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(54) **MEASUREMENT APPARATUS AND RECORDING MEDIUM RECORDING MEASUREMENT PROGRAM**

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(57) **ABSTRACT**

A measurement apparatus includes a biological sensor configured to measure a biological signal of a person to be measured, and a processor configured to: acquire posture information on a posture of the person to be measured, and change accuracy of measurement data of the biological sensor, based on the acquired posture information.

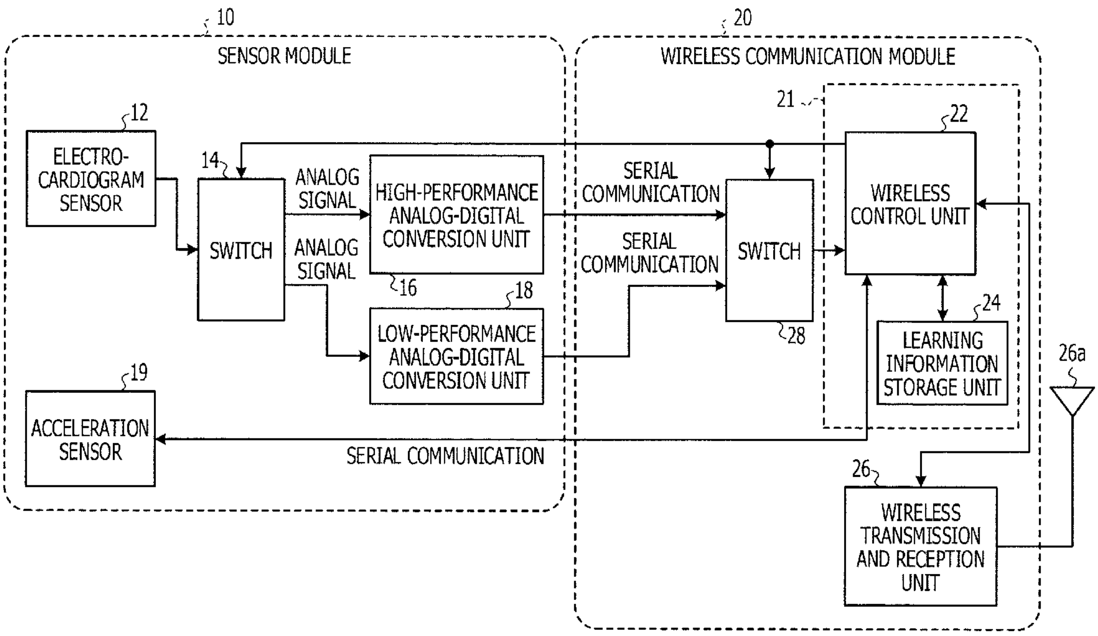


FIG. 1

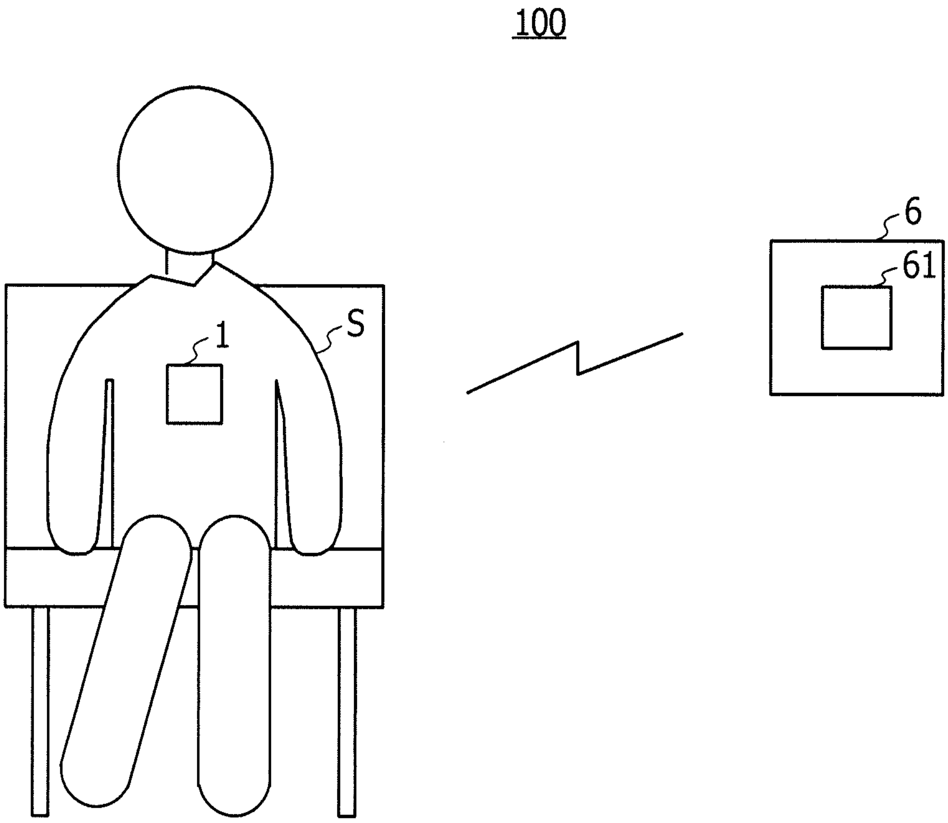


FIG. 2

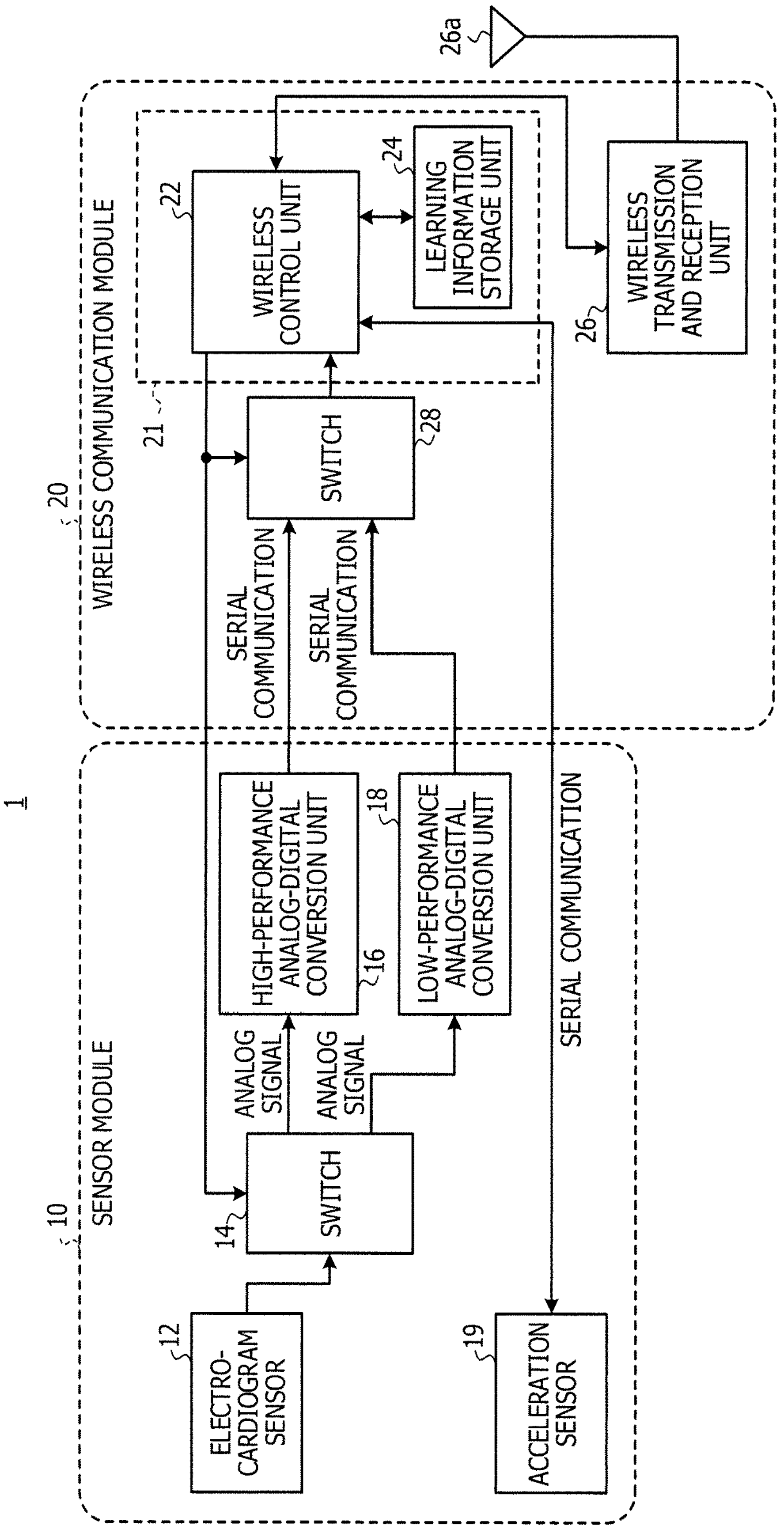

1
10
SENSOR MODULE
12
ELECTRO-CARDIOGRAM SENSOR
14
SWITCH
ANALOG SIGNAL
ANALOG SIGNAL
16
HIGH-PERFORMANCE ANALOG-DIGITAL CONVERSION UNIT
18
LOW-PERFORMANCE ANALOG-DIGITAL CONVERSION UNIT
19
ACCELERATION SENSOR
SERIAL COMMUNICATION
20
WIRELESS COMMUNICATION MODULE
SERIAL COMMUNICATION
SERIAL COMMUNICATION
21
28
SWITCH
22
WIRELESS CONTROL UNIT
24
LEARNING INFORMATION STORAGE UNIT
26
WIRELESS TRANSMISSION AND RECEPTION UNIT
26a

FIG. 3

TIME ZONE	SUCCESS PROBABILITY
0:00 TO 0:10	0 %
...	...
13:00 TO 13:10	80 %
13:10 TO 13:20	75 %
...	...
23:50 TO 0:00	0 %

FIG. 4

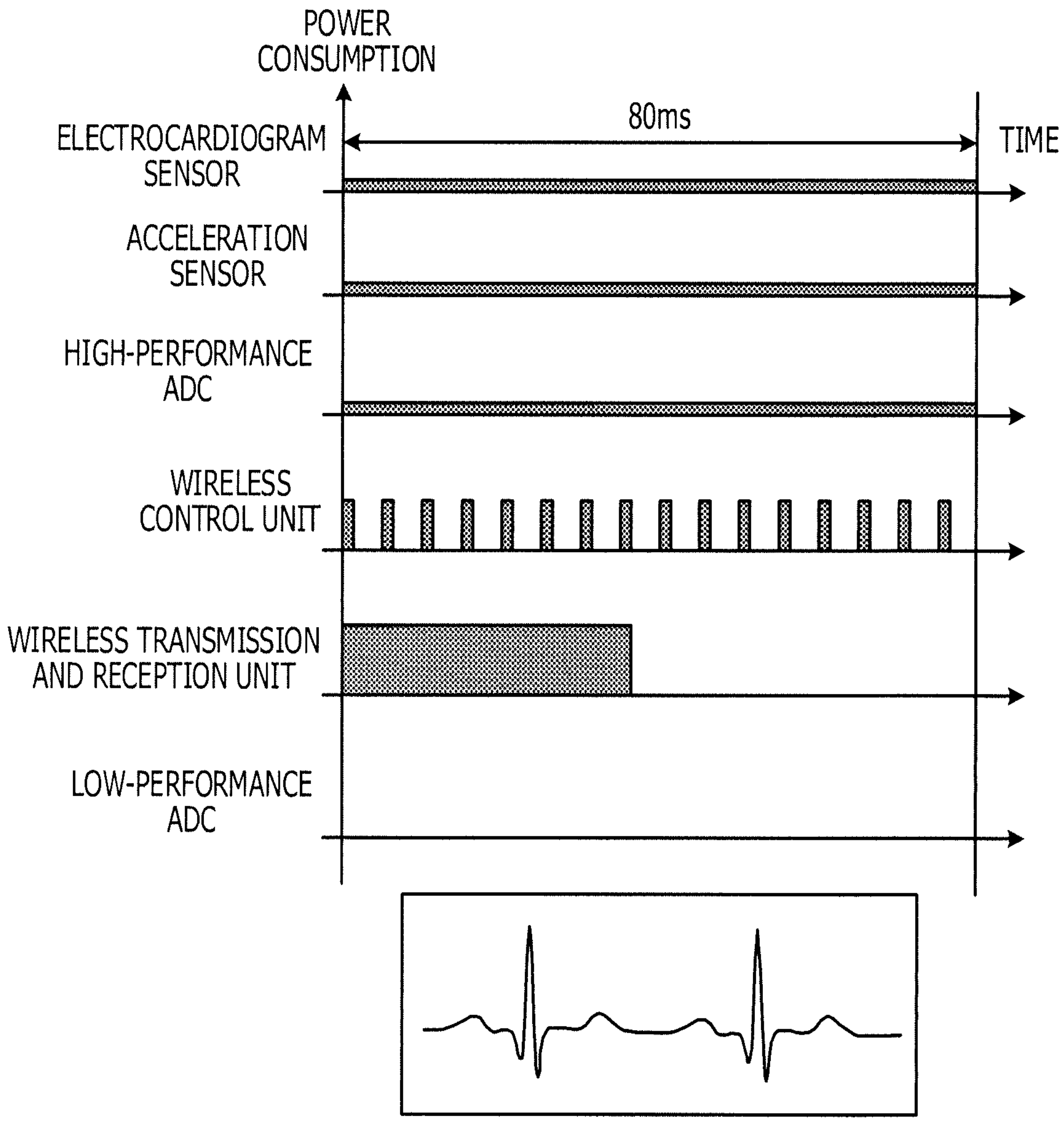

POWER CONSUMPTION
80ms
TIME
ELECTROCARDIOGRAM SENSOR
ACCELERATION SENSOR
HIGH-PERFORMANCE ADC
WIRELESS CONTROL UNIT
WIRELESS TRANSMISSION AND RECEPTION UNIT
LOW-PERFORMANCE ADC

