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(54) **Apparatus and Method for mobile health care based on biomedical signals**

Vorrichtung und Verfahren zur mobilen Gesundheitsüberwachung auf der Grundlage biomedizinischer Signale

Dispositif et procédé pour le contrôle de l'état de santé basés sur des biosignaux

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Description

[0001] The present invention relates to a mobile device capable of performing biomedical signal measurement and a health care method using the same. More particularly, the present invention relates to a mobile device capable of checking a user's state of health using a handheld mobile device mounted with a biomedical signal measurement module, which can be used both as a mobile device and in measuring biomedical signals if necessary, and a health care method using the same.

[0002] As industrial societies have developed, the modem people have suffered greatly from various kinds of adult diseases such as hypertension, corpulence, diabetes and cardiac disorders due to stress from heavy workloads and lack of physical exercise, and accordingly, the death rate tends to increase every year. Such an increase of adult diseases and the resultant death rate allows modem people to gradually pay attention to their own health. Thus, devices for allowing their own health state to be examined at any time have been actively developed.

[0003] Typical health care devices capable of examining the current state of health of a user include blood pressure gauges, thermometers, body fat analyzers, and the like. These devices are widely used in a variety of fields for the purpose of medical or non-medical treatment.

[0004] However, since most of the blood pressure gauges, thermometers and body fat analyzers should be provided with additional devices to check the user's health, they are improper for portable use. Due to the inconvenience of carrying these devices, it is difficult to perform continuous health care monitoring for users.

[0005] As a device for avoiding such inconvenience of carrying extra devices, a mobile communication terminal capable of diagnosing the cardiac function of a user or checking their obesity based on heart rate and body fat percentage detected from a user's body is disclosed in Korean Patent Laid-Open Publication No. 2002-11730 (publication date: February 9, 2002), as shown in FIG. 1. However, the mobile communication terminal cannot provide countermeasures for overcoming stress that may be fatal to modem people living in a highly competitive society. Furthermore, another device is required for managing a user's mental state of health as well as the physical condition of the user.

[0006] EP 1027860 A1 and WO 02/33846 A1 each disclose a mobile device having a number of integrated electrodes or sensors.

[0007] WO 02/060380 A2 discloses an ultrasonic transceiver unit for measuring bone density. The unit docks, interfaces, plugs into, or otherwise is in contact or communication with a personal digital assistant.

[0008] Picard et al: "Toward Machine Emotional Intelligence: Analysis of Affective Physiological State", IEEE Transactions of Pattern Analysis and Machine Intelligence, vol. 23, no. 10, October 2001, discloses a technique for analysing the user's emotional state based on a plurality of biomedical signals comprising feature analysis for analysing features of the biomedical signals detected from the user's body, a subtraction operation for obtaining differences between the features determined by the feature analysis and a baseline information on the users emotional state and classifying the user's emotional state by determining one of a plurality of emotions.

[0009] According to a first aspect of the present invention, there is provided a mobile device comprising an input unit, a display unit, a memory unit and a central control unit, the mobile device comprising: a biomedical signal measurement module for detecting biomedical signals from a user's body, classifying the detected biomedical signals by respective signals and outputting the classified signals; and a health care module for analyzing a user's emotional state and physical condition based on the classified signals input from the biomedical signal measurement module and user's physical information, the health care module comprising an emotional state analysis unit for analyzing the biomedical signals input from the biomedical signal measurement module and determining the user's emotional state and a physical condition analysis unit for analyzing the user's physical condition based on the biomedical signals input from the biomedical signal measurement module and the user's physical information, wherein the emotional state analysis unit comprises: a feature analysis unit for analyzing features of the biomedical signals detected from the user's body; a subtracter unit for obtaining differences between the analysis results from the feature analysis unit and feature values on which the user's emotional state is determined; and a support vector machine, hereinafter SVM, unit for analyzing the differences of the feature values obtained by the subtracter unit, classifying the user's emotional state, and calculating and outputting an index and level for a specific emotion among the classified emotions.

[0010] Preferably, a heart rate sensor is included for detecting heartbeat-related biomedical signals, and the biomedical signals of heartbeat are PPG signals.

[0011] Preferably, a skin temperature sensor is included for detecting skin temperature-related biomedical signals, and the biomedical signals of skin temperature are SKT signals.

[0012] Preferably, a skin resistance sensor is included for detecting skin resistance-related biomedical signals. The biomedical signals of skin resistance are preferably EDA signals.

[0013] Preferably, a body fat sensor is included for measuring body impedance required for calculation of a body fat percentage.

[0014] Each of the heart rate sensor, skin temperature sensor, skin resistance sensor and body fat sensor preferably comprises a filter for filtering the detected biomedical signals and an amplifier for amplifying the filtered biomedical signals.

[0015] The sensor control unit preferably corrects user-to-user variation of the biomedical signals which are output from the sensor unit.

[0016] Preferably, the biomedical signal measurement module is constructed in the form of a case capable of accommodating the mobile device therein.

[0017] The feature analysis unit preferably comprises a heartbeat analysis unit for receiving PPG signals to detect heartbeat signals and extracting feature values related to the heartbeat signals; a skin conductive response analysis unit for receiving EDA signals and extracting feature values related to a skin conductive response; and a skin temperature analysis unit for receiving SKT signals and extracting feature values related to skin temperature.

[0018] The heartbeat analysis unit preferably comprises a heartbeat detection unit for receiving the PPG signals to detect the heartbeat signals and converting the detected heartbeat signals into time series signals of heart rate variability; a spectrum analysis unit for analyzing a spectrum of the heartbeat signals in response to the time series signals of the heart rate variability; and a mean/standard deviation calculation unit for calculating a mean value and standard deviation value of the heartbeat signals in response to the time series signals of the heart rate variability.

[0019] The heartbeat detection unit preferably comprises a band pass filter for extracting signals falling within a specific band of the PPG signals; a median filter for removing noise existing in the filtering results of the band pass filter; an adder for calculating a difference between the filtering results of both the band pass filter and the median filter by adding a reciprocal number of the filtering result of the median filter to the filtering result of the band pass filter; a marched filter for extracting the heartbeat signals from output signals of the adder, and a zero clipper for performing zero clipping for the heartbeat signals.

[0020] The subtracter unit preferably uses feature values of a user's normal emotion as the feature values on which the user's emotional state is determined based.

[0021] The SVM unit may comprise an SVM classifier for classifying the user's emotional state into a plurality of categories by analyzing the differences of the features values obtained from the subtracter unit; and an emotional state determination unit for selecting values related to the specific emotion among values of the plurality of emotions classified by the SVM classifier and calculating and outputting the index and level for the specific emotion. At this time, the SVM unit further preferably comprises a database for storing a plurality of pieces of emotion data for training the SVM classifier, and trained results of the SVM classifier based on the emotion data.

[0022] The physical condition analysis unit preferably comprises a body fat percentage calculation unit for calculating body fat percentage based on a body impedance value detected by the biomedical signal measurement module and user's height, weight, age and sex; and a calorie consumption calculation unit for calculating calorie consumption due to exercise based on average heart rates and body fat percentages before/after exercise detected by the biomedical signal measurement module.

[0023] According to a second aspect of the present invention, there is provided a method of analyzing biomedical signals of a user using a mobile device, the method comprising classifying biomedical signals by respective signal and analyzing the user's emotional state and physical condition based on the classified signals and the user's physical information by: analyzing the biomedical signals and extracting a plurality of feature values to be used for determining user's emotional state; calculating differences between the plurality of extracted feature values and feature values on which the user's emotional state is based; classifying the user's emotional state by respective emotions based on support vector machine, hereinafter SVM, classification according to the calculated differences of the feature values; and selecting values related to an emotion selected among the classified emotions, calculating an emotional state index and level for the selected emotion, and displaying the calculated emotional state index and level on a display unit of the mobile device.

[0024] The biomedical signals preferably include biomedical signals of heartbeat. Preferably, the biomedical signals of heartbeat are PPG signals.

[0025] The biomedical signals preferably include skin temperature-related biomedical signals. Preferably, the biomedical signals of skin temperature are SKT signals.

[0026] The biomedical signals preferably include skin resistance-related biomedical signals. Preferably, the biomedical signals of skin resistance are EDA signals.

[0027] The biomedical signals preferably are filtered by a filter and then amplified by an amplifier.

[0028] The health care method preferably further comprises the step of correcting user-to-user variation of the biomedical signals.

[0029] The step of correcting the user-to-user variation of the biomedical signals preferably comprises the steps of determining whether the correction of the user-to-user variances of the biomedical signals is required; if it is determined that the correction of the user-to-user variances of the biomedical signals is required, checking whether values of the biomedical signals are above a maximum limit level and decreasing a gain of an amplifier if the values of the biomedical signals are above the maximum limit level; and if the values of the biomedical signals are equal to or less than the maximum limit level, checking whether the values of the biomedical signals are equal to or less than a minimum limit level and increasing the gain of the amplifier if the values of the biomedical signals are equal to or less than the minimum limit level.

[0030] The step of analyzing the biomedical signals and extracting the plurality of feature values to be used for determining the user's emotional state preferably comprises the steps of receiving PPG signals to detect heartbeat signals and extracting feature values related to the heartbeat signals; receiving EDA signals and extracting feature values related to a skin conductive response; and receiving SKT signals and extracting feature values related to skin temperature.

[0031] The feature values on the basis of which the user's emotional state is determined are preferably feature values of user's normal emotion.

[0032] The step of classifying the user's emotional state by the respective emotions preferably uses an SVM classifier that classifies the user's emotional state into a plurality of categories based on a statistical learning theory.

[0033] The health care method preferably further comprises the steps of selection by the user of a menu on the mobile device; selection by the user of body fat from the menu; and calculating a body fat percentage of the user's body based on a body impedance of the user and the user's physical information, and displaying the calculated body fat percentage on the display unit of the mobile device.

[0034] The health care method preferably further comprises the steps of: selection by the user of a menu on the mobile device; selection by the user of calorie consumption from the menu; and analyzing heartbeat signals of the user and a body impedance of the user before/after exercise to calculate average heart rates and body fat percentages before/after exercise, calculating calorie consumption due to exercise based on the calculated average heart rates and body fat percentages before/after exercise, exercise time, and user's physical information, and displaying the calculated calorie consumption on the display unit of the mobile device.

[0035] The health care method preferably further comprises the step of, if the user selects history management, displaying results according to respective desired terms on the display unit.

[0036] The above and other features of the present invention will become apparent from the following description of a preferred embodiment given in conjunction with the accompanying drawings, in which:

FIG. 1 is a view of a mobile communication terminal with a conventional biomedical information measurement module included therein;
FIG. 2 is a block diagram schematically illustrating a mobile device according to the present invention;
FIG. 3 is a view showing an interior configuration of a biomedical signal measurement module of the mobile device shown in FIG. 2;
FIG. 4 is a graph plotting waveforms of EDA signals measured by a skin resistance sensor unit of FIG. 3;
FIG. 5 is a view illustrating how to correct user-to-user variation of the EDA signal, which is measured through the skin resistance sensor unit of FIG. 3;
FIG. 6 is a view showing an embodiment of a mobile device according to the present invention;
FIG. 7 is a view illustrating a state where the biomedical signal measurement module is separated from the mobile device shown in FIG. 6;
FIG. 8 is a view illustrating how to measure biomedical signals using the mobile device according to the present invention;
FIG. 9 is a view showing an interior configuration of a health care module shown in FIG. 2;
FIG. 10 is a view showing a detailed configuration of a heartbeat detection unit shown in FIG. 9;
FIG. 11 is a view showing an example of a PPG signal to be used in the analysis of a heartbeat signal;
FIG. 12 is a view showing a process of obtaining time series data of a heart rate from a heartbeat signal produced by the heartbeat detection unit shown in FIG. 11;
FIG. 13 is a graph showing a waveform of the EDA signal used to detect skin conductive response (SCR);
FIG. 14 is a view showing a configuration of an SCR detection unit shown in FIG. 9;
FIG. 15 is a view showing a waveform of an SKT signal used to detect changes in skin temperature;
FIG. 16 is a block diagram showing a configuration of an SKT Mean/Max calculation unit shown in FIG. 9;
FIGS. 17a and 17b are views showing results of emotion classification by an SVM classifier shown in FIG. 9;
FIG. 18 is a flowchart illustrating a health care method using the mobile device according to the present invention;
FIG. 19 is a flowchart specifically illustrating a step of correcting the user-to-user variation of biomedical signals shown in FIG. 18;
FIG. 20 is a flowchart illustrating a step of managing stress history and providing stress information shown in FIG. 18;
FIG. 21 is a flowchart illustrating a step of managing diet history and providing diet information shown in FIG. 18;
FIG. 22 shows display screens of the mobile device in a case where a health care menu has been selected in the mobile device according to the present invention;
FIGS. 23a to 23d show display screens of the mobile device in a case where a stress manager menu has been selected in the mobile device according to present invention; and
FIGS. 24a to 24e show display screens of the mobile device in a case where a diet manager menu has been selected in the mobile device according to the present invention.

