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(54) **SIGNAL PROCESSING WARPING TECHNIQUE**

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A61B 5/00	(2006.01)
A61B 5/1455	(2006.01)

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CPC ***A61B 5/14551*** (2013.01); ***A61B 5/6829*** (2013.01); *A61B 5/726* (2013.01); ***A61B 5/6838*** (2013.01); ***A61B 5/6816*** (2013.01); *A61B 5/7264* (2013.01); *A61B 5/7207* (2013.01); *A61B 5/7203* (2013.01); ***A61B 5/6826*** (2013.01); ***A61B 5/7221*** (2013.01)

USPC **600/500**; 600/336; 600/364; 600/365; 600/501; 600/502; 600/503; 600/504

(58) **Field of Classification Search**

USPC 600/364, 365, 368, 500–504, 301, 336

See application file for complete search history.

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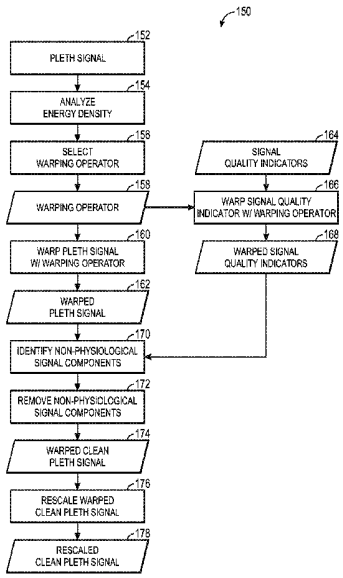
(57) **ABSTRACT**

Methods and systems are provided for using time-frequency warping to analyze a physiological signal. One embodiment includes applying a warping operator to the physiological signal based on the energy density of the signal. The warped physiological signal may be analyzed to determine whether non-physiological signal components are present. Further, the same warping operator may be applied to signal quality indicators, and the warped physiological signal may be analyzed based on the warped signal quality indicators. Non-physiological signal components, or types of non-physiological noise sources, may be identified based on a comparison of the physiological signal with the signal quality indicators. Non-physiological signal components may also be identified based on a neural network of known noise functions. In some embodiments, the non-physiological signal components may be removed to increase accuracy in estimating physiological parameters.