FIG. 5

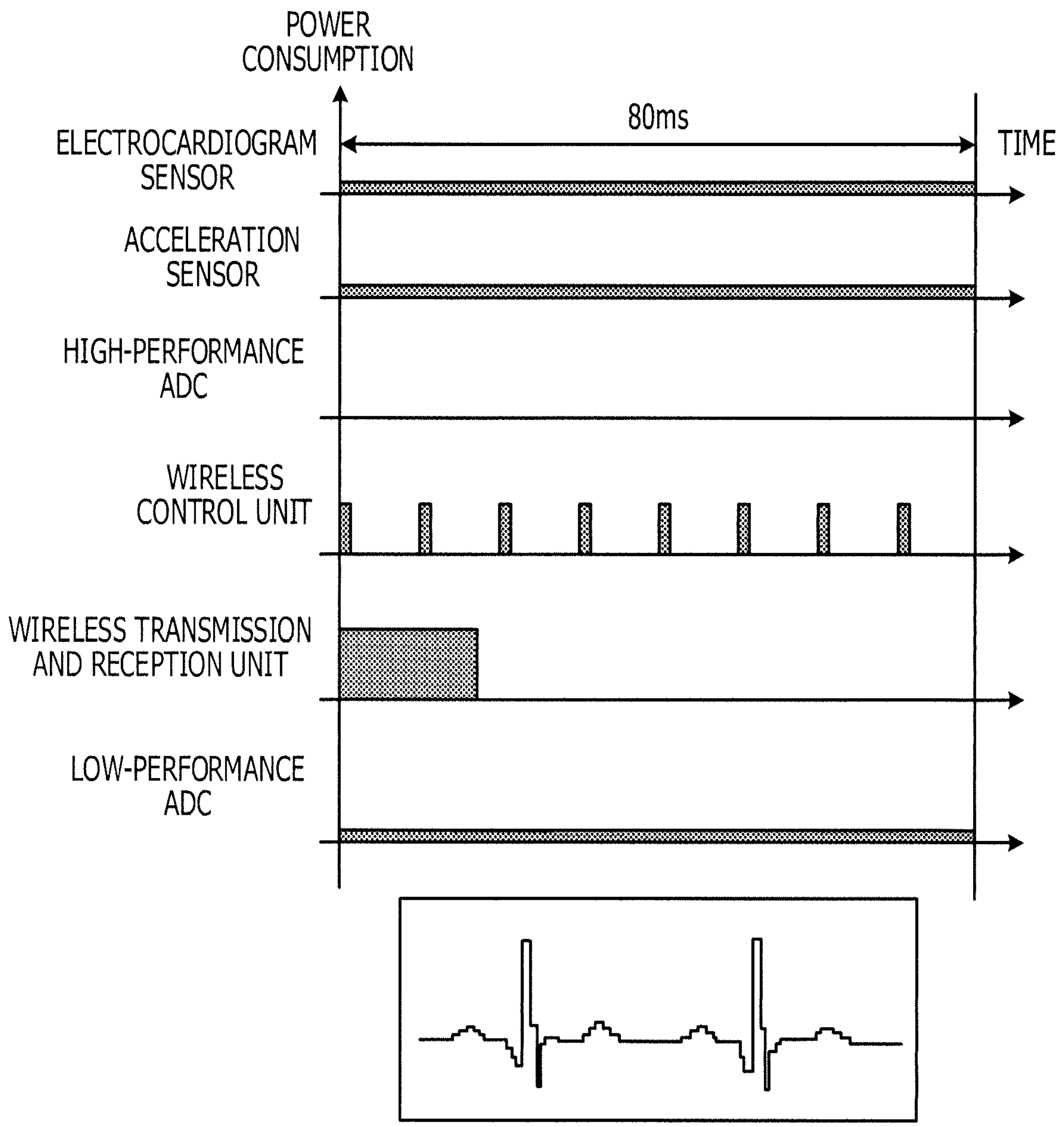

POWER
CONSUMPTION
80ms
TIME
ELECTROCARDIOGRAM
SENSOR
ACCELERATION
SENSOR
HIGH-PERFORMANCE
ADC
WIRELESS
CONTROL UNIT
WIRELESS TRANSMISSION
AND RECEPTION UNIT
LOW-PERFORMANCE
ADC

FIG. 6

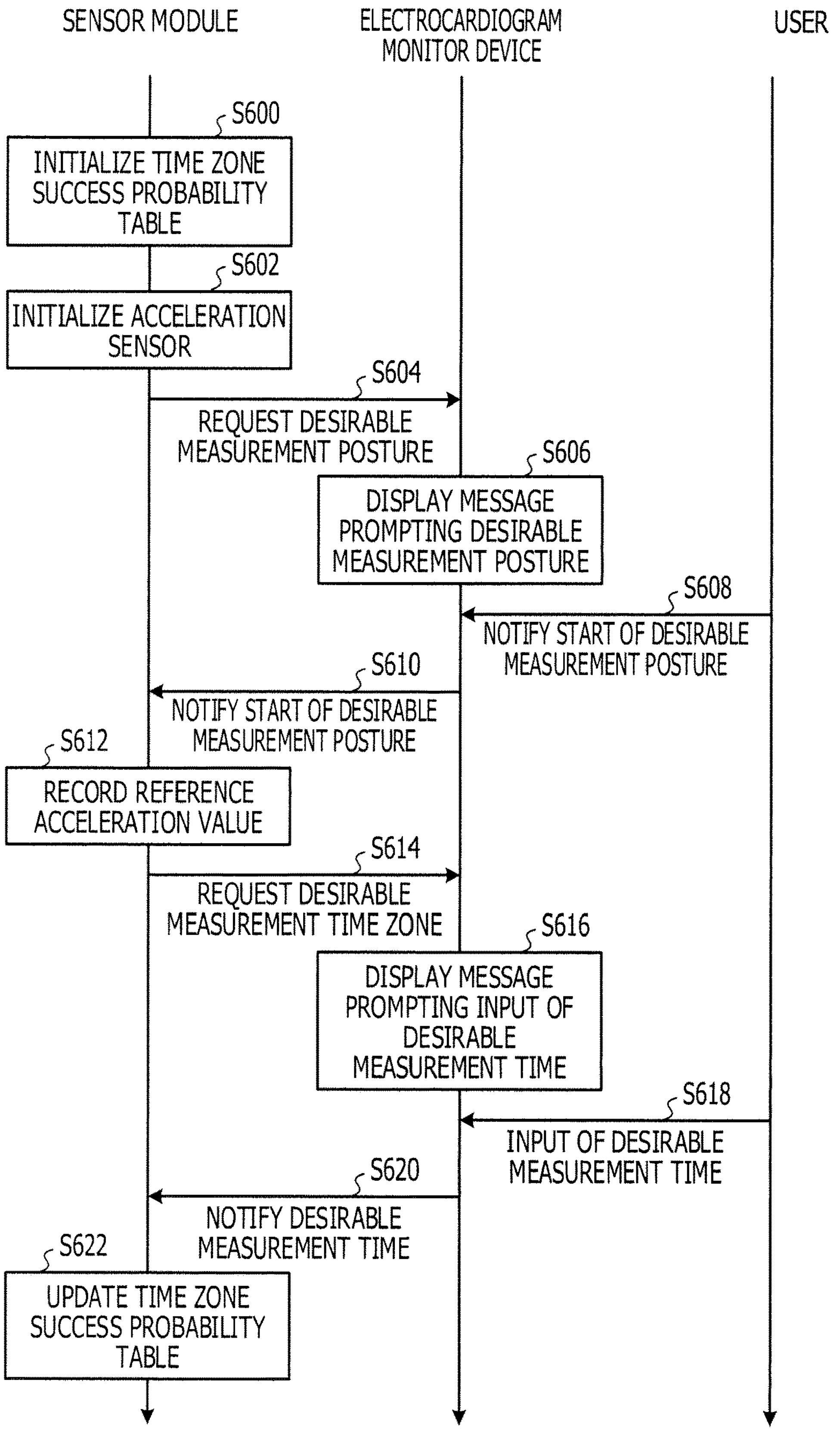

SENSOR MODULE
ELECTROCARDIOGRAM MONITOR DEVICE
USER
S600
INITIALIZE TIME ZONE SUCCESS PROBABILITY TABLE
S602
INITIALIZE ACCELERATION SENSOR
S604
REQUEST DESIRABLE MEASUREMENT POSTURE
S606
DISPLAY MESSAGE PROMPTING DESIRABLE MEASUREMENT POSTURE
S608
NOTIFY START OF DESIRABLE MEASUREMENT POSTURE
S610
NOTIFY START OF DESIRABLE MEASUREMENT POSTURE
S612
RECORD REFERENCE ACCELERATION VALUE
S614
REQUEST DESIRABLE MEASUREMENT TIME ZONE
S616
DISPLAY MESSAGE PROMPTING INPUT OF DESIRABLE MEASUREMENT TIME
S618
INPUT OF DESIRABLE MEASUREMENT TIME
S620
NOTIFY DESIRABLE MEASUREMENT TIME
S622
UPDATE TIME ZONE SUCCESS PROBABILITY TABLE

FIG. 7

TIME ZONE	MEASUREMENT DESIRE	SUCCESS PROBABILITY
0:00 TO 0:10	×	100 %
...	...	...
13:00 TO 13:10	×	100 %
13:10 TO 13:20	×	100 %
...	...	...
23:50 TO 0:00	×	100 %

FIG. 8A

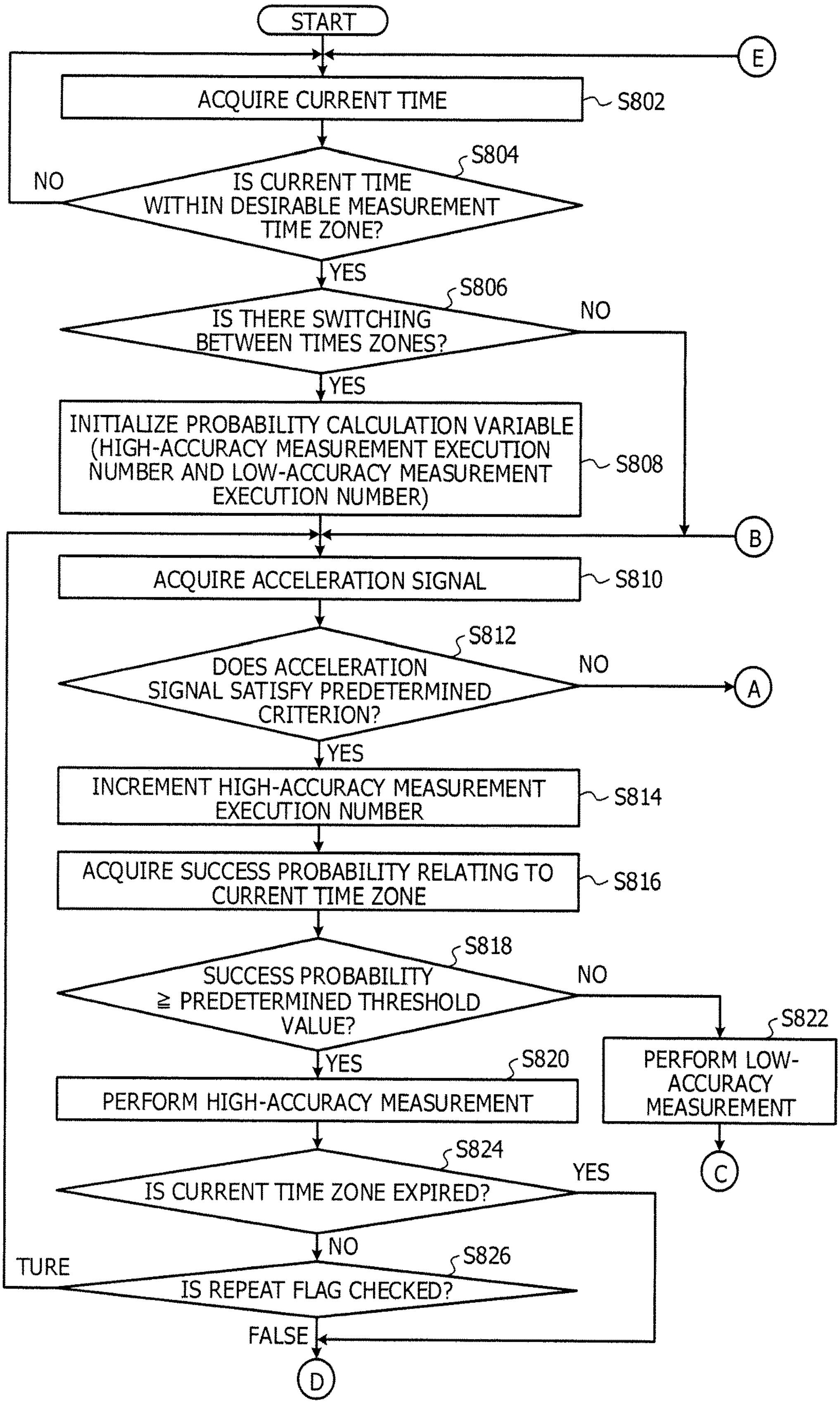

START
E
ACQUIRE CURRENT TIME
S802
S804
NO
IS CURRENT TIME WITHIN DESIRABLE MEASUREMENT TIME ZONE?
YES
S806
IS THERE SWITCHING BETWEEN TIMES ZONES?
NO
YES
INITIALIZE PROBABILITY CALCULATION VARIABLE (HIGH-ACCURACY MEASUREMENT EXECUTION NUMBER AND LOW-ACCURACY MEASUREMENT EXECUTION NUMBER)
S808
B
ACQUIRE ACCELERATION SIGNAL
S810
S812
DOES ACCELERATION SIGNAL SATISFY PREDETERMINED CRITERION?
NO
A
YES
INCREMENT HIGH-ACCURACY MEASUREMENT EXECUTION NUMBER
S814
ACQUIRE SUCCESS PROBABILITY RELATING TO CURRENT TIME ZONE
S816
S818
SUCCESS PROBABILITY ≧ PREDETERMINED THRESHOLD VALUE?
NO
S822
PERFORM LOW-ACCURACY MEASUREMENT
YES
S820
PERFORM HIGH-ACCURACY MEASUREMENT
C
S824
IS CURRENT TIME ZONE EXPIRED?
YES
NO
S826
TURE
IS REPEAT FLAG CHECKED?
FALSE
D

