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(54) **BLIND SOURCE SEPARATION OF PULSE OXIMETRY SIGNALS**

TRENNUNG VON BLINDQUELLEN VON PULSOXIMETRIESIGNALEN

SEPARATION DE SOURCES EN AVEUGLE DE SIGNAUX D'OXIMETRIE PULSEE

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US-A- 5 349 953**

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to the processing of signals obtained from a medical diagnostic apparatus such as a pulse oximeter using a blind source separation technique to separate the obtained data without prior knowledge of its magnitude or frequency into data corresponding to the desired physiological data and the undesired interference sources.

[0002] A typical pulse oximeter measures two physiological parameters, percent oxygen saturation of arterial blood hemoglobin (SpO_2 or sat) and pulse rate. Oxygen saturation can be estimated using various techniques. In one common technique, the photocurrent generated by the photo-detector is conditioned and processed to determine the ratio of modulation ratios (ratio of ratios) of the red to infrared signals. This modulation ratio has been observed to correlate well to arterial oxygen saturation. The pulse oximeters and sensors are empirically calibrated by measuring the modulation ratio over a range of in vivo measured arterial oxygen saturations (SaO_2) on a set of patients, healthy volunteers, or animals. The observed correlation is used in an inverse manner to estimate blood oxygen saturation (SpO_2) based on the measured value of modulation ratios of a patient. The estimation of oxygen saturation using modulation ratios is described in U.S. Patent No. 5,853,364, entitled "METHOD AND APPARATUS FOR ESTIMATING PHYSIOLOGICAL PARAMETERS USING MODEL-BASED ADAPTIVE FILTERING", issued December 29, 1998, and U.S. Patent No. 4,911,167, entitled "METHOD AND APPARATUS FOR DETECTING OPTICAL PULSES", issued March 27, 1990. The relationship between oxygen saturation and modulation ratio is further described in U.S. Patent No. 5,645,059, entitled "MEDICAL SENSOR WITH MODULATED ENCODING SCHEME," issued July 8, 1997. Most pulse oximeters extract the plethysmographic signal having first determined saturation or pulse rate, both of which are susceptible to interference.

[0003] A challenge in pulse oximetry is in analyzing the data to obtain a reliable measure of a physiologic parameter in the presence of large interference sources. Prior art solutions to this challenge have included methods that assess the quality of the measured data and determine to display the measured value when it is deemed reliable based upon a signal quality. Another approach involves a heuristic-based signal extraction technology, where the obtained signals are processed based on a series of guesses of the ratio, and which require the algorithm to start with a guess of the ratio, which is an unknown. Both the signal-quality determining and the heuristic signal extraction technologies are attempts at separating out a reliable signal from an unreliable one, one method being a phenomenological one and the other being a heuristic one.

[0004] On the other hand, a problem encountered in such disciplines as statistics, data analysis, signal processing, and neural network research, is finding a suitable representation of multivariate data. One such suite of methods is generally known as Independent Component Analysis (ICA), which is an approach to the problem of Blind Source Separation (BSS).

[0005] In general terms, the goal of blind source separation in signal processing is to recover independent source signals after they are linearly mixed by an unknown medium, and recorded or measured at N sensors. The blind source separation has been studied by researchers in speech processing or voice processing; antenna array processing; neural network and statistical signal processing communities (e.g. P. Comon, "Independent Component Analysis, a New Concept?", Signal Processing, vol. 36. no. 3, (April 1994), pp. 287-314, "Comon") and applied with relative degrees of success to electroencephalogram data and functional MRI imaging.

[0006] Comon defined the concept of independent component analysis as maximizing the degree of statistical independence among outputs using "contrast" functions of higher-order cumulants. Higher-order statistics refer to the expectations of products of three or more signals (e.g. 3rd-order or 4th-order moments), and cumulants are functions of the moments which are useful in relating the statistics to those of the Gaussian distribution. The 3rd-order cumulant of a distribution is called a skew, and the 4th-order cumulant is the kurtosis. A contrast function is any non-linear function which is invariant to permutation and scaling matrices, and attains its minimum value in correspondence of the mutual independence among the output components. In contrast with decorrelation techniques such as Principal Component Analysis (PCA), which ensures that output pairs are uncorrelated, ICA imposes the much stronger criterion that the multivariate probability density function of output variables factorizes. Finding such a factorization requires that the mutual information between all variable pairs go to zero. Mutual information depends on all higher-order statistics of the output variables while decorrelation normally only takes account of 2nd-order statistics.

[0007] While the general use of ICA as a means of blindly separating independent signal sources is known, the method poses unique challenges to its implementation in pulse oximetry. For instance, the mixture signals may not be exactly a linear combination of the pulse signal and sources of interference. Also, most ICA techniques are based on fourth-order cumulants, as the signals and noise commonly encountered in communications have zero third-order cumulant (skew), and cumulants of higher than fourth order are difficult to estimate accurately.

[0008] Several ICA methods are known for separating unknown source signals from sets of mixture signals, where the mixture signals are a linear combination of the source signals. As used in pulse oximetry, the mixture signals refer

to signals measured at multiple wavelengths. Source components refer to the desired physiologic data including signals corresponding to the plethysmographic signal obtained at multiple wavelengths in addition to undesired interference data, which may be caused by motion, light interference, respiratory artifacts, and other known sources of errors in pulse oximetry. Document US-A-5 349 953 discloses a method of collecting photoplethysmographic data.

[0009] There is therefore a need to apply blind source separation techniques to the field of pulse oximetry to be able to deterministically separate a source signal from various interference sources.

BRIEF SUMMARY OF THE INVENTION

[0010] The present invention is directed towards a method and apparatus for the application of Blind Source Separation (BSS), specifically Independent Component Analysis (ICA) to pulse oximetry. ICA refers to any one of several methods for separating unknown source signals from a set of "mixture" signals, which are linear combinations of the source signals. These methods may use estimates of the second- and higher-order joint statistics of the mixture signals and separate the sources by seeking to minimize the mutual information of the outputs of separation. In pulse oximetry, the signals measured at different wavelengths represent the mixture signals, while the plethysmographic signal, motion artifact, respiratory artifact and instrumental noise represent the source components.

[0011] In one embodiment the BSS is carried out by a two-step method including PCA and a higher-order decorrelation. In the first step, the method uses PCA as a preprocessing step, and in a second step, the principal components are then used to derive the independent components and the desired physiological parameters. The PCA is performed to transform the data to have zero second-order correlation before higher-order decorrelation.

[0012] In one aspect of the method of the present invention, data corresponding to a plurality of signals measured at a plurality of wavelengths are first obtained. Next, the data are processed to obtain a plurality of principal components, where in one embodiment the principal components are obtained by decorrelating the data (to minimize the cross-correlation between the signals from different wavelengths), and normalizing the decorrelated data. Next, the principal components are processed to obtain a plurality of independent components, wherein a matrix of the plurality of signals corresponds with a matrix product of a matrix of the plurality of independent components and a matrix of mixing coefficients. In one embodiment, the independent components are obtained by higher-order decorrelation of the principal components, and where the higher-order decorrelation of the principal components is achieved by minimizing a function of the higher-order cross-correlation of the data or equivalently by maximizing a function of the higher-order cumulants of the plurality of mixture signals. Since the skew of the time-derivative of the pulse signal is generally much greater in magnitude than that of interference, performance of the ICA may be enhanced by using a "contrast" function that was derived from the third-order cumulants of the derivatives of the signals.

[0013] In an aspect of the method of the present invention directed towards a pulse oximeter measuring signals at multiple wavelengths, a first independent component corresponds with a plethysmographic signal, a second independent component corresponds with the interference sources, and sat may be determined from a ratio of mixing coefficients from the mixing matrix. In pulse oximetry, the technique provides the advantage of extracting the plethysmographic signal in the presence of large motion interference and especially without requiring prior knowledge of saturation or pulse rate.

[0014] For a further understanding of the nature and advantages of the invention, reference should be made to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Fig. 1 is a block diagram of an exemplary pulse oximeter.

[0016] Fig. 2 is a flow chart of an embodiment of the method of the present invention.

[0017] Fig. 3 is a graph showing a typical pulse oximetry signals at two wavelengths.

[0018] Fig. 4 is a graph showing the typical pulse oximetry signals at two wavelengths after PCA processing.

[0019] Fig. 5 is a graph showing a typical pulse oximetry signals at two wavelengths after ICA processing.

[0020] Fig. 6 is a graph of signals of Fig. 3 plotted against one another.

[0021] Fig. 7 is a graph of the principal components of Fig. 3 plotted against one another.

[0022] Fig. 8 is a graph of the independent components of Fig. 3 plotted against one another.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The present invention is directed towards the application of Blind Source Separation (BSS), specifically Independent Component Analysis (ICA) to pulse oximetry. ICA refers to any one of several methods for separating unknown source signals from a set of "mixture" signals, which are linear combinations of the source signals. The ICA method as embodied by the present invention, uses estimates of the second- and higher-order joint statistics of the mixture signals

and separates the sources by seeking to minimize the mutual information of the outputs of separation. In pulse oximetry, the signals measured at different wavelengths represent the mixture signals, while the plethysmographic signal, motion artifact, respiratory artifact and instrumental and environmental noise represent the source components.

[0024] In one embodiment, the BSS is carried out by a two-step method including an ICA. In the first step, the method uses Principal Component Analysis (PCA) as a preprocessing step, and the Principal Components are then used to derive sat and Independent Components, where the Independent Components are determined in the second step. Before describing the BSS methods of the present invention an example of a pulse oximeter, which may be configured to practice the method of the present invention is described below.