21 Claims, 3 Drawing Sheets



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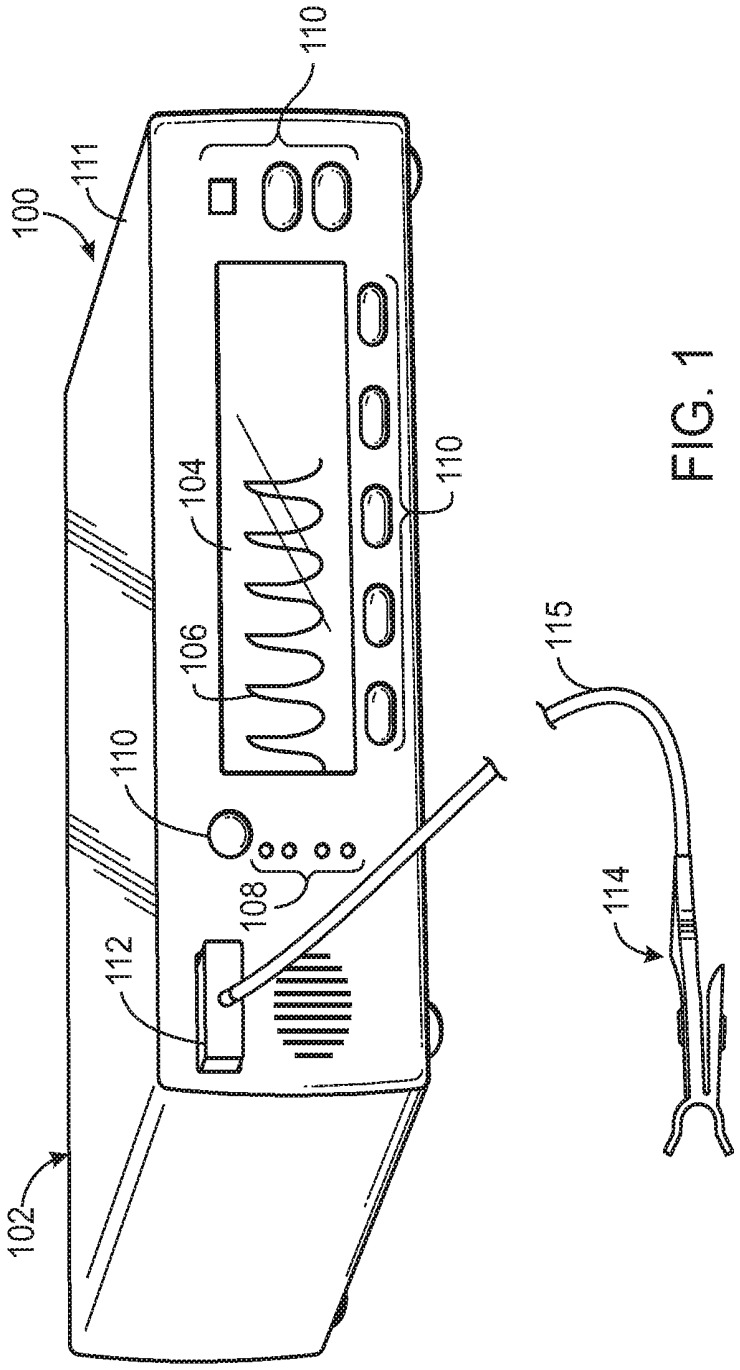
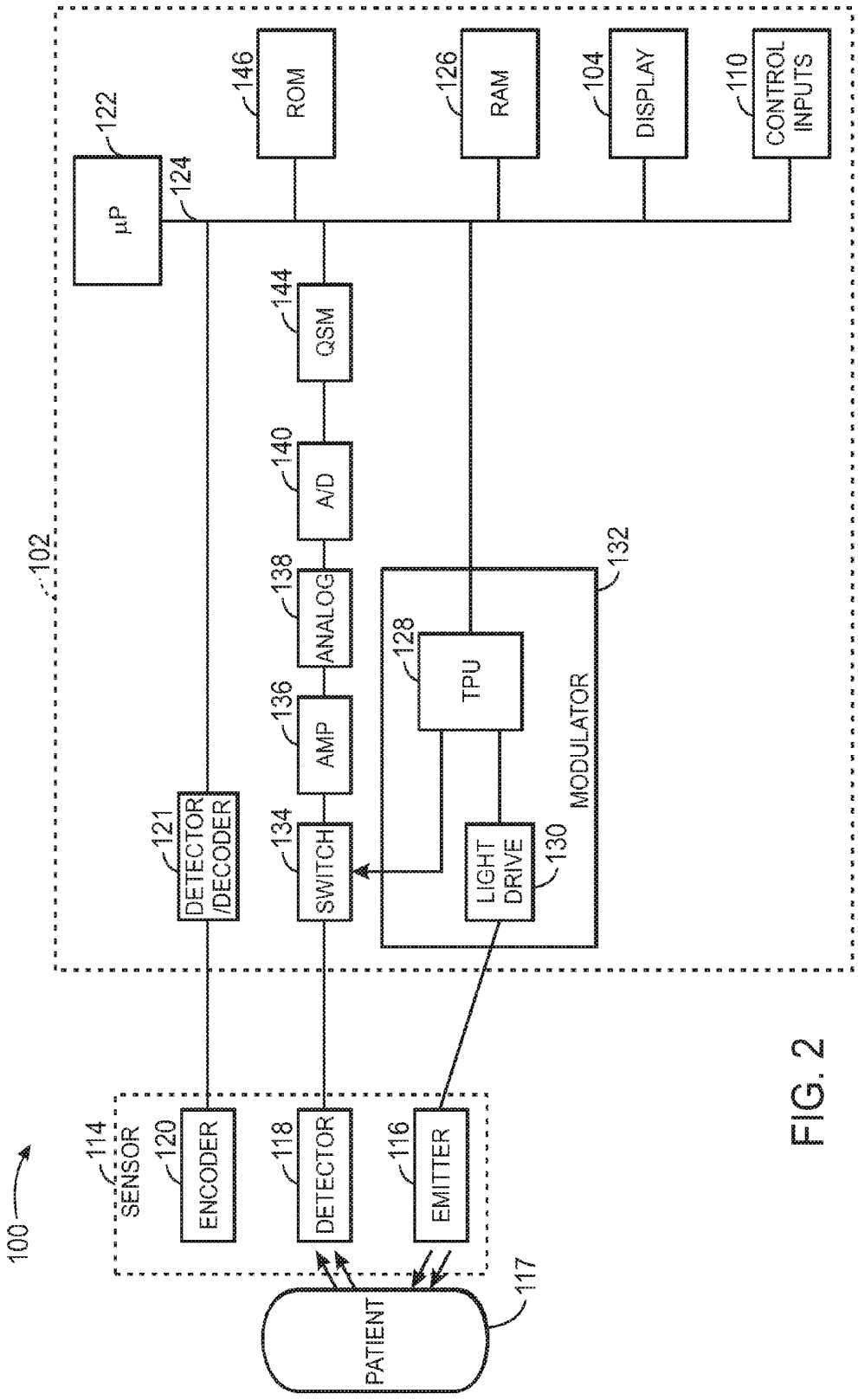


