US 20160353998A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2016/0353998 A1**

Lee et al. (43) **Pub. Date: Dec. 8, 2016**

(54) **APPARATUS AND METHOD FOR NONINVASIVE AND CUFFLESS BLOOD PRESSURE MEASUREMENT**

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(21) Appl. No.: **15/165,542**

(22) Filed: **May 26, 2016**

(30) **Foreign Application Priority Data**

Jun. 2, 2015 (TW) 104117761

Publication Classification

(51) **Int. Cl.**

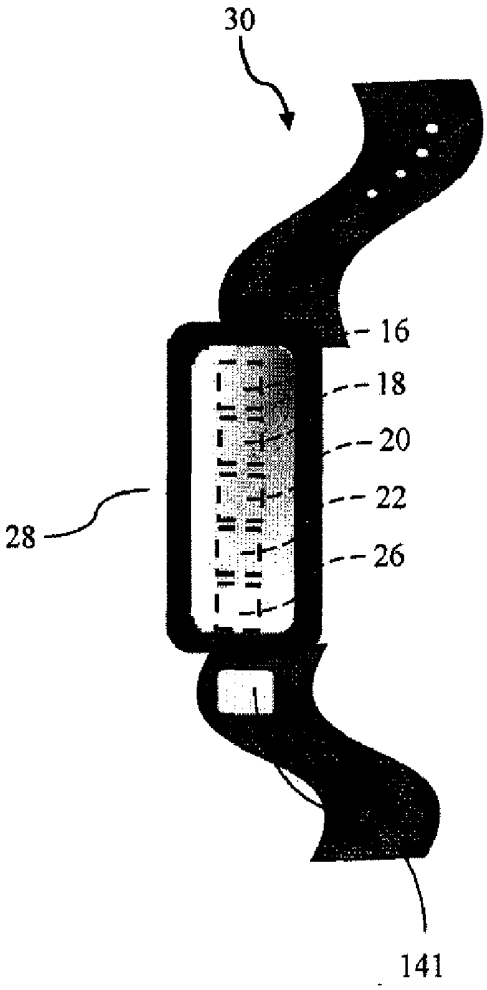
A61B 5/021	(2006.01)
A61B 5/0402	(2006.01)
A61B 5/04	(2006.01)
A61B 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 5/02108*** (2013.01); ***A61B 5/742*** (2013.01); ***A61B 5/7282*** (2013.01); ***A61B 5/0402*** (2013.01); ***A61B 5/04012*** (2013.01); ***A61B 5/681*** (2013.01); *A61B 5/02433* (2013.01)

(57) **ABSTRACT**

An apparatus and a method for noninvasive and caffless blood pressure measurement are provided. The apparatus includes: a photoplethysmography (PPG) amplitude calculation unit, a time difference calculation unit, a velocity calculation unit, and a calculation unit. The method includes the following steps: calculating amplitude differences between characteristic points of a PPG waveform; calculating differences between a time point of a peak of an electrocardiography (ECG) waveform and a time point of each of the characteristic points of the PPG waveform; calculating differences between time points of the characteristic points of the PPG waveform; performing calculation according to the length of a hand and an ECG-PPG time difference to obtain a pulse wave velocity (PWV); and performing calculation according to the PWV, one of the characteristic point amplitude difference, and one of the characteristic point time difference to obtain a systolic/diastolic blood pressure estimate.



