MINIMIZING THE PARTIAL VOLUME EFFECT USING THE RESPIRATORY SIGNAL TIMING IN THE ART OF CAPTURING IMAGES OF THE PET CT

Welder Souza Goulão a & Araken dos Santos Werneck Rodrigues b

a Faculdade UnB Gama (FGA) – Área Especial Quadra I, Setor Central- Gama – DF - Brazil
b Faculdade UnB Ceilândia (FCE) – QNN 14 Area Especial, Guariroba, Ceilândia Sul - DF - Brazil

Resumo. This work describes the development of an algorithm capable of filtering a signal captured by a breath of the NTC thermistor and then synchronizes this signal to a pulse generator. The measurement is essential for biomedical signals to obtain physiological data for diagnostic or research purposes. The information was obtained from an analysis of signals available in the database of phisionet. The greater relevance of this work is the possibility of contributing to medical research to identify the cancer cells present in small volumes of organs located in the thoracic region of patients undergoing clinical evaluation.

KEY WORDS: signal conditioning, Sync, respiratory cycle, Nuclear Medicine, Lung cancer, the partial volume error.

1. INTRODUCTION

In the thorax and abdomen, there may be considerable movement of internal organs and structure, in response to respiratory and cardiac motion. A tumor present in this region and identified by a radioactive tracer, widely used in diagnostic imaging examinations, will also move, especially during the breathing cycle. The time required for one image volume of the lungs in a modern CT (Computational Thomography) scanner is of the order of seconds and it is relatively smaller than the breathing cycle. The image volume thus provides an indication of the position of internal organs at a point in time and does not provide information about the potential movement of abnormal tissue volumes during the respiratory cycle.

In comparison, data are acquired from a PET (Positron Tomography-Emition) very differently in the time scale and the interpretation of the image obtained becomes problematic. An image obtained PET is usually over a period of 3-5 minutes, and therefore, many images of breathing cycles. The image data thus depict a distribution that is time-averaged and based on the residence time distribution of the radioactive tracer in each point of the image thus the tumor seen in CT gives only a position where it moves during breathing, while the image seen by PET shows the entire area of this movement. The PET remains a lower resolution imaging technique to CT and this compromises the detection and quantification of activity in small volumes. Thus, the tumor seen on CT has only one position where it moves during breathing while the image seen by PET shows the entire area of this movement, Figure 1 illustrates this difference.
The implications of using these devices against the movement of the entire thoracic structure are basically two. First, the difference in time required for image acquisition between PET and CT can lead to disturbances in the feature image and a quantification incorrect attenuation correction is applied to the image reconstruction. Second, the movement of radioactive tracer during the acquisition will result in an image reconstruction with distribution activity outside the real target, and staining the lesion showing a greater volume than actually exists, that phenomenon is presented as a partial volume error.

Thus, the principal effect of the respiratory motion is a spread of the tumor detected predominantly in the chest and, to a lesser extent, in areas below the diaphragm. However, since the first clinical application of PET in RTP (Radiotherapy) is in lung cancer, the issue of respiratory motion has a predominance of challenges to identify accurately determining the volume and concentration of functional activity of the markers. In particular, the case of PETCT scanners (Positron Tomography-Emission Computational Thomography) presents additional challenges, since the presence of respiratory movements produces inaccuracy in image reconstruction, not only as a result of the injury spot, but also as a result of registry error between PET and CT acquisitions. With the use of hybrid scanners, the CT maps are also used to correct the effects of attenuation on data from PET, an extra inaccuracy can be introduced when the data set obtained by CT and PET are not perfectly aligned due to error partial volume.

This can compromise efforts to delineate treatment volumes or to quantify the absorption of the lesion. These issues are being addressed by the introduction of monitoring respiratory movements that allow segmentation of images through the acquisition of timing between the movement of the marker and the acquisition, which promotes significant improvement in attenuation correction coefficients accurately and reconstruction of volumes of activity and concentrations of target cells.

2. METHODOLOGY

To display this work was performed in a research database of Physionet in order to locate signs of breathing that used sensors built based on the use of NTC (Negative Temperature Coefficient) thermistors. The database MIT-BIH Polysomnographic Database (slpdb) has basic breathing signals captured by sensors thermal and free from any kind of filtering, which represented a significant gain time to perform the initial tests of efficiency and robustness of the proposed filter this project.