[0037] Hereinafter, a preferred embodiment of a mobile device and a health care method according to the present invention will be described in detail with reference to the accompanying drawings.

[0038] FIG. 2 is a block diagram schematically illustrating a configuration of the mobile device according to the present invention. As shown in FIG. 2, the mobile device 400 of the present invention comprises a biomedical signal measurement module 100, an input unit 210, a display unit 220, a memory unit 230, a central control unit 240, and a health care module 300. The mobile device is configured such that it can be easily used both as a mobile device and as a device that can check the state of health of a user, if necessary, through the biomedical signal measurement module 100 and the health care module 300.

[0039] The mobile device 400 of the present invention can be used as a wireless communication device. In such a case, the mobile device of the present invention further comprises a wireless communication unit 250 capable of transmitting and receiving voice and characters by radio. Therefore, it can be understood in the embodiment of the present invention that the mobile device 400 can be any of the following, or similar, portable electronic equipment such as PDA (Personal Digital Assistants), Palm-Top PC, handheld PC, PCS (Personal Communication Service) phone, cellular phone, and IMT-2000 terminal.

[0040] Further, other external devices can be used with and connected to the mobile device 400 of the present invention. In such a case, the mobile device 400 can further include an interface unit 260 for transmitting and receiving data to and from external devices.

[0041] The biomedical signal measurement module 100 includes a sensor unit 150 for detecting one or more biomedical signals from the body of a user, and a sensor control unit 170 for controlling the sensor unit 150 or classifying and outputting the biomedical signals input from the sensor unit 150.

[0042] The input unit 210 is used to input numbers, symbols and characters such as the Korean and English alphabets through a keypad, scroll buttons, numeric pad and the like. At this time, the user can use a variety of functions such as the input of numerals and symbols of telephone numbers, and start and completion of a telephone call, through the input unit 210, when intending to use the mobile device as it is. Furthermore, the user can input his/her height, weight, age, sex, and the like through the input unit 210 when intending to use the mobile device as a health care device.

[0043] The display unit 220 displays either numbers/characters the user inputs or biomedical signal data of the user measured from the biomedical signal measurement module 100 onto a screen.

[0044] The memory unit 230 stores information on the user's body, directions for use of the mobile device, and general health information in addition to a variety of data including telephone numbers.

[0045] The central control unit 240 controls an overall operation of the mobile device 400. That is, the central control unit 240 measures biomedical signals through the biomedical signal measurement module 100 if necessary, and then analyzes the measured biomedical signal using the health care module 300 so as to check the state of health of the user.

[0046] The wireless communication unit 250 functions to transmit and receive voice and character data by radio and has the same constitution and operation as that used generally in the field of wireless communication terminals. Therefore, a detailed description thereof will be omitted.

[0047] The interface unit 260 receives data from external devices connected to the mobile device and outputs the input data to the central control unit 240, and functions to output the biomedical signals from the user input by the biomedical signal measurement module 100 to the central control unit 240 in a case where the biomedical signal measurement module 100 is mounted to the mobile device. At this time, the interface unit 260 transmits and receives the signal to and from the biomedical signal measurement module 100 through the use of a communication protocol such as RS232C. This is merely an example of a signal transmission method, and a variety of communication protocols can be used depending on the circuit configuration.

[0048] The configuration of the biomedical signal measurement module 100 will be more specifically explained with reference to FIG.3.

[0049] FIG. 3 shows an interior configuration of the biomedical signal measurement module 100 shown in FIG. 2. As shown in FIG. 3, the biomedical signal measurement module 100 includes the sensor unit 150 for detecting one or more biomedical signals from the body of a user, and the sensor control unit 170 for controlling the sensor unit 150 or classifying and outputting the biomedical signals input from the sensor unit 150.

[0050] Generally, in a stable mental state, a user's heartbeat becomes slow and peripheral blood vessels are expanded. Therefore, the user's body temperature at the skin and thus skin resistance are increased. However, if the user is excited or subjected to stress, the heartbeat becomes fast and the blood moves from the skin to muscles. Therefore, the user's body temperature and thus the skin resistance tend to be decreased. Consequently, such changes in heartbeat, skin temperature and skin resistance are deemed to be an important factor for determining the stress level of the user.

[0051] In the embodiment of the present invention, accordingly, the heartbeat, skin temperature and skin resistance, which quickly respond to the user's skin according to an emotional change, are measured in order to check the stress level of the user. To this end, the sensor unit 150 of the biomedical signal measurement module 100 includes a heart rate sensor 110 for detecting a biomedical signal for heartbeat, a skin temperature sensor 120 for detecting a biomedical signal for skin temperature, and a skin resistance sensor 130 for detecting a biomedical signal for skin resistance.

[0052] In the embodiment of the present invention, it is preferred that the heartbeat sensor include a PPG (photoelectric pulse plethysmograph) sensor 111 for measuring changes in blood flow according to a change in the thickness of blood vessel due to the heartbeat. It is also preferred that the skin temperature sensor 120 include an SKT sensor 121 such as a thermistor for measuring skin temperature (SKT) as a resistance value that changes in response to temperature change. Further, it is preferred that the skin resistance sensor 130 include an EDA (electrodermal activity) sensor 131 for measuring skin resistance that changes under the influence of sweat eliminated from the skin by using an electrode directly or indirectly in contact with the skin and a comparator connected with the electrode. Preferably, the skin resistance sensor 130 may include a galvanic skin resistance (GSR) sensor for measuring galvanic skin resistance instead of the EDA sensor.

[0053] According to a preferred embodiment of the present invention, the heart rate sensor 110, the skin temperature sensor 120 and the skin resistance sensor 130 include filters 112, 122 and 132 for filtering the detected biomedical signals and amplifiers 113, 123 and 133 for amplifying the filtered biomedical signals, respectively.

[0054] In the meantime, since user-to-user variation in biomedical signals detected through the sensor unit 150 largely changes depending on response sensitivity and measuring environment, the stress level of the user may not be measured exactly.

[0055] Specifically, a nickel electrode is employed in the EDA sensor 131 of the skin resistance sensor 130 so that skin resistance R_h of the user can be measured for a long time. In such cases, the nickel electrode has an advantage in that it is superior to conventional Ag/AgCl electrodes in view of their durability, but has a problem in that user-to-user variation in a DC value of the skin resistance R_h detected through the nickel electrode is increased. As shown in FIG. 4, for example, it is assumed that person A has a dry skin of which skin resistance R_h is between 1.5 ~ 2.0 MΩ whereas a person B has wet and sweaty skin of which skin resistance R_h is between 0.5 ~ 1.0 MΩ. Therefore, if there is such variation in the skin resistance R_h, it is deemed that the emotional state of the user is not properly reflected. Accordingly, it is necessary to correct user-to-user variation in skin resistance during the initialization stage of measurement.

[0056] To this end, the sensor control unit 170 of the biomedical signal measurement module 100 corrects user-to-user variation in skin resistance by decreasing or increasing the gain of the amplifier 133 according to the voltage value V_0 output from the EDA sensor 131 through the amplifier 133. Hereinafter, the variation correction of the sensor control unit 170 will be explained in detail with reference to FIG. 5.

[0057] As shown in FIG. 5, assuming that an electric current measured in the EDA sensor 131 is i, the skin resistance of the user is R_h and variable resistance for controlling the gain of the amplifier 133 is R, the voltage value V_0 input into the sensor control unit 170 can be expressed as the following formula.

$$V_0 = (R_h + R) \times i = (R_h \times i) + (R \times i),$$

where $(R_h \times i) = 0.5V$.

[0058] The above formula can also be expressed as follows.

$$V_0 = 0.5 \times \frac{R}{R_h}.$$

[0059] Therefore, the relationship $V_0 \propto R$ is satisfied. That is, the voltage value V_0 input into the sensor control unit 170 is proportional to the value R of the variable resistor. Accordingly, the voltage V_0 is decreased as the resistance value R of the variable resistor is decreased, whereas the voltage V_0 is increased as the value R of the variable resistor is increased.

[0060] In accordance with this principle, when the input voltage value V_0 is equal to or greater than an upper limit voltage, the sensor control unit 170 reduces the value R of the variable resistor and thus the gain of the amplifier 133, thereby reducing the voltage V_0. On the other hand, when the input voltage V_0 is equal to or less than a lower limit voltage, the sensor control unit 170 increases the value R of the variable resistor and thus the gain of the amplifier 133, thereby increasing the voltage value V_0.

[0061] Accordingly, the voltage value V_0 output from the amplifier 133 can be maintained between the lower limit voltage and the upper limit voltage by means of the correction of the sensor control unit 170 for the user-to-user variation. Consequently, the biomedical signal onto which variation in the emotional state of the user is properly reflected can be detected.

[0062] Although heartbeat, temperature and skin resistance as response factors for determining the emotional state of a user have been measured in the embodiment of the present invention, any one or two factors of these biomedical

signals may be measured. However, it is preferred that all the three factors be measured in order to determine the emotional state of the user more accurately.

[0063] Referring again to FIG. 3, the sensor unit 150 of the biomedical signal measurement module 100 further includes a body fat sensor unit 140 for measuring body impedance necessary to calculate body fat percentage so as to measure the body fat of the user.

[0064] The body fat percentage is referred to as a percentage of fat in the body. Appropriate body fat is essentially required for protecting body organs, shielding heat from being emitted, and maintaining body temperature. However, excessive body fat hinders smooth metabolism, and thus, becomes a primary factor for increasing aging phenomena and diseases of adult people such as hyperlipemia, sclerosis of the arteries, hypertension, and diabetes. Accordingly, it is very important to keep the body fat percentage at an appropriate level in order to preserve the user's health.

[0065] The body fat sensor unit 140 includes an impedance sensor 141 for measuring body impedance by causing a small alternating current to flow through the electrode in contact with the body surface of the user and then measuring the voltage between both ends of the electrode. Body impedance measured by the impedance sensor 141 is first amplified by a first amplifier 142, is then filtered through a filter 143, and is again amplified by a second amplifier 144. Thereafter, the body impedance is input into the sensor control unit 170.

[0066] The body fat percentage can be calculated according to the impedance method based on the body impedance measured in the body fat sensor 140 and information on the user's body (sex, age, height, weight). The impedance method is a method of measuring electrical resistance in the body and thus calculating body fat percentage based on the principle that electricity flows easily through fat-free tissues of the body since fat-free tissues contain a great deal of moisture (72~73% including electrolyte), whereas fat tissues are insulated so electricity does not flow through fat tissues since fat tissues contain significantly less moisture.

[0067] Furthermore, it is preferred that the biomedical signal measurement module 100 be configured such that it can be efficiently carried and easily used for measurement. Hereinafter, a process of implementing the biomedical signal measurement module 100 will be explained in detail with reference to FIGS. 6 to 8.

[0068] FIG. 6 is a view showing an embodiment of the mobile device according to the present invention; FIG. 7 is a view illustrating a state where the biomedical signal measurement module is separated from the mobile device shown in FIG. 6; FIG. 8 is a view illustrating how to measure biomedical signals using the mobile device according to the present invention.

[0069] It is preferred that the biomedical signal measurement module 100 be configured to be detachably mounted to the mobile device so that it can be easily carried by the user. For example, the module 100 may be configured in the form of a case with a receiving space in which the mobile device can be accommodated as shown in FIGS. 6 and 7.

[0070] In case of a case-shaped biomedical signal measurement module 100, it is preferred that a whole external appearance of the biomedical signal measurement module 100 be a shape corresponding to that of the mobile device and a front portion thereof is open such that the display unit 220 can be exposed outwardly. When the mobile device is inserted into the case-shaped biomedical signal measurement module 100, the mobile device is firmly engaged with the biomedical signal measurement module 100 while they are electrically connected with each other through the interface unit 260.

[0071] In addition, the biomedical signal measurement module 100 may be configured in the form of an additional necklace and be detachably mounted to the mobile device. Alternatively, the biomedical signal measurement module 100 may be configured to be fully housed in the mobile device.