FIG. 8B

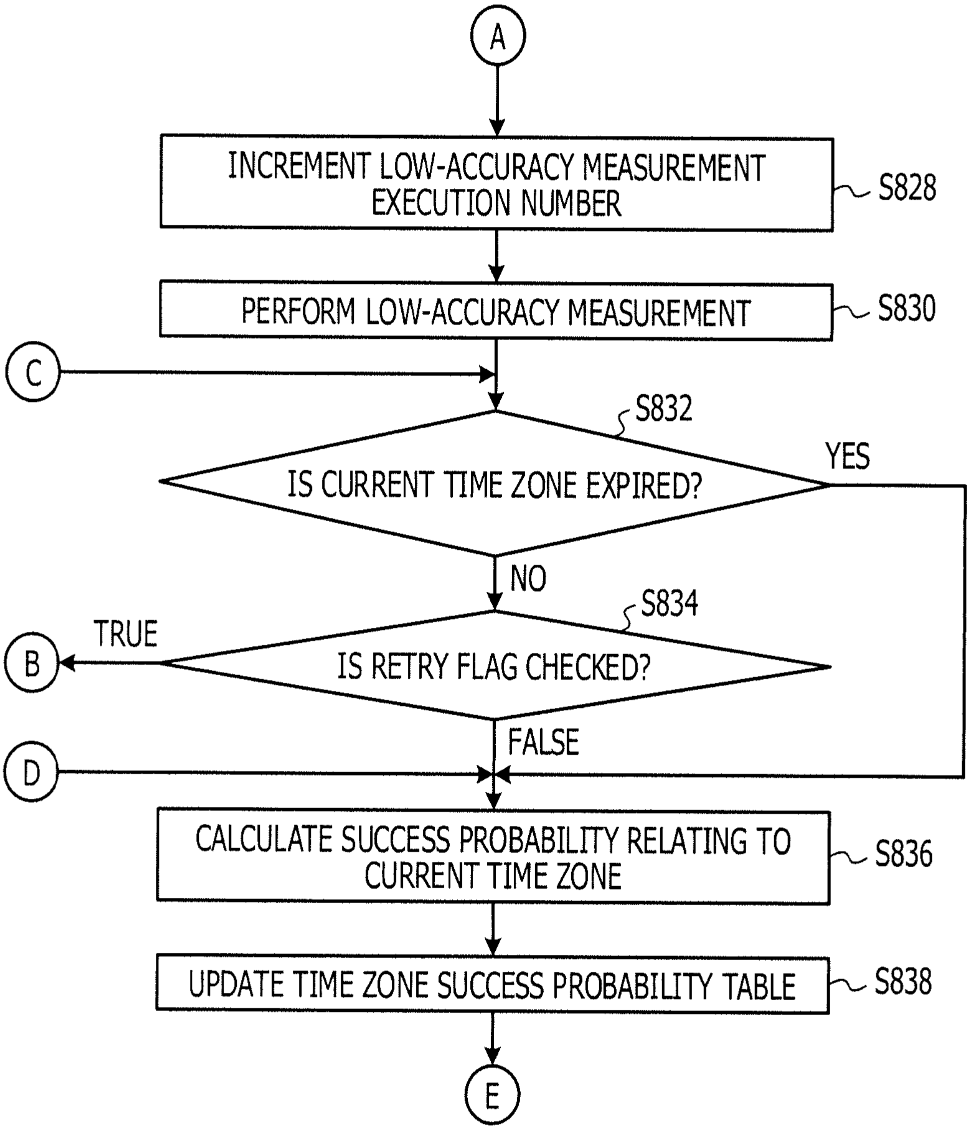
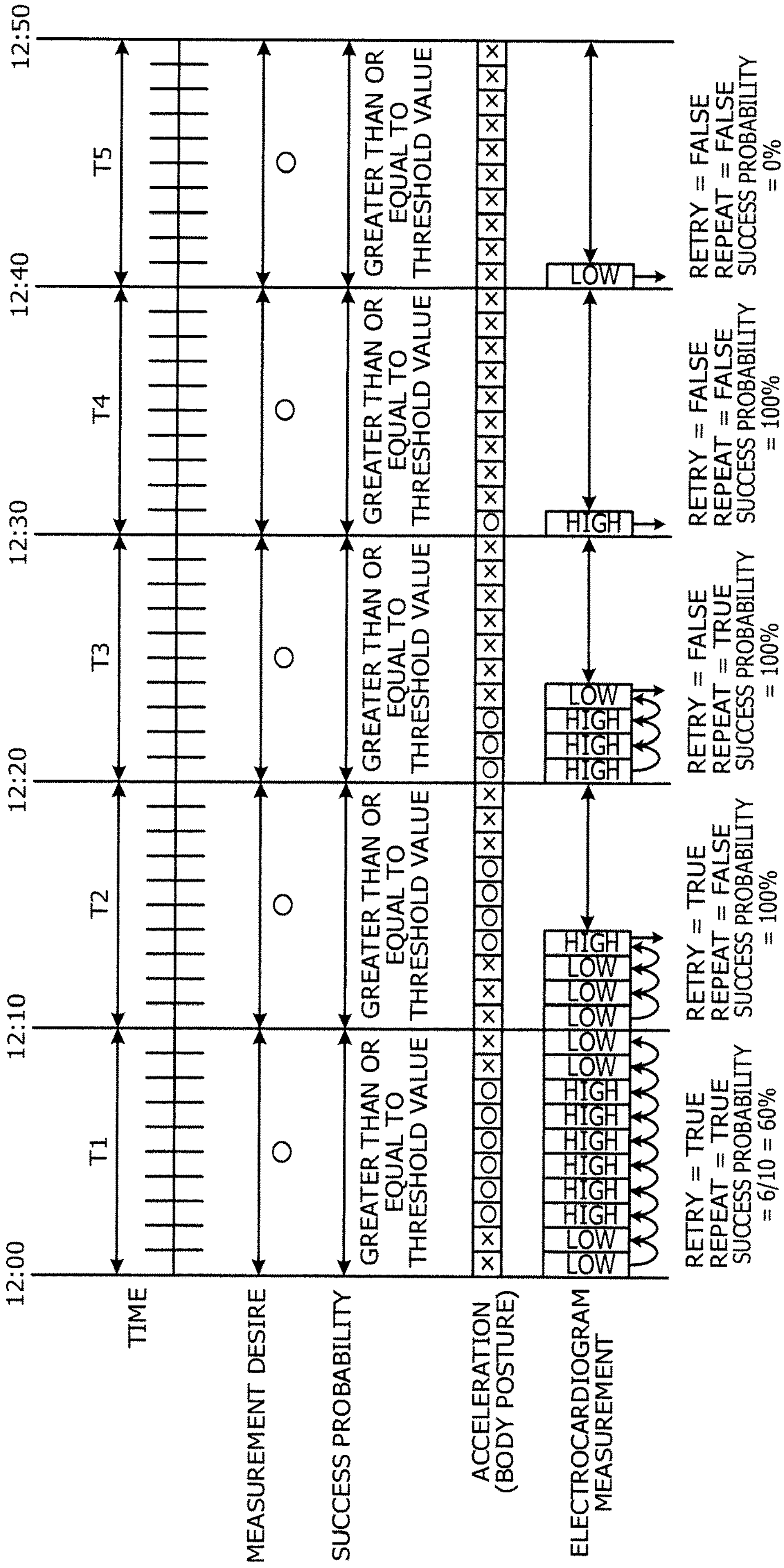

A
INCREMENT LOW-ACCURACY MEASUREMENT EXECUTION NUMBER
S828
PERFORM LOW-ACCURACY MEASUREMENT
S830
C
S832
IS CURRENT TIME ZONE EXPIRED?
YES
NO
S834
TRUE
B
IS RETRY FLAG CHECKED?
FALSE
D
CALCULATE SUCCESS PROBABILITY RELATING TO CURRENT TIME ZONE
S836
UPDATE TIME ZONE SUCCESS PROBABILITY TABLE
S838
E

FIG. 9



TIME
MEASUREMENT DESIRE
SUCCESS PROBABILITY
ACCELERATION (BODY POSTURE)
ELECTROCARDIOGRAM MEASUREMENT
12:00
12:10
12:20
12:30
12:40
12:50
T1
T2
T3
T4
T5
GREATER THAN OR EQUAL TO THRESHOLD VALUE
LOW
HIGH
RETRY = TRUE
REPEAT = TRUE
SUCCESS PROBABILITY = 6/10 = 60%
RETRY = TRUE
REPEAT = FALSE
SUCCESS PROBABILITY = 100%
RETRY = FALSE
REPEAT = TRUE
SUCCESS PROBABILITY = 100%
RETRY = FALSE
REPEAT = FALSE
SUCCESS PROBABILITY = 100%
RETRY = FALSE
REPEAT = FALSE
SUCCESS PROBABILITY = 0%

FIG. 10

TIME ZONE	SUCCESS PROBABILITY	BEFORE ONE DAY	BEFORE TWO DAYS	...	BEFORE N DAYS
0:00 TO 0:10	0 %	0 %	0 %	...	0 %
...	...	...	...	...	...
13:00 TO 13:10	AVERAGE OF A, B, ..., C	A %	A %	...	A %
13:10 TO 13:20	AVERAGE OF P, Q, ..., R	P %	P %	...	P %
...	...	...	...	...	...
23:50 TO 0:00	0 %	0 %	0 %	...	0 %

FIG. 11

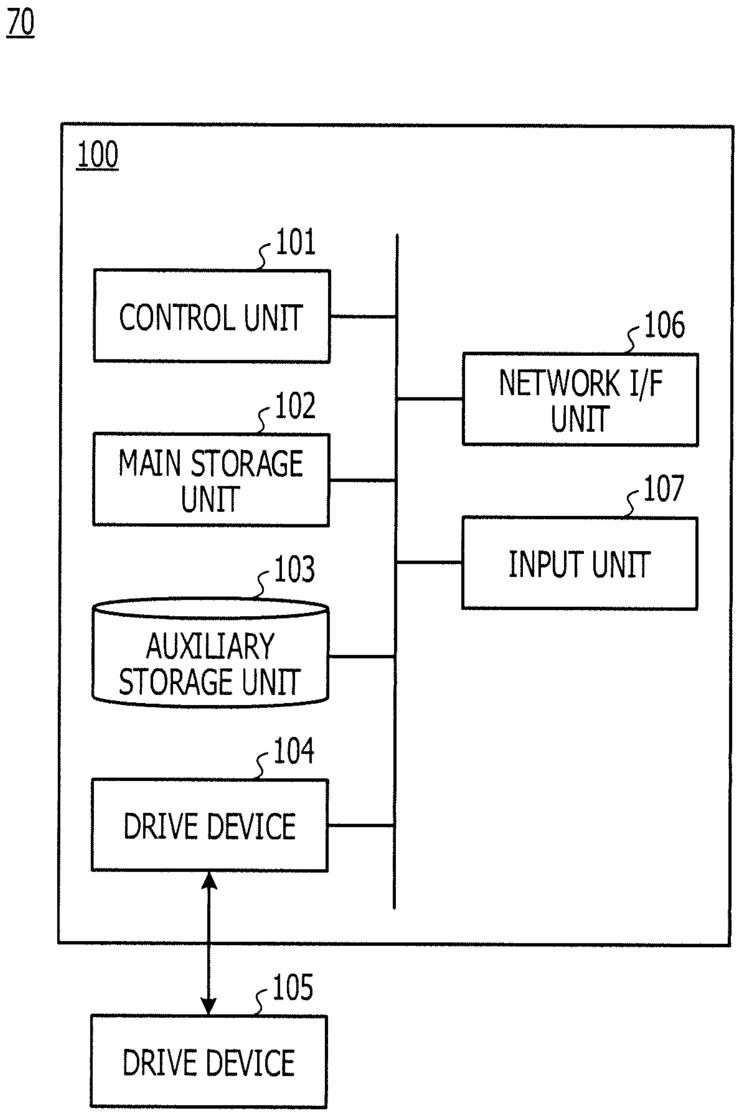
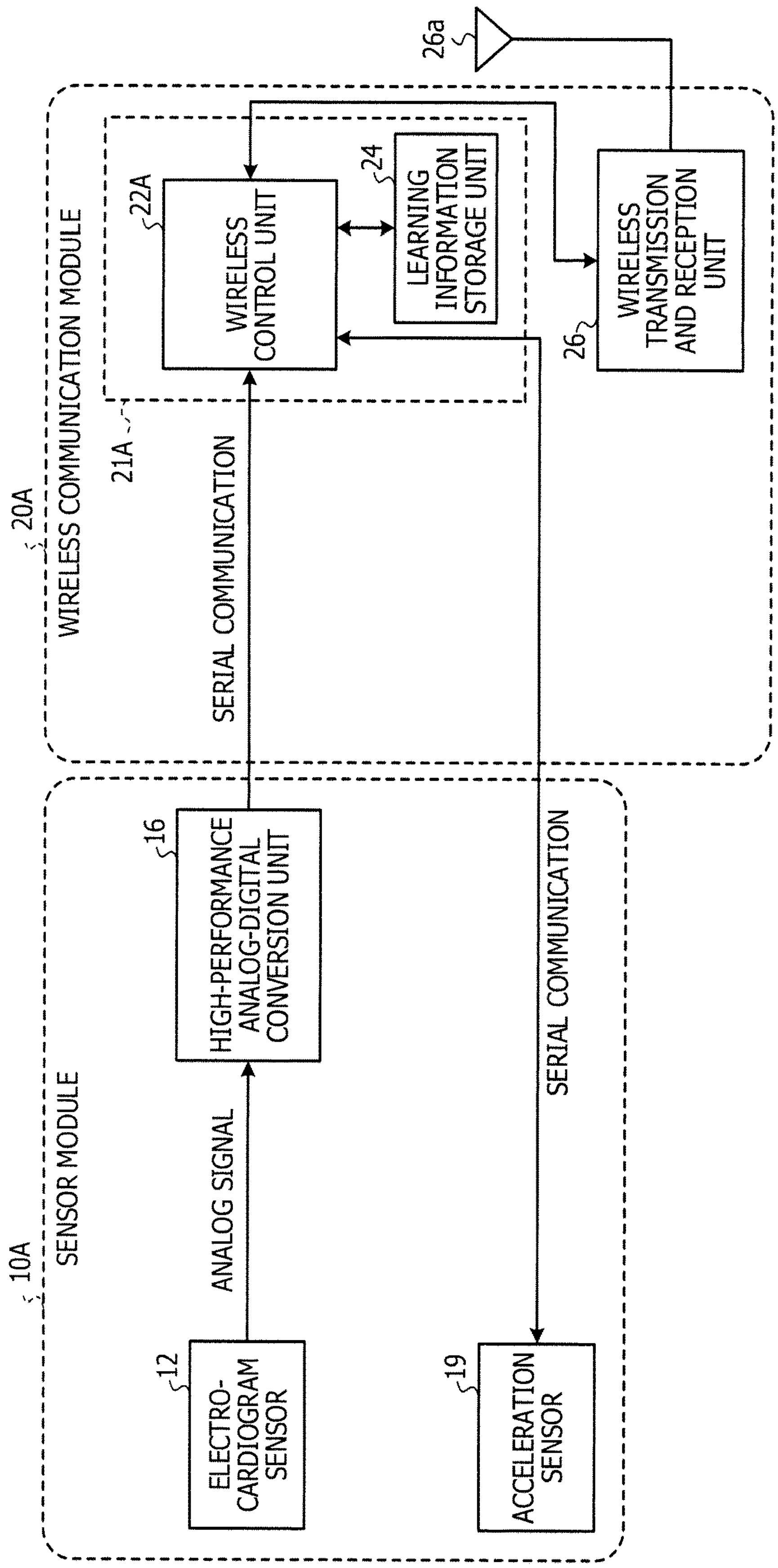

70
100
101
CONTROL UNIT
102
MAIN STORAGE UNIT
103
AUXILIARY STORAGE UNIT
104
DRIVE DEVICE
105
DRIVE DEVICE
106
NETWORK I/F UNIT
107
INPUT UNIT

FIG. 12

1A



26a
20A
WIRELESS COMMUNICATION MODULE
21A
22A
WIRELESS CONTROL UNIT
24
LEARNING INFORMATION STORAGE UNIT
26
WIRELESS TRANSMISSION AND RECEPTION UNIT
SERIAL COMMUNICATION
10A
SENSOR MODULE
12
ELECTRO-CARDIOGRAM SENSOR
ANALOG SIGNAL
16
HIGH-PERFORMANCE ANALOG-DIGITAL CONVERSION UNIT
19
ACCELERATION SENSOR
SERIAL COMMUNICATION

