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(54) **MEASUREMENT DEVICE AND MEASUREMENT METHOD**

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(57) **ABSTRACT**

A measurement device includes the following: a time-series signal obtaining unit configured to obtain a biological signal, which is time-series data of a biological signal value calculated from an image captured by imaging a living body, and obtain a determination index for the image; a biological-information calculating unit configured to divide the biological signal into pulse signals at predetermined times based on the cycle of a biological phenomenon; and a pulse determining unit configured to adopt pulse signals including biological signal vales calculated from the image that enables a determination index satisfying a determination condition to be calculated. The biological-information calculating unit calculates biological information by using the pulse signals adopted by the pulse determining unit.

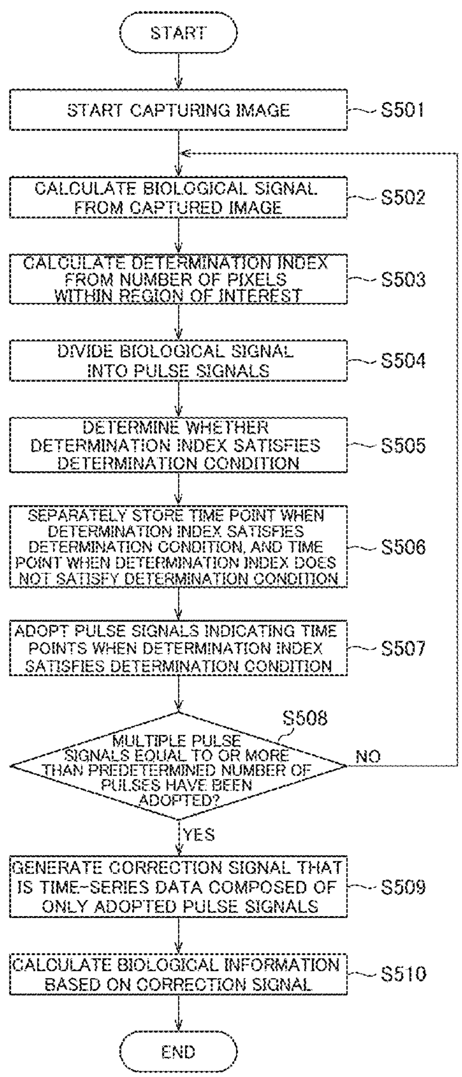


FIG. 1

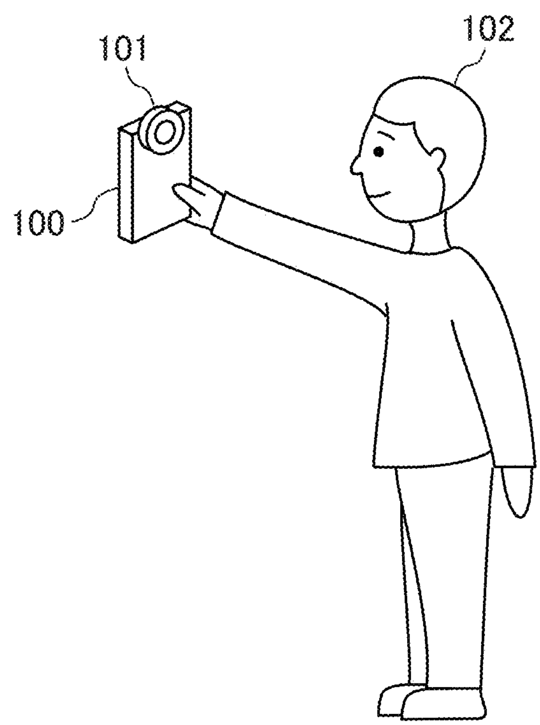


FIG. 2

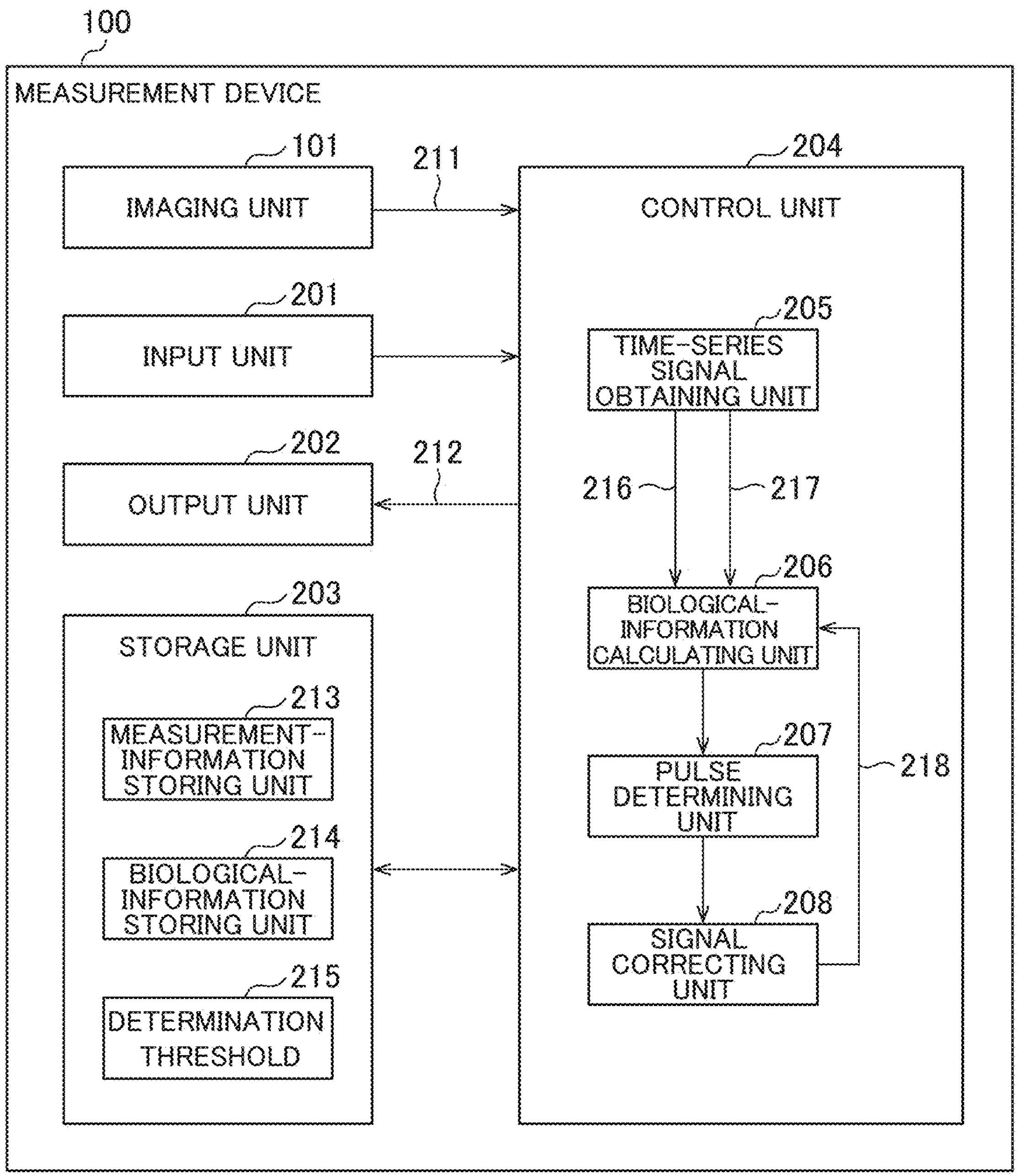

100
MEASUREMENT DEVICE
101
IMAGING UNIT
211
204
CONTROL UNIT
201
INPUT UNIT
205
TIME-SERIES SIGNAL OBTAINING UNIT
202
OUTPUT UNIT
212
216
217
206
BIOLOGICAL-INFORMATION CALCULATING UNIT
203
STORAGE UNIT
213
MEASUREMENT-INFORMATION STORING UNIT
207
PULSE DETERMINING UNIT
218
214
BIOLOGICAL-INFORMATION STORING UNIT
208
SIGNAL CORRECTING UNIT
215
DETERMINATION THRESHOLD