[0072] As shown in FIGS. 7 and 8, it is preferred that the PPG sensor unit 111 of the biomedical signal measurement module 100 be arranged at a position on which a thumb of the user is placed when the user naturally holds the mobile device 400, the SKT sensor 121 thereof be arranged at a position where an index or middle finger would be placed, and the EDA sensor 131 thereof be arranged at a position just below the PPG sensor 111 and the SKT sensor 121, that is, positions where lower portions of the thumb and index or middle finger are placed when the user naturally holds the mobile device 400, such that the biomedical signal measurement module 100 can be efficiently utilized for measurement. Further, it is preferred that two electrodes of the impedance sensor 141 are installed at a rear side of the biomedical signal measurement module 100 and the other two electrodes are installed at a front side of the biomedical signal measurement module 100 so that the two rear electrodes are in contact with the palm of the user and the two front electrodes are in contact with the fingers (e.g., index or middle finger) when the user holds the mobile device 400.

[0073] Therefore, since the fingers or palm of the user can be in contact with the PPG sensor 111, the SKT sensor 121, the EDA sensor 131 and the impedance sensor 141 whenever the user merely holds the mobile device 400, the biomedical signals of the user can be conveniently detected through a natural holding action of the user.

[0074] Referring again to FIG. 2, the health care module 300 functions to analyze the emotional and physical condition of the user based on information on the user's body and the biomedical signal data input from the biomedical signal measurement module 100. The health care module 300 will be hereinafter explained in detail with reference to FIG. 9.

[0075] FIG. 9 shows an interior configuration of the health care module 300 shown in FIG. 2. As shown in FIG. 9, the health care module 300 comprises an emotional state analysis unit 350 and a physical condition analysis unit 370 for

analyzing the emotional and physical condition of the user, respectively, based on the biomedical signal data input from the biomedical signal measurement module 100 and the information on the user's body stored in the memory unit 230.

[0076] The emotional state analysis unit 350 functions to analyze features of the biomedical signals measured from the user's body, recognizing emotions based on values between the analysis results and the features representing the user's normal emotion, and then outputting a stress index and level based on the recognized emotion. Such an emotional recognition algorithm is specifically described in Korean Patent Application No. 2002-3868 (entitled "device and method for recognizing a user's emotion through short monitoring of physiological signals") and will be explained briefly for easy understanding of the present invention.

[0077] The emotional state analysis unit 350 includes a feature analysis unit 310 for analyzing the features of the biomedical signals measured by the biomedical signal measurement module 100, a subtracter unit 320 for calculating a difference value between the results analyzed in the feature analysis unit and the features representing the user's normal emotion, and a support vector machine (SVM) unit 330 for classifying the emotional states according to the analyzed difference between the features calculated in the subtracter unit 320 and outputting the calculated index and level for the selected emotional state among the classified emotional states.

[0078] The feature analysis unit 310 includes a heartbeat analysis unit 311 for receiving PPG signals, detecting the heartbeat and extracting the feature values related to the heartbeat, a skin conductive response (SCR) analysis unit 315 for receiving the EDA signals and extracting feature values related to SCR, and an SKT Mean/Max calculation unit 318 for receiving the EDA signals and extracting feature values related to SKT (i.e., mean (Mean) and maximum value (Max) of SKT).

[0079] The heartbeat analysis unit 311 includes a heartbeat detection unit 312 for receiving the PPG signals and detecting the heartbeat, a spectrum analysis unit 313 for analyzing the spectrum of the detected heartbeat signal (Det), and a Mean/Std calculation unit 314 for calculating the mean (Mean) and standard deviation (Std) of the detected heartbeat signal (Det). In addition, the SCR analysis unit 315 includes an SCR detection unit 316 for receiving EDA signals and detecting SCR, and an SCR calculation unit 317 for calculating parameters such as amplitude of SCR.

[0080] FIG. 10 is a view showing a detailed configuration of a heartbeat detection unit 312 shown in FIG. 9, and FIG. 11 is a view showing an example of the PPG signal to be used in the analysis of the heartbeat signal.

[0081] As shown in FIG. 10, the heartbeat detection unit 312 of the present invention includes a band pass filter 340, a median filter 341, an adder 342, a matched filter 343, and a zero clipper 344.

[0082] The band pass filter 340 extracts signals falling within a specific band of the PPG signal when the PPG signal is input. The median filter 341 removes noise existing in the band-pass filtered signal. The adder 342 adds a reciprocal number of the median filtered result to the band pass filtered result and calculates the difference between the two filtered results. The difference calculated through the adder 342 is input to the matched filter 343 to extract a specific signal (i.e., heartbeat signal) included in the PPG signal. The specific signal extracted from the matched filter 343 is subjected to a zero clipping process in the zero clipper 344 and is then output as the heartbeat signal (Det). Here, parameters of the matched filter 343 can be updated, if necessary. With a heartbeat detection unit 312 constructed as such, the PPG signal corresponding to portions indicated by arrows shown in FIG. 11 are extracted as the heartbeat signal (Det).

[0083] FIG. 12 is a view showing a process of obtaining time series data of heart rate variability from a heartbeat signal produced by the heartbeat detection unit 312 shown in FIG. 11.

[0084] Referring to FIG. 12, if an obtained PPG signal 1200 is magnified, a waveform such as a waveform 1210 is illustrated. The PPG signal is shown to have periodic pulses designated by reference numeral 1210, each of which represents a QRS waveform composed of a maximum portion R and minimum portions Q and S located to the right and left of the maximum portion R, respectively.

[0085] Portions indicated by arrows among the waveform 1210 shown in FIG. 12 become an R waveform corresponding to the maximum portion of the heartbeat signal, and they are extracted through the heartbeat detection unit 312 shown in FIG. 10 to illustrate an R-R instantaneous waveform 1230 of the PPG signal. If a moving average interpolation is applied to the R-R instantaneous waveform 1230, time series data of heart rate variability (HRV) such as 1250 are extracted. A method of obtaining time series data 1250 of such heart rate variability is disclosed in the technical paper "An efficient algorithm for the spectral analysis of heart rate variability" by R. D. Berger etc. IEEE Trans. Biomed. Eng., vol. 33, 1986. The heart rate variability (HRV) signal becomes an index that can be used to quantitatively determine the degree of activation of sympathetic and parasympathetic systems.

[0086] Referring again to FIG. 9, the heartbeat signal (Det) obtained by the heartbeat detection unit 312 shown in FIG. 10 is transformed into a time series of heart rate variability (HRV) by means of the method illustrated in FIG. 12, and is then input into the spectrum analysis unit 313 and the Mean/Std calculation unit 314.

[0087] The spectrum analysis unit 313 estimates various orders of autoregressive (AR), moving average (MA), and autoregressive moving average (ARMA) models for the given time series, selects an optimal time series model by choosing a specific order of a specific model of which an index for representing estimated error can be minimized, and analyzes the spectrum of heart rate variability (HRV) using an ARMAsel algorithm for obtaining the spectrum from the selected optimal model. A method of estimating an index for an estimated error and a time series model is specifically

described in the technical paper "Fact and fiction in spectral analysis" by P. M. T. Broersen, IEEE Transactions on instrumentation and measurement, vol. 49, no. 4, pp. 766-772, 2000.

[0088] The frequency domain parameters of such heart rate variability (HRV) have been studied as an important index in many previous research efforts, and are also a very important index in biopsychology research.

[0089] The spectrum analysis unit 313 of the present invention analyzes the spectrum of heart rate variability (HRV) through signal observation for a short time of about 50 seconds by using the ARMAsel algorithm instead of a conventional periodogram method for long-term signals ranging from a few minutes to 24 hours. The results analyzed by the spectrum analysis unit 313 are transmitted to the subtracter unit 320 as feature values for determining the emotional state of the user.

[0090] Further, the Mean/Std calculation unit 314, which has received the time series signal of heart rate variability (HRV) from the heartbeat detection unit 312, calculates the mean (Mean) and standard deviation (Std) for the given time series and transmits the calculated values to the subtracter unit 320 as feature values for determining the emotional state of the user.

[0091] Next, the detailed configuration and operation of the SCR analysis unit 315 included in the feature analysis unit 310 of FIG. 9 will be explained as follows.

[0092] FIG. 13 is a graph showing the waveform of an EDA signal used to detect skin conductive response (SCR). FIG. 13 shows the waveform 1600 of an EDA signal generated from the user and an enlarged waveform 1610 for a portion of the EDA signal waveform 1600 from which SCR features are extracted. The signals indicated by 1600 and 1610 are input into the SCR detection unit 316 of the SCR analysis unit 315.

[0093] FIG. 14 is a view showing a configuration of the SCR detection unit 316 shown in FIG. 9.

[0094] Referring to FIG. 14, the SCR detection unit 316 for receiving EDA signals and detecting skin conductive response (SCR) includes a down-sampler 345, a differentiator 346, and a smoothing convolution unit 347.

[0095] The down-sampler 345 causes the input EDA signal to be down sampled to 10~12 data. The differentiator 346 differentiates the down sampled result, and the smoothing convolution unit 347 performs the smoothing convolution for the differentiated results using a Bartlett window with a length of 20. Such an SCR detection unit 316 causes the input EDA signal to be output in the form of discrete SCR data.

[0096] The discrete SCR data acquired by the SCR detection unit 316 is input to the SCR calculation unit 317 included in the SCR analysis unit 315 so that feature values such as the frequency of SCR for a predetermined period of time, SCR amplitude and SCR rise time can be produced. The SCR feature data (i.e., the frequency of SCR, the SCR amplitude, the SCR rise time, etc.) obtained by the SCR calculation unit 317 are input to the subtracter unit 320, as shown in FIG. 9.

[0097] Furthermore, a detailed configuration and operation of the SKT Mean/Max calculation unit 318 of the feature analysis unit 310 shown in FIG. 9 will be discussed as follows.

[0098] FIG. 15 is a view showing the waveform of an SKT signal used to detect changes in skin temperature, and FIG. 16 is a block diagram showing the configuration of the SKT Mean/Max calculation unit shown in FIG. 9.

[0099] Referring to FIG. 16, the SKT Mean/Max calculation unit 318 comprises a down-sampler 348 and a Mean/Max calculator 349. The SKT Mean/Max calculation unit 318 receives an SKT signal such as shown in FIG. 15 and causes the received signal to be down sampled to about 100 data. Then, a mean *Mean_SKT* and a maximum value *Max_SKT* of the down-sampled data are produced as SKT feature data.

[0100] As described above, the feature values necessary to recognize the user's emotion are extracted from the plurality of biomedical signals input from the user by means of the heartbeat analysis unit 311, the SCR analysis unit 315 and the SKT Mean/Max calculation unit 318 included in the feature analysis unit 310, and then input sequentially into the subtracter unit 320 and the SVM unit 330 so that the user's emotion can be recognized.

[0101] Referring again to FIG. 9, the feature values *Feature 1'~ Feature 4'* for the normal emotional state of the user are stored in the subtracter unit 320 as standard feature values for recognition of the user's emotion. The subtracter unit 320 calculates the difference between a plurality of the feature values *Feature 1 ~ Feature 4* input from the heartbeat analysis unit 311, the SCR analysis unit 315 and the SKT Mean/Max calculation unit 318 included in the feature analysis unit 310 and the feature values *Feature 1*' *~ Feature 4'* for the normal emotional state of the user, and then, transmits the difference to the SVM unit 330.

[0102] The SVM unit 330 comprises a support vector machine (SVM) classifier 332 for training and classifying the emotional state of the user in response to the difference between the feature values output from the subtracter unit 320, a database 334 for storing the results obtained by the SVM classifier 332, and an emotional determination unit 336 for determining and outputting the stress index and level among the plurality of emotional state values classified by the SVM classifier 332.

[0103] If a specific vector for representing a specific emotional state is generally expressed as one probability distribution in a multidimensional space and a probability density functions corresponding to the respective state are already known, a pattern classifier such as the SVM classifier 332 used for classifying the user's emotion may be a statistically optimal classifier according to Bayes' law as explained in "Pattern classification", 2nd edition, 2000, published from Wiley by R. O. Duda, P. E. Hart and D. G. Stock.

[0104] However, since probability density functions cannot in fact be correctly known, a Parzen window classifier, a

multilayer perceptron and the like for implicitly implementing Bayes' law through training with a limited amount of data are frequently used. But, the classifiers have poor generalization characteristics; a very high malfunction rate is obtained when using new data that have not yet been used in the training. Moreover, conventional pattern classifiers have wide a distribution for feature vectors and there are large overlapping portions between different state distributions. Thus, it is very likely that the malfunction rate will be increased. In order to solve the above problems, the present invention uses the SVM classifier 332, which is known for showing superior generalization characteristics, as a pattern classifier for use in emotion recognition.

