INFORMATION TECHNOLOGIES AS A BASE OF BIOMEDICAL ENGENERING EDUCATIONAL PROCESS

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Abstract: This presentation summarizes the authors experience of teaching for students studying in the field of biomedical electronics. The emphasis is on the use of modern computer and information technologies in the educational process. The approaches to the preparing and lecturing of theoretical courses, to the preparing of conducting of laboratory and practical works and to the self-dependant work of students are considered.

Introduction

Almost every medical device or system today includes some kind of computing components that serves for the tasks of biomedical signals processing, common control and interaction with the user. In this connection, acquiring of familiarity with newest and most recent computer means and also with methods of biomedical data and signal processing forms an important part of the teaching process for preparing of specialists on development, production and maintenance of biomedical equipment [1, 2]. Besides, introducing of newest information and computer technologies into the educational process makes it possible to complement traditional teaching techniques by new effective forms of the lecturing and self-dependant practical work of students.

Materials and Methods

This presentation summarizes the authors experience of preparing and teaching at the biomedical electronics and environment protection department of St.-Petersburg State Electrotechnical University (SPbSETU) of the following courses: “Biomedical signals analysis and processing methods”, “Computer technology in biomedical research”, “Automated systems for biomedical investigations” and some others.

Information and computer technologies can be effectively used in the frames of each of the main components of the teaching process:

- theoretical courses;
- practical and laboratory works;
- self-dependant work of students;
- course and diploma works.

Theoretical courses. The theoretical courses content is permanently corrected and supplemented to reflect the most modern technical level and the newest methods and algorithms of biomedical data processing and analysis. Traditional teaching techniques are combined with new possibilities (such as the use of computer presentations and media projectors). It allows use of vast illustrative material and demonstration of some methods and systems in action immediately in the course of lections. Besides, the electronic versions of lectures are put at disposal of students. On the one hand it helps students in their preparation to the examinations, and on the other – provides more exact evaluation of students knowledge by teachers.

Practical and laboratory works. Modern integrated program packages (such as MATLAB, Mathcad, LabView) represent powerful tools for preparing of practical and laboratory works, especially for the courses connected with biomedical signal processing, modeling and control [1, 2].

A series of laboratory works based on MATLAB were prepared in the frames of the course “Biomedical signals analysis and processing methods”. The aim of these works is to give students the chance to try by themselves the most important methods of signal analysis, such as digital filtering, spectral and correlation analysis. The following themes are included into the list of these works:

- Sampling theorem, aliasing.
- Digital filters with constant coefficients.
- Matched filtering.
- Adaptive filters.
- Autocorrelation and cross-correlation functions.
- Estimation of power spectral density (PSD) using FFT.
- Autoregressive PSD estimation.
- Speech signal recording and analysis.

The recordings of real electrophysiological signals, obtained in the course of investigation conducted by our department or via Internet (from numerous sites, dedicated to biomedical signal processing) are used for these works.

In the course of laboratory works students are to develop the necessary programs, realizing the studied algorithms, and draw the plots of signals on each stages of processing. Students make themselves familiar both with the algorithms of signal processing and the methods of their modeling using MATLAB. Figures 1, 2 and 3 show examples of the plots obtained as a result of one of the listed above works. Traces *a* and *b* on

Figure 1 represent electroencephalograms (EEG) from occipital (*a*) and frontal (*b*) zones of human scalp. α-rhythm is clearly seen in the occipital channel.

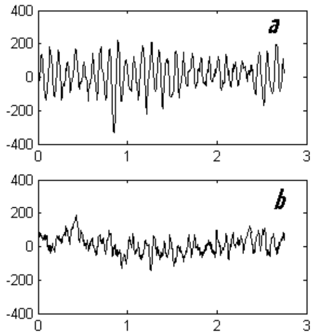

Figure 1: Synchronous recordings of EEG signals from occipital (*a*) and frontal (*b*) zones of human scalp. α-rhythm is clearly seen in upper signal.

Traces *a*, *b* and *c* on Figure 2 show autocorrelation functions (ACF) for the both signals and their cross-correlation function (CCF) respectively. It is clearly seen that α-rhythm caused characteristic appearance of ACF of the first signal in the form of slowly damping oscillations with the period about 0.1 s. ACF for the second signal reveals some low-frequency regularity. CCF of these two signals is rapidly damping function that indicates the lack of close correlation between the signals. Figure 3 shows plots of PSD estimations for the same EEG signals.

