

GENERATION OF A SYNTHETIC DATABASE OF HEART MODELS TO EVALUATE STRAIN-BASED INFARCT DETECTION ALGORITHMS

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Introduction

Accurate quantification of myocardial viability is essential to determine the best clinical treatment for heart disease patients [1]. A decline in myocardial viability influences the structural and functional properties of the heart. Regional myocardial function can be assessed via strain analysis extracted from tagged or tissue tracking MR imaging. However, further processing is required to localize infarct based on these strains. Our previous study showed promising results in using strain-based parameters to detect myocardial infarcts in the diastolic phase [2].

In this study, we introduce a methodology to design a large synthetic database of infarcted hearts based on existing healthy cases with distinct geometries, enabling ground truth data. This database will be used to evaluate the performance of the algorithms developed to locate infarcts in the left ventricle (LV).

Methods

Five healthy LV meshes (3,552 hex elements each) were obtained from [3]. Finite-element (FE) model of each LV was generated following the pipeline in Figure 1. The healthy models were incorporated with a rule-based myocardial fiber orientation and a widely implemented constitutive law [3], which consists of both the passive diastolic and the active contraction phases. The material parameters were personalized with respect to literature pressure values and measured volume changes of each specific heart.

Here, we focused on the generation of training and validation sets of synthetic pathological cases from the five healthy models. Synthetic infarct zones were created with arbitrary size and truncated spheroidal shape, whose centerpoint is defined in the endocardial surface and within the left anterior descending coronary territory. The material property of the infarct is set to be stiffer with low contractility. Eight strain-based parameters were then extracted from the FE simulations of the pathological cases; first principal strain, effective strain, three local directional strains, and strains in fiber, cross-fiber, and sheet-normal directions. This database will serve to identify the best parameter(s) to classify infarcts by means of statistical learning algorithms [4].

Preliminary Results

Figure 2 shows one example of the pathological cases; the principle strain is able to outline the envelope of the

synthetic infarct in the active contraction phase. The objectives of the proposed analysis are two-fold: (i) evaluate the variability of the strain parameters against the patient and infarct properties, and (ii) identify the sensitivity of the infarct detection algorithm. This work is still in progress at the moment.

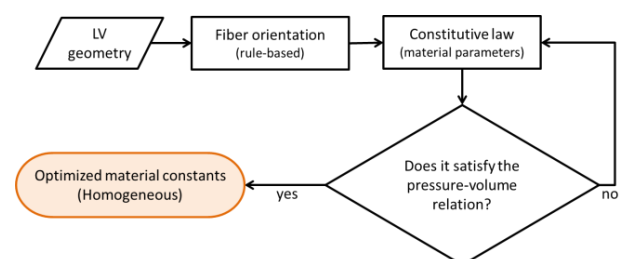


Figure 1: Workflow of inverse optimization to obtain the material parameters for the healthy heart models

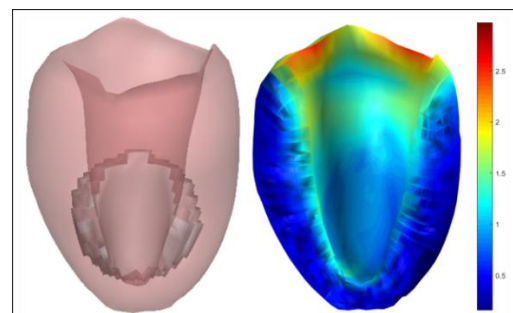


Figure 2: An example of a pathological LV with infarct (left) and active contraction (right) phase. The color displays the first principal strain.

Conclusion

Further work in this context is to validate the proposed approach using *in vivo* pathological cases, with LGE images as the ground truth for infarct location.

References

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2. Rumindo et al. *CMBBE* 2016.
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