RESPIRATORY RATE MEASUREMENT DEVICE

BACKGROUND

1. Field of the Invention

The present invention relates to respiratory rate measurement device, and more particularly, relates to a respiratory rate measurement device that measures breaths per minute in real time more accurately by reducing shock generated during the measurement process.

2. Description of the Related Art

A respiratory rate is a vital sign that is typically measured in hospitals to determine the number of breaths taken within a predetermined time period and is used to determine patient stability or medical conditions. In particular, a manual measurement of the respiratory rate is often used by manually monitoring the rise and fall of a patient's chest. This type of measurement process may however be inaccurate and is time consuming. Alternatively, a carbon dioxide monitor has been used to measure respirations by monitoring the flow of air into and out of a patient's nose and mouth. The carbon dioxide monitoring process is however costly and not always available when merely detecting vital signs during, for example, a typical medical examination. Accordingly, the measurement of a respiratory rate is limited and a non-invasive and cost efficient measurement device is required.

SUMMARY

In an exemplary embodiment of the present invention, a system for monitoring a respiratory rate includes an accelerometer, a processor, and a casing that surrounds the accelerometer and the processor. In particular, the accelerometer may be configured to measure movement of a diaphragm or breath-induced movements, in real time, by detecting tilts of the accelerometer. The accelerometer may be a one-axis, a two-axis, or a three-axis accelerometer. The processor may be connected to the accelerometer to process and filter signals that are associated with measurements from the accelerometer. In addition, the processor may be configured to compute the respiratory rate based on the filtered signals and convert the computed respiratory rate to a digital readout to then output the digital readout on a display. The casing that surrounds the accelerometer and the processor may be configured to provide shock mitigation to provide more accurate accelerometer readings. The system may also include a power source and a switch configured to turn the device on and off.

Further, the accelerometer may be configured to be attached directly to a patient via a removable adhesive or may be attached indirectly to the patient. Specifically, the accelerometer may be attached indirectly by being attached to the clothing of the patient via an adhesive, a clip, a magnet, or any other fastening mechanism. The casing that surrounds the accelerometer and the processor may be box shaped with an opening for the display, e.g., a liquid crystal display (LCD). In particular, the casing may have an adhesive at a backside thereof to attach the device directly to a patient or may have a clip integrally formed at a backside thereof to attach to the clothing of the patient. Additionally, the accelerometer may be configured to measure the diaphragm movements within about 15 seconds as a breath per minute (bpm) with an accuracy of about 2 bpm.

The filtering process of the signals received from the accelerometer may include establishing a baseline for each axis component of the accelerometer once the device is powered on and attached to a patient. An average acceleration from each axis component may then be determined and the measurements received from the accelerometer may be interpreted as deviations from the established baseline. The average acceleration may output peaks for each movement of the diaphragm, that is, for each breath that causes the chest of a patient to rise.

In another exemplary embodiment of the present invention, a method of measuring a respiratory rate includes measuring movement of a diaphragm, in real time, using an accelerometer by detecting tilts of the accelerometer. In addition, the signals associated with the measurements from the accelerometer may be processed and filtered by controller (e.g., a processor of a controller). The respiratory rate may be computed by the controller based on the filtered signals. Further, the computed respiratory rate may be converted by the controller to a digital readout to output the digital readout on a display.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments herein may be better understood by referring to the following description in conjunction with the accompanying drawings in which like reference numerals indicate identically or functionally similar element, of which:

FIG. 1 is an exemplary view of a respiratory rate measuring device according to an exemplary embodiment of the present invention;

FIG. 2 is an exemplary view of the conversion of accelerator measurements to a respiratory rate measurement in breaths per minute according to an exemplary embodiment of the present invention;

FIG. 3 is an exemplary chart of the filtering process for the signals from the accelerometer measurements according to an exemplary embodiment of the present invention;

FIG. 4 is an exemplary view of a casing for the respiratory rate measurement device according to an exemplary embodiment of the present invention; and

FIG. 5 is an exemplary flowchart of a method of measuring a respiratory rate according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

Although exemplary embodiment is described as using a plurality of units to perform the exemplary process, it is understood that the exemplary processes may also be performed by one or plurality of modules. Additionally, it is understood that the term controller refers to a hardware device that includes a memory and a processor. The memory is configured to store the modules and the processor is specifically configured to execute said modules to perform one or more processes which are described further below.

Furthermore, control logic of the present invention may be embodied as non-transitory computer readable media on a computer readable medium containing executable program instructions executed by a processor, controller or the like. Examples of the computer readable mediums include, but are not limited to, ROM, RAM, compact disc (CD)-ROMs, magnetic tapes, floppy disks, flash drives, smart cards and optical data storage devices. The computer readable recording medium can also be distributed in network coupled computer systems so that the computer readable media is stored and executed in a distributed fashion, e.g., by a telematics server or a Controller Area Network (CAN).

Unless specifically stated or obvious from context, as used herein, the term “about” is understood as within a range of normal tolerance in the art, for example within 2 standard deviations of the mean. “About” can be understood as within 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, 0.5%, 0.1%, 0.05%, or 0.01% of the stated value. Unless otherwise clear from the context, all numerical values provided herein are modified by the term “about.”

