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(54) **FEEDBACK PHOTOPLETHYSMOGRAPHY MEASURING DEVICE AND MEASURING METHOD THEREOF**

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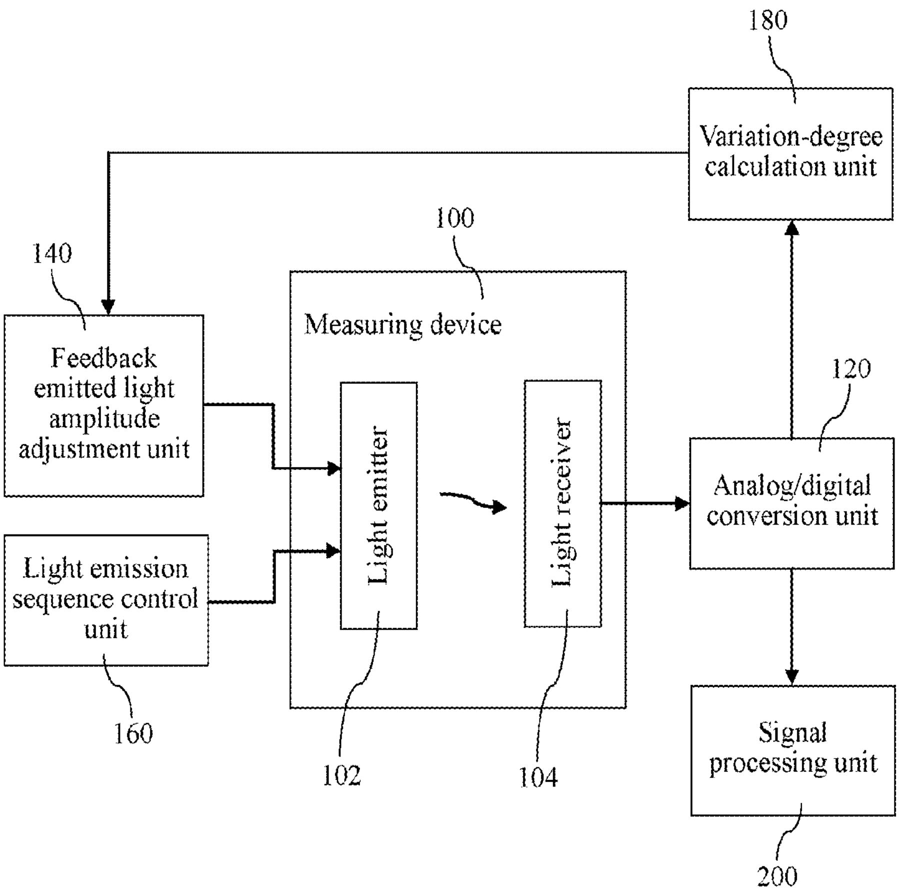
(57) **ABSTRACT**

A feedback photoplethysmography measuring device is provided, including: a measuring device that measures a human body to obtain a photoplethysmography signal; an analog/digital conversion unit that converts the photoplethysmography signal measured by the measuring device to a photoplethysmography value which is a digital value; a variation-degree calculation unit that calculates a photoplethysmography variation value according to the photoplethysmography value converted by the analog/digital conversion unit; and a feedback emitted light amplitude adjustment unit that controls the measuring device according to a plurality of preset control values or the adjusted photoplethysmography variation value calculated by the variation-degree calculation unit, and adjusts the photoplethysmography variation value to a minimum variation value.



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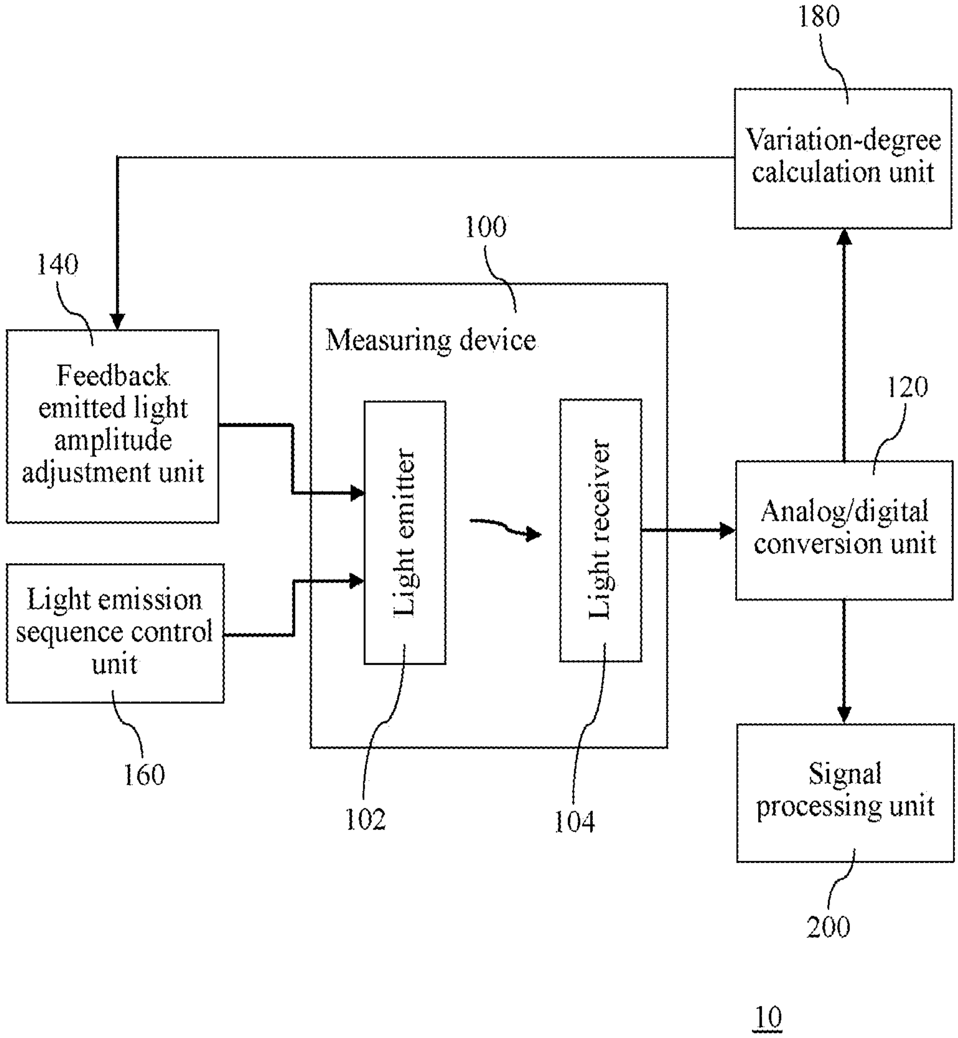

180
Variation-degree calculation unit
100
140
Measuring device
Feedback emitted light amplitude adjustment unit
120
Light emitter
Light receiver
Analog/digital conversion unit
Light emission sequence control unit
160
102
104
Signal processing unit
200
10

FIG. 1

FIG. 2A

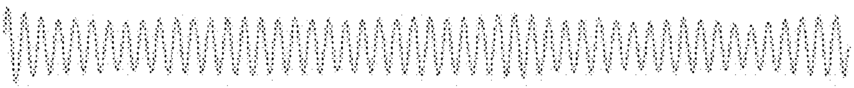


FIG. 2B

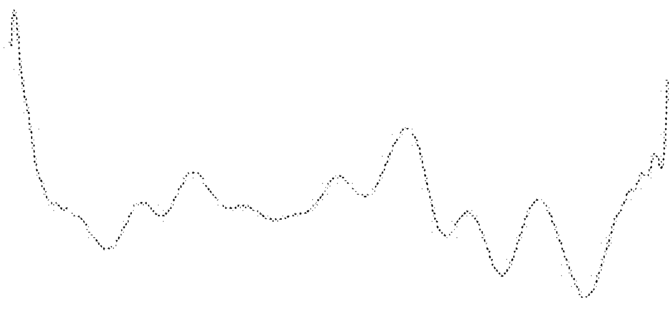


FIG. 2C

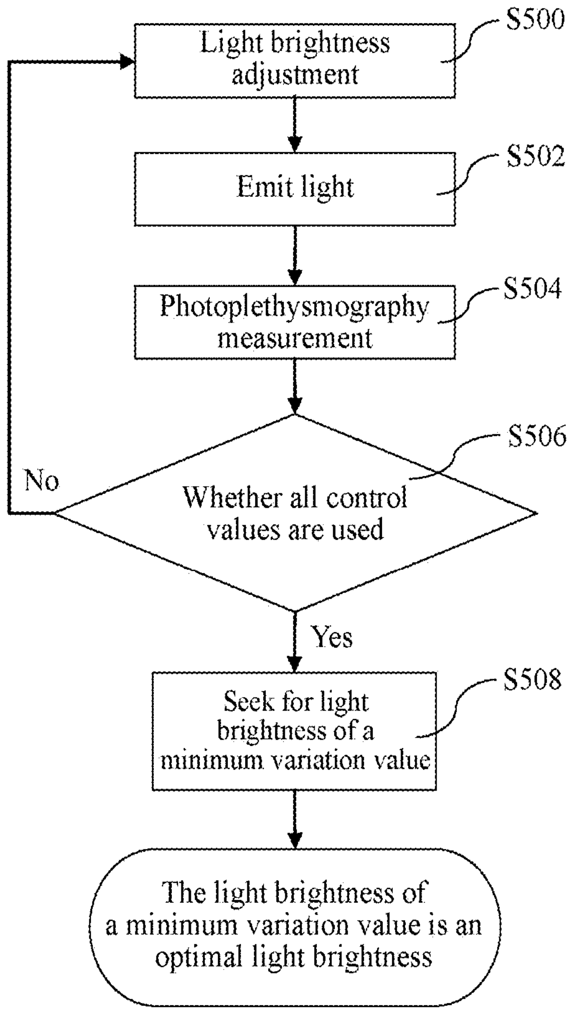

S500
Light brightness adjustment
S502
Emit light
S504
Photoplethysmography measurement
S506
Whether all control values are used
No
Yes
S508
Seek for light brightness of a minimum variation value
The light brightness of a minimum variation value is an optimal light brightness

