Didactic Platform for Biomedical Signal Processing: Module for Analog Filter

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Abstract

Recent studies about Biomedical Engineering issues, which are subjects offered in Electrical Engineering undergraduate courses in Brazil, have shown a great lack of investment in this field. That was the main motivation in developing a Didactic Platform for Biomedical Signal Processing (DPBSP), which consists in a generalized and modular biomedical acquisition board, a software to visualize and processing signals as well as, theoretical-practical tutorials which aggregate content to practical class schedules. Therefore, this present work details a study and development of a didactic tool to support teaching of analog filters applied for biomedical signals, demonstrating to student in a practical way, the importance of choice the correct filters for acquisition of biomedical signals. This module is composed of filters-type as low pass, high pass, band pass and stop pass of diverse orders and approximations (Butterworth, Chebyshev, Bessel and Elliptic). Visualization software, permits the observation of some problems about using filters, and verify, in practice, which filter is optimum to be used for each case. System Evaluation was realized in two stages. First, students of a regular Electrical Engineering class carried out practical classes. Second, a mini-course of Biomedical Engineering was created for practice. The motivational aspects of the system like, facility to use, system organization, stimulation and significance, were evaluated through a questionnaire. The results of the evaluation showed a very high motivating system with a high expectation of success.

Keywords— Didactic Hardware, Didactic Platform for Biomedical Signal Processing, Analog Filters.

1. INTRODUCTION

In Brazil, the creation of Biomedical Engineering (BE) subjects in Electrical Engineering (EE) courses at undergraduate levels, aims the perception, by the scientific leaderships in this area, of a huge market for the graduates in EE, as they seek technological solutions in the health area (ADUR, 2007).

Teaching BE depends on an array of contents taught in other classic subjects (usually applied in areas that are also considered "classic" in EE). Nonetheless, the characteristics of the signal and biomedical systems present particularities to be investigated in BE. Furthermore, given the eminently applied nature of these subjects, the referred knowledge and particularities shall be treated in a practical way, through pedagogical approaches that privilege the experience with "making" in this area (ANDRIGHETTO, 2007). In Brazil, though, there are not many subjects assessing these particularities in EE programs.

A preliminary investigation on the insertion degree of specific BE topics in EE undergraduate courses was carried out by Possa (2008). It indicates that only 7,5% of the EE courses investigated offer at least one subject with BE topics. Based on these results, the Institute for Biomedical Engineering of Santa Catarina Federal University (IEB-UFSC) decided to enhance the engineers practical and technical nature, by creating a laboratory for practical BE classes in the EE course.

The creation of the Teaching Laboratory in BE (TLBE) came about with the development of a didactic platform focused on EE undergraduate subjects called "Biomedical Signal Processing System: the Didactic Module (BSPS-DM)". The hardware, software and tutorial systems included in this platform contribute with the teaching/learning process through experiments in acquisition, processing, transmission, visualization and comprehension of the bioelectrical signal available in the IEB-UFSC Saúde+EducaçãoTM website (http://www.saudeeducacao.ufsc.br) (RATHKE, 2008). This specific work presents the basic module of the BSPS-DM platform, as well as the bioelectrical signal acquisition modules (EEG, ECG, EMG, EOG), the wireless communication module and the Visualization Software.

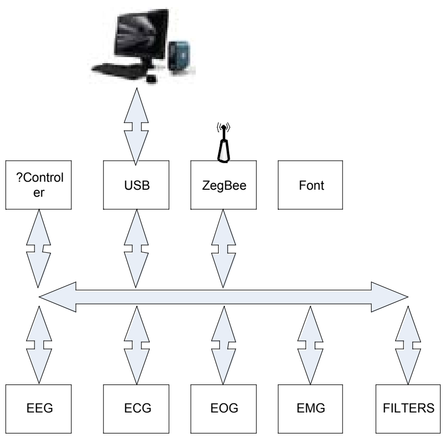
This specific work presents the development of an additional functionality for the BSPS-MD platform: A module with active filters for electroencephalogram (EEG) signal. It is composed by low pass filters, band pass, band rejection and high pass, of pre-selectable orders (2, 3, 4), containing answers types Butterworth, Chebyshev, Bessel and Elliptic.

2. DIDACTIC PLATFORM FOR BIOMEDICAL SIGNAL PROCESSING

The DPBSP is disposed modularly and contains a micro-controlled board (ADuC7026 micro-controller by Analog Devices, A/D, D/A, RS232 and USB communication protocols, feeding availability, + 5 V, -5 V, +3,3 V e GND and wireless ZigBee network) called base board (BB) and many modules for the acquisition of a specific biomedical signal: EEG Module (Electroencephalogram), ECG Module (Electrocardiogram), EMG Module (Electromiogram), EOG Module (Electrooculogram) and Filter Module (Analog Filters). The base board is responsible for converting the analogical signal coming from the modules into digital signal and for sending them to the computer. The system also has a software that was especially developed for visualizing the signal transmitted by the USB interface or ZigBee of the micro-controlled board (ADUR, 2008), (ANDRIGHETTO, 2008), (RATHKE, 2008)(POSSA, 2008), (SCOLARO,2009).