FIG. 1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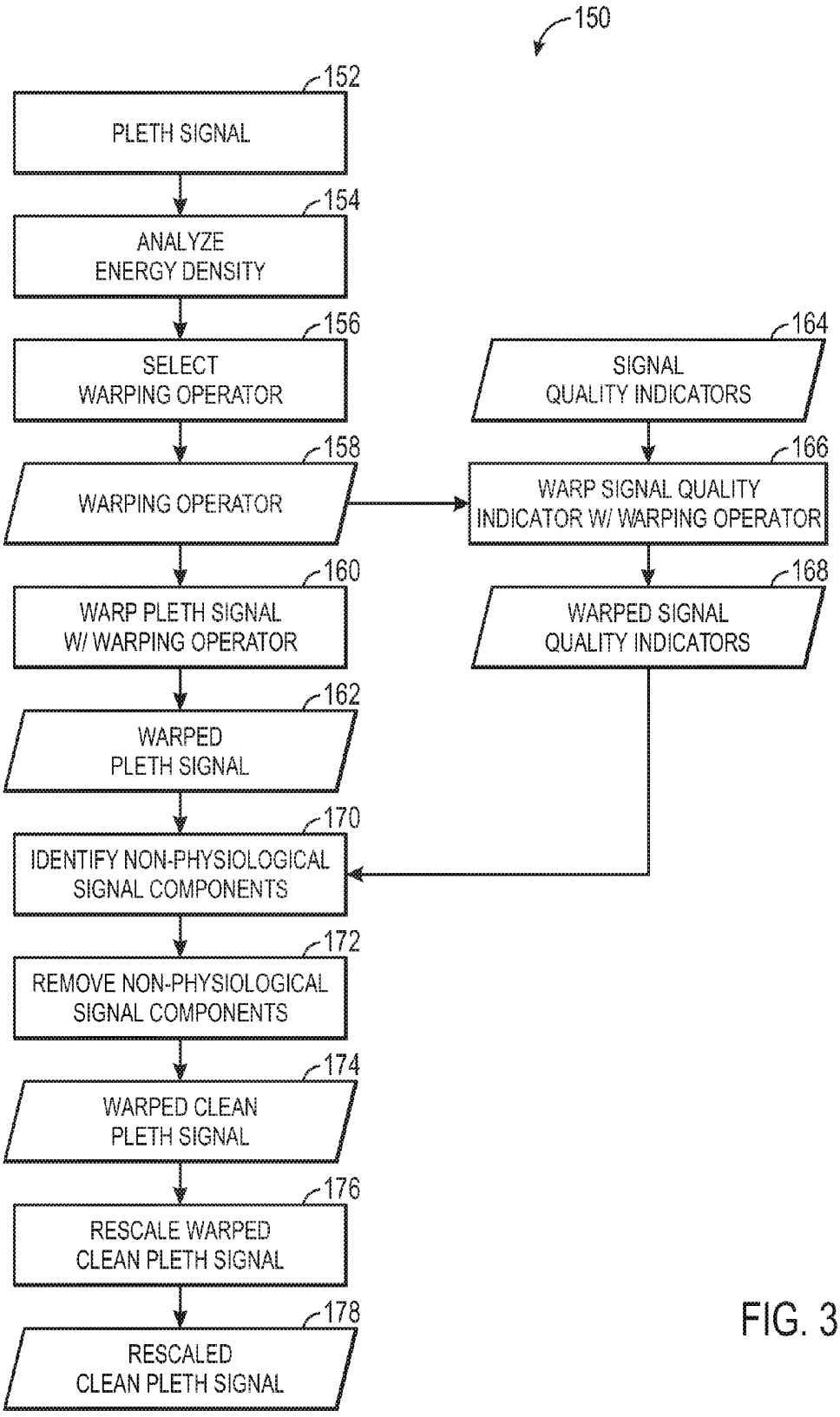
MODULATOR

FIG. 2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PLETH SIGNAL
154
ANALYZE ENERGY DENSITY
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SELECT WARPING OPERATOR
158
WARPING OPERATOR
160
WARP PLETH SIGNAL W/ WARPING OPERATOR
162
WARPED PLETH SIGNAL
164
SIGNAL QUALITY INDICATORS
166
WARP SIGNAL QUALITY INDICATOR W/ WARPING OPERATOR
168
WARPED SIGNAL QUALITY INDICATORS
170
IDENTIFY NON-PHYSIOLOGICAL SIGNAL COMPONENTS
172
REMOVE NON-PHYSIOLOGICAL SIGNAL COMPONENTS
174
WARPED CLEAN PLETH SIGNAL
176
RESCALE WARPED CLEAN PLETH SIGNAL
178
RESCALED CLEAN PLETH SIGNAL

FIG. 3

SIGNAL PROCESSING WARPING TECHNIQUE

RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 61/245,571, filed Sep. 24, 2009, which application is hereby incorporated by reference.

BACKGROUND

The present disclosure relates generally to medical devices and, more particularly, to methods of analyzing physiological parameters using signal processing warping techniques.

This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

In the field of medicine, doctors often desire to monitor certain physiological characteristics of their patients. Accordingly, a wide variety of devices have been developed for monitoring many such physiological characteristics. Such devices provide doctors and other healthcare personnel with the information they need to provide the best possible healthcare for their patients. As a result, such monitoring devices have become an indispensable part of modern medicine.

One technique for monitoring certain physiological characteristics of a patient is commonly referred to as pulse oximetry, and the devices built based upon pulse oximetry techniques are commonly referred to as pulse oximeters. Pulse oximetry may be used to measure various blood flow characteristics, such as the blood-oxygen saturation of hemoglobin in arterial blood, the volume of individual blood pulsations supplying the tissue, and/or the rate of blood pulsations corresponding to each heartbeat of a patient. In fact, the "pulse" in pulse oximetry refers to the time varying amount of arterial blood in the tissue during each cardiac cycle.

Pulse oximeters typically utilize a non-invasive sensor that transmits light through a patient's tissue and that photoelectrically detects the absorption of the transmitted light in such tissue. A typical pulse oximeter may use light emitting diodes (LEDs) to measure light absorption by the blood. The absorbed and/or scattered light may be detected by the pulse oximeter, and may result in a signal that is proportional to the intensity of the detected light. The received signal may be further processed, and various physiological parameters may be determined based on signal features.

