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Institut Thématique Multi-Organismes
Technologies pour la santé

Fusion de fluoroscopies et de modèles de planification pour assister la thérapie de resynchronisation cardiaque

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Background

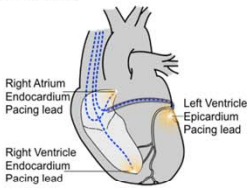
Cardiac Resynchronization Therapy (CRT)

Asynchronous Myocardial Contraction

Asynchrony of contraction due to troubled electrical conduction (atrio/inter-ventricular asynchrony), or necrosed tissue (intra-ventricular asynchrony)
Leads to heart failure

Considered Therapy: Cardiac Resynchronization Therapy (CRT)

Biventricular CRT: Implantation of three pacing leads, in right atrium, right ventricule, and on left ventricle (LV) epicardium through a coronary vein



Procedure limitations: 30-40% of non-responding patients
- Choice of left ventricle pacing site changes procedure outcome
- Access to this site through coronary veins can be tough
- Implantation guided by X-ray imaging: limited description

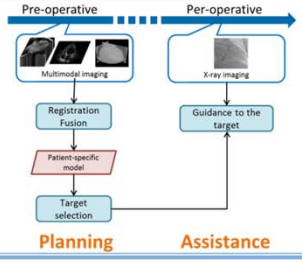
Proposed workflow

Pre-operative planning (previous works [1-3])
Fusion of multimodal images to generate a patient-specific model describing the:
- anatomy of the left ventricle and coronary veins (from CT imaging)
- function (speckle tracking echography, cine-MRI)
- tissue fibrosis (late gadolinium enhanced MRI)

→ Identification of the best pacing sites

Per-operative guidance
- Fusion of the pre-operative model on the X-ray images (angiography, fluoroscopy)

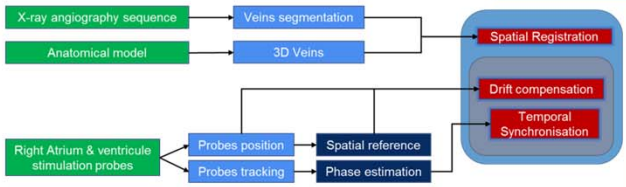
→ Guidance of the implantation to the best pacing sites



Objectives

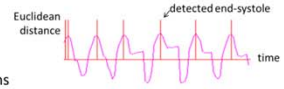
- Fusion of pre-operative multimodal model and intra operative X-Ray images
- Navigation's assistance through coronary veins to the best site on Left Ventricle
- Real-time processing to assist the physician during the procedure

Approach



Phase estimation

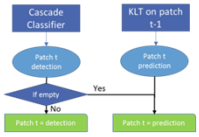
- Goal: Estimate the heart phase
- Method: use the tracked probes
  - The first detected probe is taken as the reference
  - Measure of the Euclidean distance: current /reference positions
  - A peak detection is performed, considered as end-systole (end of contraction)
  - The current phase is evaluated using the number of frames between two peaks
  - Updated at each heart cycle



Probes localization

- Goal: Probes localization in X-ray images
- Method: combination of detection and tracking
- Probe's detection: Machine learning based
  - Cascade Classifier [4]
  - Haar's features
  - Learning sets:
    - 30 positives samples (patches), captured from X-Ray sequences
    - 3000 negative images (Landscapes, objects …)
    - 3000 positive images, created from patches randomly inserted in negative images
    - Detected patches are confirmed using image based features

- Probe's tracking: Local Kanade-Lucas-Tomasi (KLT) tracker [5] to retrieve missing probes
- Combination:

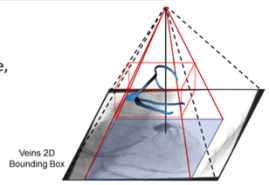


Veins segmentation in X-ray angiographic images

- Contrast enhancement using multiscale top-hat filters
- Thresholding
- Mophological operations
- Skeletonization

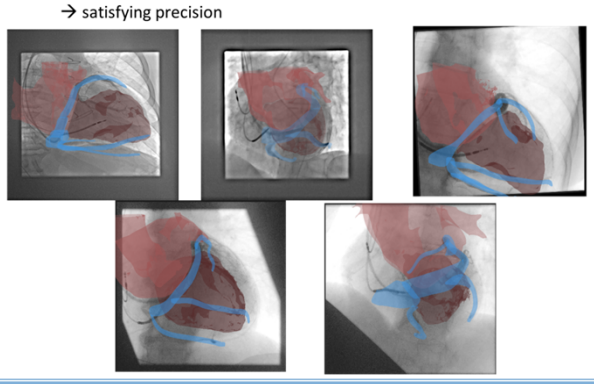
Spatial registration

- The C-arm provides projection parameters (source-detector distance, angles…)
- The 3D/2D registration is performed by aligning 2D skeleton and 3D centerline of the veins at the same cardiac phase (ICP method)



Results

The data of 5 patients were processed retrospectively
→ the proposed solution can process 40 frames a second
Results were visually assessed relying on veins
→ satisfying precision



Conclusion and Perspectives

- Method for real time dynamic anatomical model/angiography fusion
- Has been shown possible
- Has been validated on 5 patients
- Error for navigation is visually acceptable

→ To be evaluated in a real clinical setup
→ Perform quantitative analysis on registration

References

[1] Tavard et al. *Multimodal registration and data fusion for cardiac resynchronization therapy optimization*.
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[4] Freund *Game theory, on-line prediction and boosting*, 9th Annual Conference on Computational Learning Theory, 1996
[5] Bouguet *Pyramidal implementation of the Lucas Kanade feature tracker*" Intel Microprocessor Research Labs, 2000.
[6] Bai et al., *Image enhancement using multi scale image features extracted by top-hat transform*, Optics & Laser Technology, 2012, vol. 44, no. 2, pp. 328-336.