[0025] FIG. 1 is a block diagram of one embodiment of a pulse oximeter implementing the present invention. Light from light source 110 passes into patient tissue 112, and is scattered and detected by photodetector 114. A sensor 100 containing the light source and photodetector may also contain an encoder 116 which provides signals indicative of the wavelength of light source 110 to allow the oximeter to select appropriate calibration coefficients for calculating oxygen saturation. Encoder 116 may, for instance, be a resistor.

[0026] Sensor 100 is connected to a pulse oximeter 120. The oximeter includes a microprocessor 122 connected to an internal bus 124. Also connected to the bus is a RAM memory 126 and a display 128. A time processing unit (TPU) 130 provides timing control signals to light drive circuitry 132 which controls when light source 110 is illuminated, and if multiple light sources are used, the multiplexed timing for the different light sources. TPU 130 also controls the gating-in of signals from photodetector 114 through an amplifier 133 and a switching circuit 134. These signals are sampled at the proper time, depending upon which of multiple light sources is illuminated, if multiple light sources are used. The received signal is passed through an amplifier 136, a low pass filter 138, and an analog-to-digital converter 140. The digital data is then stored in a queued serial module (QSM) 142, for later downloading to RAM 126 as QSM 142 fills up. In one embodiment, there may be multiple parallel paths of separate amplifier filter and A/D converters for multiple light wavelengths or spectrums received.

[0027] Based on the value of the received signals corresponding to the light received by photodetector 114, microprocessor 122 will calculate the oxygen saturation using various algorithms. These algorithms require coefficients, which may be empirically determined, corresponding to, for example, the wavelengths of light used. These are stored in a ROM 146. The particular set of coefficients chosen for any pair of wavelength spectrums is determined by the value indicated by encoder 116 corresponding to a particular light source in a particular sensor 100. In one embodiment, multiple resistor values may be assigned to select different sets of coefficients. In another embodiment, the same resistors are used to select from among the coefficients appropriate for an infrared source paired with either a near red source or far red source. The selection between whether the near red or far red set will be chosen can be selected with a control input from control inputs 154. Control inputs 154 may be, for instance, a switch on the pulse oximeter, a keyboard, or a port providing instructions from a remote host computer. Furthermore any number of methods or algorithms may be used to determine a patient's pulse rate, oxygen saturation or any other desired physiological parameter. One such method, namely Blind Source Separation, is described below.

[0028] Blind Source Separation refers to the separation of signals given only linear combinations of those signals, such that:

$$\mathbf{x}(t) = \mathbf{A} \mathbf{s}(t)$$

where $\mathbf{x}(t)$ is a matrix of a set of observed signals (mixed signals), $x_1(t) \dots x_n(t)$,

$\mathbf{A}$ is an unknown mixing matrix,

and $\mathbf{s}(t)$ is a set of source signals $s_1(t) \dots s_m(t)$,

assumed to be statistically independent, i.e.

$$p(\mathbf{s}) = p(s_1, \dots, s_m) = \prod_{i=1}^m p_i(s_i)$$

where $p(\mathbf{s})$ is the probability distribution function of $\mathbf{s}$.

[0029] As described above, in pulse oximetry, the mixture signals correspond with signals obtained by a pulse oximeter sensor, which include both the desired signal and the undesired noise components. In one embodiment of the method of the present invention, the mixture signals are first preprocessed using PCA to transform the mixture signal to principal components. To more fully separate the signal and the noise, the data are further processed: in mathematical terms, the data are rotated. In other words, the ICA processing includes a combination of PCA and rotation.

[0030] A criterion for determining the degree of signal-noise separation is statistical independence, as described above. However, since the probability distributions are not known, the challenge of an ICA algorithm becomes the measurement of statistical independence. A measure of statistical independence is the degree of mutual information, such that by minimizing the degree of mutual information between sets of data, independent components can be determined. Algorithms determining the mutual information are generally too complicated for a direct solution of its (i.e. mutual information) minimum, and thus they lend themselves best to iterative methods. For example, one possible approach would be to search for coefficients of the mixing matrix A that would lead to statistical independence (by minimizing the data set's mutual information). One could heuristically sweep through a large range of angles about which to rotate the principal components, which would yield an independent set of data, but this approach would be excessively time-consuming.

[0031] Thus the inventor of the present invention proposes separating the data by performing higher-order decorrelation of the data, or by removing the higher-order correlation of the data obtained from the mixture signals. Thus, the BSS-based method of the present invention: (1) uses PCA to find uncorrelated components, and (2) separates the data by removing higher-order correlation to find the independent components corresponding with the desired signal source(s) and the undesired noise sources. And as used herein, higher-order correlations are higher than second-order correlations, such as third-order and fourth-order cross-correlations. In one embodiment, independence is approximated by minimizing the sum of the squares of the third-order correlations r_{xxy} and r_{xyy} , e.g.,

$$r_{xxy} = \sum_i x_i^2 y_i \text{ and } r_{xyy} = \sum_i x_i y_i^2$$

[where x and y have zero mean]

[0032] Alternately, independence is approximated by minimizing the sum of the squares of the fourth-order cross-cumulants.

[0033] In certain embodiments of the present invention, separation is achieved by maximizing the sum of the squares of the higher-order cumulants, which is equivalent to minimizing the sum of the squares of the higher-order cross-cumulants. In these and other embodiments, the second-order decorrelation and higher-order decorrelation may be effected simultaneously through an iterative, adaptive process.

[0034] The advantage of achieving separation by higher-order decorrelation is that it enables direct formulas and simple algorithms for the separation of data into its independent components.

[0035] Fig. 2 is a flow chart 200 of an embodiment the method of the present invention as applied to signals obtained by a pulse oximeter sensor. First, (step 210) a plurality of signals measured at various wavelengths are obtained by a pulse oximeter sensor. In a typical pulse oximeter, emitting optical energy at two wavelengths, the photocurrent generated by the photo-detector is conditioned and processed to determine the modulation ratios of the red and infrared signals. The example of a two-wavelength pulse oximeter is for illustration purposes only, and is not meant to limit the scope of the present invention. The detected photocurrents include the mixture signals, where the mixture signals include the plethysmographic signal, motion artifact, respiratory artifact and instrument noise. An example plot of the measured photocurrent is shown on Fig. 3. Fig. 3 shows a plot 300 of the photocurrent vs. time for measurements obtained at 595 nm (310) and at 665 nm (320). As can be seen from this figure (Fig. 3), both signals (310 and 320) show a low amplitude section and a high amplitude section, where the high amplitude section corresponds to the signals measured while the sensor is moving.

[0036] Next, (step 220) the mixture signals are processed using PCA analysis to obtain two principal components. Here, the PCA processing results in the determination of two principal components, since the original mixture signals were obtained at two different wavelengths. Embodiments of the present invention are not limited to two mixture signals or two principal components. The embodiments of the present invention are directed to the decomposition of a matrix of a set of observed signals (mixed signals) into a set of source signals and a mixing matrix, as set forth above. However, describing more than two dimensions and visualizing more dimensions is at best difficult to visualize, hence the description provided herein is kept to a two-dimensional one. In one embodiment, the Singular Value Decomposition algorithm is used to obtain the principal components. In one alternate embodiment, the data are multiplied by the inverse of the square root of the covariance matrix. In another embodiment directed to a two wavelengths approach, for each possible pair of wavelengths, the data are rotated by the angle of the best linear fit between those two signals. Fig. 4 shows a plot 400 of the two principal components. As can be seen from this figure (Fig. 4), the first principal component 410 corresponds more with the noise due to the subject's motion, since it has a low amplitude portion, which is followed by a high amplitude portion. Fig. 4 also shows that the second principal component 420 corresponds less with the noise due to the subject movement, since it does not show a distinct high amplitude portion.

[0037] Furthermore, a comparison of Figs. 6 and 7 shows that while the original mixture signals are not decorrelated,

the principal components are decorrelated. Fig. 6 shows a graph of the photocurrent at 655 nm vs. the photocurrent at 595 nm. As can be seen from this figure (Fig. 6), there is a wealth of mutual information between the two photocurrents, since the data from the two photocurrents appear to be aligned along the positively sloping diagonal line A-A. Fig. 7 shows a plot of principal component 2 vs. principal component 1. A review of this figure (Fig. 7) shows that the principal components are decorrelated, since there is no significant linear fit to the data in these coordinates.

[0038] In an alternate embodiment, before the processing according to step 220, the time derivatives of the signals are obtained. For pulse oximetry, the third-order correlations of the pulse signals are often enhanced by taking the time derivative of the signals before performing PCA/ICA analyses.

[0039] Having decorrelated the data, the principal components are further processed by ICA processing to determine the independent components describing the photocurrent data (step 230). As described above, the principal components are processed to obtain a plurality of independent components, wherein a matrix of the plurality of signals corresponds with a matrix product of a matrix of the plurality of independent components and a matrix of mixing coefficients. In one embodiment, the independent components are determined by decorrelating the data by maximizing the sum of squares of the data set's higher-order cumulants. Since the skew of the time-derivative of the pulse signal is generally much greater in magnitude than that of interference, the ICA performance is enhanced by using a "contrast" function that was derived from the third-order cumulants of the derivatives of the signals. As stated above, a contrast function is any non-linear function which is invariant to permutation and scaling matrices, and attains its minimum value in correspondence of the mutual independence among the output components. In an alternate embodiment, the independent components are determined by minimizing the estimated mutual information. Fig. 5 shows a plot 500 of the two independent components. As can be seen from this figure (Fig. 5), a first independent component 510 corresponds more with the noise due to the subject's motion, since it has a low amplitude portion, which is followed by a high amplitude portion. Fig. 5 also shows that a second principal component 520 apparently corresponds to a pulse component. Furthermore, Fig. 8 shows a plot of independent component 2 vs. independent component 1. As can be seen from this figure (Fig. 8), the plot of independent component 2 vs. independent component 1 lies along the horizontal line at (independent component = 0) B-B, showing that the data sets have a minimal amount of mutual information, and thus can be approximated as independent data sets.

