 ISSN 1984-820X

A methodology based on wavelet transform to identify the cardiac region in images of electrical impedance tomography

José Pedro de Oliveira [1]

Harki Tanaka [2]

Neli Regina Siqueira Ortega [1]

[1] Informática Médica, Faculdade de Medicina, USP
05405-000, São Paulo, SP

[2] Centro de Engenharia, Modelagem e Ciências Sociais Aplicadas, UFABC
09090-400, Santo André, SP

E-mail: jpolive@gmail.com, harkit@usp.br, neli@dim.fm.usp.br

RESUMO

Electrical Impedance Tomography (EIT) is an imaging technique, still in development, in which an image of the conductivity of a transversal section of an object is inferred from electrical measurements using a series of electrodes placed on its surface [1]. Despite the benefits presented by this technique, it has some limitations, amongst which we detach the low spatial resolution. Although the EIT method presents a high time resolution, the low spatial resolution hinders the characterization of the activity of regions according to their physiological origin in a dynamic image. These difficulties in interpreting the images, both in the anatomical and in the functional points of view, can be translated as an uncertainty of identification of the pixels.

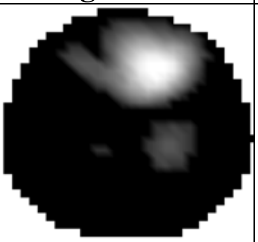
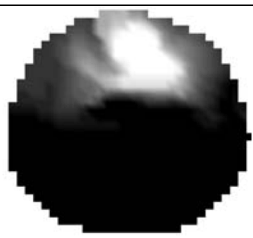
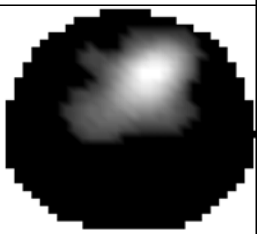
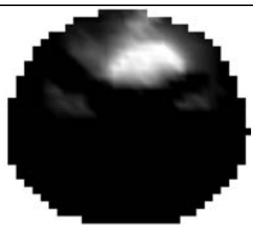
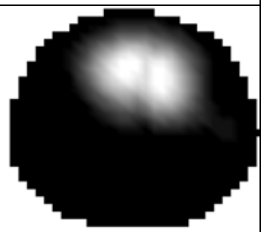
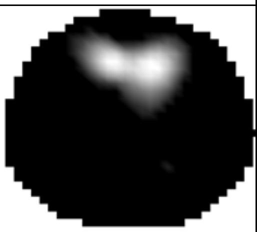
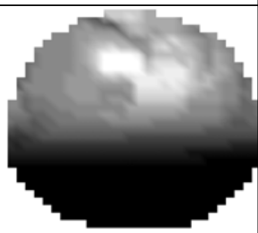
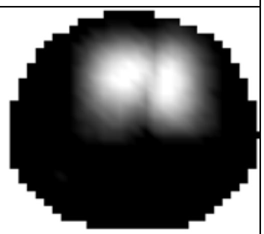
One of the most important EIT studies concerns to the images of the thorax, aiming to monitor the cardio-respiratory functions. In that sense, Tanaka et al. [2] proposed the use of fuzzy sets theory to deal with the pixels identification uncertainty through fuzzy linguistic models, aiming for a segmented image of the cardiac and pulmonary maps. Despite the good results presented, this model showed some limitations in identifying the heart in more complex situations, such as PEEP (Positive End-Expiratory Pressure) variation. Therefore, it is realized that a tool that could extract more information from EIT signal could be capable to separate with more clearness the pulmonary and cardiac regions. One of the tools capable to extract information of signals in the time and frequency domains is the Wavelet Transform.

The image generated by the EIT system used is formed by 1024 pixels, where each pixel corresponds to a certain area of the body of the object under analysis. These pixels have variations in their impedances due to the blood flow during the cardiac cycle. In order to develop a methodology to identify the heart region in the EIT images of the thorax, a qualitative analysis of the time varying information contained in these signals is necessary. Firstly, this qualitative analysis was based on the wave patterns analysis and after each pattern was discussed with the cardio-respiratory expert panel, considering the physiological knowledge. This analysis was of fundamental importance in the model development, because it provided the knowledge about the standard behavior for each region of chest (lungs, ventricle, atrium, aorta, etc.).

EIT raw data were collected in an animal experiment (pig) which was submitted to different values of PEEP: 18cmH2O (PEEP18), 12cmH2O (PEEP12) and 0cmH2O (ZEEP). This is important to evaluate the robustness of the system developed in different clinical conditions. For

each phase of these PEEPs hypertonic solution (20% NaCl) injection was used, which serves as the contrast medium for the EIT images.

Table below shows the heart maps provided by wavelet and fuzzy approaches, and also the maps found with the saline contrast. The areas under ROC curves (AUC), when the wavelet and fuzzy images are compared with saline image, are also presented. We can note in these figures that the pixels corresponding to the heart region identified by the wavelet algorithm are located in a superior central position, independently of the PEEP values. It important to detach that in this region there is a crossover of the complex cardio-pulmonary structures, such as ventricle, atrium, lung, aorta, and so on, which could cause important alterations in the EIT perfusional images compared to the expected dynamic pattern of the main cardiac compartment. The wavelet methodology proposed was able to identify the heart region from EIT data of perfusion when compared with the saline method. Although the AUC values for wavelet approach were better than the fuzzy method, they are statistically equivalents. The great advantage of the wavelet method when compared with fuzzy approach is that it does not require that the parameters of the model are adjusted in order to identify the heart region when the PEEP values vary, as it occurs in the fuzzy model.

PEEP	**Wavelet Algorithm**	**Fuzzy**	**Saline**
18 cm H2O	 AUC = 0.914	 AUC = 0.878	
12 cm H2O	 AUC = 0.966	 AUC = 0.859	
0 cm H2O (ZEEP)	 AUC = 0.827	 AUC = 0.947	

Palavras-chave: *Electrical Impedance Tomography, Medical decision support system, wavelet transform*

Referências

[1] B.H. Brown. Electrical impedance tomography (EIT): a review, Journal of Medical Engineering & Technology, vol. 27, n°3, pp. 97-108 (2003).

[2] H. Tanaka, N.R.S. Ortega, M.S. Galizia, J.B. Borges, M.B.P. Amato. Fuzzy modeling of electrical impedance tomography images of the lungs, Clinics, vol.63, no.3, pp.363-370 (2008).