We selected a short duration signal to better visualize the nuances of the curves of the respiratory cycle, and the signal was sampled lasting 10 seconds at a rate of 250 Hz, as shown in Figure 2 below.

---

1 SERGIO L. Faria et al., 2007 pg. 347
3. RESULTS
This topic will discuss the technical aspects related to the algorithm used in MATLAB to achieve the filtering stages, taking as starting point the analysis of images generated by the program and the presentation of the characteristics necessary for the development of synchronized signals at selected points in the curve breathing.

3.1. IMAGES GENERATED BY ALGORITHM
After reading the selected signal in the database of phisionet using the MATLAB program has been possible to manipulate the variable responsible for storing the values of the curve associados respiration signal.

Initially the technique used for windowing convolution signal with a filter of the type FIR (Finite Impulse Response) frequency of interest in order to obtain a significant attenuation at frequencies assossiadas the noise shown in Figure 2. With only one filtering stage, utilizando pass filter ranges of length N = 25 obtained a regular sinusoid, as indicated in figure 3.
3.2. PULSE OF TIMING
To synchronize a pulse generator with the respiration signal, it was necessary to implement an algorithm capable of identifying the peaks and valleys of the original signal and starting this identification locate points of interest on the curve, which represent the stages of inspiration and expiration breathing cycle.

Figure 5 is a sync pulse generator with the curve of breath using as reference the beginning of the expiration phase, i.e. at the end of a peak.

![Figure 5. Timing of the respiratory cycle 0% (MATLAB).](image)

In Figure 6 the signal is synchronized with the pulse generator in 50% of the descent stage of the cycle.

![Figure 6. Timing of the respiratory cycle 50% (MATLAB).](image)
3.3. PROCESSING
The respiration signal can be quantified in various ways. One can, for example, measuring their maximum amplitude, which is however a rough measure of the degree of muscular activity. Other methods consist in counting the number of peaks, or by the zero crossing number, or the number of times that a certain amplitude value is exceeded in a given time interval.

The method was used to filter the signal (band pass filter), identify the peaks and valleys and measure the distances between these points, thereby building the information base needed to sync with the pulse generator. This methodology enabled ensure that the filter after the interaction with the temporal signal was possible to maintain a linear relationship with the pulse generator.

4. CONCLUSIONS
Despite the demonstration of robustness and efficiency of the filter, this activity was an sample collected by third parties with no details about the initial conditions of data collection, or even the characteristics of the patients, thus an important variable for confirmation consistency of the algorithm.

For the commercial development of prototypes designer should consider implementing IIR (Infinite Impulse Response) type filters because of the small length and the reduction of multiplication stages, and therefore the lower computational cost and possibly faster response time series for analysis of real time data.

4.1. DISCUSSIONS
The use of FIR filter proved efficient for implementation of pulse generator synchronized to the respiration signal; however due to the need for greater attenuation of unwanted frequencies, it was necessary to increase the size of the filter, resulting in a significant delay in pulse generator. Despite the adjustment made by the small devices MATLAB, we also observed that in practice for real-time signals the best option will be the type IIR filter, which can in turn benefit the project with a smaller size and the length of the filter stages feedback, which ensure greater robustness to the filter before signals in real time, since the technical details of the filter specification are met efficiently.

5. BIBLIOGRAPHY
CARVALHO, Luis Carlos. Apostila de Instrumentação Biomédica – Capítulo IV: Eletromiografia e eletrodiagnóstico. Universidade Federal da Paraíba. UFPB.
BUTTON, Vera Lúcia da Silveira Nantes . Eletromiógrafo, Eletrocardiógrafo e Monitor Cardíaco. In: Saide Jorge Calil. (Org.). Equipamentos Médico-Hospitalares e o Gerenciamento da Manutenção. 1 ed. Brasília: Editora Ministério da Saúde, 2002, v. , p. 331-363.
BRONZINO, J. D., 2000, “The Biomedical Engineering HandBook”, Second Edition, Boca Raton: CRC Press LLC.
SERGIO L. Faria; Robert Lisbona; Jerry Stern; Slobodan Devic; Luis Souhami; R Carolyn. Use of FDG-PET/CT scan in the planning of radiation therapy for nonsmall cell lung cancer. Radiologia Brasil. v. 40, p. 345–348, 2007