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(54) **HEARTBEAT RATE CALCULATION DEVICE AND METHOD**

VORRICHTUNG UND VERFAHREN ZUR BERECHNUNG DER HERZSCHLAGFREQUENZ

DISPOSITIF ET PROCÉDÉ DE CALCUL DE RYTHME CARDIAQUE

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Description

Technical Field

[0001] The present invention relates to a heartbeat count calculation apparatus and method for calculating a heartbeat count such as a heart rate or a pulse rate and, particularly, to a heartbeat count calculation apparatus and method capable of stably calculating a heartbeat count even if instantaneous heartbeat counts include an abnormal value.

Background Art

[0002] Measurement of a heart rate fluctuation is useful to control the loading intensity of the cardiopulmonary function. In recent years, a wearable device that can measure an electrocardiogram by incorporating an electrode in clothing such as a shirt has been developed. Thus, in various scenes, a heart rate fluctuation is monitored and observed.

Related Art Literature

Non-Patent Literature

[0003] Non-Patent Literature 1: C. Park et al., "An Ultra-Wearable, Wireless, Low Power ECG Monitoring System", Biomedical Circuits and Systems Conference, 2006. BioCAS 2006. IEEE.
[0004] YANG ET AL: "Adaptive Change Detection in Heart Rate Trend Monitoring in Anesthetized Children", IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, IEEE SERVICE CENTER, PISCATAWAY, NJ, USA, vol. 53, no. 11, 1 November 2006, discloses an algorithm using an exponentially weighted moving average predictor switching between two different forgetting coefficients to allow the historical data to have a varying influence in a predicted heart rate trend signal.

Disclosure of Invention

Problem to be Solved by the Invention

[0005] However, a wearable heart rate measurement device may lead a heart rate detection error since noise is readily added to a measurement result (electrocardiographic waveform). As a result, instantaneous heart rates for respective beats obtained in time series from the measured electrocardiographic waveform include an abnormal value. To prevent calculation of such abnormal value, it is important to appropriately average the instantaneous heart rates obtained from the measured electrocardiographic waveform.
[0006] As an averaging technique, for example, non-patent literature 1 describes a technique in which when calculating a heart rate from instantaneous heart rates obtained from an electrocardiographic waveform, the moving average of input data points is obtained until predetermined data points as moving average targets are input. However, processing when time-series data of the instantaneous heart rates include an abnormal value is not mentioned.
[0007] Since noise is readily added to an electrocardiographic waveform obtained using a wearable device to lead a heart rate detection error, instantaneous heart rates include an abnormal value. Therefore, to monitor the transition of the heart rate, it is important to obtain an appropriately averaged heart rate (instantaneous heart rate).
[0008] The present invention has been made in consideration of the above problems, and has as its object to calculate a heart rate appropriately even if instantaneous heartbeat counts concerning the heartbeat count of the heart, such as instantaneous heart rates, include an abnormal value.

Means of Solution to the Problem

[0009] According to the present invention, there is provided a heartbeat count calculation apparatus as defined in claim 1.
[0010] According to the present invention, there is also provided a heartbeat count calculation method as defined in claim 8.

Effect of the Invention

[0011] As described above, according to the present invention, it is possible to obtain a great effect of calculating a heartbeat count appropriately even if instantaneous heartbeat counts include an abnormal value.

Brief Description of Drawings

[0012]

Fig. 1 is a block diagram showing the arrangement of a heartbeat count calculation apparatus according to an embodiment of the present invention;
Fig. 2 is a flowchart for explaining a heartbeat count calculation method according to the embodiment of the present invention;
Fig. 3 is a flowchart for explaining, in more detail, the heartbeat count calculation method according to the embodiment of the present invention;
Fig. 4 is a timing chart showing a change in heartbeat count calculated in a heartbeat count calculation mode (first mode) by a first calculation unit 102 by setting an averaging coefficient a (first coefficient) to 0.1;
Fig. 5 is a timing chart showing a change in heartbeat count calculated in the heartbeat count calculation mode (first mode) by the first calculation unit 102 by setting the averaging coefficient a (first coefficient) to 0.1 and a change in heartbeat count calculated in a heartbeat count calculation mode (second mode) by a second calculation unit 103 by setting an averaging coefficient a (second coefficient) to a = 0.5 - 0.4 × N/20;
Fig. 6 is a timing chart showing a change in heartbeat count of a human when suddenly performing an exercise such as pedaling with full force from a rest state;
Fig. 7 is a block diagram showing the arrangement of another heartbeat count calculation apparatus 100a according to the embodiment of the present invention;
Fig. 8A is an explanatory timing chart showing an example of determination of an abnormal period;
Fig. 8B is an explanatory timing chart showing an example of determination of an abnormal period;
Fig. 8C is an explanatory timing chart showing an example of determination of an abnormal period;
Fig. 8D is an explanatory timing chart showing an example of determination of an abnormal period;
Fig. 8E is an explanatory timing chart showing an example of determination of an abnormal period; and
Fig. 9 is a block diagram showing the hardware arrangement of the heartbeat count calculation apparatus according to the present invention.

Best Mode for Carrying Out the Invention

[0013] A heartbeat count calculation apparatus 100 according to an embodiment of the present invention will be described below with reference to Fig. 1. The heartbeat count calculation apparatus 100 includes an extraction unit 101, a first calculation unit 102, a second calculation unit 103, and a switching unit 104.

[0014] The extraction unit 101 extracts a plurality of instantaneous heartbeat counts concerning the heartbeat count of the heart in time series from biometric information obtained from a target living body (subject). The biometric information is, for example, the electrocardiographic waveform of the subject obtained by measurement using an electrocardiograph 121, and the heartbeat count is a heart rate. As is well known, an instantaneous heart rate is obtained based on the R-R interval of the electrocardiographic waveform. If the R-R interval is 2 sec, an instantaneous heart rate is 30 times/min by calculating 60 sec/2. A heart rate will be exemplified as a heartbeat count.

[0015] The first calculation unit 102 obtains the heart rate (heartbeat count) of the subject from a plurality of instantaneous heart rates (instantaneous heartbeat counts) by averaging processing with an IIR (Infinite Impulse Response) filter using the first coefficient. Note that the first coefficient is a numerical value smaller than 1, and is a fixed value. In the invention, the first calculation unit 102 updates the heart rate by obtaining the heart rates in time series by multiplying an instantaneous heart rate at a given time by the first coefficient, and adding, to the thus obtained value, a value obtained by multiplying an instantaneous heart rate at an immediately preceding time by a value obtained by subtracting the first coefficient from 1 [heart rate at current time = (instantaneous heart rate × first coefficient) + {heart rate at immediately preceding time × (1 - first coefficient)}].

[0016] The second calculation unit 103 obtains the heart rate of the subject from the plurality of instantaneous heart rates by averaging processing with an IIR filter using the second coefficient. The second coefficient is a numerical value smaller than 1 and is a variable value. In the invention, the second calculation unit 103 updates the heart rate by obtaining the heart rates in time series by adding, to a value obtained by multiplying the instantaneous heart rate by the second coefficient, a value obtained by multiplying the heart rate at the immediately preceding time by a value obtained by subtracting the second coefficient from 1. The second calculation unit 103 includes a processing unit 103a that starts the second coefficient with a value larger than the first coefficient and makes the second coefficient closer to the first coefficient for each beat. The calculation unit 103 uses the second coefficient having undergone coefficient processing by the processing unit 103a.

[0017] The switching unit 104 switches between the first calculation unit 102 and the second calculation unit 103 based on the difference between the precedingly obtained heart rate and the latest instantaneous heart rate. The switching unit 104 switches, from one of the first calculation unit 102 and the second calculation unit 103 to the other, a processing unit that is to obtain a heart rate output from the heartbeat count calculation apparatus. The switching unit 104 determines, based on the difference between the precedingly calculated heart rate and the latest instantaneous heart rate, whether to leave one of the calculation units that has calculated the heart rate last time as a processing unit to perform processing for calculating a heart rate using the latest instantaneous heart rate, or switch from the calculation unit to the other, and, when it has determined to switch the processing unit, the switching unit 104 switches the processing unit. The heartbeat count calculation apparatus outputs the heart rate calculated by the first calculation unit 102 or the second calculation unit 103 switched by the switching unit 104.

[0018] The switching unit 104 switches from the first calculation unit 102 to the second calculation unit 103 in, for example, the first state in which a state in which the difference between the latest instantaneous heart rate and the heart rate calculated by the first calculation unit 102 is equal to or larger than the set first constant continues during the set first heart count.

[0019] Furthermore, the switching unit 104 switches from the second calculation unit 103 to the first calculation unit 102 in, for example, the second state in which a state in which the difference between the latest instantaneous heart rate and the heart rate calculated by the second calculation unit 103 is equal to or smaller than the set second constant continues during the set second heartbeat count or the third state in which the second coefficient is equal to the first coefficient.

[0020] For example, if the first calculation unit 102 calculates the heart rate last time and the difference between this heart rate and the instantaneous heart rate extracted by the extraction unit 101 this time is in the first state, the switching unit 104 performs switching processing. In this case, the second calculation unit 103 calculates the heart rate this time. Alternatively, for example, if the second calculation unit 103 calculates the heart rate last time, and the difference between this heart rate and the instantaneous heart rate extracted by the extraction unit 101 this time is in the second or third state, the switching unit 104 performs switching processing. In this case, the first calculation unit 102 calculates the heart rate this time.

[0021] The heartbeat count calculation apparatus 100 according to the embodiment includes an update stopping unit 105 in addition to the above-described components. The update stopping unit 105 stops update of the heart rate when the difference between the latest instantaneous heart rate and the heart rate calculated by the first calculation unit 102 exceeds a set reference value, and limits the update value of the heart rate when the difference between the heart rate calculated at the current time by the first calculation unit 102 and that calculated at the immediately preceding time by the first calculation unit 102 exceeds the set reference value.

[0022] Next, an example (heartbeat count calculation method) of the operation of the heartbeat count calculation apparatus 100 according to the embodiment will be described with reference to Fig. 2.

