A Model Based Approach for Localization of Basket Catheters for Endocardial Mapping

Ingo H. de Boer, Frank B. Sachse, Olaf Dössel [a]

[a]Institute of Biomedical Engineering, University of Karlsruhe, D 76128 Karlsruhe

Mapping of electrical endocardial activity is an important procedure for cardiac diagnosis and surgical treatment planning. The measurement is usually done using single string catheters with a limited number of electrodes. In recent years an increasing number of mapping systems is used in clinical routine. Different systems have been introduced and discussed in literature [1][2]. These systems have local reference systems, such as the catheter itself or landmarks in the heart. To use these mapping methods in combination with additional measurements, like Body Surface Potential Maps (BSPM) for imaging bioelectric sources in the heart, new localization methods have to be applied.

This work is specialized in the localization and modeling of a multielectrode basket catheter (Constellation™), as introduced by Boston Scientific, Massachusetts, USA. It contains eight strings where six strings have eight electrodes, one string has nine electrodes and one string has ten electrodes. The aim is to localize this catheter in the reference system of a volume dataset like the human thorax for further analysis. In this way the extracorporal and intracorporal information can be combined. Data acquisition of the electorcardiogram and the electrogram is done by electrodes which are positioned on the thorax and inside the heart. The volume dataset is acquired e.g. using MR-imaging. Besides the volume dataset, the exact positions of the electrodes are needed. To achieve this, two different modalities are used: a 4-videocamera system for the extracorporal localization and a bi-planar X-ray system for the intracorporal localization. Both localization systems have been calibrated in advance. By using special reference objects, calibration matrices are determined. These matrices contain all relevant information concerning rotation, translation, perspective and scaling [3].

Special attention was paid to the localization of the electrodes of the basket catheter. Initially, all possible electrodes are found by using image analysis techniques through filters and a convolution of the source image with a mask image. This is done preferably in the frequency domain. Afterwards, the user interactively marks the strings. Each string is then traced automatically and each electrode on the string is marked. After all possible electrodes are found, the three dimensional positions are calculated using the calibration matrices from the X-ray system. In some cases not all electrodes can be found due to, e.g., image noise or overlapping catheter strings. Thus, a three dimensional computer model of the basket catheter is created and visualized. This model is compared and warped by 3D spline interpolation to the electrode positions that have been found beforehand. Finally, it contains all measured and estimated electrode positions.

The modified computer model of the basket catheter can be used in combination with the extracorporal electrode positions, the volume dataset, and the acquired electric potentials. The frame of reference is the volume dataset where all intra- and extracorporal electrodes are fixed. The complete dataset can be used for further field calculations and data analysis. Examples are the inverse and the forward problem of electrocardiography.

REFERENCES

1. R. J. Schilling et. al., “Simultaneous Endocardial Mapping in the Human Left Ventricle Using a Noncontact Catheter,” in *Circulation*, vol. 98, pp. 887–898, American Heart Association, 1998.
2. V. Barbaro et. al., “Mapping the Organization of Human Artrial Fibrillation Using a Basket Catheter,” in *Computers in Cardiology*, vol. 26, pp. 475–478, IEEE, 1999.
3. I. H. de Boer et al., “Matching von dreidimensionalen Elektrodenpositionen ausgehend von biplanaren Röntgenbildverstärkern und CCD-Farbkameras,” in *Bildverarbeitung für die Medizin 1999*, pp. 70–74, Springer Verlag, Berlin, Heidelberg, 1999.