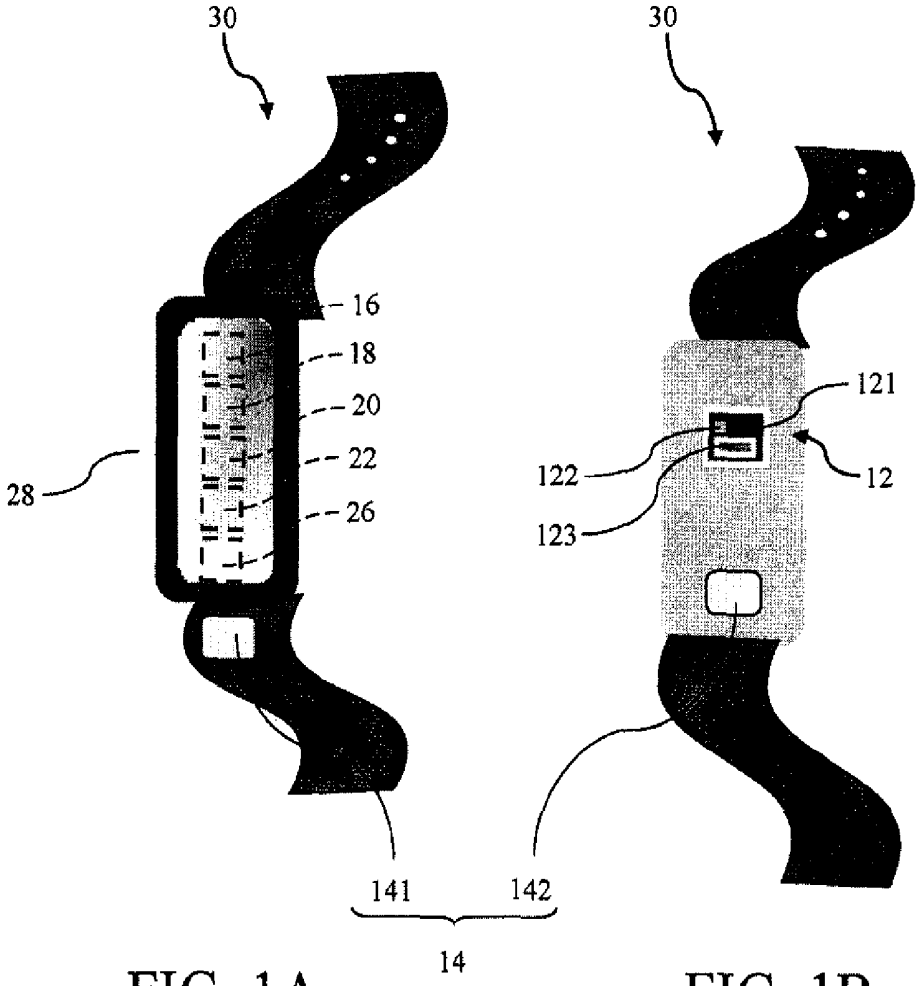


FIG. 1A FIG. 1B

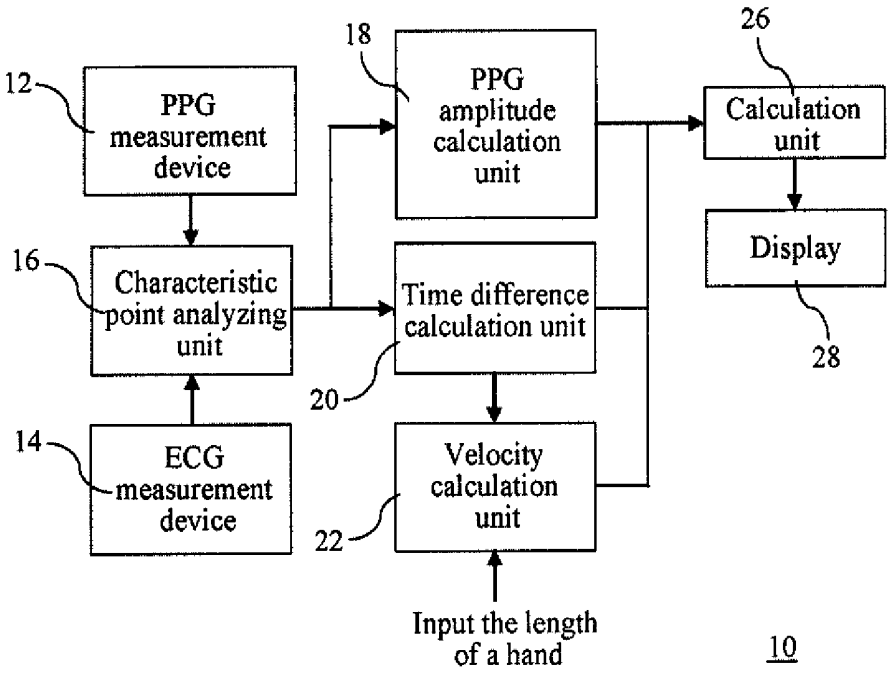

12
PPG measurement device
18
PPG amplitude calculation unit
26
Calculation unit
Display
28
16
Characteristic point analyzing unit
Time difference calculation unit
20
14
ECG measurement device
Velocity calculation unit
22
Input the length of a hand
10

