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(54) **APPARATUS AND METHOD FOR DETECTING BIO-SIGNAL FEATURE**

VORRICHTUNG UND VERFAHREN ZUR DETEKTION EINES BIOSIGNAL-FEATURES

APPAREIL ET PROCÉDÉ DE DÉTECTION D'UNE CARACTÉRISTIQUE DE BIOSIGNAL

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Description

BACKGROUND

1. Field

[0001] Apparatuses and methods consistent with exemplary relate to detecting a bio-signal feature.

2. Description of Related Art

[0002] Healthcare technology has attracted much attention due to the rapid entry into an aging society and relevant social problems such as increase in medical expenses.
Accordingly, medical devices that can be utilized by hospitals and inspection agencies as well as small-sized medical devices that can be carried by individuals such as wearable devices are being developed. In addition, such a small-sized medical device is worn by a user in the form of a wearable device capable of directly measuring cardiovascular health status such as blood pressure or the like, so that the user can directly measure and manage cardiovascular health status.

[0003] Therefore, recently, studies on a method of estimating a blood pressure by analyzing a bio-signal for minimization of a device, particularly, a method of stably detecting features of a bio-signal, which are used in estimating the blood pressure, with a small amount of computation, have been conducted.

[0004] Such an apparatus for detecting a bio-signal feature is disclosed in "Infrared and red PPG signals analysis of the healthy subjects and clinical patients" by Huotari et al. including pulse waveform analysis and envelope calculation for the PPG signal. Another example of prior art is presented in "Estimation of pulse rate from ambulatory PPG using ensemble empirical mode decomposition and adaptive thresholding" by Pittara et al. A further one is the "Real-time pulse wave detection device basing on signal envelope" according to Ming Hong. Systems and methods for non-invasive continuous blood pressure determination are also disclosed in US Patent Publication No. 2009/0326393.

SUMMARY

[0005] Present invention provides a bio-signal feature detection apparatus and method capable of detecting a bio-signal feature based on the bio-signal and an envelope signal according to independent claim 1 and independent claim 8. Preferred embodiments are depicted in the dependent claims.

[0006] According to an aspect of the invention, there is provided an apparatus for detecting a bio-signal feature, the apparatus including: a bio-signal acquirer configured to acquire a bio-signal; and a processor configured to generate an envelope signal of the bio-signal, and detect at least one feature of the bio-signal based on a difference between the envelope signal and the bio-signal.

[0007] The bio-signal may be a pulse wave signal, a first-order differential signal of the pulse wave signal, or a second-order differential signal of the pulse wave signal.

[0008] The bio-signal acquirer may include at least one of a photoplethysmogram (PPG) sensor that detects a PPG signal or a pressure pulse wave signal that corresponds to the bio-signal, and a communication interface configured to receive the bio-signal from an external device.

[0009] The candidate features may include a reflection wave component constituting the bio-signal.

[0010] The processor detects at least one peak point or at least one valley point in one period of the bio-signal, and generates the envelope signal by linearly connecting a start point, the at least one peak point or valley point, and an end point of the bio-signal in the period.

[0011] The processor determines an effective range of the bio-signal by setting a minimum point in the period of the bio-signal as the start point and setting a last zero crossing point or a last valley point in the period of the bio-signal as the end point.

[0012] The processor may calculate a plurality of separate areas between a first graph representing the envelope signal and a second graph representing the bio-signal, and may detect, as the at least one feature, a peak point or a valley point from a largest area of the plurality of separate areas between the first graph and the second graph.

[0013] The processor may divide an effective range of the bio-signal into a plurality of sections based on a peak point or a valley point within the effective range, and may calculate the plurality of separate areas by summing differences between the envelope signal and the bio-signal in each of the plurality of sections.

[0014] The processor may correct the calculated plurality of separate areas using a scaling function.

[0015] The scaling function may be generated based on probability that a feature exists in the bio-signal.

[0016] The processor may perform signal smoothing on the bio-signal.

[0017] The processor may divide an effective range of the bio-signal into a plurality of sections, may calculate an area of each of the plurality of sections by summing absolute values of differences between the envelope signal and the bio-signal in each of the plurality of sections, may detect at least one of peak points and valley points of largest N sections as candidate features, among the plurality of sections, and may detect the at least one feature from the candidate features, based on priori information, wherein N is a natural number.

[0018] The priori information may include information about a position at which the at least one feature is detected.

[0019] The processor may detect one of the candidate features that is closest to the priori information as the at

least one feature.

[0020] The processor may update the priori information based on the detected at least one feature.

[0021] According to another aspect of present invention, there is provided a method of detecting a bio-signal feature, including: acquiring a bio-signal; generating an envelope signal of the bio-signal; and detecting at least one feature of the bio-signal based a difference between the envelope signal and the bio-signal.

[0022] The bio-signal may be a pulse wave signal, a first-order differential signal of the pulse wave signal, or a second-order differential signal of the pulse wave signal.

[0023] The pulse wave signal may include a photoplethysmogram (PPG) signal and a pressure pulse wave signal.

[0024] The at least one feature may represent a reflection wave component constituting the bio-signal.

[0025] The generating the envelope signal includes: detecting at least one peak point or at least one valley point in one period of the bio-signal; and generating the envelope signal by linearly connecting a start point, the at least one peak point or valley point, and an end point of the bio-signal in the period.

[0026] The generating the envelope signal further includes determining an effective range of the bio-signal by setting a minimum point in the period of the bio-signal as the start point and setting a last zero crossing point or a last valley point in the period of the bio-signal as the end point.

[0027] The detecting the at least one feature may include: calculating a plurality of separate areas between a first graph representing the envelop signal and a second graph representing the bio-signal; and detecting, as the at least one feature, a peak point or a valley point from a largest area of the plurality of separate areas between the first graph and the second graph.

[0028] The detecting the at least one feature may further include: dividing an effective range of the bio-signal into a plurality of sections based on a peak point or a valley point within the effective range.

[0029] The calculating the plurality of separate areas may include correcting the calculated plurality of separate areas using a scaling function.

[0030] The scaling function is generated based on probability that a feature exists in the bio-signal.

[0031] The method may further include performing signal smoothing on the bio-signal, so that the envelope signal is generated based on the bio-signal, on which the signal smoothing is performed.

[0032] The detecting the at least one feature may include: dividing an effective range of the bio-signal into a plurality of sections; calculating an area of each of the plurality of sections by summing absolute values of differences between the envelope signal and the bio-signal in each of the plurality of sections; detecting at least one of peak points and valley points of largest N sections, among the plurality of sections, as the candidate features; and detecting the at least one feature from the candidate features based on priori information, wherein N is a natural number.

[0033] The priori information may include information about a position at which the at least one feature is detected.

[0034] The detecting the at least one critical feature may include detecting one of the candidate features that is closest to the priori information as the at least one feature.

[0035] The method may further include updating the priori information based on the detected at least one feature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The above and/or other aspects will be more apparent by describing certain exemplary embodiments, with reference to the accompanying drawings, in which:

FIG. 1 is a diagram illustrating a bio-signal according to present invention;
FIG. 2 is a block diagram illustrating an apparatus for detecting a bio-signal feature according to present invention;
FIG. 3 is a block diagram illustrating a processor according to present invention;
FIG. 4 is a diagram for describing an example of detecting a feature using an upper envelope signal;
FIG. 5 is a diagram for describing an example of detecting a feature using a lower envelope signal;
FIGS. 6A and 6B are diagrams for describing an example of detecting a feature using both an upper envelope signal and a lower envelope signal;
FIG. 7 is a diagram for describing a method of generating a scaling function;
FIG. 8 is a block diagram illustrating a processor according to another aspect of the invention;
FIG. 9 is a block diagram illustrating a processor according to still another aspect of the invention;
FIG. 10 is a block diagram illustrating an apparatus for detecting a bio-signal feature according to another aspect of the invention;
FIG. 11 is a flowchart illustrating a method of detecting a bio-signal feature according to present invention;
FIG. 12 is a flowchart illustrating an operation of generating an envelope signal of a bio-signal according to present invention;
FIG. 13 is a flowchart illustrating an operation of detecting a feature according to present invention; and
FIG. 14 is a flowchart illustrating the operation of detecting a feature according to another aspect of the invention.

DETAILED DESCRIPTION

[0037] Exemplary embodiments are described in

greater detail below with reference to the accompanying drawings.

[0038] Throughout the drawings and the detailed description, unless otherwise described, the same drawing reference numerals will be understood to refer to the same elements, features, and structures. The relative size and depiction of these elements may be exaggerated for clarity, illustration, and convenience. The matters defined in the description, such as detailed construction and elements, are provided to assist in a comprehensive understanding of the exemplary embodiments. However, it is apparent that the exemplary embodiments can be practiced without those specifically defined matters. Also, well-known functions or constructions are not described in detail since they would obscure the description with unnecessary detail.

[0039] It should be noted that in some alternative implementations, the functions/acts noted in the blocks may occur out of the order noted in the flowcharts. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

[0040] Terms described in below are selected by considering functions in the embodiment and meanings may vary depending on, for example, a user or operator's intentions or customs. Therefore, in the following embodiments, when terms are specifically defined, the meanings of terms should be interpreted based on definitions, and otherwise, should be interpreted based on general meanings recognized by those skilled in the art.

[0041] As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," or "includes" and/or "including" when used in this description, specify the presence of stated features, numbers, steps, operations, elements, components or combinations thereof, but do not preclude the presence or addition of one or more other features, numbers, steps, operations, elements, components or combinations thereof.

[0042] Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list. For example, the expression, "at least one of a, b, and c," should be understood as including only a, only b, only c, both a and b, both a and c, both b and c, or all of a, b, and c.

[0043] It will also be understood that the elements or components in the following description are discriminated in accordance with their respective main functions. In other words, two or more elements may be made into one element or one element may be divided into two or more elements in accordance with a subdivided function. Additionally, each of the elements in the following description may perform a part or whole of the function of another element as well as its main function, and some of the main functions of each of the elements may be performed exclusively by other elements. Each element may be realized in the form of a hardware component, a software component, and/or a combination thereof.

[0044] Meanwhile, an apparatus for detecting a bio-signal feature described herein may be implemented as a software module or in the form of a hardware chip and be mounted in an electronic device. In this case, the electronic device may include a mobile phone, a smart phone, a notebook computer, a personal digital assistant (PDA), a portable multimedia player (PMP), a navigation system, an MP3 player, a digital camera, a wearable device, etc., and the wearable device may include various types of wearable devices, such as a wristwatch type, a wristband type, a ring type, a belt-type, a necklace type, an ankle band type, a thigh band type, a forearm band type, and the like. However, the electronic device is not limited to the above mentioned examples, and the wearable device is also not limited to the above-described examples.

[0045] FIG. 1 is a diagram illustrating a bio-signal according to present invention. Specifically, FIG. 1 illustrates one embodiment of a photoplethysmogram (PPG) signal.

[0046] Referring to FIG. 1, a waveform of a PPG signal 100 may be a summation of a propagation wave 110 propagating from the heart to peripheral parts of a body and reflection waves 120 and 130 returning from the peripheral parts of the body. In the illustrated example, the PPG signal 100 is a summation of the propagation wave 110 and the reflection waves 120 and 130.

[0047] FIG. 2 is a block diagram illustrating an apparatus for detecting a bio-signal feature according to present invention.

[0048] Referring to FIG. 2, the apparatus 200 for detecting a feature of a bio-signal includes a bio-signal acquirer 210 and a processor 220.

[0049] The bio-signal acquirer 210 may acquire a bio-signal of one period. In this case, the bio-signal may be a pulse wave signal (e.g., a PPG signal or a pressure pulse wave signal), a first-order differential signal of a pulse wave signal, or a second-order differential signal of a pulse wave signal.

