

Tool for Biomedical Signals Processing

Josué Cabrera, Jesús B. Alonso, Carlos M. Travieso
Universidad de Las Palmas de Gran Canaria (ULPGC)
Las Palmas de Gran Canaria, Spain
jalonso@dsc.ulpgc.es

Abstract— Educational tool for training biomedical engineers in the biomedical signals processing field has been developed. It is software for simulation and study of the results obtained in biomedical signals when different signals processing techniques are applied. The tool has been implemented on a graphical user interface to facilitate the use.

Keywords: biomedical engineering education, biomedical image processing, biomedical signal processing, e-learning.

I. INTRODUCTION

The biomedical engineering has arisen as a way of integration of two dynamic professions, medicine and engineering, and has collaborated in the fight against affections and illnesses providing instruments (as biosensors, biomaterials, images processing, and artificial intelligence) that can be used for investigation, diagnosis and treatment by the medical professionals.

Currently, computers are common in hospitals management fields such as the information analysis for research, educational tool and administrative tasks. These fields have facilitated the development of the telemedicine that using the new communications and information technologies allow the innovation on new models of medical care [1], [2], [3].

The biomedical engineers' education need a practical education that complement the theoretical education, with practices in hospitals or simulations, in which many software tools are available such as the created ones by Cuesta [4] and Aboy [5], between others.

These software tools were created as toolboxes or software for biosignal processing, visualization, editing, etc.; and they contained general signals processing tools. Also they didn't relate basic and/or specific processing techniques with the biomedical signals to which were applied normally, complicating the educational work.

In this paper an educational tool whose aim is familiarize the student of biomedical engineering with basic signals and image processing techniques used in the new technologies applied to the telemedicine.

The software, created in Matlab environment, contains diverse processing techniques, whose typical parameters can be changed by the user, facilitating the learning and experimentation. Also the software allows to the user to add new information to process.



Fig. 1. Tool for Biomedical Signals Processing main window.

Also a didactic HTML tutorial has been included. This tutorial resolves doubts about the use of the software and explains theoretical knowledge of the processing techniques and biomedical signals and images used in this tool.

The software has been divided in modules for signals and images processing. All modules include basic and specific processing tools for the signals treated in each one of them. Also the software contains a module for load of signals. All these modules are accessible from the main window of the application shown in the Fig. 1.

II. MATERIAL AND METHOD

In this section, first the database is described. Then signals and images processing modules, as well as the processing techniques included in them, are described. Finally, didactic HTML tutorial is shown.

A. Database

The tool has a database of 253 recording signals with different pathologies and formats, obtained from free internet databases.

The signals processing modules use MAT-files and format 212 signal files from the MIT (Massachusetts Institute of Technology) [6], [7] databases. These files contain healthy and pathological signals corresponding to electrocardiograms, electroencephalograms and electromyograms.

The images processing modules use formats JPEG and BMP. The database contain healthy and pathological images

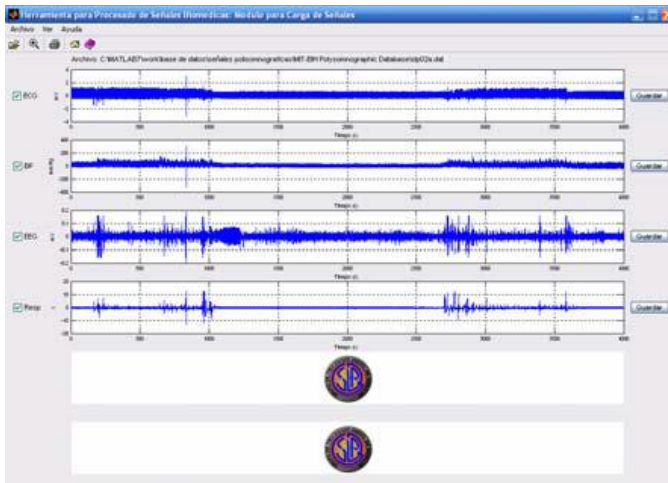


Fig. 2. Signals load module shown a polysomnographic signal

such as x-rays, mammographies, cell images and computed tomographies, extracted from Casimage project web [8], [9] and from the American Society of Hematology image bank [8], [9].

B. Signals Processing Modules

1) Signals Load Modules

Signals load modules, show in Fig. 2, allows the reading of all the signals contained in a file or record, making possible to the user to store in new files, the signals that are of his interest.