FIG. 2

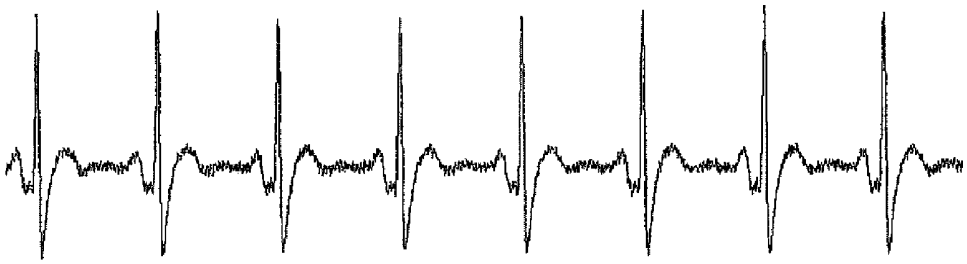


FIG. 3

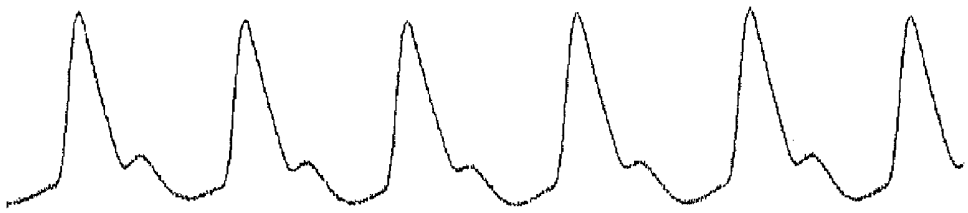


FIG. 4

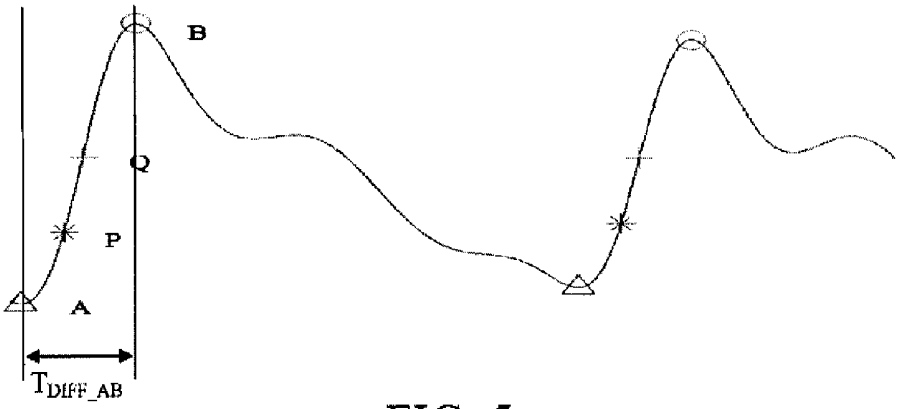


FIG. 5

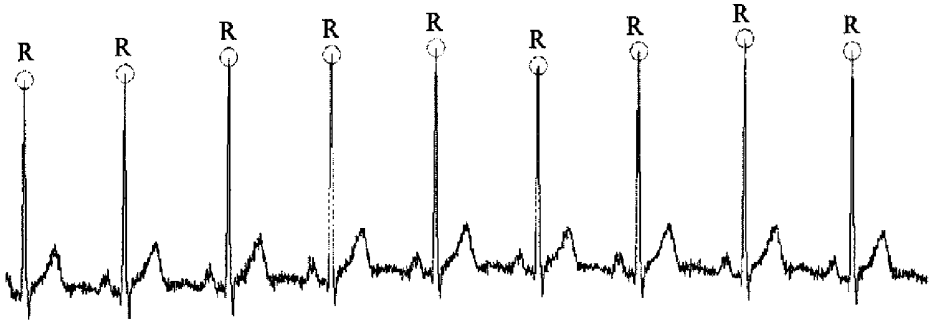


FIG. 6

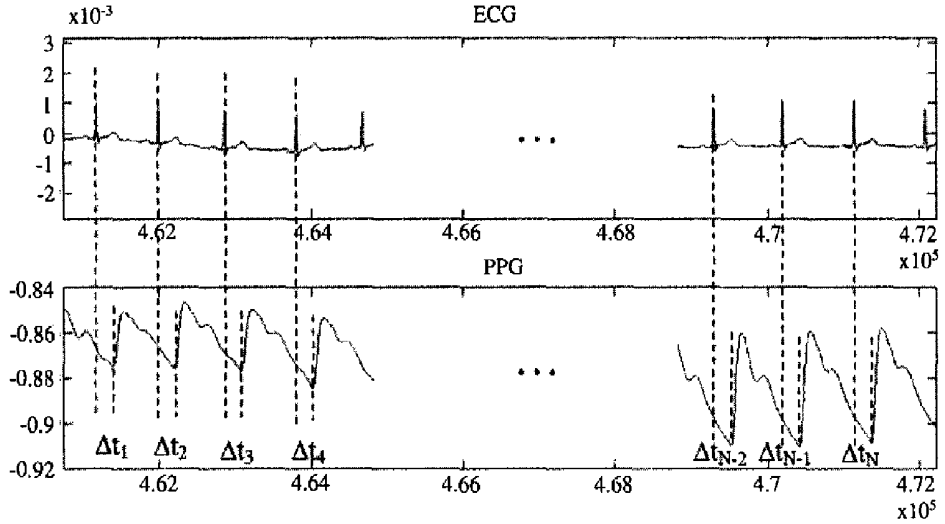

x10-3
ECG
3
2
1
0
-1
-2
4.62
4.64
4.66
4.68
4.7
4.72
x10^5
PPG
-0.84
-0.86
-0.88
-0.9
-0.92
Δt1 Δt2 Δt3 Δt4
ΔtN-2 ΔtN-1 ΔtN