The accuracy of physiological parameters determined based on the received signal may depend on a number of factors. For example, light absorption characteristics may vary depending on factors such as the location of the sensor and/or the physiology of the patient being monitored. Additionally, various types of noise and interference that can also affect accuracy may include electrical noise, physiological noise, patient motion, or other interferences. Some sources of noise are consistent, predictable, and/or minimal, while other sources of noise may be erratic, and may cause major interruptions in measuring blood flow characteristics. For example, motion of the patient may be unpredictable, and may cause interruptions that do not correspond to changes in the physiological parameters being measured. Methods of signal processing and/or signal analysis which enables the identification of non-physiological signal characteristics, such as motion, may improve the accuracy of pulse oximetry analyses.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of the disclosed techniques may become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. **1** illustrates a perspective view of a pulse oximeter in accordance with an embodiment;

FIG. **2** illustrates a simplified block diagram of a pulse oximeter, according to an embodiment; and

FIG. **3** is a flow chart depicting a process for identifying non-physiological noise in a plethysmographic (pleth) signal, according to an embodiment.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

One or more specific embodiments of the present techniques will be described below. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

Present embodiments relate to estimating physiological parameters related to blood flow and/or oxygenation in a patient by warping a physiological signal, such as a plethysmographic (pleth) signal. In one embodiment, the physiological signal may be analyzed in the time and frequency domain and non-physiological interferences may be identified using the warped physiological signal. More specifically, the physiological signal may be warped based on the energy density of the signal. Signal quality indicators, or signals used to determine the signal quality metrics (i.e., a quantification of the quality or accuracy) of the physiological signal, may likewise be warped using the same function to maintain scale invariance between the physiological signal and the signal quality indicator. By comparing the warped physiological signal with the warped signal quality indicator, non-physiological noise may be identified and/or removed.

In one or more embodiments, a physiological monitoring system, such as a pulse oximeter, may be used to estimate physiological parameters based on signals received from a sensor which correspond to a measured or observed characteristic of a patient. Estimating physiological parameters may be affected by the reliability of the received signals. For example, a reliable signal may result in a more accurate estimate. The reliability of the received signal may be affected by light absorption characteristics (i.e., the absorption of the emitted light by the patient's tissue), which may typically vary from patient to patient depending on their physiology and/or condition. The absorption characteristics may also vary depending on the location (e.g., the foot, finger, ear, etc.) where the sensor is applied, and whether there are possible interferences between the sensor and the tissue location (e.g., hair, nail polish, etc.). The design of the sensor or

the application of the sensor may also affect the received signal. In one embodiment, the received signal may refer to a physiological signal corresponding to blood flow in a patient, such as a pleth signal. By way of illustration, such a pleth signal may be used herein as an example of a suitable physiological signal for processing in accordance with the present disclosure, though other physiological signals may also be suitable for such processing.

One method of determining whether a pleth signal or other physiological signal is reliable may be to qualify the signal by comparing it with various signal quality indicators. In one embodiment, the signal quality indicators may be derived using known patterns of a pleth signal, as well as known sources of signal noise. For example, in some embodiments, signal quality indicators may include signals indicative of an arterial pulse shape, consistency of a pulse shape, arterial pulse amplitude, modulation ratios of red to infrared modulations, and/or the period of an arterial pulse, etc. Such indicators may enable assessments of the presence of known error sources in the pleth signal. Furthermore, signal indicators may also include signal patterns of known noise sources. In some embodiments, signal indicators of known noise sources may enable the pulse oximeter to identify and remove noise sources, and/or provide feedback regarding which (if any) noise sources are affecting the measured signal. Signal patterns of known noise sources may include signals indicative of a low light level, optical interferences between the sensor and the tissue, light modulation other than the patient's tissue, improper positioning of the sensor on the tissue, and/or physical movement.

In some embodiments, the pleth signal may be processed to characterize the signal over a time-frequency plane. For example, certain processing operations such as Fourier transforms or wavelet transforms may be applied to represent the pleth signal in both the time domain and the frequency domain. Combining the time and frequency analyses may produce more information regarding a pleth signal's spectral components with regard to temporal locations. For example, applying Fourier transforms or wavelet transforms on a pleth signal may result in a spectrogram, which is a depiction of the spectral density of the signal. Applying certain transformations to the pleth signal may also enable the analysis of the signal amplitude, relative to both time and frequency. Further, time-frequency warp operators may be used, such that the original pleth signal and/or a time-frequency representation of the signal (e.g., a spectrogram) may be warped (e.g., stretched, compressed, or otherwise deformed) to further enable a pulse oximeter to identify certain signal characteristics. In one embodiment, signal quality indicators may also be warped according to the same warp operators applied to the pleth signal. By warping the time-frequency representations of the pleth signal and the signal quality indicators, certain non-physiological signal contributions or sources may be identified and/or removed, thereby improving the estimate of physiological parameters from the pleth signal.

Turning to FIG. **1**, a perspective view of a medical device is illustrated in accordance with an embodiment. The medical device may be a pulse oximeter system **100**. The pulse oximeter system **100** may include a monitor **102**, such as those available from Nellcor Puritan Bennett LLC. The pulse oximeter system **100** may be utilized to observe the blood constituents of a patient's arterial blood to facilitate estimation of the state of oxygen exchange in the patient's body by emitting light into tissue and detecting the light after dispersion and/or reflection by the tissue. The amount of light that passes through the tissue and other characteristics of the light may vary in accordance with the changing amount of certain blood constituents in the tissue and the related light absorption and/or scattering. As with conventional pulse oximeter systems, the pulse oximeter system **100** may emit light from two or more LEDs or lasers into pulsatile tissue and then detect the transmitted light with a light detector (e.g., a photodiode or photo-detector) after the light has passed through the pulsatile tissue. Such measurements may be utilized to estimate a percentage of blood oxygen saturation in the probed volume of blood.