[0023] In step S101, the extraction unit 101 extracts a plurality of instantaneous heart rates in time series from biometric information obtained from a subject. The biometric information is, for example, the electrocardiographic waveform of the subject obtained by measurement using the electrocardiograph 121. In step S102, based on the difference between the latest instantaneous heart rate extracted in step S101 and the heart rate obtained last time, it is determined whether to perform switching processing (fourth step). If it is determined not to perform switching processing (NO in step S102), a heart rate is obtained, in step S103, by the same calculation processing as that performed last time. On the other hand, if it is determined to perform switching processing (YES in step S102), the switching unit 104 switches the calculation processing in step S104, and calculates a heart rate by calculation processing switched in step S105. In step S106, the heartbeat count calculation apparatus 100 determines whether an end instruction has been input. If no end instruction has been input (NO in step S106), the process returns to step S101 to continue the processing.

[0024] For example, if the first calculation unit 102 calculates the heart rate last time (second step), and the difference between this heart rate and the latest instantaneous heart rate is in the first state, the switching unit 104 determines, in step S102, to perform switching processing, switches, in step S104, from the first calculation unit 102 to the second calculation unit 103, and calculates, in step S105, the heart rate from the latest instantaneous heart rate by the second calculation unit 103 (third step).

[0025] Alternatively, for example, if the second calculation unit 103 calculates the heart rate last time (third step), and the difference between this heart rate and the latest instantaneous heart rate is in the second or third state, the switching unit 104 determines, in step S102, to perform switching processing, switches, in step S104, from the second calculation unit 103 to the first calculation unit 102, and calculates, in step S105, the heart rate from the latest instantaneous heart rate by the first calculation unit 102 (second step).

[0026] Note that in the heart rate calculation processing by the second calculation unit 103, the second coefficient starts with a value larger than the first coefficient, and is made closer to the first coefficient for each beat. This second coefficient processing is performed by the processing unit 103a. Although not shown in Fig. 2, when the difference between the latest instantaneous heart rate and the heart rate calculated by the first calculation unit 102 exceeds the set reference value, update of the heart rate can be stopped, and when the difference between the heart rate calculated at the immediately preceding time and that calculated at the current time exceeds the set reference value, the update value of the heart rate can be limited (fifth step).

[Example]

[0027] A more detailed description will be provided using an example. Heart rate calculation processing by a first calculation unit 102 will be referred to as the first mode hereinafter, and heart rate calculation processing by a second calculation unit 103 will be referred to as the second mode hereinafter.

[0028] In both the first and second modes, as averaging processing with an IIR filter for obtaining the heart rate of a subject from a plurality of instantaneous heart rates, a heart rate HR[n] is calculated by "HR[n] = (1 - a) × HR[n-1] + a × IHR[n]" using the averaging coefficient a for instantaneous heart rates IHR[n] as n time-series data.

[0029] The averaging coefficient a takes a value of 0 < a < 1. As this value is smaller, a smoothing effect of suppressing a fine fluctuation in the heart rate HR[n] is higher while a delay when following a rough change is larger.

[0030] In the first mode, the averaging coefficient a is a fixed value (first coefficient). In the second mode, the averaging coefficient a is a variable value (second coefficient).

[0031] A heart rate calculation procedure according to the example under the above-described conditions will be described with reference to Fig. 3. Fig. 3 shows one cycle of a procedure of calculating a heart rate from instantaneous heart rates. Note that ΔHRi represents the absolute value of a value obtained by subtracting, from a heart rate, the latest instantaneous heart rate when the heart rate is obtained. Furthermore, ΔHR represents a value obtained by subtracting, from the heart rate calculated at the current time, a heart rate calculated at the immediately preceding time.

[0032] In step S201, it is determined whether the current mode is the second mode. If the current mode is the second mode, it is determined in step S202 whether ΔHRi is equal to or smaller than 20 (second constant). If ΔHRi is equal to or smaller than 20, 1 is added to a counted number C2 (second heartbeat count) in step S203. In step S204, it is determined whether the counted number C2 is equal to 5. If the counted number C2 is equal to 5, in step S205 the second mode is switched to the first mode and the counted number C2 is set to 0. On the other hand, if ΔHRi exceeds 20, the counted number C2 is set to 0 in step S206.

[0033] If it is determined in step S201 that the current mode is not the second mode, it is determined in step S207 whether ΔHRi is equal to or larger than 40 (first constant). If ΔHRi is equal to or larger than 40, 1 is added to a counted number C1 (first heartbeat count) in step S208. It is then determined in step S209 whether the counted number C1 is equal to 8. If the counted number C1 is equal to 8, in step S210 the first mode is switched to the second mode and the counted number C1 is set to 0. On the other hand, if ΔHRi is smaller than 40, the counted number C1 is set to 0 in step S211.

[0034] In step S212, it is determined whether the current mode is the second mode. If the current mode is the second mode, it is determined in step S213 whether a counted number C3 is equal to 20. If the counted number C3 is equal to 20, in step S214 the second mode is switched to the first mode and the counted number C3 is set to 0. If the current mode is the first mode, it is determined in step S215 whether ΔHRi is equal to or larger than 40. If ΔHRi is smaller than 40, calculation is performed in the first mode in step S216, and it is determined in step S217 whether ΔHR is larger than 2 bpm. If ΔHR is larger than 2 bpm, HR[n] = HR[n-1] + 2 is set in step S218 as a heart rate update limitation. If ΔHR is equal to or smaller than 2 bpm, it is determined in step S219 whether ΔHR is smaller than -2 bpm. If ΔHR is smaller than -2 bpm, HR[n] = HR[n-1] - 2 is set in step S220 as a heart rate update limitation.

[0035] If it is determined in step S213 that the counted number C3 is not equal to 20, in step S221 calculation is performed in the second mode and 1 is added to the counted number C3, thereby ending the processing of one cycle.

[0036] If it is determined in step S212 that the current mode is not the second mode (the current mode is the first mode), the process shifts to step S215.

[0037] In the above-described processing, in the first mode, the averaging coefficient a is set to, for example, 0.1. Under this condition, as shown in Fig. 4, the heart rate HR[n] is moderately smoothed while a delay for a change is allowable.

[0038] In the second mode, the averaging coefficient a is given by, for example, "a = 0.5 - 0.4 × N/20 (N: a beat count after shifting to the second mode). That is, in the second mode, the averaging coefficient a starts with 0.5, is decreased by 0.02 for each beat, and returns to a value of 0.1 in the first mode at the 20th beat. By temporarily making the averaging coefficient a in the second mode large, the value of the instantaneous heart rate is strongly reflected, thereby obtaining an effect of accelerating convergence of the value of the heart rate.

[0039] If the initial instantaneous heart rate is an abnormal value at the start of calculation of the heart rate, it takes time for the heart rate to approach a correct value in the first mode. However, if the second mode is set in this status, the heart rate quickly converges to the correct value, as shown in Fig. 5.

[0040] When an instantaneous heart rate largely deviated from the heart rate continues, for example, when an instantaneous heart rate deviated from the heart rate by 40 bpm or more is successively obtained eight times, the instantaneous heart rate at this time is considered to be higher in reliability than the heart rate before this time. Therefore, it is desired to discard the heart rate before this time, and calculate a heart rate based on the instantaneous heart rate at this time. To do this, under the above condition, the mode shifts to the second mode.

[0041] After the averaging coefficient a returns to a value of 0.1 in the first mode, it is appropriate to set the first mode in which the averaging coefficient a = 0.1 is maintained. Furthermore, if it is considered that the difference between the heart rate and the instantaneous heart rate has converged, even when, for example, instantaneous heart rate deviated from the heart rate by 20 bpm or less is successively obtained five times, the mode shifts to the first mode, thereby making it possible to improve the smoothness of the heart rate.

[0042] Note that when, for example, suddenly performing an exercise such as pedaling with full force from a rest state, the heart rate of a human increases at a rate of about 2 bpm/beat at most. Fig. 6 shows this state. Conversely, it is hardly considered that the heart rate increases at a rate exceeding 2 bpm/beat. Therefore, if the change amount of the heart rate is provided with an upper limit of 2 bpm/beat, it is possible to prevent the obtained heart rate from being an abnormal value.

[0043] As processing at each time when the instantaneous heart rate is largely deviated from the heart rate, for example, if the difference between the instantaneous heart rate and the heart rate is equal to or larger than 40 bpm, it is appropriate to consider the instantaneous heart rate as an abnormal value, and this value is discarded not to update the heart rate. However, this corresponds to the first mode, and the same does not apply to the second mode as a period for recovering the state from the abnormal state.

[0044] Another heartbeat count calculation apparatus 100a according to the embodiment of the present invention will be described next with reference to Fig. 7. The heartbeat count calculation apparatus 100a includes an extraction unit 101, a first calculation unit 102, a second calculation unit 103, and a switching unit 104. These components are the same as those of the above-described heartbeat count calculation apparatus 100.

[0045] The heartbeat count calculation apparatus 100a includes an output control unit 106. The output control unit 106 determines, as an abnormal period, a period during which the second calculation unit 103 calculates a heart rate, a period during which the difference between the latest instantaneous heart rate and a heart rate calculated by the first calculation unit 102 exceeds a reference value, or a period during which the calculated heart rate falls within a set abnormal range, and stops output of the heart rate during the abnormal period. If, for example, the difference between the instantaneous heart rate and the heart rate is equal to or larger than 40 bpm, the calculated heart rate may include an abnormal value or its influence. Alternatively, the calculated heart rate may extremely be deviated from an ordinary value to become an abnormal value (falls within the set abnormal range) such as 0. In this case, an abnormal period is determined to stop output of the calculated heart rate.

[0046] Furthermore, the output control unit 106 can be configured to determine, as the second abnormal period, a period until an abnormal period is determined again within a determination period set after the abnormal period, and stop output of the heart rate during the second abnormal period. For example, if an abnormal period is determined again within 30 sec after an abnormal period is determined, a period from the last determination of the abnormal period to this determination of the abnormal period is set as the second abnormal period, and output of the heart rate is stopped during the second abnormal period.

[0047] If the heart rate obtained during the abnormal period falls within an allowable range set with respect to the heart rate obtained during a period other than the abnormal period, the output control unit 106 outputs the heart rate (heartbeat count). Even during the abnormal period, the difference between the obtained heart rate and the heart rate obtained during the period other than the abnormal period falls within, for example, a range of $\pm$ 10 bpm, the obtained heart rate is adopted as an output value.