FIG. 3

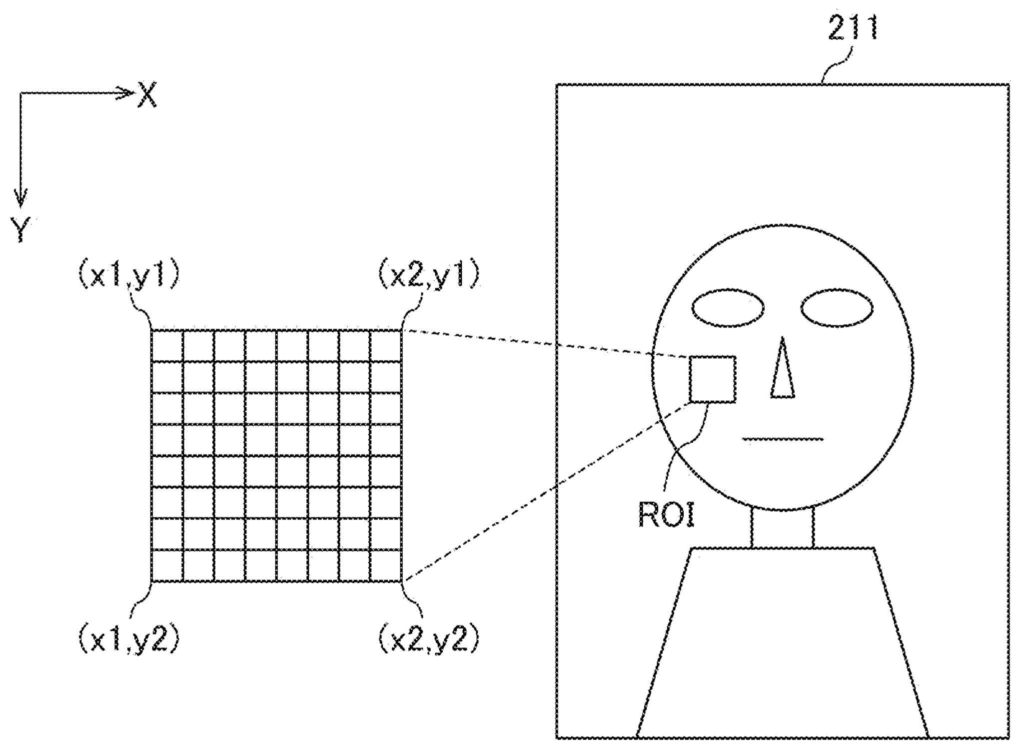


FIG. 4A

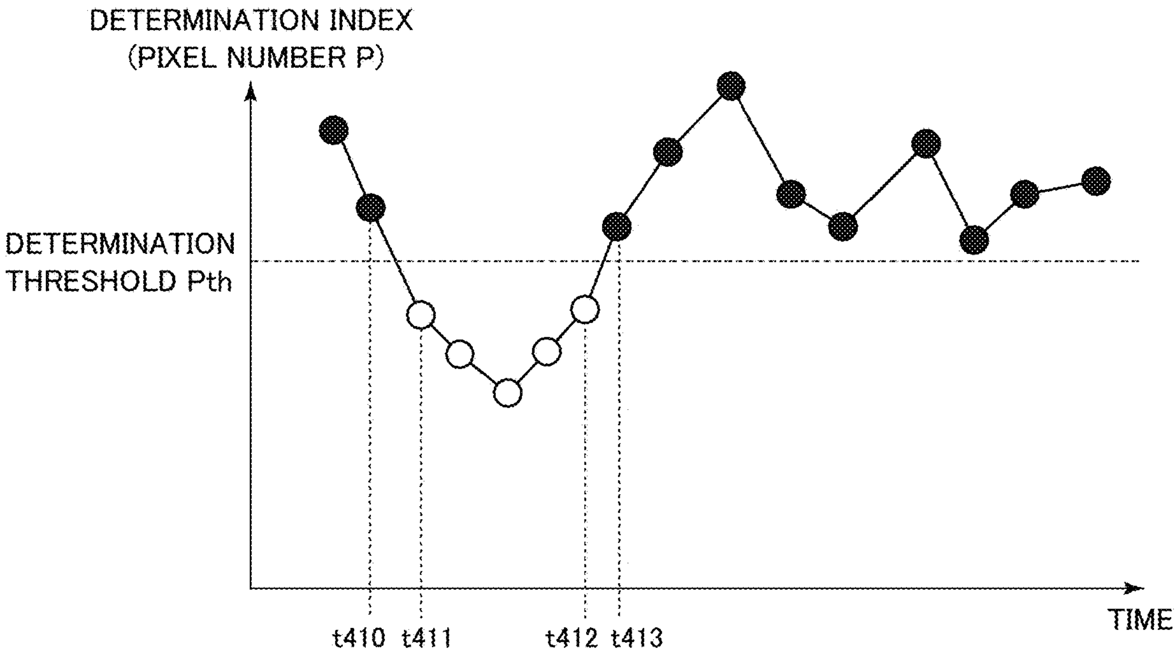

DETERMINATION INDEX
(PIXEL NUMBER P)
DETERMINATION
THRESHOLD Pth
t410
t411
t412
t413
TIME

FIG. 4B

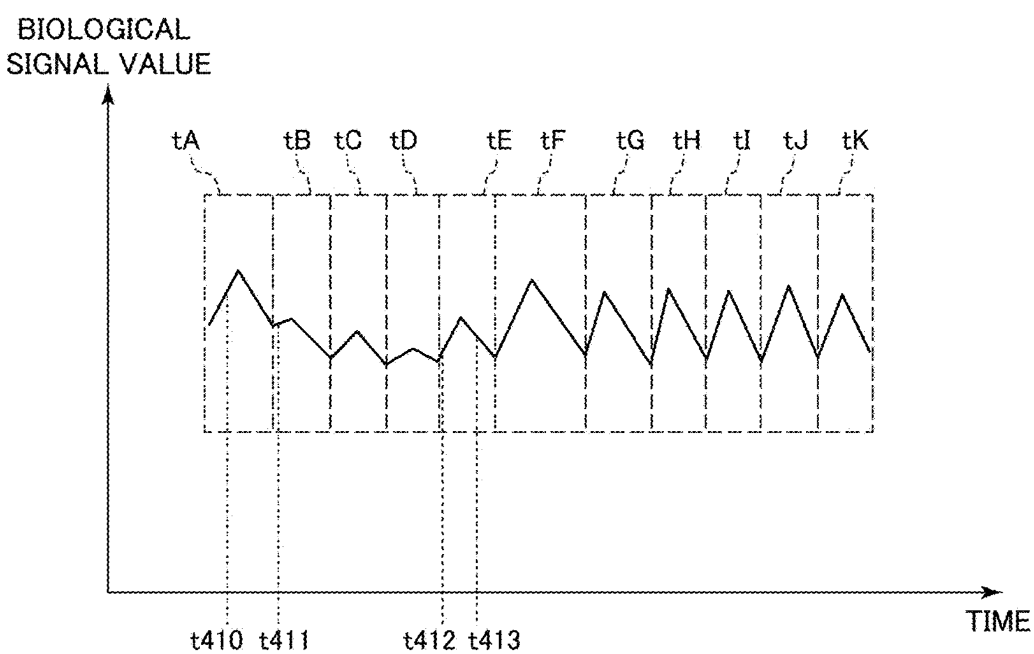

BIOLOGICAL
SIGNAL VALUE
tA
tB
tC
tD
tE
tF
tG
tH
tI
tJ
tK
t410
t411
t412
t413
TIME

FIG. 5

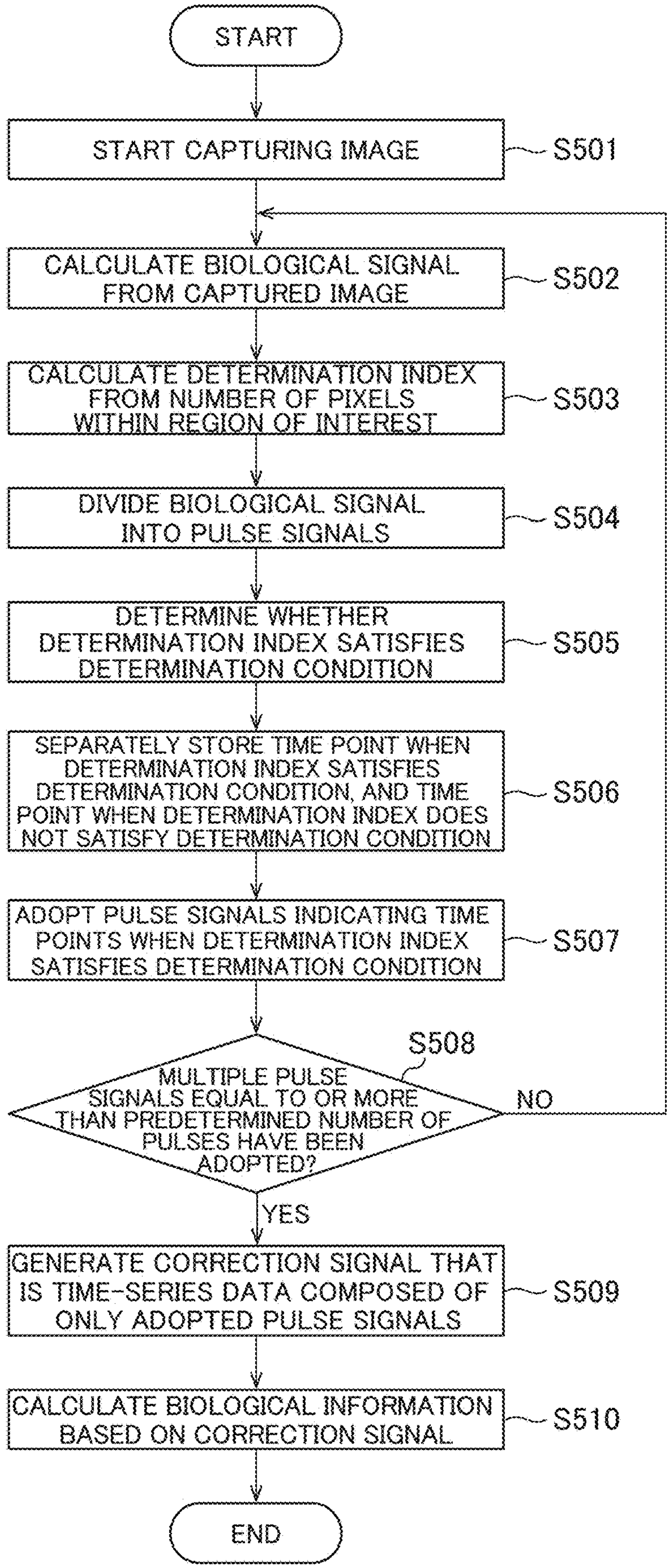

START
START CAPTURING IMAGE
S501
CALCULATE BIOLOGICAL SIGNAL FROM CAPTURED IMAGE
S502
CALCULATE DETERMINATION INDEX FROM NUMBER OF PIXELS WITHIN REGION OF INTEREST
S503
DIVIDE BIOLOGICAL SIGNAL INTO PULSE SIGNALS
S504
DETERMINE WHETHER DETERMINATION INDEX SATISFIES DETERMINATION CONDITION
S505
SEPARATELY STORE TIME POINT WHEN DETERMINATION INDEX SATISFIES DETERMINATION CONDITION, AND TIME POINT WHEN DETERMINATION INDEX DOES NOT SATISFY DETERMINATION CONDITION
S506
ADOPT PULSE SIGNALS INDICATING TIME POINTS WHEN DETERMINATION INDEX SATISFIES DETERMINATION CONDITION
S507
S508
MULTIPLE PULSE SIGNALS EQUAL TO OR MORE THAN PREDETERMINED NUMBER OF PULSES HAVE BEEN ADOPTED?
NO
YES
GENERATE CORRECTION SIGNAL THAT IS TIME-SERIES DATA COMPOSED OF ONLY ADOPTED PULSE SIGNALS
S509
CALCULATE BIOLOGICAL INFORMATION BASED ON CORRECTION SIGNAL
S510
END

