

Tomasz ADAMUSIAK<sup>\*</sup>, Radosław ZAJDEL<sup>\*</sup>,  
Michał JACYMIRSKI<sup>\*</sup>, Piotr SZCZEPANIAK<sup>\*</sup>

## **ECG 3D MAPPING AND ITS CLINICAL APPLICATIONS, A PRELIMINARY STUDY**

### SHORT NOTE

The inverse electrocardiography was under development for many years. In this novel approach one application was elaborated and described in this paper; with 3D real-time visualisation of ECG tracings on a PC. Using the electrocardiography data-stream from the chest leads, electrical excitation sequence was visualised – by the non-invasive technique, supported by the three-dimensional model of heart.

### 1. INTRODUCTION

In 1895 Einthoven published the first complete record of electrocardiogram and its new clinical equipment [2]. Since then there were several technological revolutions in the electrocardiography. In 1949 the Holter monitoring system [5] was developed and in 1963 the ECG exercises [1]. Nowadays, with the onset of new quality computers, new attempts to move the ECG into the three dimensional interfaces have been undertaken:

- DECARTO system for Dipolar ElectroCARDioTOPography elaborated by Titomir and Ruttkay-Nedecki in 1987 [9] that never came into clinical practice.
- CARTO electro anatomical mapping system [10], which gathers data using a catheter equipped with small magnetic sensors in the tip. By gating the acquisition of points in space to the cardiac electrical activity, points that represent both location and electrical activity can be acquired and displayed on a computer screen. Clinical applications of the system include defining the mechanisms of arrhythmias, designing ablation strategies, guiding ablations, and improving the safety of ablation procedures by allowing localisation of critical cardiac structures such as the atrioventricular node and His bundle [10,8,6,4]. The method was

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<sup>\*</sup> Institute Of Medical Informatics And Statistics, Medical University Of Łódź Plac Hallera 190-647 Łódź,  
Tel/Fax: 639 32 44, Office@Cindi.Org.Pl

further developed, for instance, into a non-contact-mapping system detecting far-field endocardial potentials from a multielectrode-array catheter [7].

- A non-invasive approach involves SQUIDs (superconducting quantum interference devices), which can detect magnetic fields produced by nerve signals in the brain or heart [11]. The drawbacks of the method are very high costs, which practically limit the use of these magneto cardiograms to high-end scientific research.

## 2. METHODS

An application for the .NET platform using DirectX 9.0 libraries for a real-time three-dimensional visualisation of the ECG tracings was developed. The system hardware and software requirements are: Microsoft Windows XP, Pentium III processor or higher, 3D Hardware Accelerator Card DirectX 9.0 compatible.

Data input is in ASCII format and a sample rate of at least 512Hz is required for successful presentation. Signal pre-processing includes band pass filter and base line search. Simultaneous data acquisition and presentation requires a direct connection with an ECG apparatus and an access to proprietary data on ECG transmission protocols.

A 3D representation may be displayed from any viewing projection or rotated on the demand. The excitation sequence can be paused, rewind or played forward at desired speeds. The system could be also used to visualize non-standard leads like the orthogonal system by Frank [3] or additional V4R, V8, V9 electrodes [12] as well as custom placed electrodes.

## 3. RESULTS

The currently ECG data is still gathered and is not sufficient for statistical analysis and assessment of clinical use. We believe it could provide a new method for arrhythmias screening and initial localization of activation sites for further diagnostics. Furthermore it provides undeniable educational quality.

## 4. DISCUSSION

It has to be said that the system at the moment is inaccurate, that is, it does not take into account physical dimensions of the heart and its localisation in chest. This data could be gathered either from physical examination (i.e. percussion of the heart boundaries) or CAT scans, as well as omitted if the system is used as a screening method or for educational purposes.

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