

POSTER PRESENTATION

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Optimal patient classification via statistical decomposition of a 3D left-ventricular atlas

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Background

Statistical quantification and classification of heart disease, using clinical indices such as ejection fraction (EF) or left-ventricular mass (LVM), are used routinely in clinical practice for both diagnosis and prognosis. However, 3D CMR of the left ventricle (LV) provides a wealth of shape features which can maximise the classification power and accuracy of such indices. To exploit these, we propose a framework whereby shape parameters of a 3D LV finite element atlas are used to optimally classify patients according to linear statistical decompositions (Fig. 1).

Methods

Finite-element shape models of the LV were customised to 600 cardiac MRI volumes with previously standardised and validated software (CIM v. 6.0, Auckland, NZ). The dataset comprised 300 community-based participants without a history of cardiovascular disease, aged 45-84 from 4 ethnic groups from the *Multi-Ethnic Study of Atherosclerosis* (MESA) cohort (1) and 300 patients with myocardial infarction from the *Defibrillators To Reduce Risk By Magnetic Resonance Imaging Evaluation* (DETERMINE) cohort (2) made available through the Cardiac Atlas Project (3). Bias due to scan protocol differences between cohorts was corrected (4). Shape classifiers were constructed to optimally detect which cohort each case belonged. A comparison between principal component analysis (PCA) and information preserving component analysis (IPCA) (5) was performed, using shapes at end-diastole (ED), end-systole (ES) and the difference in shape between ED and ES (ED-ES) which included information on regional wall motion. Traditional clinical classifiers of EF, end-diastolic/end-systolic volume (EDV/ESV) and

LVM were also included for comparison. Ten-fold cross-validation experiments were performed in which 90% of the cases were used for training and 10% for validation, repeated 10 times with different training/validation cases.

Results

Classification results showed that this framework was able to determine clinically relevant modes and that IPCA achieved the lowest error rates using the ED-ES shape difference, with a single classifier number. This classifier can also be used to quantify severity of disease (degree of match with each group). Ten-fold cross-validation experiments corroborated the robustness of this approach which averaged 100% specificity and 99% sensitivity for IPCA versus 83% and 93% respectively when compared to ejection fraction (Table 1). Further, by back-projecting the optimal classifier onto the atlas, we were able to quantify and visualise which regions of the LV had the most weight in the decision. For the ED-ES classifier, this was a combination of volume and wall thickness change.

Conclusions

This work shows the potential of shape based classification in the automated identification and quantification of heart disease.

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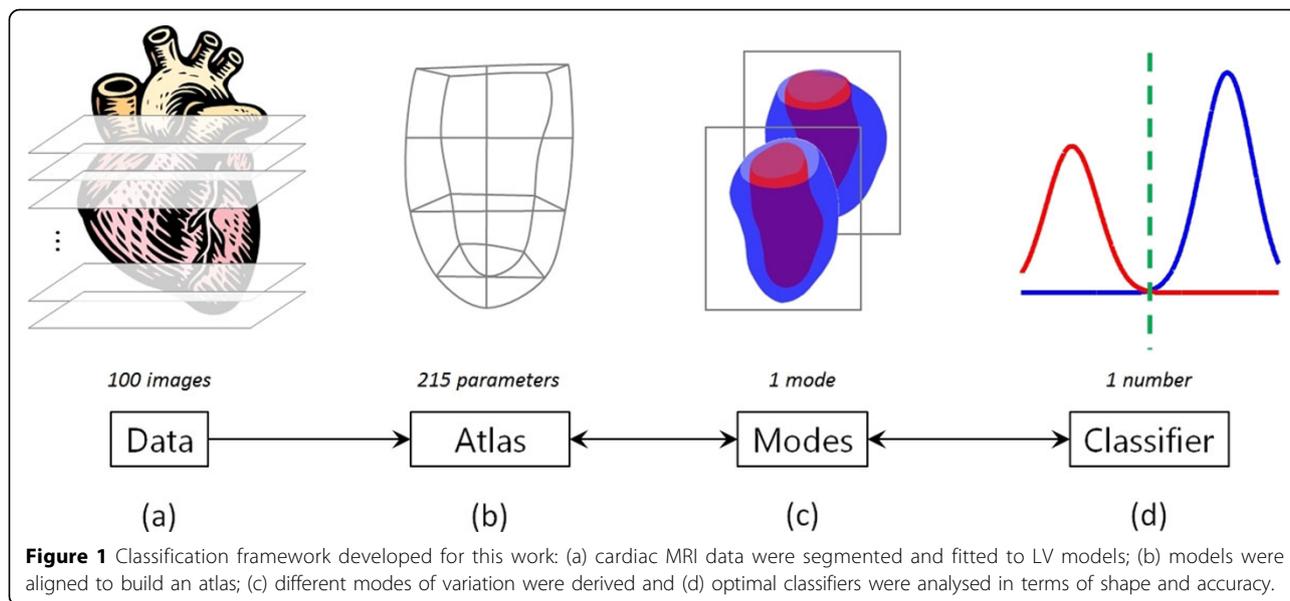


Table 1 Specificity and sensitivity are shown in brackets (in that order) for the cross-validation experiments.

	ED	ES	ED-ES
PCA	(53.8,54.4)	(77.5,75.6)	(89.4,87.9)
IPCA	(96.6,91.2)	(96.2,98.0)	(100,99.0)
EF			(82.7,93.2)
EDV	(81.6,92.4)		
ESV		(79.2,98.3)	
LVM	(67.1,70.1)		

Columns indicate the type of information used by the classifier; rows indicate which classifier is used. Top two rows are different statistical decomposition techniques of shape parameters (preserving only 1 dimension) and bottom four rows are traditional clinical heart-failure indicators. In the case of ED−ES, PCA and IPCA include information on regional wall motion.

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References

1. Bild DE, et al. *American J. Epidemiology* 2002.
2. Kadish AH, et al. *J. CV. Electrophysiology* 2009.
3. Fonseca Carissa G, et al. *Bioinformatics* 2011.
4. Medrano-Gracia P, et al. *MICCAI-STACOM* 2011.
5. Carter KM, et al. *IEEE J. Signal Processing* 2009.

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