[0048] A heartbeat count calculation method by the heartbeat count calculation apparatus 100a can include the following steps in addition to the steps described with reference to Fig. 2. It is possible to set, as an abnormal period, a period during which the second calculation unit 103 (second step) calculates a heart rate, a period during which the difference between the latest instantaneous heart rate and the heart rate calculated by the first calculation unit 102 (first step) exceeds the reference value, or a period during which the calculated heart rate falls within the set abnormal range, and stop output of the heart rate during the abnormal period (sixth step). If the heart rate obtained during the abnormal period falls within the allowable range set with respect to the heart rate obtained during the period other than the abnormal period, it is possible to output the heart rate (heartbeat count) (seventh step). Furthermore, it is possible to determine, as the second abnormal period, a period until an abnormal period is determined again within a determination period set after the abnormal period, and stop output of the heart rate during the second abnormal period (eighth step).

[0049] Examples of determination of the abnormal period will be described below with reference to Figs. 8A, 8B, 8C, 8D, and 8E. Referring to Figs. 8A, 8B, 8C, 8D, and 8E, obtained heart rates are represented by open circles.

[0050] In Fig. 8A, a result of determining whether the obtained heart rate is a normal value or an abnormal value is indicated by solid lines. If the heart rate is a normal value, 0 is determined, and if the heart rate is an abnormal value, 1 is determined. Time at which 1 is determined falls within an abnormal period, and thus the heart rate is not output.

[0051] In Fig. 8B, when an abnormal period is determined again within 30 sec after an abnormal period is determined, a result of determining, as an abnormal value (a value of 1), an entire period from the last determination of the abnormal period to this determination of the abnormal period is indicated by dotted lines. The period indicated by the dotted lines during which a value of 1 is determined is set as the second abnormal period for a heart rate acquisition period, and the obtained heart rate is not output during this period, as shown in Fig. 8C.

[0052] In Fig. 8D, a range of ±10 from each heart rate value except for the heart rates obtained during the above-described second abnormal period is indicated by solid lines. Since not all the heart rates during the second abnormal period are abnormal, the heart rate within this range can be output, as shown in Fig. 8E.

[0053] In the above description, the electrocardiographic waveform of a living body is used as biometric information and a heart rate is used as a heartbeat count. However, the present invention is not limited to this. Information concerning a pulse can be used as biometric information and a pulse rate can be used as a heartbeat count. For example, a pulse waveform is obtained in time series as biometric information by irradiating the skin with light and measuring reflected light. Since the light absorption amount of blood changes depending on the pulse to change the reflected light intensity, it is possible to measure the pulse rate from the change in reflection intensity. By forming, for example, an arrangement in which a semiconductor light emitting element is used as a light source and a photodiode measures reflected light, a measurement apparatus can be downsized, thereby obtaining a wristband type sensor. Such downsizing makes it possible to very easily use the measurement apparatus by mounting it on a subject.

[0054] Furthermore, for example, it is possible to use, as a heartbeat count, a pulse rate obtained by measuring a change in color of the skin surface of the face or the like. Since the amount of light obtained when the skin is irradiated with sunlight or illumination light and reflects the light changes depending on a pulse, a pulse rate can be measured using a result of capturing the change by a camera or the like. In this case, it is possible to obtain an advantage that it is possible to measure a pulse rate in a place away from the subject without mounting anything on the subject.

[0055] Note that the heartbeat count calculation apparatus according to the above-described embodiment is a mobile computer apparatus including a CPU (Central Processing Unit) 301, a main storage device 302, an external storage device 303, and a network connection device 304, as shown in Fig. 9. Each of the above-described functions is implemented when the CPU 301 operates by a program loaded into the main storage device 302. Note that the network connection device 304 is connected to a network 305. The respective functions can also be distributed to a plurality of computer apparatuses.

[0056] The heartbeat count calculation apparatus according to the above-described embodiment can be formed by a PLD (Programmable Logic Device) such as an FPGA (Field-Programmable Gate Array). For example, the storage unit, the extraction unit, the first calculation unit, the second calculation unit, and the switching unit are provided as circuits in the logic elements of an FPGA, the FPGA can be made to function as the heartbeat count calculation apparatus. Each of the storage unit, the extraction unit, the first calculation unit, the second calculation unit, and the switching unit is written in the FPGA by connecting a predetermined writing device.

[0057] As described above, according to the present invention, the first calculation unit that calculates a heartbeat count from a plurality of instantaneous heartbeat counts by averaging processing with an IIR filter using the first coefficient of a fixed value smaller than 1 and the second calculation unit that calculates the heartbeat count from the plurality of instantaneous heartbeat counts by averaging processing with an IIR filter using the second coefficient of a variable value smaller than 1 are switched based on the difference between the precedingly calculated heartbeat count and the latest instantaneous heartbeat count. As a result, according to the present invention, even if the instantaneous heartbeat counts include an abnormal value, it is possible to calculate a heartbeat count appropriately.

Explanation of the Reference Numerals and Signs

[0058]

100 heartbeat count calculation apparatus,
101 extraction unit, 102...first calculation unit,
103 second calculation unit, 104...switching unit,
105 update stopping unit, 106...output control unit,
121 electrocardiograph

Claims

1. A heartbeat count calculation apparatus (100) comprising:

an extraction unit (101) configured to extract a plurality of instantaneous heartbeat counts concerning a heartbeat count of a heart in time series from biometric information;

a first calculation unit (102) configured to calculate the heartbeat count from the plurality of instantaneous heartbeat counts by averaging processing with an IIR filter using a first coefficient of a fixed value smaller than 1, wherein the first calculation unit is configured to calculate an equation: heart rate at current time = (instanta-

neous heart rate × first coefficient) + {heart rate at immediately preceding time × (1 - first coefficient)};
a second calculation unit (103) configured to calculate the heartbeat count from the plurality of instantaneous heartbeat counts by averaging processing with an IIR filter using a second coefficient, wherein the second calculation unit is configured to calculate an equation:

heart rate at current time = (instantaneous heart rate × second coefficient) + {heart rate at immediately preceding time × (1 - second coefficient)};

and
a switching unit (104) configured to switch between the first calculation unit and the second calculation unit,
wherein the second calculation unit is configured to use a variable value smaller than 1 as the second coefficient, the second calculation unit includes a coefficient processing unit (103a) configured to start the second coefficient with a value larger than the first coefficient and make the second coefficient closer to the first coefficient for each beat, and
the switching unit is configured to switch between the first calculation unit and the second calculation unit based on a difference between the heartbeat count calculated by one of the first calculation unit and the second calculation unit and a latest instantaneous heartbeat count extracted by the extraction unit.

2. The heartbeat count calculation apparatus according to claim 1, wherein,

in a first state in which a state in which the difference between the latest instantaneous heartbeat count and the heartbeat count calculated by the first calculation unit is not smaller than a set first constant continues during a set first heartbeat count, the switching unit switches from the first calculation unit to the second calculation unit, and
in one of a second state in which a state in which the difference between the latest instantaneous heartbeat count and the heartbeat count calculated by the second calculation unit is not larger than a set second constant continues during a set second heartbeat count and a third state in which the second coefficient is equal to the first coefficient, the switching unit switches from the second calculation unit to the first calculation unit.

3. The heartbeat count calculation apparatus according to claim 1 or 2, further comprising an update stopping unit (105) configured to stop update of the heartbeat count when the difference between the latest instantaneous heartbeat count and the heartbeat count calculated by the first calculation unit exceeds a set reference value, and to limit an update value of the heartbeat count when a difference between the heartbeat count calculated at an immediately preceding time by the first calculation unit and the heartbeat count calculated at a current time by the first calculation unit exceeds the set reference value.

4. The heartbeat count calculation apparatus according to any one of claims 1 to 3, further comprising an output control unit (106) configured to determine, as an abnormal period, one of a period during which the second calculation unit calculates the heartbeat count, a period during which the difference between the latest instantaneous heartbeat count and the heartbeat count calculated by the first calculation unit exceeds the set reference value, and a period during which the calculated heartbeat count falls within a set abnormal range, and stop output of the heartbeat count during the abnormal period.

5. The heartbeat count calculation apparatus according to claim 4, wherein, if the heartbeat count obtained during the abnormal period falls within an allowable range set with respect to the heartbeat count obtained during a period other than the abnormal period, the output control unit outputs the heartbeat count.

6. The heartbeat count calculation apparatus according to any one of claims 1 to 5, wherein the biometric information is an electrocardiographic waveform of a living body, and the heartbeat count is a heart rate.

7. The heartbeat count calculation apparatus according to any one of claims 1 to 5, wherein the biometric information is information concerning a pulse, and the heartbeat count is a pulse rate.

8. A computer-implemented heartbeat count calculation method comprising:

a first step of extracting a plurality of instantaneous heartbeat counts in time series from biometric information;
a second step of obtaining a heartbeat count from the plurality of instantaneous heartbeat counts by averaging processing with an IIR filter using a first coefficient of a fixed value smaller than 1, wherein in the second step, an equation:

$$\text{heart rate at current time} = (\text{instantaneous heart rate} \times \text{first coefficient}) + \{\text{heart rate at immediately preceding time} \times (1 - \text{first coefficient})\},$$

is calculated;
a third step of obtaining a heartbeat count from the plurality of instantaneous heartbeat counts by averaging processing with an IIR filter using a second coefficient, wherein in the third step, an equation:

$$\text{heart rate at current time} = (\text{instantaneous heart rate} \times \text{second coefficient}) + \{\text{heart rate at immediately preceding time} \times (1 - \text{second coefficient})\},$$

is calculated; and
a fourth step of switching between the second step and the third step,
wherein in the third step, a variable value smaller than 1 is used as the second coefficient,
in the third step, the second coefficient starts with a value larger than the first coefficient, and is made closer to the first coefficient for each beat, and
in the fourth step, the switching between the second step and the third step are carried out based on a difference between an extracted latest instantaneous heartbeat count and the heartbeat count precedingly obtained in one of the second step and the third step.

9. The heartbeat count calculation method according to claim 8, wherein, in the fourth step,

in a first state in which a state in which the difference between the latest instantaneous heartbeat count and the heartbeat count obtained in the second step is not smaller than a set first constant continues during a set first heartbeat count, the second step is switched to the third step, and
in one of a second state in which a state in which the difference between the latest instantaneous heartbeat count and the heartbeat count obtained in the third step is not larger than a set second constant continues during a set second heartbeat count and a third state in which the second coefficient is equal to the first coefficient, the third step is switched to the second step.