[0050] According to present invention, the bio-signal acquirer 210 may acquire a bio-signal from an external device which senses and/or stores the bio-signal. In this case, the bio-signal acquirer 210 may correspond to a communication interface which uses various communication technologies, such as Bluetooth, Bluetooth low energy (BLE), near field communication (NFC), wireless local area network (WLAN), ZigBee, infrared data association (IrDA), Wi-Fi direct, ultra-wideband, Ant+, Wi-Fi, radio frequency identification (RFID), 3G communication, 4G communication, and 5G communication.

[0051] According to another aspect of the invention, the bio-signal acquirer 210 may include various sensors, such as an electrocardiography (ECG) sensor that measures an electrical activity of the heart by using electrodes placed on the skin of a subject, or a PPG sensor that optically senses the rate of blood flow as controlled by the heart's pumping action, to acquire a bio-signal.

[0052] The processor 220 may generate an envelope signal from the acquired bio-signal and detect a feature of the bio-signal using difference between the generated envelope signal and the bio-signal. In this case, the envelope signal may be divided into an upper envelope signal generated based on a peak point of the bio-signal and a lower envelope signal generated based on a valley point of the bio-signal.

[0053] Meanwhile, the feature may be defined as a point that represents a reflection wave component (e.g., the reflection wave components 120 and 130 of FIG. 1) constituting the bio-signal.

[0054] Hereinafter, an embodiment of the invention using the upper envelope signal, an embodiment of the invention using the lower envelope signal, and an embodiment of the invention using both the upper and lower envelope signals will be separately described.

<Embodiment of the invention using an upper envelope signal>

[0055] The processor 220 determines an effective range of the bio-signal. In this case, the effective range has a minimum point of the bio-signal as a start point and the last zero crossing point or the last valley point of the bio-signal as an end point. That is, the processor 220 detects the minimum point and the last zero crossing point or the last valley point of the bio-signal, and determines that a range from the minimum point to the last zero crossing point or the last valley point as the effective range for detecting a feature.

[0056] The processor 220 detects at least one peak point from the effective range of the bio-signal and generate the upper envelope signal by linearly connecting the start point of the effective range, the detected at least one peak point and the end point of the effective range.

[0057] The processor 220 calculates a difference between the upper envelope signal and the bio-signal. For example, the processor 220 calculates the difference between the upper envelope signal and the bio-signal by subtracting the bio-signal from the upper envelope signal. In this case, the processor 220 corrects the difference between the upper envelope signal and the bio-signal using a scaling function. The scaling function is generated based on probability information on which a feature may appear, and then is stored in an internal/external memory of the apparatus 200 for detecting a feature of a bio-signal.

[0058] The processor 220 divides the effective range of the bio-signal into a plurality of sections based on the peak points within the effective range, and calculates an area of each of the sections by summing absolute values of the differences between the upper envelope signal and the bio-signal in each section. For example, when two peak points, a first peak point and a second peak point, are present within the effective range, the processor 220 divides the effective range into three sections, a first section starting from the start point of the effective range to the first peak point, a second section from the first peak point to the second peak point, and a third section from the second peak point to the end point of the effective range, and calculate the area of each of the sections by summing absolute values of the differences between the envelope signal and the bio-signal in each section.

[0059] The processor 220 extracts a section (hereinafter referred to as a "maximum area section") having the largest area from the plurality of segmented sections based on the calculated area of each of the sections and detects a start point (peak point) and/or a valley point of the extracted maximum area section as a feature of the bio-signal.

<Embodiment of the invention using a lower envelope signal>

[0060] The processor 220 determines an effective range of the bio-signal. In this case, the effective range has a minimum point of the bio-signal as a start point and the last zero crossing point or the last valley point of the bio-signal as an end point. That is, the processor 220 detects a minimum point and the last zero-crossing point or the last valley point of the bio-signal, and determines a range from the minimum point to the last zero crossing point or the last valley point as the effective range for detecting a feature of the bio-signal.

[0061] The processor 220 detects at least one valley point within the effective range of the bio-signal and generate a lower envelop signal by linearly connecting the start point of the effective range, the detected at least one valley point, and the end point of the effective range.

[0062] The processor 220 calculates a difference between the bio-signal and the lower envelope signal. For example, the processor 220 calculates the difference between the bio-signal and the lower envelope signal by subtracting the lower envelope signal from the bio-signal. In this case, the processor 220 corrects the difference between the bio-signal and the lower envelope signal using a scaling function.

[0063] The processor divides the effective range into a plurality of sections based on the valley points within the effective range, and calculates the area of each of the sections by summing absolute values of the differences between the envelope signal and the bio-signal in each section. For example, when there are two valley points, a first valley point and a second valley point, in the effective range, the processor 220 divides the effective range into three sections, a first section from the start point of the effective range to the first valley point, a second section from the first valley point to the second valley point, and a third section from the second valley point to the end point of the effective range, and calculates the area of each of the sections by summing absolute values of the differences between the envelope signal and the bio-signal in each section.

[0064] The processor 220 extracts a maximum area section from among the plurality of sections based on

the calculated area of each of the sections, and detects a peak point and/or an end point (valley point) of the extracted maximum area as a feature of the bio-signal.

<Embodiment of the invention using an upper envelope signal and a lower envelope signal>

[0065] The processor 220 determines an effective range of a bio-signal. In this case, the effective range has a minimum point of the bio-signal as a start point and the last zero crossing point or the last valley point of the bio-signal as an end point. That is, the processor 220 detects the minimum point and the last zero-crossing point or the last valley point of the bio-signal, and determines a range from the minimum point to the last zero crossing point or the last valley point as the effective range for detecting a feature of the bio-signal.

[0066] The processor 220 detects at least one peak point from the effective range of the bio-signal, and generates an upper envelope signal by linearly connecting the start point of the effective range to the detected at least one peak point, and then to the end point of the effective range. The processor 220 generates a lower envelope signal by linearly connecting the start point of the effective range to the detected at least one peak point, and then to the end point of the effective range.

[0067] The processor 220 calculates a difference between the upper envelope signal and the bio-signal and a difference between the bio-signal and the lower envelope signal. For example, the processor 220 calculates the difference between the upper envelope signal and the bio-signal by subtracting the bio-signal from the upper envelope signal and calculates the difference between the bio-signal and the lower envelope signal by subtracting the lower envelope signal from the bio-signal. In this case, the processor 220 corrects the difference between the upper envelope signal and the bio-signal and the difference between the lower envelope signal and the bio-signal using a scaling function.

[0068] The processor 220 divides the effective range of the bio-signal into a plurality of sections (hereinafter referred to as "peak-based sections") based on the peak points within the effective range, and calculates an area of each of the sections (hereinafter referred to as "an area of each peak-based section") by summing absolute values of the differences between the upper envelope signal and the bio-signal in each section. In addition, the processor 220 divides the effective range of the bio-signal into a plurality of sections (hereinafter referred to as "valley-based sections") based on the valley points within the effective range and calculates an area of each of the sections (hereinafter referred to as "an area of each valley-based section") by summing absolute values of the differences between the lower envelope signal and the bio-signal in each section.

[0069] The processor 220 calculates an area of each integrated section by integrating the area of each peak-based section and the area of each valley-based section.

[0070] According to present invention, the processor 220 calculates an area of each integrated section by applying a first weight (e.g., 0.6) to the area of each peak-based section, applying a second weight (e.g., 0.4) to the area of each valley-based section, and summing the areas of the mutually corresponding sections. In this case, the first weight and the second weight are experimentally determined and the $(n+1)^{th}$ peak-based section and the n^{th} valley-based section mutually correspond to each other. For example, it is assumed that, in a case in which three peak-based sections (e.g., a first peak-based section to a third peak-based section) and two valley-based sections (e.g., a first valley-based section and a second valley-based section) are present, an area of the first peak-based section is 10, an area of the second peak-based section is 520, an area of the third peak-based section is 100, an area of the first valley-based section is 300, an area of the second valley-based section is 200, the first weight is 0.6, and the second weight is 0.4. In this case, the processor 220 applies the first weight of 0.6 to the area of 10 of the first peak-based section and add 0 to the resulting value, given that there is no valley-based section corresponding to the first peak-based section, to calculate an integrated area of the first peak-based section, which has a result value of 6 as follows:

$$10\times0.6 + 0 = 6.$$

[0071] In addition, the processor 220 applies the first weight of 0.6 to the area of 520 of the second peak-based section, apply the second weight of 0.4 to the area of 300 of the first valley-based section, and sums the weighted areas to calculate an integrated area of the second peak-based section (or the first valley-based section), which has a result value of 432 as follows:

$$(520\times0.6) + (300\times0.4) = 432$$

[0072] Also, the processor 220 applies the first weight of 0.6 to the area of 100 of the third peak-based section, applies the second weight of 0.4 to the area of 200 of the second valley-based section and sums the weighted areas to calculate an integrated area of the third peak-based section (or the second valley-based section), which has a result value of 140 as follows:

$$(100\times0.6) + (200\times0.4) = 140$$

[0073] The processor 220 extracts a section having the largest integrated area (hereinafter referred to as a "maximum integrated area section") from among the plurality of sections, and detects a peak point and/or a valley point of the extracted maximum integrated area section

as a feature of the bio-signal. For example, in the above example, the processor 220 extracts the second peak-based section (or the first valley-based section) whose integrated area is the largest and detect a start point (peak point) and/or a valley point of the second peak-based section (or a peak point and/or a valley point of the first valley-based section) as the feature of the bio-signal.

[0074] Meanwhile, the detected features are used to estimate a blood pressure of the subject from which the bio-signal is measured. For example, various characteristic values (e.g., time, amplitude, etc.) of the bio-signal are calculated using the features detected by the apparatus 200 for detecting a bio-signal feature and it is possible to estimate the blood pressure of the subject using the various calculated characteristic values and a prestored blood pressure estimation equation.

[0075] FIG. 3 is a block diagram illustrating a processor according to present invention. A processor 300 of FIG. 3 may be one exemplary embodiment of the processor 220 of FIG. 2.

[0076] Referring to FIG. 3, the processor 300 includes an effective range determiner 310, an envelope signal generator 320, an area calculator 330, and a feature detector 340.

[0077] The effective range determiner 310 determines an effective range of a bio-signal. For example, the effective range has a minimum point of the bio-signal as a start point and the last zero crossing point or the last valley point of the bio-signal as an end point. The effective range determiner 310 detects the minimum point and the last zero crossing point or the last valley point of the bio-signal, and determines that a range from the minimum point to the last zero crossing point or the last valley point as the effective range for detecting a feature.

[0078] The envelope signal generator 320 generates an envelope signal of the bio-signal.

[0079] For example, the envelope signal generator 320 detects at least one peak point from the effective range of the bio-signal and generates an upper envelope signal by linearly connecting the start point of the effective range to the detected at least one peak point, and then to the end point of the effective range. The envelope signal generator 320 generates a lower envelope signal by connecting the start point of the effective range to the detected at least one valley point, and then to the end point of the effective range.

[0080] The area calculator 330 calculates a difference between the bio-signal and at least one of the upper envelope signal and the lower envelope signal.

[0081] According to the present invention, in the case in which the envelope signal generator 320 generates the upper envelope signal, the area calculator 330 calculates a difference between the upper envelope signal and the bio-signal by subtracting the bio-signal from the upper envelope signal.

[0082] According to another aspect of the invention, in a case in which the envelope signal generator 320 generates the lower envelope signal, the area calculator 330 calculates a difference between the lower envelope signal and the bio-signal by subtracting the lower envelope signal from the bio-signal.