FIG. 3A

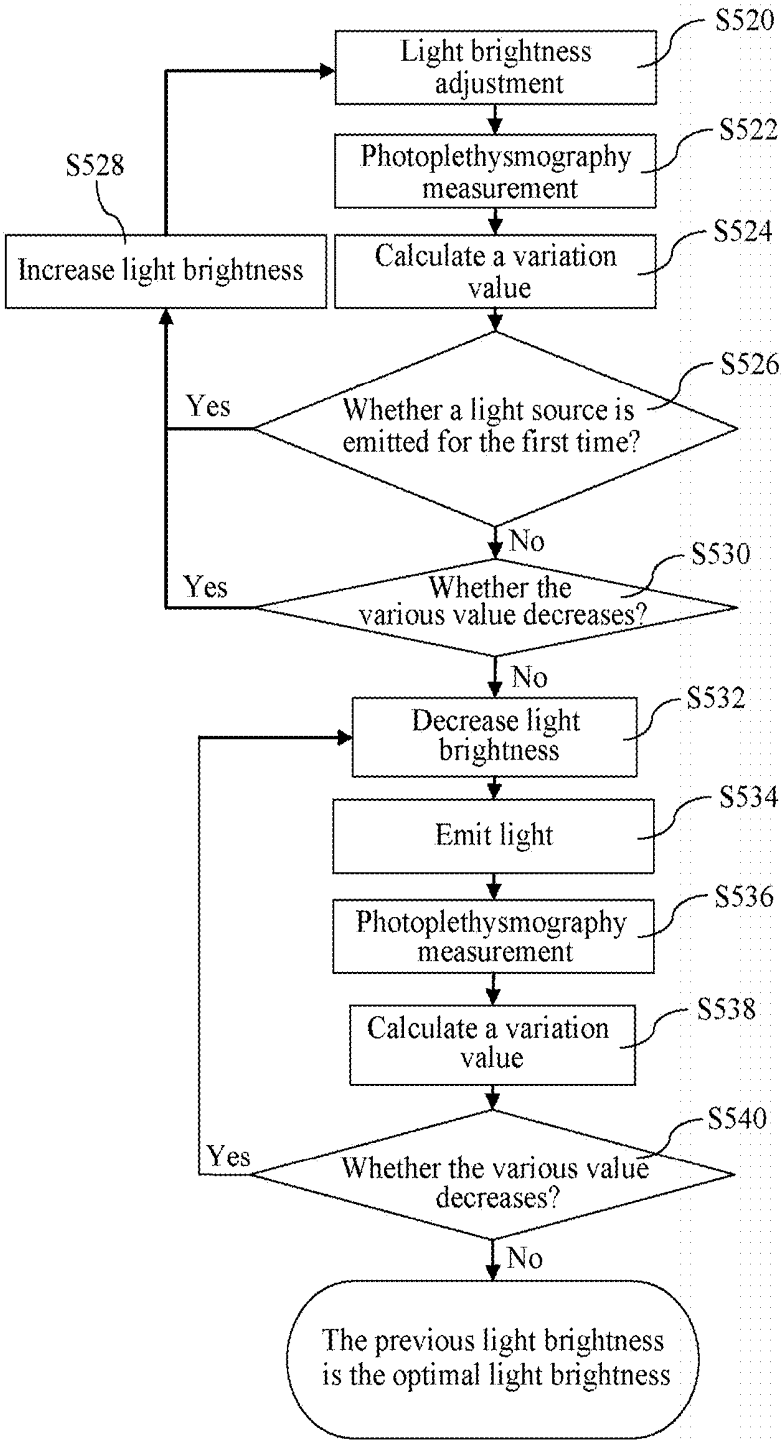
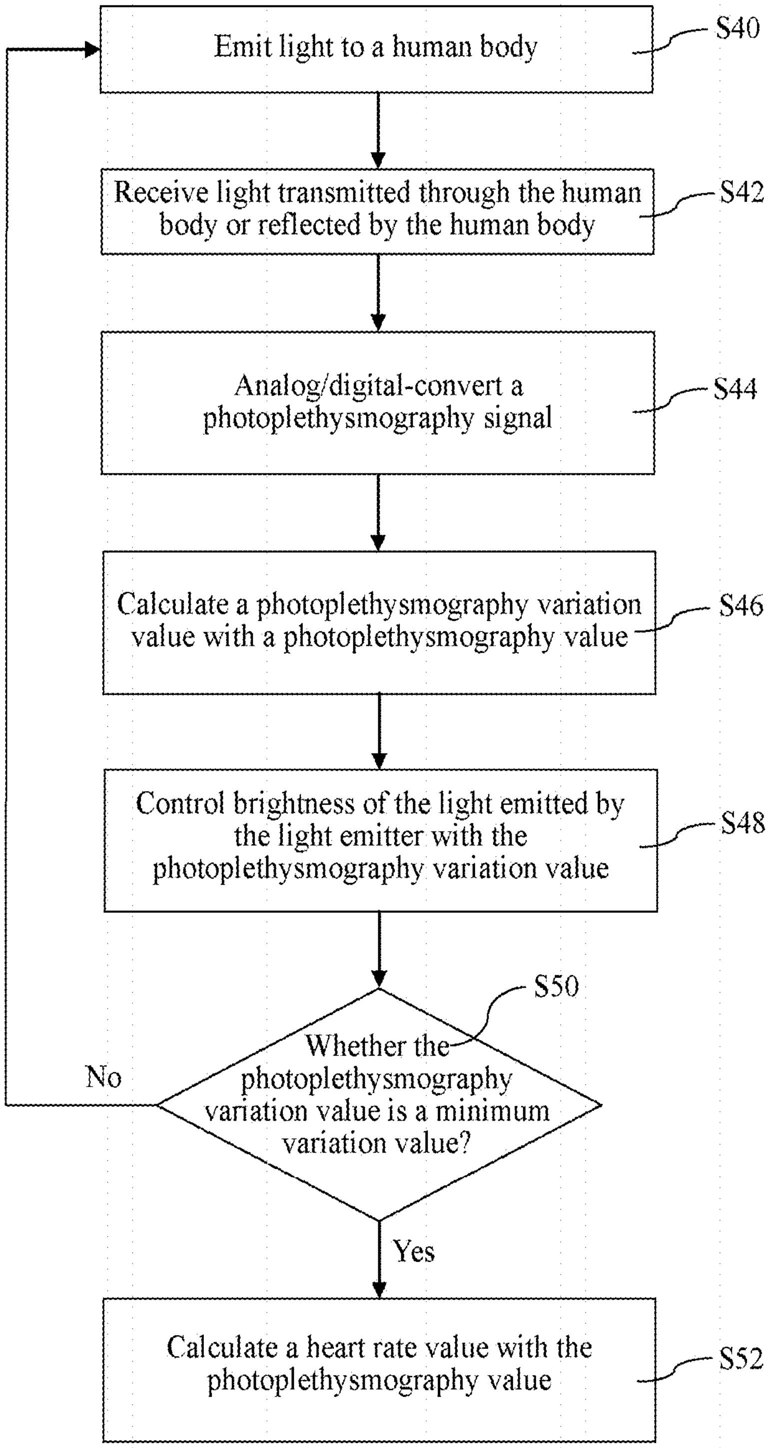

S520
Light brightness adjustment
S522
Photoplethysmography measurement
S524
Calculate a variation value
S528
Increase light brightness
S526
Whether a light source is emitted for the first time?
Yes
No
S530
Whether the various value decreases?
Yes
No
S532
Decrease light brightness
S534
Emit light
S536
Photoplethysmography measurement
S538
Calculate a variation value
S540
Whether the various value decreases?
Yes
No
The previous light brightness is the optimal light brightness

FIG. 3B



Emit light to a human body
S40
Receive light transmitted through the human body or reflected by the human body
S42
Analog/digital-convert a photoplethysmography signal
S44
Calculate a photoplethysmography variation value with a photoplethysmography value
S46
Control brightness of the light emitted by the light emitter with the photoplethysmography variation value
S48
S50
Whether the photoplethysmography variation value is a minimum variation value?
No
Yes
Calculate a heart rate value with the photoplethysmography value
S52

FIG. 4

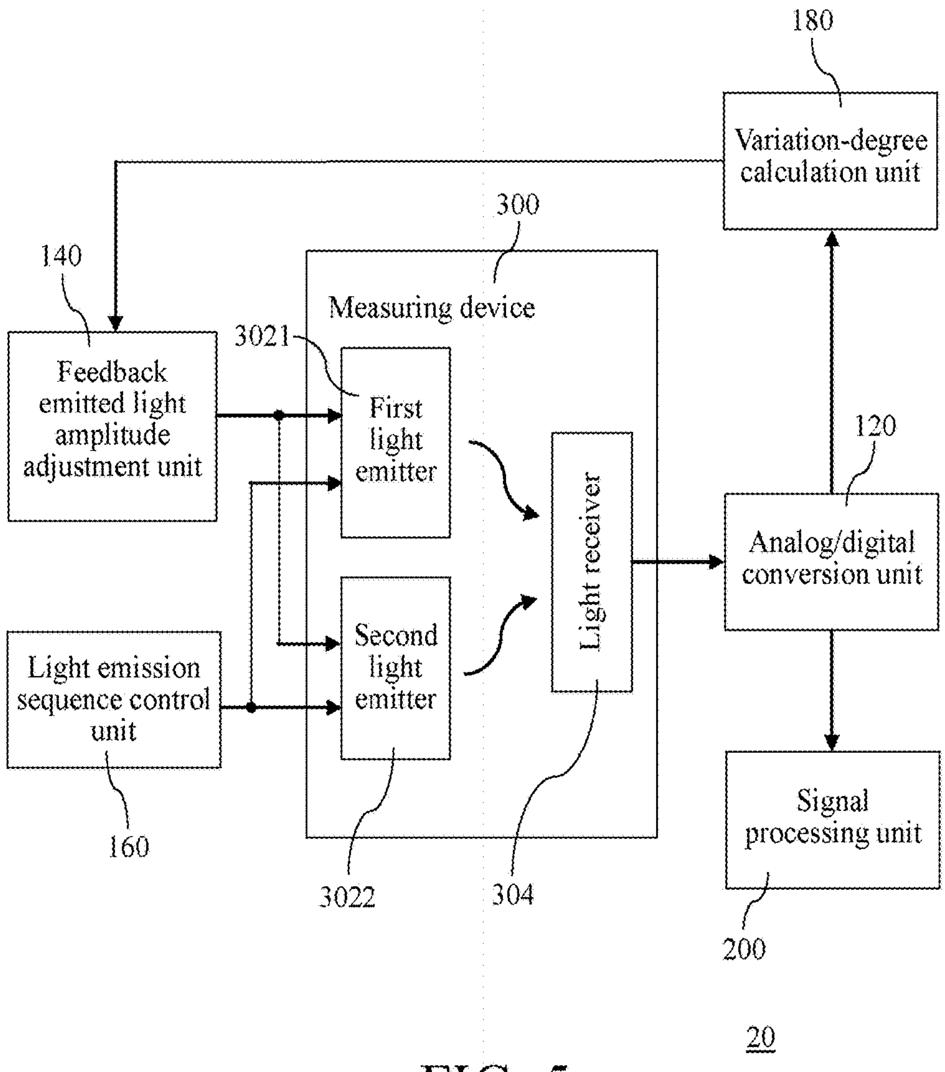

180
Variation-degree calculation unit
300
Measuring device
140
Feedback emitted light amplitude adjustment unit
3021
First light emitter
Light receiver
120
Analog/digital conversion unit
Light emission sequence control unit
Second light emitter
Signal processing unit
160
3022
304
200
20