An exemplary embodiment of the present invention provides a respiratory rate measurement device that is configured to measure breaths per minute in real time and provides more accurate measurements while mitigating shock generated during the measurement process. In particular, the device may use an accelerometer that measures movement of a patient’s torso and process those measurements to determine a breath per minute respiratory rate.

As shown in FIG. 1, the respiratory rate measurement device 100 may include a tri-axial accelerometer 105, a processor 110, a display 115, a shock absorption material 120 within a casing 135, a switch 125, and a power source 130. The accelerometer 105 is not limited to a tri-axial accelerometer and may be a one or two axial accelerometer. The processor may be a microcontroller and more specifically, may be a single board microcontroller which may be open-source hardware consisting of an 8-bit microcontroller. The 14 I/O pins of the microcontroller may be used to collect the accelerometer data and produce a single readout of breaths per minute (bpm) after the data has been filtered and processed. In addition, the display 115 may be a liquid crystal display (LCD) which is an electronically modulated optical device having a number of segments filled with liquid crystals and arrayed in front of a light source or reflector to produce images in color or monochrome. The switch 125 may be a power button (e.g., an on-off spring-loaded push button) configured to turn the device 100 on and off and may protrude out from the outer casing 135. The power source 130 may be a 5 volt coin battery or a 9 volt battery, but is not limited thereto and may be any type of power source. The shock absorption material 120 may be a foam material that allows the LCD to displace with a damped response and may operate as a layer damper for flexural vibrations. The outer casing 135 may also have thermoplastic (e.g., urethane elastomer) bumpers to further protect the device from vibrations.

FIG. 2 shows the general transformation of a physical input to a numerical respiratory rate measurement. First, a physical input 205 may be input to begin the process or measuring the respiratory rate. A sensor 210, e.g., the accelerometer, may be configured to sense the movement of the torso of a patient to produce wavelengths 215 which may then be filtered and processed 220 to provide filtered signals 225 of the sensor measurements. Further, the filtered signals 225 may be transmitted to a microprocessor 230 which may be configured to compute the respiratory rate based on the number of exhalations detected over a period of time 235. Once the respiratory rate has been computed, the microprocessor 230 may be configured to output a breath per minute 240 on a display.

Hereinafter, a detailed description of the various components of the respiratory rate measurement device and method of measuring the respiratory rate measurement device will be described with reference to FIGS. 3-5.

First, the device 100 may be attached to a patient directly or indirectly. In particular, the device 100 may be attached directly to the patient’s chest or abdomen using a removable adhesive. The removable adhesive (e.g., medical grade silicon) may be disposed on a backside of the outer casing 135 such that the display 115 is visible to display the respiratory rate. In other words, as seen in FIG. 4, the housing of the device 100 may have a box shape outer casing 135 that has an opening 410 to accommodate the display 115. In addition, after use, an additional adhesive patch may be attached to the backside of the casing 135 for reuse. Alternatively, a clip 405 may be integrally formed at the backside of the casing 135. The clip 405 may be attached to the clothing of a patient for indirect attachment. The clip may be formed of two levers which may be depressed to attach to the clothing. The present invention is however not limited to a clip to attach the device to the patient but may also be attached using a magnet, an adhesive, or any other fastening mechanism.

Once the device 100 has been attached to the patient and turned on, the accelerometer may be configured to detect and measure movement of the abdomen or chest which move when the patient breaths in and out (e.g., measuring inclination and angular changes). In other words, a sensor of the accelerometer may be configured to measure tilts of the accelerometer itself. The orientation of the accelerometer changes, that is, the accelerometer tilts as the patient breaths and the impact of gravity of the accelerometer changes accordingly. This change in the impact of gravity as the accelerometer moves is the measurement collected by the accelerometer over a predetermined period of time. The movements of the diaphragm may be measured within 15 seconds as a breath per minute with an accuracy of about 2 bpm. In addition, the accelerometer may be configured to output signals with peaks showing the expansion of the torso over the predetermined period of time (e.g., every 30 seconds, every minute, every hours, etc.). Further, the accelerometer may be based on spring-mass damper principles well known to those skilled in the art and thus, a detailed description thereof will be omitted.

Once the accelerometer 105 has detected and measured the breath-induced movements from an x channel 305, a y channel 310, and a z channel 315, the processor 110 may be configured to process and filter the signals associated with the measurements from the accelerometer. FIG. 3 illustrates the software filtering process used to display a respiratory rate. In particular, for about 1 to 2 seconds after the device 100 is attached to the patient and turned on, an average (e.g., acceleration magnitude data) of each axis channel or component may be determined and the average may be called a baseline. The values read by the processor 110 may be interpreted as deviations from the baseline. The deviations may be output as peaks for each breath as shown in the signals in FIG. 2. Furthermore, a low pass filter 320 may be used to filter the signals associated with the measurements from the accelerometer. The signals that pass through the low pass filter 320 may then be amplified 325 and passed through a noise reduction 330 step. In addition, the processor 110 may be configured to create a threshold 335 to then process the signals and compute a bpm count 340. Once the bpm count 340 has been determined, the processor 110 may be configured to display 345 both the bpm count 340 and a total number of breaths during a measurement process (e.g., a predetermined period of time).

