EXHIBIT 2114

ECG Audio Headset and Data Processing Methods

FIELD OF THE INVENTION

This invention relates generally to novel devices and methods for noninvasively qualifying and/or quantifying physiological information from an organism with sensor modules embedded in an audio headset. The invention relates more specifically to novel devices and methods for extracting electrical signals related to physiological information using a headset, novel methods of integrating multiple sensors into a headset, and novel devices and methods for transmitting physiological information from a headset to a wearable electronic device.

BACKGROUND OF THE INVENTION

Measuring physiological information on moving persons is important for ambulatory monitoring of patients, consumer health and wellness, and similar cases. But there are no technologies for measuring an electrocardiogram (ECG) from a person with an earpiece. This would be a useful technology because persons wear headsets to listen to music while exercising, and they could be monitoring heart rate and other heart rate features at the same time. Additionally, electroencephalogram (EEG), electrooculography (EOG), and other forms of physiological electrical activity would be useful to measure during physical activity.

Measuring an ECG via the ears leverages the bilateral symmetry of the human body. Namely, a potential can be measured across the left and right side of the body during the electrical generation of a systolic heart event. For this reason, a net potential may be measured from ear-to-ear during the generation of a heartbeat.

Transmitting information from embedded sensors in a headset to a wearable electronic device, such as a mobile phone or digital media player, would introduce difficulties. Namely, there are often no ports available for accessing the embedded computer in these wearable devices. Thus, a new method of communicating physiological information from an external device (such as a headset) to a wearable electronic device is needed.

SUMMARY OF THE INVENTION

The present invention addresses the aforementioned problems by providing a device that can measure the ECG and other physiological properties of an organism in the form-factor of a headset. More specifically, this invention relates to integrating ECG electrodes, other physiological sensors, and associated electronics into various locations of a headset and the earbud of a headset, as well as integrating this circuitry with a standard audio headset for use with a portable, wearable electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates the invention worn on a human.

Figure 2 illustrates the invention connected to a wearable electronic device worn on the arm.

Figure 3 illustrates a circuit for extracting an ECG signal from the ear.

Figure 4 illustrates the anatomy of the human ear for extracting an ECG signal.

Figure 5 illustrates an exemplary ECG earbud near the human ear.

Figure 6 illustrates an exemplary ECG stereo headset with embedded electrodes.

Figure 7 illustrates an exemplary ECG headset with a pinna cover.

Figure 8 illustrates an exemplary flexible ECG sensor module.

Figure 9 illustrates an exemplary modular design for an ECG audio headset.

Figure 10 illustrates a more specific modular design for an ECG audio headset.

DETAILED DESCRIPTION OF THE INVENTION

In the following description, reference is made to the accompanying drawings, which form a part hereof, and which show, by way of illustration, specific embodiments or processes in which the invention may be practiced. Where possible, the same reference numbers are used throughout the drawings to refer to the same or like components. In some instances, numerous specific details are set forth in order to provide a thorough understanding of the present invention. The present invention, however, may be practiced without the specific details or with certain alternative equivalent devices and methods to

those described herein. In other instances, well-known methods and devices have not been described in detail so as not to unnecessarily obscure aspects of the present invention.

Figure 1 illustrates a novel non-limiting invention for monitoring the physiological properties of an organism. More specifically, the invention is a headset which integrates electrodes and/or sensors for monitoring electrocardiograms (EEGs), electroencephalograms (EEGs), and other physiological properties of an organism. The headset can be designed to function as both an audio headset and a physiological monitor while maintaining essentially the same form-factor of an audio headset.

As shown in Figure 1, the headset may connect via a wire to a wearable electronic device, though wireless designs are also possible. The wearable electronic device can come from a list of several wearable devices, with nonlimiting examples including: a cellular phone, a smartphone, a digital media player, walkman, a personal digital assistant (PDA), a watch, electronic armband, or the like. An important function of the wearable electronic device is that it can display, audibly, visually, or both, raw or processed information received by the headset. This means that the wearable electronic device may be an embedded system or embedded computer. Figure 2 shows an example of the wearable electronic device worn on the arm, affixed to an arm support, such as an armband.

Figure 3 shows an exemplary, nonlimiting electronic circuit for extracting ECG signals from the ear region and generating an output. In this case, multiple gain stages are used to generate a bandpass filter centered in the prime region of an ECG response. Typically, this region will range from 40Hz to 200 Hz.

Figure 4 shows a summary of the anatomy of the human ear, where there are several locations suitable for contact with ECG electrodes. Optimal places include regions where there is a reasonably conductive skin area, such as a region with sweat pores. Nonlimiting skin contact locations for ECG electrodes include: the ear canal, the meatus, the pinna, the scapha, the helix, the tragus, the earlobe, and the periphery surrounding the region where the ear meets the head.

The ECG electrodes may be composed of any conductive material or materials that are solid or gel-like, including, but not limited to: metals, conductive polymers, conductive gels or sol-gels, alloys, conductive plastics/rubbers, semimetals or semiconductors, and the like. Silver/silver chloride electrodes, carbon rubber, copper, and gold electrodes are just a

few good examples of electrode materials. The electrodes need not be passive electrodes. In fact, active electrodes can be employed for impedance matching, impedance reduction, and noise reduction. Active electrodes may employ operational amplifiers, voltage followers, impedance-cancelling circuits, or the like.

The ECG electrodes can be located along any part of the headset touching the skin. Preferably, the electrodes are located in a headset region that is always in contact with the skin during use. Compression fixtures can be used to press the electrodes more closely against the skin, and gels, conductive gels, liquids, lubricants, or the like can be applied to the electrodes to improve the signal-to-noise ratio of electrocardiograms measured. Multiple electrodes can be embedded in each earbud fixture of a headset, for both mono- and stereo headsets. Additionally, electrodes can be embedded in bracing fixtures, such as ear clips, head supports, and the like. In such case, the bracing fixtures may also help compress the electrodes against the skin to maintain electrode contact.

In some embodiments, additional electrodes may be integrated with the headset electrodes for a more complete heart monitoring platform. For example, at least one electrode near the leg or ankle may serve as a good ground reference. In another embodiment, at least one electrode may be integrated within the wearable electronic device, as this device may be worn in such as way that it is always in contact with human skin (see Figure 2). In other embodiments, chest electrodes may be integrated within the circuit for assessed multiple chambers and functions of the heart. In each case, the "hub" for collecting, powering, and/or processing this data may be within the headset itself or the wearable electronic device. For example, all electrodes may complete a circuit within the wearable electronic device or headset.

Figure 5 shows an example of how ECG electrodes might be embedded into the earbud of an audio headset. In this case, the electrode material is located on the outer periphery of an earbud, such that the ECG electrodes are in direct contact with the skin of the mid-to-inner ear region, and such that an open region exists for the transmission of sound. Though only one electrode is shown in Figure 5, it should be understood that multiple electrodes of various shapes and orientations can be located on a single earbud.

Figure 6 shows an example of how ECG electrodes may be embedded into a stereo headset. In this case, electrodes are shown embedded in the earbud, the ear fixture, and a

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