[0040] The decomposed data set of two independent components is further processed as follows. In one embodiment, sat is obtained from a ratio of mixing coefficients (step 240). In an alternate embodiment, one of the independent components is further processed to obtain the plethysmographic signal (step 250), and the other independent signal is recognized as a measure of the interference signal (step 260).

[0041] Alternately, instead of, or in addition to taking signals that are measured at different wavelengths (step 210), signals are also obtained that are additions of signals from different times, thus an alternate embodiment of the present invention starts by processing signals obtained from mixing signals in time.

[0042] In pulse oximetry, embodiments of the present invention have the advantage of extracting the plethysmographic signal in the presence of large motion interference and especially without requiring prior knowledge of saturation or pulse rate. Additionally, the present method is extendible to measurement of other physiological variables, such as pulse rate, blood pressure, temperature, or any other physiological variable measurable by non-invasive measurement of photocurrent provided an optical-based sensor.

[0043] Accordingly, as will be understood by those of skill in the art, the present invention which is related to blind source separation of pulse oximetry signals, may be embodied in other specific forms without departing from the essential characteristics thereof. Accordingly, the foregoing disclosure is intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the following claims.

Claims

1. A method for measuring a physiological parameter by means of a pulse oximeter, comprising:

measuring a plurality of signals (210; 310, 320), wherein each of said signals (310, 320) comprises a source component corresponding to said physiological parameter and an interference component;
 processing said plurality of signals (220; 310, 320) to obtain a plurality of principal components (410, 420);
 processing said plurality of principal components (230; 510, 520) to obtain a plurality of independent components (510, 520), wherein a matrix of said plurality of signals corresponds to a matrix product of a matrix of said plurality of independent components and a matrix of mixing coefficients; and
 extracting a first measure (240) of said physiological parameter corresponding to said source component from one of said plurality of independent components (510, 520), wherein said plurality of signals (310, 320) corresponds to sensed optical energies from a plurality of wavelengths.

2. The method of claim 1 wherein said physiological parameter is a function of an oxygen saturation.
3. The method of claim wherein said physiological parameter is a function of a pulse rate.
- 5 4. The method of claim 1 wherein said plurality of signals (310, 320) corresponds to sensed optical energies from a plurality of wavelengths.
5. The method of claim 1 wherein said plurality of signals (310, 320) corresponds to sensed optical energies from a plurality of wavelengths from different times.
- 10 6. The method of claim 1 wherein said processing said plurality of signals (310, 320) further comprises obtaining a time derivative of the sensed optical energies from a plurality of wavelengths.
- 15 7. The method of claim wherein said interference component comprises signal components caused by motion, respiratory artifact, ambient light, optical scattering and other interference between a tissue location being sensed and a sensor (110).
8. The method of claim 1 wherein said processing said plurality of signals (310, 320) further comprises decorrelating said plurality of signals by minimizing a cross-correlation of said plurality of signals (310, 320), to obtain a plurality of decorrelated signals; and
20 normalizing said plurality of decorrelated signals to obtain a plurality of principal components (410, 420).
9. The method of claim. 1 wherein said processing said plurality of signals (310, 320) comprises decorrelating said plurality of signals (310, 320) by singular-value decomposition of said plurality of signals (310, 320), to obtain a plurality of principal components (410, 420).
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10. The method of claim wherein said processing said plurality of signals (310, 320) comprises decorrelating said plurality of signals (310, 320) by multiplying said plurality of signals by the inverse square root of the covariance matrix of said plurality of signals to obtain a plurality of principal components (410, 420).
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11. The method of claim 1 wherein said processing of said plurality of principal components (410, 420) comprises higher-order decorrelation of said plurality of principal components (410, 420).
12. The method of claim 1 wherein said processing said plurality of principal components (410, 420) comprises maximizing a function of the higher-order cumulants of a mixture of said plurality of signal, thus separating said source component from said interference component.
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13. The method of claim 12 wherein said higher-order cumulant is cumulant having order greater than two.
14. The method of claim 12 wherein said higher-order cumulant is a third- order cumulant of said plurality of signals.
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15. The method of claim 12 wherein said higher-order cumulant is a fourth-order cumulant of said plurality of signals.
16. The method of claim 1 further comprising obtaining a ratio of mixing coefficients from said matrix of mixing coefficients, wherein said ratio corresponds to a ratio of modulation ratios of red to infrared signals, wherein said plurality of signals (310, 320) comprise modulated optical signal in the red and infrared ranges.
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17. The method of claim 1 further comprising extracting a second measure of said physiological parameter from said ratio, wherein said second measure of said physiological parameter corresponds to an oxygen saturation.
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18. The method of claim 1 wherein said first measure of a physiological Parameter corresponds to a pulse rate.
19. the method of claim 1 further comprising extracting said interference component from another one of said plurality of independent components (510, 520).
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20. A pulse oximeter for measuring physiological parameter comprising:

a sensor (110) configured for measuring a plurality of signals (310, 320), wherein each of said signals (310,

320) comprises a source component corresponding to said physiological parameter and an interference component:

a computer useable medium having computer readable code embodied therein for measuring a physiological parameter, said computer readable code configured to execute functions comprising:

processing said plurality of signals (310, 320) to obtain a plurality of principal components (410, 420);
processing said plurality of principle components (410, 420) to obtain a plurality of independent components (510, 520), wherein a matrix of said plurality of signals (310, 320) corresponds to a matrix product of a matrix of said plurality of independent components (510, 520) and a matrix of mixing coefficients; and
extracting a first measure of said physiological parameter corresponding to said source component from one of said plurality of independent components (510, 520).

21. The pulse oximeter of claim 20 wherein said physiological parameter is an oxygen saturation.

22. The pulse oximeter of claim 20 wherein said physiological parameter is a pulse rate.

23. The pulse oximeter of claim 20 wherein said plurality of signals corresponds to sensed optical energies from a plurality of wavelengths.

24. The pulse oximeter of claim 20 wherein said plurality of signals corresponds to sensed optical energies from a plurality of wavelengths from different times.

25. The pulse oximeter of claim 20 wherein said plurality of signals corresponds to the time derivative of the sensed optical energies from a plurality of wavelengths.

26. The pulse oximeter of claim 20 wherein said interference component comprises signal components caused by motion, respiratory artifact, ambient light, optical scattering and other interference between a tissue location being sensed and a sensor (110).

27. The pulse oximeter of claim 20 wherein said processing said plurality of signals (310, 320) comprises decorrelating said plurality of signals by minimizing a cross-correlation of said plurality of signals, to obtain a plurality of decorrelated signals; and
normalizing said plurality of decorrelated signals to obtain a plurality of principal components (410, 420).

28. The pulse oximeter of claim 20 wherein said processing said plurality of signals (310, 320) comprises decorrelating said plurality of signals by singular-value decomposition of said plurality of signals (310, 320), to obtain a plurality of principal components (410, 420).

29. The pulse oximeter of claim 20 wherein said processing said plurality of signals (410, 420) comprises decorrelating said plurality of signals by multiplying said plurality of signals (310, 320) by the inverse square root of the covariance matrix of said plurality of signals to obtain a plurality of principal components (410, 420).

30. The pulse oximeter of claim 20 wherein said processing of said plurality of principal components (410, 420) comprises higher-order decorrelation of said plurality of principal components (410, 420).

31. The pulse oximeter of claim 20 wherein said processing said plurality of principal components (410, 420) comprises maximizing a function of the higher-order cumulants of a mixture of said plurality of signals (310, 320), thus separating said source component from said interference component.

32. The pulse oximeter of claim 31 wherein said higher-order cumulant is cumulant having order greater than two.

33. The pulse oximeter of claim 31 wherein said higher-order cumulant is a third-order cumulant of said plurality of signals (310, 320).

34. The pulse oximeter of claim 31 wherein said higher-order cumulant is a fourth-order cumulant of said plurality of signals (310, 320).

35. The pulse oximeter of claim 20 wherein said processing said plurality of principal components comprises successive transformations to simultaneously minimize second-and higher-order correlations among the outputs.
- 5 36. The pulse oximeter of claim 20 wherein said processing said plurality of principal components (410, 420) comprises successive rotations to minimize estimated mutual information among the outputs.
37. The pulse oximeter of claim 20 further comprising obtaining a ratio of mixing coefficients from said matrix of mixing coefficients, wherein said ratio corresponds to a ratio of modulation ratios of red to infrared signal.
- 10 38. The pulse oximeter of claim 20 further comprising extracting a second measure of said physiological parameter from said ratio, wherein said second measure of said physiological parameter corresponds to an oxygen saturation.
39. The pulse oximeter of claim 20 wherein said first measure of a physiological parameter corresponds a pulse rate.
- 15 40. The pulse oximeter of claim 20 further comprising extracting said interference component from another one of said plurality of independent components (510, 520).