Furthermore, FIG. 5 illustrates an exemplary simplified procedure 500 for measuring a respiratory rate. The procedure may start at step 505 and continues to step 510, where movement of a diaphragm may be measured in real time by an accelerometer by detecting tilts of the accelerometer. In step 515, a plurality of signals from the accelerometer measurements may be processed and filtered by a controller. Further, in step 520, the controller may be configured to compute the respiratory rate based on the filtered signals. The computed respiratory rate may then be converted in step 525 to a digital readout to be output on a display. The process may then illustratively end in step 530. However, the process may also be repeated to output continuous respiratory rates for a predetermined period of time.

The respiratory rate measurement device of the present invention is capable of measuring a respiratory rate in real time within 15 seconds as a breath per minute with an accuracy of about 2 bpm. In addition, the device may be attached to a patient directly to the patient’s skin or may be indirectly attached to the patient by being attached to the clothing of the patient. The packaging or casing of the device may include a shock absorption material to mitigate any generated shock to protect the electronic components and provide a more accurate reading of the diaphragm movements. Further, a display may be built into the measurement system and thus, may be attached to the patient without requiring any additional external displays.

The foregoing description has been directed to specific embodiments. It will be apparent; however, that other variations and modifications may be made to the described embodiments, with the attainment of some or all of their advantages. Accordingly, this description is to be taken only by way of example and not to otherwise limit the scope of the embodiments herein. Therefore, it is the object of the accompanying claims to cover all such variations and modifications as come within the true scope of the embodiments herein.

WHAT IS CLAIMED IS:

1. A system for monitoring a respiratory rate, comprising:

an accelerometer configured to measure, in real time, movement of a diaphragm by detecting tilts of the accelerometer;

a processor connected to the accelerometer and configured to:

process and filter signals associated with measurements from the accelerometer;

compute the respiratory rate based on filtered signals; and

convert the computed respiratory rate to a digital readout to output the digital readout on a display; and

a casing surrounding the accelerometer and processor to provide shock mitigation.

2. The system of claim 1, wherein the accelerometer is configured to be attached directly to a patient's abdomen using a removable adhesive.

3. The system of claim 1, wherein the accelerometer is attached to a clothing of a patient for indirect contact with the abdomen.

4. The system of claim 3, wherein the accelerometer is attached to the clothing using a clip, a magnet, an adhesive, or other fastening mechanism.

5. The system of claim 1, wherein the casing is a box shape having an opening for the display and a clip integrally formed on a backside of the casing.

6. The system of claim 1, wherein the display is a liquid crystal display (LCD) display.

7. The system of claim 1, wherein the accelerometer is configured to measure the diaphragm movements within about 15 seconds a breath per minute (bpm) with an accuracy of about 2 bpm.

8. The system of claim 1, wherein the filtering process of the signals includes:

establishing a baseline for each axis component of the accelerometer once the device is powered on and attached to a patient;

determining an average acceleration for each axis component; and

interpreting measurements received from the accelerometer as deviations from the established baseline.

9. The system of claim 8, wherein the average acceleration outputs peaks for each movement of the diaphragm.

10. The system of claim 1, wherein the accelerometer is a one-axis, two-axis, or three-axis accelerometer.

11. The system of claim 1, further comprising a power source and a switch to turn the device on and off.

12. A method of measuring a respiratory rate, comprising:

measuring in real time, by an accelerometer, movement of a diaphragm by detecting tilts of the accelerometer;

processing and filtering, by a controller, signals associated with measurements from the accelerometer;

computing, by the controller, the respiratory rate based on filtered signals; and converting, by the controller, the computed respiratory rate to a digital readout to output the digital readout on a display.

13. The method of claim 12, wherein the accelerometer is configured to be attached directly to a patient's abdomen using a removable adhesive.

14. The method of claim 12, wherein the accelerometer is attached to clothing of a patient for indirect contact with the abdomen.

15. The method of claim 14, wherein the accelerometer is attached to the clothing using a clip, a magnet, an adhesive, or other fastening mechanism.

16. The method of claim 12, wherein the accelerometer and the controller are housing within a casing that is box shaped, has an opening for the display, and a clip integrally formed on a backside of the casing.

17. The method of claim 12, wherein the display is a liquid crystal display (LCD) display.

18. The method of claim 12, further comprising:

measuring, by the accelerometer, the diaphragm movements within about 15 seconds a breath per minute (bpm) with an accuracy of about 2 bpm.

19. The method of claim 12, wherein the filtering further comprises:

establishing, by the controller, a baseline for each axis component once the device is powered on and attached to a patient;

determining, by the controller, an average acceleration for each axis component of the accelerometer; and

interpreting, by the controller, measurements received from the accelerometer as deviations from the established baseline.

20. The method of claim 12, wherein the accelerometer is a one-axis, two-axis, or three-axis accelerometer.