FIG. 7

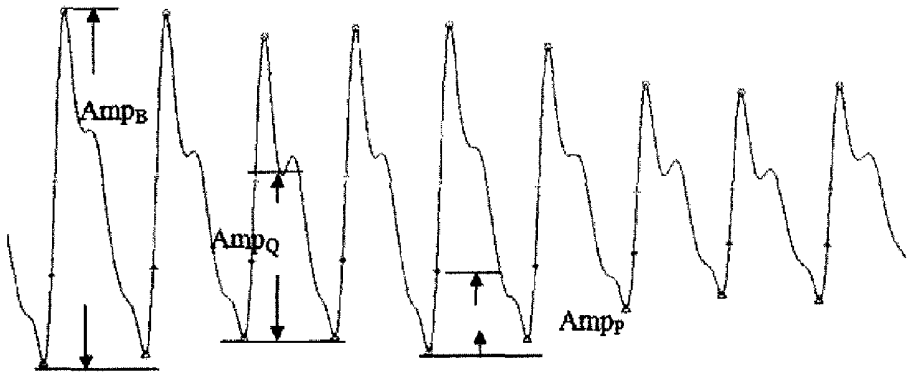

AmpB
AmpQ
AmpP

FIG. 8

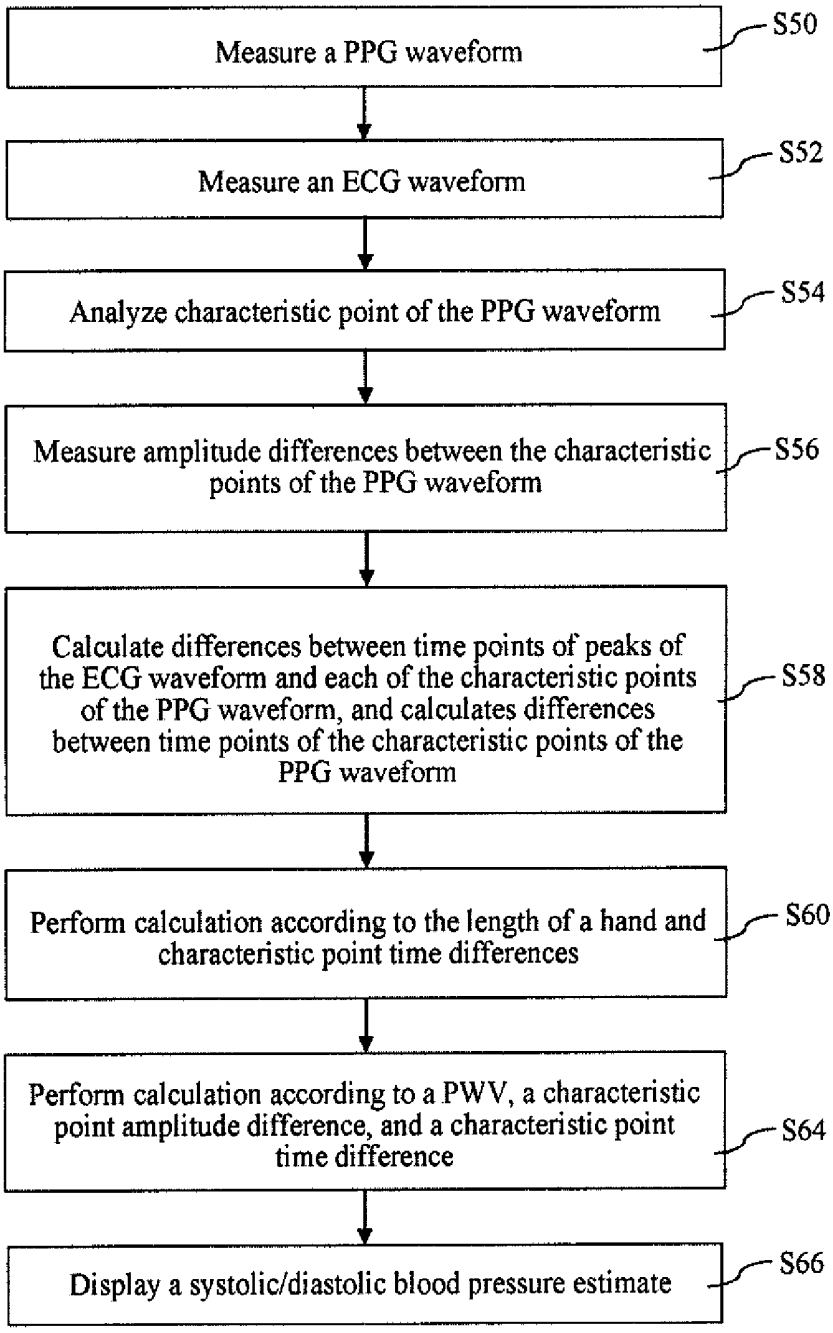

Measure a PPG waveform
S50
Measure an ECG waveform
S52
Analyze characteristic point of the PPG waveform
S54
Measure amplitude differences between the characteristic points of the PPG waveform
S56
Calculate differences between time points of peaks of the ECG waveform and each of the characteristic points of the PPG waveform, and calculates differences between time points of the characteristic points of the PPG waveform
S58
Perform calculation according to the length of a hand and characteristic point time differences
S60
Perform calculation according to a PWV, a characteristic point amplitude difference, and a characteristic point time difference
S64
Display a systolic/diastolic blood pressure estimate
S66

FIG. 9

APPARATUS AND METHOD FOR NONINVASIVE AND CUFFLESS BLOOD PRESSURE MEASUREMENT

BACKGROUND

[0001] 1. Technical Field

[0002] The present invention relates to the field of medical equipment, and in particular, to an apparatus and a method for noninvasive and cuffless blood pressure measurement.

[0003] 2. Related Art

[0004] With the rapid development of industry and commerce, work pressure of people is growing, coupled with an unbalanced diet, resulting in an increasing number of people suffering from cardiovascular diseases. According to statistics of top ten leading causes of death in Taiwan collected by Ministry of Health and Welfare of Executive Yuan from 2008 to 2012, nearly a half of the top ten leading causes of death are cardiovascular related diseases, such as heart disease, cerebrovascular disease, and hypertensive disease. The number of deaths resulted from cardiovascular related diseases is 30.3% of the total number of deaths in Taiwan in 2012, and the heart disease and the cerebrovascular disease are two main causes of the deaths resulted from cardiovascular related diseases.

[0005] Many patients consult doctors and have physical examinations only when conditions are serious, not to mention that people cannot detect their diseases by means of physical examinations because of a severe shortage of medical resources in many districts. Therefore, how to implement a self-examination at home rather than an examination in hospital and implement an early detection of a cardiovascular related disease is an important subject.

[0006] A traditional apparatus for blood pressure measurement in the market needs to use a sphygmomanometer and use a cuff to apply pressure to measure a blood pressure estimate, and the sphygmomanometer needs to be periodically calibrated, so as to prevent an error value from being generated. Some studies use electrocardiography (ECG) and photoplethysmography (PPG) to perform noninvasive blood pressure calculation, for example, blood pressure calculation is performed by using a pulse wave velocity (PWV) calculated by using ECG and PPG signals and adding a compensatory pressure device to a finger or a wrist. In addition, a PWV calculated by using ECG and PPG is used to perform noninvasive and cuffless blood pressure calculation.

SUMMARY

[0007] In view of the foregoing problem, an objective of the present invention is to provide an apparatus and a method for noninvasive and cuffless blood pressure measurement for measuring physiological signals of a tested person, such as a PPG waveform and an ECG waveform, using a PPG amplitude to represent intravascular blood volume, and using a difference between time points of characteristic points of the PPG waveform as a calibration parameter of a vascular elastic coefficient, so as to calculate an intravascular systolic/diastolic blood pressure. The apparatus for noninvasive and cuffless blood pressure measurement does not need periodic calibration, does not need a cuff for applying pressure, can measure a blood pressure estimate of a tested person according to physiological signals, can be worn by a measured person for a long time, and can measure physiological signals.

[0008] A first aspect of the present invention provides an apparatus for noninvasive and cuffless blood pressure measurement, including:

[0009] a PPG amplitude calculation unit, configured to calculate amplitude differences between a plurality of characteristic points of a PPG waveform, so as to obtain a plurality of characteristic point amplitude differences;

[0010] a time difference calculation unit, configured to calculate differences between a time point of a peak of an ECG waveform and a time point of each of the characteristic points of the PPG waveform, so as to obtain a plurality of ECG-PPG time differences, and configured to calculate differences between time points of the characteristic points of the PPG waveform, so as to obtain a plurality of characteristic point time differences;

[0011] a velocity calculation unit, configured to perform calculation according to the length of a hand and one of the ECG-PPG time differences calculated by the time difference calculation unit, so as to obtain a pulse wave velocity (PWV); and

[0012] a calculation unit, configured to perform calculation according to the PWV calculated by the velocity calculation unit, one of the characteristic point amplitude differences calculated by the PPG amplitude calculation unit, and one of the characteristic point time differences calculated by the time difference calculation unit, so as to obtain a systolic/diastolic blood pressure estimate.

