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Computer sound card used as analog-to-digital converter in a teaching physiology laboratory

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SUMMARY. Teaching electrophysiology concepts can be a challenging task when confronted with the lack of educational electronic devices. Currently, there are a number of such devices available on the market, but our physiology laboratory does not own an integrated electrophysiology system. So, in order to provide a more practical approach to teaching electrophysiology, we were motivated to seek available alternatives. The sound card microphone port of a computer converts analog signal (sound) into digital signal, also being able to display its waveform in real time. Considering this, we developed a simple device for displaying and recording the photopletismographic peripheral pulse wave and, also, converting it in the second derivative photopletismogram wave, based on which students were able to estimate arterial stiffness. Besides this topic, students were able to learn basic concepts concerning analog-to-digital conversion and data acquisition in biological systems using our device.

Keywords: analog-to-digital converter, computer sound card, electrophysiology laboratory

Introduction

An analog-to-digital converter (ADC) is an electronic device that converts an analog value (usually a voltage) to a digital number. This is very useful especially because computers can acquire and process data only in digital format and all the natural phenomena occur in analog format. Therefore, in order to create an interface between computer and any natural phenomenon, the presence of an ADC is mandatory (Trifa, 1992).

A computer soundcard is such an ADC, converting the analog sound signal into digital, computer accessible digital signal. Actually, a soundcard is a two-way converter, converting analog sound into digital signal through the microphone input port, and also converting digital signal into analog sound, through the headphones/ speakers output port (Liu, 2015).

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Considering these characteristics, the sound card can successfully be used as a data acquisition device, with two conditions: (1) to manufacture the appropriate transducer for interfacing the biological system and (2) to comply to the voltage range tolerated by the soundcard (0 – 5 V).

A sound card-based photopletismography (PPG) sensor was easy to build, required non-expensive electronic components and the PPG trace provided accurate information about pulse wave and arterial stiffness (Qawqzeh, 2010; Simek, 2005; Bortolotto, 2000). Also, constructing laboratory-made (*do-it-yourself*) didactic equipment is not unusual in the field of physiology (see also Sircar, 2015).

Materials and methods

We built a LED-based photoelectric system that collects infrared light emitted by the blood that is pulsed rhythmically through peripheral capillaries (finger pulse meter). The two infrared optic components (one LED and one photodiode) were mounted on the opposite side of a clothespin (the spring was removed in order not to compress the finger too tightly and stop the blood flow). The circuit was powered by a 9V battery, and the output voltage was around 1.5V, which is within the voltage range supported by the sound card input. No external amplifier or filter was used (Fig. 1).

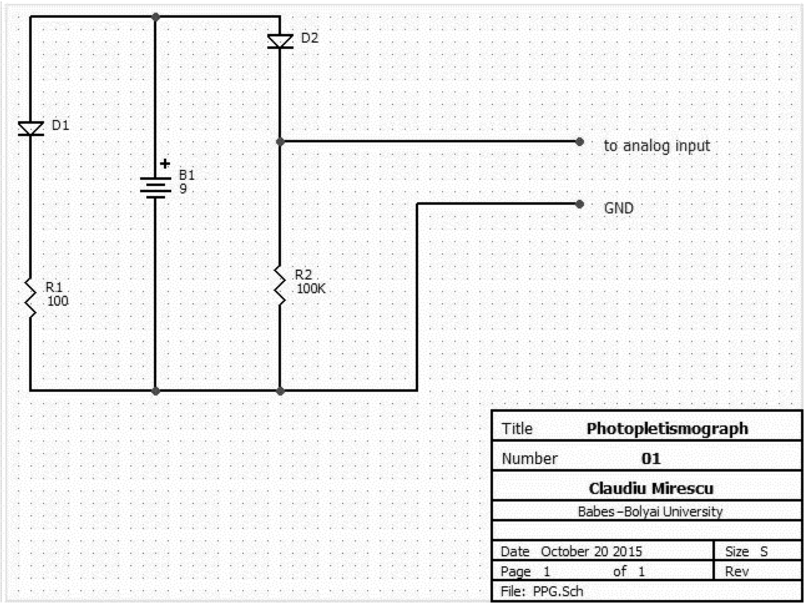

Figure 1. The circuit diagram of the infrared interface, designed using 5Spice Analysis, version 2.31.0. D1 – light emitting diode; D2 – photodiode; R1, R2 – resistors.