FIG. 6

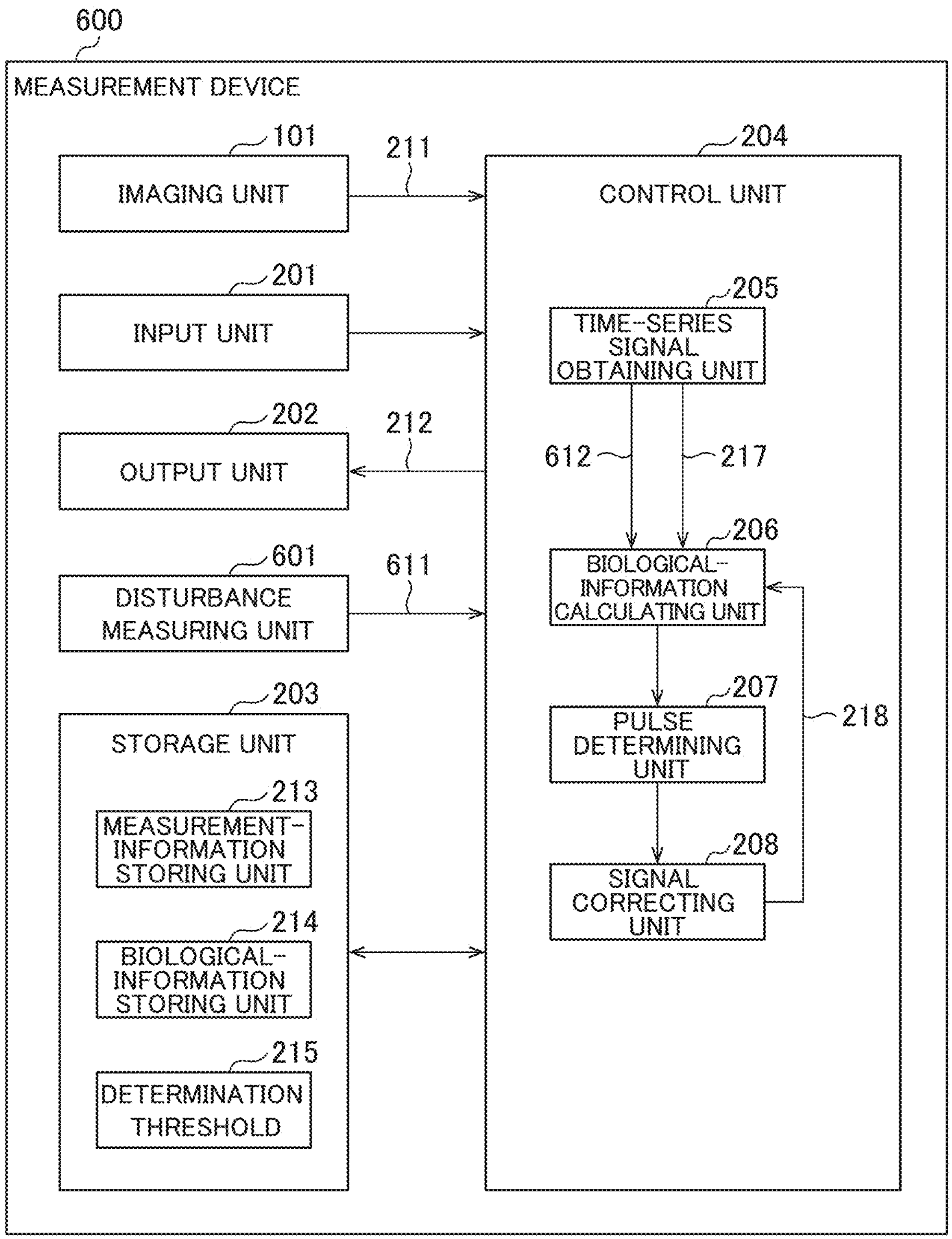

600
MEASUREMENT DEVICE
101
IMAGING UNIT
211
204
CONTROL UNIT
201
INPUT UNIT
205
TIME-SERIES SIGNAL OBTAINING UNIT
202
OUTPUT UNIT
212
612
217
206
601
DISTURBANCE MEASURING UNIT
611
BIOLOGICAL-INFORMATION CALCULATING UNIT
207
PULSE DETERMINING UNIT
218
203
STORAGE UNIT
213
MEASUREMENT-INFORMATION STORING UNIT
208
SIGNAL CORRECTING UNIT
214
BIOLOGICAL-INFORMATION STORING UNIT
215
DETERMINATION THRESHOLD

FIG. 7A

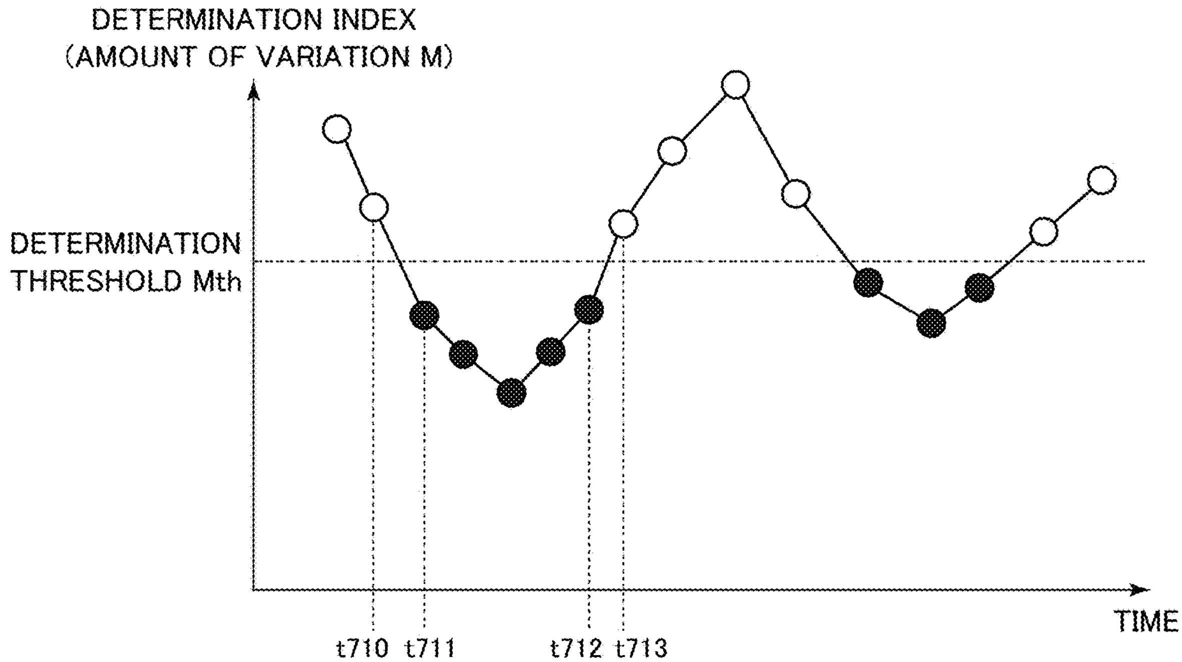

DETERMINATION INDEX
(AMOUNT OF VARIATION M)
DETERMINATION
THRESHOLD Mth
TIME
t710
t711
t712
t713

FIG. 7B

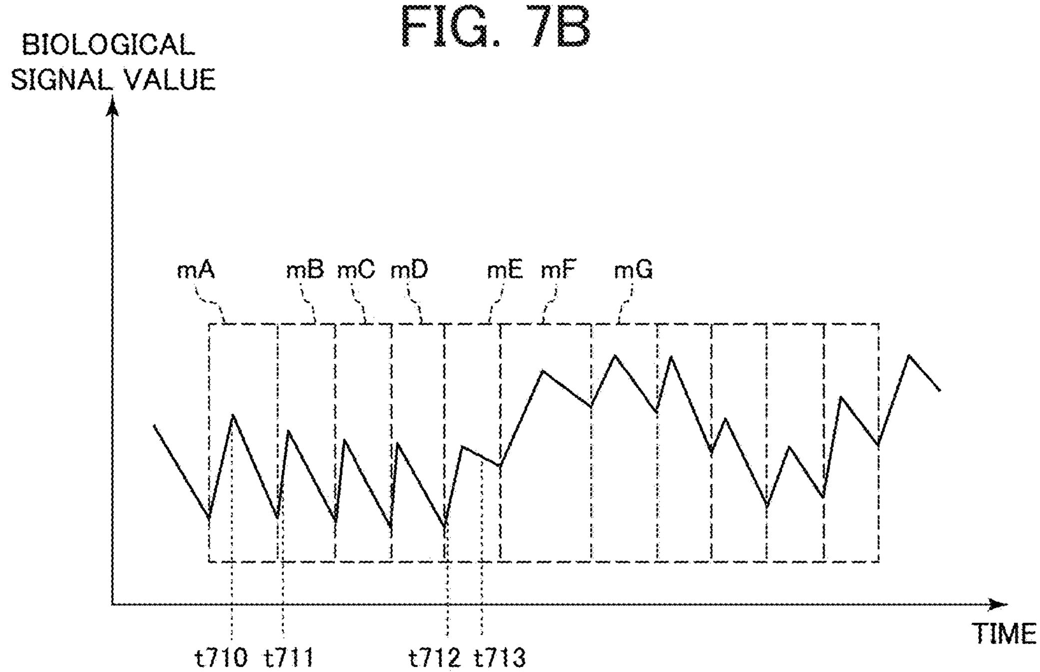
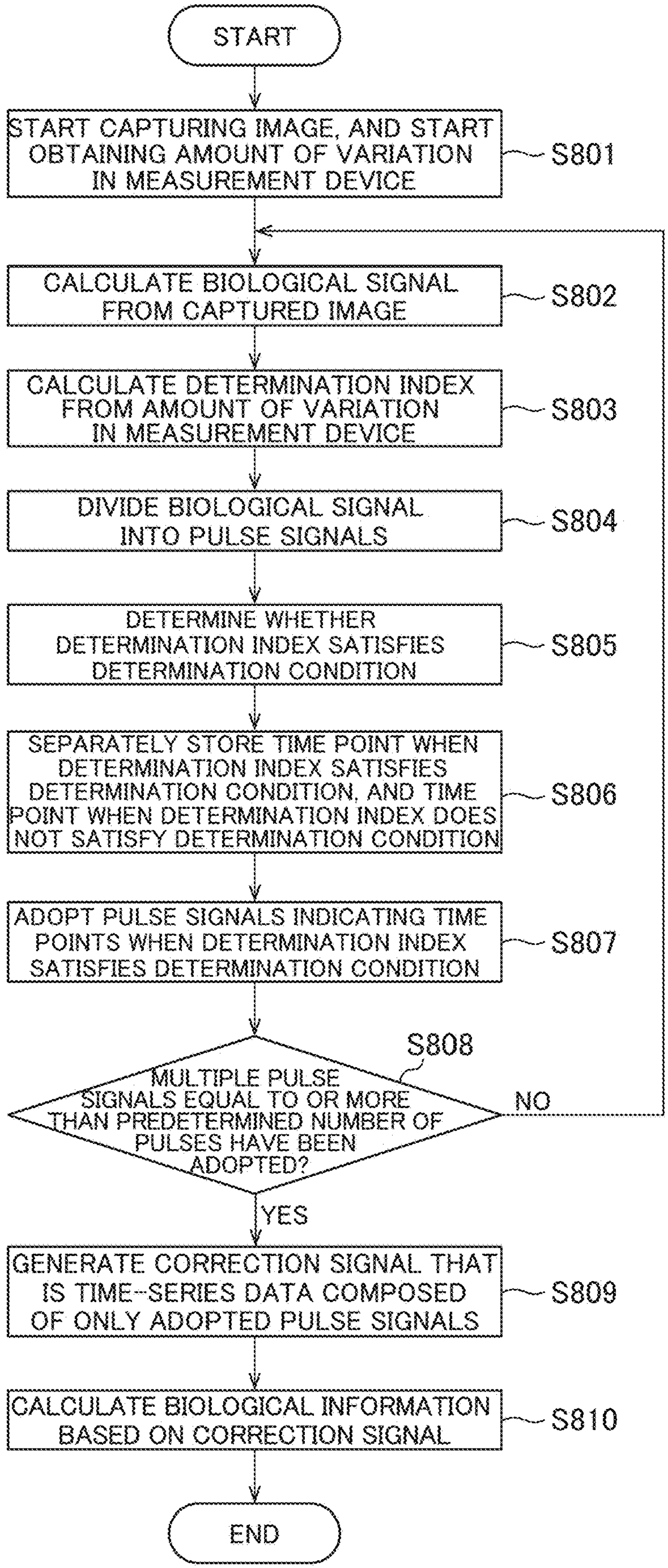