FIG. 5

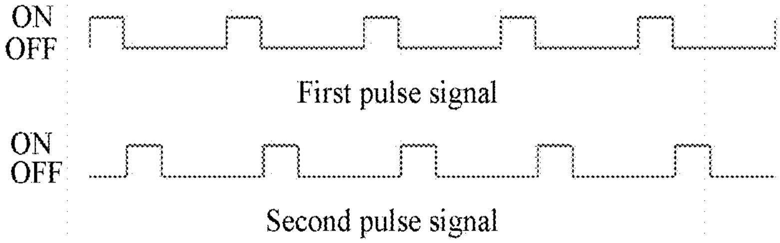


FIG. 6A

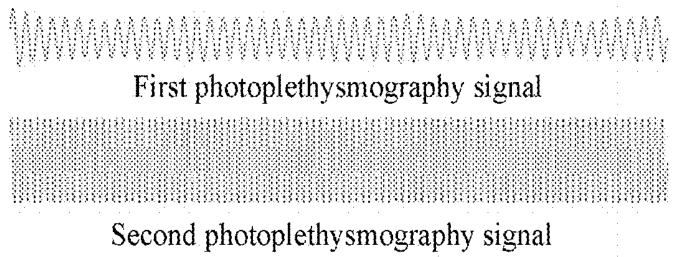


FIG. 6B

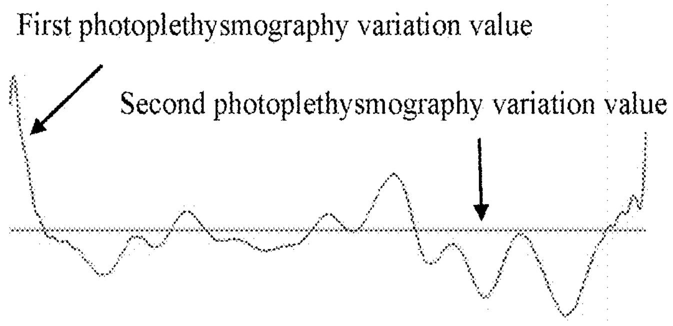


FIG. 6C

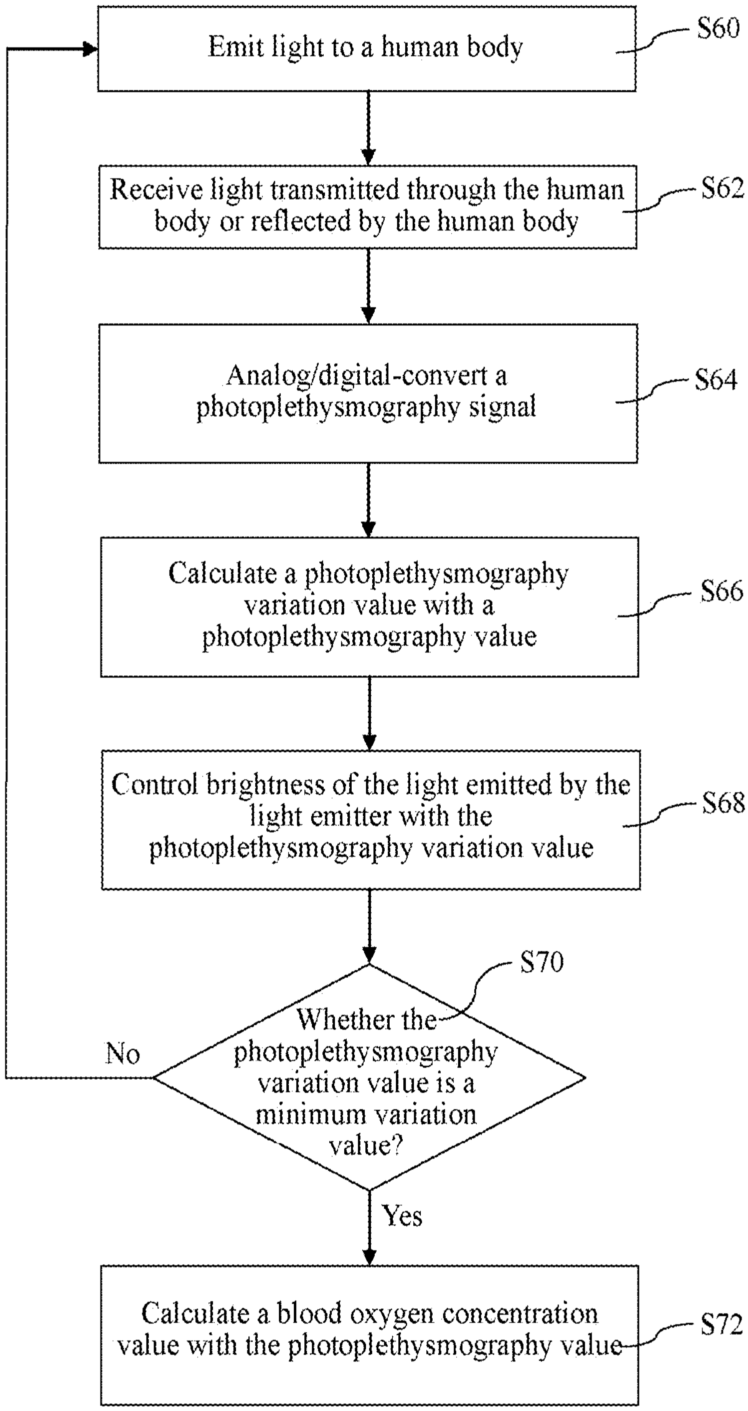

Emit light to a human body
S60
Receive light transmitted through the human body or reflected by the human body
S62
Analog/digital-convert a photoplethysmography signal
S64
Calculate a photoplethysmography variation value with a photoplethysmography value
S66
Control brightness of the light emitted by the light emitter with the photoplethysmography variation value
S68
S70
Whether the photoplethysmography variation value is a minimum variation value?
No
Yes
Calculate a blood oxygen concentration value with the photoplethysmography value
S72

FIG. 7

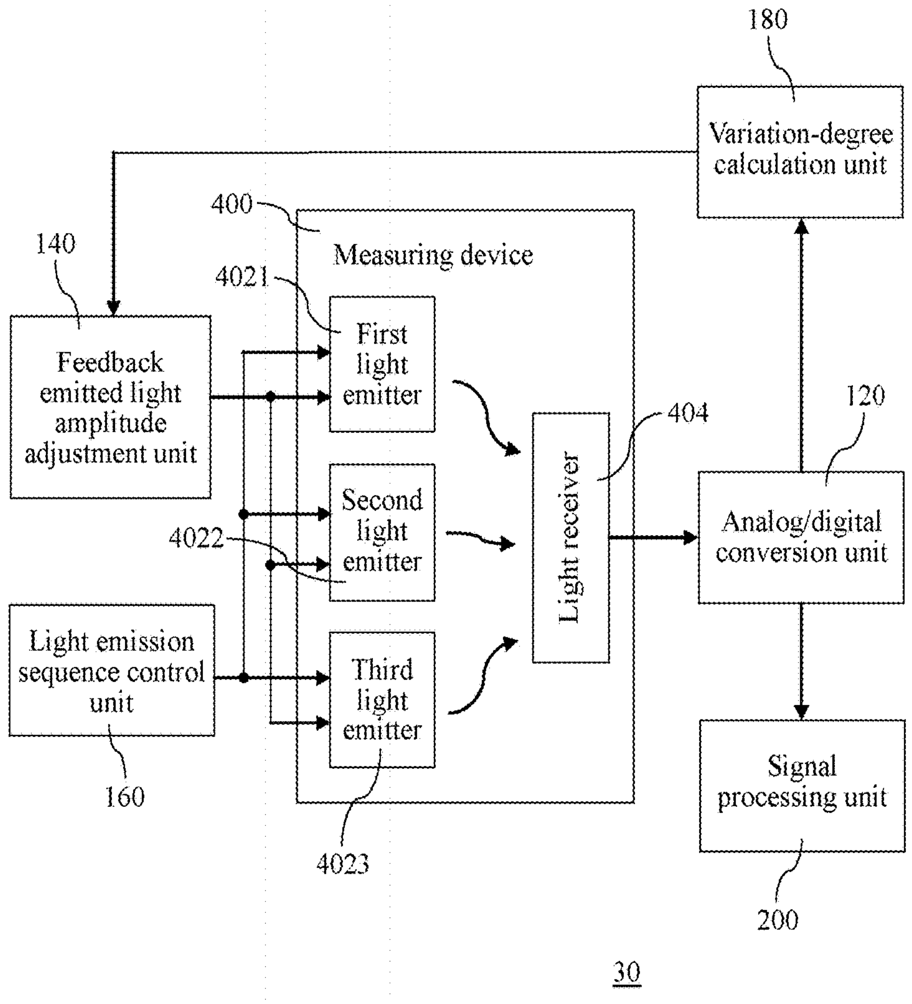

180
Variation-degree calculation unit
400
Measuring device
140
4021
First light emitter
Feedback emitted light amplitude adjustment unit
404
120
Second light emitter
Light receiver
4022
Analog/digital conversion unit
Light emission sequence control unit
Third light emitter
160
Signal processing unit
4023
200
30