For interfacing the computer, we used a sound card oscilloscope software (Zeitnitz SoundScope V1.40, available online for non-commercial purposes at *www.zeitnitz.eu*). This software instrument interfaces the 2 channel computer soundcard, plots the soundwave and, also, has the feature of saving the data in Microsoft Office Excel format, for further processing. Also, the *Cursors* option enables the user to manually measure intervals and amplitudes, directly on the plot of the waveform. The signal can be amplified or filtered using built-in features of the software.

Results and discussion

The device was introduced to the students during two laboratory classes: (1) *Data acquisition principles in biological systems* and (2) *Photoplethysmography and the second derivative photoplethysmogram*. The students observed the components of the device and were explained the concepts of data acquisition, analog-to-digital conversion and transducer, using the device and its components as an example. After this introductory lesson, the students were instructed to perform a PPG trace, using a finger of their choice. The PPG trace was transferred to a Microsoft Office Excel datasheet, were students were able to calculate (as instructed) the second derivative of the photopletismogram (2D-PPG), which studies confirm that is relevant for estimating the arterial age (Figs. 2 and 3).

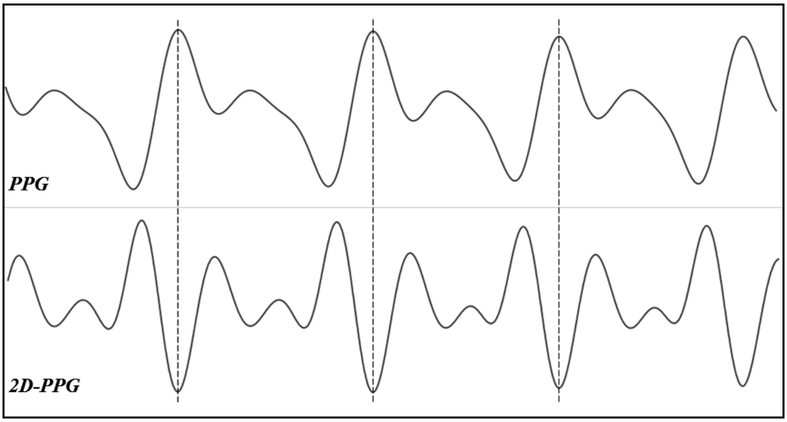

Figure 2. The photopletismographic (PPG) signal, compared with the second derivative photopletismogram (2D-PPG)

According to student feedback forms and personal testimonials, they appreciated that the device offered an explicit approach in teaching the principles of data acquisition, the components were at sight and the experiment also had a purpose: evaluating arterial stiffness.

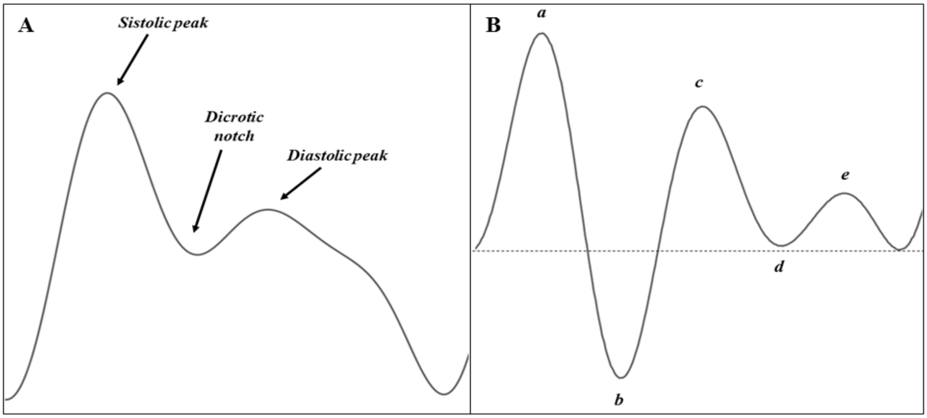

Figure 3. A complete cardiac cycle: A – photopletismogram; B – second derivative photopletismogram (normal curve, corresponding to a decreased arterial index)

Conclusions

Using devices with „at sight“ components for teaching electrophysiology proved to have a number of advantages, compared with standard, commercially available „all-in-a-box“ devices: (1) the ease of concept understanding, because all components can be seen; (2) low cost of manufacturing; (3) greater attractiveness for students. On the other hand, one major disadvantage is the lack of aesthetics.

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