[0105] Improvement on linear separation possibilities of the SVM classifier 332 can be obtained by means of multidimensional nonlinear mapping. The SVM classifier 332 is configured using a method for implementing a linear separator having an optimum generalization performance based on the statistical learning theory of Vapnik. A more detailed description is disclosed in the technical paper, "An overview of statistical learning theory", IEEE Transactions on neural network, Vol. 10, No. 5, pp. 988-999, 1999, by V. Vapnik.

[0106] FIGS. 17a and 17b are views showing emotion classification results made by an SVM classifier shown in FIG. 9. The SVM classifier 332 of the present invention linearly projects and analyzes a nonlinearly high order of input space in a feature space, and presents an optimal boundary (i.e., an optimal separating surface) between the feature data (i.e., the user's emotions) as shown in FIGS. 17a and 17b.

[0107] Referring again to FIG. 9, the emotion classification results obtained by the SVM classifier 332 are classified according to the respective emotions, and respective emotion intensities are then output in the form of numbers. For example, emotion intensities such as 0.3 (or 30%) corresponding to stress, 0.6 (or 60%) corresponding to sadness, and 0.1 (or 10%) corresponding to anger may be expressed in the form of numbers.

[0108] The emotional determination unit 336 receives intensity values for the plurality of emotions from the SVM classifier 332, determines which value corresponds to the stress index and value among the intensity values, and outputs the determined value. At this time, information on what kind of emotions should be recognized in response to the specific input feature values is stored in the database 334. Data updates on the database 334 are performed during the training of the SVM classifier 332. Once the training of the SVM classifier has been completed, data updates on the database 334 are not performed any longer. Therefore, the database 334 is necessary for the developer, but the completely developed emotion recognition system need not be provided with the database 334.

[0109] The results of emotion recognition performed by the SVM classifier 332 include delight, sadness, anger, fear, disgust, and surprise. The embodiment of the present invention is configured in such a manner that only the state values of the stress corresponding to an indicator of mental health are output through the emotional determination unit 336 so that only physical fatigue or mental stress can be determined. Of course, other embodiments of the present invention may be configured in such a manner that state values for a variety of emotional states such as delight, sadness, anger, fear, disgust, and surprise are output to determine the emotional state of the user.

[0110] Furthermore, the physical condition analysis unit 370 includes a body fat percentage calculation unit 371 and a calorie consumption calculation unit 372. The body fat percentage calculation unit 371 calculates body fat percentage based on the information stored in the memory unit 230, such as the height, weight, age and sex of the user, and the body impedance values detected through the body fat sensor unit 140 and displays the calculated value onto the screen through the display unit 220.

[0111] In the meantime, if the people take exercise, the body temperature and heart rate will be raised due to increases in blood flow, and the calorie, or energy, in the body will be consumed. Calorie consumption due to a rise in the body temperature and heart rate should be optimal since optimal calorie consumption causes the body homeostasis and thus the user's health to be kept constant. Accordingly, the calorie consumption calculation unit 372 calculates calorie consumption due to exercise based on the body fat percentage and average heart rate before/after exercising, and displays the calculated value on the screen through the display unit 220. At this time, a value obtained by analyzing the PPG signal measured in the heart rate sensor 110 of the biomedical signal measurement module 100, i.e. the average heart rate analyzed in the heartbeat analysis unit 311, is used as an average heart rate before/after exercise, a value obtained by analyzing the body impedance measured by the body fat sensor unit 140 of the biomedical signal measurement module 100, i.e. the body fat percentage calculated in percent fat by the body calculation unit 371, is used as body fat percentage.

[0112] Hereinafter, a health care method using the mobile device according to the present invention will be described in detail with reference to the accompanying drawings.

[0113] FIG. 18 is a flowchart illustrating the health care method using the mobile device according to the present invention.

[0114] When a user first selects a health care menu on the mobile device 400, a health care main screen is displayed on the display unit 220, as shown in FIG. 22 (S10). In this state, the user chooses his/her own profile, as shown in FIG. 22b (S20).

[0115] At this time, if there is no user's profile, the user can also directly input data such as user's name, height, weight, sex and age to create a user's profile, as shown in FIG. 22c.

[0116] Then, if the user selects a stress manager menu, a stress manager main screen is displayed on the display unit, as shown in FIG. 23 (S30 and S40). In this state, if the user selects a stress measurement menu, a guide message for biomedical signal measurement is displayed on the display unit and the biomedical signal measurement module 100 is simultaneously activated, as shown in FIG. 23b (S50 and S60).

[0117] Subsequently, when the user presses the start button according to the guide message while holding the mobile device 400, a plurality of biomedical signals such as heartbeat, skin temperature and skin resistance are detected from a user's body through the biomedical signal measurement module 100, and the detected biomedical signals are displayed on the display unit so that the user can confirm the results, as shown in FIG. 23b (S70). A status window for indicating a ratio of completion of biomedical signal measurement may be displayed on the display unit.

[0118] In the meantime, since the user-to-user variation of the biomedical signals measured through the biomedical signal measurement module 100 large according to response sensitivity and measurement environment, there may be cases where the emotional state of the user cannot be correctly determined due to the variation. To this end, the user-to-user variation is corrected in an initial measurement stage (S80). The step of correcting the user-to-user variance of the biomedical signals S80 will be described hereinafter in greater detail with reference to FIG. 19.

[0119] As described above with reference to FIGS. 4 and 5, since the user-to-user variation of skin resistance values of the biomedical signals measured through the biomedical signal measurement module 100 is large, the following description will be focused on skin resistance values.

[0120] First, it is determined whether user's body is in contact with the biomedical signal measurement module 100, by checking whether a voltage value V_0 input from the skin resistance sensor 130 of the biomedical signal measurement module 100 is larger than a threshold voltage value V_{th} (S81). Here, the threshold voltage value V_{th} is a minimum voltage value, which indicates that the user's body is in contact with the biomedical signal measurement module 100. It is preferred that the threshold voltage value V_{th} be stored beforehand in the memory unit 230.

[0121] If it is determined that the user's body is in contact with the biomedical signal measurement module 100, i.e. $V_0 \geq V_{th}$, it is checked whether the input voltage value V_0 is equal to or larger than a lower limit voltage V_{cutoff_min} but equal to or smaller than a upper limit voltage V_{cutoff_max}, i.e. $V_{cutoff\_min} \leq V_0 \leq V_{cutoff\_max}$. Based on the check result, it is determined whether correction of the user-to-user variation of skin resistance values is required (S82).

[0122] If it is determined that variation correction is required, i.e. $V_{cutoff\_min} \leq V_0 \leq V_{cutoff\_max}$ is not established, it is checked whether the input voltage value V_0 is above the upper limit voltage V_{cutoff_max} (S83). If it is above the upper limit voltage V_{cutoff_max}, the resistance value R of the variable resistor is reduced to decrease the gain of the amplifier 133 (S84).

[0123] If the input voltage value V_0 is equal to or less than the upper limit voltage V_{cutoff_max}, it is checked whether the input voltage value V_0 is smaller than the lower limit voltage V_{cutoff_min} (S85). If it is smaller than the lower limit voltage V_{cutoff_min}, the resistance value R of the variable resistor is increased to increase the gain of the amplifier 133 (S86).

[0124] The voltage value V_0 input from the skin resistance sensor 130 through the step of correcting the user-to-user variation can be maintained to be equal to or larger than the lower limit voltage but equal to or smaller than the upper limit voltage. Accordingly, correct biomedical signals on which a change in the emotional state of the user is properly reflected can be detected by correcting the user-to-user variation according to response sensitivity and measurement environment.

[0125] After the user-to-user variation correction of the biomedical signals is completed, the health care module 300 analyzes the biomedical signals such as the PPG signals, EDA signals, and SKT signals detected from the user's body and extracts a plurality of feature values used for determining the emotional state of the user (S90).

[0126] As for the feature values extracted in step S90, there are a spectrum of heartbeat signals extracted from PPG signals, a mean value and standard deviation value of heartbeat signals, SCR-related parameters detected from EDA signals, mean and maximum values extracted from SKT signals, and the like.

[0127] Then, differences between the plurality of extracted feature values and feature values on which the emotional state is determined based are calculated (S100). Here, the feature values on which the emotional state is determined based are feature values indicating a normal emotional state in which the user is not biased toward a specific emotion. It is preferred that the feature values on which the emotional state is determined based be stored in advance.

[0128] When the differences between the feature values are obtained, the emotional state of the user is determined based on the SVM classification according to the differences. The emotional state of the user is first classified by respective emotions and stress-related values are then selected from the respective emotions so as to calculate a stress index and level (S110).

[0129] The calculated stress index and level are displayed on the display unit as shown in FIG. 23b so that the user can check them (S120). In this state, the user may add a comment on a situation causing the stress or check the stress status on a daily, weekly or monthly basis.

[0130] Meanwhile, a case where the user selects a stress history management menu or stress information menu on the stress manager main screen of FIG. 23a will be described with reference to FIG. 20.

[0131] If the user selects the stress history management menu on the stress manager main screen, the stress history

management screen is displayed as shown in FIG. 23c (S130 and S140). In this state, if the user selects a desired term, a stress history is displayed on the display unit according to the selected term (S150 and S160). In the state where the stress history is displayed on the display unit, if the user selects a comment on a specific date, the selected comment is displayed on the display unit (S170 and S180).

[0132] On the other hand, if the user selects the stress information menu on the stress manager main screen, information on stress is displayed on the display unit as shown in FIG. 23d (S190 and S200).

[0133] The emotional state determination method of the present invention observes and analyzes the biomedical signals for a short period of time of about 50 seconds by using the ARMAsel algorithm instead of the conventional periodogram method that is performed for signals over a long period of time from a few minutes to 24 hours. Further, upon determination of the user's emotional state, the determination is performed by using the SVM classifier that exhibits high generalization characteristics. Therefore, the biomedical signals of the user can be monitored for a short period of time and the emotional state of the user can be correctly recognized.

[0134] Referring again to FIG. 18, if the user selects the diet manager menu on the health care main screen, a diet manager main screen is displayed on the display unit as shown in FIG. 24 (S210).

[0135] If the user selects the body fat measurement menu in this state, the body fat sensor 140 of the biomedical signal measurement module 100 is activated while a guide message for body fat measurement is displayed on the display unit as shown in FIG. 24b (S220 and S230).

[0136] When the user presses the measurement start button according to the guide message while holding the mobile device 400, a body impedance value is measured from the user's body through the body fat sensor 140, and the measured body impedance value is displayed on the display unit as shown in FIG. 24b so that the user can confirm the measurement result (S240). At this time, the status window for indicating the ratio of completion of biomedical signal measurement may also be displayed on the display unit.

[0137] Then, body fat percentage BodyFat % of the user's body is calculated based on the measured impedance value and the user's height, weight, age and sex stored in the memory unit 230, and the calculated body fat percentage is displayed on the display unit as shown in FIG. 24b (S250 and S260). At this time, the body fat percentage BodyFat % is expressed as the following formula 1 that is a function of the measured body impedance value R and the user's height, weight, age and sex.

$$FFM = a * Height^2 / R + b * Weight - c * Age + d * Sex + e$$

$$BodyFat = 100 * \frac{Weight - FFM}{Weight} \qquad \ldots\ldots (1)$$

[0138] The FFM in Formula 1 means Fat Free Mass that is a weight excluding body fat. Values of a, b, c and d are determined based on a multiple regression model selected according to the user's body impedance value R, and the information on the height, weight, age and sex that have been input. The FFM is calculated according to the determined values of a, b, c and d.

[0139] In the present embodiment, the body fat percentage has been calculated with the parameters of height, weight, age and sex having relatively great influences on the FFM among user's physical information. However, other parameters may be used for the calculation of the body fat percentage.

[0140] In the meantime, if the user selects the calorie consumption measurement menu on the diet manager main screen, the heart rate sensor 110 and the body fat sensor 140 of the biomedical signal measurement module 100 are activated while a guide message for calorie consumption measurement is displayed on the display unit as shown in FIG. 24c (S270 and S280).

[0141] Then, when the user presses the measurement start button according to the guide message while holding the mobile device 400, the heart rate sensor 110 measures PPG signals before exercise from the user's body while the body fat sensor 140 measures the body impedance from the user's body. After exercise is completed, the heart rate sensor 110 measures PPG signals from the user's body once more (S290). At this time, the measured PPG signals are displayed on the display unit as shown in FIG. 24c so that the user can check the measurement results, and the status window for indicating the ratio of completion of the biomedical signal measurement may also be displayed.