BIOLOGICAL
SIGNAL VALUE
mA
mB
mC
mD
mE
mF
mG
TIME
t710
t711
t712
t713

FIG. 8


START
START CAPTURING IMAGE, AND START OBTAINING AMOUNT OF VARIATION IN MEASUREMENT DEVICE
S801
CALCULATE BIOLOGICAL SIGNAL FROM CAPTURED IMAGE
S802
CALCULATE DETERMINATION INDEX FROM AMOUNT OF VARIATION IN MEASUREMENT DEVICE
S803
DIVIDE BIOLOGICAL SIGNAL INTO PULSE SIGNALS
S804
DETERMINE WHETHER DETERMINATION INDEX SATISFIES DETERMINATION CONDITION
S805
SEPARATELY STORE TIME POINT WHEN DETERMINATION INDEX SATISFIES DETERMINATION CONDITION, AND TIME POINT WHEN DETERMINATION INDEX DOES NOT SATISFY DETERMINATION CONDITION
S806
ADOPT PULSE SIGNALS INDICATING TIME POINTS WHEN DETERMINATION INDEX SATISFIES DETERMINATION CONDITION
S807
S808
MULTIPLE PULSE SIGNALS EQUAL TO OR MORE THAN PREDETERMINED NUMBER OF PULSES HAVE BEEN ADOPTED?
NO
YES
GENERATE CORRECTION SIGNAL THAT IS TIME-SERIES DATA COMPOSED OF ONLY ADOPTED PULSE SIGNALS
S809
CALCULATE BIOLOGICAL INFORMATION BASED ON CORRECTION SIGNAL
S810
END

MEASUREMENT DEVICE AND MEASUREMENT METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority from Japanese Application JP2024-027972, filed on Feb. 28, 2024, the content of which is hereby incorporated by reference into this application.

BACKGROUND

1. Field

[0002] The present disclosure relates to a measurement device and a measurement method.

2. Description of the Related Art

[0003] Japanese Unexamined Patent Application Publication No. 2018-019882 discloses a person-image detecting unit that detects an image of a person, a biological-signal detecting unit that detects a biological signal of the person, and a control unit that outputs a detected result from the biological-signal detecting unit. A vital sign detection device disclosed in Japanese Unexamined Patent Application Publication No. 2018-019882 determines that the biological-signal detecting unit is not faulty, and outputs biological information based on a biological signal in response to a determination that a biological value indicated by the biological signal is within a predetermined normal range, and that there is a person who stays still in a region detected by the person-image detecting unit.

SUMMARY

[0004] The cycle of a life activity sometimes reflects the health of a living body. For instance, biological phenomena, such as heartbeat and respiration, have their cycles of repetition of increase and decrease. Some biological signals obtained by measuring the living body reflect the cycle of such a biological phenomenon, and analyzing the signal's periodicity can offer information on the health of the living body. An exemplary signal is one obtained through measurement with a pulse sensor or a pulse oximeter. However, in the case of a disturbance adversely affecting the measurement, a detected biological signal contains noise, and such a biological signal may not appropriately indicate the periodicity based on a biological phenomenon. It is noted that the disturbance herein indicates not a signal in a specific control system, but an unexpected influence from outside a system, or an undesired external interference received the device.

[0005] The technique disclosed in Japanese Unexamined Patent Application Publication No. 2018-019882 uses a pulse sensor and an image detecting device, to output pulse information upon detection of an image of a driver, and not to output the pulse information upon no detection of the driver's image. However, a disturbance, such as a driver's body motion, sometimes occurs discontinuously on a second-by-second basis. Since pulse reflects periodic temporal variation in the heart, the pulse's pulsation varies periodically with time in conformance with the heart; typically, pulse is calculated by detecting the heart's periodicity, and thus, detection based on the period of the pulsation is desirable. However, a failure to detect the image during the period results in an interruption of the pulsation calculation during the period, and thus, the pulse is calculated based on incomplete pulsation with off-balance periodicity. As a result, the technique disclosed in Japanese Unexamined Patent Application Publication No. 2018-019882 may fail to accurately calculate the biological information in the case of a disturbance adversely affecting the measurement. As such, it is an object of one aspect of the present disclosure to provide a measurement device and a measurement method that can calculate accurate biological information reflecting the cycle of a biological phenomenon of the living body.

[0006] A measurement device according to one aspect of the present disclosure includes the following: an imaging unit configured to image a living body to capture an image as time-series data; a time-series signal obtaining unit configured to obtain a time-series biological signal indicating a temporal variation in a biological signal, and obtain a determination index temporally associated with the biological signal, the biological signal being a value relating to the living body and calculated from the image; a biological-information calculating unit configured to extract a pulse signal by dividing the time-series biological signal at a predetermined time based on a cycle of a biological phenomenon of the living body; and a pulse determining unit configured to determine whether the determination index satisfies a predetermined determination condition, and adopt the pulse signal temporally associated with the determination index satisfying the predetermined determination condition. The biological-information calculating unit calculates biological information relating to the living body by using the pulse signal adopted by the pulse determining unit.

[0007] A measurement method according to another aspect of the present disclosure includes the following: imaging a living body to capture an image as time-series data; obtaining a time-series biological signal indicating a temporal variation in a biological signal, and obtaining a determination index temporally associated with the biological signal, the biological signal being a value relating to the living body and calculated from the image; extracting a pulse signal by dividing the time-series biological signal at a predetermined time based on a cycle of a biological phenomenon of the living body; determining whether the determination index satisfies a predetermined determination condition; and calculating biological information relating to the living body by using the pulse signal temporally associated with the determination index satisfying the predetermined determination condition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** illustrates, by way of example, a measurement device being used;

[0009] FIG. **2** is a block diagram illustrating one example of the configuration of a measurement device according to a first embodiment;

[0010] FIG. **3** illustrates one example of a region of interest;

[0011] FIG. **4**A is a graph illustrating, by way of example, transition of a determination index that indicates the number of pixels within the region of interest, and a threshold that is a determination threshold;

[0012] FIG. **4**B is a graph illustrating, by way of example, pulse signals at time points shown in the transition of the determination index illustrated in FIG. **4**A;

[0013] FIG. **5** is a flowchart showing one example of the operation of the measurement device according to the first embodiment;

[0014] FIG. **6** is a block diagram illustrating one example of the configuration of a measurement device according to a second embodiment;

[0015] FIG. **7**A is a graph illustrating, by way of example, transition of a determination index that indicates the amount of variation in the measurement device, and a threshold that is a determination threshold;

[0016] FIG. **7**B is a graph illustrating, by way of example, pulse signals at time points shown in the transition of the amount of variation in the measurement device illustrated in FIG. **7**A; and

[0017] FIG. **8** is a flowchart showing one example of the operation of the measurement device according to the second embodiment.

DETAILED DESCRIPTION OF THE DISCLOSURE

First Embodiment

[0018] The first embodiment will be described with reference to FIGS. **1** to **5**. It is noted that identical or equivalent constituents will be denoted by the same signs throughout the drawings, and the descriptions of redundancies will be omitted.

[0019] FIG. **1** illustrates, by way of example, a measurement device **100** being used. As illustrated in FIG. **1**, the measurement device **100** includes an imaging unit **101**.

[0020] The measurement device **100** uses an image of a living body **102** captured as time-series data by the imaging unit **101**, to measure time-series variation in the skin surface or skin inside of the living body **102** to obtain biological information **212** (see FIG. **2**). It is noted that the image herein is captured so that a biological signal can be obtained as time-series data; for instance, it is an image of the living body **102** captured in at least a plurality of frames, such as a moving picture, or a still picture obtained as time-series data.

[0021] Example of the measurement device **100** include a personal computer (PC), a smartphone, a tablet terminal, a dedicated biological-information measuring terminal, and a watching robot equipped with the imaging unit **101**. Example of the biological information **212** include blood pressure, pulse, respiration rate, and blood oxygen saturation. FIG. **1** illustrates the imaging unit **101** imaging the living body **102** with the measurement device **100** held by the living body **102**. Nevertheless, the imaging unit **101** may image the living body **102** without the measurement device **100** held by the living body **102**.

[0022] The imaging unit **101** images the living body **102** to obtain its image as time-series data. The imaging unit **101** is installed in such a location as to be able to image an exposed body surface of the living body **102**. Examples of the exposed body surface of the living body **102** include the forehead, cheeks, fingertips, wrists, and palms of the living body **102**. The imaging unit **101** is installed in, but not limited to, a PC, a smartphone, a tablet, a display, a mirror, and a washstand.

[0023] The imaging unit **101** is a camera including a charge coupled device (CCD), a complementary metal oxide semiconductor (CMOS) image sensor, and a lens. The imaging unit **101** may include a camera image sensor including an RGB filter. For instance, the imaging unit **101** includes an RGB Bayer-arrangement color filter in order to detect a minute change of color of the skin of the living body **102**. Alternatively, the imaging unit **101** may include a color filter of RGBCy, RGBIR, or other arrangements. Color filters of RGBCy, RGBIR, and other arrangements are suitable for observing blood volume fluctuation, which is indicated by light transmitted into the skin inside and reflected.

[0024] FIG. **2** is a block diagram illustrating one example of the configuration of the measurement device **100** according to this embodiment.

[0025] The imaging unit **101** includes, but not limited to, the imaging unit **101**, an input unit **201**, an output unit **202**, a storage unit **203**, and a control unit **204**. The imaging unit **101**, the input unit **201**, the output unit **202**, and the storage unit **203** are electrically connected to the control unit **204**.

[0026] The imaging unit **101** images the living body **102** to capture the image **211** and sends the captured image **211** to the control unit **204**. For instance, the imaging unit **101** images the living body **102** to capture the image **211** at 30 to 60 frames per second (fps). The image **211** includes an image of the body surface of the living body **102**.

[0027] The input unit **201** receives an input of information necessary for the measurement device **100**. Examples of the input unit **201** include a keyboard, a mouse, and a touch panel.

[0028] The output unit **202** outputs, but not limited to, the image **211**, the biological information **212**, a message to the living body **102**, and the date and time of imaging of the image **211**. For instance, the output unit **202** includes, but not limited to, a display and a speaker.

[0029] The control unit **204** executes various kinds of processing in accordance with a program and data stored in the storage unit **203**. The control unit **204** is formed from processors, such as a central processing unit (CPU) and a graphic processing unit (GPU).

[0030] The control unit **204** includes a time-series signal obtaining unit **205**, a biological-information calculating unit **206**, a pulse determining unit **207**, and a signal correcting unit **208**.