FIG. 8

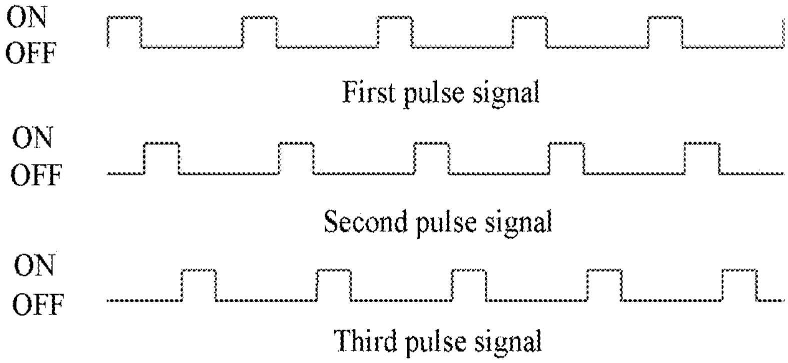


FIG. 9A

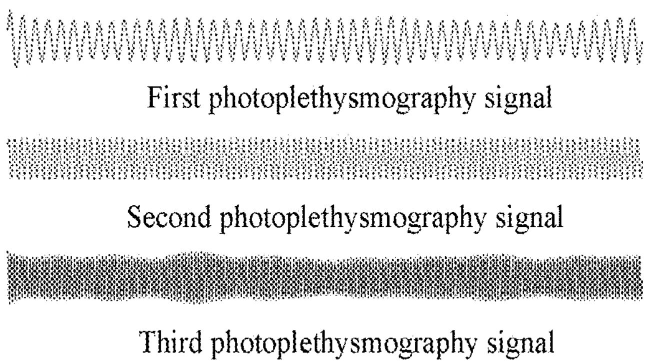


FIG. 9B

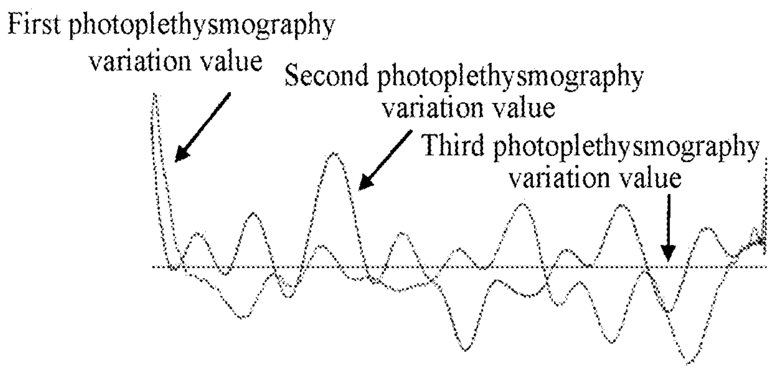


FIG. 9C

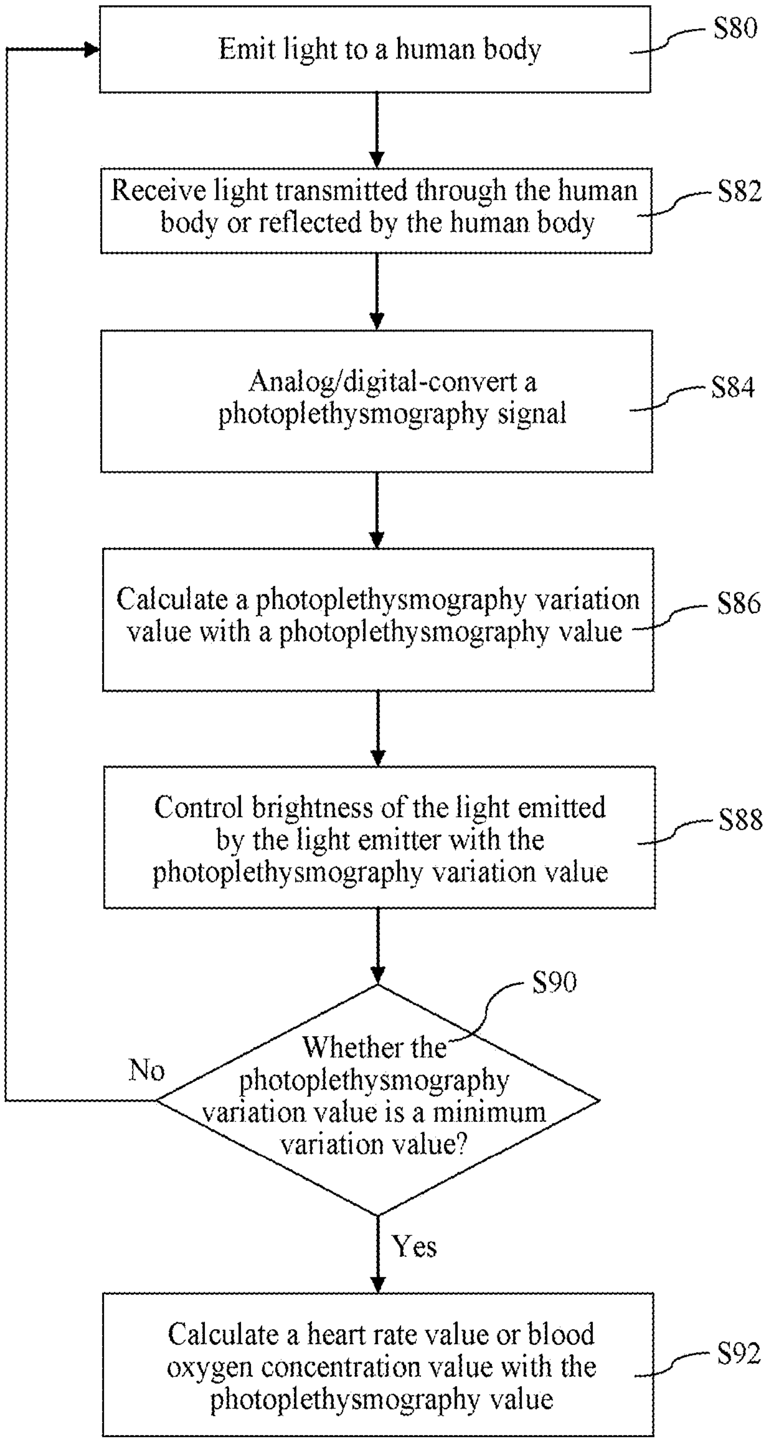

Emit light to a human body
S80
Receive light transmitted through the human body or reflected by the human body
S82
Analog/digital-convert a photoplethysmography signal
S84
Calculate a photoplethysmography variation value with a photoplethysmography value
S86
Control brightness of the light emitted by the light emitter with the photoplethysmography variation value
S88
S90
Whether the photoplethysmography variation value is a minimum variation value?
No
Yes
Calculate a heart rate value or blood oxygen concentration value with the photoplethysmography value
S92

FIG. 10

FEEDBACK PHOTOPLETHYSMOGRAPHY MEASURING DEVICE AND MEASURING METHOD THEREOF

BACKGROUND

[0001] Technical Field

[0002] The present invention relates to the field of medical measurement, and in particular, to a feedback photoplethysmography measuring device and a measuring method thereof.

[0003] Related Art

[0004] With rapid development of industry and commerce, people's working pressure is bigger and bigger, plus an imbalanced diet, the population of cardiovascular disease is increasingly more. According to the statistics of ten leading causes of death made by the ministry of treatments of the executive yuan from 2008 to 2012, nearly half of the project is cardiovascular-related diseases, such as heart diseases, cerebrovascular diseases and hypertensive diseases. The cardiovascular-related diseases deaths accounted for 30.3% of all deaths in Taiwan in 2012, and heart diseases and cerebrovascular diseases are two leading causes of death from the cardiovascular-related diseases.

[0005] For the cardiovascular-related measurement, traditionally, a photoplethysmography measuring device is used to measure oxyhemoglobin saturation and photoplethysmography signals, which may be divided into a transmissive or reflective photoplethysmography measuring device; however, the photoplethysmography measuring device in the prior art mostly uses a light emitter that fixes brightness of light to irradiate background tissues of human bodies, and thus measured signals are often poor due to different background tissues (e.g., fingers, arms, head, stomach, legs and so on).

SUMMARY

[0006] In view of the foregoing problems, an objective of the present invention is to provide a feedback photoplethysmography measuring device and a measuring method thereof, which can adjust brightness of light emitted by a light emitter of the photoplethysmography measuring device to be optimal with respect to different background tissues of a human body to be measured, to make the background tissues of the human body measured by the photoplethysmography measuring device have optimal measurement signals.

[0007] A first aspect of the present invention provides a feedback photoplethysmography measuring device, including:

[0008] a measuring device, including:

[0009] a light emitter that emits light with a particular wavelength to a human body; and

[0010] a light receiver that receives the light with a particular wavelength transmitted through the human body or reflected by the human body, and converts the light to a photoplethysmography signal which is an electrical signal;

[0011] an analog/digital conversion unit that converts the photoplethysmography signal converted by the light receiver which is an analog signal to a photoplethysmography value which is a digital value;

[0012] a variation-degree calculation unit that calculates a photoplethysmography variation value according to the photoplethysmography value converted by the analog/digital conversion unit; and a feedback emitted light amplitude adjustment unit that controls brightness of the light emitted by the light emitter according to a plurality of preset control values or the adjusted photoplethysmography variation value calculated by the variation-degree calculation unit, and adjusts the photoplethysmography variation value to a minimum variation value, to control the brightness of the light emitted by the light emitter to be optimal.

[0013] A second aspect of the present invention provides a feedback photoplethysmography measuring device, including:

[0014] a measuring device, including:

[0015] a plurality of light emitters that emit light with a particular wavelength but in different sequences to a human body respectively; and

[0016] a light receiver that receives the light with a particular wavelength but in different sequences transmitted through the human body or reflected by the human body, and converts the light to a plurality of photoplethysmography signals which are electrical signals;

[0017] a light emission sequence control unit that sends each of a plurality of emitted light sequence signals to each of the light emitters through phase, pulse or sine-wave control, to control time and frequency of the light emitted by each of the light emitters;

[0018] an analog/digital conversion unit that converts the photoplethysmography signals converted by the light receiver which are analog signals to a photoplethysmography value which is a digital value respectively;

[0019] a variation-degree calculation unit that calculates a plurality of photoplethysmography variation values according to the photoplethysmography values converted by the analog/digital conversion unit; and

[0020] a feedback emitted light amplitude adjustment unit that controls brightness of the light emitted by each of the light emitters according to a plurality of preset control values or the adjusted photoplethysmography variation values calculated by the variation-degree calculation unit, and adjusts at least one of the photoplethysmography variation values to a minimum variation value, to control the brightness of the light emitted by the light emitter corresponding to the minimum variation value to be optimal.

[0021] A third aspect of the present invention provides a measuring method of a feedback photoplethysmography measuring device, including:

[0022] emitting, by a light emitter, light with a particular wavelength to a human body;

[0023] receiving, by a light receiver, the light with a particular wavelength transmitted through the human body or reflected by the human body, and converting the light to a photoplethysmography signal which is an electrical signal;

[0024] converting, by an analog/digital conversion unit, the photoplethysmography signal converted by the light receiver which is an analog signal to a photoplethysmography value which is a digital value;

[0025] calculating, by a variation-degree calculation unit, a photoplethysmography variation value according to the photoplethysmography value converted by the analog/digital conversion unit; and

[0026] adjusting, by a feedback emitted light amplitude adjustment unit, the photoplethysmography variation value, and controlling brightness of the light emitted by the light emitter according to a plurality of preset control values or the adjusted photoplethysmography variation value calculated by the variation-degree calculation unit;

[0027] wherein the feedback emitted light amplitude adjustment unit judges whether the adjusted photoplethysmography variation value is the minimum variation value.

[0028] A fourth aspect of the present invention provides a measuring method of a feedback photoplethysmography measuring device, including:

[0029] emitting, by a plurality of light emitters, light with a particular wavelength but in different sequences to a human body;

[0030] receiving, by a light receiver, the light with a particular wavelength but in different sequences transmitted through the human body or reflected by the human body, and converting the light to a plurality of photoplethysmography signals which are electrical signals;

[0031] sending, by a light emission sequence control unit, each of a plurality of emitted light sequence signals to each of the light emitters through phase, pulse or sine-wave control, to control time and frequency of the light emitted by each of the light emitters;

[0032] converting, by an analog/digital conversion unit, the photoplethysmography signals converted by the light receiver which are analog signals to a plurality of a photoplethysmography value which is a digital value;

[0033] calculating, by a variation-degree calculation unit, a plurality of photoplethysmography variation values according to the photoplethysmography values converted by the analog/digital conversion unit; and

[0034] adjusting, by a feedback emitted light amplitude adjustment unit, the photoplethysmography variation values, and controlling brightness of the light emitted by each of the light emitters according to a plurality of preset control values or the adjusted photoplethysmography variation values calculated by the variation-degree calculation unit respectively;

[0035] wherein the feedback emitted light amplitude adjustment unit judges whether at least one of the adjusted photoplethysmography variation values is the minimum variation value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] FIG. **1** is a block diagram of a feedback photoplethysmography measuring device according to a first embodiment of the present invention;

[0037] FIG. **2**A is a sequence diagram of a pulse signal of a light emission sequence control unit according to the first embodiment of the present invention;

[0038] FIG. **2**B is a frequency diagram of a photoplethysmography signal of a light receiver according to the first embodiment of the present invention;

[0039] FIG. **2**C is a schematic diagram of photoplethysmography variation values calculated by a variation-degree calculation unit according to the first embodiment of the present invention;

[0040] FIG. **3**A is a flow chart of a method of seeking for, by a feedback emitted light amplitude adjustment unit, a minimum variation value according to the present invention;

[0041] FIG. **3**B is a flow chart of another method of seeking for, by a feedback emitted light amplitude adjustment unit, a minimum variation value according to the present invention;

[0042] FIG. **4** is a flow chart of a measuring method of a feedback photoplethysmography measuring device according to the first embodiment of the present invention;

[0043] FIG. **5** is a block diagram of a feedback photoplethysmography measuring device according to a second embodiment of the present invention;

[0044] FIG. **6**A is a sequence diagram of a pulse signal of a light emission sequence control unit according to the second embodiment of the present invention;

[0045] FIG. **6**B is a diagram of photoplethysmography variations obtained according to different emission frequencies according to the second embodiment of the present invention;

[0046] FIG. **6**C is a schematic diagram of photoplethysmography variation values calculated by a variation-degree calculation unit according to the second embodiment of the present invention;

[0047] FIG. **7** is a flow chart of a measuring method of a feedback photoplethysmography measuring device according to the second embodiment of the present invention;

[0048] FIG. **8** is a block diagram of a feedback photoplethysmography measuring device according to a third embodiment of the present invention;

[0049] FIG. **9**A is a sequence diagram of a pulse signal of a light emission sequence control unit according to the third embodiment of the present invention;

[0050] FIG. **9**B is a diagram of photoplethysmography variations obtained according to different emission frequencies according to the third embodiment of the present invention;

[0051] FIG. **9**C is a schematic diagram of photoplethysmography variation values calculated by a variation-degree calculation unit according to the third embodiment of the present invention; and

[0052] FIG. **10** is a flow chart of a measuring method of a feedback photoplethysmography measuring device according to the third embodiment of the present invention.