The monitor **102** may be configured to display calculated parameters on a display **104**. As illustrated in FIG. **1**, the display **104** may be integrated into the monitor **102**. However, the monitor **102** may also be configured to provide data via a port to an external display or secondary monitor. The display **104** may be configured to display computed physiological data including, for example, an oxygen saturation percentage, a pulse rate, and/or a plethysmographic waveform **106**. The oxygen saturation percentage may be a functional arterial hemoglobin oxygen saturation measurement in units of percentage SpO_2, while the pulse rate may indicate a patient's pulse rate in beats per minute. The monitor **102** may also display information related to alarms, monitor settings, and/or signal quality via indicator lights **108**.

To facilitate user input, the monitor **102** may include a plurality of control inputs **110**. The control inputs **110** may include fixed function keys, programmable function keys, and soft keys. Specifically, the control inputs **110** may correspond to soft key icons in the display **104**. Pressing control inputs **110** associated with, or adjacent to, an icon in the display may select a corresponding option. The monitor **102** may also include a casing **111**. The casing **111** may aid in the protection of the internal elements of the monitor **102** from damage.

The monitor **102** may further include a sensor port **112**. The sensor port **112** may allow for connection to an external sensor **114**, via a cable **115** which connects to the sensor port **112**. The sensor **114** may be of a disposable or a non-disposable type. Furthermore, the sensor **114** may obtain readings from a patient, which can be used by the monitor to calculate certain physiological characteristics such as the blood-oxygen saturation of hemoglobin in arterial blood, the volume of individual blood pulsations supplying the tissue, and/or the rate of blood pulsations corresponding to each heartbeat of a patient.

Turning to FIG. **2**, a simplified block diagram of a pulse oximeter system **100** is illustrated in accordance with an embodiment. Specifically, certain components of the sensor **114** and the monitor **102** are illustrated in FIG. **2**. The sensor **114** may include an emitter **116**, a detector **118**, and an encoder **120**. The emitter **116** may receive modulated drive signals from the monitor **102**, and may activate and deactivate a light emitting device at certain intervals. For example, the monitor **102** may activate and deactivate components that emit light of different wavelengths, such that light of different wavelength is alternately emitted.

The emitter **116** may be capable of emitting one or more wavelengths of light, e.g., RED and infrared (IR) light, into the tissue of a patient **117**, where the RED wavelength may be between about 600 nm and about 700 nm, and the IR wavelength may be between about 800 nm and about 1000 nm. The emitter **116** may include a single emitting device, for example, with two light emitting diodes (LEDs) or the emitter **116** may include a plurality of emitting devices with, for example, multiple LED's at various locations. Regardless of the number of light emitting devices, the emitter **116** may be used to measure, for example, blood oxygen saturation, water fractions, hematocrit, or other physiologic parameters of the

patient **117**, as discussed herein. It should be understood that, as used herein, the term "light" may refer to one or more of radio, microwave, millimeter wave, infrared, visible, ultraviolet, gamma ray or X-ray electromagnetic radiation, and may also include any wavelength within the radio, microwave, infrared, visible, ultraviolet, or X-ray spectra, and that any suitable wavelength of light may be appropriate for use in accordance with the present disclosure.

In one embodiment, the detector **118** may be an array of detector elements that may be capable of detecting light at various intensities and wavelengths. In operation, light enters the detector **118** after passing through the tissue of the patient **117**. The detector **118** may convert the light at a given intensity, which may be directly related to the absorbance and/or reflectance of light in the tissue of the patient **117**, into an electrical signal. That is, when more light at a certain wavelength is absorbed or reflected, less light of that wavelength is typically received from the tissue by the detector **118**. For example, the detector **118** may include one or more photodiodes, or any other element capable of converting light into either a current or voltage. After converting the received light to an electrical signal, the detector **118** may send the signal, which may be a pleth signal, to the monitor **102**, where physiological characteristics may be calculated based at least in part on the absorption of light in the tissue of the patient **117**.

In some embodiments, the sensor **114** may include an encoder **120**, which may contain information about the sensor **114**, such as what type of sensor it is (e.g., whether the sensor is intended for placement on a forehead or digit) and the wavelengths of light emitted by the emitter **116**. This information may allow the monitor **102** to select appropriate algorithms and/or calibration coefficients for calculating the patient's **117** physiological characteristics. The encoder **120** may, for instance, be a memory on which one or more of the following information may be stored for communication to the monitor **102**: the type of the sensor **114**; the wavelengths of light emitted by the emitter **116**; and the proper calibration coefficients and/or algorithms to be used for calculating the patient's **117** physiological characteristics. In one embodiment, the data or signal from the encoder **120** may be decoded by a detector/decoder **121** in the monitor **102**.

Signals from the detector **118** and the encoder **120** may be transmitted to the monitor **102**. The monitor **102** may include one or more processors **122** coupled to an internal bus **124**. Also connected to the bus **124** may be a RAM memory **126**, a ROM memory **146**, and a display **104**. The monitor **102** may also include a modulator **132**, which may include a time processing unit (TPU) **128** and light drive circuitry **130**. The modulator **132** may modulate the drive signals that activate the LEDs or other emitting structures of the emitter **116**. The modulator **132** may be hardware-based, software-based, or some combination thereof. For example, a software aspect of the modulator **132** may be stored on the memory **126** and may be controlled by the processor **122**. The TPU **128** may include a sine wave generator, and may provide timing control signals to light drive circuitry **130**, which controls when the emitter **116** is activated, and if multiple light sources are used, the multiplexed timing for the different light sources. TPU **128** may also control the gating-in of signals from detector **118** through a switching circuit **134**. These signals are sampled at the proper time, depending at least in part upon which of multiple light sources is activated, if multiple light sources are used.

