Didactic Platform for Biomedical Signal Processing:
Digital Image Processing

E E de Souza[1], F M de Azevedo[2], J Marino-Neto[3]

[1~3]Universidade Federal de Santa Catarina, Departamento de EE,
Instituto de EB, Florianópolis – Santa Catarina – Brazil.

eli@ieb.ufsc.br[1]

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, software to visualize and processing signals as well as theoretical-practical tutorials which aggregate contents to practical class schedules.

This paper presents the section of the DPBSP that approaches the subject digital image processing. It is composed of a set of tutorials implemented by a hipermídia system. Such system contains a theoretical introduction on the subject medical imaging and processing of digital images and can be exploited in virtual environment for education. The tutorials allows the student to acquire basic knowledge on the subject processing of digital images and explore the Scilab as a simulation tool. The presented processing routines are applied on medical images obtained by x-ray, ultrasound, computerized tomography (CT) and MRI.

Evaluation of the system was realized in two stages. Firstly, students of a regular Electrical Engineering class carried out practical classes. Second, a mini-course of Biomedical Engineering was created for practical work. The motivational aspects of the system like, facility to use, if the system is organized, stimulating and significant, were evaluated through a questionnaire. The results of the evaluation showed a very high motivating system with a high expectation for success.

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 [1].

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 [2]. 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 [3]. 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/layout.php) [4]. This specific work presents the development of an additional functionality for the BSPS-MD platform:

the section digital image processing of the BSPS-DM platform. It is composed of a set of tutorials implemented by a hipermídia system. Such system contains a theoretical introduction on the subject medical imaging and processing of digital images and can be exploited in virtual environment for education. The tutorials allows the student to acquire basic knowledge on the subject digital images processing and explore the Scilab as a simulation tool. The presented processing routines are applied on medical images obtained by X-ray Radiography , Ultrasonography, Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI).

Methodology and Implementation

The subject Digital Images Processing finds applications in many areas and, in BE, it has its necessity anchored in the evolution of the methods of non-invasive medical diagnosis and in the growing demand for these services.

The processing of digital images includes procedures of algorithmic order. With the exception of the acquisition and exhibition of images, the majority of the image processing functions can be implemented in software [5]. For more effective and consistent learning it is important that the students can test the diverse algorithms by visualizing the results of the performed experiments [6]. As an initial step towards the development of the functionalities to be aggregated, via new module, to the base module of the BSPS, lectures and guides for practical classes were elaborated. For that reason, the characteristics of the means where the material will be made available - the Saúde+EducaçãoTM website - were considered. The tutorial "Didactic Platform of Biomedical Engineering" contains the topic "Images Processing and Medical Imagement", which is divided in the following sub-items seen in Figure 1:

Figure 1: Tutorial's Structure sited in the Saúde+EducaçãoTM website.
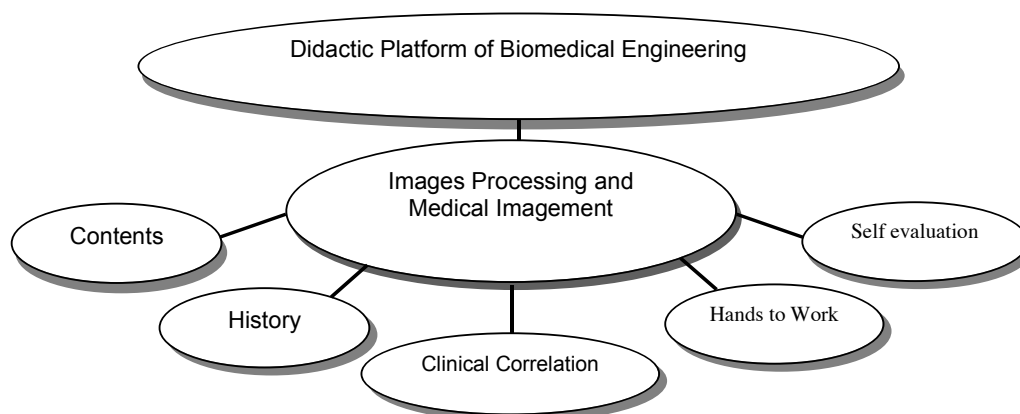
These sub-items are detailed as follows:

Contents: here is the theoretical support material discussing the main concepts such as:

a) Image; b) Medical Image; b1) X-ray Radiography; b2) CT; b3) MRI; and b4) Ultrasonography; c) Digital Image; d) Digital Image Properties; e) Digital Image Processing; e1) Point Operations; and e2) Area Operations.

History: a brief sequency of fundamental scientific findings for the development of the four types of medical imaging seen here is presented.

Clinical Correlation: in this sub-item the user finds information referent to the clinical practice. Here the topic biological effects of the ionizing radiations was discussed.

Hands on: as this sub-item is selected, the system will present laboratory practice guides for the understanding of the theoretical concepts referent to the digital images processing. Four topics have been selected for these guides: a) Fundaments of the Scilab images processing toolbox; b) Point processing techniques; c) Spacial domain filtering; d) Frequency domain filtering.

Besides that, the tutoring system provides a **Self-evaluation** composed by objective questions randomly displayed to the user who, after answering them, generates a performance index. If this index is considered low, the pedagogical agent will suggest alternatives to return to the readings aiming at reinforcing their study [7],[8]. These alternatives consider the tutorial sub-items that the student has already accessed or not. The system also provides a "Glossary"

through which one has access to the meaning of the terms highlighted in the lectures. The "Help" may be activated at any time and it contains information on how to use the environment. Another available element is the "Chat", which goal is to make possible the simultaneous communication between all users of the environment. The "Forum" is meant to create discussions about some topic mediated by the teacher. The other available option is the "Bulletin", that may be accessed by both the student, in order to check his/her performance, and the teacher, in order to visualize the performance of a group or of a specific student.