The module is capable of reading all the signals stored in MAT-files and format 212 files, using algorithms developed and executed integrally in MATLAB language.

2) Electrocardiograms Processing Module

The electrocardiogram is a recording of the electrical activity of the heart. The electrocardiograms processing module (Fig. 3) includes more 60 electrocardiographic records of healthy and pathological states.

It provides processing techniques developed for electrocardiograms, such as data compression techniques, QRS detection, filters and noise addition.

The data compression techniques, Huffman coding, Fan and Turning Point algorithms [2], [10] have been implemented. Interpolation methods for the signal reconstruction, such as lineal, cubic spline and cubic hermite interpolation, have been implemented. Finished the signal reconstruction, the software shows the resultant signal, the compression ratio, the interpolation method chosen and the Percent root mean square difference [2], [10].

The QRS detection is based on the algorithm proposed by Pan-Tompkins, using the band-pass filter, derivate and integrator described by this one [2], [10].

The filtered techniques allow lowpass, highpass and bandstop filters design. These techniques are used in the elimination of the high frequency noise, baseline wander and the 50 Hz power line interference, respectively [2], [11]. A filters design interface allow select between Butterworth,

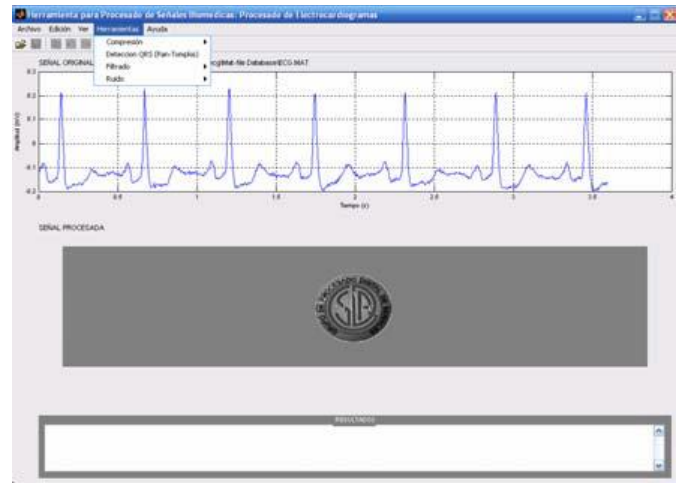


Fig. 3. Electrocardiograms processing module

Chebyshev type I and II or Elliptical analogical or digital filters. The cut-off frequency, filter order, attenuations and stopband and passband frequencies are editable.

The noise addition techniques allow adding Gaussian white noise, 50Hz power line interference and baseline wander.

3) Electroencephalograms Processing Module

The electroencephaogram is a study of electrical current within the brain. The electroencephalograms processing module contains more 50 chronic obstructive sleep apnea syndrome recordings.

This module allows Delta, Theta, Aplha, Beta and Gamma waves detection that compose the electroencephalogram by means of the passband filters application centred in the frequencies range that occupy each wave [3], [10].

4) Electromyograms Processing Module

The electromyogram is a test used to record the electrical activity of muscles, which provides information on the muscular effort [3], [12]. The electromyograms processing module contains more 40 recordings.

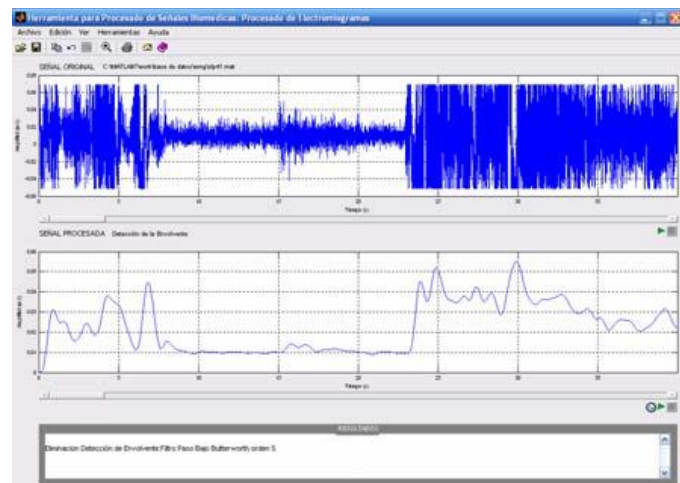


Fig. 4. Envelope detection by full wave rectifier method.