The received signal from the detector **118** may be processed to provide certain physiological data. In one embodiment, the received signal may be passed through an amplifier **136**, a low pass filter **138**, and an analog-to-digital converter (ADC) **140** for amplifying, filtering, and digitizing the electrical signals the from the sensor **114**. The digital data may then be stored in a queued serial module (QSM) **142**, for later downloading to RAM **126** as QSM **142** fills up. There may also be multiple parallel paths for separate amplifiers, filters, and A/D converters for multiple light wavelengths or spectra received. Further, the processor **122** may calculate the oxygen saturation based on the received signals corresponding to the light received by the detector **118**. For example, the processor **122** may perform instructions or algorithms stored on the memory **144**, and may be configured to perform calculations to estimate physiological parameters based on the received signals.

In accordance with the present embodiments, the processor **122** may perform signal quality analyses using signal quality indicators stored on the memory **144** or in another location accessible by the processor **122**. Furthermore, the processor **122** may perform other processing operations (e.g., Fourier transforms or wavelet transforms, etc.), and may use time-frequency warping to analyze a received signal. For example, the processor **122** may apply warp operators to identify and/or remove non-physiological noise from the received signal to produce a more accurate signal. In some embodiments, the more accurate signal may undergo further processing and/or calculations to produce physiological data.

As discussed, the received signals at the detector **118**, such as a pleth signal, may include information for calculating certain physiological parameters and may also include signal components resulting from non-physiological conditions. For example, the physiology of the patient's tissue, the type of sensor, and movement of the patient may all result in a pleth signal that is less reliable, or less likely to produce accurate estimates of physiological parameters. In one or more embodiments, the pleth signal may be analyzed in the time and frequency domain, and warped according to the energy density of the signal. The same warping function may be applied to signal quality indicators, such that scale invariance may be maintained between the pleth signal and the signal quality indicators. Based on a comparison between the warped pleth signal and warped signal quality indicators, non-physiological wave components may be identified. In some embodiments, these wave components may be removed, or further used by the pulse oximeter system **100** to provide feedback to a user (e.g., a patient **117** or any person monitoring the patient **117**) as to likely noise sources which may be interfering with obtaining accurate physiological data.

One example of an algorithm or process **150** using time and frequency warping to analyze a pleth signal is depicted in the flow chart of FIG. **3**. In one embodiment, a pleth signal **152** may be output from a detector **118** (from FIG. **2**). The pleth signal **152** may be a signal proportional to the intensity of light emitted from the emitter **116**, transmitted and/or scattered through the tissue, and received at the detector **118**. The pleth signal **152** may be an example of any type of signal received at the detector **118** which may be decoded, processed, and/or calculated to determine various physiological parameters of the patient **117** (e.g., oxygen saturation, pulse rate, etc.). The pleth signal **152** may also include non-physiological signal components resulting from noise sources such as patient physiology, sensor type, incorrect sensor placement, and/or movement of the patient **117**. The non-physiological signal components in the pleth signal **152** may decrease the reliability of the signal **152** as noise may decrease the likelihood of accurately estimating certain physiological data.

In one embodiment, a monitor **102** may analyze the energy density of the pleth signal **152** (block **154**). Analyzing the energy density of the pleth signal **152** may include analyzing the changes in energy density of the signal **152**. To analyze changes in energy density, the signal **152** may be transformed to be represented in the time and/or frequency domains. In one embodiment, a time and frequency representation of the pleth signal **152** may enable the analysis of signal amplitude with respect to both time and frequency. For example, representations of a time and frequency signal, such as a spectrogram, may provide the spectral density of the signal with respect to time (typically x-axis) and frequency (typically y-axis).

A pleth signal **152** may vary from patient to patient, or vary depending on the type or location of the sensor. Thus, the energy density of the signal **152** may vary, and may have different signal characteristics (e.g., amplitude, frequency, noise, etc.) The monitor **102** may analyze the energy density (block **154**) of the signal **152** to determine how the signal **152** may be warped to facilitate analysis. The monitor **102** may select a warping operator **158** (block **156**) to warp the signal **152** (block **160**). For example, the warping function **158** may stretch the signal **152** to make certain features more discernable. By analyzing the features of the warped pleth signal **162**, certain non-physiological signal components may be identified.

The process **150** may also involve analyzing the warped pleth signal **162** in conjunction with signal quality indicator(s) **164**. As previously discussed, signal quality indicators **164** may be signals derived based on known patterns of a pleth signal **152**, as well as known patterns of signal noise. Such signal quality indicators **164** may enable assessments of the presence of known error sources in the pleth signal **152** by analyzing the wave patterns of the warped pleth signal **162** in view of the signal quality indicators **164**. To maintain scale invariance between the warped pleth signal **162** and the signal quality indicators **164**, the signal quality indicators **164** may also be warped based on the same operator **158** selected to warp the pleth signal **152** (block **166**).