[0083] Meanwhile, the area calculator 330 corrects the difference between the upper envelope signal and the bio-signal and the difference between the bio-signal and the lower envelope signal using a scaling function.

[0084] The area calculator 330 divides the effective range based on the peak points or the valley point within the effective range and calculates an area of each section by summing absolute values of the differences between the envelope signal and the bio-signal in each section.

[0085] According to present invention, in a case in which the envelope signal generator 320 generates the upper envelope signal, the area calculator 330 divides the effective range of the bio-signal into a plurality of sections based on the peak points within the effective range, and calculates an area of each of the sections by summing absolute values of the differences between the upper envelope signal and the bio-signal in each section.

[0086] According to another aspect of the invention, in a case in which the envelope signal generator 320 generates the lower envelope signal, the area calculator 330 divides the effective range into a plurality of sections on the valley point within the effective range, and calculates the area of each of the sections by summing the differences between the envelope signal and the bio-signal in each section.

[0087] According to still another aspect of the invention, in a case in which the envelope signal generator 320 generates both the upper envelope signal and the lower envelope signal, the area calculator 330 divides the effective range into a plurality of peak-based sections and into a plurality of valley-based sections, respectively, calculates an area of each peak-based section by summing differences between the upper envelope signal and the bio-signal in each peak-based section, and calculates an area of each valley-based section by summing differences between the bio-signal and the lower envelope signal in each valley-based section. In addition, the area calculator 330 calculates an area of each integrated section by applying a first weight to the area of each peak-based section, applying a second weight to the area of each valley-based section, and thereafter, summing areas of the mutually corresponding sections.

[0088] The feature detector 340 selects a maximum area section based on the calculated areas for each section and detect a peak point and/or a valley point of the selected maximum area section as a feature of the bio-signal.

[0089] According to present invention, the feature detector 340 selects a maximum area section from the plurality of peak-based sections and detects a start point (peak point) of the selected maximum area section and/or a valley point thereof as a feature of the bio-signal.

[0090] According to another aspect of the invention, the feature detector 340 selects a maximum area section

from the plurality of valley-based sections and detects a peak point of the selected maximum area section and/or an end point (valley point) thereof as a feature of the bio-signal.

[0091] According to still another aspect of the invention, the feature detector 340 extracts a maximum integrated area section from the plurality of sections (the plurality of peak-based sections and the valley-based sections) and detects a peak point of the extracted maximum integrated area section and/or a valley point thereof as a feature of the bio-signal.

[0092] FIG. 4 is a diagram for describing an example of detecting a feature using an upper envelope signal. In FIG. 4, a bio-signal 410 represents a second-order differential signal of a pulse wave signal.

[0093] Referring to FIGS. 3 and 4, the effective range determiner 310 detects a minimum point a and the last zero crossing point f from the bio-signal 410 and determines a range from the minimum point a to the last zero crossing point f as an effective range.

[0094] The envelope signal generator 320 detects peak points b and d in the effective range and generate an upper envelope signal 420 by connecting the start point a of the effective range, the peak points b and d, and the end point f of the effective range.

[0095] The area calculator 330 calculates a difference between the upper envelope signal 420 and the bio-signal 410 by subtracting the bio-signal 410 from the upper envelope signal 420. In this case, the area calculator 330 may correct the difference between the upper envelope signal 420 and the bio-signal 410 using a scaling function.

[0096] The area calculator 330 divides the effective range into three sections (a first section, a second section, and a third section) based on the peak points b and d in the effective range and calculates an area of each section by summing absolute values of the differences between the upper envelope signal 420 and the bio-signal 410 in each section.

[0097] The feature detector 340 selects a third section that is a maximum area section from among the three sections (i.e., the first section to the third section) based on the calculated areas for each section, and detects a start point d of the third section and/or a valley point e as a feature of the bio-signal 410.

[0098] FIG. 5 is a diagram for describing an example of detecting a feature using a lower envelope signal. In FIG. 5, a bio-signal 510 represents a second-order differential signal of a pulse wave signal.

[0099] Referring to FIGS. 3 and 5, the effective range determiner 310 detects a minimum point a and the last zero crossing point f from the bio-signal 510 and determine a range from the minimum point a to the last zero crossing point f as an effective range.

[0100] The envelope signal generator 320 detects valley points c and e in the effective range and generates a lower envelope signal 520 by connecting the start point a of the effective range, the valley points c and e in the effective range, and the end point f of the effective range.

[0101] The area calculator 330 calculates a difference between the bio-signal 510 and the lower envelope signal 520 by subtracting the lower envelope signal 520 from the bio-signal 510. In this case, the area calculator 330 may correct the difference between the bio-signal 510 and the lower envelope signal 520 using a scaling function.

[0102] The area calculator 330 divides the effective range into three sections (a first section, a second section, and a third section) based on the valley points c and e in the effective range and calculates an area of each section by summing absolute values of the differences between the bio-signal 510 and the lower envelope signal 520 in each section.

[0103] The feature detector 340 selects the second section that is a maximum area section from among the three sections (i.e., the first section to the third section) based on the calculated areas for each section, and detects a peak point d of the second section and/or an end point e thereof as a feature of the bio-signal 510.

[0104] FIGS. 6A and 6B are diagrams for describing an example of detecting a feature using both an upper envelope signal and a lower envelope signal. In FIGS. 6A and 6B, a bio-signal 610 represents a second-order differential signal of a pulse wave signal.

[0105] Referring to FIGS. 3, 6A and 6B, the effective range determiner 310 detects a minimum point a and the last zero crossing point f of the bio-signal 610 and determines a range from the minimum point a to the last zero crossing point f as an effective range.

[0106] The envelope signal generator 320 detects peak points b and d in the effective range, and generates an upper envelope signal 620 by connecting the start point a of the effective range, the peak points b and d, and the end point f of the effective range, with reference to FIG. 6A. The envelope signal generator 320 detects valley points c and e in the effective range, and generates a lower envelope signal 520 by connecting the start point a of the effective range, the valley points c and e in the effective range, and an end point f of the effective range, with reference to FIG. 6B.

[0107] The area calculator 330 calculates a difference between the upper envelope signal 620 and the bio-signal 610 by subtracting the bio-signal 610 from the upper envelope signal 620, with reference to FIG. 6A. In addition, the area calculator 330 calculates a difference between the bio-signal 610 and the lower envelope signal 630 by subtracting the lower envelope signal 630 from the bio-signal 610, with reference to FIG. 6B. The area calculator 330 may correct the difference between the upper envelope signal 620 and the bio-signal 610 and the difference between the bio-signal 610 and the lower envelope signal 630 using a scaling function.

[0108] The area calculator 330 divides the effective range into three sections (e.g., a first peak-based section, a second peak-based section, and a third peak-based section) based on the peak points b and d in the effective range and calculates an area of each section by summing

absolute values of the differences between the upper envelope signal 620 and the bio-signal 610 in each peak-based section, with reference to FIG. 6A). In addition, the area calculator 330 divides the effective range into three sections (e.g., a first valley-based section, a second valley-based section, and a third valley-based section) based on the valley points c and e in the effective range and calculates an area of each section by summing the differences between the bio-signal 610 and the lower envelope signal 630 in each valley-based section, with reference to FIG. 6B.

[0109] The area calculator 330 calculates an area of each integrated section by applying a first weight to the area of each peak-based section, applying a second weight to the area of each valley-based section, and thereafter, summing areas of the mutually corresponding sections. In this case, the second peak-based section corresponds to the first valley-based section, and the third peak-based section corresponds to the second valley-based section. On the other hand, there is no valley-based section that corresponds to the first peak-based section and there is no peak-based section that corresponds to the third valley-based section.

[0110] The feature detector 340 selects the third peak-based section that is a maximum integrated area section from among the three peak-based sections (i.e., the first peak-based section, the second peak-based section, and the third peak-based section) based on the calculated areas of each of integrated sections, and detects a start point d of the third peak-based section and/or a valley point e thereof as a feature of the bio-signal 610. Alternatively, or in addition to the third peak-based section, the feature detector 340 may select the second valley-based section that is a maximum integrated area section from among the three valley-based sections (i.e., the first valley-based section, the second valley-based section, and the third valley-based section) based on the calculated areas of each of integrated sections, and detect a peak point d of the second valley-based section and/or an end point e thereof as a feature of the bio-signal 610.

[0111] FIG. 7 is a diagram for describing a method of generating a scaling function.

[0112] A feature according to present invention may mostly appear near an inflection point of a lower envelope signal. Therefore, a scaling function is generated based on such a characteristic.

[0113] With reference to FIG. 2, the processor 220 or an external device that communicates with the processor generates a scaling function. Hereinafter, it is assumed that the processor 220 generates the scaling function and a bio-signal 710 is a second-order differential signal of a pulse wave signal.

[0114] Referring to FIG. 7, the processor 220 forms a best-fit line that passes through a start point and two valley points of the bio-signal to generate a lower envelope signal 720 in a curved-shape. The processor 220 generates a scaled lower envelope signal 730 by scaling the lower envelope signal 720 to have a range of 0 to 1.

[0115] The processor 220 generates a signal 740 that is horizontally symmetric to the lower envelope signal 730 scaled based on a time central axis 770.

[0116] The processor 220 generates a signal based on the scaled lower envelope signal 730 and the horizontally symmetric signal 740 and generates a scaling function 760 by scaling the generated signal 750 to have a range of 0 to 1.

[0117] FIG. 8 is a block diagram illustrating a processor according to another aspect of the invention. A processor 800 of FIG. 8 may be one exemplary embodiment of the processor 220 of FIG. 2.

[0118] Referring to FIG. 8, the processor 800 includes an effective range determiner 310, an envelope signal generator 320, an area calculator 330, a feature detector 340, and a smoother 810. Here, the effective range determiner 310, the envelope signal generator 320, the area calculator 330, and the feature detector 340 have been described with reference to FIG. 3, and hence detailed descriptions thereof will be omitted.

[0119] The smoother 810 smoothes a bio-signal. For example, the smoother 810 performs single smoothing by removing noise from the bio-signal using a low-pass filter (e.g., a moving average filter).

[0120] FIG. 9 is a block diagram illustrating a processor according to still another aspect of the invention. A processor 900 of Fig. 9 may be one exemplary embodiment of the processor 220 of FIG. 2.

[0121] Referring to FIG. 9, the processor 900 includes an effective range determiner 310, an envelope signal generator 320, an area calculator 330, a feature candidate detector 910, a feature detector 920, and a priori information updater 930. Here, the effective range determiner 310, the envelope signal generator 320, and the area calculator 330 have been described with reference to FIG. 3, and hence detailed descriptions thereof will be omitted.

[0122] The feature candidate detector 910 selects top N sections (N is an arbitrary natural number) having large areas based on areas of each section calculated by the area calculator 330, and detects peak points and/or valley points in the selected N sections as feature candidates. For example, an effective range is divided into five sections (e.g., a first section to a fifth section), and relative sizes of areas of each of the sections are expressed as follows: the third section > the fourth section > the second section > the first section > the fifth section, wherein N is 2. In this case, the feature candidate detector 910 detects a peak point and/or a valley point of the third section and a peak point and/or a valley point of the fourth section as feature candidates.

[0123] The feature detector 920 detects one of the feature candidates as a feature based on pre-stored priori information. In this case, the priori information is information about a position from which the feature is detected. According to present invention, the feature detector 920 calculates distances between the priori information

and each of the feature candidates, and detects the feature candidate that is closest to the priori information as a feature of the bio-signal.

[0124] The priori information updater 930 updates the pre-stored priori information based on position information of the detected feature.

[0125] FIG. 10 is a block diagram illustrating an apparatus for detecting a bio-signal feature according to another aspect of the invention.