DETAILED DESCRIPTION

[0053] For the purposes of promoting an understanding of the principles of the invention, the feedback photoplethysmography measuring device and method of the present invention are described below, and in applicants' Taiwanese priority application No. 105102054, filed Jan. 22, 2016, the entire contents of which are hereby incorporated herein by reference. The written description and drawings are intended to illustrate the invention in a manner that allows persons of ordinary skill in the art to be able to understand and appreciate the broad scope of the invention and its preferred embodiments, and to enable any person skilled in the art to which the invention pertains, or with which it is most nearly connected, to make and use the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, with such alterations and modifications to the illustrated device being contemplated as would normally occur to one skilled in the art to which the invention relates.

First Embodiment

[0054] FIG. **1** is a block diagram of a feedback photoplethysmography measuring device according to a first embodiment of the present invention. In FIG. **1**, the feedback photoplethysmography measuring device **10** includes a measuring device **100**, an analog/digital conversion unit

120, a feedback emitted light amplitude adjustment unit **140**, a light emission sequence control unit **160**, a variation-degree calculation unit **180** and a signal processing unit **200**. The measuring device **100** includes a light emitter **102** and a light receiver **104**.

[0055] The light emission sequence control unit **160** sends an emitted light sequence signal to the light emitter **102** through phase, pulse or sine-wave control, to control time and frequency of the light emitted by the light emitter **102**. As shown in FIG. **2**A which is a sequence diagram of a pulse signal of a light emission sequence control unit according to the first embodiment of the present invention, the frequency of the light emitted by the light emitter **102** is the same as the frequency of the pulse signal of the light emission sequence control unit **160**, and the ON cycle in the pulse signal of the light emission sequence control unit **160** makes the light emitter **102** emit light with a particular wavelength.

[0056] The light with a particular wavelength emitted by the light emitter **102** may be green light with a wavelength of 495 nm to 570 nm, red light with a wavelength of 620 nm to 750 nm or infrared light with a wavelength of 780 nm to 1000 nm.

[0057] The light receiver **104** receives light with a particular wavelength transmitted through background tissues of a human body or reflected by the background tissues of the human body, and converts the light to a photoplethysmography signal which is an electrical signal, as shown in FIG. **2**B which is a frequency diagram of a photoplethysmography signal of a light receiver according to the first embodiment of the present invention.

[0058] The analog/digital conversion unit **120** converts the photoplethysmography signal converted by the light receiver which is an analog signal **104** to a photoplethysmography value which is a digital value. The variation-degree calculation unit **180** calculates a photoplethysmography variation value Var according to the photoplethysmography value converted by the analog/digital conversion unit **120**.

[0059] As shown in FIG. **2**C which is a schematic diagram of photoplethysmography variation values calculated by a variation-degree calculation unit according to the first embodiment of the present invention, the photoplethysmography variation value is

$$Var = \frac{1}{N}\left[\sum_{n=1}^{N} (I[n] - M)^2\right],$$

wherein N is the total data number of the photoplethysmography value through sequence analysis or Fourier transform, I[n] is the corresponding light intensity of the photoplethysmography value via sequence analysis or Fourier transform at the time n, and M is an average value of I[n].

[0060] The feedback emitted light amplitude adjustment unit **140** controls the brightness of the light emitted by the light emitter **102** according to a plurality of preset control values or the adjusted photoplethysmography variation value Var calculated by the variation-degree calculation unit **180**, and until the photoplethysmography variation value Var converted and calculated according to the photoplethysmography signal converted by the light receiver **104** is a minimum variation value, the feedback emitted light amplitude adjustment unit **140** controls the brightness of the light emitted by the light emitter **102** to be optimal.

[0061] FIG. **3**A is a flow chart of a method of seeking for, by a feedback emitted light amplitude adjustment unit, a minimum variation value according to the present invention. In FIG. **3**A, the feedback emitted light amplitude adjustment unit **140** first adjusts the brightness of the light emitted by the light emitter **102** according to a first control value in the plurality of control values (step S**500**), and the light emitter **102** emits the brightness of the light corresponding to the first control value of the feedback emitted light amplitude adjustment unit **140** (step S**502**).

[0062] The light receiver **104** receives the light with a particular wavelength transmitted through background tissues of a human body or reflected by the background tissues of the human body, and converts the light to a photoplethysmography which is an electrical signal, the analog/digital conversion unit **120** converts the photoplethysmography signal converted by the light receiver which is an analog signal **104** to a photoplethysmography value which is a digital value, and the variation-degree calculation unit **180** calculates a photoplethysmography variation value Var according to the photoplethysmography value converted by the analog/digital conversion unit **120** (step S**504**).

[0063] Next, the feedback emitted light amplitude adjustment unit **140** receives the photoplethysmography variation value Var calculated by the variation-degree calculation unit **180**, and judges whether all control values have been used to adjust the brightness of the light emitted by the light emitter **102** (step S**506**).

[0064] As the feedback emitted light amplitude adjustment unit **140** adjusts the brightness of the light emitted by the light emitter **102** with the first control value but not all the control values are used, next, step S**500** is performed, to adjust the brightness of the light emitted by the light emitter **102** with a second control value, and when step S**500** is performed subsequently, the brightness of the light emitted by the light emitter **102** is adjusted with a subsequent control value.

[0065] If the feedback emitted light amplitude adjustment unit **140** has used all the control values to adjust the brightness of the light emitted by the light emitter **102**, the feedback emitted light amplitude adjustment unit **140** seeks for a minimum value in each photoplethysmography variation value Var corresponding to each control value, and the minimum value is the minimum variation value with which the feedback emitted light amplitude adjustment unit **140** controls the brightness of the light emitted by the light emitter **102** to be optimal (step S**508**).

[0066] FIG. **3**B is a flow chart of another method of seeking for, by a feedback emitted light amplitude adjustment unit, a minimum variation value according to the present invention. In FIG. **3**B, the feedback emitted light amplitude adjustment unit **140** first controls the brightness of the light emitted by the light emitter **102** with a preset value (step S**520**).

[0067] The light receiver **104** receives the light with a particular wavelength transmitted through background tissues of the human body or reflected by the background tissues of the human body, and converts the light to a photoplethysmography signal which is an electrical signal (step S**522**).

[0068] The analog/digital conversion unit **120** converts the photoplethysmography signal converted by the light receiver which is an analog signal **104** to a photoplethysmography value which is a digital value, and the variation-degree calculation unit **180** calculates a photoplethysmography variation value Var according to the photoplethysmography value converted by the analog/digital conversion unit **120** (step S**524**).

[0069] Next, the feedback emitted light amplitude adjustment unit **140** receives the photoplethysmography variation value Var calculated by the variation-degree calculation unit **180**, and judges whether the light emitter **120** is controlled to emit light for the first time (step S**526**).

[0070] As the feedback emitted light amplitude adjustment unit **140** controls the light emitter **120** to emit light for the first time, the feedback emitted light amplitude adjustment unit **140** adjusts the size of the received photoplethysmography variation value Var to control the brightness of the light emitted by the light emitter **102** to increase (step S**528**), and next, step S**500** is performed, to control the brightness of the light emitted by the light emitter **102** with the adjusted photoplethysmography variation value Var (step S**530**).

[0071] When steps S**520**, S**522** and S**524** are performed more than twice, in step S**526**, this is not the first time that the feedback emitted light amplitude adjustment unit **140** controls the light emitter **102** to emit light, the feedback emitted light amplitude adjustment unit **140** judges whether the current photoplethysmography variation value Var calculated by the variation-degree calculation unit **180** is less than the previous photoplethysmography variation value Var (step S**530**).

[0072] If the current photoplethysmography variation value Var is less than the previous photoplethysmography variation value Var, steps S**520**, S**522**, S**524**, S**526**, S**528** and so on are performed; if the current photoplethysmography variation value Var is greater than the previous photoplethysmography variation value Var, the feedback emitted light amplitude adjustment unit **140** adjusts the size of the received photoplethysmography variation value Var to control the brightness of the light emitted by the light emitter **102** to decrease (step S**532**), and the feedback emitted light amplitude adjustment unit **140** controls the brightness of the light emitted by the light emitter **102** with the adjusted photoplethysmography variation value Var (step S**534**).

[0073] The light receiver **104** receives the light with a particular wavelength transmitted through background tissues of the human body or reflected by the background tissues of the human body, and converts the light to a photoplethysmography signal which is an electrical signal (step S**536**).

[0074] The analog/digital conversion unit **120** converts the photoplethysmography signal converted by the light receiver which is an analog signal **104** to a photoplethysmography value which is a digital value, and the variation-degree calculation unit **180** calculates a photoplethysmography variation value Var according to the photoplethysmography value converted by the analog/digital conversion unit **120** (step S**538**).

[0075] The feedback emitted light amplitude adjustment unit **140** judges whether the current photoplethysmography variation value Var calculated by the variation-degree calculation unit **180** is less than the previous photoplethysmography variation value Var (step S**540**).

[0076] If the current photoplethysmography variation value Var is less than the previous photoplethysmography variation value Var, steps S**532**, S**534**, S**536**, S**538** and so on are performed; if the current photoplethysmography variation value Var is greater than the previous photoplethysmography variation value Var, the previous photoplethysmography variation value Var is a minimum variation value, and the feedback emitted light amplitude adjustment unit **140** controls the brightness of the light emitted by the light emitter **102** to be optimal with the minimum variation value.

[0077] The signal processing unit **200** calculates a heart rate value with the photoplethysmography value when the photoplethysmography variation value is the minimum variation value. The heart rate value=60/time difference (heart rate/minute), and the time difference is a time length between adjacent crests in the photoplethysmography value.

[0078] A measuring method of a feedback photoplethysmography measuring device according to the first embodiment of the present invention is described with reference to the block diagram of the feedback photoplethysmography measuring device according to the first embodiment of the present invention.

[0079] FIG. **4** is a flow chart of a measuring method of a feedback photoplethysmography measuring device according to the first embodiment of the present invention. In FIG. **3**, the light emission sequence control unit **160** sends a pulse signal which is the emitted light sequence signal in FIG. **2**A to the light emitter **102**, to control time and frequency of the light emitted by the light emitter **102**, the feedback emitted light amplitude adjustment unit **140** controls brightness of the light emitted by the light emitter **102** with a preset control value to be preset brightness, and the light emitter **102** emits the light with the preset brightness to background tissues of the human body (step S**40**).

