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BioDAQ - a simple biosignal acquisition system for didactic use

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Abstract. A simple non expensive device for biosignal acquisition is presented. It mainly meets the requirements for didactic purposes specific in medical informatics laboratory classes. The system has two main types of devices: `student unit`- the simplest one, used during lessons on real signals and `demo unit`, which can be also used in medical practice or for collecting biological signals. It is able to record: optical pulse, sphygmogram, ECG (1-4 leads) EEG or EMG (1-4 channels). For didactical purposes it has a large scale of recording options: variable sampling rate, gain and filtering. It can also be used in tele-acquisition via Internet.

1. Introduction

The topic of signal processing occurs several times during the curriculum of a medical student - at biophysics, physiology, medical informatics, physiopathology and internal medicine/cardiology, etc. However each discipline aims at a different target. The very basic understanding of signal acquisition principles (sampling, quantization, filtering) followed by a large and comprehensive palette of processing methods is the main objective of `biosignal` chapter in medical informatics [1].

The equipment used in medical practice is highly specialized – for each type of signal, and also expensive; moreover, the classes of medical informatics are usually placed in preclinical years and the students do not have yet enough knowledge for a fuel understanding of these signals interpretation. Thence the necessity to build simpler devices, such as Biopac [2]. However, it is adapted to physiology laboratory classes and does not cover all parameter settings or the processing methods. A largely used solution was adopted in several schools – simulation programs [3, 4] which can be developed to achieve any of the mentioned performances. However, the attractivity of a lesson on real signals versus simulated signals is much higher, mainly for medical students, for whom even the skill of placing electrodes and preparing the patient for recording is important.

The equipment presented in this paper tried to fulfill most of the requirements of a medical informatics laboratory class on biosignal acquisition and analysis.

2. Methods

2.1. Description of BioDAQ system

The BioDAQ system comprises an acquisition software running on Windows platforms and two types of devices: `student unit` and `demo unit`. A BioDAQ set has 6 student units and one demo unit.

2.2. The student unit

The student unit was designed for acquisition of three types of biological signals. Each signal amplifier has one or more outputs connected to different measuring channels as in the following:

- Non-invasive blood pressure with an absolute and a relative output
- Optical pulse wave
- ECG amplifier with three output channels:
  - direct one with a 0.3..1000Hz bandwidth
  - notch filtered for 50Hz noise
  - low pass filtered at 35 Hz

This unit works connected to a PC using one of the RS232 serial ports. Only on-line measures are possible using the BioDAQ program running on a 32 bit Windows platform.

2.3. The demo unit

This is a more sophisticated device being able to make records in a hospital on real pathological cases as a stand-alone device. It has eight data channels:

- One non-invasive blood pressure measuring amplifier
- One optical pulse amplifier
- 6 programmable biological signal amplifiers with different selection of the following electrical parameters:
  - programmable gain in 4 steps : 1000,2000,4000,10000
  - on/off selection of a 50 Hz notch filter
  - low pass filter selection for 35,70,140 and 1000 Hz

Setting different transfer parameters and gain for the biological amplifier makes it possible to use it equally for ECG, EMG and EEG signal acquisition. A QVGA display allows checking of correct electrode placement and quality of signal. Data will be downloaded to a PC using one of the RS232 serial ports and can be further interpreted using the BioDAQ program.

2.4. The BioDAQ software

A PC program running under 32 bit Windows is provided for measure/download control and viewing, filtering of recorded data. Settings for each measure can be done like:

- Selecting target device (student or demo)
- Setting up the serial port for proper communication
- Choosing the sample rate
- Selecting needed channels and assigning calibration values for each

Channels are displayed in different windows and can be viewed using zooming. Each channel's spectrum can be displayed using FFT algorithm. Standard digital filters can be

selected for each channel (low pass, high pass, band pass and band stop) and the result may be viewed in time domain or in frequency domain[5].

The software works in TCP/IP protocol using networks and can establish a connection with a remote computer allowing the professor to view each student's measuring or for each student to see a demo data measuring running on another computer. The second option may be useful for presenting real cases from a clinical hospital using an Internet connection, thus introducing the student in the world of telemedicine[6].