[0126] Referring to FIG. 10, an apparatus 1000 for detecting a bio-signal feature includes a bio-signal acquirer 210, a processor 220, an input interface 1010, a storage 1020, a communication interface 1030, and an output interface 1040. In this case, the bio-signal acquirer 210 and the processor 220 have been described with reference to FIG. 2, and thus detailed descriptions thereof will be omitted.

[0127] The input interface 1010 receives various operation signals input by a user. According to present invention, the input interface 1010 includes a key pad, a dome switch, a capacitive or resistive touch pad, a jog wheel, a jog switch, a hardware button, and the like. In particular, when the touch pad has a layered structure with a display, this structure may be referred to as a touch screen.

[0128] The storage 1020 stores programs or instructions for operations of the apparatus 1000 for detecting a bio-signal feature and stores data input to the apparatus 1000 and data output from the apparatus 1000. In addition, the storage 1020 stores bio-signal data acquired through the bio-signal acquirer 210 and feature data detected by the processor 220.

[0129] The storage 1020 includes at least one type of storage medium, such as a flash memory, a hard disk, a micro type multimedia card, and a card type memory (e.g., secure digital (SD) or XD memory), a random access memory (RAM), a static random access memory (SRAM), a read only memory (ROM), an electrically erasable programmable read only memory (EEPROM), a programmable read only memory (PROM), a magnetic memory, a magnetic disk, and an optical disk. In addition, the apparatus 1000 operates an external storage medium, such as a web storage serving a storage function.

[0130] The communication interface 1030 communicates with an external device. For example, the communication interface 1030 transmits the bio-signal data acquired through the bio-signal acquirer 210 and the feature data detected by the processor 220 to the external device and receives various pieces of data helpful for detecting a feature of the bio-signal from the external device.

[0131] In this case, the external device may be a medical device using the acquired bio-signal data and/or the bio-signal feature data, a printer to output results, or a display device to display the bio-signal data and the bio-signal feature data. In addition, the external device may be a digital TV, a desktop computer, a mobile phone, a smart phone, a tablet computer, a notebook computer, a PDA, a PMP, a navigation system, an MP3 player, a digital camera, a wearable device, or the like, but is not limited thereto.

[0132] The communication interface 1030 communicates with the external device via Bluetooth communication, Bluetooth low energy (BLE) communication, near-field communication (NFC), wireless local area network (WLAN) communication, ZigBee communication, infrared data association (IrDA) communication, Wi-Fi direct (WFD) communication, ultra-wideband (UWB) communication, Ant+ communication, Wi-Fi communication, radio frequency identification (RFID) communication, 3G communication, 4G communication, 5G communication, or the like. However, these are merely examples and the type of communication is not limited thereto.

[0133] The output interface 1040 outputs the bio-signal data and/or the bio-signal feature data. According to present invention, the output interface 1040 outputs the bio-signal data and/or the bio-signal feature data using at least one of an audible method, a visual method, and a tactile method. To this end, the output interface 1040 includes a display, a speaker, a vibrator, and the like.

[0134] FIG. 11 is a flowchart illustrating a method of detecting a bio-signal feature according to present invention. The method shown in FIG. 11 may be performed by the apparatus 200 for detecting a bio-signal feature of FIG. 2.

[0135] Referring to FIGS. 2 and 11, the apparatus 200 for detecting a bio-signal feature acquires a bio-signal of one period, in operation 1110. In this case, the bio-signal is a pulse wave signal (e.g., a PPG signal or a pressure pulse wave signal) a first-order differential signal of a pulse wave signal, or a second-order differential signal of a pulse wave signal. For example, the apparatus 200 acquires the bio-signal from an external device configured to sense and/or store the bio-signal or directly acquires the bio-signal using various sensors, such as a PPG sensor, configured to sense the bio-signal.

[0136] The apparatus 200 generates an envelope signal of the bio-signal from the acquired bio-signal, in operation 1120. In this case, the envelope signal is classified into an upper envelope signal generated based on a peak point of the bio-signal and a lower envelope signal generated based on a valley point of the bio-signal.

[0137] The apparatus 200 detects a feature of the bio-signal using a difference between the generated envelope signal and the bio-signal, in operation 1130. In this case, the feature is defined as a point that represents a reflection wave component (e.g., the reflection wave components 120 and 130 of FIG. 1) constituting the bio-signal.

[0138] FIG. 12 is a flowchart illustrating an operation 1120 of generating an envelope signal of a bio-signal according to one exemplary embodiment.

[0139] Referring to FIGS. 2 and 12, the apparatus 200 for detecting a bio-signal feature determines an effective range of the bio-signal, in operation 1210. For example, the apparatus 200 detects a minimum point and the last zero crossing point or the last valley point of the bio-

signal, and determines that a range from the minimum point to the last zero crossing point or the last valley point as the effective range of the bio-signal.

[0140] The apparatus 200 detects at least one peak point or at least one valley point within the effective range of the bio-signal, in operation 1220.

[0141] The apparatus 200 generates an envelope signal of the bio-signal based on the detected at least one peak point and/or the detected at least one valley point, in operation 1230. For example, the apparatus 200 generates an upper envelope signal by connecting a start point of the effective range, the detected at least one peak point, and an end point of the effective range, or generates a lower envelope signal by connecting the start point of the effective range, the detected at least one valley point, and the end point of the effective range.

[0142] FIG. 13 is a flowchart illustrating an operation 1130 of detecting a feature according to present invention.

[0143] Referring to FIGS. 2 and 13, the apparatus 200 for detecting a bio-signal feature divides an effective range into a plurality of sections based on the peak point or the valley point within the effective range, in operation 13010. For example, the apparatus 200 divides the effective range into a plurality of sections based on the peak point within the effective range (when using an upper envelope signal), divides the effective range into a plurality of sections based on the valley point within the effective range (when using a lower envelope signal), or divides the effective range into a plurality of sections based on the peak point within the effective range and also divides the effective range into a plurality of sections based on the valley point within the effective range (when using both the upper envelope signal and the lower envelope signal).

[0144] The apparatus 200 calculates a difference between the bio-signal and the envelope signal, and calculates an area of each of the sections by summing the differences between the bio-signal and the envelope signal in each section, in operation 1320. For example, the apparatus 200 calculates a difference between the upper envelope signal and the bio-signal by subtracting the bio-signal from the upper envelope signal and calculates an area of each of the sections by adding absolute values of the differences between the upper envelope signal and the bio-signal in each section (when using the upper envelope signal). In addition, the apparatus 200 calculates a difference between the bio-signal and the lower envelope signal by subtracting the lower envelope signal from the bio-signal and calculates an area of each of the sections by adding absolute values of the differences between the bio-signal and the lower envelope signal in each section (when using the lower envelope signal). Also, the apparatus 200 calculates an area of each peak-based section by summing absolute values of differences between the upper envelope signal and the bio-signal in each peak-based section, calculates an area of each valley-based section by summing absolute values of differences between the bio-signal and the lower envelope signal in each valley-based section, and calculates an area of each integrated section by applying a first weight to the area of each peak-based section, applying a second weight to the area of each valley-based section, and thereafter, summing areas of the mutually corresponding sections (when using both the upper envelope signal and the lower envelope signal).

[0145] In this case, the apparatus 200 corrects the difference between the upper envelope signal and the bio-signal and the difference between the bio-signal and the lower envelope signal using a scaling function.

[0146] The apparatus 200 selects a maximum area section based on the calculated areas for each section and detects a peak point and/or a valley point of the selected maximum area section as a feature of the bio-signal, in operation 1330. For example, the apparatus 200 selects a maximum area section from the plurality of peak-based sections and detects a start point (peak point) of the selected maximum area section and/or a valley point thereof as a feature of the bio-signal (when using the upper envelope signal). In addition, the apparatus 200 selects a maximum area section from the plurality of valley-based sections and detects a peak point of the selected maximum area section and/or an end point (valley point) thereof as a feature of the bio-signal (when using the lower envelope signal). Also, the apparatus 200 selects a maximum integrated area section from a plurality of peak-based sections or from a plurality of valley-based sections and detects a peak point and/or a valley point of the extracted maximum integrated area section as a feature of the bio-signal.

[0147] FIG. 14 is a flowchart illustrating an operation 1130 of detecting a feature according to another aspect of the invention.

[0148] Referring to FIGS. 2 and 14, the apparatus 200 for detecting a bio-signal feature divides an effective range into a plurality of sections based on a peak point or a valley point within the effective range, in operation 1410.

[0149] The apparatus 200 calculates a difference between the bio-signal and an envelope signal and calculates an area of each of the sections by summing absolute values of the differences between the bio-signal and the envelope signal in each section, in operation 1420.

[0150] In this case, the apparatus 200 corrects the difference between the upper envelope signal and the bio-signal and the difference between the bio-signal and the lower envelope signal using a scaling function.

[0151] The apparatus 200 selects the top N sections (N is an arbitrary natural number) having large areas based on calculated areas of each section, and detects peak points and/or valley points in the selected N sections as feature candidates, in operation 1440.

[0152] The apparatus 200 detects one of the feature candidates as a feature based on pre-stored priori information, in operation 1440. In this case, the priori information may be information about a position from which

the feature is detected. For example, the apparatus 200 calculates distances between the priori information and each of the feature candidates, and detects the feature candidate that is closest to the priori information as a feature of the bio-signal.

[0153] The apparatus 200 updates pre-stored priori information based on position information of the detected feature, in operation 1450.

[0154] Meanwhile, the detected features are used to estimate a blood pressure of the subject from which the bio-signal is measured. For example, various characteristic values (e.g., time, amplitude, etc.) of the bio-signal are calculated using the features detected by the apparatus 200 for detecting a bio-signal feature and it is possible to estimate the blood pressure of the subject using the various calculated characteristic values and a pre-stored blood pressure estimation equation.

[0155] While not restricted thereto, an exemplary embodiment can be embodied as computer-readable code on a computer-readable recording medium. The computer-readable recording medium is any data storage device that can store data that can be thereafter read by a computer system. Examples of the computer-readable recording medium include read-only memory (ROM), random-access memory (RAM), CD-ROMs, magnetic tapes, floppy disks, and optical data storage devices. The computer-readable recording medium can also be distributed over network-coupled computer systems so that the computer-readable code is stored and executed in a distributed fashion. Also, an exemplary embodiment may be written as a computer program transmitted over a computer-readable transmission medium, such as a carrier wave, and received and implemented in general-use or special-purpose digital computers that execute the programs. Moreover, it is understood that in exemplary embodiments, one or more units of the above-described apparatuses and devices can include circuitry, a processor, a microprocessor, etc., and may execute a computer program stored in a computer-readable medium.

[0156] The foregoing exemplary embodiments are merely examples and are not to be construed as limiting. The present teaching can be readily applied to other types of apparatuses. Also, the description of the exemplary embodiments is intended to be illustrative, and not to limit the scope of the claims, and many alternatives, modifications, and variations will be apparent to those skilled in the art.

Claims

1. An apparatus (200) for detecting a bio-signal feature, the apparatus (200) comprising:

   a bio-signal acquirer (210) configured to acquire a bio-signal; and
   a processor (220) configured to:
   detect at least one peak point or at least one valley point in one period of the bio-signal,
   generate an envelope signal of the bio-signal, and
   detect at least one feature of the bio-signal based on a difference between the envelope signal and the bio-signal;
   the processor (220) characterized in being further configured to determine an effective range of the bio-signal by setting a minimum point in the period of the bio-signal as a start point and setting a last zero crossing point or a last valley point in the period of the bio-signal as an end point, and
   generate the envelope signal by linearly connecting the start point, the at least one peak point or valley point detected in the effective range, and the end point of the bio-signal.