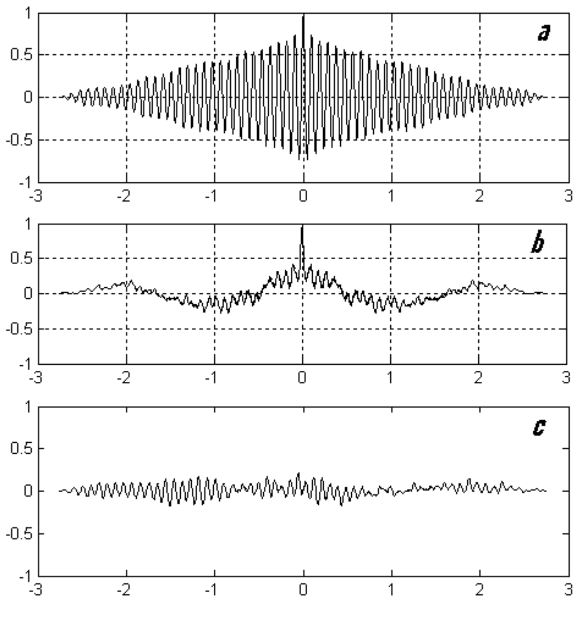

Figure 2: Plots of ACF (*a* and *b*) for both EEGs shown on Figure 1. Plot of CCF between these two EEG signals (*c*). The appearance of the shown functions clearly demonstrates special features of each signal and interrelations between them.

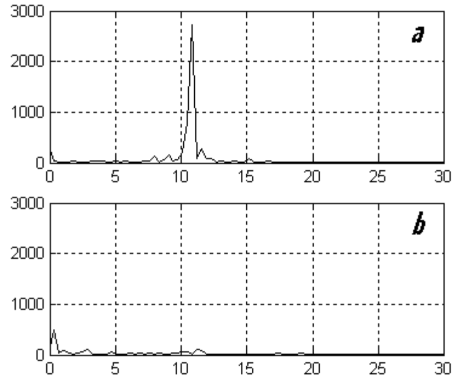

Figure 3: Plots of PSD estimations for the EEG signals shown on Figure 1. Trace *a* (in distinction to trace *b*) has sharp peak at the frequency about 10 Hz corresponding to α-rhythm.

As one can see all these figures clearly demonstrate for students the informative value of the used methods for the analysis and interpretation of EEG signal and interrelation between mathematically acquired parameters of biomedical signals and underlying physiological phenomena.

Valuable source of materials for laboratory works comprises numeral demonstrative programs of commercial medical systems (free available via Internet and readily proposed by their producers). As a result of these works implementation students both become acquainted to the corresponding medical procedures and study in practice the methods of computerized medical investigations.

The following laboratory works for the course "Automated systems for biomedical investigations" were prepared on the base of software products of several firms:

- Computer-based system for the ECG monitoring of cardiac patients heart rhythm in intensive care units (Figure 4).
- Computer-based system for the standard ECG diagnostics (Figure 5).
- Computer-based system for the exercise testing (Figure 6).
- Software package for the heart rate variability analysis.
- Computer-based system for the rheography investigations.

Demonstrative programs, as a rule, are not exactly suitable for the use in teaching process, as they were developed by their authors for other purposes (first of all - commercial). So preparing of laboratory work based on such software products requires some additional efforts (planning of works and preparing of methodical instructions for students).

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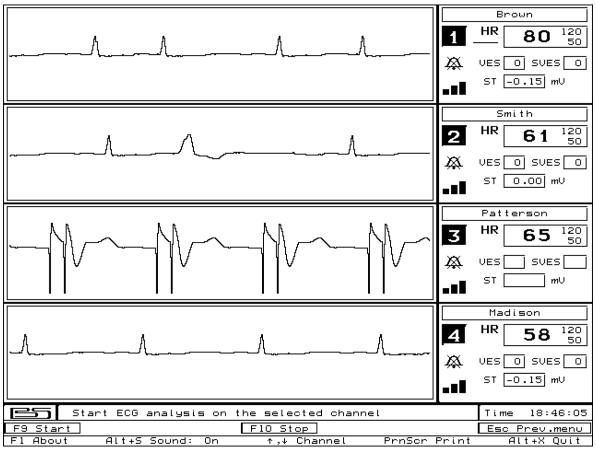

Figure 4: Screen view of the laboratory work "Computer-based system for the ECG monitoring of cardiac patients heart rhythm in intensive care units".

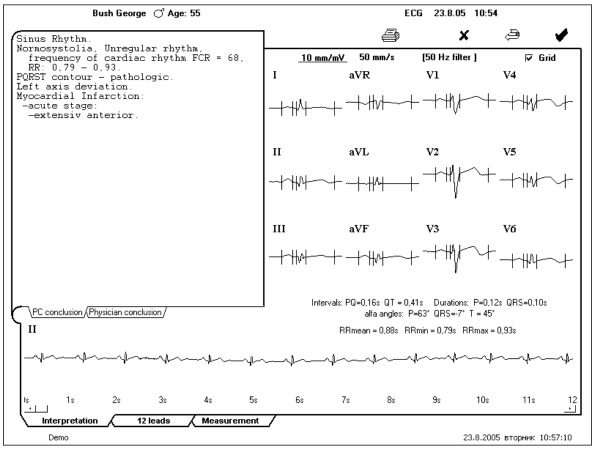

Figure 5: Screen view of the laboratory work "Computer-based system for the standard ECG diagnostics".