[0031] The time-series signal obtaining unit **205** calculates a biological signal from the image **211**. Since the image **211** is captured as time-series data, which is temporal variation for each frame of the image of the living body **102**, the time-series signal obtaining unit **205** can obtain a time-series biological signal **217**, which is time-series data of a biological signal value calculated from the image **211**. For instance, the biological signal value is a representative value or average value of the pixel values of a plurality of pixels included in a region of interest ROI, and the time-series biological signal **217** is temporal variation in the biological signal value. In the time-series biological signal **217**, a time-series biological signal value, i.e., the biological signal value calculated from the image **211**, is associated with the time point of obtainment of the biological signal value. Here, the time point of obtainment of the biological signal value is defined as a time point when the imaging unit **101** captures a frame with the biological signal value calculated in the image **211**. The biological signal value is actually obtained through the following: the time-series signal obtaining unit **205** sets the region of interest ROI in a predetermined frame of the image **211** and then calculates the biological signal value from the pixel values of the pixels included in the region of interest ROI. Since the time point of imaging of the living body **102** is the timing of obtainment of the biological signal value reflecting the conditions of the living body **102** at that time, a timing when the imaging unit **101** captures a frame with the biological signal value calculated is herein defined as a time point when the biological signal value is obtained from the frame. Although the biological signal value can be calculated without performing, for each frame, the setting of the region of interest ROI, and the calculation using the image within the region of interest ROI, these processes are desirably performed for each frame because doing so at shorter time intervals can obtain the biological signal as time-series data more accurately. For this reason, the biological signal value in this embodiment is obtained for each frame and obtained as time-series data.

[0032] Furthermore, the time-series signal obtaining unit **205** obtains a determination index for the image **211** at predetermined timings to obtain a determination index signal **216**, which is time-series data of the determination index. The determination index according to this embodiment indicates the number of pixels within the region of interest ROI included in the image **211**. In the present disclosure, the number of pixels is information indicating the number of pixels included in the image **211**; for instance, it is the number of subpixels for each of red (R), green (G), and blue (B) in an RGB space, or the number of pixels calculated from a subpixel value.

[0033] The biological-information calculating unit **206** obtains pulse signals by temporally dividing the time-series biological signal **217** on the basis of the cycle of a biological phenomenon that a user wants to detect. Each pulse signal is thus temporally associated with the time point of obtainment of the biological signal value included in the pulse signal. Exemplary biological phenomena that can be a detection target include pulse, heartbeat, respiration, blood pressure fluctuation, and blood enzyme, and they are determined in accordance with the type of the biological information **212** that the user wants to detect.

[0034] The biological-information calculating unit **206** calculates the biological information **212** on the basis of a correction signal **218**, which is generated by the signal correcting unit **208**. The biological information **212** indicates information about the living body **102** that the user wants to detect. For instance, the biological information **212** indicates his/her blood pressure, heart rate, or blood oxygen saturation.

[0035] The pulse determining unit **207** determines whether the pulse signal satisfies a determination condition on the basis of a determination index value obtained from the determination index signal **216**. The pulse determining unit **207** then adopts pulse signals temporally associated with determination indices satisfying the determination condition. The determination condition according to this embodiment is that the number of pixels within the region of interest ROI exceeds a determination threshold **215** (a first determination threshold) according to this embodiment.

[0036] The signal correcting unit **208** generates the correction signal **218** formed from the pulse signals adopted by the pulse determining unit **207**.

[0037] The storage unit **203** is a recording medium that can record, but not limited to, various data pieces and programs and is a hard disk, a solid state driver (SSD), a semiconductor memory, or other things. The storage unit **203** includes a measurement-information storing unit **213**, a biological-information storing unit **214**, and a determination threshold **215**. The storage unit **203** may store a plurality of determination thresholds **215**.

[0038] The measurement-information storing unit **213** stores, but not limited to, a pre-stored program and a user-registered information piece that are necessary for measuring the biological information **212**. For instance, the measurement-information storing unit **213** stores a calculation formula relating to the biological information **212**, and a calculation formula relating to the determination index. For instance, the user is the living body **102** or an administrator of the measurement device **100**.

[0039] The biological-information storing unit **214** stores, as adopted-pulse information, information that enables identifying which of all the pulse signals are adopted pulse signals. For example, an adopted pulse signal itself, a unique number that enables identifying the adopted pulse signal, information, such as the time point of obtainment of the determination index temporally associated with the adopted pulse signal, or a biological signal value included in the adopted pulse signal is stored as the adopted-pulse information. The adopted-pulse information may include other information relating to the determination index. For example, the adopted-pulse information may include a time when the determination index satisfies the determination condition, or a unique number that enables identifying the time when the determination index satisfies the determination condition.

[0040] At least one of the measurement-information storing unit **213** and biological-information storing unit **214** may store, but not limited to, information relating to the living body **102**. For example, the information relating to the living body **102** indicates a log of the biological information **212**.

[0041] FIG. **3** illustrates one example of the region of interest ROI.

[0042] The measurement device **100** according to this embodiment calculates the biological information **212** from the pixel values of the pixels included in the region of interest ROI set in the image **211**.

[0043] It is noted that to calculate the biological information **212**, it is desirable to select and use, as the region of interest ROI, an image of a site suitable for calculation, such as a body surface site that is exposed to facilitate observing a pixel value change in a body surface image resulting from, for instance, a volume change in blood vessel. For instance, a cheek image of the living body **102** is suitable for calculating the biological information **212**.

[0044] For example, the time-series signal obtaining unit **205** sets the region of interest ROI within the image **211** by using a face detection algorithm. To be specific, the time-series signal obtaining unit **205** extracts the amount of facial feature from the image **211** by using a face detection algorithm based on pattern recognition, machine learning, or other means. For instance, the amount of facial feature indicates the positions and shapes of the nose and eyes. The time-series signal obtaining unit **205** then sets the region of interest ROI on the basis of the extracted amount of facial feature. The time-series signal obtaining unit **205** can obtain the set position of the region of interest ROI as coordinates in the image **211**; for example, the region of interest ROI illustrated in FIG. **3** is rectangular, and the coordinates of its vertices are denoted as (x**1**, y**1**), (x**1**, y**2**), (x**2**, y**1**), and (x**2**, y**2**) in the image **211**.

[0045] The size of the face image of the living body **102** included in the image **211** may change in the case of a hand-induced shake of the living body **102** holding the measurement device **100**, or a body motion of the living body **102**. To be specific, the size of the face image included in the image **211** changes depending on the distance between the measurement device **100** and living body **102**. For example, the further the living body **102** is away from the measurement device **100**, the smaller the face image included in the image **211** becomes. As a result, the number of pixels within the region of interest ROI included in the image **211** decreases.

[0046] If there is an insufficient number of pixels within the region of interest ROI, the quality of the time-series biological signal **217** may degrade. That is, a pulse signal obtained at a time point when the number of pixels, which is hereinafter referred to as a pixel number P, within the region of interest ROI is equal to or smaller than a threshold Pth that is the determination threshold **215** may be unsuitable for accurately calculating the biological information **212**. Accordingly, it is desirable that the biological-information calculating unit **206** do not use this pulse signal to calculate the biological information **212**. Let the determination condition be so defined that the pixel number P within the region of interest ROI is greater than the threshold Pth, which is herein a value of 25. The pulse determining unit **207** in this case determines not to adopt a pulse signal including a biological signal value obtained at a time point when the pixel number P within the region of interest ROI is equal to or smaller than 25.

[0047] The process in the pulse determining unit **207** will be detailed with reference to FIGS. **4**A and **4**B. FIG. **4**A is a graph illustrating, by way of example, transition of the determination index that indicates the pixel number P within the region of interest ROI, and the threshold Pth that is the determination threshold **215**. In FIG. **4**A, the lateral axis represents time, and the longitudinal axis represents the pixel number P, which is a determination index, within the region of interest ROI. Each point shown in the graph illustrated in FIG. **4**A indicates the pixel number P within the region of interest ROI included in the image **211** obtained at mutually different time points.

[0048] FIG. **4**B is a graph illustrating, by way of example, pulse signals at time points shown in the transition of the pixel number P within the region of interest ROI illustrated in FIG. **4**A. In FIG. **4**B, the lateral axis represents time, and the longitudinal axis represents biological signal value. For example, when the time-series biological signal **217** indicates a pulse wave signal, the biological signal value illustrated in FIG. **4**B indicates pulse wave intensity. In FIG. **4**B, 11 pulse signals are denoted by signs tA to tK, respectively, by way of example. The obtainment interval of the determination index shown in the longitudinal axis in FIG. **4**A and the calculation interval of the biological signal value shown in the longitudinal axis in FIG. **4**B are not limited to the foregoing as long as one or more determination indices are obtained for at least each pulse signal. For example, the biological signal value and determination index may be calculated for each frame of the image **211**; alternatively, a plurality of determination indices may be obtained per pulse signal, and their average may be calculated. A disturbance, such as a body motion of the living body **102**, can be observed in temporally more detail along with decrease in the obtainment time interval of the determination index. However, a shorter time interval than necessary complicates the calculation. It is hence desirable to determine the time interval in accordance with a desired calculation accuracy of the biological signal. It is noted that in this embodiment, both of the biological signal value and determination index are calculated for each frame of the image **211**, and that the determination index and the biological signal temporally associated with the determination index are obtained at the same time point; in other words, the obtainment interval of the determination index and the calculation interval of the biological signal are identical. However, for the sake of description, the obtainment interval of the determination index illustrated in FIG. **4**A is not identical to the calculation interval of the biological signal illustrated in FIG. **4**B.

[0049] In this embodiment, as illustrated in FIG. **4**B, the biological-information calculating unit **206** divides a signal that varies temporally based on the cycle of a biological phenomenon of the living body **102**, at predetermined times based on the cycle. Some biological phenomena have periodic variation reflecting the conditions of a living body, such as respiration, heartbeat, blood pressure. For example, when the time-series biological signal **217** reflects information about the blood vessel of the living body **102**, the intensity of the time-series biological signal **217** also fluctuates temporally in accordance with the cycle of blood vessel pulsation caused by the heart periodically repeating contraction and expansion, and has a cycle of repetition of increase and decrease. Since an actual biological phenomenon sensitively reacts to health or mental conditions, its cycle is not necessarily constant and is sometimes disturbed as in arrhythmia for example. However, since most biological phenomena vary with time in accordance with a certain degree of cycle, the biological-information calculating unit **206** can divide the time-series biological signal **217** at the predetermined times. It is noted that a biological signal obtained at a time point during which the biological signal is disturbed to such an extent that it cannot be divided may be regarded as being of poor quality and may be thus not used, and that the biological-information calculating unit **206** may divide, at the predetermined times, the time-series biological signal **217** other than the signal at that point.