[0013] A second aspect of the present invention provides a method for noninvasive and cuffless blood pressure measurement, including the following steps:

[0014] calculating amplitude differences between a plurality of characteristic points of a PPG waveform, so as to obtain a plurality of characteristic point amplitude differences;

[0015] calculating differences between a time point of a peak of an ECG waveform and a time point of each of the characteristic points of the PPG waveform, so as to obtain a plurality of ECG-PPG time differences, and calculating differences between time points of the characteristic points of the PPG waveform, so as to obtain a plurality of characteristic point time differences;

[0016] performing calculation according to the length of a hand and one of the ECG-PPG time differences, so as to obtain a PWV; and

[0017] performing calculation according to the PWV, one of the characteristic point amplitude differences, and one of the characteristic point time differences, so as to obtain a systolic/diastolic blood pressure estimate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. **1**A is a front view of a wrist-worn apparatus for noninvasive and cuffless blood pressure measurement according to the present invention;

[0019] FIG. **1**B is a rear view of the wrist-worn apparatus for noninvasive and cuffless blood pressure measurement according to the present invention;

[0020] FIG. **2** is a block diagram of the apparatus for noninvasive and cuffless blood pressure measurement according to the present invention;

[0021] FIG. **3** is a diagram of an ECG waveform according to the present invention;

[0022] FIG. **4** is a diagram of a PPG waveform according to the present invention;

[0023] FIG. **5** is a schematic diagram of characteristic points of the PPG waveform according to the present invention;

[0024] FIG. **6** is a schematic diagram of the ECG waveform according to the present invention;

[0025] FIG. **7** is a schematic diagram of time differences between time points of peaks of the ECG waveform and a time point of a characteristic point A of the PPG waveform according to the present invention;

[0026] FIG. **8** is a schematic diagram of values of amplitude differences between characteristic points of the PPG waveform according to the present invention; and

[0027] FIG. **9** is a flowchart of a method for noninvasive and cuffless blood pressure measurement according to the present invention.

DETAILED DESCRIPTION

[0028] To make persons of ordinary skill in the art further understand the present invention, features and effects of the present invention are described in detail below through preferred embodiments with reference to the accompanied drawings.

[0029] FIG. **1**A is a front view of a wrist-worn apparatus for noninvasive and cuffless blood pressure measurement according to the present invention; FIG. **1**B is a rear view of the wrist-worn apparatus for noninvasive and cuffless blood pressure measurement according to the present invention; and FIG. **2** is a block diagram of the apparatus for noninvasive and cuffless blood pressure measurement according to the present invention. In FIG. **1**A, FIG. **1**B, and FIG. **2**, an apparatus for noninvasive and cuffless blood pressure measurement **10** includes a PPG measurement device **12**, an ECG measurement device **14**, a characteristic point analyzing unit **16**, a PPG amplitude calculation unit **18**, a time difference calculation unit **20**, a velocity calculation unit **22**, a calculation unit **26**, and a display **28**.

[0030] In this embodiment, the apparatus for noninvasive and cuffless blood pressure measurement **10** is arranged in a wrist-worn member **30** in a wrist-worn manner, but the present invention is not limited thereto. The apparatus for noninvasive and cuffless blood pressure measurement **10** may also be arranged in a finger-worn manner or a head-mounted manner.

[0031] The ECG measurement device **14** includes a first pole piece **141** and a second pole piece **142**. The first pole piece **141** is arranged at a front surface of the wrist-worn member **30**, and the second pole piece **142** is arranged at a rear surface of the wrist-worn member **30**. The first pole piece **141** and the second pole piece **142** are, for example, separately in contact with skin of two hands, so as to measure an ECG waveform of heartbeats as shown in FIG. **3**, a diagram of an ECG waveform according to the present invention.

[0032] The PPG measurement device **12** arranged at the rear surface of the wrist-worn member **30** includes a first emitter **121**, a second emitter **122**, and a receiver **123**. Each of the first emitter **121** and the second emitter **122** is a transmissive emitter or a reflective emitter for emitting green light, red light, or infrared rays. The receiver **123** is a transmissive receiver or a reflective receiver for receiving green light, red light, or infrared rays. A wavelength of the green light is 495 nm to 570 nm, a wavelength of the red light is 620 nm to 750 nm, and a wavelength of the infrared rays is 780 nm to 1000 nm.

[0033] In this embodiment, the PPG measurement device **12** including two emitters is described, but the present invention is not limited thereto. Any specific number of emitters is applicable to the present invention.

[0034] The first emitter **121** and the second emitter **122** emit light of the foregoing specific wavelength to an object such as an arm or a finger, and the receiver **123** receives light of a specific wavelength that transmits the finger or the arm or is reflected by the finger or the arm, so that the PPG measurement device **12** measures a PPG waveform indicating blood volume changes under light irradiation, as shown in FIG. **4**, a diagram of a PPG waveform according to the present invention.

[0035] The characteristic point analyzing unit **16** arranged in the wrist-worn member **30** analyzes the PPG waveform measured by the PPG measurement device **12**, and refers to the content in Characters available in photoplethysmogram for blood pressure estimation: beyond the pulse transit time (Australasian College Physical Scientists and Engineers in Medicine (2014) 37:367-376 published by Yanjun Li, Zengli Wang, Lin Zhang, Xianglin Yang, Jinzhong Song, etc., so as to obtain amplitudes and time points of characteristics of the PPG waveform as shown in FIG. **5**, a schematic diagram of characteristic points of the PPG waveform according to the present invention.

[0036] In FIG. **5**, a characteristic point B is a peak in the PPG waveform; a characteristic point A is a valley in the PPG waveform; a characteristic point P is a position between the valley (that is, the characteristic point A) and the peak (that is, the characteristic point B) and with a distance between the position and the valley being ¼ of a distance between the valley and the peak; and a characteristic point Q is a position of a maximum slope between the valley and the peak.