[0142] Then, the heartbeat signals and body impedance values before/after the exercise are analyzed to calculate average heart rates and body fat percentages before/after the exercise. Calorie consumption due to exercise is calculated based on the calculated average heart rates and body fat percentages before/after exercise, exercise time, and the user's height, weight, age and sex. The calculated calorie consumption is displayed on the display unit as shown in FIG.

24c (S300 and S310).

[0143] The calculation of the calorie consumption will be described in greater detail. The calorie consumption due to can vary according to a user's basal metabolic rate. Since the basal metabolic rate is determined depending on the user's weight and body fat percentage, it is necessary to accurately measure the user's basal metabolic rate in order to calculate correct calorie consumption.

[0144] However, in order to accurately measure the user's basal metabolic rate, expensive equipment is required and the user should rest for a long time while wearing a facial mask and a mouthpiece. For this reason, a method of calculating calorie consumption by multiplying standard values of basal metabolic rates predetermined on the basis of sex and age by user's weight has been generally used.

[0145] However, since the standard values of the basal metabolic rates are calculated based on persons with standard physical figures, there may be great differences between the standard values and actual basal metabolic rates of users according to corpulence, slenderness, sex and age of each user. Therefore, the calorie consumption due to exercise cannot be correctly checked.

[0146] In order to solve this problem, according to the present invention, the body fat percentage is obtained based on the body impedance measured by the body fat sensor 140 and the user's basal metabolic rate is then calculated based on the acquired body fat percentage. Since such a calorie consumption calculation method is disclosed in detail in Japanese Patent Laid-Open Publication No. 1996-52119, a detailed description thereof will be omitted.

[0147] Next, a case where the user selects the diet history management menu or diet information menu on the diet manager main screen of FIG. 24a will be described with reference to FIG. 21.

[0148] If the user selects the diet history management menu on the diet manager main screen, diet history management screen, a diet history management screen is displayed as shown in FIG. 24d (S320 ~ S330). If the user selects a desired term in this state, a diet history is displayed on the display unit according to the selected term (S340 and S350). In a state where the diet history is displayed on the display unit, if the user selects a comment on a specific date, the selected comment is displayed on the display unit (S360 and S370).

[0149] Meanwhile, if the user selects the diet information menu on the diet manager main screen, information on a diet is displayed on the display unit as shown in FIG. 24e (S380 and S390).

[0150] As described above, the stress level, the body fat percentage of the user's body and the calorie consumption due to exercise can be measured at any time if necessary by using the mobile device according to the present invention.

[0151] According to the present invention, the user can conveniently check his/her own emotional state and physical condition at any time by using the mobile device. Therefore, there is an advantage in that modern people who lack time to care for their health can more easily manage their own health condition.

[0152] Further, according to the present invention, there is an advantage in that the users can simply check their own emotional state and physical condition through natural operations for using the mobile device.

[0153] Moreover, according to present invention, service differentiation can be promoted by adding functions, which can greatly interest users, to the mobile device. Therefore, there is an advantage in that a manufacturer of the mobile device can obtain increased benefits by manufacturing terminals capable of cooperating with a variety of physical condition measurement devices.

[0154] Although the present invention has been described in connection with the preferred embodiment illustrated in the drawings, this is merely illustrative. It will be understood by those skilled in the art that various modifications, changes and equivalents can be made thereto. In particular, although the present invention has been described by way of example in connection with the case where stress is selected among a variety of emotions and the level of stress is checked, the health care method of the present invention is not limited thereto but can allow the checking of a variety of emotions based on a variety of biomedical signals measured by the biomedical signal measurement module. Therefore, the true technical scope of the present invention should be defined by the scope of the appended claims.

Claims

1. A mobile device comprising an input unit (210), a display unit (220), a memory unit (230) and a central control unit (240), the mobile device comprising:

   a biomedical signal measurement module (100) for detecting biomedical signals from a user's body, classifying the detected biomedical signals by respective signals and outputting the classified signals; and
   a health care module (300) for analyzing a user's emotional state and physical condition based on the classified signals input from the biomedical signal measurement module (100) and user's physical information, the health care module (300) comprising an emotional state analysis unit (280) for analyzing the biomedical signals input from the biomedical signal measurement module (100) and determining the user's emotional state and a physical condition analysis unit (290) for analyzing the user's physical condition based on the biomedical signals input

from the biomedical signal measurement module (100) and the user's physical information, wherein the emotional state analysis unit comprises:

a feature analysis unit (310) for analyzing features of the biomedical signals detected from the user's body;
a subtracter unit (320) for obtaining differences between the analysis results from the feature analysis unit (310) and feature values on which the user's emotional state is determined; and
a support vector machine, hereinafter SVM, unit (330) for analyzing the differences of the feature values obtained by the subtracter unit (320), classifying the user's emotional state, and calculating and outputting an index and level for a specific emotion among the classified emotions.

2. The mobile device as claimed in claim 1, wherein the biomedical signal measurement module (100) comprises:

a sensor unit (150) for detecting one or more biomedical signals from the user's body; and
a sensor control unit (170) for controlling the sensor unit (150), classifying the biomedical signals input from the sensor unit (150) by the respective biomedical signals and outputting the classified biomedical signals.

3. The mobile device as claimed in claim 2, wherein the sensor unit (150) comprises a heart rate sensor (111) for detecting heartbeat-related biomedical signals.

4. The mobile device as claimed in claim 3, wherein the biomedical signals of heartbeat are photoelectric pulse plethsmograph, hereinafter PPG, signals.

5. The mobile device as claimed in claim 2, wherein the sensor unit (150) comprises a skin temperature sensor (121) for detecting skin temperature-related biomedical signals.

6. The mobile device as claimed in claim 5, wherein the biomedical signals of skin temperature are skin temperatures, hereinafter SKT, signals.

7. The mobile device as claimed in claim 2, wherein the sensor unit (150) comprises a skin resistance sensor (131) for detecting skin resistance-related biomedical signals.

8. The mobile device as claimed in claim 7, wherein the biomedical signals of skin resistance are electrodermal activity, hereinafter EDA, signals.

9. The mobile device as claimed in claim 2, wherein the sensor unit (150) comprises a body fat sensor (141) for measuring body impedance required for calculation of a body fat percentage.

10. The mobile device as claimed in any one of claims 3 to 9, wherein the heart rate sensor (111), skin temperature sensor (121), skin resistance sensor (131) or body fat sensor (141) comprises a filter (112, 122, 132, 143) for filtering the detected biomedical signals and an amplifier (113, 123, 133, 142, 144) for amplifying the filtered biomedical signals.

11. The mobile device as claimed in any one of claims 3 to 10, wherein the heart rate sensor (111), skin temperature sensor (121), skin resistance sensor (131) or body fat sensor (141) is installed at a position on the mobile device with which user's hand comes into contact when the user holds the mobile device.

12. The mobile device as claimed in any one of claims 2 to 11, wherein the sensor control unit (170) corrects user-to-user variation of the biomedical signals which are output from the sensor unit (150).

13. The mobile device as claimed in any one of the preceding claims, wherein the biomedical signal measurement module (100) is constructed to be detachably coupled to the mobile device.

14. The mobile device as claimed in claim 13, wherein the biomedical signal measurement module (100) is constructed in the form of a case capable of accommodating the mobile device therein.

15. The mobile device as claimed in claim 1, wherein the feature analysis unit (310) comprises:

a heartbeat analysis unit (311) for receiving PPG signals to detect heartbeat signals and extracting feature

values related to the heartbeat signals;
a skin conductive response analysis unit (315) for receiving EDA signals and extracting feature values related to a skin conductive response; and
a skin temperature analysis unit (318) for receiving SKT signals and extracting feature values related to skin temperature.

16. The mobile device as claimed in claim 15, wherein the heartbeat analysis unit (311) comprises:

a heartbeat detection unit (312) for receiving the PPG signals to detect the heartbeat signals and converting the detected heartbeat signals into time series signals of heart rate variability;
a spectrum analysis unit (313) for analyzing a spectrum of the heartbeat signals in response to the time series signals of the heart rate variability; and
a mean/standard deviation calculation unit (314) for calculating a mean value and standard deviation value of the heartbeat signals in response to the time series, signals of the heart rate variability.

17. The mobile device as claimed in claim 16, wherein the heartbeat detection unit (312) comprises:

a band pass filter (340) for extracting signals falling within a specific band of the PPG signals;
a median filter (341) for removing noise existing in the filtering results of the band pass filter (340);
an adder (342) for calculating a difference between the filtering results of both the band pass filter (340) and the median filter (341) by adding a reciprocal number of the filtering result of the median filter (341) to the filtering result of the band pass filter (340);
a matched filter (343) for extracting the heartbeat signals from output signals of the adder (342); and
a zero clipper (344) for performing zero clipping for the heartbeat signals.

18. The mobile device as claimed in any one of the preceding claims, wherein the subtracter unit (320) uses feature values of a user's normal emotion as the feature values on which the user's emotional state is based.

19. The mobile device as claimed in any one of the preceding claims, wherein the SVM unit (330) comprises:

an SVM classifier (332) for classifying the user's emotional state into a plurality of categories by analyzing the differences of the features values obtained from the subtracter unit (320); and
an emotional state determination unit (336) for selecting values related to the specific emotion among values of the plurality of emotions classified by the SVM classifier (332) and calculating and outputting the index and level for the specific emotion.

20. The mobile device as claimed in claim 19, wherein the SVM unit (330) further comprises:

a database (334) for storing a plurality of pieces of emotion data for training the SVM classifier (332), and trained results of the SVM classifier (332)based on the emotion data.

21. The mobile device as claimed in any one of the preceding claims, wherein the physical condition analysis unit (290) comprises:

a body fat percentage calculation unit (371) for calculating body fat percentage based on a body impedance value detected by the biomedical signal measurement module (100) and user's height, weight, age and sex; and
a calorie consumption calculation unit (372) for calculating calorie consumption due to exercise based on average heart rates and body fat percentages before/after exercise detected by the biomedical signal measurement module (100).

22. A method of analyzing biomedical signals of a user using a mobile device, the method comprising classifying biomedical signals by respective signal and analyzing the user's emotional state and physical condition based on the classified signals and the user's physical information by:

analyzing the biomedical signals and extracting a plurality of feature values to be used for determining user's emotional state (S90);
calculating differences between the plurality of extracted feature values and feature values on which the user's emotional state is based (S100);

classifying the user's emotional state by respective emotions based on support vector machine, hereinafter SVM, classification according to the calculated differences of the feature values (S 110); and
selecting values related to an emotion selected among the classified emotions, calculating an emotional state index and level for the selected emotion, and displaying the calculated emotional state index and level on a display unit of the mobile device (S120).

23. The method as claimed in claim 22, further comprising:

accepting user input to select a health care menu on the mobile device, the mobile device having a biomedical signal measurement module (100); and
activating the biomedical signal measurement module (100) if the user selects emotional state measurement (S30).

24. The method as claimed in any one of claims 22 or 23, wherein the biomedical signals include biomedical signals of heartbeat.

25. The method as claimed in claim 24, wherein the biomedical signals of heartbeat are photoelectric pulse plethsmograph, hereinafter PPG, signals.

26. The method as claimed in any one of claims 22 to 25, wherein the biomedical signals include skin temperature-related biomedical signals.

27. The method as claimed in claim 26, wherein the biomedical signals of skin temperature are skin temperature, hereinafter SKT, signals.

28. The method as claimed in any one of claims 22 to 27, wherein the biomedical signals include skin resistance-related biomedical signals.

29. The method as claimed in claim 28, wherein the biomedical signals of skin resistance are electrodermal activity, hereinafter EDA, signals.

30. The method as claimed in any one of claims 22 to 29, wherein the biomedical signals are filtered by a filter (112, 122, 132, 143) and then amplified by an amplifier (113, 123, 133, 142, 144).

31. The method as claimed in claim 22, further comprising the step of correcting user-to-user variation in the biomedical signals (S80).

32. The method as claimed in claim 31, wherein the step of correcting the user-to-user variation of the biomedical signals comprises the steps of:

determining whether the correction of the user-to-user variances of the biomedical signals is required (S82);
if it is determined that the correction of the user-to-user variances of the biomedical signals is required, checking whether values of the biomedical signals are above a maximum limit level and decreasing a gain of an amplifier if the values of the biomedical signals are above the maximum limit level (S83, S84); and
if the values of the biomedical signals are equal to or less than the maximum limit level, checking whether the values of the biomedical signals are equal to or less than a minimum limit level and increasing the gain of the amplifier if the values of the biomedical signals are equal to or less than the minimum limit level (S85, S86).