10. The heartbeat count calculation method according to claim 8 or 9, further comprising a fifth step of stopping update of the heartbeat count when the difference between the latest instantaneous heartbeat count and the heartbeat count obtained in the second step exceeds a set reference value, and limiting an update value of the heartbeat count when a difference between the heartbeat count calculated at an immediately preceding time in the second step and the heartbeat count calculated at a current time in the second step exceeds the set reference value.

11. The heartbeat count calculation method according to any one of claims 8 to 10, further comprising a sixth step of determining, as an abnormal period, one of a period during which the heartbeat count is obtained in the third step, a period during which the difference between the latest instantaneous heartbeat count and the heartbeat count obtained in the second step exceeds the set reference value, and a period during which the obtained heartbeat count falls within a set abnormal range, and stopping output of the heartbeat count during the abnormal period.

12. The heartbeat count calculation method according to claim 11, further comprising a seventh step of outputting the

heartbeat count when the heartbeat count obtained during the abnormal period falls within an allowable range set with respect to the heartbeat count obtained during a period other than the abnormal period.

13. The heartbeat count calculation method according to any one of claims 8 to 12, wherein the biometric information is the electrocardiographic waveform of a living body, and the heartbeat count is a heart rate.

14. The heartbeat count calculation method according to any one of claims 8 to 12, wherein the biometric information is information concerning a pulse, and the heartbeat count is a pulse rate.

Patentansprüche

1. Vorrichtung (100) zur Berechnung der Anzahl der Herzschläge, umfassend:

eine Extraktionseinheit (101), die so konfiguriert ist, dass sie eine Vielzahl von momentanen Anzahlen der Herzschläge, die eine Anzahl der Herzschläge eines Herzens in Zeitreihen betreffen, aus biometrischen Informationen extrahiert;
eine erste Berechnungseinheit (102), die so konfiguriert ist, dass sie die Anzahl der Herzschläge aus der Vielzahl der momentanen Anzahlen der Herzschläge durch eine Mittelwertbildung mit einem IIR-Filter unter Verwendung eines ersten Koeffizienten mit einem fixen Wert kleiner als 1 berechnet, wobei die erste Berechnungseinheit so konfiguriert ist, dass sie eine Gleichung berechnet:

$$\text{Herzfrequenz zum aktuellen Zeitpunkt} = (\text{momentane Herzfrequenz} \times \text{erster Koeffizient}) + \{\text{Herzfrequenz zum unmittelbar vorangegangenen Zeitpunkt} \times (1 - \text{erster Koeffizient})\};$$

eine zweite Berechnungseinheit (103), die so konfiguriert ist, dass sie die Anzahl der Herzschläge aus der Vielzahl der momentanen Herzschlag-Anzahlen durch Mittelwertbildung mit einem IIR-Filter unter Verwendung eines zweiten Koeffizienten berechnet, wobei die zweite Berechnungseinheit so konfiguriert ist, dass sie eine Gleichung berechnet:

$$\text{Herzfrequenz zum aktuellen Zeitpunkt} = (\text{momentane Herzfrequenz} \times \text{zweiter Koeffizient}) + \{\text{Herzfrequenz zum unmittelbar vorangegangenen Zeitpunkt} \times (1 - \text{zweiter Koeffizient})\};$$

und
eine Schalteinheit (104), die zum Umschalten zwischen der ersten Berechnungseinheit und der zweiten Berechnungseinheit konfiguriert ist,
wobei
die zweite Berechnungseinheit so konfiguriert ist, dass sie einen variablen Wert kleiner als 1 für den zweiten Koeffizienten verwendet,
die zweite Berechnungseinheit eine Koeffizienten-Verarbeitungseinheit (103a) enthält, die so konfiguriert ist, dass sie den zweiten Koeffizienten mit einem Wert beginnt, der größer als der erste Koeffizient ist, und den zweiten Koeffizienten bei jedem Schlag näher an den ersten Koeffizienten heranbringt, und

die Schalteinheit so konfiguriert ist, dass sie zwischen der ersten Berechnungseinheit und der zweiten Berechnungseinheit auf der Grundlage einer Differenz zwischen der Anzahl der Herzschläge, die von einer der ersten Berechnungseinheit und der zweiten Berechnungseinheit berechnet wurde, und einer jüngsten momentanen Anzahl der Herzschläge, die von der Extraktionseinheit extrahiert wurde, umschaltet.

2. Vorrichtung zur Berechnung der Anzahl der Herzschläge nach Anspruch 1, wobei,

in einem ersten Zustand, in dem ein Zustand, in dem die Differenz zwischen der jüngsten momentanen Anzahl der Herzschläge und der von der ersten Berechnungseinheit berechneten Anzahl der Herzschläge nicht kleiner als eine eingestellte erste Konstante ist, während einer eingestellten ersten Anzahl der Herzschläge fortbesteht, die Schalteinheit von der ersten Berechnungseinheit zu der zweiten Berechnungseinheit umschaltet, und

in einem von einem zweiten Zustand, in dem ein Zustand, in dem die Differenz zwischen der jüngsten momentanen Anzahl der Herzschläge und der von der zweiten Berechnungseinheit berechneten Anzahl der Herzschläge nicht größer als eine eingestellte zweite Konstante ist, während einer eingestellten zweiten Anzahl der Herzschläge fortbesteht, und einem dritten Zustand, in dem der zweite Koeffizient gleich dem ersten Koeffizienten ist, die Schalteinheit von der zweiten Berechnungseinheit zur ersten Berechnungseinheit umschaltet.

3. Vorrichtung zur Berechnung der Anzahl der Herzschläge nach Anspruch 1 oder 2, die ferner eine Aktualisierungs-Stoppeinheit (105) umfasst, die so konfiguriert ist, dass sie eine Aktualisierung der Anzahl der Herzschläge stoppt, wenn die Differenz zwischen der jüngsten momentanen Anzahl der Herzschläge und der von der ersten Berechnungseinheit berechneten Anzahl der Herzschläge einen eingestellten Referenzwert überschreitet, und, dass sie einen Aktualisierungswert der Anzahl der Herzschläge begrenzt, wenn eine Differenz zwischen der zu einem unmittelbar vorhergehenden Zeitpunkt von der ersten Berechnungseinheit berechneten Anzahl der Herzschläge und der zu einem aktuellen Zeitpunkt von der ersten Berechnungseinheit berechneten Anzahl der Herzschläge den eingestellten Referenzwert überschreitet.

4. Vorrichtung zur Berechnung der Anzahl der Herzschläge nach einem der Ansprüche 1 bis 3, die ferner eine Ausgabesteuerungseinheit (106) umfasst, die so konfiguriert ist, dass sie eine von einer Periode, während der die zweite Berechnungseinheit die Anzahl der Herzschläge berechnet, einer Periode, während der die Differenz zwischen der jüngsten momentanen Anzahl der Herzschläge und der von der ersten Berechnungseinheit berechneten Anzahl der Herzschläge den eingestellten Referenzwert überschreitet, und einer Periode, während der die berechnete Anzahl der Herzschläge in einen eingestellten anormalen Bereich fällt, als eine anormale Periode bestimmt und die Ausgabe der Anzahl der Herzschläge während der anormalen Periode stoppt.

5. Vorrichtung zur Berechnung der Anzahl der Herzschläge nach Anspruch 4, wobei die Ausgabesteuerungseinheit die Anzahl der Herzschläge ausgibt, wenn die während der abnormalen Periode erhaltene Anzahl der Herzschläge in einen zulässigen Bereich fällt, der eingestellt ist in Bezug auf die während einer anderen als der abnormalen Periode erhaltene Anzahl der Herzschläge.

6. Gerät zur Berechnung der Anzahl der Herzschläge nach einem der Ansprüche 1 bis 5, wobei die biometrische Information eine elektrokardiographische Wellenform eines lebenden Körpers ist und die Anzahl der Herzschläge eine Herzfrequenz ist.

7. Gerät zur Berechnung der Anzahl der Herzschläge nach einem der Ansprüche 1 bis 5, wobei die biometrische Information eine Information über einen Puls ist und die Anzahl der Herzschläge eine Pulsfrequenz ist.

8. Computerimplementiertes Verfahren zur Berechnung der Anzahl der Herzschläge, umfassend:

einen ersten Schritt des Extrahierens einer Vielzahl von momentanen Anzahlen der Herzschläge in Zeitreihen aus biometrischen Informationen;

einen zweiten Schritt des Erhaltens einer Anzahl der Herzschläge aus der Vielzahl der momentanen Anzahlen der Herzschläge durch Mittelwertbildung mit einem IIR-Filter unter Verwendung eines ersten Koeffizienten mit einem fixen Wert kleiner als 1, wobei in dem zweiten Schritt eine Gleichung:

Herzfrequenz zum aktuellen Zeitpunkt = (momentane Herzfrequenz × erster Koeffizient) + {Herzfrequenz zum unmittelbar vorangegangenen Zeitpunkt × (1 - erster Koeffizient)},

berechnet wird;
einen dritten Schritt des Erhaltens einer Anzahl der Herzschläge aus der Vielzahl der momentanen Anzahlen der Herzschläge durch Mittelwertbildung mit einem IIR-Filter unter Verwendung eines zweiten Koeffizienten, wobei in dem dritten Schritt eine Gleichung:

Herzfrequenz zum aktuellen Zeitpunkt = (momentane Herzfrequenz × zweiter Koeffizient) + {Herzfrequenz zum unmittelbar vorangegangenen Zeitpunkt × (1 - zweiter Koeffizient)},

berechnet wird; und
einen vierten Schritt des Umschaltens zwischen dem zweiten Schritt und dem dritten Schritt, wobei
im dritten Schritt als zweiter Koeffizient ein variabler Wert kleiner als 1 verwendet wird,
im dritten Schritt der zweite Koeffizient mit einem Wert beginnt, der größer als der erste Koeffizient ist, und bei jedem Schlag näher an den ersten Koeffizienten herangeführt wird, und
im vierten Schritt das Umschalten zwischen dem zweiten Schritt und dem dritten Schritt auf der Grundlage einer Differenz zwischen einer extrahierten jüngsten momentanen Anzahl der Herzschläge und der Anzahl der Herzschläge, die zuvor in einem der Schritte, dem zweiten oder dem dritten Schritt, erhalten wurde, durchgeführt wird.