2. The apparatus of claim 1, wherein the bio-signal is a pulse wave signal, a first-order differential signal of the pulse wave signal, or a second-order differential signal of the pulse wave signal.

3. The apparatus according to anyone of claims 1 or 2, wherein the bio-signal acquirer (210) comprises at least one of a photoplethysmogram (PPG) sensor that detects a PPG signal or a pressure pulse wave signal that corresponds to the bio-signal, and a communication interface (1030) configured to receive the bio-signal from an external device.

4. The apparatus according to anyone of claims 1 to 3, wherein the at least one feature represents a reflection wave component constituting the bio-signal.

5. The apparatus according to anyone of claims 1 to 4, wherein the processor (220) is configured to:

   determine a plurality of separate areas between a first graph representing the envelope signal and a second graph representing the bio-signal, and to detect, as the at least one feature, a peak point or a valley point from a largest area of the plurality of separate areas between the first graph and the second graph,
   divide the effective range of the bio-signal into a plurality of sections based on a peak point or a valley point within the effective range, and
   determine the plurality of separate areas by summing differences between the envelope signal and the bio-signal in each of the plurality of sections,
   correct the determined plurality of separate areas using a scaling function,
   wherein the scaling function is generated based on probability that a feature exists in the bio-

signal.

6. The apparatus according to anyone of claims 1 to 5, wherein the processor (220) is further configured to:

perform signal smoothing on the bio-signal,
divide the effective range of the bio-signal into a plurality of sections,
determine an area of each of the plurality of sections by summing absolute values of differences between the envelope signal and the bio-signal in each of the plurality of sections,
detect at least one of peak points and valley points of largest N sections as candidate features, among the plurality of sections, and
detect the at least one feature from the candidate features, based on priori information, wherein N is a natural number,
wherein the priori information comprises information about a position at which the at least one feature is detected.

7. The apparatus of claim 6, wherein the processor (220) is further configured to:

detect one of the candidate features that is closest to the priori information as the at least one feature, and
update the priori information based on the detected at least one feature.

8. A method of detecting a bio-signal feature, the method comprising:

acquiring, by means of a bio-signal acquirer (210), a bio-signal;
detecting by means of a processor (220), at least one peak point or at least one valley point in one period of the bio-signal;
generating, by means of the processor (220), an envelope signal of the bio-signal; and
detecting by means of the processor (220), at least one feature of the bio-signal based a difference between the envelope signal and the bio-signal;
the method characterized in
determining, by means of the processor (220), an effective range of the bio-signal by setting a minimum point in the period of the bio-signal as a start point and setting a last zero crossing point or a last valley point in the period of the bio-signal as an end point, and
the envelope signal being generated by linearly connecting the start point, the at least one peak point or valley point detected in the effective range, and the end point of the bio-signal by means of the processor (220).

9. The method of claim 8, wherein the bio-signal is a pulse wave signal, a first-order differential signal of the pulse wave signal, or a second-order differential signal of the pulse wave signal, and
wherein the pulse wave signal comprises a photoplethysmogram (PPG) signal and a pressure pulse wave signal.

10. The method according to anyone of claims 8 or 9, wherein the at least one feature represents a reflection wave component constituting the bio-signal.

11. The method according to anyone of claims 8 to 10, wherein the detecting the at least one feature comprises:

determining a plurality of separate areas between a first graph representing the envelop signal and a second graph representing the bio-signal;
detecting, as the at least one feature, a peak point or a valley point from a largest area of the plurality of separate areas between the first graph and the second graph, and
dividing the effective range of the bio-signal into a plurality of sections based on a peak point or a valley point within the effective range,
wherein the determining the plurality of separate areas comprises correcting the determined plurality of separate areas using a scaling function, and
wherein the scaling function is generated based on probability that a feature exists in the bio-signal.

12. The method according to anyone of claim 8 to 11, further comprising performing signal smoothing on the bio-signal, so that the envelope signal is generated based on the bio-signal, on which the signal smoothing is performed.

13. The method of claim 8, wherein the detecting the at least one feature comprises:

dividing the effective range of the bio-signal into a plurality of sections;
determining an area of each of the plurality of sections by summing absolute values of differences between the envelope signal and the bio-signal in each of the plurality of sections;
detecting at least one of peak points and valley points of largest N sections, among the plurality of sections, as the candidate features, wherein N is a natural number;
detecting the at least one feature from the candidate features based on priori information,
wherein the priori information comprises information about a position at which the at least one

feature is detected; and
detecting one of the candidate features that is closest to the priori information as the at least one feature,
wherein the method further comprises:
updating the priori information based on the detected at least one feature.

Patentansprüche

1. Eine Vorrichtung (200) zur Detektion eines Biosignal Features, die Vorrichtung umfassend:

einen Biosignal-Erwerber (210) gestaltet, um eine Biosignal zu erwerben; und
einen Prozessor (220) gestaltet, um:

zumindest einen Spitzenpunkt oder zumindest einen Talpunkt in einer Periode des Biosignals zu erkennen,
ein Hüllkurvensignal des Biosignals zu erzeugen, und
zumindest ein Feature des Biosignals basierend auf einem Unterschied zwischen dem Hüllkurvensignal und dem Biosignal zu erkennen;
der Prozessor (220) dadurch gekennzeichnet, ferner gestaltet zu sein, um
einen effektiven Umfang des Biosignals zu bestimmen, indem ein Minimumpunkt in der Periode des Biosignals als ein Startpunkt festgelegt wird und ein letzter Nulldurchgangspunkt oder ein letzter Talpunkt in der Periode des Biosignals als ein Endpunkt festgelegt wird, und
das Hüllkurvensignal zu erzeugen, indem der Startpunkt, der zumindest eine Spitzenpunkt oder Talpunkt, der im effektiven Umfang erkannt wurde und der Endpunkt des Biosignals linear verbunden werden.

2. Die Vorrichtung nach Anspruch 1, wobei das Biosignal ein Pulswellensignal, ein Differentialsignal erster Ordnung des Pulswellensignals oder ein Differentialsignal zweiter Ordnung des Pulswellensignals ist.

3. Die Vorrichtung gemäß einem der Ansprüche 1 oder 2, wobei der Biosignal-Erwerber (210) zumindest einen Fotoplethysmogramm (PPG) Sensor, der ein PPG Signal oder ein Druckimpulswellensignal, das dem Biosignal entspricht, erkennt oder eine Kommunikationsschnittstelle (1030), gestaltet, um ein Biosignal von einem externen Gerät zu empfangen, umfasst.

4. Die Vorrichtung gemäß einem der Ansprüche 1 bis 3, wobei das zumindest eine Feature eine Reflexionswellenkomponente, die das Biosignal bildet, darstellt.

5. Die Vorrichtung gemäß einem der Ansprüche 1 bis 4, wobei der Prozessor (220) gestaltet ist, um:

eine Vielzahl von separaten Gebieten zwischen einem ersten Grafen, der das Hüllkurvensignal darstellt und einem zweiten Grafen, der das Biosignal darstellt, zu bestimmen und als das zumindest eine Feature, einen Spitzenpunkt oder einen Talpunkt aus dem größten Gebiet der Vielzahl von separaten Gebieten zwischen dem ersten Grafen und dem zweiten Grafen zu erfassen,
den effektiven Umfang des Biosignals in eine Vielzahl von Sektionen basierend auf einem Spitzenpunkt oder einem Talpunkt innerhalb des effektiven Umfangs zu zerlegen, und
die Vielzahl von separaten Gebieten zu bestimmen, indem die Unterschiede zwischen dem Hüllkurvensignal und dem Biosignal in jedem der Vielzahl von Sektionen aufsummiert werden,
die bestimmte Vielzahl von separaten Gebieten mithilfe einer Skalierungsfunktion zu korrigieren,
wobei die Skalierungsfunktion basierend auf einer Wahrscheinlichkeit, dass ein Feature im Biosignal existiert, erzeugt wird.

6. Die Vorrichtung gemäß einem der Ansprüche 1 bis 5, wobei der Prozessor ferner gestaltet ist, um:

Signalglättung am Biosignal durchzuführen,
den effektiven Umfang des Biosignals in eine Vielzahl von Sektionen zu zerlegen,
ein Gebiet jeder der Vielzahl von Sektionen durch Summieren der absoluten Werte der Unterschiede zwischen dem Hüllkurvensignal und dem Biosignal in jedem der Vielzahl von Sektionen zu bestimmen,
zumindest einen der Spitzenpunkte und Talpunkte der größten N Sektionen als Kandidaten Feature unter der Vielzahl von Sektionen zu erkennen, und
zumindest ein Feature der Kandidaten Features basierend auf priori-Information zu erkennen,
wobei N eine natürliche Zahl ist,
wobei die priori-Information Informationen über eine Position umfasst, an der das zumindest eine Feature erkannt wurde.

7. Die Vorrichtung nach Anspruch 6, wobei der Prozessor (220) ferner gestaltet ist, um:

eines der Kandidaten Features, das am nächsten an der priori-Information als das zumindest

eine Feature ist, zu ermitteln, und
die priori-Information basierend auf dem ermittelten zumindest einen Feature zu aktualisieren.

8. Ein Verfahren zur Detektion eines Biosignal Features, das Verfahren umfassend:

Erwerben eines Biosignals mittels eines Biosignal-Erwerbers (210);
Erkennen zumindest eines Spitzenpunkts oder zumindest eines Talpunkts in einer Periode des Biosignals mittels eines Prozessors (220);
Erzeugen eines Hüllkurvensignals des Biosignals mittels eines Prozessors (220);
Erkennen von zumindest einem Feature des Biosignals basierend auf einem Unterschied zwischen dem Hüllkurvensignal und dem Biosignal mittels eines Prozessors (220);
das Verfahren gekennzeichnet durch
Bestimmen eines effektiven Umfangs des Biosignals mittels eines Prozessors (220), indem ein Minimumpunkt in der Periode des Biosignals als ein Startpunkt festgelegt wird und ein letzter Nulldurchgangspunkt oder ein letzter Talpunkt in der Periode des Biosignals als ein Endpunkt festgelegt wird, und
das Hüllkurvensignal mittels eines Prozessors (220) erzeugt wird, indem der Startpunkt, der zumindest eine Spitzenpunkt oder Talpunkt, der im effektiven Umfang erkannt wurde und der Endpunkt des Biosignals linear verbunden werden.

9. Das Verfahren Nach Anspruch 8, wobei das Biosignal ein Pulswellensignal, ein Differentialsignal erster Ordnung des Pulswellensignals oder ein Differentialsignal zweiter Ordnung des Pulswellensignals ist, und
wobei das Pulswellensignal ein Fotoplethysmogramm (PPG) Signal und ein Druckimpulswellensignal umfasst.

10. Das Verfahren nach einem der Ansprüche 8 oder 9, wobei das zumindest eine Feature eine Reflexionswellenkomponente, die das Biosignal bildet, darstellt.

11. Das Verfahren nach einem der Ansprüche 8 bis 10, wobei das Erkennen des zumindest einen Features umfasst:

eine Vielzahl von separaten Gebieten zwischen einem ersten Grafen, der das Hüllkurvensignal darstellt und einem zweiten Grafen, der das Biosignal darstellt, zu bestimmen;
als das zumindest eine Feature, einen Spitzenpunkt oder einen Talpunkt aus dem größten Gebiet der Vielzahl von separaten Gebieten zwischen dem ersten Grafen und dem zweiten Grafen zu erfassen;
den effektiven Umfang des Biosignals in eine Vielzahl von Sektionen basierend auf einem Spitzenpunkt oder einem Talpunkt innerhalb des effektiven Umfangs zu zerlegen, und
wobei Bestimmen der Vielzahl von separaten Gebieten umfasst, die bestimmte Vielzahl von separaten Gebieten mithilfe einer Skalierungsfunktion zu korrigieren,
wobei die Skalierungsfunktion basierend auf einer Wahrscheinlichkeit, dass ein Feature im Biosignal existiert, erzeugt wird.