[0037] The characteristic point analyzing unit **16** arranged in the wrist-worn member **30** analyzes an ECG waveform measured by the ECG measurement device **14**, so as to obtain amplitudes and time points of peaks of the ECG waveform as shown in FIG. **6**, a schematic diagram of the ECG waveform according to the present invention. In FIG. **6**, Rs represent peaks of the ECG waveform.

[0038] The time difference calculation unit **20** arranged in the wrist worn member **30** calculates differences between time points of the Rs of the ECG waveform and a time point of each of the characteristic points B, Q, P, and A of the PPG waveform, so as to obtain a plurality of ECG-PPG time differences Δt_N, for example, as shown in FIG. **7**, a schematic diagram of time differences between time points of peaks of the ECG waveform and a time point of the characteristic point A of the PPG waveform according to the present invention, the time difference calculation unit **20** calculates differences between the time points of the Rs of the ECG waveform and the time point of the characteristic point A of the PPG waveform, so as to obtain ECG-PPG time differences Δt_N.

[0039] The time difference calculation unit **20** calculates differences between time points of the characteristic points B, Q, P, and A of the PPG waveform, so as to obtain a plurality of characteristic point time differences T_{DIFF}, referring to FIG. **5**, for example, calculates a difference between a time point of the characteristic point B and a time point of

the characteristic point A of the PPG waveform to obtain a characteristic point time difference T_{DIFF_AB}, calculates a difference between a time point of the characteristic point Q and the time point of the characteristic point A of the PPG waveform to obtain a characteristic point time difference T_{DIFF_AQ}, calculates a difference between a time point of the characteristic point P and the time point of the characteristic point A of the PPG waveform to obtain a characteristic point time difference T_{DIFF_AP}, and the like.

[0040] The velocity calculation unit **22** arranged in the wrist-worn member **30** performs calculation according to the length of a hand of a tested person and one of the ECG-PPG time differences Δt_N calculated by the time difference calculation unit **20**, so as to obtain a PWV, where data of the length of the hand of the tested person may be input into the velocity calculation unit **22** by an input apparatus (not shown) of the wrist-worn member **30**.

[0041] The PPG amplitude calculation unit **18** arranged in the wrist-worn member **30** calculates amplitude differences between the characteristic points B, Q, P, and A of the PPG waveform to obtain a plurality of characteristic point amplitude differences Amp, referring to FIG. **8**, a schematic diagram of values of characteristic point amplitude differences of the PPG waveform according to the present invention, for example, calculates an amplitude difference between the characteristic point B and the characteristic point A of the PPG waveform to obtain a characteristic point amplitude difference Amp_B, calculates an amplitude difference between the characteristic point Q and the characteristic point A of the PPG waveform to obtain a characteristic point amplitude difference Amp_Q, calculates an amplitude difference between the characteristic point P and the characteristic point A of the PPG waveform to obtain a characteristic point amplitude difference Amp_P, and the like.

[0042] The calculation unit **26** arranged in the wrist-worn member **30** performs calculation according to the PWV calculated by the velocity calculation unit **22**, one of the plurality of characteristic point amplitude differences Amp calculated by the PPG amplitude calculation unit **18**, and one of the plurality of characteristic point time differences T_{DIFF} calculated by the time difference calculation unit **20**, so as to obtain a systolic/diastolic blood pressure estimate BP_{EST}.

[0043] The systolic/diastolic blood pressure estimate BP_{EST}=C**1***PWV+C**2***Amp+C**3***T_{DIFF}+C**4**, where C**1**, C**2**, C**3**, and C**4** are constants; the pulse wave velocity PWV=the length of a hand/Δt_N; Δt_N is an ECG-PPG time difference; Amp is a characteristic point amplitude difference; and T_{DIFF} is a characteristic point time difference. In the present invention, according to a requirement of a systolic/diastolic blood pressure, calculation may be performed by using the foregoing parameters.

[0044] A display **28** that may be a liquid crystal display (LCD) screen is arranged at a front surface of the wrist-worn member **30**. The display **28** is configured to display the systolic/diastolic blood pressure estimate BP_{EST} calculated by the calculation unit **26**, so that a blood pressure estimate may be directly observed since the apparatus can be worn by a tested person for a long time and can measure physiological signals.

[0045] Operations of a method for noninvasive and cuffless blood pressure measurement of the present invention are described with reference to the block diagram and the configuration diagram of an apparatus for noninvasive and cuffless blood pressure measurement, the diagrams of waveforms measured by the apparatus for noninvasive and cuffless blood pressure measurement, and other relevant drawings.

[0046] FIG. **9** is a flowchart of a method for noninvasive and cuffless blood pressure measurement according to the present invention. In FIG. **9**, a first emitter **121** and a second emitter **122** of a PPG measurement device **12** arranged at a rear surface of a wrist-worn member **30** emit the foregoing light of a specific wavelength (green light, red light, or infrared rays) to an arm or a finger, and a receiver **123** of the PPG measurement device **12** receives light of a specific wavelength that transmits the finger or arm or is reflected by the finger or arm, so that the PPG measurement device **12** measures a PPG waveform indicating blood volume changes under light irradiation (step S**50**), as shown in the waveform of FIG. **4**.

[0047] A first pole piece **141** and a second pole piece **142** of an ECG measurement device **14** separately arranged at a front surface and a rear surface of the wrist-worn member **30** are separately in contact with skin of two hands, so as to measure an ECG waveform of heartbeats (step S**52**), as shown in the waveform of FIG. **3**.

[0048] A characteristic point analyzing unit **16** arranged in the writs-worn member **30** analyzes the PPG waveform measured by the PPG measurement device **12**, and refers to the content of the foregoing document, so as to obtain amplitudes and time points of characteristic points B, Q, P, and A of the PPG waveform (step S**54**), as shown in FIG. **5**.