Patentansprüche

- 20 1. . Verfahren zum Messen eines physiologischen Parameters mittels eines Pulsoxymeters, umfassend:
- Messen einer Mehrzahl von Signalen (210; 310, 320), wobei jedes der Signale (310, 320) eine Quellkomponente entsprechend dem physiologischen Parameter und eine Interferenzkomponente umfasst;
- 25 Verarbeiten der Mehrzahl von Signalen (220; 310, 320), um eine Mehrzahl von Hauptkomponenten (410, 420) zu erhalten;
- Verarbeiten der Mehrzahl von Hauptkomponenten (230; 510, 520), um eine Mehrzahl von unabhängigen Komponenten (510, 520) zu erhalten, wobei eine Matrix der Mehrzahl von Signalen einem Matrixprodukt einer Matrix der Mehrzahl von unabhängigen Komponenten und einer Matrix von Mischkoeffizienten entspricht; und
- 30 Extrahieren eines ersten Maßes (240) des physiologischen Parameters entsprechend der Quellkomponente von einer der Mehrzahl von unabhängigen Komponenten (510, 520), wobei die Mehrzahl von Signalen (310, 320) erfassten optischen Energien von einer Mehrzahl von Wellenlängen entspricht.
- 35 2. . Verfahren nach Anspruch 1, bei welchem der physiologische Parameter eine Funktion einer Sauerstoffsättigung ist.
3. . Verfahren nach Anspruch 1, bei welchem der physiologische Parameter eine Funktion einer Pulsrate ist.
- 40 4. . Verfahren nach Anspruch 1, bei welchem die Mehrzahl von Signalen (310, 320) erfassten optischen Energien von einer Mehrzahl von Wellenlängen entspricht.
5. . Verfahren nach Anspruch 1, bei welchem die Mehrzahl von Signalen (310, 320) erfassten optischen Energien von einer Mehrzahl von Wellenlängen von verschiedenen Zeiten entspricht.
- 45 6. . Verfahren nach Anspruch 1, bei welchem das Verarbeiten der Mehrzahl von Signalen (310, 320) ferner das Erhalten einer Zeitableitung der erfassten optischen Energien von einer Mehrzahl von Wellenlängen umfasst.
7. . Verfahren nach Anspruch 1, bei welchem die Interferenzkomponente Signalkomponenten umfasst, die durch Bewegung, Atmungsartefakt, Umgebungslicht, optische Streuung und andere Interferenz zwischen einem zu erfassenden Gewebeort und einem Sensor (110) verursacht werden.
- 50 8. . Verfahren nach Anspruch 1, bei welchem das Verarbeiten der Mehrzahl von Signalen (310, 320) ferner das Entkorrelieren der Mehrzahl von Signalen durch Minimieren einer Kreuzkorrelation der Mehrzahl von Signalen (310, 320) umfasst, um eine Mehrzahl von entkorrelierten Signalen zu erhalten; und
- Normalisieren der Mehrzahl von entkorrelierten Signalen, um eine Mehrzahl von Hauptkomponenten (410, 420) zu erhalten.
- 55 9. . Verfahren nach Anspruch 1, bei welchem das Verarbeiten der Mehrzahl von Signalen (310, 320) das Entkorrelieren der Mehrzahl von Signalen (310, 320) durch Singulärwertzerlegung der Mehrzahl von Signalen (310, 320) umfasst,

um eine Mehrzahl von Hauptkomponenten (410, 420) zu erhalten.

10. . Verfahren nach Anspruch 1, bei welchem das Verarbeiten der Mehrzahl von Signalen (310, 320) das Entkorrelieren der Mehrzahl von Signalen (310, 320) durch Multiplizieren der Mehrzahl von Signalen mit der inversen Quadratwurzel der Kovarianzmatrix der Mehrzahl von Signalen umfasst, um eine Mehrzahl von Hauptkomponenten (410, 420) zu erhalten.

11. . Verfahren nach Anspruch 1, bei welchem das Verarbeiten der Mehrzahl von Hauptkomponenten (410, 420) eine Dekorrelation höherer Ordnung der Mehrzahl von Hauptkomponenten (410, 420) umfasst.

12. . Verfahren nach Anspruch 1, bei welchem das Verarbeiten der Mehrzahl von Hauptkomponenten (410, 420) das Maximieren einer Funktion der Summenwerte höherer Ordnung einer Mischung der Mehrzahl von Signalen umfasst, wobei folglich die Quellkomponente von der Interferenzkomponente getrennt wird.

13. . Verfahren nach Anspruch 12, bei welchem der Summenwert höherer Ordnung ein Summenwert mit einer Ordnung größer als Zwei ist.

14. . Verfahren nach Anspruch 12, bei welchem der Summenwert höherer Ordnung ein Summenwert dritter Ordnung der Mehrzahl von Signalen ist.

15. . Verfahren nach Anspruch 12, bei welchem der Summenwert höherer Ordnung ein Summenwert vierter Ordnung der Mehrzahl von Signalen ist.

16. . Verfahren nach Anspruch 1, ferner umfassend das Erhalten eines Verhältnisses von Mischkoeffizienten von der Matrix von Mischkoeffizienten, wobei das Verhältnis einem Verhältnis von Modulationsverhältnissen von roten zu infraroten Signalen entspricht, wobei die Mehrzahl von Signalen (310, 320) modulierte optische Signale in den Bereichen rot und infrarot umfasst.

17. . Verfahren nach Anspruch 1, ferner umfassend das Extrahieren eines zweiten Maßes des physiologischen Parameters von dem Verhältnis, wobei das zweite Maß des physiologischen Parameters einer Sauerstoffsättigung entspricht.

18. . Verfahren nach Anspruch 1, bei welchem das erste Maß eines physiologischen Parameters einer Pulsrate entspricht.

19. . Verfahren nach Anspruch 1, ferner umfassend das Extrahieren der Interferenzkomponente von einer anderen der Mehrzahl von unabhängigen Komponenten (510, 520).

20. . Pulsoxymeter zum Messen eines physiologischen Parameters, umfassend:

einen Sensor (110), konfiguriert zum Messen einer Mehrzahl von Signalen (310, 320), wobei jedes der Signale (310, 320) eine Quellkomponente entsprechend einem physiologischen Parameter und eine Interferenzkomponente umfasst;

ein computemutzbare Medium mit darin verkörpertem computerlesbarem Code zum Messen eines physiologischen Parameters, wobei der computerlesbare Code konfiguriert ist, um Funktionen auszuführen, umfassend:

Verarbeiten der Mehrzahl von Signalen (310, 320), um eine Mehrzahl von Hauptkomponenten (410, 420) zu erhalten;

Verarbeiten der Mehrzahl von Hauptkomponenten (410, 420), um eine Mehrzahl von unabhängigen Komponenten (510, 520) zu erhalten, wobei eine Matrix der Mehrzahl von Signalen (310, 320) einem Matrixprodukt einer Matrix der Mehrzahl von unabhängigen Komponenten (510, 520) und einer Matrix von Mischkoeffizienten entspricht; und

Extrahieren eines ersten Maßes des physiologischen Parameters entsprechend der Quellkomponente von einer der Mehrzahl von unabhängigen Komponenten (510, 520).

21. . Pulsoxymeter nach Anspruch 20, bei welchem der physiologische Parameter eine Sauerstoffsättigung ist.

22. . Pulsoxymeter nach Anspruch 20, bei welchem der physiologische Parameter eine Pulsrate ist.

23. . Pulsoxymeter nach Anspruch 20, bei welchem die Mehrzahl von Signalen erfassten optischen Energien von einer Mehrzahl von Wellenlängen entspricht.
- 5 24. . Pulsoxymeter nach Anspruch 20, bei welchem die Mehrzahl von Signalen erfassten optischen Energien von einer Mehrzahl von Wellenlängen von verschiedenen Zeiten entspricht.
25. . Pulsoxymeter nach Anspruch 20, bei welchem die Mehrzahl von Signalen der Zeitableitung der erfassten optischen Energien von einer Mehrzahl von Wellenlängen entspricht.
- 10 26. . Pulsoxymeter nach Anspruch 20, bei welchem die Interferenzkomponente Signalkomponenten umfasst, die durch Bewegung, Atmungsartefakte, Umgebungslicht, optische Streuung und andere Interferenz zwischen einem zu erfassenden Gewebeort und einem Sensor (110) verursacht werden.
- 15 27. . Pulsoxymeter nach Anspruch 20, bei welchem das Verarbeiten der Mehrzahl von Signalen (310, 320) das Entkorrelieren der Mehrzahl von Signalen durch Minimieren einer Kseuzkorrelation der Mehrzahl von Signalen umfasst, um eine Mehrzahl von entkorrelierten Signalen zu erhalten; und Normalisieren der Mehrzahl von entkorrelierten Signalen, um eine Mehrzahl von Hauptkomponenten (410, 420) zu erhalten.
- 20 28. . Pulsoxymeter nach Anspruch 20, bei welchem das Verarbeiten der Mehrzahl von Signalen (310, 320) das Entkorrelieren der Mehrzahl von Signalen durch Singulärwertzerlegung der Mehrzahl von Signalen (310, 320) umfasst, um eine Mehrzahl von Hauptkomponenten (410, 420) zu erhalten.
- 25 29. . Pulsoxymeter nach Anspruch 20, bei welchem das Verarbeiten der Mehrzahl von Signalen (410, 420) das Entkorrelieren der Mehrzahl von Signalen durch Multiplizieren der Mehrzahl von Signalen (310, 320) mit der inversen Quadratwurzel der Kovarianzmatrix der Mehrzahl von Signalen umfasst, um eine Mehrzahl von Hauptkomponenten (410, 420) zu erhalten.
- 30 30. . Pulsoxymeter nach Anspruch 20, bei welchem das Verarbeiten der Mehrzahl von Hauptkomponenten (410, 420) eine Dekorrelation höher Ordnung der Mehrzahl von Hauptkomponenten (410, 420) umfasst.
- 35 31. . Pulsoxymeter nach Anspruch 20, bei welchem das Verarbeiten der Mehrzahl von Hauptkomponenten (410, 420) das Maximieren einer Funktion der Summenwerte höherer Ordnung einer Mischung der Mehrzahl von Signalen (310, 320) umfasst, wobei folglich die Quellkomponente von der Interferenzkomponente getrennt wird.
32. . Pulsoxymeter nach Anspruch 31, bei welchem der Summenwert höherer Ordnung ein Summenwert mit einer Ordnung größer als Zwei ist.
- 40 33. . Pulsoxymeter nach Anspruch 31, bei welchem der Summenwert höherer Ordnung ein Summenwert dritter Ordnung der Mehrzahl von Signalen (310, 320) ist.
34. . Pulsoxymeter nach Anspruch 31, bei welchem der Summenwert höherer Ordnung ein Summenwert vierter Ordnung der Mehrzahl von Signalen (310, 320) ist.
- 45 35. . Pulsoxymeter nach Anspruch 20, bei welchem das Verarbeiten der Mehrzahl von Hauptkomponenten aufeinander folgende Transformationen umfasst, um simultan Korrelationen zweiter und höherer Ordnung unter den Ausgaben zu minimieren.
- 50 36. . Pulsoxymeter nach Anspruch 20, bei welchem das Verarbeiten der Mehrzahl von Hauptkomponenten (410, 420) aufeinander folgende Rotationen umfasst, um geschätzte wechselseitige Informationen unter den Ausgaben zu minimieren.
- 55 37. . Pulsoxymeter nach Anspruch 20, ferner umfassend das Erhalten eines Verhältnisses von Mischkoeffizienten von der Matrix von Mischkoeffizienten, wobei das Verhältnis einem Verhältnis von Modulationsverhältnissen von roten zu infraroten Signalen entspricht.
38. . Pulsoxymeter nach Anspruch 20, ferner umfassend das Extrahieren eines zweiten Maßes des physiologischen Parameters von dem Verhältnis, wobei das zweite Maß des physiologischen Parameters einer Sauerstoffsättigung

entspricht.