3. Results

It was developed a non-expensive, simple and versatile acquisition system having two main types of hardware devices: 'student unit' and 'demo unit' both driven by Windows-based software. The BioDAQ system has been used experimentally for one year at the Medical School in Timisoara. A 'student unit' was available for every two students playing the role of the patient and the doctor. The impact on students was very good and a deeper understanding of basic knowledge in the chapter on biosignal was visible. In the same time the students was very eager to see their own pulse wave or ECG and analyze them.

The students have to make their own settings before starting measuring, learning how to setup a connection between a PC computer and an external hardware device using a serial port or a network connection. They can see the effects (positive or negative) on the measured signal of different parameter settings. Also they learn how to get the best result using digital filtering.

A library of various signals, corresponding to several pathologies is under construction.

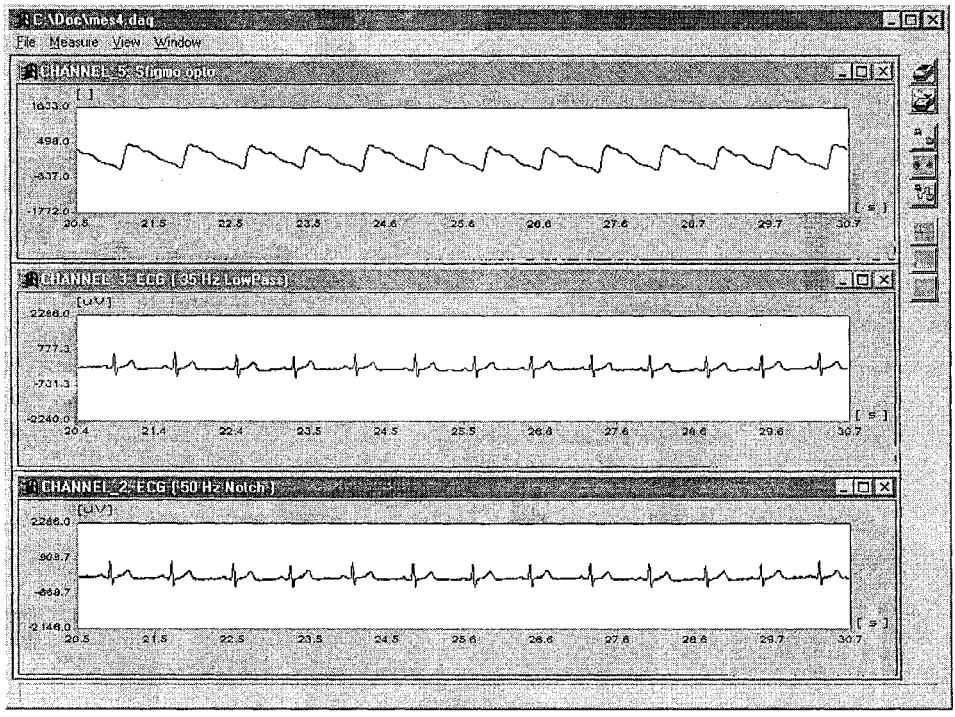

Figure 1

A typical image of the screen displayed during an online recording session is presented in figure 1. Three channels are used for recording of:

- optical pulse
- a low pass filtered (35Hz) output channel with a clean ECG signal
- an unfiltered ECG signal

4. Conclusions

The use of the described system in medical informatics laboratory classes for medical students offers some advantages:

- The system proved to be reliable and easy to use.
- The student get a deeper understanding of the main concepts used in biosignal processing and also learn how to use standard Windows-based programs foor signal acquisition.
- We aimed to have the student unit as a performant and cheap for 1 unit / student instead of one expensive for one class/group of students.
- It is simple allows focusing on the informatics problems and features.
- For real pathological cases we developed the demo unit based on a versatile biosignal programmable amplifier used for all of three ECG/EMG/EEG signal acquisition which could replace (of course only for didactical purposes) three sophisticated and more expensive units in most cases hard to move away of the designated place.
- The software is able to work also in TCP/IP networks.

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