[0080] The light receiver **104** receives the light with a particular wavelength transmitted through background tissues of the human body or reflected by the background tissues of the human body, and converts the light to a photoplethysmography signal which is an electrical signal as shown in FIG. 2B (step S**42**).

[0081] The analog/digital conversion unit **120** converts the photoplethysmography signal converted by the light receiver which is an analog signal **104** to a photoplethysmography value which is a digital value (step S**44**). The variation-degree calculation unit **180** calculates a photoplethysmography variation value Var according to the photoplethysmography value converted by the analog/digital conversion unit (step S**46**).

[0082] When the photoplethysmography variation value Var in the steps of the flow as shown in FIG. **3**A or FIG. **3**B is not a minimum variation value, the feedback emitted light amplitude adjustment unit **140** controls the light emitted by the light emitter **102** to be optimal with the photoplethysmography variation value Var which is the minimum variation value (step S**48**).

[0083] As the steps of the flow shown in FIG. **3**A or FIG. 3B, the feedback emitted light amplitude adjustment unit **140** judges whether the calculated photoplethysmography variation value Var is a minimum variation value (step S**50**), if no, step S**40** is performed; and if yes, the signal processing unit **200** calculates the heart rate value with the photoplethysmography variation value Var which is the minimum variation value (step S**52**).

Second Embodiment

[0084] FIG. **5** is a block diagram of a feedback photoplethysmography measuring device according to a second embodiment of the present invention. In FIG. **5**, the feedback photoplethysmography measuring device **20** includes a measuring device **300**, an analog/digital conversion unit **120**, a feedback emitted light amplitude adjustment unit **140**, a light emission sequence control unit **160**, a variation-degree calculation unit **180** and a signal processing unit **200**. The measuring device **300** includes a first light emitter **3021**, a second light emitter **3022** and a light receiver **304**.

[0085] The light emission sequence control unit **160** sends two groups of pulse signals which are emitted light sequence signals to the first light emitter **3021** and the second light emitter **3022** through phase, pulse or sine-wave control, to control time and frequency of the light emitted by the first light emitter **3021** and the second light emitter **3022**. As shown in FIG. **6**A which is a sequence diagram of a pulse signal of a light emission sequence control unit according to the second embodiment of the present invention, the frequency of the light emitted by the first light emitter **3021** and the second light emitter **3022** is the same as the frequency of a first pulse signal and a second pulse signal of the light emission sequence control unit **160**, and ON cycles in the first pulse signal and the second pulse signal of the light emission sequence control unit **160** makes the first light emitter **3021** and the second light emitter **3022** emit red light and infrared light with a particular wavelength.

[0086] The light emitted by the first light emitter **3021** may be red light with a wavelength of 620 nm to 750 nm and the light emitted by the second light emitter **3022** may be infrared light with a wavelength of 780 nm to 1000 nm.

[0087] The light receiver **304** receives red light and infrared light with a particular wavelength transmitted through background tissues of a human body or reflected by the background tissues of the human body, and converts the light to a first photoplethysmography signal and a second photoplethysmography signal which is an electrical signal, as shown in FIG. **6**B which is a diagram of photoplethysmography variations obtained according to different emission frequencies according to the second embodiment of the present invention.

[0088] The analog/digital conversion unit **120** converts the first photoplethysmography signal and the second photoplethysmography signal converted to analog signals by the light receiver **104** to a first photoplethysmography value and a second photoplethysmography value which are digital values respectively. The variation-degree calculation unit **180** calculates a first photoplethysmography variation value and a second photoplethysmography variation value as the above photoplethysmography variation value Var according to the first photoplethysmography value and the second photoplethysmography value converted by the analog/digital conversion unit **120**, as shown in FIG. **6**C which is a schematic diagram of photoplethysmography variation values calculated by a variation-degree calculation unit according to the second embodiment of the present invention.

[0089] The feedback emitted light amplitude adjustment unit **140** controls sizes of the brightness of the light emitted by the first light emitter **3021** and the second light emitter **3022** respectively according to a plurality of preset control values or the adjusted first photoplethysmography variation value and second photoplethysmography variation value calculated by the variation-degree calculation unit **180**, as the steps of the flow shown in FIG. **3**A or FIG. **3**B, until the first photoplethysmography variation value and the second photoplethysmography variation value converted and calculated according to the first photoplethysmography signal and the second photoplethysmography signal converted by the light receiver **304** is a minimum variation value respectively, the feedback emitted light amplitude adjustment unit **140** controls the brightness of the light emitted by the first light emitter **3021** and the second light emitter **3022** to be optimal.

[0090] The signal processing unit **200** calculates a ratio R with the first photoplethysmography value and the second photoplethysmography value when the first photoplethysmography variation value and the second photoplethysmography variation value are a minimum variation value respectively, and obtains a blood oxygen concentration value by looking up a table.

[0091] The blood oxygen concentration value is

$$R=\left[\frac{(S_{R\_max}-S_{R\_min})}{S_{R\_mean}}\right]\Big/\left[\frac{S_{IR\_max}-S_{IR\_min}}{S_{IR\_mean}}\right],$$

wherein S_{R_max} is the crest value in the photoplethysmography variation value of which the corresponding minimum variation value is red light, S_{R_min} is the trough value in the photoplethysmography variation value of which the corresponding minimum variation value is red light, $S_{R\_mean}=(S_{R\_max}+S_{R\_min})/2$, S_{IR_max} is the crest value in the photoplethysmography variation value of which the corresponding minimum variation value is infrared light, S_{IR_min} is the trough value in the photoplethysmography variation value of which the corresponding minimum variation value is infrared light, and $S_{IR\_mean}=(S_{IR\_max}+S_{IR\_min})/2$.

[0092] A measuring method of a feedback photoplethysmography measuring device according to the second embodiment of the present invention is described with reference to the block diagram of the feedback photoplethysmography measuring device according to the second embodiment of the present invention.

[0093] FIG. **7** is a flow chart of a measuring method of a feedback photoplethysmography measuring device according to the second embodiment of the present invention. In FIG. **7**, the light emission sequence control unit **160** sends a first pulse signal and a second pulse signal which are the emitted light sequence signals in FIG. **6**A to the first light emitter **3021** and the second light emitter **3022**, to control time and frequency of the red light and the infrared light emitted by the first light emitter **3021** and the second light emitter **3022**, the feedback emitted light amplitude adjustment unit **140** controls brightness of the light emitted by the first light emitter **3021** and the second light emitter **3022** with a first preset control value and a second preset control value to be preset brightness, and the first light emitter **3021** and the second light emitter **3022** emit the red light and the infrared light with the preset brightness to background tissues of the human body (step S**60**).

[0094] The light receiver **304** receives the red light and the infrared light with a particular wavelength transmitted through background tissues of the human body or reflected by the background tissues of the human body, and converts the light to a first photoplethysmography signal and a second photoplethysmography signal which is an electrical signal as shown in FIG. **6**B (step S**62**).

[0095] The analog/digital conversion unit **120** converts the first photoplethysmography signal and the second photoplethysmography signal converted to analog signals by the light receiver **304** to a first photoplethysmography value and a second photoplethysmography value which are digital values (step S**64**).

[0096] The variation-degree calculation unit **180** calculates a first photoplethysmography variation value and a second photoplethysmography variation value according to the first photoplethysmography value and the second photoplethysmography value converted by the analog/digital conversion unit **120** (step S**66**).

[0097] When the first photoplethysmography variation value and the second photoplethysmography variation value in the steps of the flow as shown in FIG. **3**A or FIG. **3**B are not a minimum variation value, the feedback emitted light amplitude adjustment unit **140** controls sizes of the first photoplethysmography variation value and the second photoplethysmography variation value, and the values thereof control the sizes of brightens of the red light and the infrared light emitted by the first light emitter **3021** and the second light emitter **3022** respectively; when the first photoplethysmography variation value and the second photoplethysmography variation value are both calculated as the minimum variation value, the feedback emitted light amplitude adjustment unit **140** controls the red light and the infrared light emitted by the first light emitter **3021** and the second light emitter **3022** to be optimal with the first photoplethysmography variation value and the second photoplethysmography variation value which are the minimum variation value (step S**68**).

[0098] As the steps of the flow shown in FIG. **3**A or FIG. **3**B, the feedback emitted light amplitude adjustment unit **140** judges whether the calculated first photoplethysmography variation value and second photoplethysmography variation value are a minimum variation value (step S**70**), if no, step S**60** is performed; and if yes, the signal processing unit **200** calculates the blood oxygen concentration value with the first photoplethysmography variation value and the second photoplethysmography variation value which are the minimum variation value (step S**72**).

Third Embodiment

[0099] FIG. **8** is a block diagram of a feedback photoplethysmography measuring device according to a third embodiment of the present invention. In FIG. **8**, the feedback photoplethysmography measuring device **300** includes a measuring device **400**, an analog/digital conversion unit **120**, a feedback emitted light amplitude adjustment unit **140**, a light emission sequence control unit **160**, a variation-degree calculation unit **180** and a signal processing unit **200**. The measuring device **400** includes a first light emitter **4021**, a second light emitter **4022**, a third light emitter **4023** and a light receiver **404**. In this embodiment, the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** are three light emitters of light with a group of particular wavelengths but at different frequencies and different brightness (green light, red light or infrared light); however, the number of the light emitters is not limited to three, more than two light emitters are applicable to the present invention, and the present invention is also applicable to multiple light emitters of light with multiple groups of particular wavelengths.

[0100] The light emission sequence control unit **160** sends three groups of pulse signals which are emitted light sequence signals to the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** through phase, pulse or sine-wave control, to control time and frequency of the light emitted by the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** respectively. As shown in FIG. **9**A which is a sequence diagram of a pulse signal of a light emission sequence control unit according to the third embodiment of the present invention, the frequencies of the light emitted by the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** are the same as the frequencies of a first pulse signal, a second pulse signal and a third pulse signal of the light emission sequence control unit **160**, and ON cycles in the first pulse signal, the second pulse signal and the third pulse signal of the light emission sequence control unit **160** make the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** emit light with particular wavelengths. The frequencies of the first pulse signal, the second pulse signal and the third pulse signal sent by the light emission sequence control unit **160** are different.

[0101] The light receiver **404** receives light with particular wavelengths and having different brightness and different frequencies transmitted through background tissues of a human body or reflected by the background tissues of the human body, and converts the light to a first photoplethysmography signal, a second photoplethysmography signal and a third photoplethysmography signal which are electrical signals, as shown in FIG. **9**B which is a diagram of photoplethysmography variations obtained according to different emission frequencies according to the third embodiment of the present invention.

[0102] The analog/digital conversion unit **120** converts the first photoplethysmography signal, the second photoplethysmography signal and the third photoplethysmography signal converted to analog signals by the light receiver **404** to a first photoplethysmography value, a second photoplethysmography value and a third photoplethysmography value which are digital values, and the first photoplethysmography value, the second photoplethysmography value and the third photoplethysmography value respectively correspond to light with different brightness and different frequencies. The variation-degree calculation unit **180** calculates a first photoplethysmography variation value, a second photoplethysmography variation value and a third photoplethysmography variation value as the above photoplethysmography variation value Var according to the first photoplethysmography value, the second photoplethysmography value and the third photoplethysmography value converted by the analog/digital conversion unit **120**, as shown in FIG. **9**C which is a schematic diagram of photoplethysmography variation values calculated by a variation-degree calculation unit according to the third embodiment of the present invention.