FIG. 13

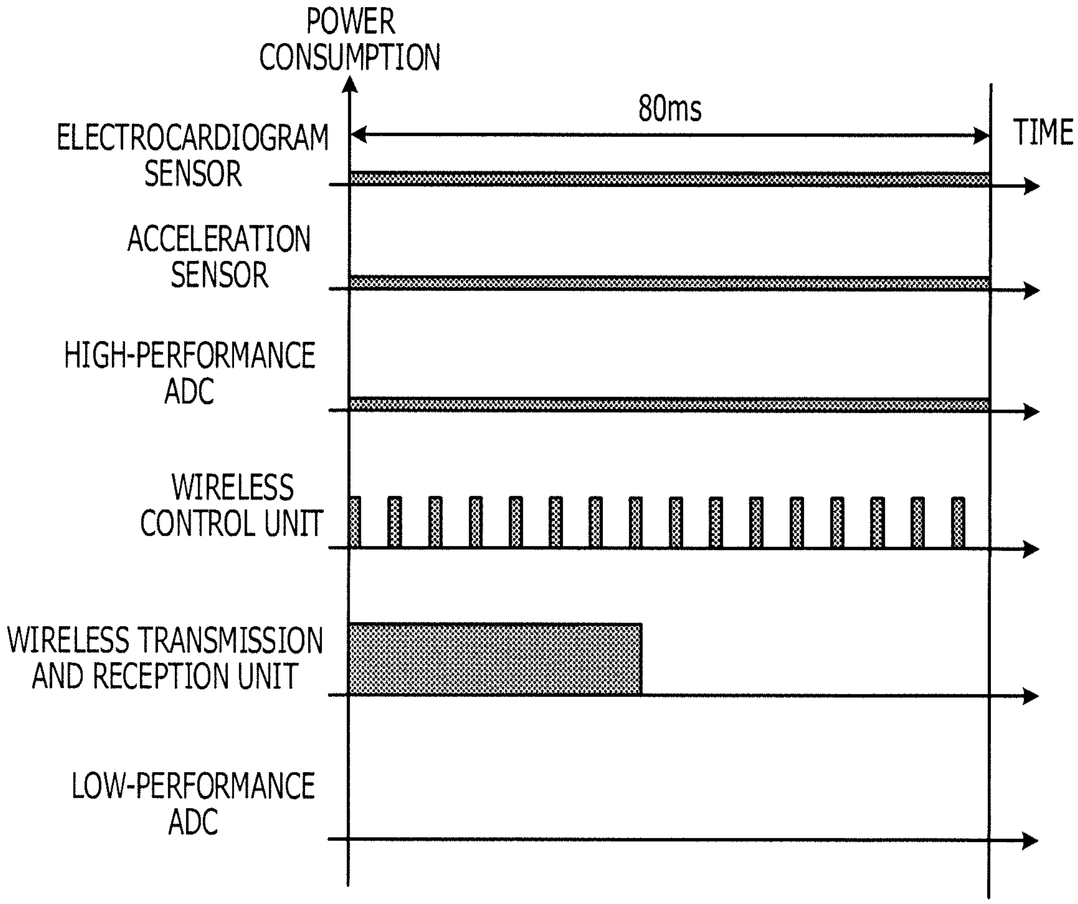
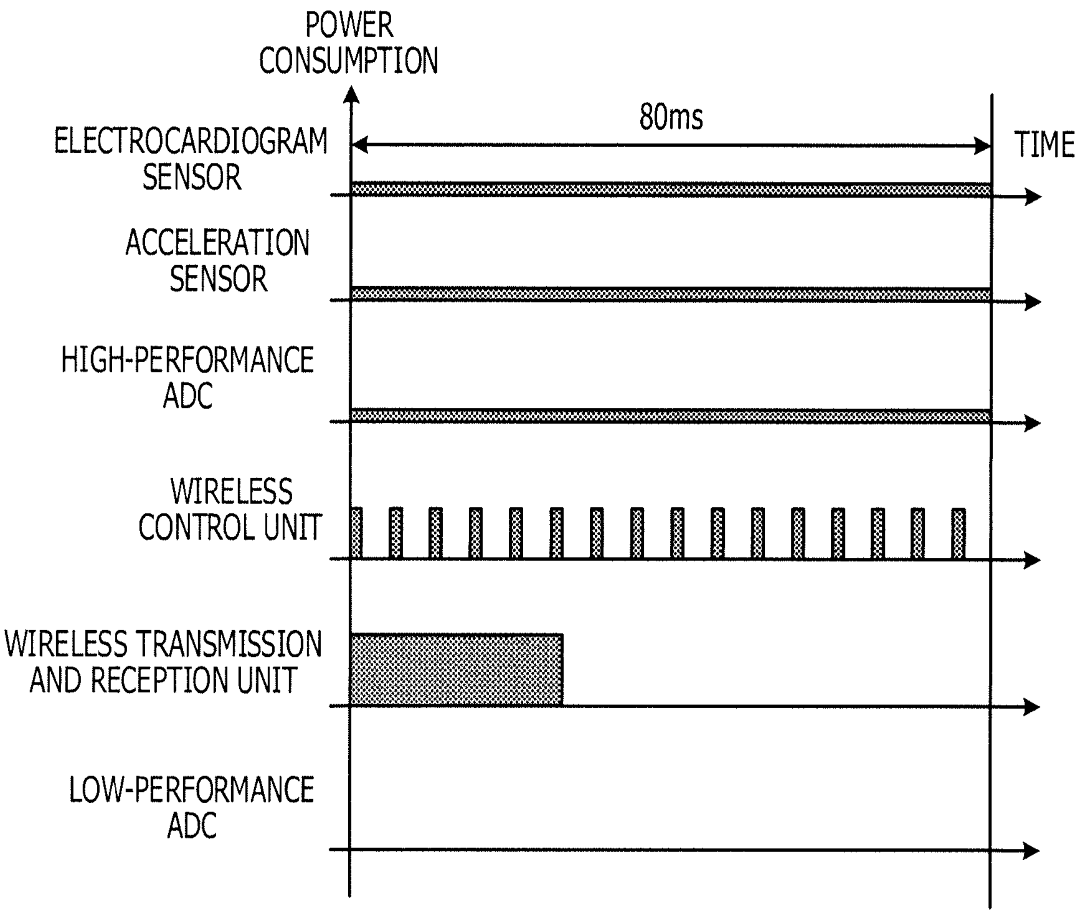

POWER
CONSUMPTION
80ms
TIME
ELECTROCARDIOGRAM
SENSOR
ACCELERATION
SENSOR
HIGH-PERFORMANCE
ADC
WIRELESS
CONTROL UNIT
WIRELESS TRANSMISSION
AND RECEPTION UNIT
LOW-PERFORMANCE
ADC

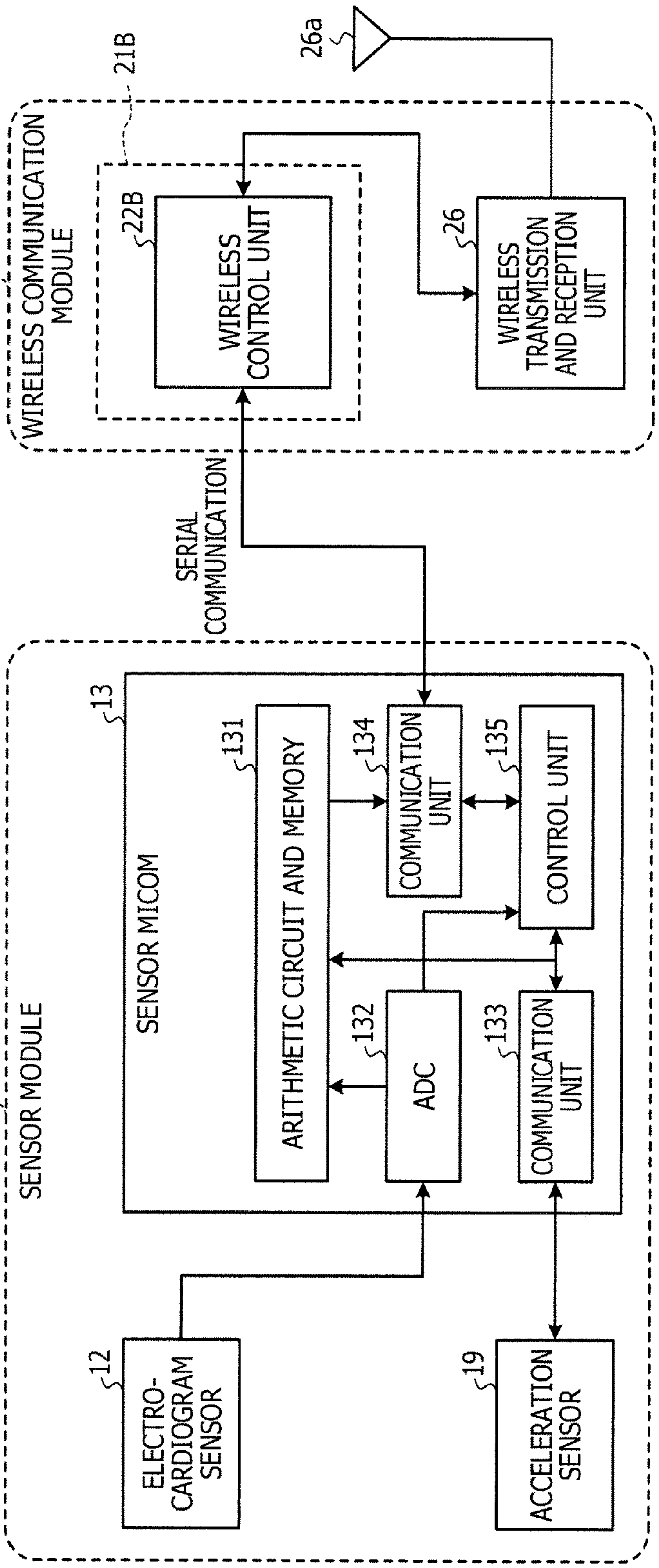
FIG. 14



POWER CONSUMPTION
80ms
TIME
ELECTROCARDIOGRAM SENSOR
ACCELERATION SENSOR
HIGH-PERFORMANCE ADC
WIRELESS CONTROL UNIT
WIRELESS TRANSMISSION AND RECEPTION UNIT
LOW-PERFORMANCE ADC

FIG. 15

1B


20B
WIRELESS COMMUNICATION MODULE
21B
22B
WIRELESS CONTROL UNIT
26
WIRELESS TRANSMISSION AND RECEPTION UNIT
26a
SERIAL COMMUNICATION
10B
SENSOR MODULE
13
SENSOR MICOM
131
ARITHMETIC CIRCUIT AND MEMORY
134
COMMUNICATION UNIT
135
CONTROL UNIT
132
ADC
133
COMMUNICATION UNIT
12
ELECTRO-CARDIOGRAM SENSOR
19
ACCELERATION SENSOR

MEASUREMENT APPARATUS AND RECORDING MEDIUM RECORDING MEASUREMENT PROGRAM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation application of International Application PCT/JP2016/055833 filed on Feb. 26, 2016 and designated the U.S., the entire contents of which are incorporated herein by reference.

FIELD

[0002] The present disclosure relates to a measurement apparatus and a measurement program.

BACKGROUND

[0003] There is a known technology of calculating biological information (for example, a heartbeat from an electrocardiogram, a pulse rate from a pulse wave).

[0004] Related Art is disclosed in Japanese Laid-open Patent Publication No. 2015-112205, Japanese Laid-open Patent Publication No. 2006-312010, or International Publication Pamphlet No. WO 2011/024425.

SUMMARY

[0005] According to one aspect of the embodiments, a measurement apparatus includes a biological sensor configured to measure a biological signal of a person to be measured, and a processor configured to: acquire posture information on a posture of the person to be measured, and change accuracy of measurement data of the biological sensor, based on the acquired posture information.

[0006] The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

[0007] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** is a diagram schematically illustrating an example of an electrocardiogram monitor system **100**.

[0009] FIG. **2** is a diagram illustrating a configuration example of an electrocardiogram measurement apparatus **1** according to Embodiment 1.

[0010] FIG. **3** is a table chart illustrating an example of learning information.

[0011] FIG. **4** is a diagram schematically illustrating a time series of power consumption of an electrocardiogram sensor **12** and the like in a high-accuracy measurement mode.

[0012] FIG. **5** is a diagram schematically illustrating the time series of the power consumption of the electrocardiogram sensor **12** and the like in a low-accuracy measurement mode.

[0013] FIG. **6** is a sequence diagram illustrating an example of initial setting processing of the electrocardiogram monitor system **100**.

[0014] FIG. **7** is an explanatory diagram of a time zone success probability table.

[0015] FIGS. **8**A and **8**B are a flowchart illustrating an example of measurement processing performed by the electrocardiogram measurement apparatus **1**.

[0016] FIG. **9** is an explanatory diagram of a success probability calculating method.

[0017] FIG. **10** is an explanatory diagram of another calculation method of success probability.

[0018] FIG. **11** is a diagram illustrating an example of a hardware configuration of a wireless control device **21** of an electrocardiogram monitor device **6**.

[0019] FIG. **12** is a diagram illustrating a configuration example of an electrocardiogram measurement apparatus **1**A according to Embodiment 2.

[0020] FIG. **13** is a diagram schematically illustrating a time series of power consumption in the electrocardiogram sensor **12** and the like during high-accuracy measurement.

[0021] FIG. **14** is a diagram schematically illustrating the time series of the power consumption of the electrocardiogram sensor **12** and the like during a low-accuracy measurement.

[0022] FIG. **15** is a diagram illustrating a configuration example of an electrocardiogram measurement apparatus **1**B according to Embodiment 3.

DESCRIPTION OF EMBODIMENTS

[0023] For example, a motion of a person to be measured is detected using acceleration, a biological signal is acquired from a biological sensor under fixed measurement conditions, and biological information (for example, a heartbeat from an electrocardiogram, a pulse rate from a pulse wave) is calculated. The motion of the person to be measured is, for example, a stationary state or a motion state, and the fixed measurement conditions are, for example, a sampling frequency and data accuracy, and the biological signal is, for example, measurement data such as an electrocardiogram and a pulse wave. The biological information is, for example, a heartbeat obtained from the electrocardiogram and the pulse rate obtained from the pulse wave.

[0024] However, a measurement apparatus may not change accuracy of measurement data of a biological sensor depending on a posture of a person to be measured.

[0025] For example, a measurement apparatus and a measurement program that can change accuracy of measurement data of a biological sensor depending on a posture of a person to be measured are provided.

[0026] Hereinafter, each embodiment will be described in detail with reference to the accompanying drawings.