33. The method as claimed in claim 22, wherein the step of analyzing the biomedical signals and extracting the plurality of feature values to be used for determining the user's emotional state comprises the steps of:

receiving PPG signals to detect heartbeat signals and extracting feature values related to the heartbeat signals;
receiving EDA signals and extracting feature values related to a skin conductive response; and
receiving SKT signals and extracting feature values related to skin temperature.

34. The method as claimed in claim 22, wherein the feature values on which the user's emotional state is based are feature values of user's normal emotion.

35. The method as claimed in claim 22, wherein the step of classifying the user's emotional state by the respective emotions uses an SVM classifier that classifies the user's emotional state into a plurality of categories based on a statistical learning theory.

36. The method as claimed in claim 23, wherein the biomedical signal measurement module (100) is configured to be detachably coupled to the mobile device.

37. The method as claimed in claim 36, wherein the biomedical signal measurement module (100) is constructed in the form of a case capable of accommodating the mobile device therein.

38. The method as claimed in claim 23, further comprising the steps of, if the user selects body fat measurement:

activating the biomedical signal measurement module (S230, S240); and
calculating a body fat percentage of the user's body based on a body impedance of the user and the user's physical information, and displaying the calculated body fat percentage on the display unit of the mobile device (S250, S260).

39. The method as claimed in claim 23, further comprising the steps of, if the user selects calorie consumption measurement:

activating the biomedical signal measurement module (S280, S290); and
analyzing heartbeat signals of the user and a body impedance of the user before/after exercise to calculate average heart rates and body fat percentages before/after exercise, calculating calorie consumption due to exercise based on the calculated average heart rates and body fat percentages before/after exercise, exercise time, and user's physical information, and displaying the calculated calorie consumption on the display unit of the mobile device (S300, S310).

40. The method as claimed in any one of claims 22, 38 and 39, further comprising the step of, if the user selects history management, displaying results according to respective desired terms on the display unit (220).

Patentansprüche

1. Mobiles Gerät, das eine Eingabeeinheit (210), eine Anzeigeeinheit (220), eine Speichereinheit (230) und eine zentrale Steuereinheit (240) umfasst, wobei das mobile Gerät Folgendes umfasst:

ein Messmodul für biomedizinische Signale (100) zum Erfassen von biomedizinischen Signalen von einem Körper eines Anwenders, wobei die erfassten biomedizinischen Signale durch entsprechende Signale klassifiziert und die klassifizierten Signale ausgegeben werden; und
ein Gesundheitsüberwachungsmodul (300) zur Analyse der Befindlichkeit und des physischen Zustands eines Anwenders auf der Grundlage der Eingabe von klassifizierten Signalen von dem Messmodul für biomedizinische Signale (100) und der physischen Information des Anwenders, wobei das Gesundheitsüberwachungsmodul (300) eine Analyseneinheit für die Befindlichkeit (280) zur Analyse der Eingabe von biomedizinischen Signalen von dem Messmodul für biomedizinische Signale (100) und zur Bestimmung der Befindlichkeit eines Anwenders und eine Analyseneinheit für den physischen Zustand (290) zur Analyse des physischen Zustands eines Anwenders auf der Grundlage der Eingabe von biomedizinischen Signalen von dem Messmodul für biomedizinische Signale (100) und der physischen Information des Anwenders umfasst, worin die Analyseneinheit für die Befindlichkeit Folgendes umfasst:

eine Einheit für die Merkmalsanalyse (310) zur Analyse von Merkmalen der biomedizinischen Signale, die vom Körper des Anwenders erfasst werden;
eine Subtraktoreinheit (320) zum Erhalten der Differenzen zwischen den Analyseergebnissen aus der Einheit für die Merkmalsanalyse (310) und den Merkmalswerten, durch die die Befindlichkeit des Anwenders bestimmt wird; und
eine Einheit der Support Vector Machine, nachstehend SVM, (330) zur Analyse der Differenzen der Merkmalswerte, die von der Subtraktoreinheit (320) erhalten werden, zur Klassifikation der Befindlichkeit des Anwenders und zur Berechnung und Ausgabe eines Index und einer Höhe für ein spezielles Gefühl unter den klassifizierten Gefühlen.

2. Mobiles Gerät nach Anspruch 1, worin das Messmodul für biomedizinische Signale (100) Folgendes umfasst:

eine Sensoreinheit (150) zur Erfassung von einem oder mehreren biomedizinischen Signalen vom Körper des Anwenders; und
eine Sensorsteuereinheit (170) zur Steuerung der Sensoreinheit (150), wobei die Eingabe der biomedizinischen Signale von der Sensoreinheit (150) durch die entsprechenden biomedizinischen Signale klassifiziert und die klassifizierten biomedizinischen Signale ausgegeben werden.

3. Mobiles Gerät nach Anspruch 2, worin die Sensoreinheit (150) einen Herzfrequenzsensor (111) zur Erfassung von der Herzfrequenz zugehörigen, biomedizinischen Signalen umfasst.

4. Mobiles Gerät nach Anspruch 3, worin die biomedizinischen Signale des Herzschlags Signale der Photoplethysmographie, nachstehend PPG, sind.

5. Mobiles Gerät nach Anspruch 2, worin die Sensoreinheit (150) einen Hauttemperatursensor (121) zur Erfassung von der Hauttemperatur zugehörigen, biomedizinischen Signalen umfasst.

6. Mobiles Gerät nach Anspruch 5, worin die biomedizinischen Signale der Hauttemperatur Hauttemperatur-, nachstehend SKT, Signale sind.

7. Mobiles Gerät nach Anspruch 2, worin die Sensoreinheit (150) einen Hautwiderstandssensor (131) zur Erfassung von dem Hautwiderstand zugehörigen, biomedizinischen Signalen umfasst.

8. Mobiles Gerät nach Anspruch 7, worin die biomedizinischen Signale des Hautwiderstands Signale der elektrodermalen Aktivität, nachstehend EDA, sind.

9. Mobiles Gerät nach Anspruch 2, worin die Sensoreinheit (150) einen Körperfettsensor (141) zur Messung der Körperimpedanz umfasst, die zur Berechnung eines Körperfett-Prozentsatzes erforderlich ist.

10. Mobiles Gerät nach einem der Ansprüche 3 bis 9, worin der Herzfrequenzsensor (111), Hauttemperatursensor (121), Hautwiderstandssensor (131) oder Körperfettsensor (141) einen Filter (112, 122, 132, 143) zum Filtern der erfassten biomedizinischen Signale und einen Verstärker (113, 123, 133, 142, 144) zum Verstärken der gefilterten biomedizinischen Signale umfasst.

11. Mobiles Gerät nach einem der Ansprüche 3 bis 10, worin der Herzfrequenzsensor (111), Hauttemperatursensor (121), Hautwiderstandssensor (131) oder Körperfettsensor (141) in einer Position an dem mobilen Gerät installiert ist, mit der die Hand des Anwenders in Kontakt kommt, wenn der Anwender das mobile Gerät hält.

12. Mobiles Gerät nach einem der Ansprüche 2 bis 11, worin die Sensorsteuereinheit (170) die Abweichung der biomedizinischen Signale, die die Ausgabe von der Sensoreinheit (150) sind, von Anwender zu Anwender korrigiert.

13. Mobiles Gerät nach einem der vorstehenden Ansprüche, worin das Messmodul für biomedizinische Signale (100) so konstruiert ist, dass es mit dem mobilen Gerät abtrennbar verbunden ist.

14. Mobiles Gerät nach Anspruch 13, worin das Messmodul für biomedizinische Signale (100) in Form eines Gehäuses konstruiert ist, das das mobile Gerät darin aufnehmen kann.

15. Mobiles Gerät nach Anspruch 1, worin die Einheit für die Merkmalsanalyse (310) Folgendes umfasst:

eine Herzschlaganalyseneinheit (311) zum Empfang von PPG-Signalen, um Herzschlagsignale zu erfassen, und zur Extraktion von Merkmalswerten, die sich auf die Herzschlagsignale beziehen;
eine Analyseneinheit der Hautleitfähigkeitsreaktion (315) zum Empfang von EDA-Signalen und zur Extraktion von Merkmalswerten, die sich auf eine Hautleitfähigkeitsreaktion beziehen; und
eine Analyseneinheit der Hauttemperatur (318) zum Empfang von SKT-Signalen und zur Extraktion von Merkmalswerten, die sich auf die Hauttemperatur beziehen.

16. Mobiles Gerät nach Anspruch 15, worin die Herzschlaganalyseneinheit (311) Folgendes umfasst:

eine Herzschlagerfassungseinheit (312) zum Empfang der PPG-Signale, um die Herzschlagsignale zu erfassen, und zur Umwandlung der erfassten Herzschlagsignale in Zeitreihensignale der Herzfrequenzvariabilität;
eine Spektrumanalyseneinheit (313) zur Analyse eines Spektrums der Herzschlagsignale als Reaktion auf die Zeitreihensignale der Herzfrequenzvariabilität; und
eine Berechnungseinheit des Mittelwerts/der Standardabweichung (314) zur Berechnung eines Mittelwerts und eines Werts der Standardabweichung der Herzschlagsignale als Reaktion auf die Zeitreihensignale der Herzfrequenzvariabilität.

17. Mobiles Gerät nach Anspruch 16, worin die Herzschlagerfassungseinheit (312) Folgendes umfasst:

einen Bandpassfilter (340) zur Extraktion von Signalen, die in ein spezielles Band der PPG-Signale fallen;
einen Medianfilter (341) zur Entfernung von Rauschen, das bei den Filterergebnissen des Bandpassfilters (340) auftritt;
einen Addierer (342) zur Berechnung einer Differenz zwischen den Filterergebnissen von sowohl dem Bandpassfilter (340) als auch dem Medianfilter (341) durch Addition einer reziproken Zahl des Filterergebnisses des Medianfilters (341) zum Filterergebnis des Bandpassfilters (340);
einen angepassten Filter (343) zur Extraktion der Herzschlagsignale von den Ausgabesignalen des Addierers (342); und
einen Null-Clipper (344) zur Durchführung von Null-Clipping für die Herzschlagsignale.

18. Mobiles Gerät nach einem der vorstehenden Ansprüche, worin die Subtraktoreinheit (320) Merkmalswerte eines normalen Gefühls des Anwenders als Merkmalswerte verwendet, auf denen die Befindlichkeit eines Anwenders basiert.

19. Mobiles Gerät nach einem der vorstehenden Ansprüche, worin die SVM-Einheit (330) Folgendes umfasst:

einen SVM-Klassifikator (332) zur Klassifikation der Befindlichkeit des Anwenders in eine Vielzahl von Kategorien durch Analyse der Differenzen der Merkmalswerte, die von der Subtraktoreinheit (320) erhalten werden; und
eine Bestimmungseinheit der Befindlichkeit (336) zur Auswahl von Werten, die sich auf das spezielle Gefühl beziehen, unter den Werten der Vielzahl von Gefühlen, die durch den SVM-Klassifikator (332) klassifiziert werden, und zur Berechnung und Ausgabe des Index und der Höhe für das spezielle Gefühl.

20. Mobiles Gerät nach Anspruch 19, worin die SVM-Einheit (330) weiter Folgendes umfasst:

eine Datenbank (334) zur Speicherung einer Vielzahl von Teilen von Gefühlsdaten zur Schulung des SVM-Klassifikators (332) und von geschulten Ergebnissen des SVM-Klassifikators (332) auf der Grundlage der Gefühlsdaten.

21. Mobiles Gerät nach einem der vorstehenden Ansprüche, worin die Analyseneinheit für den physischen Zustand (290) Folgendes umfasst:

eine Berechnungseinheit des Körperfett-Prozentsatzes (371) zur Berechnung des Körperfett-Prozentsatzes auf der Grundlage eines Körperimpedanzwertes, der durch das Messmodul für biomedizinische Signale (100) erfasst wird, der Größe, des Gewichts, Alters und Geschlechts des Anwenders; und
eine Berechnungseinheit des Kalorienverbrauchs (372) zur Berechnung des Kalorienverbrauchs aufgrund von körperlicher Anstrengung auf der Grundlage von durchschnittlichen Herzfrequenzen und Körperfett-Prozentsätzen vor/nach der körperlichen Anstrengung, die durch das Messmodul für biomedizinische Signale (100) erfasst werden.