By warping the signal quality indicators **164** by the same operator **158**, the warped signal quality indicators **168** and the warped pleth signal **162** may have the same time scale, such that frequency and/or amplitude characteristics of the warped pleth signal **162** and the warped signal quality indicators **168** may be compared with the same temporal frame of reference. As the signal quality indicators **164** may have signal characteristics based on known patterns of signal noise (e.g., physical movement of a patient), the monitor **102** may analyze the warped pleth signal **162** based on the warped signal quality indicator **168** to identify such signal noise components in the warped pleth signal **162** (block **170**). Furthermore, the time-frequency warping may improve pleth signal analyses, as some non-physiological signal components may be accounted for with respect to time and frequency. For example, signal irregularities such as physical movement of a patient may have signal characteristics which may be identified based on their temporal components. While some transformations of the pleth signal **152** may result in globally averaged energy value without information regarding the temporal components of the signal **152**, in one implementation a transformation (such as a wavelet transformation) may be employed that allows both time and frequency components to be analyzed. Such an approach may facilitate the identification of some non-physiological signal components.

The warped signal quality indicator **168** and the warped pleth signal **162** may be analyzed using a suitable process for comparing and/or distinguishing signal characteristics, which may indicate certain physiological or non-physiological signal components in the warped pleth signal **162**. For example, in one or more embodiments, analyzing the signals may include cross-correlating the warped signal quality indicator **168** with the warped pleth signal **162**, and determining whether any portion of the cross-correlated signal surpasses a threshold (e.g., an intensity threshold on a cross-correlated spectrogram), indicating an occurrence of a known physiological or non-physiological signal component.

In one embodiment, if the monitor **102** identifies a non-physiological signal component (block **170**) in the warped pleth signal **162**, the monitor **102** may remove the non-physiological signal component (block **172**). The warped and "clean" pleth signal **174** may then be resealed (block **176**), such that the resealed clean pleth signal **178** may be used for further processing, and physiological parameters may be calculated using the rescaled clean pleth signal **178** having the non-physiological signal components removed. Identifying and/or removing non-physiological signal components may result in a more reliable rescaled pleth signal **178**, increasing the likelihood of making more accurate estimates of physiological parameters.

In another embodiment, the monitor **102** may indicate that noise is affecting the measurement upon the identification of non-physiological signal components at block **170**. Further, in some embodiments, the monitor **102** may provide more specific feedback regarding the quality of the signal, including indicating a cause of the noise affecting the measurement. For example, the monitor **102** may use multiple signal quality indicators **164**, and may analyze a pleth signal **152** with more than one signal quality indicator **164**, each identifying one or more physiological or non-physiological conditions. If the monitor **102** determines that non-physiological signal components are present in the warped pleth signal **162** based on an analysis with a signal quality indicator, the monitor **102** may provide feedback as to the source of the non-physiological signal component. For example, if a warped signal quality indicator **164** associated with patient motion corresponds to signal components of the warped pleth signal **162**, the monitor **102** may indicate that motion is affecting the accuracy of the pulse oximetry measurement.

Although the above process **150** discusses time-frequency warping and use of signal quality indicators to identify non-physiological signal components, another process in accordance with the present techniques may utilize algorithms, for example, neural network software algorithms, such that some processing steps may be eliminated or streamlined. For example, in some embodiments, the monitor **102** may use a learning algorithm to train a neural network to recognize certain signal characteristics as non-physiological signal components. A neural network of recognized non-physiological signal components may save processing time, as certain signals may not need to be warped in order to identify the occurrence or type of non-physiological noises in the pleth signal **152**. For example, a monitor **102** may initially warp a pleth signal **152** and use a warped signal quality indicator **168** to identify and/or remove a non-physiological signal component, as outlined in the process **150** above. Once the monitor **102** identifies the non-physiological signal component, future occurrences of the non-physiological signal component may be identified without applying all the steps of the process **150**. In one embodiment, the monitor **102** may identify a previously identified non-physiological component in a warped pleth signal **162** without using signal quality indicators. Furthermore, in one embodiment, the monitor **102**

may identify a non-physiological component in an unwarped pleth signal **152** without warping and/or without using signal quality indicators.

While the disclosure may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the embodiments provided herein are not intended to be limited to the particular forms disclosed. Indeed, the disclosed embodiments may not only be applied to measurements of blood oxygen saturation, but these techniques may also be utilized for the measurement and/or analysis of other blood constituents. For example, using the same, different, or additional wavelengths, the present techniques may be utilized for the measurement and/or analysis of carboxyhemoglobin, met-hemoglobin, total hemoglobin, fractional hemoglobin, intravascular dyes, and/or water content. Rather, the various embodiments may cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the following appended claims.

What is claimed is:

1. A method for measuring a physiological parameter of a human, comprising the acts of:

analyzing, by using a processor, an energy density of a signal having a physiological component and a non-physiological component to determine one or more changes in the energy density of the signal over time;

determining, by using the processor, based on the one or more changes in the energy density of the signal over time, a warping function configured to enable identification of characteristics of the signal corresponding to the non-physiological component;

stretching or compressing along a time scale, by using the processor, the signal having the physiological component and the non-physiological component by using the warping function to produce a warped signal;

stretching or compressing, by using the processor, a signal quality indicator by using the warping function to produce a warped signal quality indicator;

identifying, by using the processor, the non-physiological component of the signal based on an analysis of the warped signal with the warped signal quality indicator; and

using the physiological component of the signal and disregarding the non-physiological component of the signal to determine the physiological parameter.

2. The method, as set forth in claim **1**, comprising warping a signal quality indicator with the warping function, and wherein identifying the non-physiological signal component is based on an analysis of the warped signal and a warped signal quality indicator.

3. The method, as set forth in claim **2**, wherein the signal quality indicator comprises one or more signals derived from known physiological and non-physiological signal characteristics.