9. Verfahren zur Berechnung der Anzahl der Herzschläge nach Anspruch 8, wobei im vierten Schritt,

in einem ersten Zustand, in dem ein Zustand, in dem die Differenz zwischen der jüngsten momentanen Anzahl der Herzschläge und der im zweiten Schritt erhaltenen Anzahl der Herzschläge nicht kleiner als eine eingestellte erste Konstante ist, während einer eingestellten ersten Anzahl der Herzschläge fortbesteht, der zweite Schritt in den dritten Schritt umgeschaltet wird, und
in einem von einem zweiten Zustand, in dem ein Zustand, in dem die Differenz zwischen der jüngsten momentanen Anzahl der Herzschläge und der im dritten Schritt erhaltenen Anzahl der Herzschläge nicht größer als eine eingestellte zweite Konstante ist, während einer eingestellten zweiten Anzahl der Herzschläge fortbesteht, und einem dritten Zustand, in dem der zweite Koeffizient gleich dem ersten Koeffizienten ist, der dritte Schritt in den zweiten Schritt umgeschaltet wird.

10. Verfahren zur Berechnung der Anzahl der Herzschläge nach Anspruch 8 oder 9, das ferner einen fünften Schritt umfasst, bei dem die Aktualisierung der Anzahl der Herzschläge gestoppt wird, wenn die Differenz zwischen der jüngsten momentanen Anzahl der Herzschläge und der im zweiten Schritt erhaltenen Anzahl der Herzschläge einen eingestellten Referenzwert überschreitet, und bei dem ein Aktualisierungswert der Anzahl der Herzschläge begrenzt wird, wenn eine Differenz zwischen der zu einem unmittelbar vorhergehenden Zeitpunkt im zweiten Schritt berechneten Anzahl der Herzschläge und der zu einem aktuellen Zeitpunkt im zweiten Schritt berechneten Anzahl der Herzschläge den eingestellten Referenzwert überschreitet.

11. Verfahren zur Berechnung der Anzahl der Herzschläge nach einem der Ansprüche 8 bis 10, das ferner einen sechsten Schritt umfasst, in dem eine von einer Periode, während der die Anzahl der Herzschläge im dritten Schritt erhalten wird, einer Periode, während der die Differenz zwischen der jüngsten momentanen Anzahl der Herzschläge und der im zweiten Schritt erhaltenen Anzahl der Herzschläge den eingestellten Referenzwert überschreitet, und einer Periode, während der die erhaltene Anzahl der Herzschläge in einen eingestellten anormalen Bereich fällt, als anormale Periode bestimmt wird, und während der anormalen Periode die Ausgabe der Anzahl der Herzschläge gestoppt wird.

12. Verfahren zur Berechnung der Anzahl der Herzschläge nach Anspruch 11, das ferner einen siebten Schritt umfasst, bei dem die Anzahl der Herzschläge ausgegeben wird, wenn die während der abnormalen Periode ermittelte Anzahl der Herzschläge in einen zulässigen Bereich fällt, der in Bezug auf die während einer anderen als der abnormalen Periode ermittelte Anzahl der Herzschläge eingestellt ist.

13. Verfahren zur Berechnung der Anzahl der Herzschläge nach einem der Ansprüche 8 bis 12, wobei die biometrische Information die elektrokardiographische Wellenform eines lebenden Körpers ist und die Anzahl der Herzschläge eine Herzfrequenz ist.

14. Verfahren zur Berechnung der Anzahl der Herzschläge nach einem der Ansprüche 8 bis 12, wobei die biometrische Information eine Information über einen Puls ist und die Anzahl der Herzschläge eine Pulsfrequenz ist.

Revendications

1. Appareil de calcul d'un nombre de battements cardiaques (100) comprenant :

une unité d'extraction (101) configurée pour extraire une pluralité de nombres de battements cardiaques instantanés concernant un nombre de battements cardiaques d'un cœur dans une série temporelle à partir d'informations biométriques ;
une première unité de calcul (102) configurée pour calculer le nombre de battements cardiaques à partir de la pluralité de nombres de battements cardiaques instantanés par un processus de moyennage avec un filtre IIR en utilisant un premier coefficient d'une valeur fixe inférieure à 1, dans lequel la première unité de calcul est configurée pour calculer une équation :

fréquence cardiaque au moment actuel = (fréquence cardiaque instantanée x premier coefficient) + {fréquence cardiaque à un moment immédiatement précédent x (1 - premier coefficient)} ;

une deuxième unité de calcul (103) configurée pour calculer le nombre de battements cardiaques à partir de la pluralité de nombres de battements cardiaques instantanés par un processus de moyennage avec un filtre IIR en utilisant un deuxième coefficient, dans lequel la deuxième unité de calcul est configurée pour calculer une équation :

fréquence cardiaque au moment actuel = (fréquence cardiaque instantanée x deuxième coefficient) + {fréquence cardiaque à un moment immédiatement précédent x (1 - deuxième coefficient)} ;

une unité de permutation (104) configurée pour permuter entre la première unité de calcul et la deuxième unité de calcul,
dans lequel la deuxième unité de calcul est configurée pour utiliser une valeur variable inférieure à 1 en tant que deuxième coefficient,
la deuxième unité de calcul comporte une unité de traitement de coefficient (103a) configurée pour commencer le deuxième coefficient avec une valeur supérieure à celle du premier coefficient et faire se rapprocher le

deuxième coefficient du premier coefficient pour chaque battement, et
l'unité de permutation est configurée pour permuter entre la première unité de calcul et la deuxième unité de calcul sur la base d'une différence entre le nombre de battements cardiaques calculé par l'une de la première unité de calcul et de la deuxième unité de calcul et un nombre de battements cardiaques instantané le plus récent extrait par l'unité d'extraction.

2. Appareil de calcul d'un nombre de battements cardiaques selon la revendication 1, dans lequel,

dans un premier état dans lequel un état dans lequel la différence entre le nombre de battements cardiaques instantanés le plus récent et le nombre de battements cardiaques calculé par la première unité de calcul n'est pas inférieure à une première constante définie continue durant un premier nombre de battements cardiaques défini, l'unité de permutation permute la première unité de calcul avec la deuxième unité de calcul, et
dans l'un d'un deuxième état dans lequel un état dans lequel la différence entre le nombre de battements cardiaques instantanés le plus récent et le nombre de battements cardiaques calculé par la deuxième unité de calcul n'est pas supérieure à une deuxième constante définie continue durant un deuxième nombre de battements cardiaques défini et d'un troisième état dans lequel le deuxième coefficient est égal au premier coefficient, l'unité de permutation permute la deuxième unité de calcul avec la première unité de calcul.

3. Appareil de calcul d'un nombre de battements cardiaques selon la revendication 1 ou 2, comprenant en outre une unité d'arrêt de mise à jour (105) configurée pour arrêter la mise à jour du nombre de battements cardiaques lorsque la différence entre le nombre de battements cardiaques instantanés le plus récent et le nombre de battements cardiaques calculé par la première unité de calcul dépasse une valeur de référence définie, et pour limiter une valeur de mise à jour du nombre de battements cardiaques lorsqu'une différence entre le nombre de battements cardiaques calculé à un moment immédiatement précédent par la première unité de calcul et le nombre de battements cardiaques calculé à un moment actuel par la première unité de calcul dépasse la valeur de référence définie.

4. Appareil de calcul d'un nombre de battements cardiaques selon l'une quelconque des revendications 1 à 3, comprenant en outre une unité de commande de sortie (106) configurée pour déterminer, en tant que période anormale, l'une d'une période durant laquelle la deuxième unité de calcul calcule le nombre de battements cardiaques, d'une période durant laquelle la différence entre le nombre de battements cardiaques instantanés le plus récent et le nombre de battements cardiaques calculé par la première unité de calcul dépasse la valeur de référence définie, et d'une période durant laquelle le nombre de battements cardiaques calculé est situé à l'intérieur d'une plage anormale définie, et pour arrêter la sortie du nombre de battements cardiaques pendant la période anormale.

5. Appareil de calcul d'un nombre de battements cardiaques selon la revendication 4, dans lequel, si le nombre de battements cardiaques obtenu durant la période anormale est situé dans une plage autorisée définie par rapport au nombre de battements cardiaques obtenus durant une période autre que la période anormale, l'unité de commande de sortie sort le nombre de battements cardiaques.

6. Appareil de calcul d'un nombre de battements cardiaques selon l'une quelconque des revendications 1 à 5, dans lequel les informations biométriques sont une forme d'onde électrocardiographique d'un corps vivant et le nombre de battements cardiaques est une fréquence cardiaque.

7. Appareil de calcul d'un nombre de battements cardiaques selon l'une quelconque des revendications 1 à 5, dans lequel les informations biométriques sont des informations qui concernent un pouls, et le nombre de battements cardiaques est une fréquence du pouls.

8. Procédé informatique de calcul d'un nombre de battements cardiaques comprenant :

une première étape d'extraction d'une pluralité de nombres de battements cardiaques instantanés dans une série temporelle à partir d'informations biométriques ;
une deuxième étape d'obtention d'un nombre de battements cardiaques à partir de la pluralité de nombres de battements cardiaques instantanés par un processus de moyennage avec un filtre IIR en utilisant un premier coefficient d'une valeur fixe inférieure à 1, dans lequel à la deuxième étape, une équation :

fréquence cardiaque au moment actuel = (fréquence cardiaque instantanée x premier coefficient) + {fréquence cardiaque à un moment immédiatement précédent x (1 - premier coefficient)},

est calculée ;
une troisième étape d'obtention d'un nombre de battements cardiaques à partir de la pluralité de nombres de battements cardiaques instantanés par un processus de moyennage avec un filtre IIR en utilisant un deuxième coefficient, dans lequel à la troisième étape, une équation :

fréquence cardiaque au moment actuel = (fréquence cardiaque instantanée x deuxième coefficient) + {fréquence cardiaque à un moment immédiatement précédent x (1 - deuxième coefficient)},

est calculée ; et
une quatrième étape de permutation entre la première étape et la troisième étape,
dans lequel
à la troisième étape, une valeur variable inférieure à 1 est utilisée en tant que deuxième coefficient,
à la troisième étape, le deuxième coefficient commence avec une valeur supérieure au premier coefficient, et est amené à se rapprocher du premier coefficient pour chaque battement, et
à la quatrième étape, la permutation entre la deuxième étape et la troisième étape est réalisée sur la base d'une différence entre un nombre de battements cardiaques instantanés le plus récent extrait et le nombre de battements cardiaques précédemment obtenus à l'une de la deuxième étape et de la troisième étape.