The objective of this equipment is to make available the opportunity to apply in practice the Hardware concepts (analogical filtering, phase and angle displacement, A/D conversion, amplification), Software (signal sampling, processing and visualization), particular problems associated to the acquisition of this signal (noise, skin-electrode impedance, associated electromagnetic interferences, acquisition of signal in low amplitude) among others (RATHKE, 2008), as it can be seen in Figure 1.

Figure 1 – General view of the system

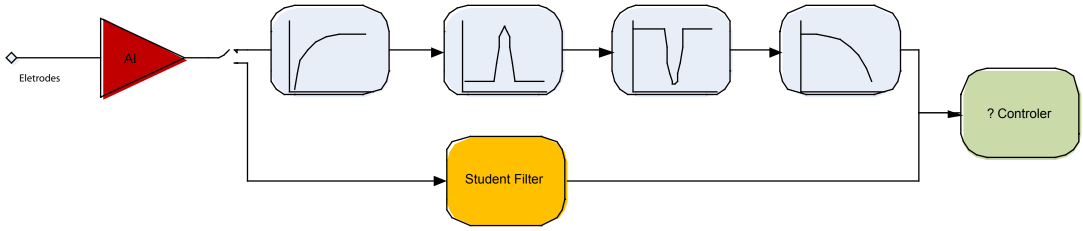


2.1 ANALOG FILTER MODULE

The Analog Filter Mode was developed with the intent of demonstrating to the BE undergraduate students the different options of analog filters and their main problems in the usage of biomedical signal. The module is composed by low pass filters, band pass, band rejection and high pass. Each one of the filters has the availability for order selection (2, 3 or 4) via selecting key, with answers of the types: Butterworth, Chebyshev, Bessel and Elliptic. Space and access for the student to create his/her own filter in the system is also provided. Figure 2 shows the block diagram of the Analog Filter Module. The module also has an offset circuit (variable), gain (variable) and tension protection.

The active filters utilized range 0,5-100 Hz, and supply the minimum needs for the acquisition of electroencephalogram signal (WEBSTER, 1998). A passive filter of first order was introduced at the entrance of the module in order to attenuate the high frequency components irradiated by the TV channels, radio, cell phone etc. The passive filter is directly connected at the entrance of the instrumentation amplifier (which has a gain of approximately 3). Since the initial gain is reduced, the insertion of one more preliminary gain before the system of filters was made necessary. (PALLAS-ARENY, 1988).

Figure 2 – Diagram of Filter Module.



The high pass filter was calculated to attenuate the half cell potentials, and a cutting frequency of 0.53 Hz was adopted (NAYAK, 2007). The beta wave band (13-22 Hz) was selected for the low pass filter (TYNER, 1983). The low pass filter was selected according to two sampling frequency possibilities of the BM (100 Hz and 500 Hz) in order to avoid problems of spectral scattering and to attenuate the undesired high frequencies irradiated to the system. For the three former filters there are options for selection of answers of the following types: Butterworth, Chebyshev, Bessel and Elliptic. In the case of the band rejection filter the choice was to use two topologies besides the former ones: the Fliege and the Twin-T (HUHTA, 1973), (CARTER, 2006).

The circuit layout has testing points along the acquisition chain, allowing the verification and analysis of the signal in different points. Components of capsuling Dual in Line and single amplifiers were chosen. The module has a visual identification of the circuit's electric scheme printed on the board. That allows the making of a PCI that contains the circuits in a form that is the closest to the sequence followed by the signal in the acquisition chain, making the understanding of the electric scheme more accessible, thus making it easier for the student to keep up with what happens with the signal along the circuit.

It is also available for the student to substitute any one of the filters found in the acquisition chain through the by pass of the original circuit. In order to do so, connectors of easy access by the student were inserted, making available a connector that supplies feeding to the external filter.

3 TUTORIAL

The tutorial's objective is to help the students develop the desirable abilities and knowledge in the BE area. These abilities and knowledge include recognizing, understanding, developing and using mechanisms of acquisition, amplification and filtering of biomedical relevance.

Guides for practical classes with many experiments were developed. These guides present an initial content with concepts and basic fundaments about the subject to be raised. Moreover, they present detailed information about the use of the hardware components (base and didactic modules) and visualization software.

4. SYSTEM EVALUATION

In order to evaluate the system, two EB mini-courses were held in practice. In them, the students performed the setting up of the experiments containing in the practical classes guides. The goal was to evaluate the performance of the system in a real usage situation. The students were advised to previously read the tutorial and the practice guides containing in the Saúde+EducaçãoTM website (RATHKE, 2008).

At the end of every mini-course a questionnaire (Webmac 4.0 Senior (ARNONE & SMALL, 1999)) containing questions about the system was employed as a means to evaluate four aspects: if it is motivating, easy to use, significant and organized (RATHKE, 2008).

The evaluation is in progress, with an electric engineering class of UFSC. As of Da Rosa (2009) and Scolaro (2009), the first results, with the practical applications, has been showing that is more easily learning with the practical module than only the theoretical knowledge without the practical application.

5. CONCLUSION

The learning system described in the present work includes integrated hardware and software tools that may represent an effective support to the study and understanding of biomedical signal processing themes. From the assessments carried out during regular disciplines and mini-courses, the students acknowledged the tutorials and experimental procedures on electromedical apparatuses and the possibility to work on simulated or real biomedical signals extracted from themselves, as major advantages of the system in support learning on interdisciplinary themes, suggesting that this approach deserves further developments.

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