[0050] In this way, the biological-information calculating unit **206** in this embodiment divides the time-series biological signal **217** into a plurality of pulse signals on the basis of the cycle of a biological phenomenon of the living body **102**. To be specific, as denoted by the pulse signals tA to tK illustrated in FIG. **4**B, the biological-information calculating unit **206** divides the time-series biological signal **217** into pulse signals at predetermined times based on a single cycle of fluctuation in the biological signal value. Let the pulse signals illustrated in FIG. **4**B indicate pulse wave signals, and let the type of the biological information **212** be heartbeat or blood pressure. In this case, as illustrated in FIG. **4**B, the biological-information calculating unit **206** sets, as a single cycle, a period from the rising edge to falling edge of the pulse wave accompanying the heart's contraction and expansion. FIG. **4**B shows pulse signals divided in respective sections each partitioned by a rectangular dotted line, which denotes a signal cycle.

[0051] As described above, in order to measure the time-series biological signal **217** to calculate the biological information **212**, the biological-information calculating unit **206** temporally divides the time-series biological signal **217**, which varies with time, into a plurality of pulse signals on the basis of the cycle of a biological phenomenon of the living body **102**. The biological-information calculating unit **206** then adopts pulse signals satisfying the determination condition from among these pulse signals and calculates the biological information **212** by using the adopted pulse signals. The biological-information calculating unit **206** can consequently calculate the biological information **212** accurately on the basis of the cycle of the biological phenomenon.

[0052] In the graphs illustrated in FIGS. **4**A and **4**B, the pixel number P that is a determination index at a time point before a time point t**410** inclusive and after a time point t**413** inclusive exceeds the threshold Pth. The pulse determining unit **207** accordingly adopts pulse signals associated with the time point before the time point t**410** inclusive and after the time point t**413** inclusive. To be specific, the pulse determining unit **207** adopts the pulse signals tA and tF to tK.

[0053] On the other hand, the pixel number P that is a determination index at a time point ranging from a time point t**411** to a time point t**412** both inclusive is equal to or smaller than the threshold Pth that is the determination threshold **215**. The pulse determining unit **207** accordingly does not adopt pulse signals including biological signal values associated with the time point ranging from the time point t**411** to the time point t**412** both inclusive. To be specific, the pulse determining unit **207** does not adopt the pulse signals tB to tE. It is noted that the pulse signal tE partly includes a time point when the pixel number P is equal to or smaller than the threshold Pth. Hence, the pulse determining unit **207** does not adopt the pulse signal tE.

[0054] Then, information that enables identifying which of all the pulse signals are adopted pulse signals is stored as adopted-pulse information. The signal correcting unit **208** generates the correction signal **218** based on the adopted-pulse information. The signal correcting unit **208** can consequently generate the correction signal **218** formed from the adopted pulse signals.

[0055] The biological-information calculating unit **206** calculates the biological information **212** from the correction signal **218**. To be specific, the biological-information calculating unit **206** calculates the biological information **212** by using a pulse signal temporally associated with a time point when the determination index exceeds the threshold Pth. That is, the biological-information calculating unit **206** calculates the biological information **212** from the image **211** by using the pulse signals tA and tF to tK illustrated in FIG. **4**B.

[0056] It is noted that a lower threshold Pth may lead to the biological information **212** of lower quality. On the other hand, a higher threshold Pth leads to reduction in the number of pixels within the region of interest ROI resulting from a hand-induced shake of the living body **102** holding the measurement device **100** or a body motion of the living body **102**; accordingly, the determination index does not satisfy the determination condition, and the pulse determining unit **207** is less likely to adopt a pulse signal. This may result in a long time that is required from when the imaging unit **101** starts imaging the living body **102** and to when the biological information **212** is output. It is hence preferable that the threshold Pth be set in accordance with pixel quality allowed for the biological information **212**, and waiting time allowed by the living body **102**.

[0057] FIG. **5** is a flowchart showing one example of the operation of the measurement device **100** according to this embodiment.

[0058] In Step S**501**, the imaging unit **101** starts imaging the living body **102** to capture the image **211**.

[0059] In Step S**502**, the time-series signal obtaining unit **205** calculates a biological signal from the image **211** captured in Step S**501**. To be specific, in Step S**502**, the time-series signal obtaining unit **205** obtains the time-series biological signal **217**, which is temporal variation in a biological signal that can be calculated from the image **211** captured by the imaging unit **101**. For instance, the time-series signal obtaining unit **205** sets the region of interest ROI within the image **211** and calculates the time-series biological signal **217** from the RGB pixel values of the pixels included in the region of interest ROI by using a calculation formula stored in the storage unit **203** in advance. Further, if necessary, the time-series signal obtaining unit **205** may obtain the time-series biological signal **217** indicating a pulse wave converted into, for instance, light absorbance, from temporal variation of a value calculated by substituting the luminance value of the pixels within the region of interest ROI of the image **211** into a predetermined mathematical formula. Alternatively, the time-series signal obtaining unit **205** may obtain the time-series biological signal **217** indicating a pulse wave, through independent component analysis, biogenic component separation, or other methods.

[0060] In Step S**503**, the time-series signal obtaining unit **205** calculates a determination index indicating the pixel number P within the region of interest ROI, to obtain the determination index signal **216**, which is time-series data indicating temporal variation in the determination index calculated from the image **211**.

[0061] In Step S**504**, the biological-information calculating unit **206** divides the time-series biological signal **217** into pulse signals. To be specific, the biological-information calculating unit **206** divides the time-series biological signal **217** into a plurality of pulse signals at predetermined times based on a single cycle of a biological phenomenon of the living body **102**. The cycle based on the biological phenomenon of the living body **102** for pulse signal division is set in accordance with the type of the biological information **212** to be measured.

[0062] In Step S**505**, the pulse determining unit **207** determines whether the determination index satisfies a determination condition. The determination condition is that the number of pixels within the region of interest ROI indicated by the determination index exceeds the determination threshold **215**.

[0063] That is, the pulse determining unit **207** determines whether the pixel number P is greater than the threshold Pth. If the pixel number P within the region of interest ROI exceeds the threshold Pth, the pulse determining unit **207** determines that the determination index satisfies the determination condition. On the other hand, if the pixel number P within the region of interest ROI is equal to or smaller than the threshold Pth, the pulse determining unit **207** determines that the determination index does not satisfy the determination condition. The pulse determining unit **207** determines whether the determination index satisfies the determination condition, for each time point of the determination index signal **216**, which is time-series data.

[0064] It is noted that when the storage unit **203** stores a plurality of determination thresholds **215**, the pulse determining unit **207** may select one of the determination thresholds **215** in measurement. It is also noted that the pulse determining unit **207** may change the determination threshold **215** that is to be used, upon the input unit **201** receiving an operation to change the determination threshold **215** that is to be used among the plurality of determination thresholds **215** stored in the biological-information storing unit **214**. For example, the pulse determining unit **207** may use an optimal determination threshold for each user among determination thresholds that are set in accordance with a plurality of users, and that are stored in the biological-information storing unit **214**, so that the biological information **212** can be obtained more accurately.

[0065] In Step S**506**, the control unit **204** stores the time point when the determination index satisfies the determination condition, and the time point when the determination index does not satisfy the determination condition separately in the measurement-information storing unit **213** so that they can be distinguished from each other. Examples of information indicating the time points include time, and identification information associated with the time points. It is noted that the measurement-information storing unit **213** may not necessarily store the time point when the determination index does not satisfy the determination condition.

[0066] In Step S**507**, the pulse determining unit **207** adopts pulse signals associated with the time points when the determination index satisfies the determination condition. To be specific, the pulse determining unit **207** adopts pulse signals with their biological signal values calculated from the pixel values within the region of interest ROI of an image captured at the time points when the determination index satisfies the determination condition, and the pulse determining unit **207** stores adopted-pulse information relating to the adopted pulse signals.

[0067] The accuracy of the biological information **212** calculated by the biological-information calculating unit **206** may not be guaranteed when the imaging unit **101** does not image the living body **212** for a predetermined time required for appropriately calculating the biological information **212**. Likewise, the accuracy of the biological information **212** calculated by the biological-information calculating unit **206** may not be guaranteed when the total number of adopted pulse signals is less than a predetermined number of pulses required for appropriately calculating the biological information **212**.

[0068] Accordingly, in Step S**508**, the pulse determining unit **207** determines whether pulse signals equal to or more than the predetermined number of pulses have been adopted. To be specific, the pulse determining unit **207** determines whether the living body **102** has been imaged, and whether pulse signals equal to or more than the predetermined number of pulses have been adopted. The predetermined number of pulses is stored in the measurement-information storing unit **213** in advance. The predetermined number of pulses may be different depending on the type of the biological information **212** to be measured. Alternatively in Step S**508**, the pulse determining unit **207** may determine whether the number of pulse signals whose total time satisfies a predetermined time or longer have been adopted. In this case, the predetermined time is stored in the measurement-information storing unit **213** in advance. That is, in Step S**508**, the pulse determining unit **207** adopts a plurality of pulse signals satisfying at least one of the predetermined number of pulses or more, and the predetermined time or longer.

[0069] If pulse signals satisfying at least one of the predetermined number of pulses or more, and the predetermined time or longer are not adopted in Step S**508**, the control unit **204** returns the process to Step S**502**. In the process after Step S**502**, the pulse determining unit **207** adds, to an already adopted pulse signals, pulse signals adopted anew on or after the time point associated with the already adopted pulse signal, and the pulse determining unit **207** stores the adopted-pulse information in the measurement-information storing unit **213**. This enables the measurement device **100** to reduce a time required for adopting the number of pulse signals satisfying at least one of the predetermined number of pulses or more, and the predetermined time or longer.

[0070] On the other hand, if the number of pulse signals satisfying at least one of the predetermined number of pulses or more, and the predetermined time or longer is adopted in Step S**508**, the signal correcting unit **208** in Step S**509** generates the correction signal **218** or time-series data composed of only the adopted pulse signals. Accordingly, the signal correcting unit **208** generates the correction signal **218** including pulse signals with their biological signal values associated with the time points when the determination index satisfies the determination condition.

[0071] In Step S**510**, the biological-information calculating unit **206** calculates the biological information **212** from the correction signal **218**. That is, the biological-information calculating unit **206** calculates the biological information **212** by using the pulse signals adopted by the pulse determining unit **207**. To be specific, the biological-information calculating unit **206** calculates the biological information **212** by using the pulse signals adopted by the pulse determining unit **207** as satisfying at least one of the predetermined number of pulses or more, and the predetermined time or longer. Then, the output unit **202** outputs the biological information **212**, as necessary. For example, the output unit **202** outputs the biological information **212** so as to display the biological information **212** on a display device (not shown) connected to the measurement device **100**. Then, the control unit **204** ends the process.