22. Verfahren zur Analyse von biomedizinischen Signalen eines Anwenders unter Verwendung eines mobilen Geräts, wobei das Verfahren die Klassifikation von biomedizinischen Signalen durch ein entsprechendes Signal und die Analyse der Befindlichkeit und des physischen Zustands des Anwenders auf der Grundlage der klassifizierten Signale und der physischen Information des Anwenders durch Folgendes umfasst:

Analyse der biomedizinischen Signale und Extraktion einer Vielzahl von Merkmalswerten, die zur Bestimmung der Befindlichkeit des Anwenders verwendet werden (S90);
Berechnung der Differenzen zwischen der Vielzahl von extrahierten Merkmalswerten und Merkmalswerten, auf denen die Befindlichkeit des Anwenders basiert (S100);

Klassifikation der Befindlichkeit des Anwenders durch entsprechende Gefühle auf der Grundlage der Klassifikation der Support Vector Machine, nachstehend SVM, gemäß den berechneten Differenzen der Merkmalswerte (S110); und
Auswahl von Werten, die sich auf ein Gefühl beziehen, das unter den klassifizierten Gefühlen ausgewählt wird, Berechnung eines Befindlichkeitsindex und der Höhe für das ausgewählte Gefühl und Anzeige des berechneten Befindlichkeitsindex und der Höhe auf einer Anzeigeeinheit des mobilen Geräts (S120).

23. Verfahren nach Anspruch 22, das weiter Folgendes umfasst:

Annahme einer Eingabe eines Anwenders, um ein Gesundheitsüberwachungsmenü am mobilen Gerät auszuwählen, wobei das mobile Gerät ein Messmodul für biomedizinische Signale (100) besitzt; und
Aktivierung des Messmoduls für biomedizinische Signale (100), falls der Anwender die Messung der Befindlichkeit auswählt (S30).

24. Verfahren nach einem der Ansprüche 22 oder 23, worin die biomedizinischen Signale biomedizinische Signale des Herzschlags einschließen.

25. Verfahren nach Anspruch 24, worin die biomedizinischen Signale des Herzschlags Signale der Photoplethysmographie, nachstehend PPG, sind.

26. Verfahren nach einem der Ansprüche 22 bis 25, worin die biomedizinischen Signale der Hauttemperatur zugehörige, biomedizinische Signale einschließen.

27. Verfahren nach Anspruch 26, worin die biomedizinischen Signale der Hauttemperatur Hauttemperatur-, nachstehend SKT, Signale sind.

28. Verfahren nach einem der Ansprüche 22 bis 27, worin die biomedizinischen Signale dem Hautwiderstand zugehörige, biomedizinische Signale einschließen.

29. Verfahren nach Anspruch 28, worin die biomedizinischen Signale des Hautwiderstands Signale der elektrodermalen Aktivität, nachstehend EDA, sind.

30. Verfahren nach einem der Ansprüche 22 bis 29, worin die biomedizinischen Signale durch einen einen Filter (112, 122, 132, 143) gefiltert und dann durch einen Verstärker (113, 123, 133, 142, 144) verstärkt werden.

31. Verfahren nach Anspruch 22, das weiter den Schritt der Korrektur der Abweichung der biomedizinischen Signale von Anwender zu Anwender umfasst (S80).

32. Verfahren nach Anspruch 31, worin der Schritt der Korrektur der Abweichung der biomedizinischen Signale von Anwender zu Anwender folgende Schritte umfasst:

Bestimnmung, ob die Korrektur der Abweichungen der biomedizinischen Signale von Anwender zu Anwender erforderlich ist (S82);
falls bestimmt wird, dass die Korrektur der Abweichungen der biomedizinischen Signale von Anwender zu Anwender erforderlich ist, Kontrolle, ob die Werte der biomedizinischen Signale über einem maximalen Grenzwert liegen, und Reduzierung einer Zunahme eines Verstärkers, falls die Werte der biomedizinischen Signale über dem maximalen Grenzwert liegen (S83, S84); und
falls die Werte der biomedizinischen Signale gleich dem oder geringer als der maximale Grenzwert sind, Kontrolle, ob die Werte der biomedizinischen Signale gleich dem oder geringer als ein minimaler Grenzwert sind und Erhöhung der Zunahme des Verstärkers, falls die Werte der biomedizinischen Signale gleich dem oder geringer als der minimale Grenzwert sind (S85, S86).

33. Verfahren nach Anspruch 22, worin der Schritt der Analyse der biomedizinischen Signale und der Extraktion der Vielzahl von Merkmalswerten, die zur Bestimmung der Befindlichkeit des Anwenders zu verwenden sind, folgende Schritte umfasst:

Empfang von PPG-Signalen, um Herzschlagsignale zu erfassen, und Extraktion von Merkmalswerten, die sich auf die Herzschlagsignale beziehen;

Empfang von EDA-Signalen und Extraktion von Merkmalswerten, die sich auf eine Hautleitfähigkeitsreaktion beziehen; und
Empfang von SKT-Signalen und Extraktion von Merkmalswerten, die sich auf die Hauttemperatur beziehen.

34. Verfahren nach Anspruch 22, worin die Merkmalswerte, auf denen die Befindlichkeit des Anwenders basiert, Merkmalswerte eines normalen Gefühls des Anwenders sind.

35. Verfahren nach Anspruch 22, worin der Schritt der Klassifikation der Befindlichkeit des Anwenders durch die entsprechenden Gefühle einen SVM-Klassifikator verwendet, der die Befindlichkeit des Anwenders in eine Vielzahl von Kategorien auf der Grundlage einer statistischen Lerntheorie klassifiziert.

36. Verfahren nach Anspruch 23, worin das Messmodul für biomedizinische Signale (100) so konfiguriert ist, dass es mit dem mobilen Gerät abtrennbar verbunden ist.

37. Verfahren nach Anspruch 36, worin das Messmodul für biomedizinische Signale (100) in Form eines Gehäuses konstruiert ist, das das mobile Gerät darin aufnehmen kann.

38. Verfahren nach Anspruch 23, das weiter den Schritt der, falls der Anwender sie auswählt, Messung des Körperfetts umfasst:

Aktivierung des Messmoduls für biomedizinische Signale (S230, S240); und
Berechnung des Körperfett-Prozentsatzes des Körpers des Anwenders auf der Grundlage einer Körperimpedanz des Anwenders und der physischen Information des Anwenders und Anzeige des berechneten Körperfett-Prozentsatzes auf der Anzeigeeinheit des mobilen Geräts (S250, S260).

39. Verfahren nach Anspruch 23, das weiter den Schritt der, falls der Anwender sie auswählt, Messung des Kalorienverbrauchs umfasst:

Aktivierung des Messmoduls für biomedizinische Signale (S280, S290); und
Analyse der Herzschlagsignale des Anwenders und einer Körperimpedanz des Anwenders vor/nach körperlicher Anstrengung, um durchschnittliche Herzfrequenzen und Körperfett-Prozentsätze vor/nach der körperlichen Anstrengung zu berechnen, Berechnung des Kalorienverbrauchs aufgrund von körperlicher Anstrengung auf der Grundlage der berechneten durchschnittlichen Herzfrequenzen und Körperfett-Prozentsätze vor/nach der körperlichen Anstrengung, der Zeit der körperlichen Anstrengung und der physischen Information des Anwenders und Anzeige des berechneten Kalorienverbrauchs auf der Anzeigeeinheit des mobilen Geräts (S300, S310).

40. Verfahren nach einem der Ansprüche 22, 38 und 39, das weiter den Schritt des, falls der Anwender es auswählt, History Management (Verwaltung des Entwicklungsverlaufs) umfasst, wobei Ergebnisse gemäß den entsprechenden gewünschten Zeitpunkten auf der Anzeigeeinheit (220) angezeigt werden.

Revendications

1. Dispositif mobile qui comprend une unité de saisie (210), une unité d'affichage (220), une unité de mémorisation (230) et une unité de contrôle central (240), le dispositif mobile comprenant :

un module de mesure de signaux biomédicaux (100) pour détecter des signaux biomédicaux provenant du corps d'un utilisateur, classer les signaux biomédicaux détectés selon les biosignaux correspondantss et présenter les signaux ainsi classés ; et
un module de soins de santé (300) pour analyser l'état émotionnel et la condition physique d'un utilisateur sur la base des signaux catégorisés saisis à partir du module de mesure de signaux biomédicaux (100) et de l'information physique de l'utilisateur, le module de soins de santé (300) comprenant une unité d'analyse de l'état émotionnel (280) qui analyse les signaux biomédicaux fournis par le module de mesure de signaux biomédicaux (100) et détermine l'état émotionnel de l'utilisateur, et une unité d'analyse de la condition physique (290) qui analyse la condition physique de l'utilisateur sur la base des signaux biomédicaux fournis par le module de mesure de signaux biomédicaux (100) et de l'information physique de l'utilisateur, l'unité d'analyse de l'état émotionnel comprenant :

une unité d'analyse de caractéristiques (310) qui analyse les caractéristiques des signaux biomédicaux détectés à partir du corps de l'utilisateur ;
une unité de soustraction (320) qui indique les différences entre les résultats des analyses produites par l'unité d'analyse de caractéristiques (310) et des valeurs de caractéristiques à partir desquelles l'état émotionnel de l'utilisateur est déterminé ; et
une machine à vecteurs de support désignée ci-après classeur SVM (330) qui analyse les différences entre les valeurs de caractéristiques obtenues par l'unité de soustraction (320), classe l'état émotionnel de l'utilisateur, et calcule et présente un indice et un niveau attribués à une émotion spécifique parmi les émotions classées.

2. Dispositif mobile selon la revendication 1, dans lequel le module de mesure de signaux bomédicaux (100) comprend :

une unité détectrice (150) qui détecte un ou plusieurs signaux biomédicaux provenant du corps de l'utilisateur ; et une unité de contrôle de détection (170) qui contrôle l'unité détectrice (150), classe les signaux biomédicaux fournis par l'unité détectrice (150) selon les signaux biomédicaux correspondants et présente les signaux biomédicaux ainsi classés.

3. Dispositif mobile selon la revendication 2, dans lequel l'unité détectrice (150) comprend un détecteur de fréquence cardiaque (111) qui détecte les signaux biomédicaux associés aux battements cardiaques.

4. Dispositif mobile selon la revendication 3, dans lequel les signaux biomédicaux associés aux battements cardiaques sont des signaux pléthysmographiques à pulsations photoélectriques désignés ci-après signaux PPG.

5. Dispositif mobile selon la revendication 2, dans lequel l'unité détectrice (150) comprend un détecteur de température cutanée (121) qui détecte les signaux biomédicaux associés à la température cutanée.

6. Dispositif mobile selon la revendication 5, dans lequel les signaux biomédicaux associés à la température cutanée sont des signaux de température cutanée désignés ci-après signaux SKT.

7. Dispositif mobile selon la revendication 2, dans lequel l'unité détectrice (150) comprend un détecteur de résistance cutanée (131) qui détecte les signaux biomédicaux associés à la résistance cutanée.

8. Dispositif mobile selon la revendication 7, dans lequel les signaux biomédicaux associés à la résistance cutanée sont des signaux d'activité électrodermique désignés ci-après signaux EDA.

9. Dispositif mobile selon la revendication 2, dans lequel l'unité détectrice (150) comprend un détecteur de graisse corporelle (141) qui mesure l'impédance corporelle requise pour le calcul d'un pourcentage de graisse corporelle.

10. Dispositif mobile selon l'une quelconque des revendications 3 à 9, dans lequel le détecteur de fréquence cardiaque (111), le détecteur de température cutanée (121), le détecteur de résistance cutanée (131) ou le détecteur de graisse corporelle (141) comprend un filtre (112, 122, 132, 143) qui filtre les signaux biomédicaux détectés, et un amplificateur (113, 123, 133, 142, 144) qui amplifie les signaux biomédicaux filtrés.

11. Dispositif mobile selon l'une quelconque des revendications 3 à 10, dans lequel le détecteur de fréquence cardiaque (111), le détecteur de température cutanée (121), le détecteur de résistance cutanée (131) ou le détecteur de graisse corporelle (141) est installé sur le dispositif mobile en une position en laquelle la main de l'utilisateur entre en contact avec le détecteur quand l'utilisateur tient le dispositif mobile en main.

12. Dispositif mobile selon l'une quelconque des revendications 2 à 11, dans lequel l'unité de contrôle de détection (170) corrige les variations, d'un utilisateur à un autre, de signaux biomédicaux fournis par l'unité détectrice (150).

13. Dispositif mobile selon l'une quelconque des revendications précédentes, dans laquelle le module de mesure de signaux biomédicaux (100) est réalisé de sorte à pouvoir être couplé au dispositif mobile de façon détachable.

14. Dispositif mobile selon la revendication 13, dans lequel le module de mesure de signaux biomédicaux (100) est réalisé sous forme d'un boîtier capable de contenir le dispositif mobile.