[0049] In FIG. **5**, the characteristic point B is a peak in the PPG waveform; the characteristic point A is a valley in the PPG waveform; the characteristic point P is a position between the valley (that is, the characteristic point A) and the peak (that is, the characteristic point B) and with a distance between the position and the valley being ¼ of a distance between the valley and the peak; and the characteristic point Q is a position of a maximum slope between the valley and the peak.

[0050] Referring to FIG. **8**, a PPG amplitude calculation unit **18** arranged in the wrist-worn member **30** calculates an amplitude difference between the characteristic point B and the characteristic point A of the PPG waveform, so as to obtain a characteristic point amplitude difference Amp_B, calculates an amplitude difference between the characteristic point Q and the characteristic point A of the PPG waveform, so as to obtain a characteristic point amplitude difference Amp_Q, calculates an amplitude difference between the characteristic point P and the characteristic point A of the PPG waveform, so as to obtain a characteristic point amplitude difference Amp_P, and performs calculation to obtain a plurality of characteristic point amplitude differences Amp (step S**56**).

[0051] A time difference calculation unit **20** arranged in the wrist-worn member **30** calculates differences between time points of Rs of the ECG waveform and each of the characteristic points B, Q, P, and A of the PPG waveform, so as to obtain a plurality of ECG-PPG time differences Δt_N. As shown in FIG. **7**, the time difference calculation unit **20** calculates differences between the time points of the Rs of the ECG waveform and the time point of the characteristic point A of the PPG waveform to obtain ECG-PPG time differences Δt_N.

[0052] Referring to FIG. **5**, the time difference calculation unit **20** calculates a difference between a time point of the characteristic point B and a time point of the characteristic

point A of the PPG waveform to obtain a characteristic point time difference T_{DIFF_AB}, calculates a difference between a time point of the characteristic point Q and the time point of the characteristic point A of the PPG waveform to obtain a characteristic point time difference T_{DIFF_AQ}, calculates a difference between a time point of the characteristic point

[0053] P and the time point of the characteristic point A of the PPG waveform to obtain a characteristic point time difference T_{DIFF_AN} and performs calculation to obtain a plurality of characteristic point time differences T_{DIFF} (step S**58**).

[0054] A velocity calculation unit **22** arranged in the wrist-worn member **30** performs calculation according to the length of a hand of a tested person, and one of the ECG-PPG time differences Δt_N calculated by the time difference calculation unit **20**, so as to obtain a PWV (step S**60**), where data of the length of the hand of the tested person may be input into the velocity calculation unit **22** by an input apparatus (not shown) of the wrist-worn member **30**.

[0055] By means of the foregoing formula for calculating a blood pressure estimate, a calculation unit **26** arranged in the wrist-worn member **30** performs calculation according to the PWV calculated by the velocity calculation unit **22**, one of the plurality of characteristic point amplitude differences Amp calculated by the PPG amplitude calculation unit **18**, and one of the plurality of characteristic point time differences T_{DIFF} calculated by the time difference calculation unit **20**, so as to obtain a systolic/diastolic blood pressure estimate BP_{EST} (step S**64**).

[0056] A display **28** arranged at the front surface of the wrist-worn member **30** displays the systolic/diastolic blood pressure estimate BP_{EST} calculated by the calculation unit **26**, so that a blood pressure estimate can be directly observed since the apparatus can be worn by a tested person for a long time and can measure physiological signals (step S**66**).

[0057] An objective of the present invention is to provide an apparatus and a method for noninvasive and cuffless blood pressure measurement with advantages of measuring physiological signals of a tested person, such as a PPG waveform and an ECG waveform, using a PPG amplitude to represent intravascular blood volume, and using a difference between time points of characteristic points of the PPG waveform as a calibration parameter of a vascular elastic coefficient, so as to calculate an intravascular systolic/diastolic blood pressure. The apparatus for noninvasive and cuffless blood pressure measurement does not need periodic calibration, does not need a cuff for applying pressure, can measure a blood pressure estimate of a tested person according to physiological signals, can be worn by a tested person for a long time, and can measure physiological signals.

[0058] The present invention is described above with reference to preferred embodiments and exemplary drawings, but is not limited thereto. Various modifications, omissions, and variations made to the forms and content of the embodiments by persons killed in the art shall not go beyond the scope claimed in the claims of the present invention.

DESCRIPTION OF SYMBOLS

[0059] **10** Apparatus for noninvasive and cuffless blood pressure measurement

[0060] **12** PPG measurement device

[0061] **14** ECG measurement device

[0062] **16** Characteristic point analyzing unit

[0063] **18** PPG amplitude calculation unit

[0064] **20** Time difference calculation unit

[0065] **22** Velocity calculation unit

[0066] **26** Calculation unit

[0067] **28** Display

[0068] **30** Wrist-worn member

[0069] **121** First emitter

[0070] **122** Second emitter

[0071] **123** Receiver

[0072] **141** First pole piece

[0073] **142** Second pole piece

What is claimed is:

1. An apparatus for noninvasive and cuffless blood pressure measurement, comprising:

a photoplethysmography (PPG) amplitude calculation unit, configured to calculate amplitude differences between a plurality of characteristic points of a PPG waveform, so as to obtain a plurality of characteristic point amplitude differences;

a time difference calculation unit, configured to calculate differences between a time point of a peak of an ECG waveform and a time point of each of the characteristic points of the PPG waveform, so as to obtain a plurality of ECG-PPG time differences, and configured to calculate differences between time points of the characteristic points of the PPG waveform, so as to obtain a plurality of characteristic point time differences;

a velocity calculation unit, configured to perform calculation according to the length of a hand and one of the ECG-PPG time differences calculated by the time difference calculation unit, so as to obtain a pulse wave velocity (PWV); and

a calculation unit, configured to perform calculation according to the PWV calculated by the velocity calculation unit, one of the characteristic point amplitude differences calculated by the PPG amplitude calculation unit, and one of the characteristic point time differences calculated by the time difference calculation unit, so as to obtain a systolic/diastolic blood pressure estimate.