[0072] As described above, the measurement device **100** according to this embodiment determines whether each pulse signal included in the time-series biological signal **217** is appropriate. To be specific, the measurement device **100** does not adopt a pulse signal associated with a time point when the pixel number P within the region of interest ROI decreases so significantly that the determination index no longer exceeds the determination threshold **215**, thus not satisfying the determination condition, but adopts a pulse signal of high quality associated with a time point when the pixel number P exceeds the determination threshold **215**.

[0073] Calculating the biological information **212** by the use of biological signal values included in pulse signals of high quality can improve the calculation accuracy further than calculating the biological information **212** by the use of all the biological signal values included in the time-series biological signal **217**.

[0074] At this time, performing a determination for each pulse signal enables the biological information **212** to be calculated by the use of a biological signal whose values based on a single cycle of a biological phenomenon are complete, and that is thus suitable for measuring the biological information **212**. As a result, the measurement device **100** according to this embodiment can accurately calculate the biological information **212** reflecting the cycle of the biological phenomenon of the living body **102**.

[0075] It is noted that the pulse determining unit **207** may determine whether the time point when the determination index satisfies the determination condition continues for a certain time or longer. If the time point when the determination index satisfies the determination condition continues for the certain time or longer, the pulse determining unit **207** may then adopt a pulse signal indicating a biological signal value calculated from the image **211** captured at the time point when the determination index satisfies the determination condition. As a result, the measurement device **100** according to this embodiment can accurately calculate the biological information **212** by the use of a biological signal temporally continuously reflecting the cycle of a biological phenomenon of the living body **102**.

[0076] Further, among information pieces to be stored in the storage unit **203**, information other than information pieces that need to be stored, such as a user log, does not necessarily have to be stored over the long term; for example, the time when the determination index satisfies the determination condition, or identification information about the adopted pulse signals may be stored in such a manner as to be stored in the form of a variable temporarily during the calculation of the biological information **212**, and it may be deleted after the calculation is completed. Alternatively, such information may remain stored even after the calculation is completed; information stored over the long term can be used in, but not limited to, data analysis for enhancing the calculation accuracy of the biological information **212**.

First Modification

[0077] The first modification of the first embodiment will be described. It is noted that identical or like constituents will be denoted by the same signs throughout the drawings, and the descriptions of redundancies will be omitted.

[0078] The position of the region of interest ROI within the image **211** is shifted significantly in some cases at, for instance, a time point of occurrence of a hand-induced shake of the living body **102** holding the measurement device **100**, or a time point of occurrence of a body motion of the living body **102**. To be more specific, the coordinates of the region of interest ROI within the image **211** vary significantly in some cases. It is noted that the coordinates here are a position within the image **211**. Such a variation caused by a hand-induced shake, a body motion, or other things becomes a disturbance, which can cause a biological signal value and a pulse signal value to vary. Accordingly, the time-series signal obtaining unit **205** according to this modification calculates a determination index from a displacement of the coordinates of the region of interest ROI within the image **211** captured at different time points. For instance, the time-series signal obtaining unit **205** according to this modification calculates a determination index from a displacement between different frames at each of some or all of coordinates (x**1**, y**1**), (x**1**, y**2**), (x**2**, y**1**), and (x**2**, y**2**), which are the coordinates of the vertices of the region of interest ROI illustrated in FIG. **3**. That is, the determination index according to this modification indicates a displacement of the coordinates of a region of interest set within the image **211** captured at different time points. A determination condition according to this modification is that the coordinate displacement is equal to or smaller than the determination threshold **215** (a second determination threshold) according to this modification.

[0079] Let the coordinates of the vertex at the upper left corner of the region of interest ROI included in the image **211** in an i-th frame be denoted as (x**1***i*, y**1***i*). Here, i is a natural number equal to or greater than 1. In addition, let the coordinates of the vertex at the upper left corner of the region of interest ROI included in the image **211** in an n-th frame be denoted as (x**1***n*, y**1***n*). Here, n is a natural number equal to or greater than i+1. The displacement of the vertex at the upper left corner of the region of interest ROI between the i-th and n-th frames is denoted as (x**1***n*−x**1***i*, y**1***n*−y**1***i*). Furthermore, let the determination threshold **215** according to this modification indicate xth, which is a threshold for the x-coordinates in the region of interest ROI, and yth, which is a threshold for the y-coordinates in the region of interest ROI. In x**1***n*−x**1***i*≤xth and y**1***n*−y**1***i*≤yth, the pulse determining unit **207** determines that the determination index satisfies the determination condition, and adopts pulse signals associated with time points when the i-th to n-th frames are captured. On the other hand, in x**1***n*−x**1***i*>xth and y**1***n*−y**1***i*>yth, the pulse determining unit **207** determines that the determination index does not satisfy the determination condition, and does not adopt the pulse signals associated with the time points when the i-th to n-th frames are captured.

[0080] As described above, the measurement device **100** according to this modification does not use a biological signal value obtained at a time point when the coordinates of the region of interest ROI vary beyond the determination threshold **215**, for calculating the biological information **212**. As a result, the measurement device **100** according to this modification can accurately calculate the biological information **212** reflecting the cycle of a biological phenomenon of the living body **102** even in the case of occurrence of a hand-induced shake or a body motion of the living body **102** holding the measurement device **100** while the imaging unit **101** is imaging the living body **102**.

[0081] It is noted that the foregoing determination condition according to this modification is a mere example and is not restrictive. For example, the determination condition may be x**1***n*−x**1***i*≤xth or y**1***n*−y**1***i*≤yth. Further, the determination condition may be indicated only by displacements in the x-coordinates in the region of interest ROI. Further, when the region of interest ROI is rectangular, the determination condition may be indicated by displacements in the coordinates of its four corners. Further, the determination condition may be set in accordance with the type of the biological information **212** to be measured, or an accuracy required for the biological information **212**. This modification has described, by way of example, that a displacement of the region of interest ROI occurring when it moves is expressed using the coordinates of the region of interest ROI in the image **211**. Any index indicating a movement of the region of interest ROI may be used; a desirable index is one expressing a displacement as a numeric value, such as coordinates.

Second Modification

[0082] The second modification of the first embodiment will be described. It is noted that identical or like constituents will be denoted by the same signs throughout the drawings, and the descriptions of redundancies will be omitted.

[0083] In response to a motion of the living body **102**, such as eye blinking, the face skin of the living body **102** moves, and a sudden fluctuation in biological signal value may occur like spike noise. Such a disturbance causes the quality of the time-series biological signal **217** obtained during the eye blinking of the living body **102** to become lower than the quality of the time-series biological signal **217** obtained at a time point during which the living body **102** is not producing motions, such as eye blinking. Accordingly, the time-series signal obtaining unit **205** according to this modification calculates a determination index indicating the number of motions of the living body **102** per unit time calculated from the image **211**. For example, the number of motions indicated by the determination index is the number of eye blinks per unit time.

[0084] To be specific, the time-series signal obtaining unit **205** according to this modification calculates, for each pulse signal, the number of motions of the living body **102** per unit time within a time period during which biological signals included in a single pulse signal are obtained. For example, the time-series signal obtaining unit **205** according to this modification calculates, as the determination index, the number of eye blinks per unit time in an image of the eyelids included in the image **211**. A determination condition according to this modification is that the number of motions of the living body **102** per unit time is equal to or smaller than the determination threshold **215** (a third determination threshold) according to this modification. For instance, the determination condition according to this modification is that the number of eye blinks of the living body **102** per unit time is equal to or smaller than the determination threshold **215**.

[0085] The determination threshold **215** according to this modification indicates a threshold for the number of motions per unit time. For instance, the determination threshold **215** according to this modification indicates a threshold for the number of eye blinks per unit time. In this case, if the number of eye blinks indicated by the determination index exceeds the threshold for the number of eye blinks indicated by the determination threshold **215**, the pulse determining unit **207** according to this modification determines that the determination index does not satisfy the determination condition. The pulse determining unit **207** does not thus adopt pulse signals calculated from the image **211** obtained at time points included in a time period during which the number of eye blinks exceeds the threshold for the number of eye blinks indicated by the determination threshold **215**.

[0086] As described above, upon the number of motions of the living body **102**, such as eye blinks, exceeding the determination threshold **215**, the measurement device **100** according to this modification does not use a biological signal value calculated from an image captured during the time period of the motions, for calculating the biological information **212**. As a result, the measurement device **100** according to this modification can accurately calculate the biological information **212** reflecting the cycle of a biological phenomenon of the living body **102**, by excluding biological signal values obtained during a time period of motions, such as eye blinks, even when the living body **102** produces motions, such as eye blinks, a number of counts exceeding the determination threshold **215** per unit time.

Second Embodiment

[0087] The second embodiment will be described with reference to FIGS. **6** to **8**. It is noted that identical or equivalent constituents will be denoted by the same signs throughout the drawings, and the descriptions of redundancies will be omitted.

[0088] FIG. **6** is a block diagram illustrating one example of the configuration of a measurement device **600** according to this embodiment. The measurement device **600** illustrated in FIG. **6** is different from the measurement device **100** illustrated in FIG. **2** in that the measurement device **600** includes a disturbance measuring unit **601** illustrated in FIG. **6**.

[0089] When the imaging unit **101** images the living body **102** producing a body motion with the measurement device **600** held by the living body **102**, the measurement device **600** moves due to the body motion of the living body **102**. A body motion of the living body **102** holding the measurement device **600**, such as a hand-induced shake, a sneeze, a cough, or swaying, becomes a disturbance, so that a noise or an undesirable variation may be mixed to a biological signal calculated from the image **211**.

[0090] Accordingly, the measurement device **600** includes the disturbance measuring unit **601** that obtains disturbance information **611** indicating the amount of variation in the measurement device **600** varying spatially based on, but not limited to, a body motion of the living body **102** or the intensity of the body motion. The disturbance information **611** indicates at least one selected from the group consisting of a displacement of the measurement device **600** per unit time, the amount of velocity variation in the measurement device **600**, the amount of acceleration variation in the measurement device **600**, and the amount of angular-velocity variation in the measurement device **600**. The measurement device **600** includes a device that can measure the amount of spatial variation in the measurement device **600** as time-series data, and the measurement device **600** obtains the disturbance information **611**, which is time-series data of the amount of spatial variation measured by this device. Examples of the device that can measure the amount of spatial variation in the measurement device **600** include an accelerometer and a gyroscope, both of which can measure position, acceleration, angular velocity, and other things.

[0091] The time-series signal obtaining unit **205** according to this embodiment calculates a determination index obtained from the disturbance information **611** and obtains a determination index signal **612**, which is time-series data of the determination index. That is, the determination index according to this embodiment indicates the amount of spatial variation in the measurement device **600** and is temporally associated with a pulse signal including biological signal values obtained from the image **211**. A determination condition according to this embodiment is that the amount of spatial variation in the measurement device **600** is equal to or smaller than the determination threshold **215** (a fourth determination threshold) according to this embodiment.

[0092] The process in the pulse determining unit **207** according to this embodiment will be detailed with reference to FIGS. **7**A and **7**B.