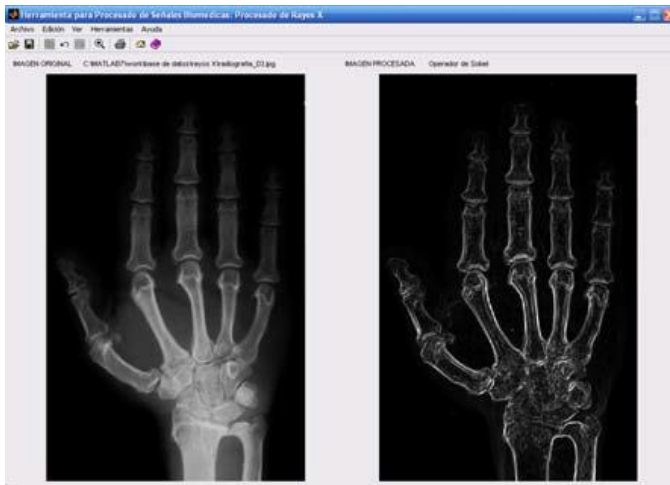


Fig. 5. X-rays processing module

The envelope detection by full wave rectifier method (Fig. 4), which consists of converting the negative part of the signal in positive and applies a lowpass filter, is implemented.

C. Images Processing Modules

1) X-rays Processing Module

The x-rays are a diagnostic imaging test in which ionizing radiation passing through the patient's body enables an image to be produced on film. Fifty images, between x-rays, mammographies and computed tomographies are included in the module.

The x-rays processing module, shown in Fig 5, provides processing tools such as like edges detection, dynamic range compression, and application of masks, filters and noise addition.

Edges detectors such as Roberts, Sobel, Prewitt, and Frei-Chen operators, Laplacian, Laplacian of Gaussian filter and the Canny operators [11], [13], are included. It is necessary the user introduces values of certain parameters that characterize the operators by means of emerging windows.

The user can add Gaussian white, salt and pepper, and Poisson noises to the image, previous definition of certain necessary parameters.

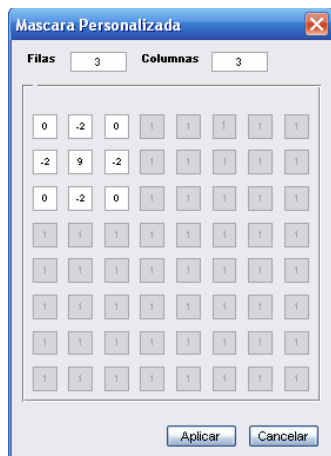


Fig. 6. Customized masks design.

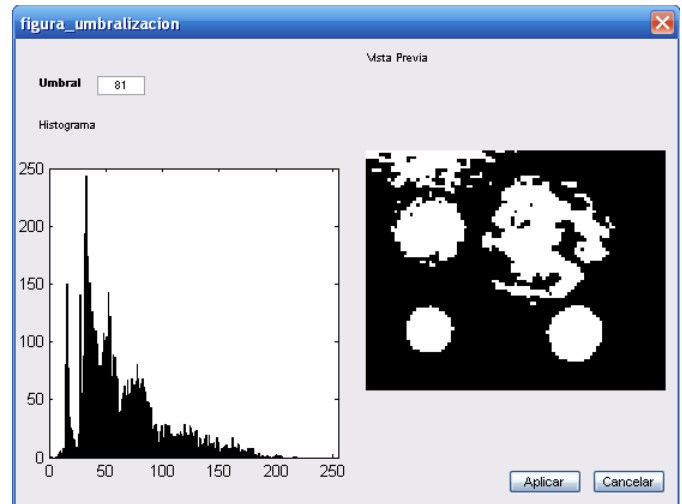


Fig. 7. Thresholding segmentation method interface.

The filtered techniques used by the module are lowpass and highpass filters, such as median, Wiener, Gaussian lowpass, average and Unsharp masking filters. The masks are editable.

Also, application for customized masks, with maximum size of 8x8, is provided (Fig 6).

The dynamic range compression of the image by logarithmic or quadratic compression, is implemented.

2) Cell Images processing Paralinguistic Feature

The cell images are biological images obtained from microscopes. The user can use 20 biological images for experimenting. The cell images processing module contributes segmentation and mathematical morphology tools used to process biological images, facilitating the determination of the quantity, form and diameter of the cells in the image.