9. Procédé de calcul du nombre de battements cardiaques selon la revendication 8, dans lequel, à la quatrième étape, dans un premier état dans lequel un état dans lequel la différence entre le nombre de battements cardiaques instantanés le plus récent et le nombre de battements cardiaques obtenus à la deuxième étape n'est pas inférieure à une première constante définie continue durant un premier nombre de battements cardiaques défini, la deuxième étape permute avec la troisième étape, et
dans l'un d'un deuxième état dans lequel un état dans lequel la différence entre le nombre de battements cardiaques instantanés le plus récent et le nombre de battements cardiaques obtenus à la troisième étape n'est pas supérieure à une deuxième constante définie continue durant un deuxième nombre de battements cardiaques défini et d'un troisième état dans lequel le deuxième coefficient est égal au premier coefficient, la troisième étape permute avec la deuxième étape.

10. Procédé de calcul d'un nombre de battements cardiaques selon la revendication 8 ou 9, comprenant en outre une cinquième étape d'arrêt de mise à jour du nombre de battements cardiaques lorsque la différence entre le nombre de battements cardiaques instantanés le plus récent et le nombre de battements cardiaques obtenu à la deuxième étape dépasse une valeur de référence définie, et de limitation d'une valeur de mise à jour du nombre de battements cardiaques lorsqu'une différence entre le nombre de battements cardiaques calculé à un moment immédiatement précédent à la deuxième étape et le nombre de battements cardiaques calculé à un moment actuel à la deuxième étape dépasse la valeur de référence définie.

11. Procédé de calcul d'un nombre de battements cardiaques selon l'une quelconque des revendications 8 à 10, comprenant en outre une sixième étape de détermination, en tant que période anormale, de l'une d'une période durant laquelle le nombre de battements cardiaques est obtenu à la troisième étape, d'une période durant laquelle la différence entre le nombre de battements cardiaques instantanés le plus récent et le nombre de battements cardiaques obtenu à la deuxième étape dépasse la valeur de référence définie, et d'une période durant laquelle le nombre de battements cardiaques obtenu est situé à l'intérieur d'une plage anormale définie, et d'arrêt de la sortie du nombre de battements cardiaques pendant la période anormale.

12. Procédé de calcul d'un nombre de battements cardiaques selon la revendication 11, comprenant en outre une septième étape de sortie d'un nombre de battements cardiaques lorsque le nombre de battements cardiaques obtenu pendant la période anormale est situé à l'intérieur d'une plage permissible définie par rapport au nombre de battements cardiaques obtenus durant une période autre que la période anormale.

13. Procédé de calcul d'un nombre de battements cardiaques selon l'une quelconque des revendications 8 à 12, dans lequel les informations biométriques sont la forme d'onde électrocardiographique d'un corps vivant, et le nombre de battements cardiaques est une fréquence cardiaque.

14. Procédé de calcul d'un nombre de battements cardiaques selon l'une quelconque des revendications 8 à 12, dans lequel les informations biométriques sont des informations concernant un pouls, et le nombre de battements cardiaques est une fréquence du pouls.

FIG.1

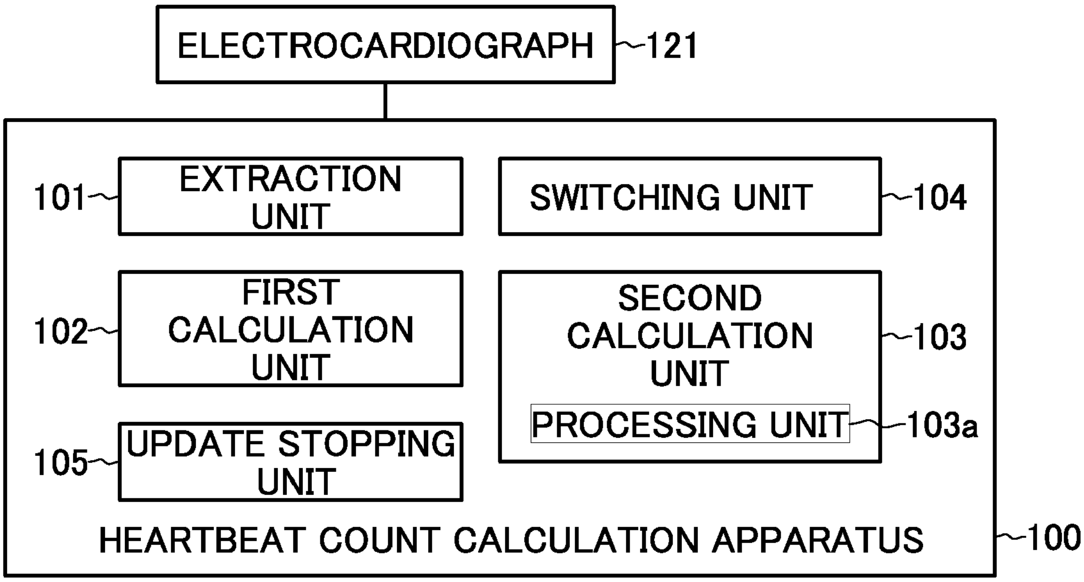

ELECTROCARDIOGRAPH
121
101
EXTRACTION UNIT
SWITCHING UNIT
104
102
FIRST CALCULATION UNIT
SECOND CALCULATION UNIT
103
PROCESSING UNIT
103a
105
UPDATE STOPPING UNIT
HEARTBEAT COUNT CALCULATION APPARATUS
100

FIG.2

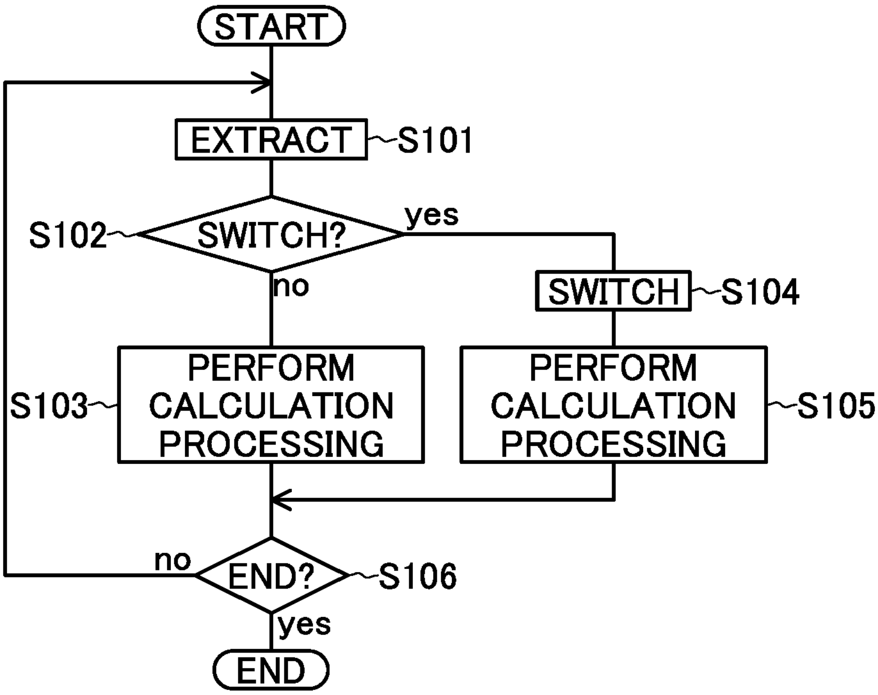

START
EXTRACT
S101
S102
SWITCH?
yes
no
SWITCH
S104
S103
PERFORM CALCULATION PROCESSING
PERFORM CALCULATION PROCESSING
S105
no
END?
S106
yes
END