12. Das Verfahren nach einem der Ansprüche 8 bis 11, ferner umfassend, Signalglättung am Biosignal durchzuführen, so dass das Hüllkurvensignal basierend auf dem Biosignal erzeugt wird, an dem Signalglättung durchgeführt wurde.

13. Das Verfahren nach Anspruch 8, wobei das Erfassen des zumindest einen Features umfasst:

den effektiven Umfang des Biosignals in eine Vielzahl von Sektionen zu zerlegen;
ein Gebiet jeder der Vielzahl von Sektionen durch Summieren der absoluten Werte der Unterschiede zwischen dem Hüllkurvensignal und dem Biosignal in jedem der Vielzahl von Sektionen zu bestimmen;
zumindest einen der Spitzenpunkte und Talpunkte der größten N Sektionen als Kandidaten Features unter der Vielzahl von Sektionen zu erkennen, wobei N eine natürliche Zahl ist;
zumindest ein Feature der Kandidaten Features basierend auf priori-Information zu erkennen;
wobei die priori-Information Informationen über eine Position umfasst, an der das zumindest eine Feature erkannt wurde; und
eines der Kandidaten Features, das am nächsten an der priori-Information als das zumindest eine Feature ist, zu ermitteln,
wobei das Verfahren ferner umfasst:
die priori-Information basierend auf dem ermittelten zumindest einen Feature zu aktualisieren.

Revendications

1. Appareil (200) de détection d'une caractéristique de biosignal, l'appareil (200) comprenant :

un acquéreur de biosignal (210) configuré pour acquérir un biosignal ; et
un processeur (220) configuré pour :

détecter au moins un point de crête ou au moins un point de vallée dans une période

du biosignal,
générer un signal d'enveloppe du biosignal, et
détecter au moins une caractéristique du biosignal sur la base d'une différence entre le signal d'enveloppe et le biosignal ;

le processeur (220) étant caractérisé en qu'il est en outre configuré pour

déterminer une plage efficace du biosignal en établissant un point minimum dans la période du biosignal en tant que point de départ et en établissant un dernier point de passage par zéro ou un dernier point de vallée dans la période du biosignal en tant que point de fin, et
générer le signal d'enveloppe en reliant linéairement le point de départ, le au moins un point de crête ou point de vallée détecté dans la plage efficace, et le point de fin du biosignal.

2. Appareil selon la revendication 1, dans lequel le biosignal est un signal d'onde de pouls, un signal différentiel de premier ordre du signal d'onde de pouls, ou un signal différentiel de second ordre du signal d'onde de pouls.

3. Appareil selon l'une quelconque des revendications 1 ou 2, dans lequel l'acquéreur de biosignal (210) comprend au moins l'un parmi un capteur photoplethysmogramme (PPG) qui détecte un signal PPG ou un signal d'onde de pouls de pression qui correspond au biosignal, et une interface de communication (1030) configurée pour recevoir le biosignal provenant d'un dispositif externe.

4. Appareil selon l'une quelconque des revendications 1 à 3, dans lequel la au moins une caractéristique représente une composante d'onde de réflexion constituant le biosignal.

5. Appareil selon l'une quelconque des revendications 1 à 4, dans lequel le processeur (220) est configuré pour :

déterminer une pluralité de zones séparées entre un premier graphique représentant le signal d'enveloppe et un second graphique représentant le biosignal, et pour détecter, comme la au moins une caractéristique, un point de crête ou un point de vallée à partir d'une zone la plus grande de la pluralité de zones séparées entre le premier graphique et le second graphique,
diviser la plage efficace du biosignal en une pluralité de sections sur la base d'un point de crête ou d'un point de vallée dans la plage efficace, et
déterminer la pluralité de zones séparées en additionnant des différences entre le signal d'enveloppe et le biosignal dans chacune de la pluralité de sections,
corriger la pluralité déterminée de zones séparées en utilisant une fonction de mise à l'échelle, dans lequel la fonction de mise à l'échelle est générée sur la base d'une probabilité qu'une caractéristique existe dans le biosignal.

6. Appareil selon l'une quelconque des revendications 1 à 5, dans lequel le processeur (220) est en outre configuré pour :

effectuer un lissage de signal sur le biosignal,
diviser la plage efficace du biosignal en une pluralité de sections,
déterminer une zone de chacune de la pluralité de sections en additionnant des valeurs absolues de différences entre le signal d'enveloppe et le biosignal dans chacune de la pluralité de sections,
détecter au moins l'un parmi des points de crête et des points de vallée de N sections les plus grandes en tant que caractéristiques candidates, parmi la pluralité de sections, et
détecter la au moins une caractéristique parmi les caractéristiques candidates, sur la base d'informations *a priori*, où N est un nombre naturel, dans lequel les informations a *priori* comprennent des informations sur une position à laquelle la au moins une caractéristique est détectée.

7. Appareil selon la revendication 6, dans lequel le processeur (220) est en outre configuré pour :

détecter l'une des caractéristiques candidates qui est la plus proche des informations a *priori* en tant que la au moins une caractéristique, et
mettre à jour les informations a *priori* sur la base de la au moins une caractéristique détectée.

8. Procédé de détection d'une caractéristique de biosignal, le procédé comprenant les étapes consistant à :

acquérir, au moyen d'un acquéreur de biosignal (210), un biosignal ;
détecter au moyen d'un processeur (220), au moins un point de crête ou au moins un point de vallée dans une période du biosignal ;
générer, au moyen du processeur (220), un signal d'enveloppe du biosignal ; et
détecter au moyen du processeur (220), au moins une caractéristique du biosignal sur la base d'une différence entre le signal d'enveloppe et le biosignal ;
le procédé étant **caractérisé par**

la détermination, au moyen du processeur (220), d'une plage efficace du biosignal en établissant un point minimum dans la période du biosignal en tant que point de départ et en établissant un dernier point de passage par zéro ou un dernier point de vallée dans la période du biosignal en tant que point de fin, et
le signal d'enveloppe étant généré en reliant linéairement le point de départ, le au moins un point de crête ou point de vallée détecté dans la plage efficace, et le point de fin du biosignal au moyen du processeur (220).

9. Procédé selon la revendication 8, dans lequel le biosignal est un signal d'onde de pouls, un signal différentiel de premier ordre du signal d'onde de pouls, ou un signal différentiel de second ordre du signal d'onde de pouls, et
dans lequel le signal d'onde de pouls comprend un signal de photopléthysmogramme (PPG) et un signal d'onde de pouls de pression.

10. Procédé selon l'une quelconque des revendications 8 ou 9, dans lequel la au moins une caractéristique représente une composante d'onde de réflexion constituant le biosignal.

11. Procédé selon l'une quelconque des revendications 8 à 10, dans lequel la détection de la au moins une caractéristique comprend les étapes consistant à :

déterminer une pluralité de zones séparées entre un premier graphique représentant le signal d'enveloppe et un second graphique représentant le biosignal ;
détecter, comme la au moins une caractéristique, un point de crête ou un point de vallée à partir d'une zone la plus grande de la pluralité de zones séparées entre le premier graphique et le second graphique,
diviser la plage efficace du biosignal en une pluralité de sections sur la base d'un point de crête ou d'un point de vallée dans la plage efficace,
dans lequel la détermination de la pluralité de zones séparées comprend de corriger la pluralité déterminée de zones séparées en utilisant une fonction de mise à l'échelle, et
dans lequel la fonction de mise à l'échelle est générée sur la base d'une probabilité qu'une caractéristique existe dans le biosignal.

12. Procédé selon l'une quelconque des revendications 8 à 11, comprenant en outre l'exécution d'un lissage de signal sur le biosignal, de sorte que le signal d'enveloppe est généré sur la base du biosignal, sur lequel le lissage de signal est effectué.

13. Procédé selon la revendication 8, dans lequel la détection de la au moins une caractéristique comprend les étapes consistant à :

diviser la plage efficace du biosignal en une pluralité de sections ;
déterminer une zone de chacune de la pluralité de sections en additionnant des valeurs absolues de différences entre le signal d'enveloppe et le biosignal dans chacune de la pluralité de sections,
détecter au moins l'un parmi des points de crête et des points de vallée de N sections les plus grandes, parmi la pluralité de sections, en tant que caractéristiques candidates, où N est un nombre naturel ;
détecter la au moins une caractéristique parmi les caractéristiques candidates sur la base d'informations *a priori*,
dans lequel les informations a *priori* comprennent des informations sur une position à laquelle la au moins une caractéristique est détectée ; et
détecter l'une des caractéristiques candidates qui est la plus proche des informations a *priori* en tant que la au moins une caractéristique, et
dans lequel le procédé comprend en outre :
la mise à jour des informations a *priori* sur la base de la au moins une caractéristique détectée.

FIG. 1

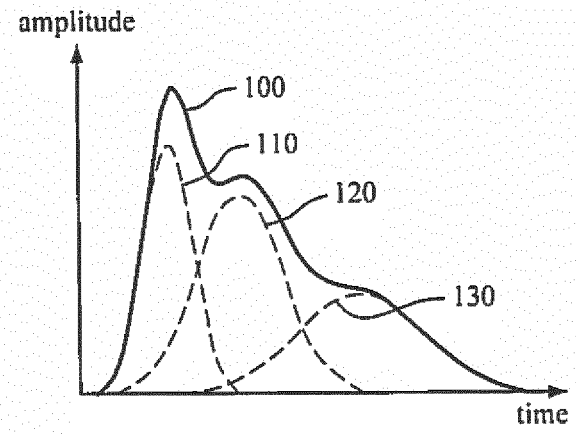


FIG. 2

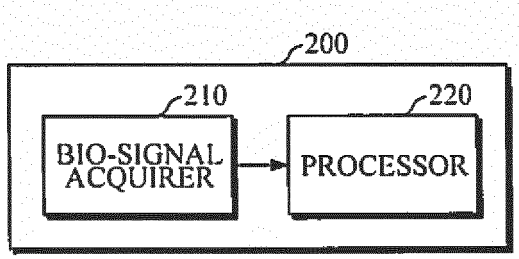


FIG. 3

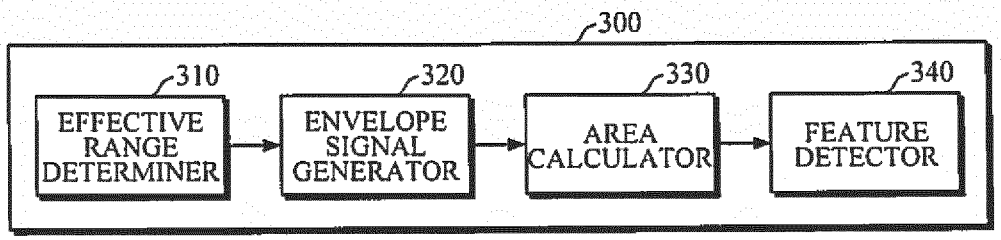

300
310
EFFECTIVE RANGE DETERMINER
320
ENVELOPE SIGNAL GENERATOR
330
AREA CALCULATOR
340
FEATURE DETECTOR

FIG. 4

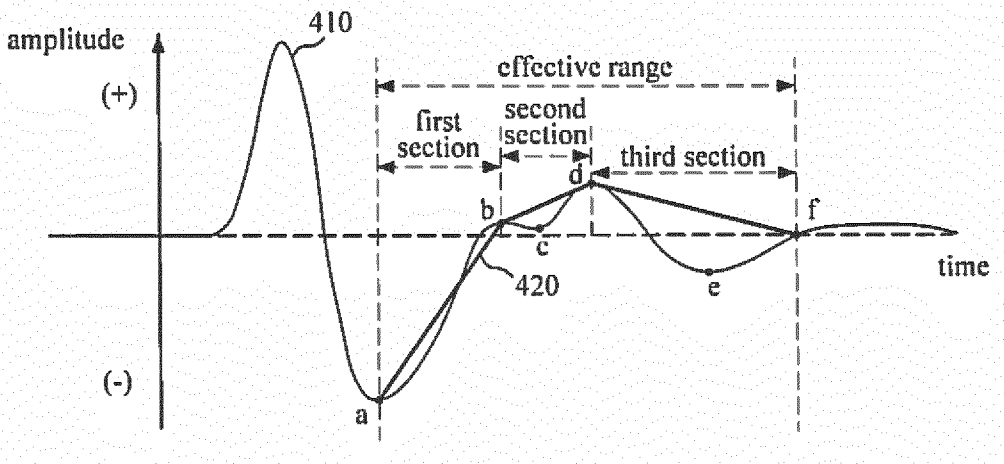

amplitude
(+)
(-)
410
effective range
first section
second section
third section
a
b
c
d
e
f
420
time

