

NON-INVASIVE ELECTRICAL IMAGING OF THE HEART

A. J. Pullan[†], L. K. Cheng[†], M. P. Nash* and D. J. Paterson*

[†] Department of Engineering Science, The University of Auckland,
Private Bag 92019, Auckland, New Zealand.

* University Laboratory of Physiology, University of Oxford.
email: a.pullan@auckland.ac.nz

Abstract — The performance of an electrical imaging procedure for the heart ideally needs to be validated against invasive electrical recordings made directly on the heart. We report here on an experimental and modelling program that is working towards obtaining the necessary *in-vivo* data required for model validation. We also present results illustrating the performance of a recently published activation imaging algorithm using some of the data obtained to date.

Keywords — Inverse problem, activation imaging, *in-vivo* data

I INTRODUCTION

The goal of non-invasive electrical imaging of the heart is to quantitatively reconstruct information about the electrical activity of the heart from densely sampled thoracic ECG signals. Recently a new activation imaging algorithm has emerged that provides powerful physiological constraints on the underlying cardiac activity. With such constraints, the problem of generating the activation sequence from remote ECG signals is well-posed. Thus, one can expect to produce myocardial electrical source images of sufficient stability and accuracy to be useful in the clinical assessment of the heart. However, before this process can be applied in a clinical sense it needs to be quantified. We describe here a joint research program that is undertaking the experimental and modelling task needed for this verification.

II THEORY AND MODEL DEVELOPMENT

The basic inverse algorithm is presented in Huiskamp and Greensite [1]. The procedure revolves around the identification of the critical points and times of the surface activation function (*i.e.*, epi- and endocardial breakthrough/termination points and times) via the use of a modified MUSIC algorithm. To use this method on a given individual/animal requires the construction of an appropriate transfer function or mapping from the activation sequence to body surface potentials.

A generic anatomically accurate computational model of a pig has been constructed from CT images using the fitting procedure of Bradley *et al.* [2]. This produces a computational model from which the appropriate transfer map can be constructed. This model can also be customised to a given pig by morphing it using a small number of measurements from another pig (*e.g.*, length of sternum, heart size and position). Alternatively, once the experimental procedure becomes more routine, it is possible to CT or MRI the current experimental animal to create a more accurate computational model.

III EXPERIMENTAL PROCEDURE

Experimental work has begun with the aim of trying to simultaneously measure epicardial, endocardial and body surface potentials on an anaesthetised pig, together with the geometric positions of all recording electrodes. Such data would not only provide the necessary data to validate the activation imaging algorithm of Huiskamp and Greensite, but also provide data with which to quantify epicardial inverse procedures against. The current experimental protocol is as follows: the animal is thoracotomised and a 127 channel epicardial sock is placed on the heart. The chest is re-closed and simultaneous body surface and epicardial recordings are made (the inclusion of endocardial recordings will be added at a later stage). Electrode positions and *in-vivo* heart geometry are recorded using a combination of ultrasound and a mechanical digitiser.

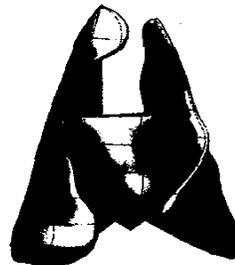


Figure 1: Activation map on the ventricular surface created using the algorithm of Huiskamp and Greensite [1].

IV RESULTS

The generic pig model has been customised to a given experimental animal, and the inverse activation map obtained using this model displays the appropriate generic features as seen from epicardial sock maps. Work is continuing in the areas of improving the *in-vivo* epicardial electrode localisation, and investigating the possibility of recording endocardial events as well.

REFERENCES

- [1] G Huiskamp and F Greensite, "A new method for myocardial activation imaging," *IEEE Trans. Biomed. Eng.*, vol. 44, pp. 433-446, 1997.
- [2] 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.