FIG.3

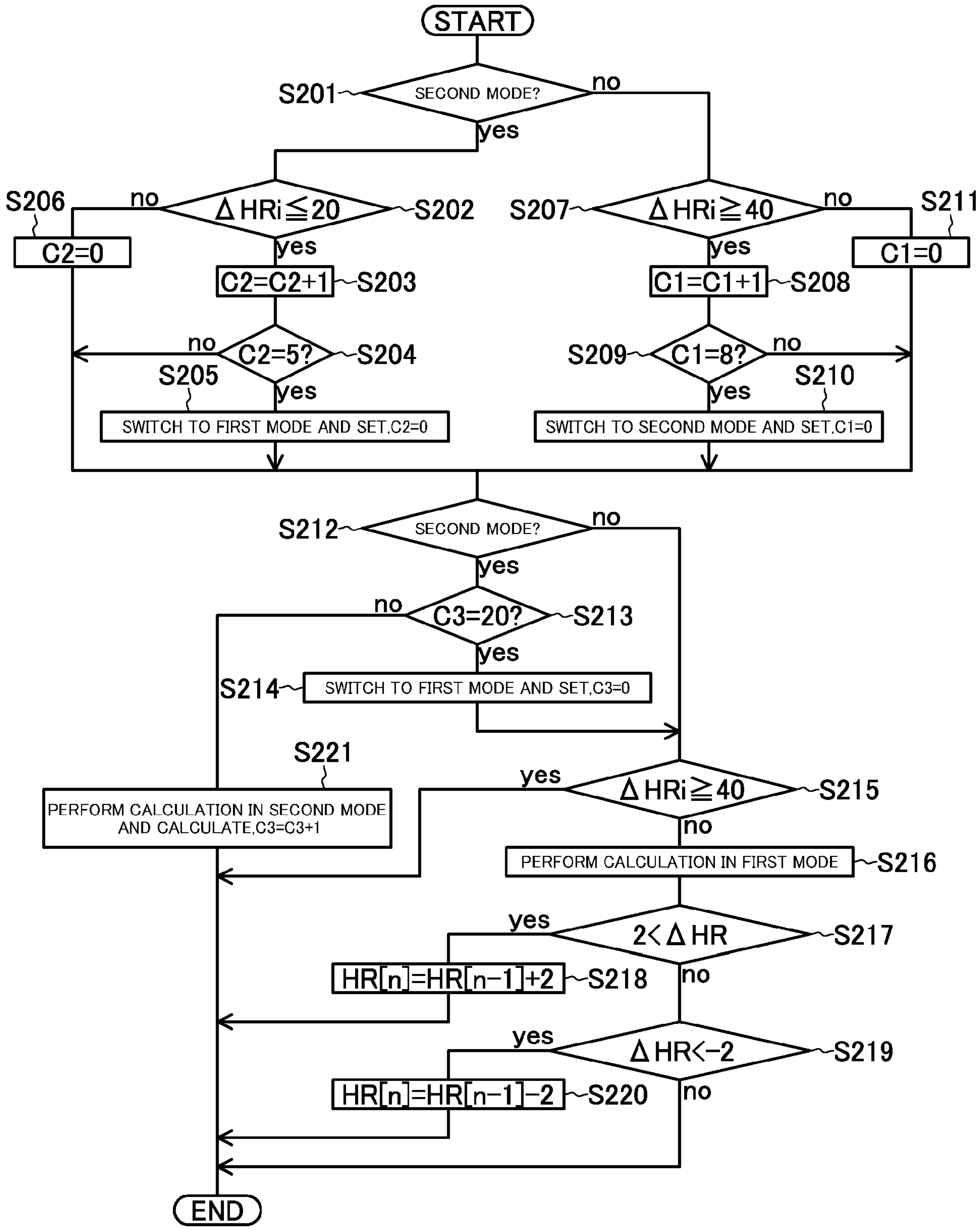

START
S201
SECOND MODE?
no
yes
S206
no
ΔHRi≦20
S202
S207
ΔHRi≧40
no
S211
C2=0
yes
C1=0
C2=C2+1
S203
yes
C1=C1+1
S208
no
C2=5?
S204
S209
C1=8?
no
S205
yes
yes
S210
SWITCH TO FIRST MODE AND SET,C2=0
SWITCH TO SECOND MODE AND SET,C1=0
S212
SECOND MODE?
no
yes
no
C3=20?
S213
yes
S214
SWITCH TO FIRST MODE AND SET,C3=0
S221
yes
ΔHRi≧40
S215
PERFORM CALCULATION IN SECOND MODE AND CALCULATE,C3=C3+1
no
PERFORM CALCULATION IN FIRST MODE
S216
yes
2<ΔHR
S217
HR[n]=HR[n−1]+2
S218
no
yes
ΔHR<−2
S219
HR[n]=HR[n−1]−2
S220
no
END

FIG.4

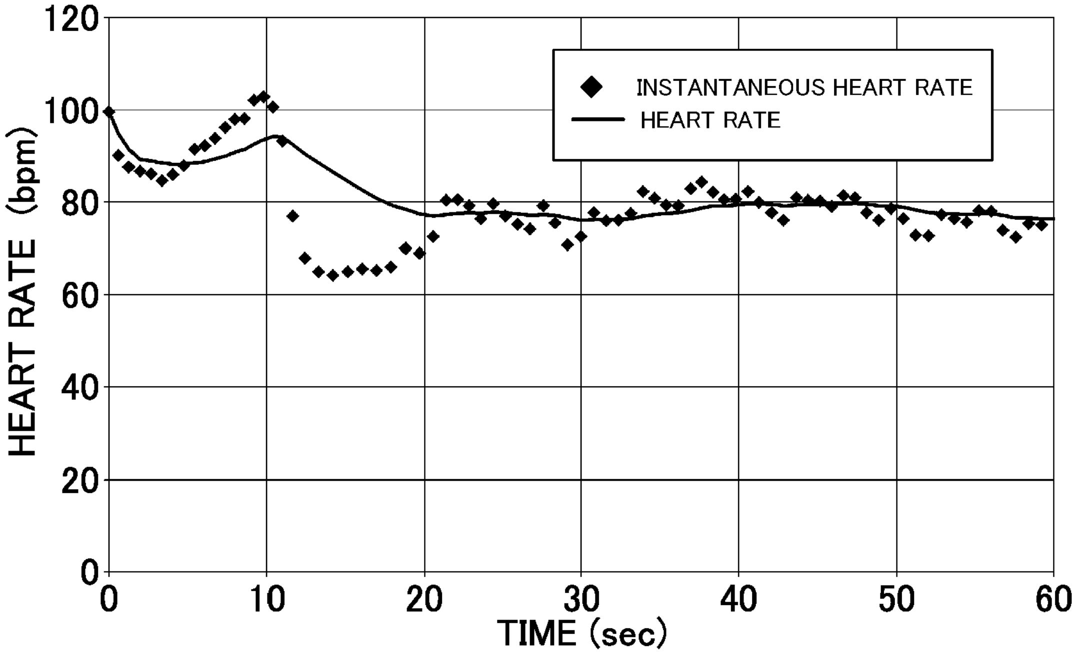

120
100
80
60
40
20
0
HEART RATE (bpm)
0
10
20
30
40
50
60
TIME (sec)
INSTANTANEOUS HEART RATE
HEART RATE

FIG.5

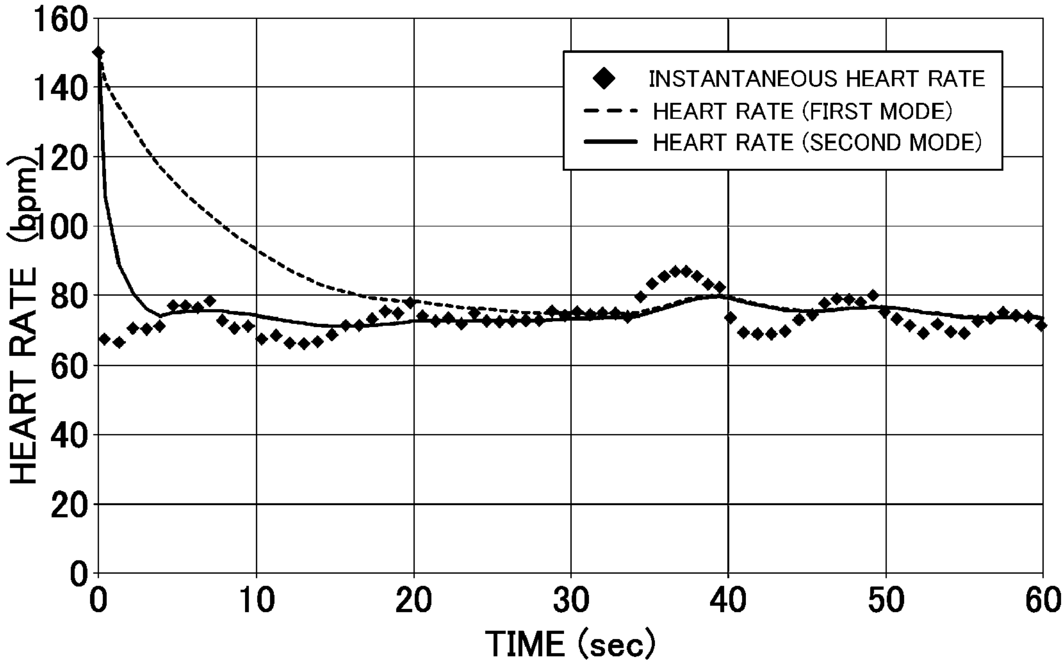

160
140
120
100
80
60
40
20
0
HEART RATE (bpm)
0
10
20
30
40
50
60
TIME (sec)
INSTANTANEOUS HEART RATE
HEART RATE (FIRST MODE)
HEART RATE (SECOND MODE)

FIG.6

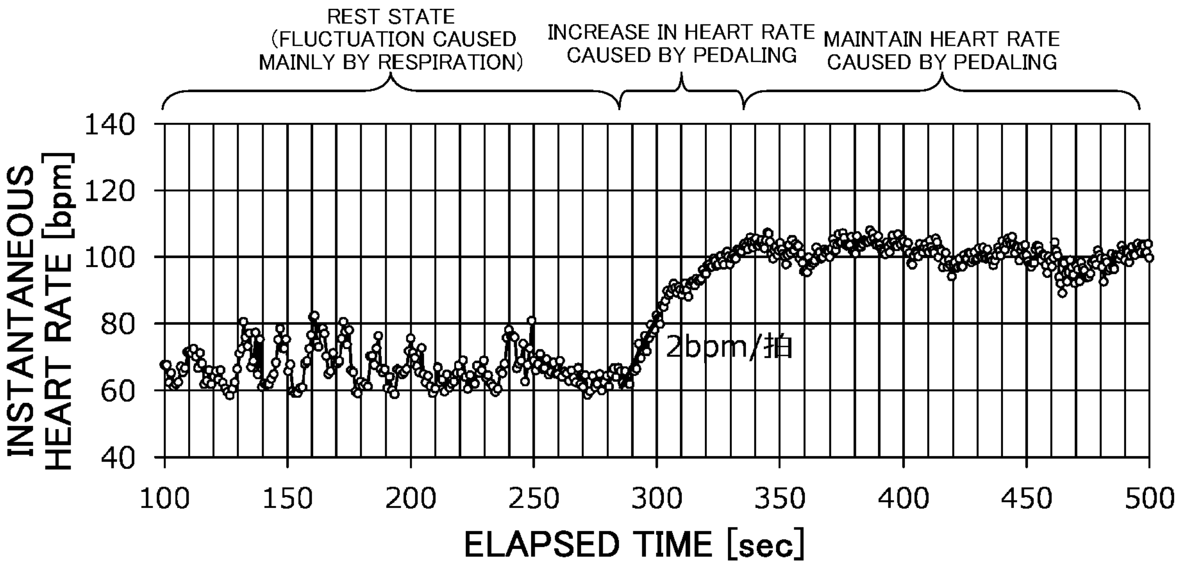

REST STATE
(FLUCTUATION CAUSED
MAINLY BY RESPIRATION)
INCREASE IN HEART RATE
CAUSED BY PEDALING
MAINTAIN HEART RATE
CAUSED BY PEDALING
INSTANTANEOUS
HEART RATE [bpm]
140
120
100
80
60
40
2bpm/拍
100
150
200
250
300
350
400
450
500
ELAPSED TIME [sec]

