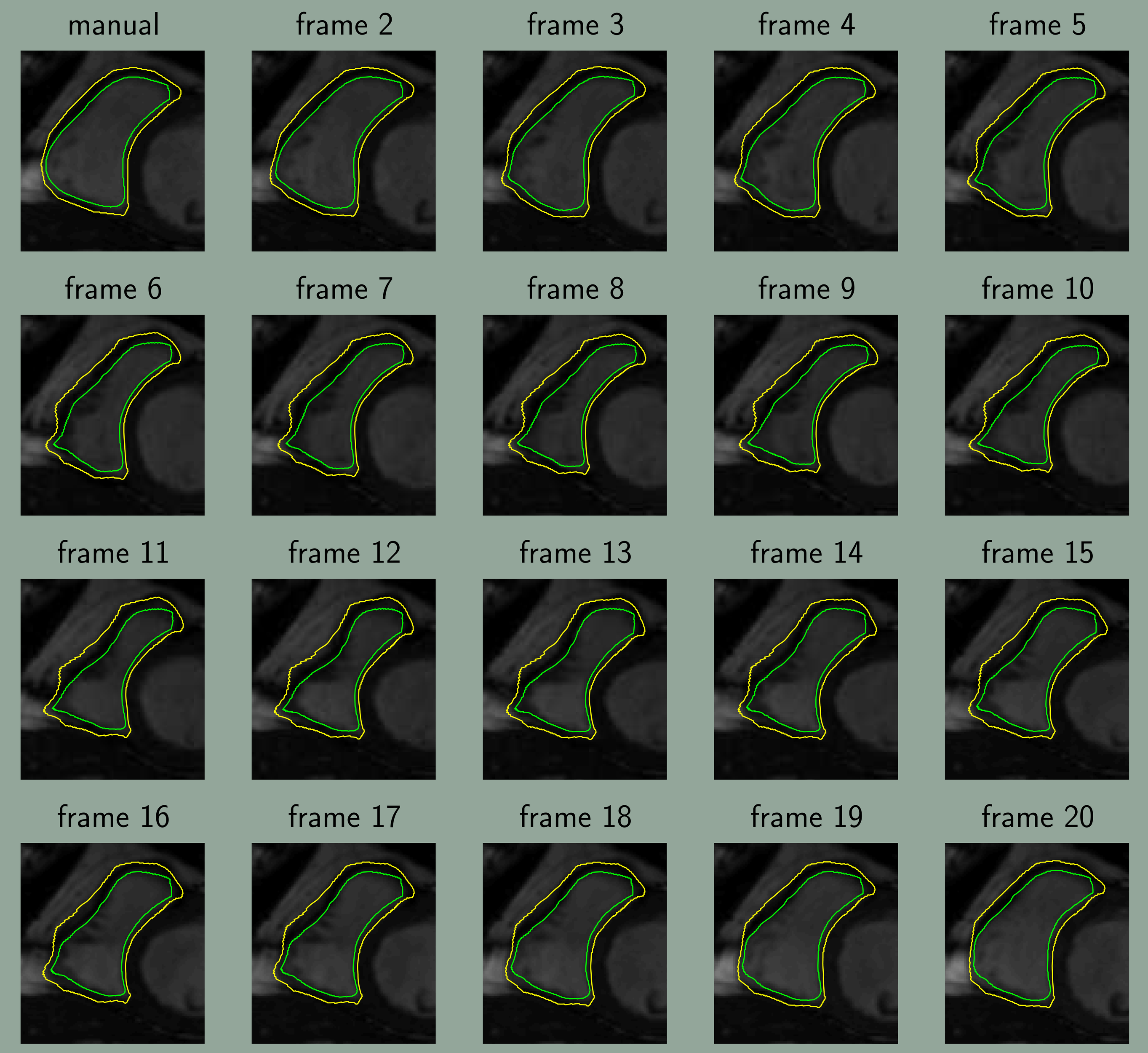


Data

- The proposed method was evaluated over the Training and Test1 sets provided by the RV segmentation challenge, MICCAI 2012 (http://www.litislab.eu/rvsc/).
- Each data set consists of short-axis MRI volumes of 16 subjects.
- The data sets were acquired on 1.5T MR scanners (Symphony Tim, Siemens Medical Systems, Erlangen, Germany) with steady-state free precession acquisition mode.

Visual Inspection

Figure : Representative example of segmented endocardial (green) and epicardial (yellow) borders of the RV over a complete cardiac cycle.



