CleveLab® course equipment for physiological measurement teaching laboratory

A. Katashev

Institute of Biomedical Engineering and Nanotechnologies, Riga Technical University, Latvia

E-mail: katashev@latnet.lv

Introduction. Education of the future engineers whiting the university curriculum could not been thought without sound practical training; laboratory experiments being the most valuable part of it. Despite of fast development of computer technologies, one should not switch university labs to purely virtual experiments. Technical students have to have direct contact with the "hardware" that gives them sense of how the equipment is designed. Besides, equipping a good teaching lab is a tough task that requires substantial financial investment. Such question as "what instruments and methods to select" and "would we use rather expensive clinically used samples of equipment, or cheaper functional prototype models" should be addressed as well

Requirement to the laboratory equipment. Initial purpose of the laboratory at the Institute of Biomedical Engineering and Nanotechnologies of Riga Technical University was delivery of the laboratory-based course "Physiological measurements". The following criteria were used to select appropriate equipment: 1) The lab experiments should cover typical clinically used types of equipment and methods and have possibilities to go beyond routine clinical practice to some experimental research. Laboratory experiments were selected from those ones, described in the existing physiology laboratory courses for medical students (see, for instance, [1]). Selection of labs covered electrophysiology (ECG, EMG, EEG), circulatory system physiology (blood pressure and photopletismography), respiration system physiology (respiratory monitoring, spirometry, pulsoxymetry), motion physiology (gait analysis), preference was given to non-invasive clinically used methods. Any labs, based on preparative or animal experiments were avoided, as well as electrical stimulation experiments. 2) Number of laboratory experimental kits should be enough to have about 5 student groups working simultaneously. This last requirement appeared due to confidence that in a lab course consisted from separate laboratory experiments, students must work individually, at least in groups not more than 2 persons.

At the time of selection of the prototype, two options were considered: CleveLab® Biomedical measurement system (Cleveland Medical Device Inc) [2] and KL-720 Biomedical measurement (K&H MFG. Co., Ltd) [3]. CleveLab® system was selected mainly on the base of 2nd criteria as most cost – effective solution.

One should note, that following one year experience with the acquired equipment, additional criteria arose: the laboratory has to be used for the

courses "Measurements technique in medicine" and "Biomedical instrumentation", that covers such questions as how and with which instrument to measure, due to this laboratory kits have to illustrate measurement principles, functional design and data processing peculiarities.

Laboratory system CleveLab® includes data acquisition kit BioRadio® 150, accessories (cables, electrodes, transducers ets), all-purpose data acquisition software BioRadio Capture Lite® and laboratory course software CleveLab®. Totally 5 kits was obtained, that allows 10 students work in pairs simultaneously.

System hardware. Data acquisition kit (Fig. 1) consists of patient module and USB-connected computer module. Data, acquired by the patient module, are transferred to the computer module over 2.4 – 2.485 GHz channel radio link over the distance up to 30 m (direct sight). Since patient unit is powered with two 1.5 V batteries, electrical safety issues may not be addressed.

Data acquisition module has 8 differential input channels, auxiliary DC channel, pressure-based airflow channel, built-in accelerometer and body position channels, heart rate and Hb saturation channels (required pulsoximetry probe to be attached to the device). Differential channels may be configured for AC or DC input with the input range ± 750 μV to ± 2 V; bit resolution 8, 12 or 16 bits/ sample and sampling rate 128 – 960 samples/s. Sampling rate of the accelerometer, body position, heart rate and SpO2 is 10 times less: form 12.8 to 96 Hz. Detailed hardware specification is available at CleveMed web-site [4].

Hardware accessories. CleveLab® basic kit included snap electrode wires, golden cup EEG wires, starter electrode kit (ECG electrodes, contact gel, cleansing pads etc). To provide maximal functionality of the system, additional accessories have been ordered: blood pressure cuff (2 items), force plate, hand dynamometer, nasal/oral thermocouple (2 items), piezo-electric respiratory effort belt (2 items), pulse oximeter finger clip sensor (2 items), spirometer (2 items). Some of the above sensors required special transducer interface cable to be connected to BioRadio®. Disposable supplies include, besides ECG electrodes, nasal/oral cannulas for air flow measurements.

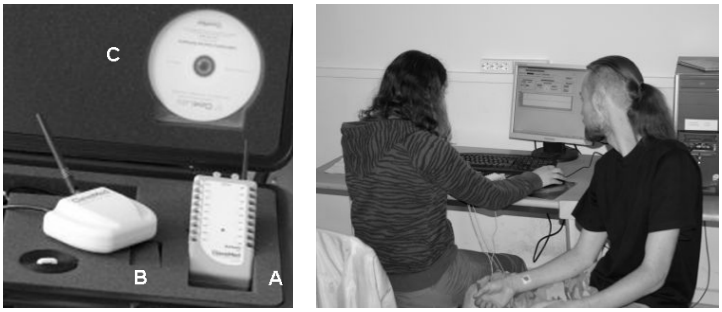

Fig. 1. Left: Measurement kit BioRadio® 150: A – patient unit, B – computer unit; C – course software. Right: Fragment of laboratory classes

Bio-Radio Capture Lite® (Fig. 2) is a LabView® [5] based software that provides data acquisitions functions for the BioRadio® unit. Software has integrated unit-programming utility, that allows selecting channels to display, channel input ranges, sampling rate. Using built-in digital filter utility, low pass, high pass, band-pass or band stop filters may be applied to each channel, alongside with additional 50/60 Hz notch filter. Data may be saved into text file. Spectral analysis of separate channels may be performed as well.