[0103] The feedback emitted light amplitude adjustment unit **140** controls sizes of the brightness of the light emitted by the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** respectively according to a plurality of preset control values or the adjusted first photoplethysmography variation value, second photoplethysmography variation value and third photoplethysmography variation value calculated by the variation-degree calculation unit **180**, as the steps of the flow shown in FIG. **3**A or FIG. **3**B, until one of the first photoplethysmography variation value, the second photoplethysmography variation value and the third photoplethysmography variation value converted and calculated according to the first photoplethysmography signal, the second photoplethysmography signal and the third photoplethysmography signal converted by the light receiver **104** is a minimum variation value, the feedback emitted light amplitude adjustment unit **140** controls the brightness of the light emitted by one of the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** to be optimal.

[0104] The signal processing unit **200** calculates the heart rate value with the photoplethysmography value which is the minimum variation value when one of the first photoplethysmography variation value, the second photoplethysmography variation value and the third photoplethysmography variation value is the minimum variation value. Photoplethysmography measurement is carried out with a plurality of light emitters, and when one of the plurality of light emitters is at the optimal brightness, the heart rate value is calculated with the photoplethysmography value of the light emitter which is correspondingly at the optimal brightness, in this way, the heart rate value can be quickly obtained during photoplethysmography measurement.

[0105] In another embodiment, a first group of multiple light emitters emit different-brightness and different-frequency red light with particular wavelengths, a second group of multiple light emitters emit different-brightness and different-frequency infrared light with particular wavelengths, and the signal processing unit **200** calculates the ratio R with the photoplethysmography value in the first group of multiple light emitters which is a minimum variation value and the photoplethysmography value in the second group of multiple light emitters which is a minimum variation value, and obtains a blood oxygen concentration value by looking up a table.

[0106] FIG. **10** is a flow chart of a measuring method of a feedback photoplethysmography measuring device according to the third embodiment of the present invention. In FIG. **10**, the light emission sequence control unit **160** sends the first pulse signal, the second pulse signal and the third pulse signal in FIG. **9**A which are emitted light sequence signals to the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023**, to control time and frequency of the light emitted by the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** respectively (the frequencies of the light emitted by the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** are different), the feedback emitted light amplitude adjustment unit **140** controls the brightness of the red light and the infrared light emitted by the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** as preset brightness with a first preset control value, a second preset control value and the third preset control value (the brightness of the light emitted by the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** is different), and the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023** respectively emit light with preset brightness to background tissues of the human body (step S**80**).

[0107] The light receiver **404** receives a plurality of different-frequency and different-brightness light with the particular wavelengths transmitted through the background tissues of the human body or reflected by the background tissues of the human body, and converts the light to a first photoplethysmography signal, a second photoplethysmography signal and a third photoplethysmography signal which are electrical signals as shown in FIG. **9**B (step S**82**).

[0108] The analog/digital conversion unit **120** converts the first photoplethysmography signal, the second photoplethysmography signal and the third photoplethysmography signal converted to analog signals by the light receiver **404** to a first photoplethysmography value, a second photoplethysmography value and a third photoplethysmography value which are digital values (step S**84**).

[0109] The variation-degree calculation unit **180** obtains a first photoplethysmography variation value, a second photoplethysmography variation value and a third photoplethysmography variation value respectively through calculation with the first photoplethysmography value, the second photoplethysmography value and the third photoplethysmography value converted by the analog/digital conversion unit **120** (step S**86**).

[0110] When the first photoplethysmography variation value, the second photoplethysmography variation value and the third photoplethysmography variation value in the steps of the flow as shown in FIG. **3**A or FIG. **3**B are not minimum variation values, the feedback emitted light amplitude adjustment unit **140** adjusts the sizes of the first photoplethysmography variation value, the second photoplethysmography variation value and the third photoplethysmography variation value, and the values thereof respectively control the sizes of brightness of the light emitted by the first light emitter **4021**, the second light emitter **4022** and the third light emitter **4023**, when one of the first photoplethysmography variation value, the second photoplethysmography variation value and the third photoplethysmography variation value is a minimum variation value, the feedback emitted light amplitude adjustment unit **140** controls the light emitted by the light emitter corresponding to the minimum variation value to be the optimal brightness with the photoplethysmography variation value which is the minimum variation value (step S**88**).

[0111] As the steps of the flow shown in FIG. **3**A or FIG. **3**B, the feedback emitted light amplitude adjustment unit **140** judges whether one of the calculated first photoplethysmography variation value, second photoplethysmography variation value and third photoplethysmography variation value is a minimum variation value (step S**90**), if no, step S**80** is performed; if yes, the signal processing unit **200** calculates the heart rate value with the photoplethysmography variation value which is the minimum variation value (step S**92**).

[0112] In another embodiment, a first group of multiple light emitters emit different-brightness and different-frequency red light with particular wavelengths, a second group of multiple light emitters emit different-brightness and different-frequency infrared light with particular wavelengths, and the signal processing unit **200** calculates the ratio R with the photoplethysmography value in the first group of multiple light emitters which is a minimum variation value and the photoplethysmography value in the second group of multiple light emitters which is a minimum variation value, and obtains a blood oxygen concentration value by looking up a table.

[0113] The present invention provides a feedback photoplethysmography measuring device and a measuring method thereof, which can adjust brightness of light emitted by a light emitter of the photoplethysmography measuring device to be optimal with respect to different background tissues of a human body to be measured, to make the background tissues of the human body measured by the photoplethysmography measuring device have optimal measurement signals, and measure photoplethysmography with a plurality of light emitters, which can rapidly measure the heart rate value and the blood oxygen concentration value of the human body.

[0114] Although the present invention has been stated as above with reference to preferred embodiments and exemplary drawings, they should not be regarded as limitative. Various modifications, omissions and variations made by those skilled in the art to the forms and the contents of the embodiments do not depart from the scope claimed by the claims of the present invention.

What is claimed is:

1. A feedback photoplethysmography measuring device, comprising:

a measuring device, comprising:

a light emitter that emits light with a particular wavelength to a human body; and

a light receiver that receives the light with a particular wavelength transmitted through the human body or reflected by the human body, and converts the light to a photoplethysmography signal which is an electrical signal;

an analog/digital conversion unit that converts the photoplethysmography signal converted by the light receiver which is an analog signal to a photoplethysmography value which is a digital value;

a variation-degree calculation unit that calculates a photoplethysmography variation value according to the photoplethysmography value converted by the analog/digital conversion unit; and

a feedback emitted light amplitude adjustment unit that controls brightness of the light emitted by the light emitter according to a plurality of preset control values or the adjusted photoplethysmography variation value calculated by the variation-degree calculation unit, and adjusts the photoplethysmography variation value to a minimum variation value, to control the brightness of the light emitted by the light emitter to be optimal.

2. The feedback photoplethysmography measuring device according to claim **1**, further comprising: a light emission sequence control unit that sends an emitted light sequence signal to the light emitter through phase, pulse or sine-wave control, to control time and frequency of the light emitted by the light emitter.

3. The feedback photoplethysmography measuring device according to claim **1**, further comprising: a signal processing unit that calculates a heart rate value with the photoplethysmography value when the photoplethysmography variation value is the minimum variation value.

4. The feedback photoplethysmography measuring device according to claim **3**, wherein the heart rate value=60/time difference (heart rate/minute), and the time difference is a time length between adjacent crests in the photoplethysmography value.

5. The feedback photoplethysmography measuring device according to claim **1**, wherein the light emitted by the light emitter is one of green light with a wavelength of 495 nm to 570 nm, red light with a wavelength of 620 nm to 750 nm and infrared light with a wavelength of 780 nm to 1000 nm.

6. The feedback photoplethysmography measuring device according to claim **1**, wherein the photoplethysmography variation value is

$$Var = \frac{1}{N}\left[\sum_{n=1}^{N} (I[n] - M)^2\right],$$

wherein N is the total data number of the photoplethysmography value through sequence analysis or Fourier transform, I[n] is the corresponding light intensity of the photoplethysmography value via sequence analysis or Fourier transform at the time n, and M is an average value of I[n].

7. The feedback photoplethysmography measuring device according to claim **1**, wherein the feedback emitted light amplitude adjustment unit controls the brightness of the light emitted by the light emitter with each of the control values, and judges that the minimum one in the photoplethysmography variation value of each of the corresponding control values calculated by the variation-degree calculation unit as the minimum variation value.

8. The feedback photoplethysmography measuring device according to claim **1**, wherein, when the feedback emitted light amplitude adjustment unit judges that the current photoplethysmography variation value calculated by the variation-degree calculation unit is less than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to increase, and when the current photoplethysmography variation value calculated by the variation-degree calculation unit is greater than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to decrease, wherein, when the current photoplethysmography variation value calculated by the variation-degree calculation unit is judged to be less than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to decrease, and when the current photoplethysmography variation value calculated by the variation-degree calculation unit is greater than the previous photoplethysmography variation value, the previous photoplethysmography variation value is the minimum variation value.

9. A feedback photoplethysmography measuring device, comprising:

a measuring device, comprising:

a plurality of light emitters that emit light with a particular wavelength but in different sequences to a human body respectively; and

a light receiver that receives the light with a particular wavelength but in different sequences transmitted through the human body or reflected by the human body, and converts the light to a plurality of photoplethysmography signals which are electrical signals;

a light emission sequence control unit that sends each of a plurality of emitted light sequence signals to each of the light emitters through phase, pulse or sine-wave control, to control time and frequency of the light emitted by each of the light emitters;

an analog/digital conversion unit that converts the photoplethysmography signals converted by the light receiver which are analog signals to a photoplethysmography value which is a digital value respectively;

a variation-degree calculation unit that calculates a plurality of photoplethysmography variation values according to the photoplethysmography values converted by the analog/digital conversion unit; and

a feedback emitted light amplitude adjustment unit that controls brightness of the light emitted by each of the light emitters according to a plurality of preset control values or the adjusted photoplethysmography variation values calculated by the variation-degree calculation unit, and adjusts at least one of the photoplethysmography variation values to a minimum variation value, to control the brightness of the light emitted by the light emitter corresponding to the minimum variation value to be optimal.

10. The feedback photoplethysmography measuring device according to claim **9**, further comprising: a signal processing unit that calculates a heart rate value for the photoplethysmography value which is the minimum variation value when one of the photoplethysmography variation values is the minimum variation value.

11. The feedback photoplethysmography measuring device according to claim **10**, wherein the heart rate value=60/time difference (heart rate/minute), and the time difference is a time length between adjacent crests in the photoplethysmography value which is the minimum variation value.

12. The feedback photoplethysmography measuring device according to claim **9**, further comprising: a signal processing unit calculates that, when one of the photoplethysmography variation values of which the wavelength is red light and one of the photoplethysmography variation values of which the wavelength is infrared light are both the minimum variation value, a ratio R for the photoplethysmography variation value of which the wavelength of the minimum variation value is red light and the photoplethysmography variation value of which the wavelength is infrared light, and obtains a blood oxygen concentration value by looking up a table.