[0027] FIG. **1** is a diagram schematically illustrating an example of an electrocardiogram monitor system **100**. The electrocardiogram monitor system **100** includes an electrocardiogram measurement apparatus **1** (an example of a measurement apparatus) and an electrocardiogram monitor device **6**.

[0028] The electrocardiogram measurement apparatus **1** measures an electrocardiogram (an example of a biological signal) of a user S (an example of a person to be measured) and transmits measurement data to the electrocardiogram monitor device **6**. The user S is random, but it is preferable for the user to be, for example, a pregnant woman. Hereinafter, it is assumed that the user S is a pregnant woman as an example. Hereinafter, it is assumed that the electrocardiogram of the user S includes an electrocardiogram of a fetus in the body of the user S, unless described in particular. In addition, when distinguishing between these two electrocardiograms, a term "mother electrocardiogram" and a term "fetal electrocardiogram" are used.

[0029] The electrocardiogram measurement apparatus **1** is mounted on the user S when being used, for example, as schematically illustrated in FIG. **1**. For example, the electrocardiogram measurement apparatus **1** is mounted on the chest of the user S.

[0030] The electrocardiogram monitor device **6** has a function of displaying an electrocardiogram or the like on a display unit **61**, based on measurement data transmitted from the electrocardiogram measurement apparatus **1**. The electrocardiogram monitor device **6** may be a mobile terminal (for example, a tablet terminal or a smart phone) carried by the user S or may be a stationary type terminal. As schematically illustrated in FIG. **1**, the electrocardiogram monitor device **6** is capable of wireless communication with the electrocardiogram measurement apparatus **1**. However, the electrocardiogram monitor device **6** may be configured to communicate with the electrocardiogram measurement apparatus **1** via a wire. Hereinafter, it is assumed that the communication between the electrocardiogram monitor device **6** and the electrocardiogram measurement apparatus **1** is realized by wireless communication as an example. Meanwhile, the wireless communication may be based on a standard such as Bluetooth (registered trademark) or worldwide interoperability for microwave access (WiMAX).

[0031] Next, each embodiment of the electrocardiogram measurement apparatus suitable for being used for the electrocardiogram monitor system **100** will be described.

Embodiment 1

[0032] FIG. **2** is a diagram illustrating a configuration example of the electrocardiogram measurement apparatus **1** according to Embodiment 1.

[0033] The electrocardiogram measurement apparatus **1** has two or more measurement modes. In the example illustrated in FIG. **2**, the electrocardiogram measurement apparatus **1** has two measurement modes of a low-accuracy measurement mode for measuring an electrocardiogram of a mother, and a high-accuracy measurement mode for measuring an electrocardiogram of a fetus in addition to the electrocardiogram of the mother. Details of the low-accuracy measurement mode and the high-accuracy measurement mode will be described below.

[0034] The electrocardiogram measurement apparatus **1** includes a sensor module **10** and a wireless communication module **20**.

[0035] The sensor module **10** includes an electrocardiogram sensor **12** (an example of a biological sensor), a switch **14**, and a high-performance analog-digital conversion unit **16** (hereinafter, referred to as a high-performance ADC **16**) (an example of a first analog-digital conversion unit). In addition, the sensor module **10** further includes a low-performance analog-digital conversion unit **18** (hereinafter, referred to as a low-performance ADC **18**) (an example of a second analog-digital conversion unit) and an acceleration sensor **19** (an example of a posture sensor).

[0036] The electrocardiogram sensor **12** generates an electrical signal (hereinafter, referred to as an "electrocardiogram signal") corresponding to an electrocardiogram of the user S, and inputs the electrocardiogram signal to the switch **14**. Meanwhile, the electrocardiogram signal output from the electrocardiogram sensor **12** is an analog signal (for example, −3.3 V to +3.3 V). The electrocardiogram sensor **12** is a contact-type sensor including an electrode to be attached to the chest of the user S, but may be a non-contact-type sensor. Then electrocardiogram sensor **12** may be a sensor to be attached to a portion other than the chest.

[0037] The switch **14** is switched between a first state and a second state in response to a switching signal (will be described below) input from a wireless communication module **20**. In the first state of the switch **14**, an electrocardiogram signal from the electrocardiogram sensor **12** is input to the high-performance ADC **16**. Thereby, the high-accuracy mode is realized. In the second state of the switch **14**, the electrocardiogram signal from the electrocardiogram sensor **12** is input to the low-performance ADC **18**. Thereby, the low-accuracy mode is realized. By doing so, the electrocardiogram measurement apparatus **1** operates in the low-accuracy measurement mode or the high-accuracy measurement mode, according to a state of the switch **14** being switched in response to the switching signal (will be described below) input from the wireless communication module **20**.

[0038] The high-performance ADC **16** functions in the high-accuracy measurement mode. The high-performance ADC **16** converts an analog electrocardiogram signal input from the electrocardiogram sensor **12** via the switch **14** into a digital electrocardiogram signal. The high-performance ADC **16** has at least one of a higher resolution and a higher sampling frequency than the low-performance ADC **18**. The high-performance ADC **16** performs conversion processing at the resolution and the sampling frequency at which the fetal electrocardiogram can be measured. In Embodiment 1, the high-performance ADC **16** has both a higher resolution and a higher sampling frequency than the low-performance ADC **18** as an example. This is because a fetal electrocardiogram is significantly weaker than a mother electrocardiogram (an amplitude is small) and it is more advantageous that both the resolution and the sampling frequency of the fetal electrocardiogram are higher than those in a case where only the mother electrocardiogram is measured so as to accurately measure the fetal electrocardiogram. Specifically, the resolution and the sampling frequency of the high-performance ADC **16** are 24 bits and 200 Hz, respectively. In such a case, the fetal electrocardiogram can be accurately measured.

[0039] The low-performance ADC **18** functions in the low-accuracy measurement mode. The low-performance ADC **18** converts an analog signal input from the electrocardiogram sensor **12** via the switch **14** into a digital electrocardiogram signal. The low-performance ADC **18** performs conversion processing at a resolution and a sampling frequency in which the mother electrocardiogram can be measured. In Embodiment 1, the resolution and the sampling frequency of the low-performance ADC **18** are 16 bits and 100 Hz, respectively as an example.

[0040] The acceleration sensor **19** generates an electrical signal (hereinafter, referred to as an "acceleration signal") (an example of posture information) corresponding to accelerations in three axial directions orthogonal to each other. The acceleration sensor **19** transmits the acceleration signal to the wireless communication module **20**. In the example illustrated in FIG. **2**, the acceleration sensor **19** transmits the acceleration signal to the wireless communication module **20** by serial communication.

[0041] Meanwhile, when the user S takes a predetermined stable posture, a gravitational acceleration appears in a direction of three axes. Since a method of mounting the electrocardiogram measurement apparatus **1** is the same every time, an angle relationship between the three axes in the gravitational direction does not change. Accordingly, each value (each component in the three axial directions) of the acceleration output by the acceleration sensor **19** is approximately the same value (that is, a value satisfying a certain allowable range) each time the user S reaches a predetermined stable posture.

[0042] The wireless communication module **20** generates measurement data, based on the acceleration signal from the acceleration sensor **19** and learning information (will be described below) stored therein, in accordance with the electrocardiogram sensor **12**. The wireless communication module **20** transmits the generated measurement data to the outside (for example, the electrocardiogram monitor device **6** in FIG. **1**).

[0043] The wireless communication module **20** includes a wireless control device **21**, a wireless transmission and reception unit **26**, and a switch **28**.

[0044] The wireless control device **21** is formed by, for example, a computer (see FIG. **11**). The wireless control device **21** includes a wireless control unit **22** (an example of a processing unit) and a learning information storage unit **24**.

[0045] The wireless control unit **22** determines a posture of the user S, based on the acceleration signal from the acceleration sensor **19**. The wireless control unit **22** switches a measurement mode between the high-accuracy measurement mode and the low-accuracy measurement mode, based on the posture of the user S. Thereby, it is possible to change accuracy of the measurement data of the electrocardiogram sensor **12** depending on the posture of the user S.

[0046] The wireless control unit **22** preferably switches a measurement mode in a predetermined time zone between the high-accuracy measurement mode and the low-accuracy measurement mode, based on learning information on a posture of the user S in the predetermined time zone (or a plurality of time zones) in addition to the posture of the user S. Thereby, as will be described below, it is possible to determine a possibility (probability) that the user S will take a stable posture in the predetermined time zone. Accordingly, for example, by setting the measurement mode to the high-accuracy measurement mode only in a time zone in which there is a high possibility that the user S will take a stable posture, it is possible to achieve both an increase in opportunity to make a high-accuracy measurement and improvement in efficiency of power consumption, as will be described below. In Embodiment 1, it is assumed that the wireless control unit **22** switches the measurement mode, based on the posture of the user S and the learning information as an example.

[0047] The wireless control unit **22** generates learning information on the posture of the user S for each time zone, based on the acceleration signal from the acceleration sensor **19**, and stores the learning information in the learning information storage unit **24**. The time zone is a time zone delimited every predetermined time in one day, and the predetermined time is random. For example, the time zone is a time zone delimited by the order of minutes and may be a time zone delimited every 10 minutes or every 3 minutes. Here, the acceleration signal from the acceleration sensor **19** represents a posture of the user S. The learning information may be data of the acceleration signal itself for each time zone, and may be information on the posture of the user S that can be derived from the acceleration signal, such as a type and an attribute of the posture of the user S for each time zone. In Embodiment 1, it assumed that the time zone is a time zone delimited every 10 minutes in one day and the learning information is a success probability for each time zone as an example as illustrated in FIG. **3**. FIG. **3** illustrates a table chart representing an example of the success probability for each time zone. The success probability is a probability that a high-accuracy measurement is successfully made in a desired aspect. The desired aspect may include, for example, at least one success within 10 minutes, multiple successes within 10 minutes, multiple consecutive successes within 10 minutes, and the like. The high-accuracy measurement is a measurement in which the high-performance ADC **16** is used, and specifically, a measurement in the high-accuracy measurement mode. Meanwhile, the low-accuracy measurement is a measurement in which the low-performance ADC **18** is used, and specifically, a measurement in the low-accuracy measurement mode.

[0048] Whether or not a high-accuracy measurement is successful in a desired aspect may be determined based on feed-back information (for example, information indicating accuracy of the fetal electrocardiogram and the like) from the electrocardiogram monitor device **6**. Alternatively, whether or not the high-accuracy measurement is successful in the desired aspect in a certain time zone may be determined based on the acceleration signal from the acceleration sensor **19** in the time zone. This can be used as a material for determining whether or not there is a posture of the user S which hinders success of the high-accuracy measurement in the time zone because the acceleration signal from the acceleration sensor **19** represents the posture of the user S. In Embodiment 1, the wireless control unit **22** determines whether or not the high-accuracy measurement is successful in the desired aspect, based on the acceleration signal from the acceleration sensor **19** as an example. For example, the wireless control unit **22** determines whether or not the acceleration signal from the acceleration sensor **19** satisfies a predetermined criterion when measurement starts in the high-accuracy measurement. In this case, the wireless control unit **22** may determine that the high-accuracy measurement is successful in a case where the acceleration signal from the acceleration sensor **19** satisfies the predetermined criterion when the measurement starts in the high-accuracy measurement. The predetermined criterion is a criterion for detecting the stable posture of the user S and may be set based on the acceleration signal when the user S is in the stable posture. Alternatively, the wireless control unit **22** may determine whether or not the acceleration signal from the acceleration sensor **19** satisfies the predetermined criterion during the measurement in the high-accuracy measurement instead of or in addition to when the measurement starts in the high-accuracy measurement. In this case, the wireless control unit **22** may determine that the high-accuracy measurement is successful during the measurement by the high-accuracy measurement in a case where the acceleration signal from the acceleration sensor **19** satisfies the predetermined criterion. Hereinafter, the learning information derived in this way by using the acceleration signals at a plurality of points of time during one measurement is referred to as "learning information under measurement" when it is pointed out in particular.

[0049] The wireless control unit **22** determines a measurement mode when the measurement starts. In Embodiment 1, the measurement mode is one of the high-accuracy measurement mode and the low-accuracy measurement mode as an example. The wireless control unit **22** generates a switching signal for switching between the high-accuracy measurement mode and the low-accuracy measurement mode, based on the acceleration signal from the acceleration sensor **19** and the learning information in the learning information storage unit **24**. The wireless control unit **22** provides the generated switching signal to the switch **14** and the switch **28**. For example, the wireless control unit **22** determines whether or not the acceleration signal satisfies a predetermined criterion when the measurement starts (for example, one point of time at which the measurement starts and/or a predetermined period immediately before the measurement starts). The predetermined criterion may be the same as described above. In addition, the wireless control unit **22** determines whether or not the success probability relating to the time zone to which a current time belongs is greater than or equal to a predetermined threshold value, based on the learning information. The predetermined threshold value corresponds to a comparatively high probability, and may be, for example, a value greater than or equal to 70[%]. The predetermined threshold value may be set by the user S. In a case where the acceleration signal satisfies the predetermined criterion when the measurement starts and the success probability relating to the time zone to which the current time belongs is greater than or equal to the predetermined threshold value, the wireless control unit **22** generates the switching signal such that measurement in the high-accuracy measurement mode is realized. Meanwhile, in a case where the acceleration signal does not satisfy the predetermined criterion when the measurement starts or in a case where the success probability relating to the time zone to which the current time belongs is not greater than or equal to the predetermined threshold value, the wireless control unit **22** generates the switching signal such that the measurement in the low-accuracy measurement mode is realized. Each of the switch **14** and the switch **28** may form a state (a first state or a second state) realizing either one of the high-accuracy measurement mode and the low-accuracy measurement mode in a normal state. In this case, the switching signal may be provided to the switch **14** and the switch **28** only when a state other the normal state is formed. In the example illustrated in FIG. **2**, two switches **14** and **28** are provided, but either one of the two switches **14** and **28** may be omitted.

[0050] The wireless control unit **22** acquires an electrocardiogram signal from the electrocardiogram sensor **12** input via the switch **28**. In the high-accuracy measurement mode, the wireless control unit **22** acquires the electrocardiogram signal converted by the high-performance ADC **16**. In the low-accuracy measurement mode, the wireless control unit **22** acquires the electrocardiogram signal converted by the low-performance ADC **18**. The wireless control unit **22** acquires measurement data of the electrocardiogram sensor **12** to the wireless transmission and reception unit **26**, based on the acquired electrocardiogram signal.

[0051] The learning information storage unit **24** stores learning information. The learning information storage unit **24** may be, for example, a nonvolatile memory (for example, a flash memory, a hard disk drive, or the like) that can be rewritten.

[0052] The wireless transmission and reception unit **26** generates a transmission signal for transmitting the measurement data received from the wireless control unit **22**. The wireless transmission and reception unit **26** transmits the generated transmission signal to the electrocardiogram monitor device **6** via the antenna **26*a***.