39. . Pulsoxymeter nach Anspruch 20, bei welchem das erste Maß eines physiologischen Parameters einer Pulsrate entspricht.

40. . Pulsoxymeter nach Anspruch 20, ferner umfassend das Extrahieren der Interferenzkomponente von einer anderen der Mehrzahl von unabhängigen Komponenten (510, 520).

Revendications

1. Procédé de mesure d'un paramètre physiologique au moyen d'un oxymètre par impulsion, comprenant :

la mesure d'une pluralité de signaux (210, 310, 320) dans laquelle chacun desdits signaux (310, 320) comprend un composant source correspondant audit paramètre physiologique et un composant d'interférence ;
le traitement de ladite pluralité de signaux (220, 310, 320) pour obtenir une pluralité de principaux composants (410, 420) ;
le traitement de ladite pluralité de principaux composants (230, 510, 520) pour obtenir une pluralité de composants indépendants (510, 520), dans lesquels une matrice de ladite pluralité de signaux correspond à un produit de matrice d'une matrice de ladite pluralité de composants indépendants et une matrice de coefficients de mélange ; et
l'extraction d'une première mesure (240) dudit paramètre physiologique correspondant audit composant source d'une de ladite pluralité de composants indépendants (510, 520), dans lequel ladite pluralité de signaux (310, 320) correspond à des énergies optiques détectées d'une pluralité de longueurs d'onde.

2. Procédé selon la revendication 1 dans lequel ledit paramètre physiologique dépend d'une saturation d'oxygène.

3. Procédé selon la revendication 1, dans lequel ledit paramètre physiologique dépend d'une vitesse d'impulsion.

4. Procédé selon la revendication 1, dans lequel ladite pluralité de signaux (310, 320) correspond à des énergies optiques détectées d'une pluralité de longueurs d'ondes.

5. Procédé selon la revendication 1, dans lequel ladite pluralité de signaux (310, 320) correspond des énergies optiques détectées d'une pluralité de longueurs d'onde provenant de différents moments.

6. Procédé selon la revendication 1, dans lequel ledit traitement de ladite pluralité de signaux (310, 320) comprend en outre l'obtention d'un dérivé de temps des énergies optiques détectées à partir d'une pluralité de longueurs d'ondes.

7. Procédé selon la revendication 1, dans lequel ledit composant d'interférence comprend des composants de signal provoqués par le mouvement, l'artéfact respiratoire, la lumière ambiante, la diffusion optique et d'autres interférences entre un emplacement de tissu détecté et un capteur (110).

8. Procédé selon la revendication 1, dans lequel ledit traitement de ladite pluralité de signaux (310, 320) comprend en outre la décorrélation de ladite pluralité de signaux en minimisant une corrélation croisée de ladite pluralité de signaux (310, 320) pour obtenir une pluralité de signaux décorrélés ; et
la normalisation de ladite pluralité de signaux décorrélés pour obtenir une pluralité de principaux composants (410, 420).

9. Procédé selon la revendication 1, dans lequel ledit traitement de ladite pluralité de signaux (310, 320) comprend la décorrélation de ladite pluralité de signaux (310, 320) par décomposition de valeur individuelle de ladite pluralité de signaux (310, 320), pour obtenir une pluralité de principaux composants (410, 420).

10. Procédé selon la revendication 1, dans lequel ledit traitement de ladite pluralité de signaux (310, 320) comprend la décorrélation de ladite pluralité de signaux (310, 320) en multipliant ladite pluralité de signaux par la racine carrée inverse de la matrice de covariance de ladite pluralité de signaux pour obtenir une pluralité de composants principaux (410, 420).

11. Procédé selon la revendication 1, dans lequel ledit traitement de ladite pluralité de principaux composants (410, 420) comprend une décorrélation d'ordre supérieur de ladite pluralité de principaux composants (410, 420).
- 5 12. Procédé selon la revendication 1, dans lequel ledit traitement de ladite pluralité de principaux composants (410, 420) comprend l'optimisation d'une fonction des cumulants d'ordre supérieur d'un mélange de ladite pluralité de signaux, en séparant donc ledit composant source dudit composant d'interférence.
13. Procédé selon la revendication 12, dans lequel ledit cumulant d'ordre supérieur est un cumulant ayant un ordre
10 supérieur à deux.
14. Procédé selon la revendication 12, dans lequel ledit cumulant d'ordre supérieur est un cumulant de troisième ordre de ladite pluralité de signaux.
15. Procédé selon la revendication 12, dans lequel ledit cumulant d'ordre supérieur est un cumulant de quatrième ordre de ladite pluralité de signaux.
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16. Procédé selon la revendication 1, comprenant en outre l'obtention d'un rapport de coefficients de mélange de ladite
matrice de coefficients de mélange, dans lequel ledit rapport correspond à un rapport de rapports de modulation
de signaux rouges à infrarouges, dans lequel ladite pluralité de signaux (310, 320) comprennent un signal optique
20 modulé dans les gammes rouges et infrarouges.
17. Procédé selon la revendication 1, comprenant en outre l'extraction d'une seconde mesure dudit paramètre physio-
logique dudit rapport, dans lequel ladite seconde mesure dudit paramètre physiologique correspond à une saturation
d'oxygène.
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18. Procédé selon la revendication 1, dans lequel ladite première mesure d'un paramètre physiologique correspond à
une vitesse d'impulsion.
19. Procédé selon la revendication 1, comprenant en outre l'extraction dudit composant d'interférence d'une autre de
ladite pluralité de composants indépendants (510, 520).
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20. Oxymètre d'impulsion pour mesurer un paramètre physiologique, comprenant :

un capteur (110) configuré pour mesurer une pluralité de signaux (310, 320) dans lesquels chacun desdits
35 signaux (310, 320) comprend un composant source correspondant audit paramètre physiologique et un com-
posant d'interférence ;
un système utilisable par ordinateur ayant un code lisible par ordinateur, intégré à l'intérieur pour mesurer un
paramètre physiologique, ledit code lisible par ordinateur étant configuré pour exécuter des fonctions
comprenant :
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le traitement de ladite pluralité de signaux (310, 320) pour obtenir une pluralité de principaux composants
(410, 420) ;
le traitement de ladite pluralité de principaux composants (410, 420) pour obtenir une pluralité de compo-
sants indépendants (510, 520), dans lesquels une matrice de ladite pluralité de signaux (310, 320) corres-
45 pond à un produit matrice d'une matrice de ladite pluralité de composants indépendants (510, 520) et une
matrice de coefficients de mélange; et
l'extraction d'une première mesure dudit paramètre physiologique correspondant audit composant source
d'une desdites pluralités de composants indépendants (510, 520).
- 50 21. Oxymètre par impulsion selon la revendication 20, dans lequel ledit paramètre physiologique est une saturation
d'oxygène.
22. Oxymètre par impulsion selon la revendication 20, dans lequel ledit paramètre physiologique est une vitesse par
impulsions.
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23. Oxymètre par impulsion selon la revendication 20 dans lequel ladite pluralité de signaux correspond à des énergies
optiques détectées à partir d'une pluralité de longueurs d'ondes.