FIG.7

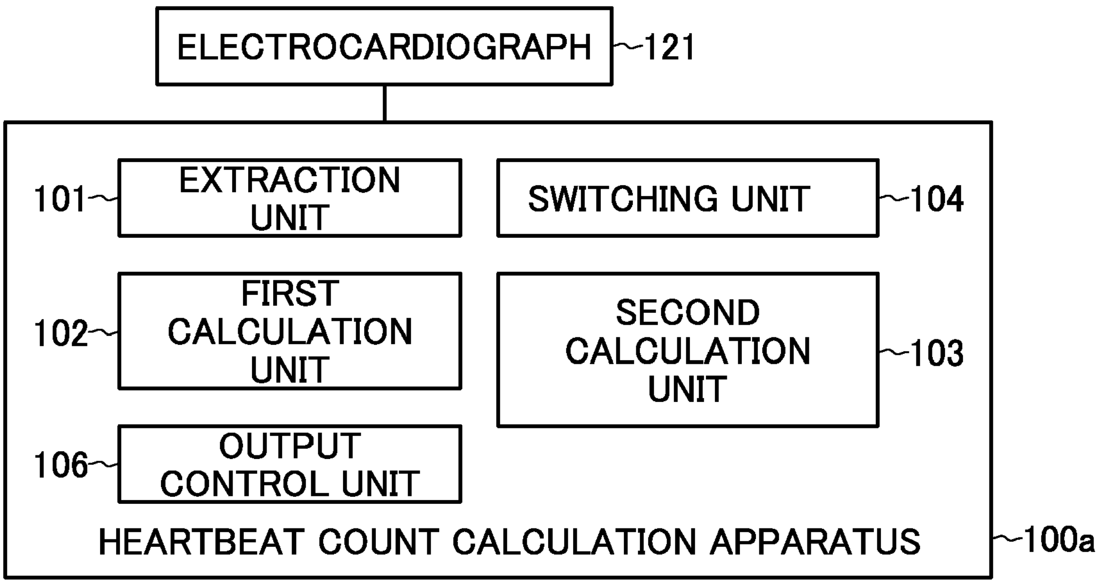

ELECTROCARDIOGRAPH
121
101
EXTRACTION UNIT
SWITCHING UNIT
104
102
FIRST CALCULATION UNIT
SECOND CALCULATION UNIT
103
106
OUTPUT CONTROL UNIT
HEARTBEAT COUNT CALCULATION APPARATUS
100a

FIG.8A

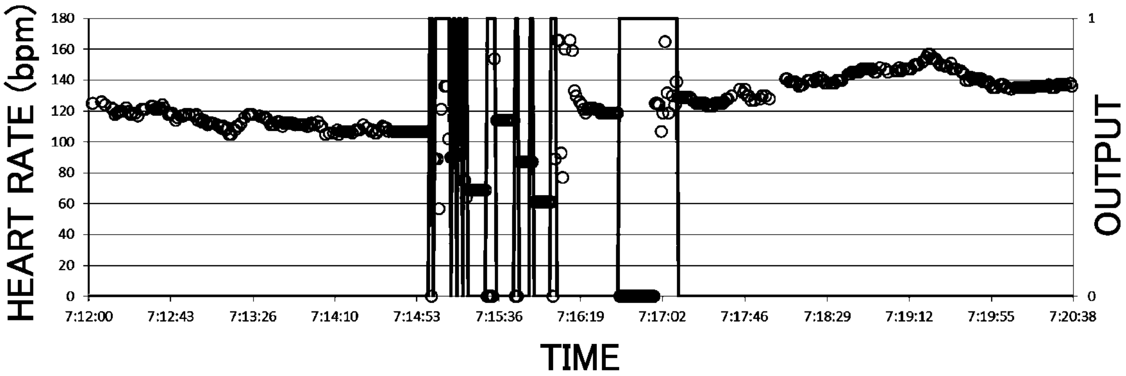


FIG.8B

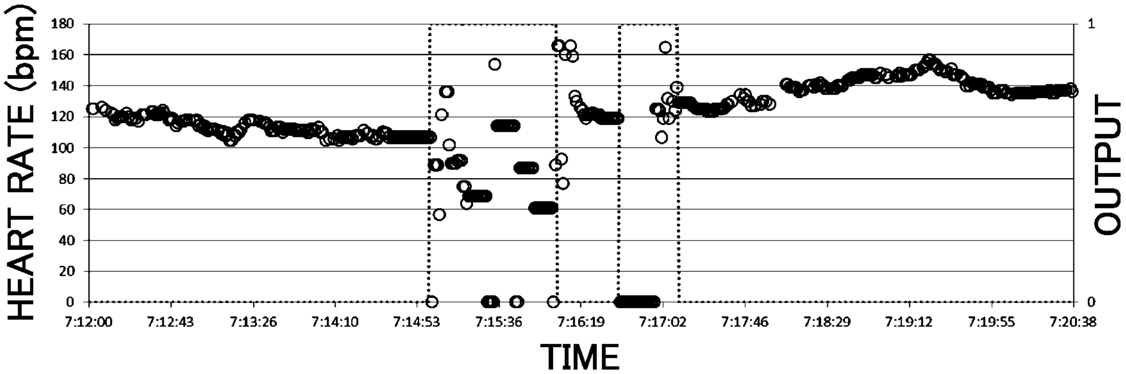


FIG.8C

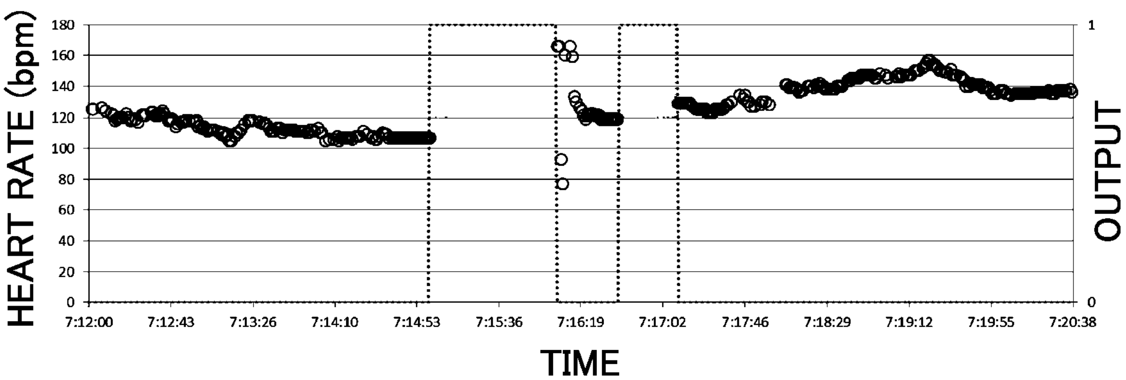


FIG.8D

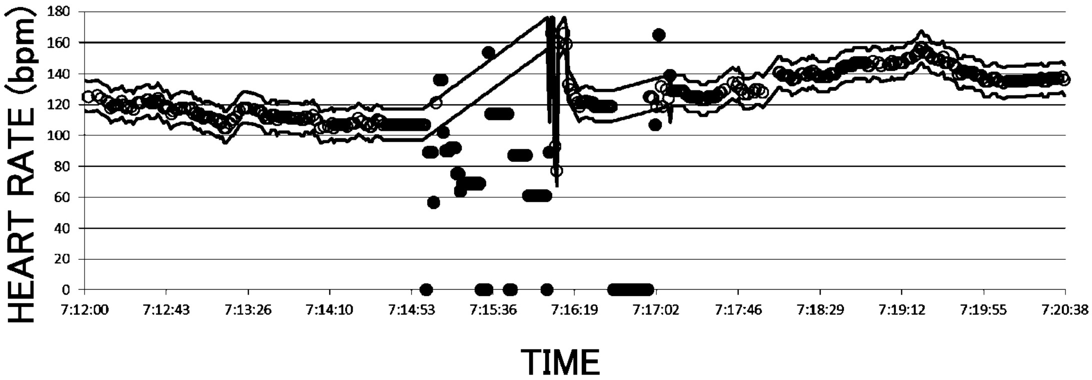


FIG.8E

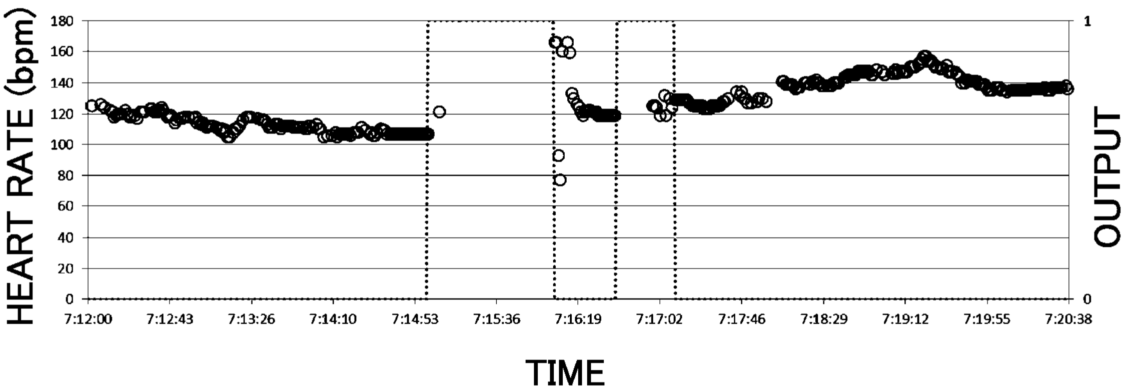
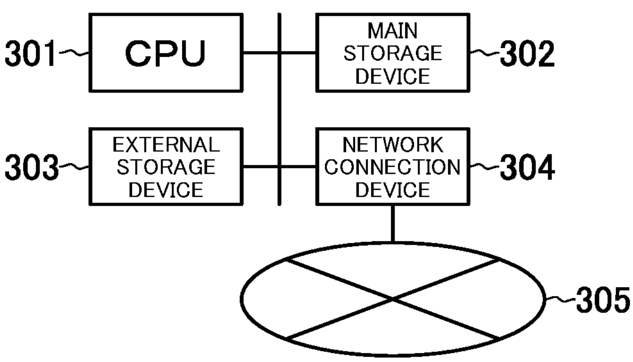


FIG.9



REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- **C. PARK et al.** An Ultra-Wearable, Wireless, Low Power ECG Monitoring System. *Biomedical Circuits and Systems Conference,* 2006 **[0003]**
- BioCAS. IEEE, 2006 **[0003]**
- Adaptive Change Detection in Heart Rate Trend Monitoring in Anesthetized Children. **YANG et al.** IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, IEEE SERVICE CENTER. 01 November 2006, vol. 53 **[0004]**