[0053] The switch **28** is switched between the first state and the second state in response to the switching signal input from the wireless control unit **22**. The first state of the switch **28** is formed in the high-accuracy measurement mode. In the first state of the switch **28**, the electrocardiogram signal from the high-performance ADC **16** is provided to the wireless control unit **22**. Thereby, the wireless transmission and reception unit **26** can generate the transmission signal, based on the electrocardiogram signal obtained from the high-performance ADC **16**. The second state of the switch **28** is formed during the low-accuracy measurement mode. In the second state of the switch **28**, the electrocardiogram signal from the low-performance ADC **18** is provided to the wireless control unit **22**. Thereby, the wireless transmission and reception unit **26** can generate the transmission signal, based on the electrocardiogram signal obtained from the low-performance ADC **18**. By doing so, the wireless communication module **20** transmits measurement data with different accuracy depending on the measurement mode of the electrocardiogram measurement apparatus **1** to the electrocardiogram monitor device **6**.

[0054] FIG. **4** is a diagram schematically illustrating a time series of power consumption of the electrocardiogram sensor **12** and the like in the high-accuracy measurement mode. FIG. **5** is a diagram schematically illustrating the time series of the power consumption of the electrocardiogram sensor **12** and the like in the low-accuracy measurement mode. Specifically, in FIGS. **4** and **5**, the time series of each power consumption of the electrocardiogram sensor **12**, the acceleration sensor **19**, the high-performance ADC **16**, the wireless control unit **22**, the wireless transmission and reception unit **26**, and the low-performance ADC **18** are schematically illustrated in order from the top. In FIG. **4** and FIG. **5**, measurements for a measurement period of 80 ms are illustrated. In addition, in FIG. **4** and FIG. **5**, an image diagram of a waveform displayed on the display unit **61** of the electrocardiogram monitor device **6** is illustrated on the lowermost side. The power consumed in the wireless transmission and reception unit **26** illustrated in FIG. **4** is power consumed when the measurement data obtained in the previous (another measurement period of 80 ms immediately before the measurement period illustrated in FIG. **4**) high-accuracy measurement is processed, and the power consumed in the wireless transmission and reception unit **26** illustrated in FIG. **5** is power consumed when the measurement data obtained in the previous low-accuracy measurement is processed.

[0055] In the example illustrated in FIG. **4**, the high-performance ADC **16** converts the electrocardiogram signal into a digital signal with 16 samples×24 bits (3 bytes) during the measurement period of 80 ms. Meanwhile, in the example illustrated in FIG. **5**, the low-performance ADC **18** converts the electrocardiogram signal into a digital signal with 8 samples×16 bits (2 bits) during the measurement period of 80 ms. As a result, in the wireless control unit **22** in the high-accuracy measurement mode, the number of acquisitions of the electrocardiogram signal is 16 for 16 samples, which is twice the number of acquisitions in the low-accuracy measurement mode, and the power consumption is also approximately twice. In addition, in the high-accuracy measurement mode, the wireless transmission and reception unit **26** transmits measurement data of three packets, based on the electrocardiogram signal from the high-performance ADC **16**. In contrast, in the low-accuracy measurement mode, the wireless transmission and reception unit **26** transmits the measurement data of one packet, based on the electrocardiogram signal from the low-performance ADC **18**. As a result, in the radio transmission and reception unit **26** in the high-accuracy measurement mode, the power consumption also increases as much as the number of packets to be transmitted, compared with the power consumption in the low-accuracy measurement mode. In the examples illustrated in FIGS. **4** and **5**, the transmission signal to be transmitted to the electrocardiogram monitor device **6** includes the measurement data of the acceleration sensor **19** in addition to the measurement data of the electrocardiogram sensor **12**. The measurement data of the acceleration sensor **19** is transmitted as one packet together with the header.

[0056] As described above, according to Embodiment 1, a measurement mode is switched between the high-accuracy measurement mode and the low-accuracy measurement mode depending on a posture of the user S, and thus, it is possible to change the accuracy of the measurement data of the electrocardiogram sensor **12** depending on the posture of the user S.

[0057] Here, since an electrocardiogram of a fetus is a very small signal, there is a possibility that the electrocardiogram of the fetus may not be acquired with high accuracy even in the high-accuracy measurement mode, in a case where noise is included in the electrocardiogram signal acquired by the wireless control unit **22**, such as when the user S is not in a stable posture. That is, even in the high-accuracy measurement mode, there is a possibility that a high-accuracy measurement of the electrocardiogram of the fetus may not be performed depending on the posture of the user S.

[0058] Accordingly, when the user S is not in a stable posture, it is desirable to perform measurement in the low-accuracy measurement mode with relatively low power consumption without performing the measurement in the high-accuracy measurement mode with relatively high power consumption from the viewpoint of power consumption.

[0059] In this regard, according to Embodiment 1, as described above, the posture of the user S is determined based on the acceleration signal when the measurement starts, and thereby, only when the user S is in a stable posture at the start of starting the measurement, measurement in the high-accuracy measurement mode can be performed. Specifically, when the user S is in a stable posture, a high-accuracy measurement can be realized, and when the user S is not in a stable posture, a low-accuracy measurement can be performed. Thereby, it is possible to improve efficiency of power consumption of the electrocardiogram measurement apparatus **1** and to improve high accuracy of the measurement data of the electrocardiogram sensor **12**, depending on the posture of the user S.

[0060] In addition, according to Embodiment 1, as described above, a measurement mode is switched between a high-accuracy measurement mode and a low-accuracy measurement mode, based on learning information on a posture of the user S for each time zone. Thereby, high accuracy measurement can be attempted in a time zone in which there is a high possibility that the user S will be in a stable posture. Thereby, it is possible to achieve both an increase in opportunities to perform a high-accuracy measurement and the improvement in efficiency of power consumption.

[0061] Here, even if the user S is in a stable posture at the time of starting the measurement, the user S may not be in a stable posture during measurement after the measurement starts. Also in such a case, there is a possibility that high-accuracy measurement of the fetal electrocardiogram may not be performed, and thus, it is desirable that the measurement is performed in the low-accuracy measurement mode in which power consumption is relatively low, without performing the measurement in the high-accuracy measurement mode in which power consumption is relatively high, from the viewpoint of power consumption.

[0062] In this regard, in the configuration in which learning information is used during above-described measurement, the possibility that a stable posture of a user S is continuously maintained during the high-accuracy measurement is determined based on the learning information during measurement, and thereby, it is possible to reduce inconvenience in a case where the user S is not in a stable posture during the high-accuracy measurement after the high-accuracy measurement starts. That is, as described above, since the in-measurement learning information on the posture of the user S in the same time zone in the past is used, it is possible to accurately determine the possibility that a stable posture of the user S will be continuously maintained during the measurement in the same time zone. As a result, in a case where there is a high possibility that the user S is not in a stable posture during the high-accuracy measurement after the high-accuracy measurement starts, a situation that the high-accuracy measurement starts is reduced, and high-accuracy measurement can be made only in the time zone in which there is a possibility that the user S is continuously in the stable posture. Thereby, it is possible to further achieve both the increase in opportunity to make the high-accuracy measurement with a high accuracy and the improvement in efficiency of power consumption. A configuration using the in-measurement learning information is suitable for a measurement application in which one measurement time is relatively long.

[0063] In Embodiment 1, the high-accuracy measurement mode and the low-accuracy measurement mode are switched to each other but can be switched to other aspects. For example, instead of being measured in the low-accuracy measurement mode, measurement may not be made (that is, the measurement may be prohibited). Hereinafter, such a modification example will be referred to as a “first modification example”. The first modification is suitable in a case where an electrocardiogram desired by the user S is not a mother electrocardiogram but a fetal electrocardiogram (or in a case of the mother electrocardiogram and the fetal electrocardiogram). A switching aspect according to the first modification example and a switching aspect according to the above-described Embodiment 1 may be selectable by the user S, for example, by a setting change and the like. In the first modification example, prohibition of measurement may be realized by deactivating the electrocardiogram sensor **12**, deactivating the high-performance analog-digital conversion unit **16** and the low-performance analog-digital conversion unit **18**, deactivating the wireless communication module **20** or the like.

[0064] In addition, in Embodiment 1, a success probability for each time zone may be calculated irrespective of the day of the week, the season or the like, and may be calculated according to the day of the week, the season, or the like. Hereinafter, such a modification example will be referred to as a "second modification example". For example, the success probability for each time zone may separately include the success probability for each time zone on a weekday and the success probability for each time zone on a holiday. This is because a life pattern of the user S may be different between the weekday and the holiday. From the same point of view, the success probability for each time zone may be calculated separately for each season, or may be calculated separately for each climate.

[0065] Next, an operation example of the electrocardiogram monitor system **100** will be described with reference to FIGS. **6** to **10**.

[0066] FIG. **6** is a sequence diagram illustrating an example of initial setting processing of the electrocardiogram monitor system **100**. FIG. **6** illustrates a relationship between the electrocardiogram measurement apparatus **1**, the electrocardiogram monitor device **6**, and the user S at the time of initial setting. The sequence illustrated in FIG. **6** may be performed for example, when the electrocardiogram measurement apparatus **1** and the electrocardiogram monitor device **6** are powered on by the user S and a connection between the electrocardiogram measurement apparatus **1** and the electrocardiogram monitor device **6** is established. In addition, the sequence illustrated in FIG. **6** may be performed, for example, when the initialization setting completion flag is "0 (FALSE)". An initial value of the initialization setting completion flag is "0". The initial setting completion flag may be able to be initialized by the user S.

[0067] The wireless control unit **22** of the electrocardiogram measurement apparatus **1** initializes a table (hereinafter, referred to as a "time zone success probability table") representing a desired time zone and success probability (step S**600**). FIG. **7** illustrates an example of the time zone success probability table in an initial state. FIG. **7** illustrates information indicating presence or absence of measurement desire and success probability for each time zone. For the information indicating the presence or absence of the measurement desire, ○ (not illustrated) represents "with desire", and x represents "no desire". An initial value of the information indicating presence or absence of the measurement desire is, for example, "no desire". The initial value of the success probability is, for example, "100".

[0068] Next, the wireless control unit **22** initializes the acceleration sensor **19** (step S**602**). Next, the wireless control unit **22** requests the electrocardiogram monitor device **6** to acquire the desirable posture (hereinafter, referred to as a "measurement desirable posture") of the user S regarding a posture taken by the user S during measurement (step S**604**).

[0069] The electrocardiogram monitor device **6** outputs a message prompting the user S to take a desirable measurement posture in a state where the electrocardiogram measurement apparatus **1** is mounted and to press a predetermined button of the electrocardiogram monitor device **6** in the desirable measurement posture, to the display unit **61** (step S**606**). Other outputs (including a sound output, flickering of a light source, and the like) may be used instead of outputting a message to the display unit **61**. The user S takes a desirable measurement posture in a state where the electrocardiogram measurement apparatus **1** is mounted, and presses a predetermined button (not illustrated) of the electrocardiogram monitor device **6** in the desirable measurement posture. The desirable measurement posture is basically a stable posture, and, for example, a seated posture, a posture in which a user lies on a bed, or the like. Instead of pressing the predetermined button, other operations (including a voice input, a gesture input, and the like) may be used. If the predetermined button of the electrocardiogram monitor device **6** is pressed (step S**608**), the electrocardiogram monitor device **6** transmits information indicating that the measurement desired posture is being taken to the electrocardiogram measurement apparatus **1** (step S**610**).

[0070] If receiving the information indicating that the desirable measurement posture is being taken, the wireless control unit **22** acquires the acceleration signal from the acceleration sensor **19** and stores each value (a_{x0}, a_{y0}, a_{z0}) of accelerations in three axial directions in the learning information storage unit **24** (step S**612**). Each value (a_{x0}, a_{y0}, a_{z0}) of accelerations in three axial directions may be an average value during a certain period or may be a representative value during a certain period. Each value (a_{x0}, a_{y0}, a_{z0}) of the accelerations in the three axial directions functions as a reference value for determining whether or not a posture of the user S is a desirable measurement posture, and is hereinafter referred to as a "reference acceleration value". Next, the wireless control unit **22** requests the electrocardiogram monitor device **6** to acquire a time zone desired to be measured (step S**614**).

[0071] The electrocardiogram monitor device **6** outputs a message for prompting the user S to input the time zone desired to be measured to the display unit **61** (step S**616**). The user S inputs the time zone desired to be measured from an operation unit (not illustrated) of the electrocardiogram monitor device **6**. At this time, it is desirable that the user S inputs a time zone (for example, a time zone of a lunch break) in which there is a high possibility that a stable posture will be positively taken, or a time zone (for example, a time zone immediately before going to bed) in which there is a high possibility that a stable posture is naturally taken, as a time zone in which measurement is desired. Thereby, it is possible to make measurement in a time zone in which there is a high probability that the user S is in a stable posture. If the time zone desired to be measured is input (step S**618**), the electrocardiogram monitor device **6** transmits the time zone desired to be measured to the electrocardiogram measurement apparatus **1** (step S**620**).

[0072] If receiving the time zone desired to be measured, the wireless control unit **22** updates the time zone success probability table (see FIG. **7**) such that the time zone desired to be measured becomes "with desire". If the time zone success probability table is updated based on the time zone desired to be measured, the wireless control unit **22** sets a value of an initial setting completion flag to "1 (TRUE)". Hereinafter, the time zone which becomes "with desire" in the time zone success probability table is referred to as a "desirable measurement time zone".

[0073] In the example illustrated in FIG. **6**, the user S inputs a time zone desired to be measured, but the user S may input time desired to be measured. In this case, a time zone to which the desired time belongs may be treated as the desirable measurement time zone.

[0074] FIGS. **8**A and **8**B are a flowchart illustrating an example of measurement processing performed by the electrocardiogram measurement apparatus **1**. The processing illustrated in FIGS. **8**A and **8**B may be performed, for example, when the electrocardiogram measurement apparatus **1** and the electrocardiogram monitor device **6** are power on by the user S, a connection between the electrocardiogram measurement apparatus **1** and the electrocardiogram monitor device **6** is established, and the initial setting completion flag is set to "1". Alternatively, the processing illustrated in FIGS. **8**A and **8**B may be performed when a measurement start instruction from the user S is input via the electrocardiogram monitor device **6**.

[0075] In the processing illustrated in FIGS. **8**A and **8**B, a retry flag and a repeat flag are used as an example. The retry flag and the repeat flag are set in advance from the following viewpoint: In a case where a user wants to measure the entire time zone regardless of measurement accuracy in one desirable measurement time zone, the retry flag is set to TRUE and the repeat flag is set to TRUE. In a case where the high-accuracy measurement may be able to be performed at least once in the one desirable measurement time zone, the retry flag is set to TRUE and the repeat flag is set to FALSE. If the user wants to perform a high-accuracy measurement as continuously as possible from the beginning in one desirable measurement time zone (that is, in a case where the user wants to end the measurement at a point of time in a case of a low-accuracy measurement even once), the retry flag is set to FALSE and the repeat flag is set to TRUE. In a case where the user wants to perform measurement only once regardless of whether the measurement is a low-accuracy measurement or a high-accuracy measurement in one desirable measurement time zone, the retry flag is set to FALSE, and the repeat flag is set to FALSE. In this way, setting for the retry flag and the repeat flag depends on a measurement usage and the like. The setting for the retry flag and the repeat flag may be able to be changed by the user S.