24. Oxymètre par impulsion selon la revendication 20, dans lequel ladite pluralité de signaux correspond à des énergies optiques détectées à partir d'une pluralité de longueurs d'ondes à partir de différents moments.
- 5 25. Oxymètre par impulsion selon la revendication 20, dans lequel ladite pluralité de signaux correspond au dérivé de temps des énergies optiques détectées à partir d'une pluralité de longueurs d'onde.
- 10 26. Oxymètre par impulsion selon la revendication 20, dans lequel ledit composant par interférence comprend des composants de signaux causés par le mouvement, l'artéfact respiratoire, la lumière ambiante, la diffusion optique et d'autres interférences entre un emplacement de tissu détectées et un capteur (110).
- 15 27. Oxymètre par impulsion selon la revendication 20, dans lequel ladite pluralité de signaux (310, 320) comprend la décorrélation de ladite pluralité de signaux en minimisant une corrélation croisée de ladite pluralité de signaux, afin d'obtenir une pluralité de signaux décorrélés ; et normaliser ladite pluralité de signaux décorrélés pour obtenir une pluralité de composants principaux (410, 420).
- 20 28. Oxymètre par impulsion selon la revendication 20, dans lequel ledit traitement de ladite pluralité de signaux (310, 320) comprend la décorrélation de ladite pluralité de signaux par une décomposition de valeur unique de ladite pluralité de signaux (310, 320) pour obtenir une pluralité de principaux composants (410, 420).
- 25 29. Oxymètre par impulsion selon la revendication 20 dans lequel ledit traitement de ladite pluralité de signaux (410, 420) comprend la décorrélation de ladite pluralité de signaux en multipliant ladite pluralité de signaux (310, 320), par la racine carrée inverse de la matrice de covariance de ladite pluralité de signaux pour obtenir une pluralité de principaux composants (410, 420).
- 30 30. Oxymètre par impulsion selon la revendication 20, dans lequel ledit traitement de ladite pluralité de principaux composants (410, 420) comprend une décorrélation d'ordre supérieur de ladite pluralité de principaux composants (410, 420).
- 35 31. Oxymètre par impulsion selon la revendication 20, dans lequel ledit traitement de ladite pluralité de principaux composants (410, 420) comprend l'optimisation d'une fonction des cumulants d'ordre supérieur d'un mélange de ladite pluralité de signaux (310, 320) en séparant donc ledit composant source dudit composant par interférence.
- 40 32. Oxymètre par impulsion selon la revendication 31, dans lequel ledit cumulant d'ordre supérieur est un cumulant ayant un ordre supérieur à deux.
- 45 33. Oxymètre par impulsion selon la revendication 31, dans lequel ledit cumulant d'ordre supérieur est un cumulant de troisième ordre de ladite pluralité de signaux (310, 320).
- 50 34. Oxymètre par impulsion selon la revendication 31, dans lequel ledit cumulant d'ordre supérieur est un cumulant de quatrième ordre de ladite pluralité de signaux (310, 320).
- 55 35. Oxymètre par impulsion selon la revendication 20, dans lequel ledit traitement de ladite pluralité de principaux composants comprend des transformations successives pour minimiser simultanément des corrélations de second ordre et plus parmi les émissions.
36. Oxymètre par impulsion selon la revendication 20, dans lequel ledit traitement de ladite pluralité de principaux composants (410, 420) comprend des rotations successives, afin de minimiser les informations mutuelles estimées parmi les émissions.
37. Oxymètre par impulsion selon la revendication 20, comprenant en outre l'obtention d'un rapport de coefficients de mélange de ladite matrice de coefficients de mélange, dans lequel ledit rapport correspond à un rapport de rapports de modulation de signaux rouges à infrarouges.
38. Oxymètre par impulsion selon la revendication 20, comprenant en outre l'extraction d'une seconde mesure dudit paramètre physiologique depuis ledit rapport, dans lequel ladite seconde mesure dudit paramètre physiologique correspond à une saturation d'oxygène.
39. oxymètre par impulsion selon la revendication 20, dans lequel ladite première mesure d'un paramètre physiologique

correspond à une vitesse d'impulsion.

- 40.** Oxymètre par impulsion selon la revendication 20, comprenant en outre l'extraction dudit composant d'interférence d'une autre de ladite pluralité de composants indépendants (510, 520).

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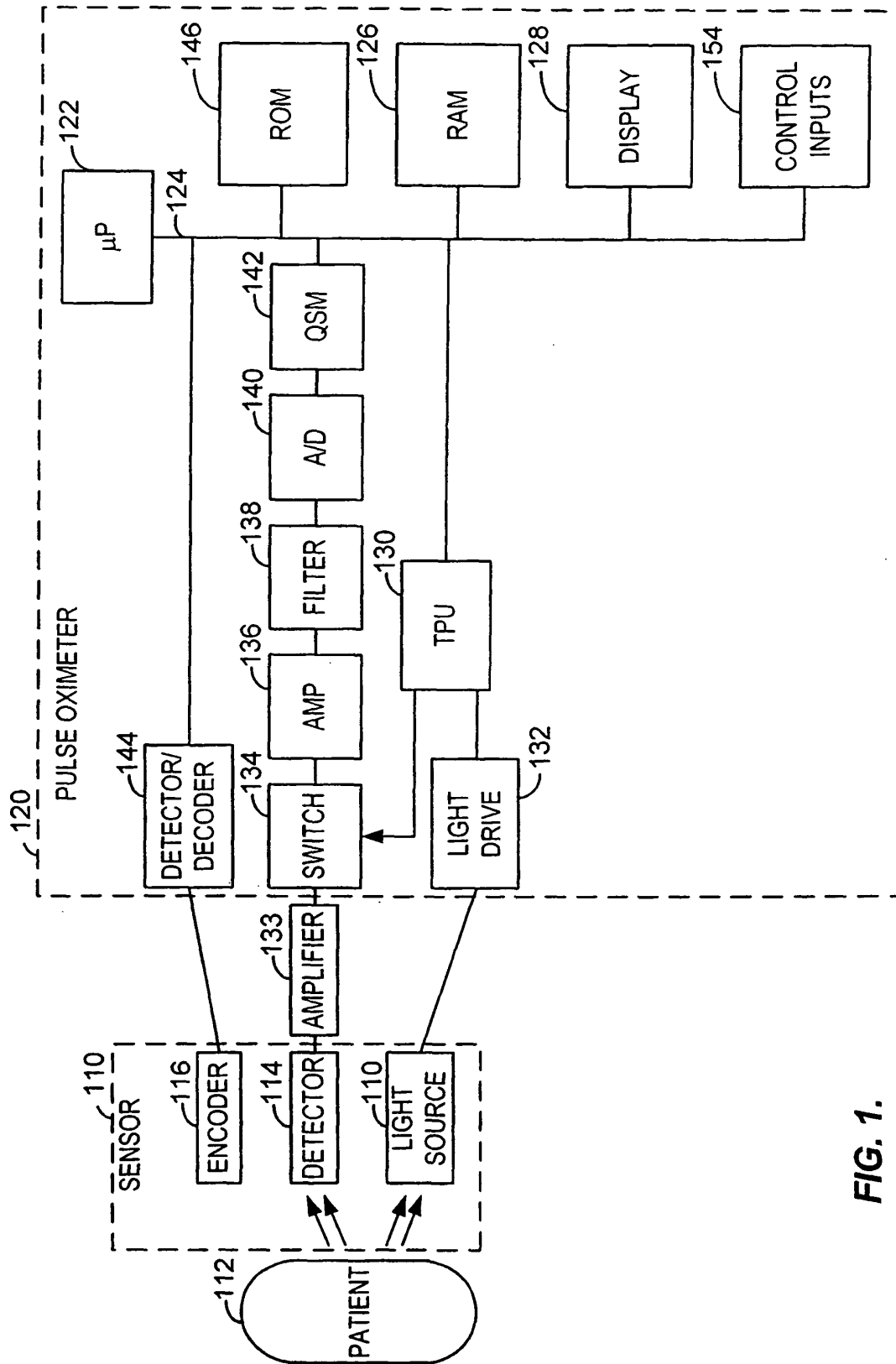


FIG. 1.

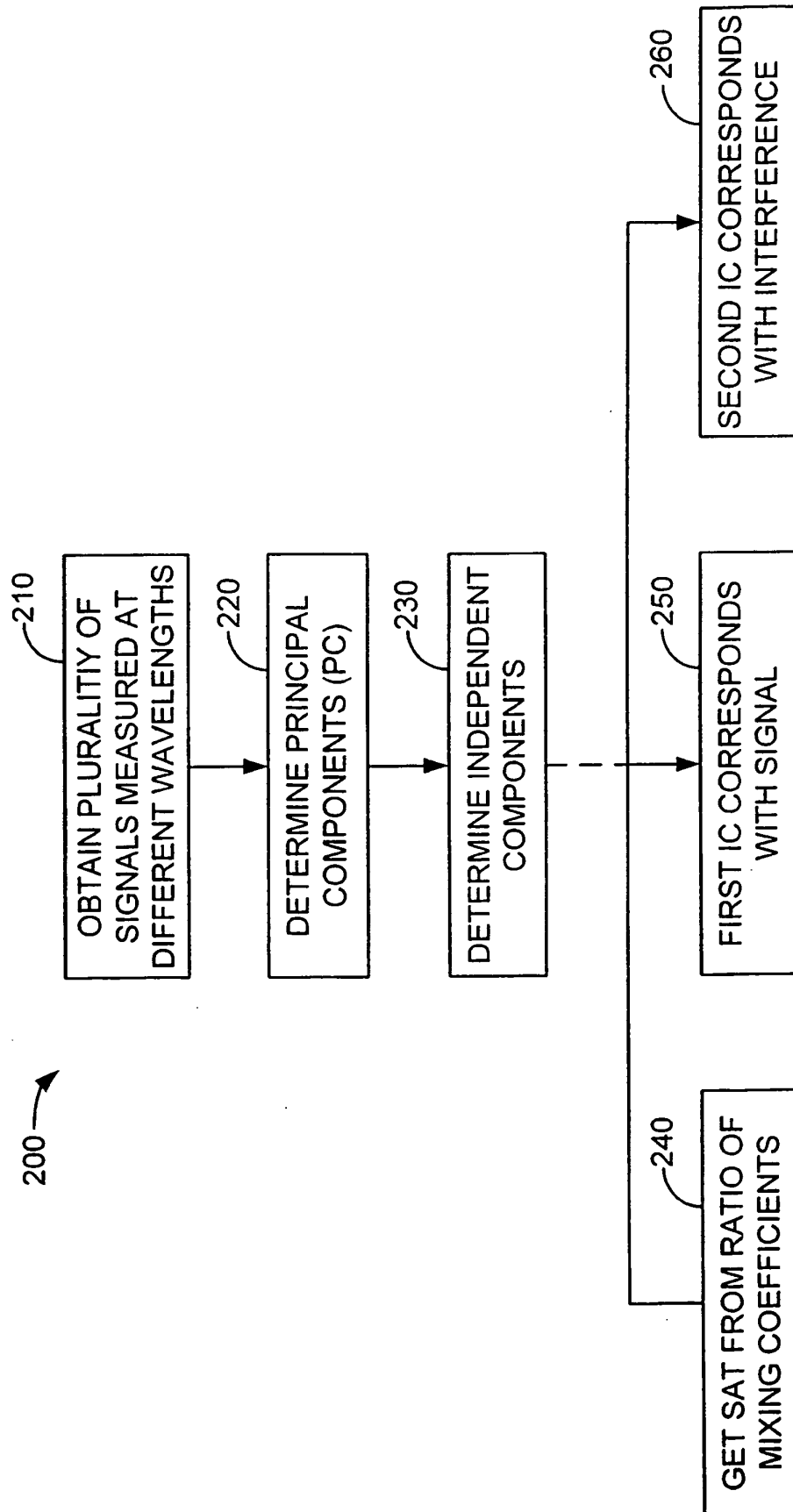


FIG. 2.