13. The feedback photoplethysmography measuring device according to claim **12**, wherein the ratio is

$$R = \left[\frac{(S_{R\_max} - S_{R\_min})}{S_{R\_mean}}\right] \Big/ \left[\frac{S_{IR\_max} - S_{IR\_min}}{S_{IR\_mean}}\right],$$

wherein S_{R_max} is the crest value in the photoplethysmography variation value of which the corresponding minimum variation value is red light, S_{R_min} is the trough value in the photoplethysmography variation value of which the corresponding minimum variation value is red light, $S_{R\_mean}=(S_{R\_max}+S_{R\_min})/2$, S_{IR_max} is the crest value in the photoplethysmography variation value of which the corresponding minimum variation value is infrared light, S_{IR_min} is the trough value in the photoplethysmography variation value of which the corresponding minimum variation value is infrared light, and $S_{IR\_mean}=(S_{IR\_max}+S_{IR\_min})/2$.

14. The feedback photoplethysmography measuring device according to claim **9**, wherein the light emitted by the light emitters is one green light with a wavelength of 495 nm to 570 nm, red light with a wavelength of 620 nm to 750 nm and infrared light with a wavelength of 780 nm to 1000 nm.

15. The feedback photoplethysmography measuring device according to claim **9**, wherein each of the photoplethysmography variation values is

$$Var = \frac{1}{N}\left[\sum_{n=1}^{N} (I[n] - M)^2\right],$$

wherein N is the total data number of each of the photoplethysmography values through sequence analysis or Fourier transform, I[n] is the corresponding light intensity of each of the photoplethysmography values via sequence analysis or Fourier transform at the time n, and M is an average value of I[n].

16. The feedback photoplethysmography measuring device according to claim **9**, wherein the feedback emitted light amplitude adjustment unit controls the brightness of the light emitted by the light emitter with each of the control values, and judges that the minimum one in the photoplethysmography variation value of each of the corresponding control values calculated by the variation-degree calculation unit as the minimum variation value.

17. The feedback photoplethysmography measuring device according to claim **9**, wherein, when the feedback emitted light amplitude adjustment unit judges that the current photoplethysmography variation value calculated by the variation-degree calculation unit is less than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to increase, and when the current photoplethysmography variation value calculated by the variation-degree calculation unit is greater than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to decrease, wherein, when the current photoplethysmography variation value calculated by the variation-degree calculation unit is judged to be less than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to decrease, and when the current photoplethysmography variation value calculated by the variation-degree calculation unit is greater than the previous photoplethysmography variation value, the previous photoplethysmography variation value is the minimum variation value.

18. A measuring method of a feedback photoplethysmography measuring device, comprising:

emitting, by a light emitter, light with a particular wavelength to a human body;

receiving, by a light receiver, the light with a particular wavelength transmitted through the human body or reflected by the human body, and converting the light to a photoplethysmography signal which is an electrical signal;

converting, by an analog/digital conversion unit, the photoplethysmography signal converted by the light receiver which is an analog signal to a photoplethysmography value which is a digital value;

calculating, by a variation-degree calculation unit, a photoplethysmography variation value according to the photoplethysmography value converted by the analog/digital conversion unit; and

adjusting, by a feedback emitted light amplitude adjustment unit, the photoplethysmography variation value, and controlling brightness of the light emitted by the light emitter according to a plurality of preset control values or the adjusted photoplethysmography variation value calculated by the variation-degree calculation unit;

wherein the feedback emitted light amplitude adjustment unit judges whether the adjusted photoplethysmography variation value is the minimum variation value.

19. The measuring method according to claim **18**, wherein, in the step of controlling, by the feedback emitted light amplitude adjustment unit, brightness of the light emitted by the light emitter, a light emission sequence control unit that sends an emitted light sequence signal to the light emitter through phase, pulse or sine-wave control, to control time and frequency of the light emitted by the light emitter.

20. The measuring method according to claim **18**, after the step of judging, by the feedback emitted light amplitude adjustment unit, the adjusted photoplethysmography variation value to be the minimum variation value, further comprising: calculating, by a signal processing unit, a heart rate value with the photoplethysmography value when the photoplethysmography variation value is the minimum variation value.

21. The measuring method according to claim **20**, wherein the heart rate value=60/time difference (heart rate/minute), and the time difference is a time length between adjacent crests in the photoplethysmography value.

22. The measuring method according to claim **18**, wherein the light emitted by the light emitter is one of green light with a wavelength of 495 nm to 570 nm, red light with a wavelength of 620 nm to 750 nm and infrared light with a wavelength of 780 nm to 1000 nm.

23. The measuring method according to claim **18**, wherein the photoplethysmography variation value is

$$Var = \frac{1}{N}\left[\sum_{n=1}^{N} (I[n] - M)^2\right],$$

wherein N is the total data number of the photoplethysmography value through sequence analysis or Fourier transform, I[n] is the corresponding light intensity of the photoplethysmography value via sequence analysis or Fourier transform at the time n, and M is an average value of I[n].

24. The measuring method according to claim **18**, wherein the feedback emitted light amplitude adjustment unit controls the brightness of the light emitted by the light emitter with each of the control values, and judges that the minimum one in the photoplethysmography variation value of each of the corresponding control values calculated by the variation-degree calculation unit as the minimum variation value.

25. The measuring method according to claim **18**, wherein, when the feedback emitted light amplitude adjustment unit judges that the current photoplethysmography variation value calculated by the variation-degree calculation unit is less than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to increase, and when the current photoplethysmography variation value calculated by the variation-degree calculation unit is greater than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to decrease, wherein, when the current photoplethysmography variation value calculated by the variation-degree calculation unit is judged to be less than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to decrease, and when the current photoplethysmography variation value calculated by the variation-degree calculation unit is greater than the previous photoplethysmography variation value, the previous photoplethysmography variation value is the minimum variation value.

26. A measuring method of a feedback photoplethysmography measuring device, comprising:

emitting, by a plurality of light emitters, light with a particular wavelength but in different sequences to a human body;

receiving, by a light receiver, the light with a particular wavelength but in different sequences transmitted through the human body or reflected by the human body, and converting the light to a plurality of photoplethysmography signals which are electrical signals;

sending, by a light emission sequence control unit, each of a plurality of emitted light sequence signals to each of the light emitters through phase, pulse or sine-wave control, to control time and frequency of the light emitted by each of the light emitters;

converting, by an analog/digital conversion unit, the photoplethysmography signals converted by the light receiver which are analog signals to a plurality of a photoplethysmography value which is a digital value;

calculating, by a variation-degree calculation unit, a plurality of photoplethysmography variation values according to the photoplethysmography values converted by the analog/digital conversion unit; and

adjusting, by a feedback emitted light amplitude adjustment unit, the photoplethysmography variation values, and controlling brightness of the light emitted by each of the light emitters according to a plurality of preset control values or the adjusted photoplethysmography variation values calculated by the variation-degree calculation unit respectively;

wherein the feedback emitted light amplitude adjustment unit judges whether at least one of the adjusted photoplethysmography variation values is the minimum variation value.

27. The measuring method according to claim **26**, after the step of judging, by the feedback emitted light amplitude adjustment unit, at least one of the adjusted photoplethysmography variation values to be the minimum variation value, further comprising: calculating, by a signal processing unit, a heart rate value for the photoplethysmography value which is the minimum variation value when at least one of the photoplethysmography variation values is the minimum variation value.

28. The measuring method according to claim **27**, wherein the heart rate value=60/time difference (heart rate/minute), and the time difference is a time length between adjacent crests in the photoplethysmography value which is the minimum variation value.

29. The measuring method according to claim **26**, after the step of judging, by the feedback emitted light amplitude adjustment unit, at least one of the adjusted photoplethysmography variation values to be the minimum variation value, further comprising: calculating, by a signal processing unit, when one of the photoplethysmography variation values of which the wavelength is red light and one of the photoplethysmography variation values of which the wavelength is infrared light are both the minimum variation value, a ratio R for the photoplethysmography variation value of which the wavelength of the minimum variation value is red light and the photoplethysmography variation value of which the wavelength is infrared light, and obtaining a blood oxygen concentration value by looking up a table.

30. The measuring method according to claim **29**, wherein the ratio is

$$R = \left[\frac{(S_{R\_max} - S_{R\_min})}{S_{R\_mean}}\right] \Big/ \left[\frac{S_{IR\_max} - S_{IR\_min}}{S_{IR\_mean}}\right],$$

wherein S_{R_max} is the crest value in the photoplethysmography variation value of which the corresponding minimum variation value is red light, S_{R_min} is the trough value in the photoplethysmography variation value of which the corresponding minimum variation value is red light, $S_{R\_mean}=(S_{R\_max}+S_{R\_min})/2$, S_{IR_max} is the crest value in the photoplethysmography variation value of which the corresponding minimum variation value is infrared light, S_{IR_min} is the trough value in the photoplethysmography variation value of which the corresponding minimum variation value is infrared light, and $S_{IR\_mean}=(S_{IR\_max}+S_{IR\_min})/2$.

31. The measuring method according to claim **30**, wherein the light emitted by the light emitters is one green light with a wavelength of 495 nm to 570 nm, red light with a wavelength of 620 nm to 750 nm and infrared light with a wavelength of 780 nm to 1000 nm.

32. The measuring method according to claim **26**, wherein each of the photoplethysmography variation values is

$$Var = \frac{1}{N}\left[\sum_{n=1}^{N} (I[n] - M)^2\right],$$

wherein N is the total data number of each of the photoplethysmography values through sequence analysis or Fourier transform, I[n] is the corresponding light intensity of each of the photoplethysmography values via sequence analysis or Fourier transform at the time n, and M is an average value of I[n].

33. The measuring method according to claim **26**, wherein the feedback emitted light amplitude adjustment unit controls the brightness of the light emitted by the light emitter with each of the control values, and judges that the minimum one in the photoplethysmography variation value of each of the corresponding control values calculated by the variation-degree calculation unit as the minimum variation value.

34. The measuring method according to claim **26**, wherein, when the feedback emitted light amplitude adjustment unit judges that the current photoplethysmography variation value calculated by the variation-degree calculation unit is less than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to increase, and when the current photoplethysmography variation value calculated by the variation-degree calculation unit is greater than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to decrease, wherein, when the current photoplethysmography variation value calculated by the variation-degree calculation unit is judged to be less than the previous photoplethysmography variation value, the feedback emitted light amplitude adjustment unit adjusts the current photoplethysmography variation value to control the brightness of the light emitted by the light emitter to decrease, and when the current photoplethysmography variation value calculated by the variation-degree calculation unit is greater than the previous photoplethysmography variation value, the previous photoplethysmography variation value is the minimum variation value.

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专利名称(译)	反馈光电容积描记测量装置及其测量方法		
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摘要(译)

本发明提供一种反馈光电容积脉搏波测量装置，包括：测量人体以获得光电容积脉搏波信号的测量装置;模拟/数字转换单元，将由测量装置测量的光电容积脉搏波信号转换成光电容积脉搏波值，该值是数字值;变化度计算单元，根据由模拟/数字转换单元转换的光电容积描记值计算光电容积描记变化值;反馈发光调幅单元，根据多个预设控制值或由变化度计算单元计算出的调整后的光电容积脉搏波变化值控制测量装置，并将光电容积描记变化值调整为最小变化值。