FIG. 5

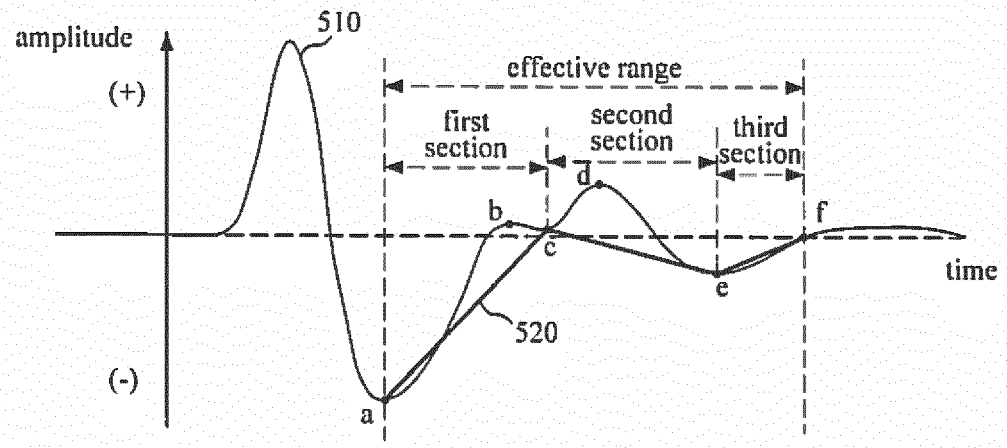

amplitude
(+)
(-)
510
520
effective range
first section
second section
third section
a
b
c
d
e
f
time

FIG. 6A

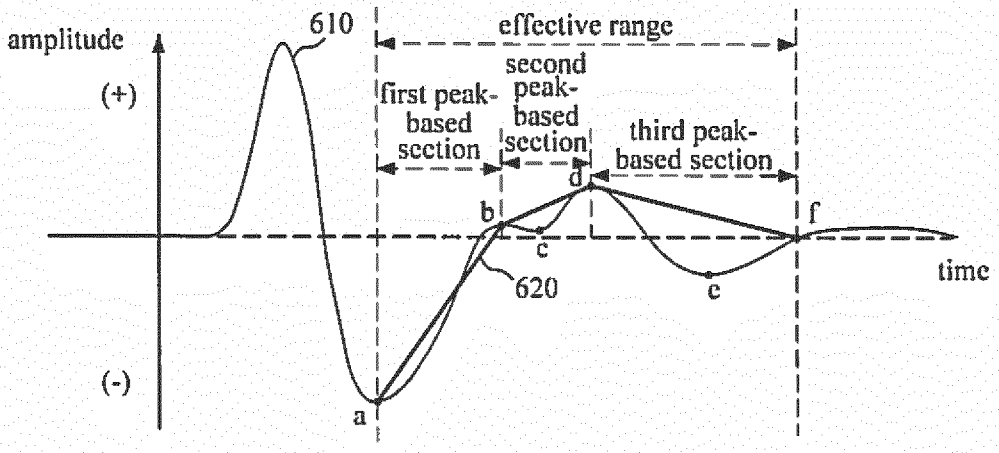

amplitude
(+)
(-)
610
effective range
first peak-based section
second peak-based section
third peak-based section
a
b
c
d
e
f
620
time

FIG. 6B

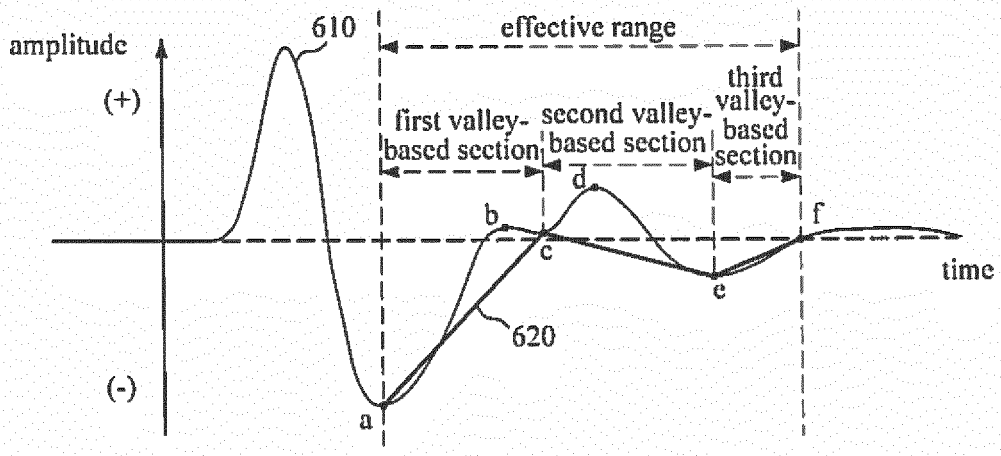

amplitude
(+)
(-)
610
effective range
first valley-based section
second valley-based section
third valley-based section
a
b
c
d
e
f
620
time

FIG. 7

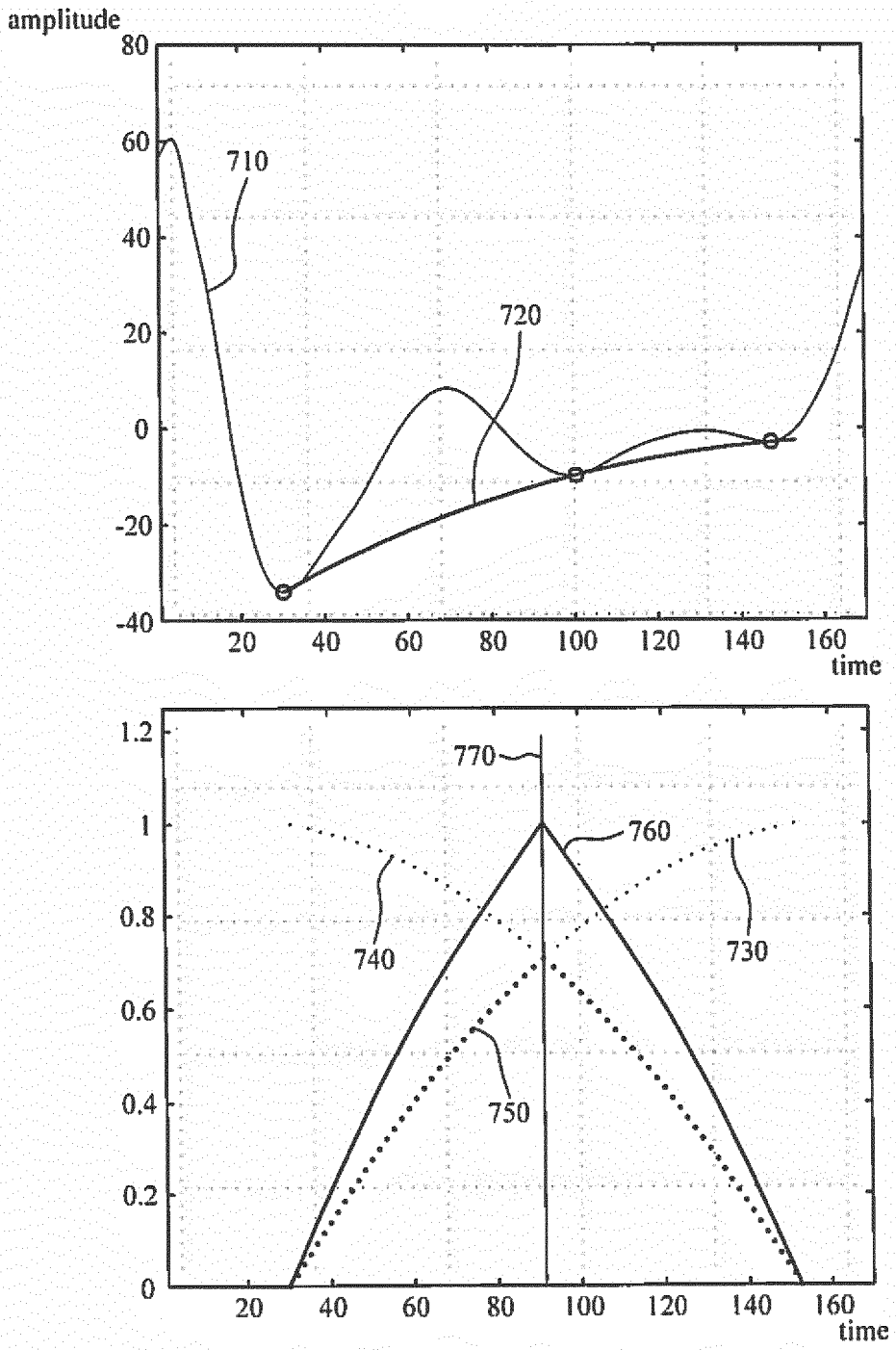

amplitude
80
60
40
20
0
-20
-40
710
720
20
40
60
80
100
120
140
160
time
1.2
1
0.8
0.6
0.4
0.2
0
770
760
740
730
750
20
40
60
80
100
120
140
160
time