Main disadvantage of the software is that even with filters applied, only row data is saved into file.

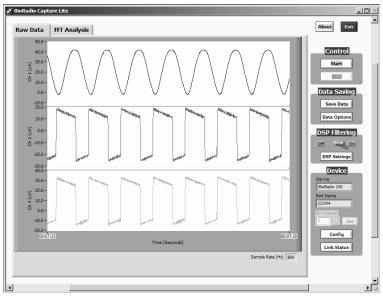

Fig. 2. BioRadio Capture Lite® screen with the test data.

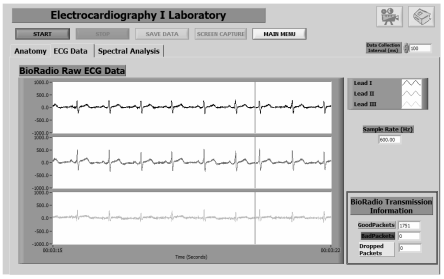

Fig. 3. CleveLab® ECG laboratory screen with student ECG data

Clevelab Lavoratory course software® (Fig. 3) is LabView® based also. The software provides convenient frame for the laboratory experiments. Software functions include screen capture, data writing to text file, spectral analysis and filtering of single selected channel. Some functions, such as rectification or pulse rate detection are specific for the particular experiments. Altogether CleveLab® software includes 27 thematic labs (Table 1). Data processing toolbox utility allows recall and proceeding obtained data, including spectral analysis, later on, without attached BioRadio, for instance, at home. Unfortunately, there is no possibility to write processed data and spectral data to file, although screen capture may be made.

Experience using CleveLab®. Until now, eight laboratory experiments have been adopted for the need of the department teaching lab: DAQ basic, Biopotential basic, ECG I, EEG I, EMG I, Blood pressure, Pusloximetry and

Spirometry. Labs are attractive for students, have easy-to-learn interface. Comprehensive guides minimize tutor load explaining "what-to-do", and student may concentrates on explaining principal concepts.

Table 1. Available CleveLab® experiments

Accelerometry	Electrocardiography II	Image Processing
Alertness Detection	Electroencephalography I	Motor Control
Biofeedback	Electroencephalography II	Polysomnography
Biomechanics	Electromyography I	Pressure Based Airflow
Biopotential Basics	Electromyography II	Pulse Oximetry
Blood Pressure	Electro-oculography I	Respiration
Data Acquisition Basics	Environmental Controls	Speech Recognition
Digital Signal Processing	Gait Analysis	Spirometry
Electrocardiography	Heart Rate Detection	Statistical Analysis

Technically equipment performs generally well. The problems met are: poor recognition of the hardware by PC required the software have to be relaunched several time; equipment does not operated normally at 960 Hz sampling frequency, that was solved by changing sampling rate to 800 Hz in all configuration files. Hardware use unshielded wires, due to this is susceptible to noises, but this is rather advantage, because illustrates noise and noise elimination concepts. Other disadvantage are, for instance, absence of right leg driven circuits for ECG or impossibility to see raw pulsoximetry diodes data.

Software has number of disadvantages as well, main of them is low resolution of the time axis in the data graphs: although it possible to set axis range to 0.1 s, only integer values for seconds will be displayed.

Conclusion. CleveLab® laboratory course kit is flexible and budget solution for the teaching lab within Biomedical engineering curricula with the emphasis on physiological measurements and data processing, but not on the equipment design.

References

1. Kamkin A.G. (ed) Great physiologcal practicum (Boljshoj praktikum po fiziologii), M, „Akademija", 2007, p442 (in Russian)
2. http://www.clevemed.com/
3. http://www.kandh.com.tw/kh/s_product/red/catalog_s/KL-720.htm
4. http://www.clevemed.com/clevemed_pdfs/BioRadio_specs.pdf
5. http://www.ni.com/labview/

CleveLab® course equipment for physiological measurement teaching laboratory

A. Katashev
Institute of Biomedical Engineering and Nanotechnologies, Riga Technical University, Latvia

Since 2007, Riga Technical University uses CleveLab hardware and software at the physiological measurement laboratory course within the Biomedical Engineering curriculum. Equipment, developed by Cleveland Medical Devices, provides basis for about 30 laboratory experiments. The paper analyses pro and contra of the equipment on the base of pilot course experience.