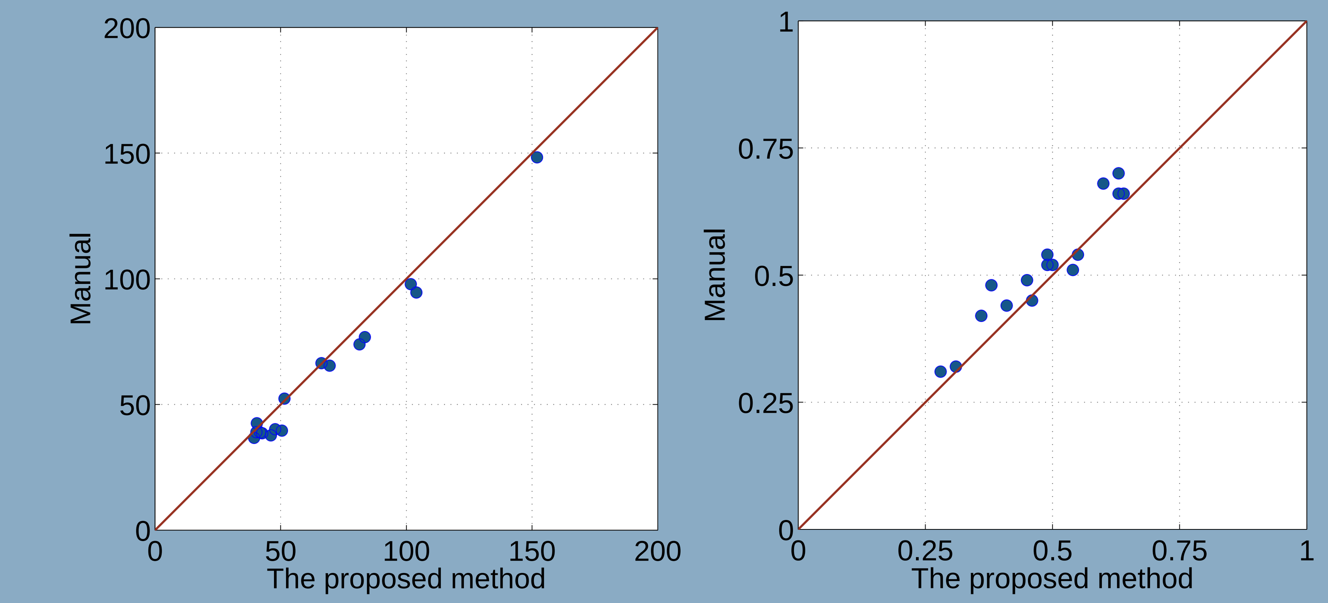
Quantitative evaluation

Table : Mean and standard deviation of Dice metric (DM) and Hausdorff distance (HD) between the proposed segmentation and manual delineation at the end-systole.

	Dice metric	Hausdorff distance (mm)
Training Set		
Endocardium	0.8168 ± 0.15	7.07 ± 4.03
Epicardium	0.8627 ± 0.10	7.53 ± 3.73
Test1 Set		
Endocardium	0.7676 ± 0.16	9.64 ± 4.15
Epicardium	0.8220 ± 0.10	9.99 ± 3.85

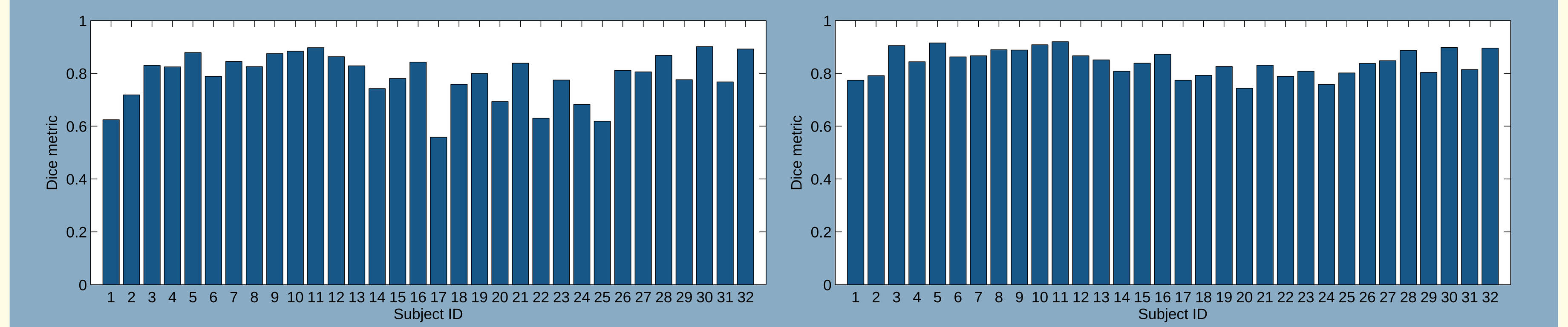
Statistical performance evaluation

Figure : Comparisons of manual and automatic segmentations over 16 subjects from the Training set. (a) Automatic versus manual end-systolic volumes. The proposed method obtained a high correlation coefficient of $R = 0.9929$ (b) Automatic versus manual ejection fractions. The proposed method obtained a correlation coefficient of $R = 0.9611$.



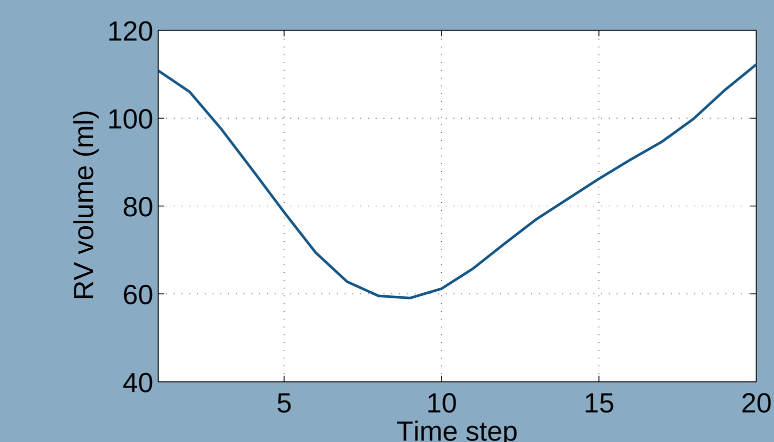
(a) ES volume (b) Ejection fraction

Figure : Average Dice scores for endocardium and epicardium for each subject in the Training and Test1 sets at end-systole.



(a) Endocardium (b) Epicardium

Figure : A representative example of the RV endocardial volume curve computed using the proposed approach. We applied Simpson's rule in computing the volumes using segmented RV areas and slice spacing.



Acknowledgment

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References

[1] H.-m. Chen, A. Goela, G. J. Garvin, and S. Li, "A parameterization of deformation fields for diffeomorphic image registration and its application to myocardial delineation," in *MICCAI 2010*, ser. LNCS, T. Jiang *et al.*, Eds., vol. 6361. Springer, 2010, pp. 340–348.