Analysis of endo-atrial electrograms and fibrotic tissue from DE-MRI in atrial fibrillation

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Introduction

Atrial fibrillation (AF) therapy remains suboptimal because the mechanisms that sustain it are not yet clearly identified. In this regard, many theories based on atrial electrical activation or on atrial structural remodeling have been proposed.

Goals

Development of a framework for AF analysis through:

- Automatic computation of phase map from endo-atrial electrograms;
- 3D model of left atrium (LA) fibrosis.

Methods

✓ 18 patients with paroxysmal AF were enrolled in the study;

✓ Magnetic resonance angiography (MRA), delayed-enhanced MR imaging (DE-MRI) and electrograms were acquired and in six of them a 64- pole basket catheter was used to acquire unipolar electrograms;

✓ A modified version of the sinusoidal wavelet recomposition [2] was implemented to detect atrial activations timings (AAT) which were compared with manual annotations performed by an expert cardiologist;

✓ A 3D model of LA fibrosis distribution was obtained by segmenting MRA data applying an edge-based level set approach guided by a phase-based edge detector and a multimodality affine registration was applied to register MRA and DE-MRI data. Gray intensity levels from DE-MRI were used as a texture of the 3D model ;

✓ The obtained 3D model was then compared with the electroanatomical map.

✓ Signals and images were processed using custom software developed in MatLab (Mathworks, Natick, MA; USA).

Results

Comparison between AATs detected with our method on a segment basis in 471 signals in sinus rhythm (5412 AATs) is reported in the table. Mean cycle length duration was computed and showed an error of 1.6 % ± 1.9%.

AATs detected	TP	FP	FN	Se (SD)	PPV (SD)
5347	4508	839	905	83% (10%)	84% (9.4%)

Table. TP: true positive; FP/FN: false positive/negative; Se: sensitivity; PPV: positive predictive value.

A preliminary result of the application of our method in AF condition is shown in figure 1. In addition the phase and activation maps in sinus and AF condition were obtained (movies).

References: [1] Y. Miyasaka , M.E. Barnes, B.J. Gersh, et al., "Secular trends in incidence of atrial fibrillation," Circulation 2006;114:119 –25. [2] P. Kuklik, S. Zeemering, B. Maesen, J. Maessen, H.J. Crijns, Sander Verheule, A.N. Ganesan, and U.Schotten, "Reconstruction of Instantaneous Phase of Unipolar Atrial Contact Electrogram Using a Concept of Sinusoidal Recomposition and Hilbert Transform," IEEE transactions on biomedical engineering, vol.62, NO. 1, January 2015.

