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TOWARDS NON-INVASIVE ELECTRICAL HEART IMAGING

L. K. Cheng, A. J. Pullan
Department of Engineering Science, The University of Auckland,
Private Bag 92019, Auckland, New Zealand.
email: l.cheng@auckland.ac.nz

Abstract — Before accurate, non-invasive, electrical images of the heart can be reconstructed several issues must be addressed. Geometric models must be created to match the subject, the appropriate resolution of the computational mesh must be determined and a continuous potential field must be generated from discretely sampled ECG signals. We investigate each of these issues with reference to a porcine model.

Keywords — Inverse problem, patient specific model, customisation, signal interpolation, mesh resolution.

I INTRODUCTION

Three-dimensional generic male and female human and porcine models have been constructed from CT and MRI images using the non-linear fitting procedure of Bradley *et al.* [1]. These models have been constructed from C^1 bicubic Hermite surface elements. Prior to realising the ultimate goal of using such models for the non-invasive reconstruction of the electrical state of the heart, several issues must be addressed. These include determining the appropriate computational mesh resolution, model customisation to a given individual in the absence of full MRI/CT data and signal interpolation over the entire mesh.

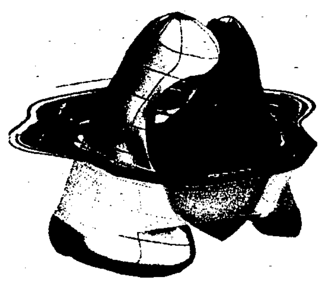

Figure 1: Porcine model of lungs and epicardial surface with CT image from which the model was digitised overlayed.

II COMPUTATIONAL MESH RESOLUTION

Before the inverse problem can be tackled, the mesh resolution, required to obtain a converged solution, must be determined. Using a simplified, constant current heart source, a variety of simulations were performed to investigate the important regions of the thoracic cavity to model and the appropriate resolution required to generate a converged forward solution.

III PATIENT SPECIFIC MODELS

To study the inverse problem of electrocardiology, the geometry of the computational model must match that of the subject. Ideally, geometric models should be created by digitising MRI or CT images and fitting to this data. However, this process of model construction is laborious and time consuming. In the absence of such detailed geometric data a generic mesh can be approximately customised using a small number of measurements and landmark positions obtained from the specific subject (*e.g.*, sternum length, heart position and orientation). This process can also be used to generate an initial mesh for further non-linear fitting if full data is available.

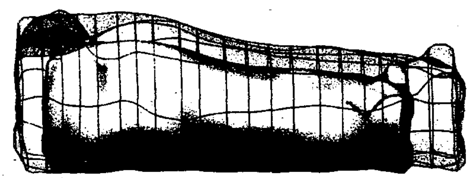

Figure 2: Customisation of the smaller generic porcine model to a larger specific animal.

IV SIGNAL INTERPOLATION

Densely sampled thoracic ECG signals provide a non-uniform geometrically discrete data set. However, computational algorithms require this disjoint information to be transformed to a continuous field at key nodal positions. The use of cubic splines has been a common approach to interpolate this information. We present a new approach of finite element field fitting to reconstruct the signals. This method can produce either a linear or derivative continuous cubic field through the choice of basis function.

V RESULTS

The three issues identified above in preparing a process for use in electrical inverse studies have been successfully addressed. These procedures are now being used as part of an experimental program to validate inverse procedures.

REFERENCES

[1] C P Bradley, A J Pullan, and P J Hunter, "Geometric modelling of the human torso using cubic Hermite elements," *Ann. Biomed. Eng.*, vol. 25, pp. 96–111, 1997.