[0076] In step S**802**, the wireless control unit **22** acquires a current time. The current time can be acquired based on, for example, a timepiece or a timer (both are not illustrated) that are embedded in the electrocardiogram measurement apparatus **1**.

[0077] In step S**804**, the wireless control unit **22** determines whether or not a time zone to which the current time belongs is a desirable measurement time zone with reference to the time zone success probability table (see FIG. **7**). In a case where it is determined that the time zone to which the current time belongs is the desirable measurement time zone, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**806**, and in the other cases, the processing illustrated in FIGS. **8**A and **8**B starts again from step S**802** after a predetermined time passes (for example, after one minute). Hereinafter, the time zone to which the current time belongs is referred to as a "current time zone".

[0078] In step S**806**, the wireless control unit **22** determines whether or not there is switching between time zones. The switching between time zones is switching between a plurality of time zones illustrated in FIG. **7**. In a case where there is the switching of time zone, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**810** via step S**808**, and in the other cases, the processing illustrated in FIGS. **8**A and **8**B skips step S**808** and proceeds to step S**810**.

[0079] In step S**808**, the wireless control unit **22** initializes a probability calculation variable to zero. The probability calculation variable includes a high-accuracy measurement execution number and a low-accuracy measurement execution number. The high-accuracy measurement execution number represents the number of executions of the high-accuracy measurement in the current time zone, and the low-accuracy measurement execution number represents the number of executions of the high-accuracy measurement in the current time zone.

[0080] In step S**810**, the wireless control unit **22** acquires an acceleration signal from the acceleration sensor **19**.

[0081] In step S**812**, the wireless control unit **22** determines whether the acquired acceleration signal satisfies a predetermined criterion. That is, the wireless control unit **22** determines whether or not a posture of the user S is the desirable measurement posture (stable posture). The predetermined criterion is set based on a reference acceleration value. Thereby, it is possible to accurately determine whether or not the posture of the user S is in the desirable measurement posture. For example, the wireless control unit **22** determines whether or not each value in the three axial directions of the acquired acceleration signal is within an error range of the reference acceleration value. In a case where the posture of the user S is the desirable measurement posture, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**814**, and in the other cases, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**828**.

[0082] In step S**814**, the wireless control unit **22** increments a value of the high-accuracy measurement execution number only by "1".

[0083] In step S**816**, the wireless control unit **22** acquires a success probability relating to the current time zone with reference to the time zone success probability table (see FIG. **7**).

[0084] In step S**818**, the wireless control unit **22** determines whether or not the success probability relating to the current time zone is greater than or equal to a predetermined threshold value. In a case where the success probability is greater than or equal to the predetermined threshold value, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**820**, and in the other cases, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**822**.

[0085] In step S**820**, the wireless control unit **22** performs a high-accuracy measurement (measurement in a high-accuracy measurement mode). The high-accuracy measurement may be continuously performed for a predetermined period (for example, one minute). If the high-accuracy measurement (high-accuracy measurement for one time) for the predetermined period is completed, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**824**.

[0086] In step S**822**, the wireless control unit **22** performs a low-accuracy measurement (measurement in a low-accuracy measurement mode). The low-accuracy measurement may be continuously performed for a predetermined period (for example, one minute). If the low-accuracy measurement (low-accuracy measurement for one time) for the predetermined period is completed, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**824**.

[0087] In step S**824**, the wireless control unit **22** determines whether or not the current time zone is expired. For example, when the current time zone is "13:00-13:10", the current time zone is expired at **13**:**10**. In a case where the current time zone is expired, the processing illustrated in FIGS. **8**A and **86** proceeds to step S**836**, and in the other cases, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**826**.

[0088] In step S**826**, the wireless control unit **22** checks the repeat flag. In a case where the repeat flag is "TRUE", the processing illustrated in FIGS. **8**A and **8**B returns to step S**810**, and a new measurement is repeated. Meanwhile, in a case where the repeat flag is "FALSE", the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**836**.

[0089] In step S**828**, the wireless control unit **22** increments a value of the low-accuracy measurement execution number only "1".

[0090] In step S**830**, the wireless control unit **22** performs a low-accuracy measurement (measurement in the low-accuracy measurement mode). The low-accuracy measurement may be continuously performed for a predetermined period (for example, one minute). If the low-accuracy measurement (low-accuracy measurement for one time) for the predetermined period is completed, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**832**.

[0091] In step S**832**, the wireless control unit **22** determines whether or not the current time zone is expired. In a case where the current time zone is expired, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**836**, and in the other cases, the processing illustrated in FIGS. **8**A and **8**B proceeds to step S**834**.

[0092] In step S**834**, the wireless control unit **22** checks the retry flag. In a case where the retry flag is "TRUE", the processing illustrated in FIGS. **8**A and **8**B returns to step S**810**, and a new high-accuracy measurement is attempted. Meanwhile, in a case where the retry flag is "FALSE", the processing proceeds to step S**836**.

[0093] In step S**836**, the wireless control unit **22** calculates a success probability in the current time zone, based on each value of the high-accuracy measurement execution time and the low-accuracy measurement execution time, and each state of the repeat flag and the retry flag. FIG. **9** is an explanatory diagram of a method of calculating the success probability in step S**836**. In FIG. **9**, five time zones T1 to T5 are denoted every 10 minutes from 12:00 to 12:50. In FIG. **9**, it is assumed that one measurement (interval) takes 1 minute, all the time zones T1 to T5 are the desirable measurement time zones, and the success probability relating to all the time zones T1 to T5 is greater than or equal to a predetermined threshold value. In FIG. **9**, each section of the acceleration is classified corresponding to each measurement period every minute, "○" in the section means that an acceleration signal in the measurement period satisfies a predetermined criterion, and "x" means that the acceleration signal in the measurement period does not satisfy the predetermined criterion. In addition, in FIG. **9**, each section of the electrocardiogram measurement is divided corresponding to each measurement of one time, "high" in the section means that the high-accuracy measurement is performed, and "low" in the section means that the low-accuracy measurement is performed.

[0094] In a case where the retry flag is TRUE and the repeat flag is TRUE, a success probability Ps in the current time zone may be as follows.

$$Ps=N1/(N1+N2)$$

[0095] Here, N1 is a value of the high-accuracy measurement execution number, and N2 is a value of the low-accuracy measurement execution number. In FIG. **9**, the retry flag is TRUE and the repeat flag is TRUE in a time zone T1 between of 12:00 and 12:10, 10 measurements are performed, and N1=6 and N2=4. In this case, Ps=60 (=6/10×100) [%].

[0096] Meanwhile, in a case where both the retry flag and the repeat flag are not TRUE (that is, in a case where the retry flag is not TRUE or the repeat flag is not TRUE), the success probability Ps in the current time zone depends on the value of the high-accuracy measurement execution number, and may be as follows.

$$Ps=100\ (N1\geq 1)$$

$$Ps=0\ (N1=0)$$

[0097] In FIG. **9**, in a time zone T2 between 12:10 and 12:20, the retry flag is TRUE and the repeat flag is FALSE, and the high-accuracy measurement can be realized in a fourth measurement. In this case, Ps becomes 100[%]. In addition, in a time zone T3 between 12:20 and 12:30, the retry flag is FALSE and the repeat flag is TRUE, and the high-accuracy measurement can be consecutively performed from the first measurement to the third measurement. In this case, Ps becomes 100[%]. In addition, in a time zone T4 between 12:30 and 12:40, the retry flag is FALSE and the repeat flag is FALSE, and the first measurement is the high-accuracy measurement. In this case, Ps becomes 100 [%]. In addition, in a time zone T5 between 12:40 and 12:50, the retry flag is FALSE and the repeat flag is FALSE, and the first measurement is the low-accuracy measurement. In this case Ps becomes 0[%].

[0098] In step S**838**, the wireless control unit **22** updates the time zone success probability table, based on the success probability Ps, which is calculated in step S**836**, in the current time zone. For example, the wireless control unit **22** may overwrite the success probability in the same time zone in the time zone success probability table with the success probability Ps in the current time zone calculated in step S**836**. Alternatively, the wireless control unit **22** may update the success probability in the same time zone in the time zone success probability table by averaging the success probability Ps in the current time zone calculated in step S**836** and each success probability in the same time zone corresponding to a predetermined number of recent days. FIG. **10** illustrates a table in which the success probabilities for N days is stored. In this case, the success probability for each time zone is calculated by averaging the success probabilities of N days for each time zone. For example, the success probability relating to the time zone between 13:00 and 13:10 is calculated by averaging the success probabilities (A, B, . . . , C) for N days in the same time zone. If the processing of step S**838** ends, the processing illustrated in FIGS. **8**A and **8**B returns to step S**802**.

[0099] In the example illustrated in FIGS. **8**A and **8**B, the repeat flag and the retry flag are used so as to be able to flexibly cope with a change or the like of a measurement usage, but any one or both of the flags may be omitted (hereinafter, the modification example is referred to as a "third modification example"). For example, in a case where the retry flag may be fixed to TRUE and the repeat flag may be fixed to TRUE, the determinations in step S**826** and step S**834** may be omitted.

[0100] In the example illustrated in FIGS. **8**A and **8**B, whether or not there is a possibility that a stable posture of the user S is maintained is determined based on learning information in step S**818**, but the learning information may not be used (hereafter, the modification example is referred to as a "fourth modification example"). In this case, the step **S808**, the step **S814**, the step **S816**, the step **S818**, the step **S822**, the step **S828**, the step **S836**, and the step **S838** may be omitted in FIGS. **8**A and **8**B. In FIGS. **8**A and **8**B, in a case where the result of the determination in step **S812** is "YES", the processing illustrated in FIGS. **8**A and **8**B may proceed to step **S820**. In the fourth modification example, actually, the measurement mode is switched between the high-accuracy measurement mode and the high-accuracy measurement mode, based on only the acceleration signal when the measurement starts. The fourth modification example is suitable in a case where two kinds of biological signals (that is, the mother electrocardiogram and the fetal electrocardiogram) are measured by a common biological sensor as in Embodiment 1 described above and one measurement period is relatively short.

[0101] In addition, in the example illustrated in FIGS. **8**A and **8**B, whether or not the time zone to which the current time belongs is the desirable measurement time zone is determined in Step **S804**, but the determination may be omitted (hereinafter, the modification example is referred to as a fifth modification example). In the fifth modification example, steps **S614** to **S622** may be omitted in the initial setting processing illustrated in FIG. **6**.

[0102] In addition, in the example illustrated in FIGS. **8**A and **8**B, the determination in step **S818** is performed only when the measurement starts but may be continuously performed during the measurement after the measurement starts (hereinafter, the modification example is referred to as a "sixth modification example"). That is, the above-described in-measurement learning information may be generated. In the sixth modification example, step **S814** is omitted, and instead thereof, the determination of step **S812** is repeated step **S820** may be performed during the measurement in step **S820**. Then, in a case where the number of times or a ratio at which the determination result of step **S812** is "YES" during one measurement made in step **S820** is greater than or equal to the predetermined threshold value, the value of the high-accuracy measurement execution number may be incremented only by "1".

[0103] The third to sixth modification examples can be combined in a random aspect.

[0104] FIG. **11** is diagram illustrating an example of a hardware configuration of the wireless control device **21** of the electrocardiogram monitor device **6**. In the example illustrated in FIG. **11**, the wireless control device **21** includes a control unit **101**, a main storage unit **102**, an auxiliary storage unit **103**, a drive device **104**, a network I/F unit **106**, and an input unit **107**.

[0105] The control unit **101** is an arithmetic device that executes a program stored in the main storage unit **102** or the auxiliary storage unit **103**, receives data from the input unit **107** or the storage device, an arithmetic operation and processing for the data are performed, and thereafter, the data is output to the storage device or the like.

[0106] The main storage unit **102** is a read only memory (ROM), a random access memory (RAM), or the like. The main storage unit **102** is a storage device that stores or temporarily retains an operating system (OS) that is a basic software executed by the control unit **101**, a program such as an application software, and data.

[0107] The auxiliary storage unit **103** is a storage device that is a flash memory, a hard disk drive (HDD), or the like and stores data relating to application software. The auxiliary storage unit **103** may form the learning information storage unit **24** described above.

[0108] The drive device **104** reads a program from a recording medium **105**, for example, a flexible disk, and installs the program in the storage device.

[0109] The recording medium **105** stores a program. The program stored in the recording medium **105** is installed in the wireless control device **21** via the drive device **104**. The installed predetermined program can be executed by the wireless control device **21**.

[0110] The network I/F unit **106** is an interface between a peripheral device (for example, a sensor module **10** or the wireless transmission and reception unit **26**) having a communication function via a network constructed by a data transmission line such as a wired and/or a wireless line, and the wireless control device **21**.

[0111] The input unit **107** includes a keyboard, a mouse, a touch pad, and the like, which include a cursor key, numeric input and various function keys, and the like.

[0112] In the example illustrated in FIG. **11**, the above-described various kinds of processing of the wireless control unit **22** can be realized by executing a program in the wireless control device **21**. In addition, it is also possible to realize various kinds of processing of the wireless control unit **22** described above by recording the program in the recording medium **105** and making the wireless control device **21** read the program stored in the recording medium **105**. The recording medium **105** can use various kinds of recording media. For example, the recording medium **105** may be a recording medium such as a compact disc (CD)-ROM, a flexible disk, or a magnetooptical disk for recording information optically, electrically or magnetically, a semiconductor memory such a ROM or a flash memory for electrically recording information, or the like. The recording medium **105** does not include a carrier wave.

Embodiment 2

[0113] FIG. **12** is a diagram illustrating a configuration example of an electrocardiogram measurement apparatus **1**A (an example of a measurement apparatus) according to Embodiment 2. In Embodiment 2 which will be described below, the same configuration elements as those described in Embodiment 1 described above are denoted by the same reference numerals or symbols as in FIG. **12** and description thereof will be omitted.

[0114] In Embodiment 1 described above, the accuracy of the measurement data of the electrocardiogram sensor **12** is changed by switching between the high-performance ADC **16** and the low-performance ADC **18**, but in the following Embodiment 2, the accuracy of the measurement data of the electrocardiogram sensor **12** is changed in an aspect different from the above-described Embodiment 1. Although description will be specifically made hereinafter, the accuracy of the measurement data of the electrocardiogram sensor **12** is changed by a wireless communication module **20**A in Embodiment 2.

[0115] The electrocardiogram measurement apparatus **1**A includes a sensor module **10**A and a wireless communication module **20**A.

[0116] The sensor module **10**A is different from the sensor module **10** according to Embodiment 1 described above in that the switch **14** and the low-performance ADC **18** are omitted. An analog electrocardiogram signal from the electrocardiogram sensor **12** is input to the high-performance

ADC **16**. The high-performance ADC **16** converts the analog electrocardiogram signal into a digital electrocardiogram signal. The high-performance ADC **16** outputs the digital electrocardiogram signal to a wireless control unit **22**A through a serial communication.