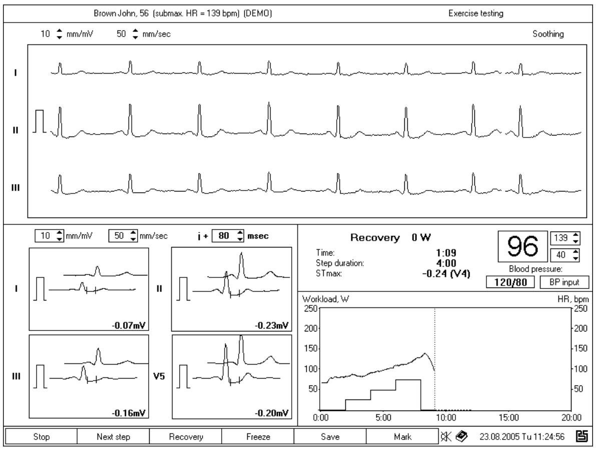

Figure 6: Screen view of the laboratory work "Computer-based system for the exercise testing".

The laboratory works for the course "Automated biomedical investigations" is based on graphical programming system LabVIEW, that represents a powerful tool for the modeling of signal analysis systems and processes. The following works were prepared:

- Model of the system for biomedical investigations.
- Examination of the cardiac pacemaker model.
- Estimation of biomedical signal PSD (Figure 7).
- Analysis of biomedical signal ACF.
- Examination of aperture signal compression method.
- Examination of spline-interpolation algorithm.
- Adaptive digital filter for the elimination of power line interference.

Students are also take part in the preparing of laboratory works. In particular, this kind of tasks is often proposed to them as a subject of their diploma works.

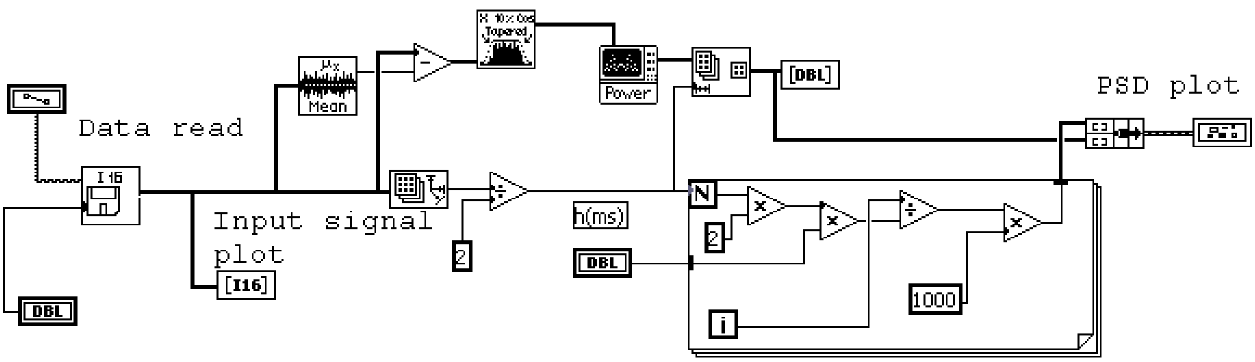

Figure 7: Block-diagram of the PSD estimation computing with the use of graphical programming system LabVIEW.

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Course and diploma works. As actually all students today have personal computers in their possession, the common requirement is preparing of course and diploma works with the maximum use of computer means of development, investigation, modeling and documenting. Furthermore, due to the high level of automation provided by modern specialized program packages it becomes possible to propose much more complex themes for student's work ranging up to development of completed software packages and devices for medical purposes.

In the frames of the course "Biomedical signals analysis and processing methods" students should perform their course work on the theme "Digital filtering". The idea of the work is the following. A filter is defined in some form (as difference equation, block-diagram or transfer function). Two short recordings of the real biological signal (i.e. ECG or EEG) and random noise (high-frequency or low frequency) are also provided. It is required to investigate all time-domain and frequency-domain characteristics of the filter, to realize the filter as a program, to implement digital filtering of biomedical signal, random noise and their mixture and to estimate signal-to-noise ratio before and after the filtering. The important requirement is that all steps of the work should be implemented with the use of modern computer technologies.

Self-dependant work of students. The Internet plays important part in this direction. One of the interesting forms of the global network use is preparing of essays and reviews by students. The information found by them is helpful not only for these particular students but is also widely used later by teaches themselves in the educational process.

Results

Several courses connected with biomedical data processing and computer-based medical systems development were updated and modernized with the use of new information technologies during the last several years at the biomedical electronics department of SPbSETU.

Discussion

Introducing of the computer and information technologies into educational process represents important and urgent task. At the same time, permanent development and updating of these technologies requires from teaching staff to observe carefully all latest achievements in order to correct timely both the forms and the content of the educational process.

Conclusions

The use of modern information and computer technologies provides, on the one hand, more effective teaching and assimilation of university courses on bioengineering and on the other – better training of students for their future practical work in the field of biomedical equipment and software development.

References

[1] RANGAYYAN, R. M. (2002) 'Biomedical Signal Analysis. A Case-Study Approach', (John Wiley & Sons, Inc., New York), 516 p.
[2] AKAY, M. (1994) 'Biomedical Signal Processing', (Academic Press, Inc., San Diego, California), 378 p.