In image segmentation a threshold is used. The threshold is defined by the user. The image segmentation interface helps to the user by image histogram visualization and a previous view of the result (Fig. 7).

The module allows, using binary and grayscale mathematical morphology, admitting operations of erosion, dilation, opening, closing, top-hat and bottom-hat. The user has an interface where to choose between several structural elements, to define the size of them and to visualize previously the effect that will produce in the image.

D. Tutorial

The software includes a HTML user guide, shown in Fig. 8, which provides a description of the theoretical knowledge about signals and processing tools implemented.

III. CONCLUSIONS

In this paper, an educational biomedical signals processing tool has been presented. The tool developed provides the biomedical signals and images more usually studied in biomedicine, as well as processing techniques and standard databases.

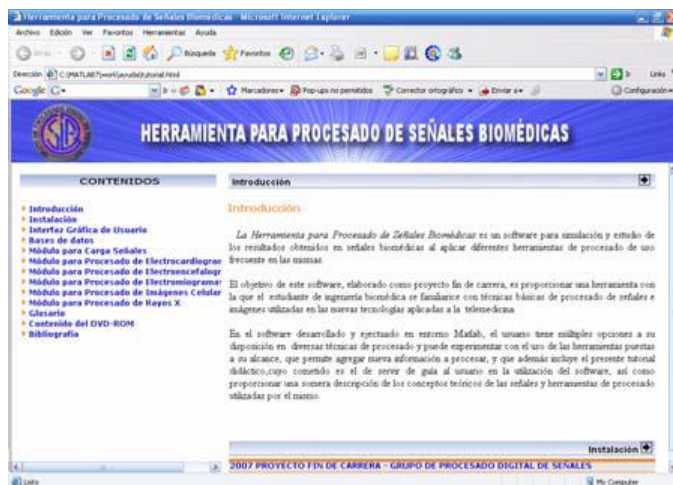


Fig. 8. User guide.

The tool includes six modules for specific processing of biomedical signals. The educational task is facilitated by simulate basic and specific processing techniques.

The software also integrates an html user guide that describes characteristics software, presents theoretical knowledge about the biomedical signals and images, and processing techniques, shows graphic examples and animations, and facilitates the teaching in the field of the biomedical engineering.

This tool brings near to the engineers to the medical concepts and to the medical professionals to the digital processing techniques used in the biomedical area.

Future versions of the software will contemplate increase the current processing techniques and add new processing modules.

REFERENCES

- [1] John Enderle, Susan Blanchard, Joseph Bronzino. Introducción to biomedical engineering. Academic Press, 2000.
- [2] Willis J. Tompkins. Biomedical digital signal processing: C-language examples and laboratory experiments for the IBM PC. Prentice-Hall, 2000.
- [3] Joseph Bronzino. The biomedical engineering handbook second edition. CRC Press, 2000.
- [4] Cuesta, D.; Mico, P.; Aboy, M.; Novak, D.; Brezny, R.; Samblas, L.; Pastor, D.; Sancho, S. Biosignal laboratory: a software tool for biomedical signal processing and analysis. Proceedings of the 25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2003, Volume 4, Issue , 17-21 Sept. 2003 Page(s): 3544 - 3547 Vol.4
- [5] M. Aboy, C. Crespo, J. McNames, J. Bassale, L. Jenkins and B. Goldstein, A Biomedical Signal Processing Toolbox, Conference Biosignal 2002, Jun. 2002, pp. 49–52.
- [6] Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, Ivanov PCh, Mark RG, Mietus JE, Moody GB, Peng CK, Stanley HE. PhysioBank, PhysioToolkit, and Physionet: Components of a new research resource for complex physiologic signals. American Heart Association, Inc, Circulation, Jun. 2000, vol. 101, n° 23, p. e215-e220
- [7] [Online] Available: <http://www.physionet.org>
- [8] [Online] Available: <http://ashimagebank.hematologylibrary.org/>
- [9] [Online] Available: <http://www.library.uthscsa.edu/main.cfm>
- [10] Arnon Cohen. Biomedical signal processing. Crc Press, 1996.

- [11] John L. Semmlow. Biosignal and biomedical image processing: MATLAB based-applications. Marcel Dekker, Inc, 2004.
- [12] Suresh Devasahayam. Signals and systems in biomedical engineering: signal processing and physiological systems modelling. Kluwer Academic, 2000.
- [13] Isaac N. Bankman. Handbook of medical imaging: Processing and analysis. Academic Press, 2000.