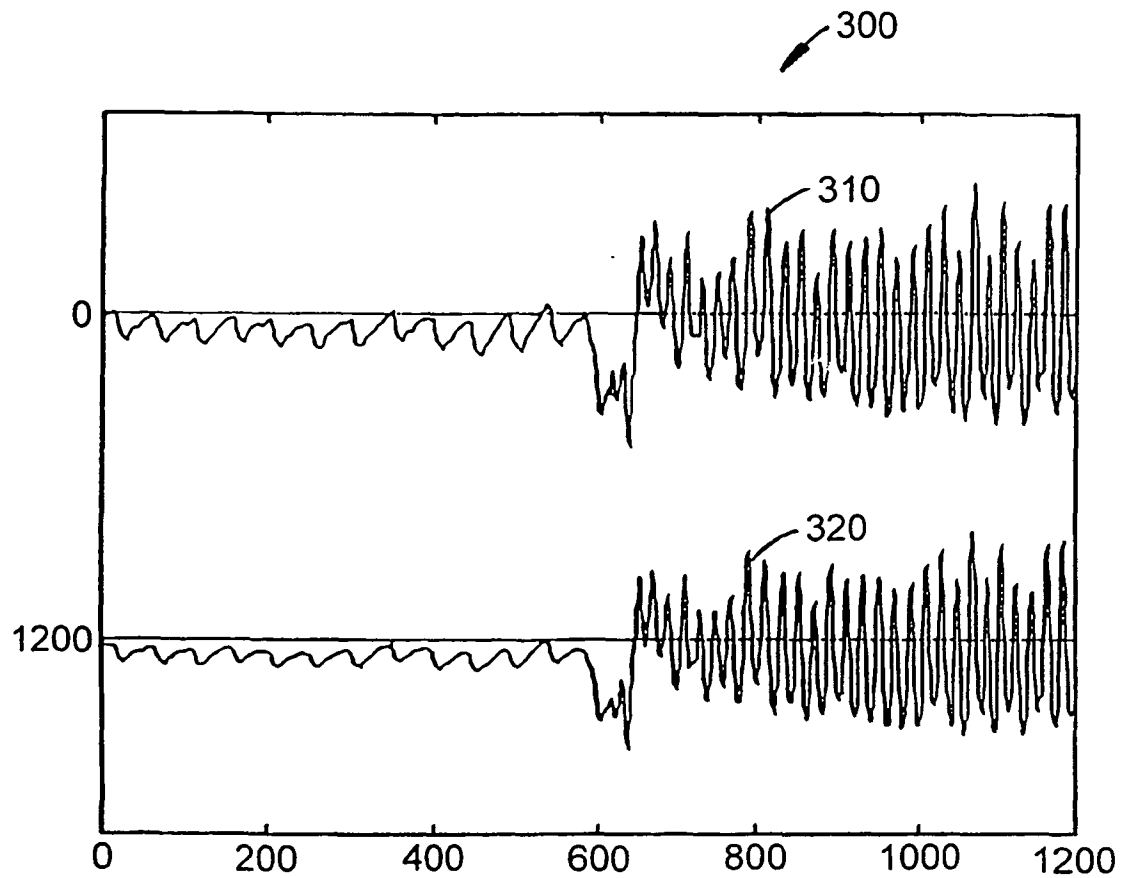


FIG. 3.

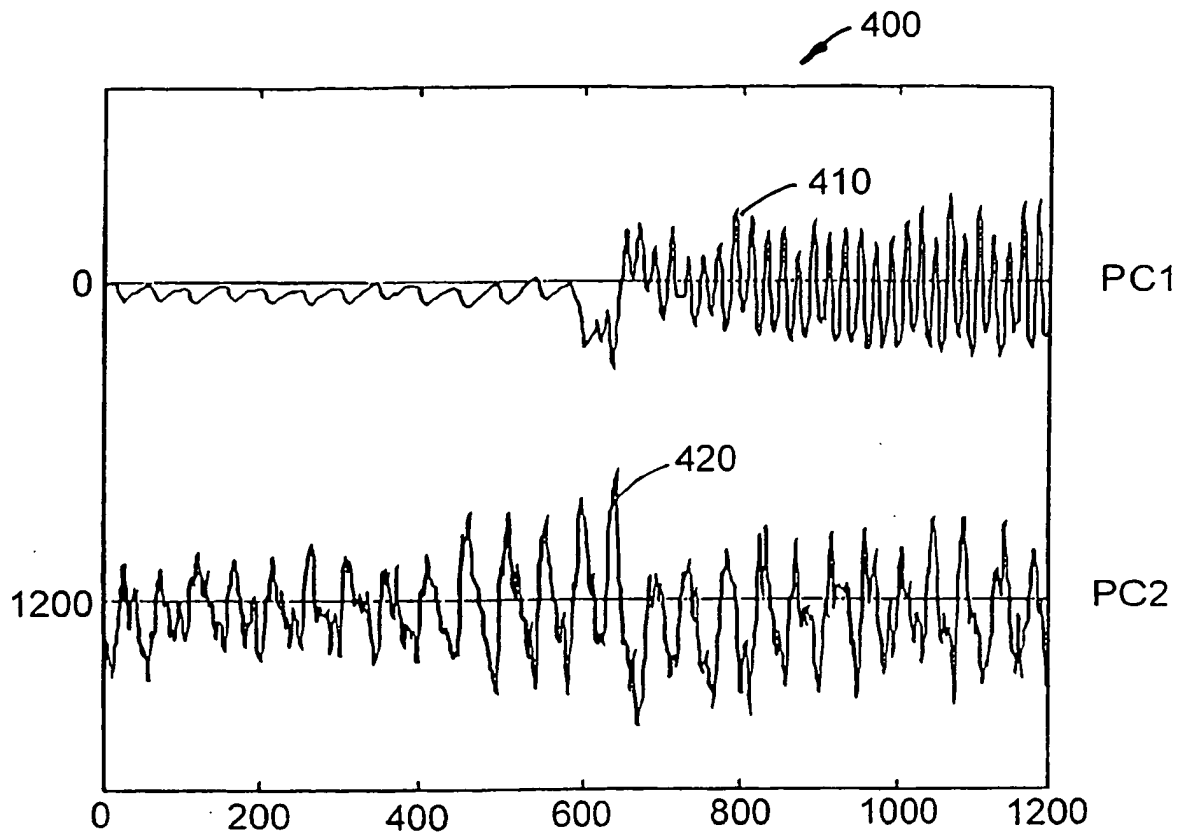


FIG. 4.

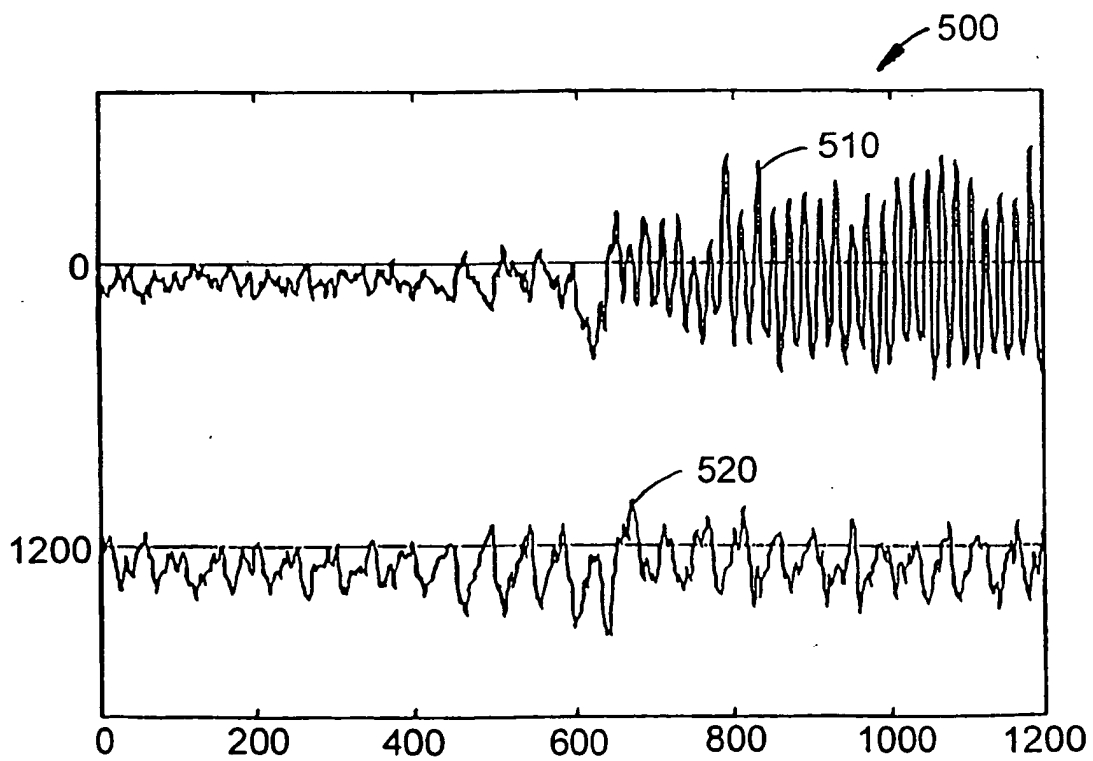


FIG. 5.