4. The method, as set forth in claim **2**, wherein the signal quality indicator comprises one or more signals indicative of optical interference, undesired light modulation, physical movement of a patient, or improper sensor placement.

5. The method, as set forth in claim **1**, wherein the signal comprises a plethysmographic signal or a spectrogram corresponding to the plethysmographic signal.

6. The method, as set forth in claim **1**, comprising indicating the presence of the non-physiological component on a pulse oximeter measuring the signal.

7. The method, as set forth in claim **1**, comprising indicating a source of the non-physiological component on a pulse oximeter measuring the signal.

8. The method, as set forth in claim **1**, comprising using the non-physiological component in a neural network and identifying future occurrences of the non-physiological component based on the neural network.

9. A method for measuring a physiological parameter of a human, comprising the acts of:

analyzing, by using a processor, an energy density of a signal having a physiological component and a non-physiological component to determine one or more changes in the energy density of the signal over time;

determining, by using the processor, based on the one or more changes in the energy density of the signal over time, a warping function configured to enable identification of characteristics of the signal corresponding to the non-physiological component;

stretching or compressing along a time scale, by using the processor, the signal having the physiological component and the non-physiological component by using the warping function to produce a warped signal;

stretching or compressing along a time scale, by using the processor, a signal quality indicator by using the warping function to produce a warped signal quality indicator;

analyzing, by using the processor, the warped signal and the warped signal quality indicator;

identifying, by using the processor, the non-physiological component of the signal based on the analysis of the warped signal and the warped signal quality indicator; and

using the physiological component of the signal and disregarding the non-physiological component of the signal to determine the physiological parameter.

10. The method, as set forth in claim **9**, wherein analyzing the warped signal and the warped signal quality indicator comprises analyzing the two signals in a common time scale.

11. The method, as set forth in claim **10**, wherein analyzing the warped signal and the warped signal quality indicator comprises cross-correlating the two signals.

12. The method, as set forth in claim **11**, wherein identifying the non-physiological component comprises determining whether a cross-correlation of the two signals indicates a non-physiological component.

13. The method, as set forth in claim **12**, wherein the non-physiological component is identifiable based on whether a portion of the cross-correlation surpasses a threshold.

14. The method, as set forth in claim **9**, wherein identifying the non-physiological signal component comprises comparing a scalogram of the warped signal with a scalogram of the warped signal quality indicator.

15. A pulse oximetry system, comprising:

data processing circuitry configured to:

analyze a three dimensional time-frequency representation of a signal comprising a physiological component and a non-physiological component to determine one or more changes in the energy density of the signal over time, to determine, based on the one or more changes in the energy density of the signal over time, a warping operator configured to enable identification of the non-physiological component;

warp the signal, via the processor, with the warping operator to produce a warped signal;

warp a signal quality indicator, via the processor, with the warping operator to produce a warped signal quality indicator;

identify the non-physiological component of the signal based on a comparison of the warped signal and the warped signal quality indicator; and

determine a physiological parameter by disregarding the non-physiological component of the signal and by using the physiological component of the signal.

16. The pulse oximetry system of claim **15**, wherein the signal comprises a plethysmographic signal or a spectrogram corresponding to the plethysmographic signal.

17. The pulse oximetry system of claim **15**, wherein the data processing circuitry is further configured to warp a signal quality indicator with the warping operator to produce a warped signal quality indicator.

18. The pulse oximetry system of claim **17**, wherein the data processing circuitry is configured to compare the warped signal and the warped signal quality indicator to identify the non-physiological component of the signal.

19. The pulse oximetry system of claim **15**, wherein the warping operator comprises an operator for stretching the signal along the time scale or a compressing operator for compressing the signal along the time scale.

20. The pulse oximetry system of claim **15**, comprising a display on which the data processing circuitry displays an indication of the type or presence of the identified non-physiological component.

21. The method, as set forth in claim **1**, wherein analyzing the energy density of the signal comprises characterizing the signal over a time-frequency plane to generate a three dimensional time-frequency representation of the signal, and analyzing the three dimensional time-frequency representation of the signal to determine the spectral density of the signal with respect to time and frequency.

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[标]申请(专利权)人(译)	内尔科尔普里坦贝内特公司		
申请(专利权)人(译)	NELLCOR PURITAN BENNETT LLC		
当前申请(专利权)人(译)	COVIDIEN LP		
[标]发明人	MCKENNA EDWARD M PETERS DANIEL JON		
发明人	MCKENNA, EDWARD M. PETERS, DANIEL JON		
IPC分类号	A61B5/02 A61B5/00 A61B5/1455		
CPC分类号	A61B5/14551 A61B5/6829 A61B5/6838 A61B5/6816 A61B5/6826 A61B5/7221 A61B5/726 A61B5/7264 A61B5/7207 A61B5/7203		
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摘要(译)

提供了使用时频变形来分析生理信号的方法和系统。一个实施例包括基于信号的能量密度将翘曲算子应用于生理信号。可以分析变形的生理信号以确定是否存在非生理信号分量。此外，可以将相同的变形操作符应用于信号质量指示符，并且可以基于变形的信号质量指示符来分析变形的生理信号。可以基于生理信号与信号质量指示符的比较来识别非生理信号分量或非生理噪声源的类型。还可以基于已知噪声函数的神经网络来识别非生理信号分量。在一些实施例中，可以去除非生理信号分量以提高估计生理参数的准确度。