In order to execute the practical activities in the sub-item "Hands to Work", Scilab was adopted as an simulation tool. Scilab is a numeric programming software, it is free and distributed with the font code [9]. In order to manipulate the images files the toolbox Scilab Image and Video Processing - SIVP² was adopted.

The guides for practical classes are composed by sections presenting the objectives of the class, a brief abstract of the concepts with which to be worked and, finally, advise on the usage of the pre-developed algorithms. These algorithms are applied in previously selected images that compose an images base (that were obtained from the internet). The student instantly observes the effect of the processing techniques and the alteration in the parameters of the algorithms.

Figure 2 shows a group of original and processed images that the student generates as the guides for practical classes are executed.

Figure 2: Example of Contrast Stretching (a)Original images and its histogram; (b) resulting from the processing and its histogram
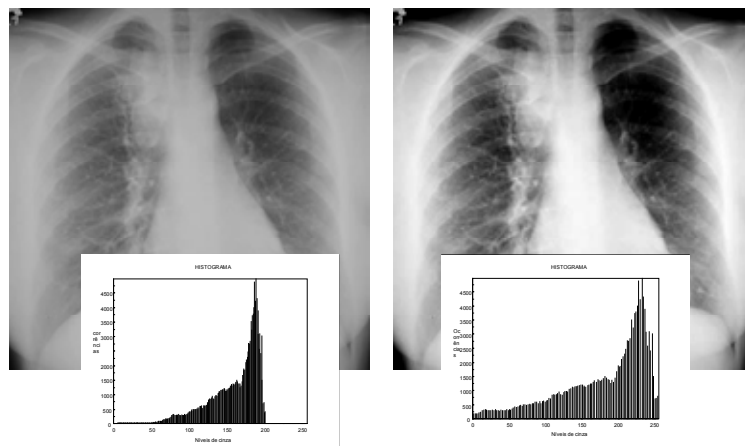
Evaluation

In order to evaluate the system, a EB mini-course was held in practice. In them, the students performed the implementation of the algoritms containing in the practical classes guides. The goal was to evaluate the performance of the system in a real usage situation. At the end of the mini-course a questionnaire containing questions about the system was employed as a means to evaluate four aspects: if it is motivating, easy to use, significant and organized [1], [2], [3] and [4].

The results have shown to be promising, mainly because of the practical approach of teaching the subjects. Such aproachs can be seen in [10] and [11].

Conclusion

The learning system described in the present work includes a tutorial set that may represent an effective support to the study of biomedical signal processing themes. From the assessments carried out during regular disciplines and mini-course, 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 develop-

ments.

References

01. 1. Adur, R. (2008), Sistema de Processamento de Sinais Biomédicos: Módulo Didático de Eletroencefalograma. Dissertação (Mestrado) – Universidade Federal de Santa Catarina. Florianópolis.

02. Andrighetto, E. (2008), Sistema de Processamento de Sinais Biomédicos: Rede Wireless Zigbee com Aplicação do Padrão IEEE 802.15.4. Dissertação (Mestrado) – Universidade Federal de Santa Catarina. Florianópolis.

03. Possa, P. R. (2008), Sistema de Processamento de Sinais Biomédicos: Módulo Didático de Amplificador de Potenciais Bioelétricos. Dissertação (Mestrado) – Universidade Federal de Santa Catarina. Florianópolis.

04. Rathke, J. E. (2008), Sistema de Processamento de Sinais Biomédicos: Módulos Didáticos de Aquisição de ECG, EMG e EOG e Conversão Analógico Digital de Biossinais. Dissertação (Mestrado) – Universidade Federal de Santa Catarina. Florianópolis.

05. Gonzalez, R. C., Woods, R. E. (2000). Processamento de Imagens Digitais, Editora Edgard Blücher Ltda.

06. Jardim, S., Gonçalves, P.S. (2002), Aplicação Informática para o Ensino de Processamento Digital de Imagem Escola de Superior de Tecnologia Castelo Branco. Available from: http://www.est.ipcb.pt/pessoais/paulog/papers/2002_ccte_isel_sandra_ paulo.pdf.

07. Oldoni, A., Fernandes, A. M. R., Deters, J. I., (2007), Desenvolvimento de uma arquitetura de comunicação de um agente pedagógico inteligente em Java. RESI-Revista Eletrônica de Sistemas de Informação, Edição 10, Nº1.

08. Deters, J. I., Oldoni, A., Fernandes, A. M. R., (2006). Bernardo - Agente Pedagógico do Sistema Tutor Inteligente Aplicado a Neurofisiologia. In: Anais XVII Simpósio Brasileiro de Informática na Educação, Brasilia.

09. Pires, P. S. M. (2004) Introdução ao Scilab - Versão 3.0. Available from: http://www.dca.ufrn.br/~pmotta/sciport-3.0.pdf.

10. Scolaro, G. R., Azevedo, F.M., Rathke, J. E., Possa, P. R. C., Andrighetto, E., Adur, R., Marino-Neto, J. (2009). Didactic Platform for Biomedical Signal Processing: Modules for Acquisition of bioelectrical signals, A/D - D/A Conversion and ZigBee Wireless Network. International Conference on Engineering Education and Research. Submited.

11. da Rosa, D. L., de Azevedo, F.M., Garcia, R.O., Argoud, F.I.M ,(2009) Didactic Platform for Biomedical Signal Processing: Module for Electroencephalography Signal Digital Filtering. International Conference on Engineering Education and Research. Submited.