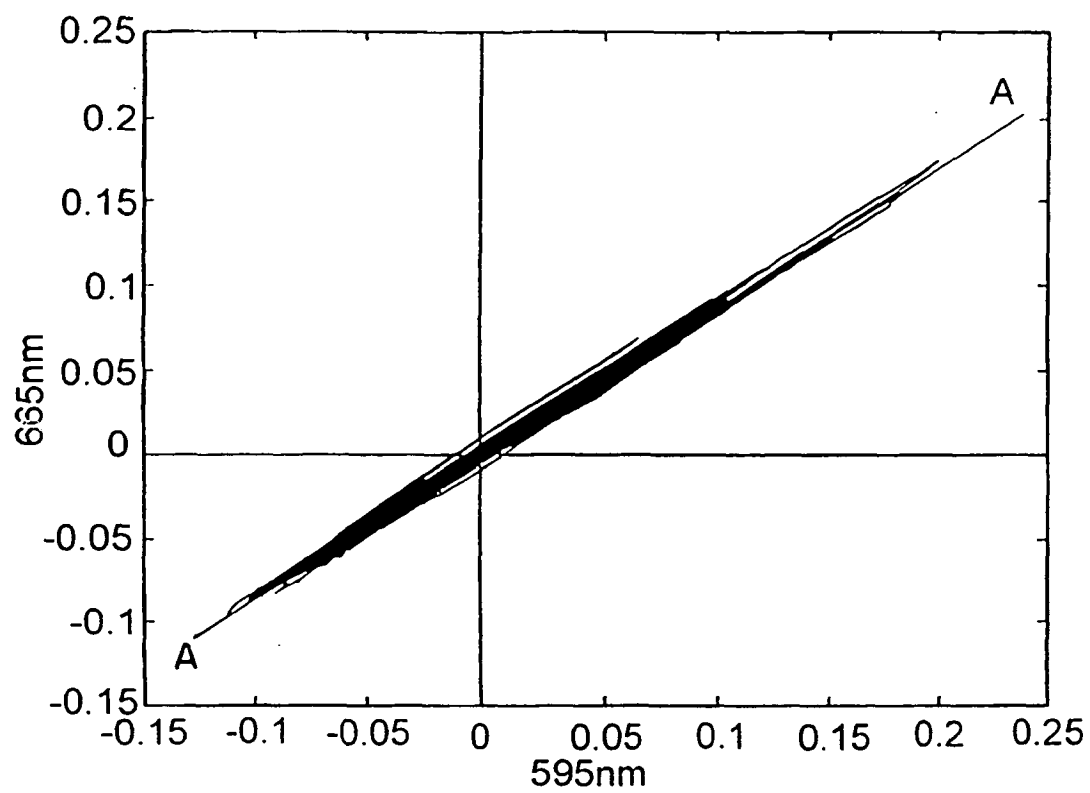


FIG. 6

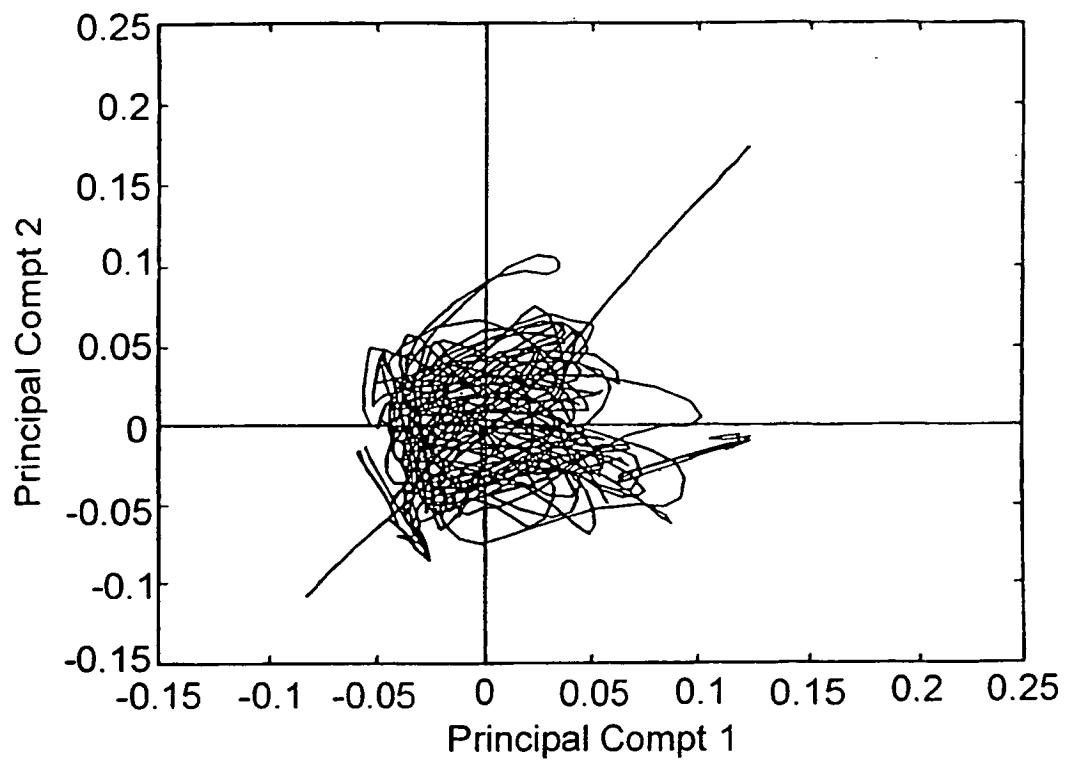


FIG. 7.

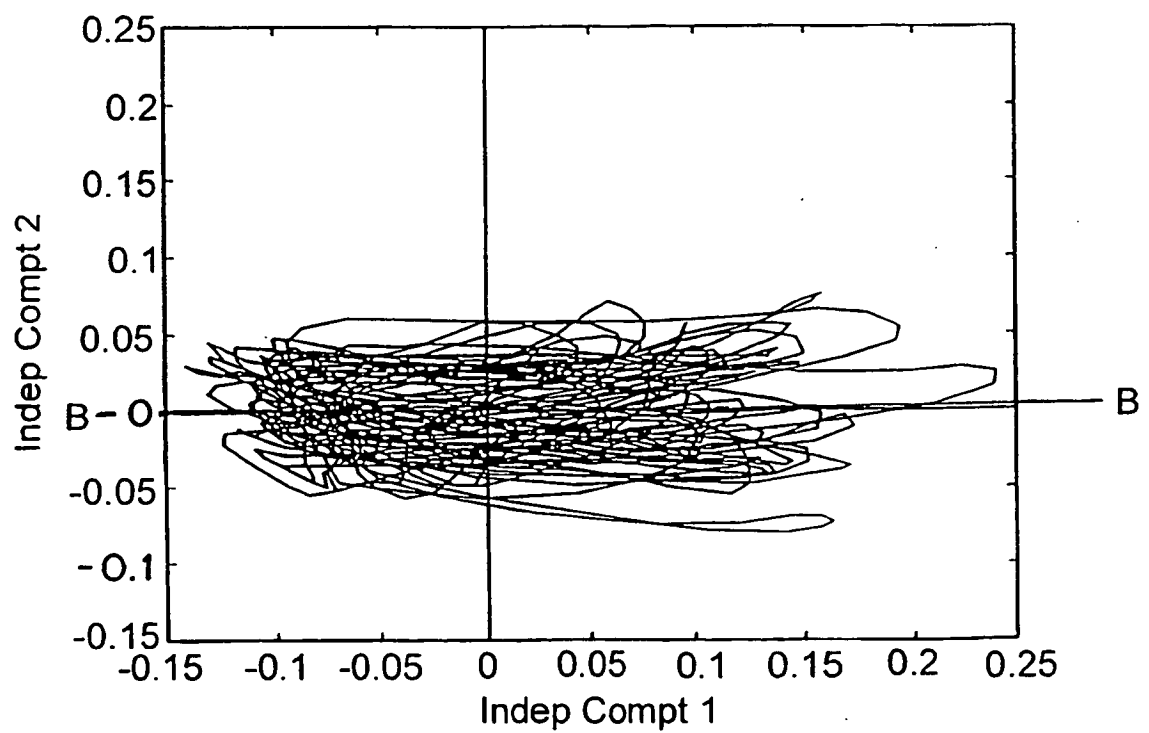


FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	脉冲血氧饱和度信号的盲源分离		
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申请(专利权)人(译)	NELLCOR PURITAN BENNETT INCORPORATED		
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其他公开文献	EP1450676A2		
外部链接	Espacenet		

摘要(译)

一种用于将盲源分离 (BSS)，特别是独立分量分析 (ICA) 应用于由脉冲血氧计传感器获得的混合信号的方法和装置。在脉搏血氧仪中，在不同波长处测量的信号表示混合信号，而体积描记信号，运动伪影，呼吸伪影和仪器噪声表示源组件。 BSS通过包括ICA的两步法进行。在第一步中，该方法使用主成分分析 (PCA) 作为预处理步骤，然后使用主成分导出sat和独立成分，其中独立成分在第二步中确定。在一个实施例中，通过主成分的高阶去相关来获得独立分量，通过最大化多个混合信号的高阶累积量的平方和来实现。

$$X(t) = A S(t)$$