Innovative Solution for Music Listening and Heart Rate Monitoring

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Commercially available heart rate monitors exploit commonly used chest belt based measurement of the electrical activity of the heart. To improve user comfort and maximize positive emotions of a person achieving a heart rate controlled work-out, an iPhone application for heart rate monitoring has been developed. The application requires no supplementary sensor probe since heart rate is monitored by an earphone integrated infrared sensor. During exercising, music and iPhone based multimedia applications are at the disposal of the person in order to increase pleasure during work-out.

Many people have discovered how helpful it is to exercise with music that synchronizes up with their gestural frequency. Examples are given by the large number of recreational joggers or bikers working-out on treadmills, stationary bikes or kinetics trainers in fitness or wellness centers, isolated in their own universe through MP3-player driven earphones. This observation has also been confirmed by recent studies which have shown that listening to music while exercising seems to increase the positive emotions perceived by the person and decrease the subjective perception of fatigue and exhaustion [1]. Nevertheless, exercising with specific objectives, namely fat-burning or improvement of aerobic capacities can only be achieved effectively when using a heartbeat monitor. Such monitors are commonly based on the surface ECG measurement and require a chest-belt which may be perceived by a person as oppressive and cumbersome.

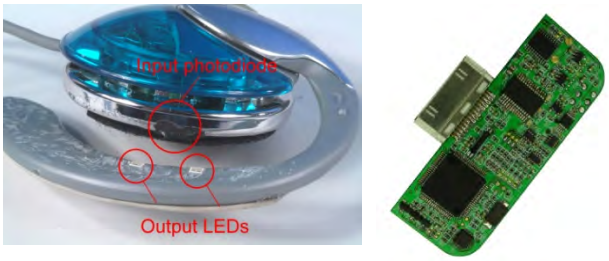

Figure 1: Developed earphone integrated heart rate sensor (left) and electronic interface board (right) to exploit sensor signals with the iPhone application.

In order to allow a person to maximize his positive emotions while exercising, an iPhone integrated approach for heart rate monitoring has been developed. The system is based on optical measurements of the subcutaneous blood flow through photoplethysmography. A commercial earphone has been modified in such a way that infrared LEDs are embedded in the hook and a photodiode is hidden behind the foam cushion (Figure 1 left)—mostly transparent at this wavelength. The infrared light is modulated by the pulse-wise swelling of the arterioles. The intrinsic high sensitivity of photo-plethysmography to motion artifacts is compensated by a specific signal processing algorithm that exploits the extra information of a multi-axis accelerometer sensor, also embedded in the earphone. The earphone is connected via a specifically developed electronic interface board (Figure 2 right) to the iPhone where a graphic user interface displays the heart rate of the user. The specifically developed electronic interface board is attached directly to the iPhone and constitutes, thanks to the design of an appropriate housing an integral part of it (Figure 2). A person may comfortably wear the iPhone in an appropriate armband during exercising; or use it, during recovery periods to analyze the training session, communicate with friends, divert himself with specific iPhone applications or even transmit the content of the last interval session to his coach via internet to obtain immediate advice for training efficiency improvement.

A further advantage of the proposed solution consists in the control of a subject's heart rate on a higher non-conscious level, namely through the selection of appropriate songs. If the subject is below the targeted heart rate zone the associated software switches automatically to a song with higher pulse-beat-rating and vice versa. Such a biofeedback directed heart rate control is optimal for subjects who have an adversity to any limitation in their freedom during exercising.

Figure 2: Smartphone and developed graphical user interface with evolution of heart rate during a music directed short term session for improvement of maximal aerobic running speed.

The developed heart rate monitor has been validated on 49 files of 22 subjects, a total duration of 50 hours and various activities such as running, cycling, walking, daily office activity and fitness training. In average over all activities the provided heart rate was in 86% within 3 beats per minute of the POLAR RS800 reference device with a promising 94% for running.

The presented platform has been developed in a generic way and, in future, an extension of the physiological parameter space will be developed. More particularly, the ear sensor integrated multi-axis accelerometer opens the way to the integration of running speed and efficiency analysis tools which are part of the CSEM patent portfolio.

The financial support of the European Space Agency, within the Technology Transfer Program (PULSEAR-TTP project), is thankfully acknowledged.

[1] S. H. Boutcher, M. Trenske, "The effects of sensory deprivation and music on perceived exertion and affect during exercise" Journal of Sports & Exercise Physiology, 1990