[0117] The wireless communication module **20**A is different from the wireless communication module **20** according to Embodiment 1 described above in that the wireless control device **21** is replaced with a wireless control device **21**A. The wireless control device **21**A is different from the wireless control device **21** according to Embodiment 1 described above in that the switch **28** is omitted and the wireless control unit **22** is replaced with a wireless control unit **22**A (an example of a processing unit).

[0118] The wireless control unit **22**A determines a posture of the user S, based on the acceleration signal from the acceleration sensor **19** in the same manner as in Embodiment 1 described above. The wireless control unit **22**A changes the accuracy of the measurement data of the electrocardiogram sensor **12**, based on the posture of the user S. Specifically, the wireless control unit **22**A decreases the accuracy of the measurement data of the electrocardiogram sensor **12** by performing interleaving processing for the electrocardiogram signal obtained from the high-performance ADC **16**. The interleaving processing may be performed by, for example, at least one of reduction of a resolution of the electrocardiogram signal and resampling of the electrocardiogram signal. By doing so, the wireless control unit **22**A transmits measurement data obtained by changing the accuracy in accordance with the posture to the wireless transmission and reception unit **26**.

[0119] In the same manner as Embodiment 1 described above, the wireless control unit **22**A preferably changes the accuracy of the measurement data of the electrocardiogram sensor **12**, based on learning information about a posture of the user S in a predetermined time zone in addition to the posture of the user S. Thereby, it is possible to achieve both an increase in opportunity to make a high-accuracy measurement and improvement in efficiency of power consumption, as described above.

[0120] In this way, in Embodiment 2, the "high-accuracy measurement" in Embodiment 1 described above is realized as the wireless control unit **22**A does not perform the interleaving processing, and the "low-accuracy measurement" in Embodiment 1 is realized as the wireless control unit **22**A performs the interleaving processing.

[0121] FIG. **13** is a diagram schematically illustrating a time series of power consumption of the electrocardiogram sensor **12** and the like during a high-accuracy measurement, and FIG. **14** is a diagram schematically illustrating the time series of the power consumption of the electrocardiogram sensor **12** and the like during a low-accuracy measurement.

[0122] In the examples illustrated in FIGS. **13** and **14**, the electrocardiogram signal is converted into a digital signal with 16 samples×24 bits (3 bytes) by the high-performance ADC **16** during a measurement period of 80 ms.

[0123] During the high-accuracy measurement (FIG. **13**), the electrocardiogram signal from the high-performance ADC **16** is not subjected to interleaving processing in the wireless control unit **22**A. Accordingly, measurement data based on the electrocardiogram signal from the high-performance ADC **16** is transmitted as three packets. In contrast to this, during the low-accuracy measurement (FIG. **14**), the electrocardiogram signal from the high-performance ADC **16** is subjected to the interleaving processing in the wireless control unit **22**A. For example, in a case where the interleaving processing for resampling at 100 Hz is performed, the number of packets is reduced from 3 to 1.5 (≈2). In addition, for example, in a case where the interleaving processing for cutting down to accuracy of 16 bits is performed, the number of packets is reduced from 3 to 2. In this way, in the wireless transmission and reception unit **26**, power consumption in the high-accuracy measurement is also increased because the number of packets to be transmitted is larger than in the low-accuracy measurement.

[0124] The operation examples (including the third to sixth modification examples described above) described with reference to FIGS. **6** to **10** in Embodiment 1 are also applied to Embodiment 2 in the same manner. However, as described above, in Embodiment 2, the "high-accuracy measurement mode" in Embodiment 1 corresponds to the mode in which the interleaving processing is not performed, and the "low-accuracy measurement mode" in Embodiment 1 corresponds to the mode in which the interleaving processing is performed.

[0125] The same effect as in Embodiment 1 described above is also obtained in Embodiment 2. According to Embodiment 2, a hardware configuration can be simplified as compared with Embodiment 1 described above, as can be seen from a comparison between FIG. **2** and FIG. **12**. In Embodiment 2, modification examples such as the first modification example and the second modification example in Embodiment 1 described above can also be used. In Embodiment 2, prohibition of measurement according to the first modification example is actually equivalent to a fact that a sampling frequency of a measurement value of the electrocardiogram sensor **12** is lower than a frequency corresponding to one time zone. Alternatively, in Embodiment 2, the prohibition of measurement according to the first modification example is actually equivalent to a fact that a resolution of the measurement value of the electrocardiogram sensor **12** is reduced to zero bit.

Embodiment 3

[0126] FIG. **15** is a diagram illustrating a configuration example of an electrocardiogram measurement apparatus **1**B (an example of a measurement apparatus) according to Embodiment 2. The electrocardiogram measurement apparatus **1**B includes a sensor module **10**B and a wireless communication module **20**B.

[0127] The sensor module **10**B is different from the sensor module **10** according to Embodiment 1 described above in that the switch **14**, the high-performance ADC **16**, and the low-performance ADC **18** are replaced with a microcomputer **13**. The microcomputer **13** is hereinafter referred to as a "sensor micom **13**". The sensor micom **13** includes an arithmetic circuit and memory **131**, an ADC **132** (hereinafter, referred to as an "ADC **132**"), communication units **133** and **134**, and a control unit **135** (an example of a processing unit).

[0128] A storage unit of the arithmetic circuit and memory **131** realizes the learning information storage unit **24** that stores the learning information described above.

[0129] The low-performance ADC **132** may have the same configuration as the above-described high-performance ADC **16**. The low-performance ADC **132** provides the control unit **135** with an electrocardiogram signal converted into a digital format.

[0130] The communication unit **133** acquires an acceleration signal from the acceleration sensor **19** through a serial communication and provides the acquired acceleration signal to the control unit **135**.

[0131] The communication unit **134** transmits the data obtained from the control unit **135** or the like to the wireless communication module **20**B through a serial communication.

[0132] The control unit **135** performs the same function as the wireless control unit **22**A according to Embodiment 2 described above. That is, the control unit **135** determines a posture of the user S, based on the acceleration signal from the acceleration sensor **19**. The control unit **135** changes accuracy of measurement data of the electrocardiogram sensor **12** through the interleaving processing, based on the posture of the user S. In the same manner, the control unit **135** preferably changes the accuracy of the measurement data of the electrocardiogram sensor **12**, based on learning information on the posture of the user S in a predetermined time zone (a plurality of times zones can be used), in addition to the posture of the user S.

[0133] In this way, in Embodiment 3, the "high-accuracy measurement" in Embodiment 1 is realized as the control unit **135** does not perform the interleaving processing, and the "low-accuracy measurement" is realized as the control unit **135** performs the interleaving processing.

[0134] The wireless communication module **20**B is different from the wireless communication module **20** according to Embodiment 1 in that the wireless control device **21** is replaced with a wireless control device **21**B. The wireless control device **21**B is different from the wireless control device **21** according to Embodiment 1 described above in that the switch **28** and the learning information storage unit **24** do not exist and the wireless control unit **22** is replaced with the wireless control unit **22**B.

[0135] The wireless control unit **22**B transmits the measurement data of the electrocardiogram sensor **12** obtained from the sensor module **10**B to the wireless transmission and reception unit **26**.

[0136] The operation examples (including the third to sixth modification examples described above) described with reference to FIGS. **6** to **10** in Embodiment 1 are also applied to Embodiment 3 in the same manner. However, as described above, in Embodiment 3, the "high-accuracy measurement mode" in Embodiment 1 corresponds to the mode in which the interleaving processing is not performed, and the "low-accuracy measurement mode" in Embodiment 1 corresponds to the mode in which the interleaving processing is performed.

[0137] The same effect as in Embodiment 1 described above is also obtained in Embodiment 3. According to Embodiment 3, the sensor micom **13** is included, and thereby, a processing load of the wireless control unit **22** can be reduced compared with Embodiment 1 described above. In Embodiment 3, modification examples such as the first modification example and the second modification example in Embodiment 1 described above can also be used. In Embodiment 3, prohibition of measurement according to the first modification example is actually equivalent to a fact that a sampling frequency of a measurement value of the electrocardiogram sensor **12** is lower than a frequency corresponding to one time zone. Alternatively, in Embodiment 3, the prohibition of measurement according to the first modification example is actually equivalent to a fact that a resolution of the measurement value of the electrocardiogram sensor **12** is reduced to zero bit.

[0138] As described above, although the respective embodiments are described in detail, the present disclosure is not limited to a specific embodiment, various modifications and changes can be made within a range described in the scope of claims. In addition, it is also possible to combine all or some of the configuration elements of the embodiments described above.

[0139] For example, in Embodiment 1 to Embodiment 3 described above, an electrocardiogram is a biological signal to be measured, but other biological signals (for example, an electrograph, an electromyogram, a pulse wave, or the like) may be a person to be measured. In addition, various kinds of biological information (for example, a heartbeat, a pulse, and the like) may be acquired based on the measured biological signal.

[0140] In addition, in Embodiment 1 to Embodiment 3 described above, the acceleration sensor **19** is used to detect a posture of the user S, but other sensors (for example, a gyro sensor, an image sensor, and the like) may be used instead of the acceleration sensor **19** or in addition to the acceleration sensor **19**. For example, in a case where an image sensor is used, it is possible to determine whether or not the user S is in a stable posture by image recognition, based on an image of a plurality of frames.

[0141] In addition, in Embodiment 1 to Embodiment 3 described above, learning information in the learning information storage unit **24** is generated (updated) during an operation, but learning information in the learning information storage unit **24** may be acquired from the outside as previously generated information.

[0142] All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a illustrating of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A measurement apparatus comprising:

a biological sensor configured to measure a biological signal of a person to be measured; and

a processor configured to:

acquire posture information on a posture of the person to be measured; and

change accuracy of measurement data of the biological sensor, based on the acquired posture information.

2. The measurement apparatus according to claim **1**, wherein, in a case where the posture of the person to be measured is a stable posture, the processor increases the accuracy of the measurement data of the biological sensor, compared with a case where the posture of the person to be measured is not the stable posture.

3. The measurement apparatus according to claim **1**, wherein the accuracy of the measurement data includes at least one of a resolution of a value that is measured by the biological sensor and a sampling frequency.

4. The measurement apparatus according to claim **3**, wherein, in a case where the posture information that is acquired in a first time zone satisfies a criterion, the processor increases at least one of the resolution of the value that is measured by the biological sensor in the first time zone and the sampling frequency, compared with a case where the posture information which is acquired in the first time zone does not satisfy the criterion.

5. The measurement apparatus according to claim **4**, wherein, in a case where the posture information that is acquired in the first time zone does not satisfy the criterion, the processor prohibits measurement which is performed by the biological sensor.

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

a learning information storage configured to store learning information on the posture of the person to be measured in a past first time zone,

wherein the processor changes the accuracy of the measurement data in a current first time zone, based on the posture information that is acquired in the current first time zone and the learning information.

7. The measurement apparatus according to claim **6**, wherein the learning information includes information indicating whether or not the posture information relating to the past first time zone satisfies a criterion.

8. The measurement apparatus according to claim **6**, wherein the learning information indicates a probability that the posture information on the past first time zone satisfies a criterion.

9. The measurement apparatus according to claim **8**, wherein, in a case where the probability is greater than or equal to a threshold value, the processor increases at least one of a resolution of a value that is measured by the biological sensor in the current first time zone and a sampling frequency, compared with a case where the probability is less than the threshold value.

10. The measurement apparatus according to claim **9**, wherein, in a case where the probability is less than the threshold value, the processor prohibits measurement that is performed by the biological sensor.

11. The measurement apparatus according to claim **8**, wherein, in a case where the probability is greater than or equal to a threshold value and the posture information that is acquired in the current first time zone satisfies the criterion, the processor increases at least one of a resolution of a value that is measured by the biological sensor in the current first time zone and a sampling frequency, compared with a case where the probability is not greater than the threshold value and the posture information that is acquired in the current first time zone does not satisfy the criterion.

12. The measurement apparatus according to claim **4**, wherein the first time zone is a time zone that is designated by the person to be measured.

13. The measurement apparatus according to claim **7**, wherein the processor updates the learning information, based on a result of determination on whether or not the posture information that is acquired in the current first time zone satisfies the criterion.

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

a first analog-digital converter configured to convert an analog signal of the biological sensor into a digital signal; and

a second analog-digital converter configured to convert the analog signal of the biological sensor into the digital signal in a state where at least one of a resolution and a sampling frequency is lower than a resolution and a sampling frequency of the first analog-digital converter,

wherein the processor is coupled to the first analog-digital converter and the second analog-digital converter, and

wherein the accuracy of the measurement data includes a selectively use of the first analog-digital converter or the second analog-digital converter.

15. The measurement apparatus according to claim **1**, wherein the biological signal is an electrocardiogram.

16. The measurement apparatus according to claim **1**,

wherein the accuracy of the measurement data includes selectively use of a measurement mode of the biological sensor between a first measurement mode in which the biological sensor measures a first biological signal of the person to be measured and a second measurement mode in which the biological sensor measures a second biological signal which has a smaller amplitude than the first biological signal, in addition to the first biological signal.

17. The measurement apparatus according to claim **16**, wherein the first biological signal is an electrocardiogram of the person to be measured and the second biological signal is an electrocardiogram of a fetus of the person to be measured.

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

a posture sensor configured to detect the posture of the person to be measured,

wherein the processor acquires the posture information from the posture sensor.

19. The measurement apparatus according to claim **4**, wherein the criterion is set based on the posture information when the posture of the person to be measured is a stable posture.

20. A non-transitory computer-readable recording medium recording a measurement program which causes a computer to execute a process, the process comprising:

acquiring posture information on a posture of a person to be measured; and

changing accuracy of measurement data of a biological sensor configured to measure a biological signal of the person to be measured, based on the acquired posture information.

* * * * *

patsnap

专利名称(译)	测量装置和记录介质记录测量程序		
公开(公告)号	[US20180338698A1](US20180338698A1)	公开(公告)日	2018-11-29
申请号	US16/055519	申请日	2018-08-06
[标]申请(专利权)人(译)	富士通株式会社		
申请(专利权)人(译)	FUJITSU LIMITED		
当前申请(专利权)人(译)	FUJITSU LIMITED		
[标]发明人	YOSHIMURA KAZUHIRO		
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IPC分类号	A61B5/0452 A61B5/024 A61B5/00		
CPC分类号	A61B5/0452 A61B5/02405 A61B5/0006 A61B5/02444 A61B5/0402 A61B5/0428 A61B5/1116 A61B5/1118 A61B5/721 A61B5/7221 A61B2562/0219		
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摘要(译)

一种测量装置，包括：生物传感器，被配置为测量被测量者的生物信号;以及处理器，被配置为：获取关于被测量者的姿势的姿势信息，以及改变生物传感器的测量数据的准确度，基于获取的姿势信息。