2. The apparatus according to claim **1**, further comprising:

a PPG measurement device, comprising: a receiver and at least one emitter, wherein the at least one emitter emits light of a specific wavelength to an object, and the receiver receives light of a specific wavelength that transmits the object or is reflected by the object, so as to measure a PPG waveform indicating blood volume changes under light irradiation;

an ECG measurement device, configured to measure an ECG waveform of heartbeats;

a characteristic point analyzing unit, configured to analyze the PPG waveform measured by the PPG measurement device, so as to obtain amplitudes and time points of the characteristic points of the PPG waveform, and configured to analyze the ECG waveform measured by the ECG measurement device, so as to obtain an amplitude and a time point of the peak of the ECG waveform; and

a display, configured to display the systolic/diastolic blood pressure estimate calculated by the calculation unit.

3. The apparatus according to claim **2**, wherein the at least one emitter is a transmissive emitter or a reflective emitter for emitting one of green light, red light, and infrared rays,

and the receiver is a transmissive receiver or a reflective receiver for receiving one of the green light, the red light, and the infrared rays.

4. The apparatus according to claim **3**, wherein a wavelength of the green light is 495 nm to 570 nm, a wavelength of the red light is 620 nm to 750 nm, and a wavelength of the infrared rays is 780 nm to 1000 nm.

5. The apparatus according to claim **2**, wherein the display is a liquid crystal display (LCD) screen.

6. The apparatus according to claim **2**, wherein the characteristic points comprise the peak, a valley, a position between the valley and the peak and with a distance between the position and the valley being **1/4** of a distance between the valley and the peak, and a position of a maximum slope between the valley and the peak in the PPG waveform.

7. The apparatus according to claim **6**, wherein the systolic/diastolic blood pressure estimate BP_{EST}=C**1***PWV+C**2***Amp+C**3***T_{DIFF}+C**4**, wherein C**1**, C**2**, C**3**, and C**4** are constants; PWV is the pulse wave velocity; PWV=the length of a hand/Δt_N; Δt_N is an ECG-PPG time difference; Amp is a characteristic point amplitude difference; and T_{DIFF} is a characteristic point time difference.

8. A method for noninvasive and cuffless blood pressure measurement, comprising the following steps:

calculating amplitude differences between a plurality of characteristic points of a PPG waveform, so as to obtain a plurality of characteristic point amplitude differences;

calculating differences between a time point of a peak of an ECG waveform and a time point of each of the characteristic points of the PPG waveform, so as to obtain a plurality of ECG-PPG time differences, and calculating differences between time points of the characteristic points of the PPG waveform, so as to obtain a plurality of characteristic point time differences;

performing calculation according to the length of a hand and one of the ECG-PPG time differences, so as to obtain a PWV; and

performing calculation according to the PWV, one of the characteristic point amplitude differences, and one of the characteristic point time differences, so as to obtain a systolic/diastolic blood pressure estimate.

9. The method according to claim **8**, wherein before the calculating characteristic point amplitude differences of a PPG waveform, the method further comprises the following steps:

emitting light of a specific wavelength to an object, and receiving light of a specific wavelength that transmits the object or is reflected by the object, so as to measure a PPG waveform indicating blood volume changes under light irradiation;

measuring an ECG waveform of heartbeats; and

analyzing the PPG waveform to obtain amplitudes and time points of the characteristic points of the PPG waveform, and analyzing the ECG waveform to obtain an amplitude and a time point of the peak of the ECG waveform.

10. The method according to claim **9**, wherein after the performing calculation according to the PWV, one of the characteristic point amplitude differences, and one of the characteristic point time differences, the method further comprises the following step:

displaying the systolic/diastolic blood pressure estimate.

11. The method according to claim **9**, wherein the light of the specific wavelength is one of green light of a wavelength of 495 nm to 570 rim, red light of a wavelength of 620 nm to 750 nm, and infrared rays of a wavelength of 780 nm to 1000 nm.

12. The method according to claim **9**, wherein the characteristic points comprise the peak, a valley, a position between the valley and the peak and with a distance between the position and the valley being ¼ of a distance between the valley and the peak, and a position of a maximum slope between the valley and the peak in the PPG waveform.

13. The apparatus according to claim **9**, wherein the systolic/diastolic blood pressure estimate BP_{EST}=C**1***PWV+C**2***Amp+C**3***T_{DIFF}+C**4**, wherein C**1**, C**2**, C**3**, and C**4** are constants; PWV is the pulse wave velocity; PWV=the length of a hand/Δt_N; Δt_N is an ECG-PPG time difference; Amp is a characteristic point amplitude difference; and T_{DIFF} is a characteristic point time difference.

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专利名称(译)	用于无创和无袖血压测量的装置和方法		
公开(公告)号	US20160353998A1	公开(公告)日	2016-12-08
申请号	US15/165542	申请日	2016-05-26
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IPC分类号	A61B5/021 A61B5/0402 A61B5/04 A61B5/00		
CPC分类号	A61B5/02108 A61B5/742 A61B5/7282 A61B5/0245 A61B5/04012 A61B5/681 A61B5/02433 A61B5/0402 A61B5/02125 A61B5/6824		
优先权	104117761 2015-06-02 TW		
外部链接	Espacenet USPTO		

摘要(译)

提供了一种用于无创和无血压测量的装置和方法。该装置包括：光电容积脉搏波（PPG）幅度计算单元，时间差计算单元，速度计算单元和计算单元。该方法包括以下步骤：计算PPG波形的特征点之间的幅度差异;计算心电图（ECG）波形的峰值的时间点与PPG波形的每个特征点的时间点之间的差异;计算PPG波形特征点的时间点之间的差异;根据手的长度和ECG-PPG时间差进行计算，得到脉搏波速度（PWV）;并根据PWV，特征点振幅差之一和特征点时间差之一进行计算，以获得收缩/舒张血压估计值。