[0093] FIG. **7**A is a graph illustrating, by way of example, transition of the determination index indicating an amount of variation M in the measurement device **600**, and a threshold Mth being the determination threshold **215**. In FIG. **7**A, the lateral axis represents time, and the longitudinal axis represents the amount of variation M, which is indicated by the determination index. The points shown in the graph illustrated in FIG. 7A each indicate the amount of variation M indicated by the disturbance information **611** obtained at mutually different time points.

[0094] FIG. 7B is a graph illustrating, by way of example, pulse signals at time points shown in the transition of the amount of variation M illustrated in FIG. 7A. In FIG. 4B, the lateral axis represents time, and the longitudinal axis represents biological signal value. It is noted that in FIG. 7B, although the measurement still continues after a pulse signal mG, it will be omitted for description. FIG. 7B, which is similar to FIG. 4B other than the foregoing, will not be detailed.

[0095] In pulse signals mA to mG in the graphs illustrated in FIGS. 7A and 7B, since the amount of variation M indicated by the disturbance information **611** at a time point before the time point t**710** inclusive and after the time point t**713** inclusive is larger than the threshold Mth, which is the determination threshold value **215**, the pulse determining unit **207** does not adopt pulse signals including biological signal values calculated from the image **211** captured at the time point before the time point t**710** inclusive and after the time point t**713** inclusive. To be specific, the pulse determining unit **207** determines not to adopt the pulse signal mA and the pulse signals mE to mG among the pulse signals mA to mG.

[0096] On the other hand, since the amount of variation M indicated by the determination index at a time point ranging from a time point t**711** to a time point t**712** both inclusive is equal to or smaller than the threshold Mth, which is the determination threshold value **215**, the pulse determining unit **207** adopts pulse signals including biological signal values calculated from the image **211** captured at the time point ranging from the time points t**711** to t**712** both inclusive. To be specific, the pulse determining unit **207** adopts the pulse signals mB to mD. It is noted that the pulse determining unit **207** determines to adopt pulse signals including only biological signal values calculated from an image captured at time points when the amount of variation M, which is indicated by the disturbance information **611**, is equal to or smaller than the threshold Mth. For instance, the pulse determining unit **207** does not adopt the pulse signal mE because the pulse signal mE in FIG. 7B, which includes both of the time point t**712** when the amount of variation M, indicated by the disturbance information **611**, is equal to or smaller than the threshold Mth, and the time point t**713** when the amount of variation M is equal to or greater than the threshold Mth, includes at least one time point when the amount of variation M is equal to or greater than the threshold Mth.

[0097] Accordingly, the biological-information calculating unit **206** calculates the biological information **212** from the image **211** by using the pulse signals mB to mD illustrated in FIG. 7B. That is, the biological-information calculating unit **206** calculates the biological information **212** by using pulse signals including biological signal values calculated from an image at time points when the determination index is equal to or smaller than the threshold Mth.

[0098] FIG. **8** is a flowchart showing one example of the operation of the measurement device **600** according to this embodiment. It is noted that process steps similar to those shown in FIG. **5** will not be detailed.

[0099] The difference between the flowchart shown in FIG. **8** and the flowchart shown in FIG. **5** lies in that the amount of spatial variation in the measurement device **600**, which is indicated by the disturbance information **611** obtained by the disturbance measuring unit **601**, is used as a determination index.

[0100] In Step S**801**, the imaging unit **101** starts capturing the image **211**, and the disturbance measuring unit **601** starts obtaining the amount of variation in the measurement device.

[0101] In Step S**802**, the time-series signal obtaining unit **205** obtains the time-series biological signal **217** from the image **211** captured by the imaging unit **101**.

[0102] In Step S**803**, the time-series signal obtaining unit **205** calculates a determination index from the amount of variation indicated by the disturbance information **611**, to obtain the determination index signal **216** as its time-series data.

[0103] In Step S**804**, the biological-information calculating unit **206** divides the time-series biological signal **217** into pulse signals. Step S**804**, which is similar to Step S**504** shown in FIG. **5**, will not be detailed.

[0104] In Step S**805**, the pulse determining unit **207** determines whether the determination index calculated in Step S**803** satisfies a determination condition. The determination condition according to this embodiment is that the amount of variation M, which is indicated by the disturbance information **611**, is equal to or smaller than the threshold Mth. That is, the pulse determining unit **207** determines whether the amount of variation M, which is indicated by the disturbance information **611**, is equal to or smaller than the threshold Mth. If the amount of variation M, which is indicated by the disturbance information **611**, is equal to or smaller than the threshold Mth, the pulse determining unit **207** determines that the determination index satisfies the determination condition. On the other hand, if the amount of variation M, which is indicated by the disturbance information **611**, is greater than the threshold Mth, the pulse determining unit **207** determines that the determination index does not satisfy the determination condition. The pulse determining unit **207** determines whether the determination index satisfies the determination condition, for each time point of the determination index signal **216**, which is time-series data. Then, the control unit **204** moves the process to Step S**806**. Step S**806** and the subsequent process, which are similar to Step S**506** and the subsequent process shown in FIG. **5**, will not be detailed.

[0105] It is noted that the foregoing is one aspect; the pulse determining unit **207** may use disturbance information obtained from an image captured by the imaging unit **101**, to determine whether this disturbance is really undesirable. That is, the pulse determining unit **207** may determine, as an undesirable disturbance, a disturbance obtained from an image at the almost same timing as a disturbance detected by the disturbance measuring unit **601**. To be specific, when the time difference between a time point of a large body motion, such as a large facial motion of the living body **102** that can be detected from an image included in the image **211**, and a time point when the amount of variation M, which is indicated by the disturbance information **611**, does not satisfy the determination condition is smaller than a predetermined range, the pulse determining unit **207** does not adopt pulse signals including these time points. In this case, comparing the information obtained from the image with the information obtained from the disturbance measuring unit **601** can determine whether the disturbance is really undesirable, thereby enabling the effect of the disturbance to be eliminated more accurately.

[0106] As described above, the measurement device **600** according to this embodiment can accurately calculate the biological information **212** reflecting the cycle of a biological phenomenon of the living body **102** by more accurately eliminating the effect of a body motion of the living body **102**.

[0107] The individual processes executed in the foregoing embodiments are not limited to the process aspects exemplified in the respective embodiments. The foregoing functional blocks may be implemented by using either a logic circuit (hardware) formed in an integrated circuit or other things, or software using a CPU. The individual processes executed in the foregoing embodiments may be executed by a plurality of computers. For instance, the process executed by the control unit **204** may be partly executed by another computer, or the whole process may be shared by a plurality of computers.

[0108] The present disclosure is not limited to the above-described embodiments. The present disclosure may be replaced with a configuration substantially identical to that described in the above-described embodiments, a configuration that provides the same action and effect, or a configuration that can achieve the same object. In the present disclosure, an embodiment that is obtained in combination, as appropriate, with the technical means disclosed in the respective embodiments is also encompassed within the technical scope of the present disclosure. Furthermore, combining the technical means disclosed in the respective embodiments can form a new technical feature.

[0109] While there have been described what are at present considered to be certain embodiments of the disclosure, it will be understood that various modifications may be made thereto, and it is intended that the appended claim cover all such modifications as fall within the true spirit and scope of the disclosure.

What is claimed is:

1. A measurement device comprising:

an imaging unit configured to image a living body to capture an image as time-series data;

a time-series signal obtaining unit configured to obtain a time-series biological signal indicating a temporal variation in a biological signal, and obtain a determination index temporally associated with the biological signal, the biological signal being a value relating to the living body and calculated from the image;

a biological-information calculating unit configured to extract a pulse signal by dividing the time-series biological signal at a predetermined time based on a cycle of a biological phenomenon of the living body; and

a pulse determining unit configured to determine whether the determination index satisfies a predetermined determination condition, and adopt the pulse signal temporally associated with the determination index satisfying the predetermined determination condition,

wherein the biological-information calculating unit calculates biological information relating to the living body by using the pulse signal adopted by the pulse determining unit.

2. The measurement device according to claim **1**, wherein at time points each indicating a time of capturing of the image with a value of the biological signal calculated, the value of the biological signal is calculated from a pixel value of a pixel within a region of interest included in the image captured at each of the time points.

3. The measurement device according to claim **2**, wherein

the determination index indicates a number of pixels within the region of interest, and

the predetermined determination condition is that the number of pixels exceeds a first determination threshold.

4. The measurement device according to claim **1**, wherein

the determination index indicates a displacement between the regions of interest included in the image captured at the time points different from each other, and

the predetermined determination condition is that the displacement is equal to or smaller than a second determination threshold.

5. The measurement device according to claim **1**, wherein

the determination index indicates a number of motions of the living body per unit time calculated from the image, and

the predetermined determination condition is that the number of motions is equal to or smaller than a third determination threshold.

6. The measurement device according to claim **5**, wherein the number of motions is a number of eye blinks per unit time.

7. The measurement device according to claim **1**, further comprising a disturbance measuring unit configured to obtain disturbance information indicating an amount of spatial variation in the measurement device,

wherein the determination index indicates the amount of spatial variation, and

the predetermined determination condition is that the amount of spatial variation is equal to or smaller than a fourth determination threshold.

8. The measurement device according to claim **1**, wherein the biological-information calculating unit calculates the biological information based on a plurality of pulse signals satisfying at least one of a predetermined number of pluses or more, and a predetermined time or longer.

9. A measurement method comprising:

imaging a living body to capture an image as time-series data;

obtaining a time-series biological signal indicating a temporal variation in a biological signal, and obtaining a determination index temporally associated with the biological signal, the biological signal being a value relating to the living body and calculated from the image;

extracting a pulse signal by dividing the time-series biological signal at a predetermined time based on a cycle of a biological phenomenon of the living body;

determining whether the determination index satisfies a predetermined determination condition; and

calculating biological information relating to the living body by using the pulse signal temporally associated with the determination index satisfying the predetermined determination condition.

10. The measurement device according to claim **2**, wherein

the determination index indicates a displacement between the regions of interest included in the image obtained at the time points different from each other, and the predetermined determination condition is that the displacement is equal to or smaller than a second determination threshold.

11. The measurement device according to claim **2**, wherein

the determination index indicates a number of motions of the living body per unit time calculated from the image, and

the predetermined determination condition is that the number of motions is equal to or smaller than a third determination threshold.

12. The measurement device according to claim **11**, wherein the number of motions is a number of eye blinks per unit time.

13. The measurement device according to claim **2**, further comprising a disturbance measuring unit configured to obtain disturbance information indicating an amount of spatial variation in the measurement device,

wherein the determination index indicates the amount of spatial variation, and

the predetermined determination condition is that the amount of spatial variation is equal to or smaller than a fourth determination threshold.

14. The measurement device according to claim **2**, wherein the biological-information calculating unit calculates the biological information based on a plurality of pulse signals satisfying at least one of a predetermined number of pluses or more, and a predetermined time or longer.

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