FIG. 8

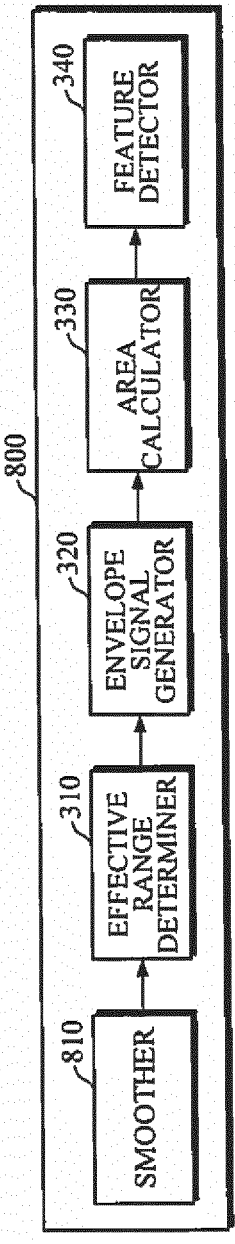

800
810
SMOOTHER
310
EFFECTIVE RANGE DETERMINER
320
ENVELOPE SIGNAL GENERATOR
330
AREA CALCULATOR
340
FEATURE DETECTOR

FIG. 9

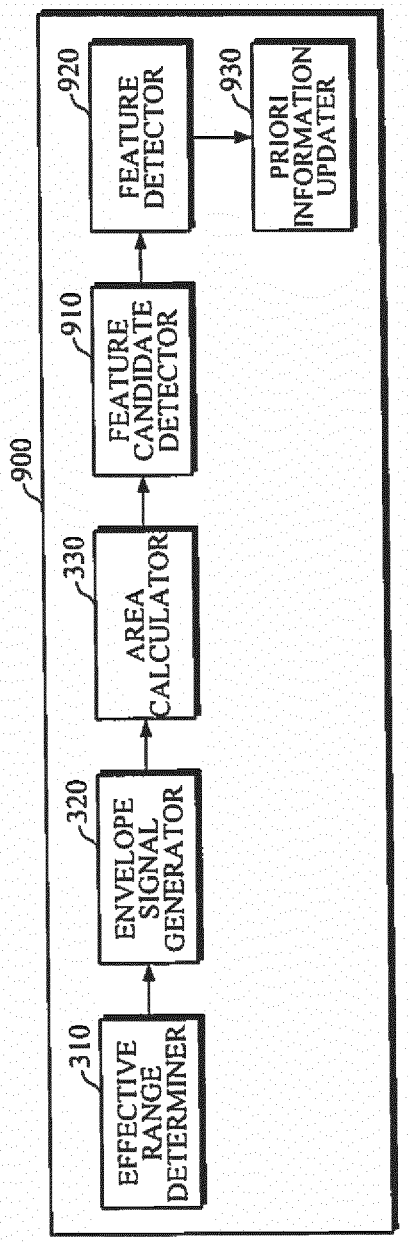

900
310
EFFECTIVE RANGE DETERMINER
320
ENVELOPE SIGNAL GENERATOR
330
AREA CALCULATOR
910
FEATURE CANDIDATE DETECTOR
920
FEATURE DETECTOR
930
PRIORI INFORMATION UPDATER

FIG. 10

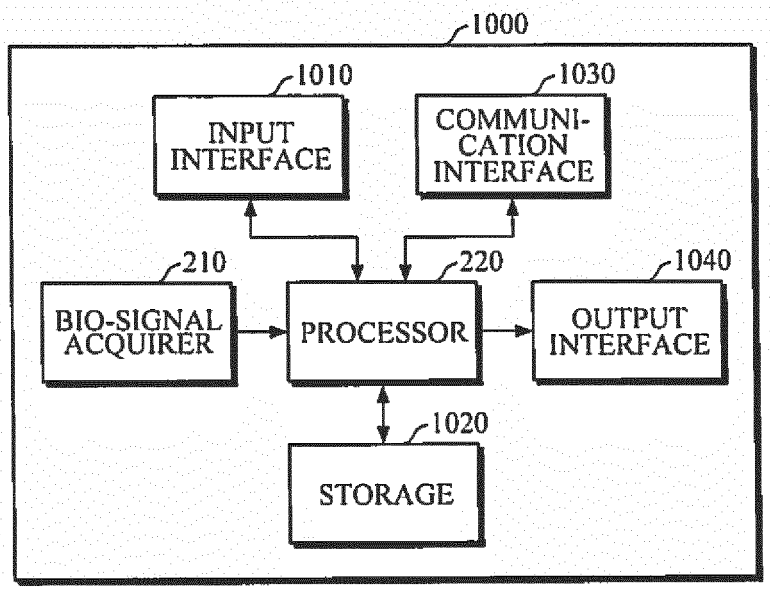

1000
1010
INPUT INTERFACE
1030
COMMUNI-CATION INTERFACE
210
BIO-SIGNAL ACQUIRER
220
PROCESSOR
1040
OUTPUT INTERFACE
1020
STORAGE

FIG. 11

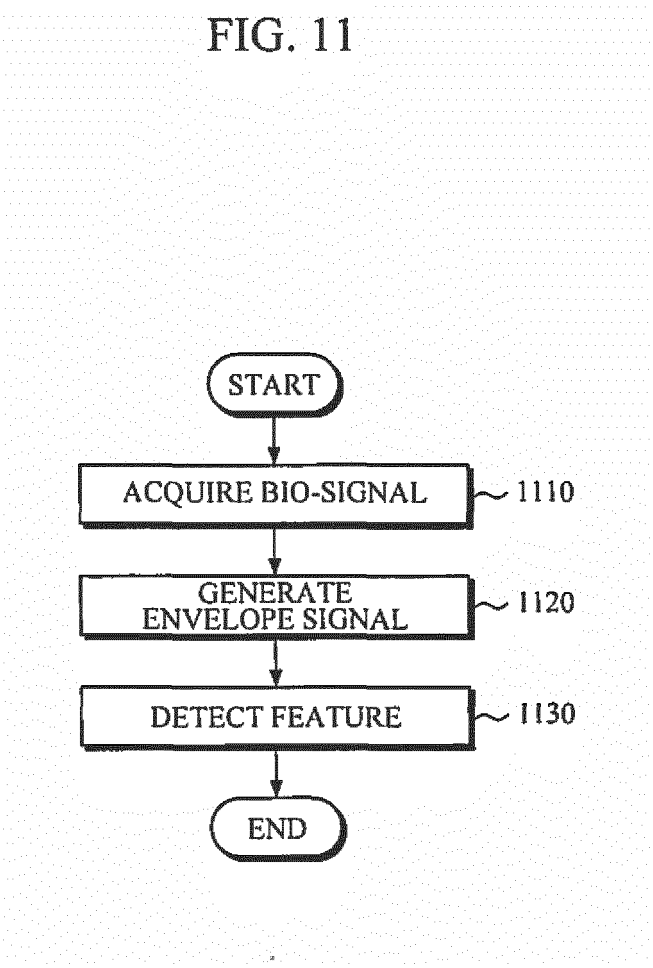

START
ACQUIRE BIO-SIGNAL
1110
GENERATE ENVELOPE SIGNAL
1120
DETECT FEATURE
1130
END

FIG. 12

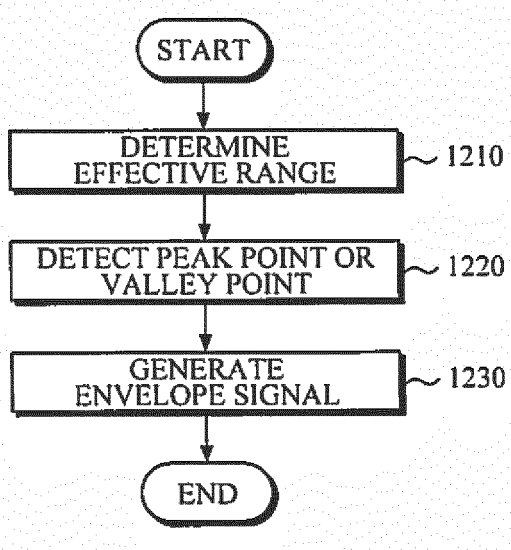

START
DETERMINE EFFECTIVE RANGE
1210
DETECT PEAK POINT OR VALLEY POINT
1220
GENERATE ENVELOPE SIGNAL
1230
END

FIG. 13

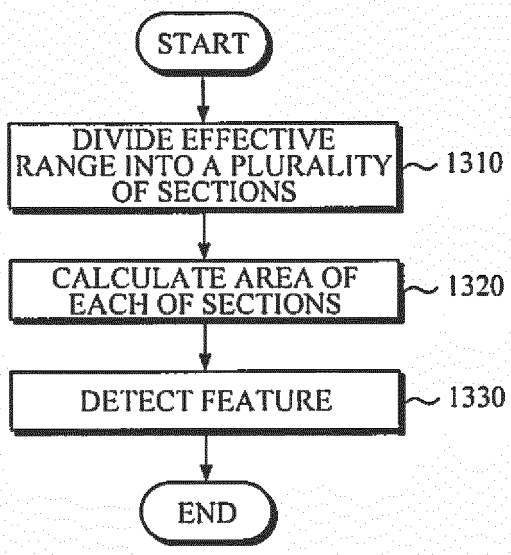
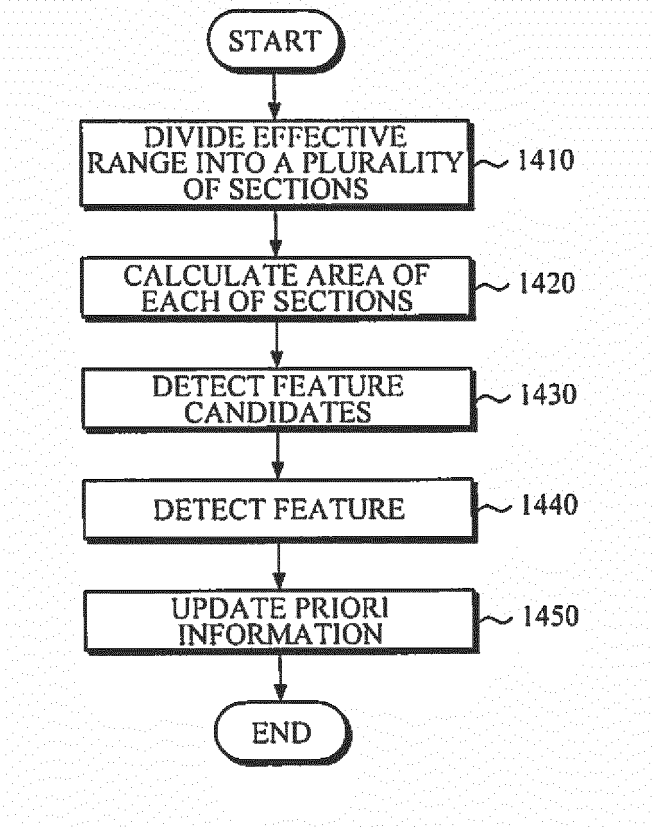

START
DIVIDE EFFECTIVE RANGE INTO A PLURALITY OF SECTIONS
1310
CALCULATE AREA OF EACH OF SECTIONS
1320
DETECT FEATURE
1330
END

FIG. 14


START
DIVIDE EFFECTIVE RANGE INTO A PLURALITY OF SECTIONS
1410
CALCULATE AREA OF EACH OF SECTIONS
1420
DETECT FEATURE CANDIDATES
1430
DETECT FEATURE
1440
UPDATE PRIORI INFORMATION
1450
END

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20090326393 A **[0004]**

Non-patent literature cited in the description

- **HUOTARI.** *Infrared and red PPG signals analysis of the healthy subjects and clinical patients* **[0004]**
- **PITTARA.** *Estimation of pulse rate from ambulatory PPG using ensemble empirical mode decomposition and adaptive thresholding* **[0004]**
- **MING HONG.** *Real-time pulse wave detection device basing on signal envelope* **[0004]**

专利名称(译)	检测生物特征的装置和方法		
公开(公告)号	EP3434181B1	公开(公告)日	2020-06-17
申请号	EP2018185204	申请日	2018-07-24
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD.		
[标]发明人	JANG DAE GEUN		
发明人	JANG, DAE GEUN		
IPC分类号	A61B5/024 A61B5/021 A61B5/00		
CPC分类号	A61B5/02108 A61B5/02416 A61B5/7235 A61B5/02116 A61B5/7203 A61B5/7239 A61B5/7278 G06K9/00516 G06K9/0053 H04W4/80		
优先权	1020170094310 2017-07-25 KR		
其他公开文献	EP3434181A1		
外部链接	Espacenet		

摘要(译)

提供了一种用于检测生物信号特征的设备和方法。 根据一个方面的设备可以包括：生物信号获取器，被配置为获取生物信号；以及 处理器，被配置为生成生物信号的包络信号，并基于包络信号和生物信号之间的差来检测生物信号的至少一个特征。