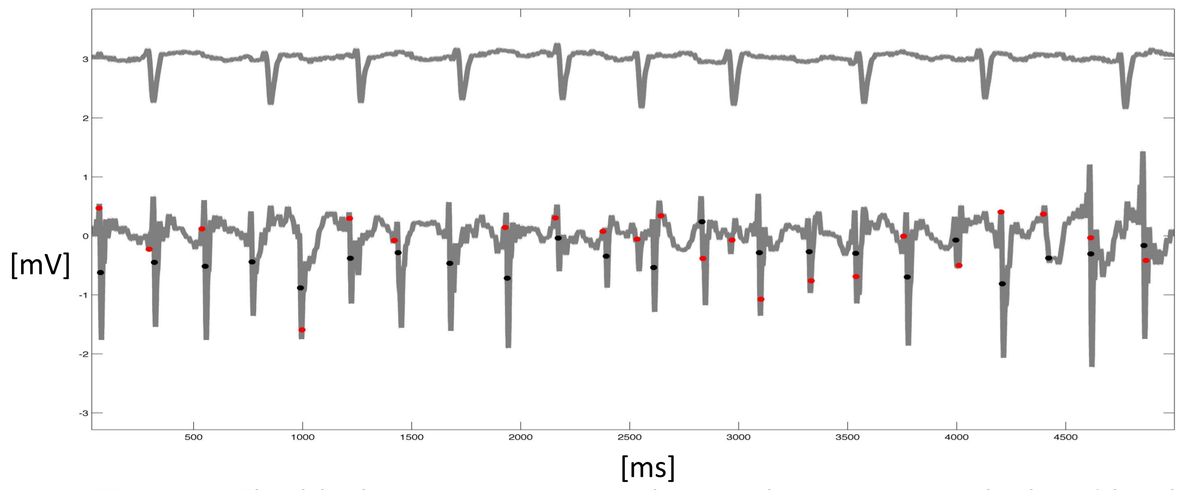
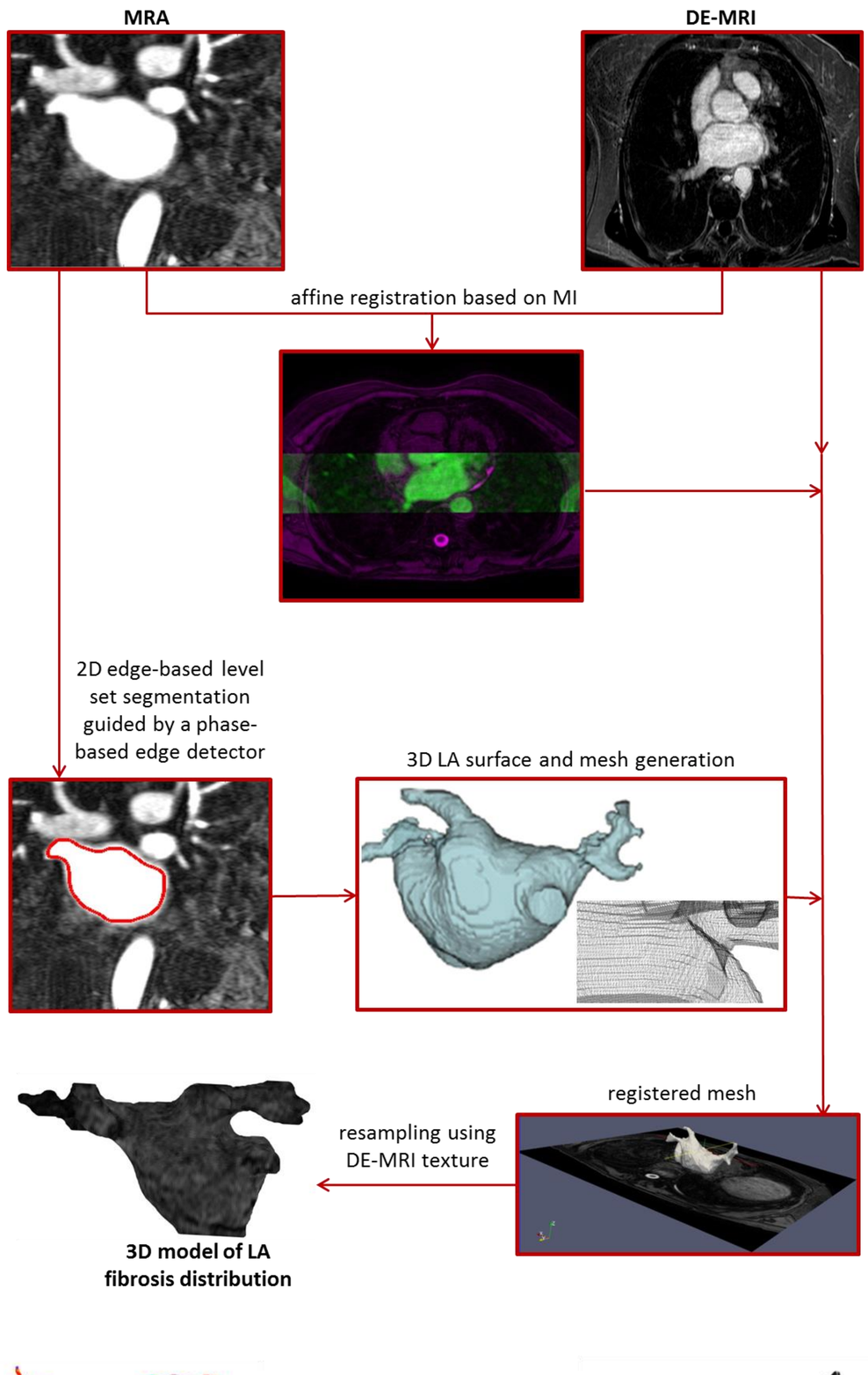


Figure 1. The black points represent the atrial activations calculated by the algorithm, the red points the manually annotated activations.

The workflow of the reconstruction of the 3D model of LA fibrosis is shown in the following figure:



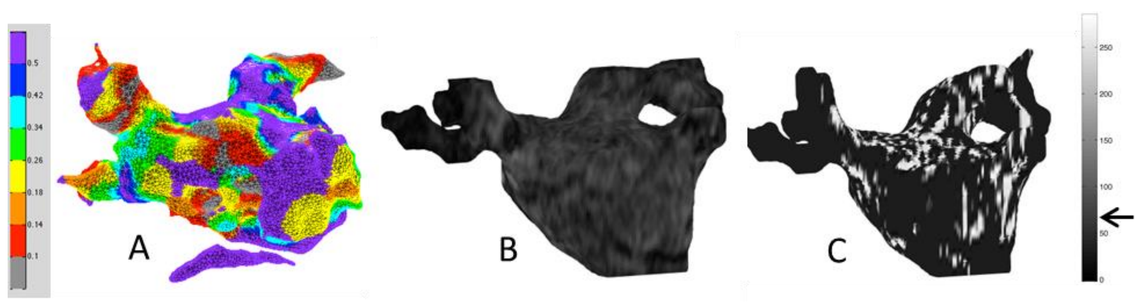


Figure 2. Example of the comparison between the electro-anatomical map (A) and the 3D model of LA fibrosis distribution (in grayscale (B) and thresholded (C) in one patient.

Conclusions

Preliminary results on detected AATs using the developed algorithm are promising. Further investigation is required to confirm the correspondence between low-potential areas in EAM maps and high enhanced in DE-MRI. The next step will be the integration of electrical propagation pattern and structural remodeling information.