15. Dispositif mobile selon la revendication 1, dans lequel l'unité d'analyse de caractéristiques (310) comprend :

une unité d'analyse de battements cardiaques (311) qui reçoit des signaux PPG pour détecter des signaux de battements cardiaques et extrait des valeurs de caractéristiques associées aux signaux de battements cardiaques ;
une unité d'analyse de réactions de conduction cutanée (315) qui reçoit des signaux EDA et extrait des valeurs de caractéristiques associées à une réaction de conduction cutanée ; et
une unité d'analyse de température cutanée (318) qui reçoit des signaux SKT et extrait des valeurs de caractéristiques associées à la température cutanée.

16. Dispositif mobile selon la revendication 15, dans lequel l'unité d'analyse de battements cardiaques (311) comprend :

une unité de détection de battements cardiaques (312) qui reçoit les signaux de battements cardiaques PPG pour détecter ces signaux de battements cardiaques et les convertir en signaux de séries temporelles de variabilité de la fréquence cardiaque ;
une unité d'analyse spectrale (313) qui analyse un spectre des signaux de battements cardiaques en réponse aux signaux de séries temporelles de variabilité de la fréquence cardiaque ; et
une unité de calcul d'écart moyen et d'écart type (314) qui calcule une valeur moyenne et une valeur d'écart type des signaux de battements cardiaques en réponse aux signaux de séries temporelles de variabilité de la fréquence cardiaque.

17. Dispositif mobile selon la revendication 16, dans lequel l'unité de détection de battements cardiaques (312) comprend :

un filtre passe-bande (340) qui extrait les signaux compris dans une bande spécifique des signaux PPG ;
un filtre médian (341) qui élimine le bruit présent dans les signaux résultant du filtrage par le filtre passe-bande (340) ;
un sommateur (342) qui calcule une différence entre les résultats du filtrage par le filtre passe-bande (340) ainsi que par le filtre médian (341) en ajoutant un nombre réciproque du résultat de filtrage par le filtre médian (341) au résultat de filtrage du filtre passe-bande (340);
un filtre adapté (343) qui extrait les signaux de battements cardiaques à partir des signaux sortis du sommateur (342) ; et
un limiteur "zéro clipper" (344) qui écrête les signaux de battements cardiaques au niveau zéro.

18. Dispositif mobile selon l'une quelconque des revendications précédentes, dans lequel l'unité de soustraction (320) utilise des valeurs de caractéristiques d'une émotion normale d'un utilisateur comme valeurs caractéristiques de base pour déterminer l'état émotionnel de l'utilisateur.

19. Dispositif mobile selon l'une quelconque des revendications précédentes, dans lequel l'unité SVM (330) comprend :

un classeur SVM (332) pour classer l'état émotionnel de l'utilisateur en plusieurs catégories en analysant les différences des valeurs de caractéristiques fournies par l'unité de soustraction (320) ; et
une unité de détermination d'états émotionnels (336) qui sélectionne des valeurs associées à une émotion spécifique faisant partie des valeurs de la pluralité d'émotions catégorisées par le classeur SVM (332), et calcule et présente l'indice et le niveau de l'émotion spécifique en question.

20. Dispositif mobile selon la revendication 19, dans lequel l'unité SVM (330) comprend de plus :

une base de données (334) de mémorisation d'une pluralité d'éléments d'émotion pour l'entraînement du classeur SVM (332) et les résultats, basés sur les données d'émotion, du classeur SVM (332) après l'entraînement.

21. Dispositif mobile selon l'une quelconque des revendications précédentes, dans lequel l'unité d'analyse de la condition physique (290) comprend :

une unité de calcul du pourcentage de graisse corporelle (371) qui calcule le pourcentage de graisse corporelle basé sur une valeur d'impédance corporelle détectée par le module de mesure de signaux biomédicaux (100) ainsi que sur la taille, le poids, l'âge et le sexe de l'utilisateur ou de l'utilisatrice ; et
une unité de calcul de consommation de calories (372) qui calcule la consommation de calories due à l'exercice, sur la base des fréquences cardiaques moyennes et des pourcentages de graisse corporelle moyens avant et après l'exercice, tels que détectés par le module de mesure de signaux biomédicaux (100).

22. Procédé d'analyse de signaux biomédicaux d'un utilisateur qui utilise un dispositif mobile, le procédé comprenant le classement des signaux biomédicaux selon les signaux correspondants et l'analyse de l'état émotionnel et de la condition physique de l'utilisateur sur la base des signaux ainsi classés et de l'information physique de l'utilisateur, par les moyens suivants :

analyse des signaux biomédicaux et extraction d'une pluralité de valeurs de caractéristiques à utiliser pour déterminer l'état émotionnel de l'utilisateur (S90) ;
calcul des différences entre la pluralité de valeurs de caractéristiques extraites et les valeurs de caractéristiques sur lesquelles est basé l'état émotionnel de l'utilisateur (S100) ;
classement de l'état émotionnel de l'utilisateur selon les émotions respectives sur la base du classement de la machine à vecteurs de support désignée ci-après SVM, le classement étant conforme aux différences calculées des valeurs de caractéristiques (S110) ; et
sélection de valeurs associées à une émotion choisie parmi les émotions classées, calcul d'un indice et d'un niveau émotionnels pour l'émotion sélectionnée, et affichage de l'indice et du niveau émotionnels ainsi calculés sur une unité d'affichage du dispositif mobile (S120).

23. Procédé selon la revendication 22 qui comprend de plus:

acceptation des données provenant de l'utilisateur pour sélectionner, sur le dispositif mobile, un menu de soins de santé, le dispositif mobile étant pourvu d'un module de mesure de signaux biomédicaux (100) ; et
activation du module de mesure de signaux biomédicaux (100) si l'utilisateur sélectionne la mesure de l'état émotionnel (S30).

24. Procédé selon l'une quelconque des revendications 22 ou 23, selon lequel les signaux biomédicaux incluent des signaux biomédicaux de battements cardiaques.

25. Procédé selon la revendication 24, selon lequel les signaux de battements cardiaques sont des signaux pléthysmographiques à pulsations photoélectriques désignés ci-après signaux PPG.

26. Procédé selon l'une quelconque des revendications 22 à 25, selon lequel les signaux biomédicaux incluent des signaux biomédicaux associés à la température cutanée.

27. Procédé selon la revendication 26, selon lequel les signaux biomédicaux de température cutanée sont des signaux de température cutanée désignés ci-après signaux SKT.

28. Procédé selon l'une quelconque des revendications 22 à 27, selon lequel les signaux biomédicaux incluent des signaux biomédicaux associés à la résistance cutanée.

29. Procédé selon la revendication 28, selon lequel les signaux biomédicaux de résistance cutanée sont des signaux d'activité électrodermique désignés ci-après signaux EDA.

30. Procédé selon l'une quelconque des revendications 22 à 29, selon lequel les signaux biomédicaux sont filtrés par un filtre (112, 122 132, 143), puis amplifiés par un amplificateur (113, 123, 133, 142, 144).

31. Procédé selon la revendication 22, qui comprend de plus l'opération de correction de la variation des signaux biomédicaux d'un utilisateur à un autre (S80).

32. Procédé selon la revendication 31, selon lequel l'opération de correction de la variation des signaux médicaux d'un utilisateur à un autre comprend les étapes consistant à :

déterminer si la correction des variations des signaux biomédicaux d'un utilisateur à un autre est nécessaire (S82) ;
s'il est déterminé que la correction des variations des signaux biomédicaux d'un utilisateur à un autre est nécessaire, vérifier si les valeurs des signaux biomédicaux dépassent un niveau maximum admissible et réduire le gain d'un amplificateur si les valeurs des signaux biomédicaux dépassent le niveau maximum admissible (S83, S84) ; et
si les valeurs des signaux biomédicaux sont égales ou inférieures au niveau maximum admissible, vérifier si les valeurs des signaux biomédicaux sont égales ou inférieures à un niveau minimum admissible et augmenter

le gain de l'amplificateur si les valeurs des signaux biomédicaux sont égales ou inférieures au niveau minimum admissible (S85, S86).

33. Procédé selon la revendication 22, selon lequel l'opération d'analyse des signaux biomédicaux et l'extraction de la pluralité de valeurs de caractéristiques à utiliser pour déterminer l'état émotionnel de l'utilisateur comprend les étapes consistant à :

recevoir des signaux PPG pour détecter les signaux de battements cardiaques, et extraire des valeurs de caractéristiques associées aux signaux de battements cardiaques ;
recevoir des signaux EDA et extraire des valeurs de caractéristiques associées à une réaction de conduction cutanée ; et
recevoir des signaux SKT et extraire des valeurs de caractéristiques associées à la température cutanée.

34. Procédé selon la revendication 22, selon lequel les valeurs de caractéristiques sur lesquelles est basé l'état émotionnel de l'utilisateur sont des valeurs de caractéristiques émotionelles normales de l'utilisateur.

35. Procédé selon la revendication 22, selon lequel l'étape de classement de l'état émotionnel de l'utilisateur en fonction des émotions respectives utilise un classeur SVM qui classe les états émotionnels de l'utilisateur en plusieurs catégories sur la base d'une théorie d'entraînement statistique.

36. Procédé selon la revendication 23, selon lequel le module de mesure de signaux biomédicaux (100) est configuré de sorte à pouvoir être couplé de façon détachable au dispositif mobile.

37. Procédé selon la revendication 36, selon lequel le module de mesure de signaux biomédicaux (100) est réalisé sous forme d'un boîtier capable de contenir le dispositif mobile.

38. Procédé selon la revendication 23, qui comprend de plus, si l'utilisateur sélectionne la mesure de la graisse corporelle, les étapes consistant à :

activer le module de mesure de signaux biomédicaux (S230, S240) ; et
calculer un pourcentage de graisse corporelle du corps de l'utilisateur sur la base d'une impédance corporelle de l'utilisateur et de l'information physique de l'utilisateur, et présenter le pourcentage calculé de graise corporelle sur l'unité d'affichage du dispositif mobile (S250, S260).

39. Procédé selon la revendication 23, qui comprend de plus, si l'utilisateur sélectionne la mesure de consommation de calories, les étapes consistant à :

activer le module de mesure de signaux biomédicaux (S280, S290) ; et
analyser les signaux des battements cardiaques et d'une impédance corporelle de l'utilisateur avant et après l'exercice pour calculer les fréquences cardiaques moyennes et pourcentages de graisse corporelle moyens avant et après l'exercice, calculer la consommation de calories due à l'exercice sur la base des fréquences cardiaques moyennes et des pourcentages de graisse corporelle moyens calculés avant et après l'exercice, la durée de l'exercise, et de l'information physique de l'utilisateur, et présenter la consommation de calories calculée sur l'unité d'affichage du dispositif mobile (S300, S310).

40. Procédé selon l'une quelconque des revendications 22, 38 et 39 qui comprend de plus, si l'utilisateur a sélectionné la gestion historique, l'affichage des résultats sur l'unité d'affichage (220) en fonction de termes correspondants souhaités.

FIG. 1

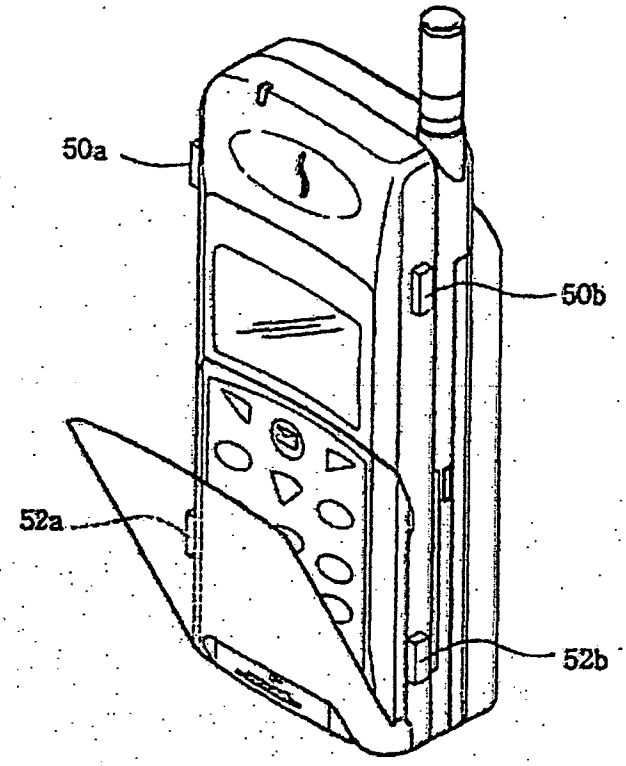


FIG. 2

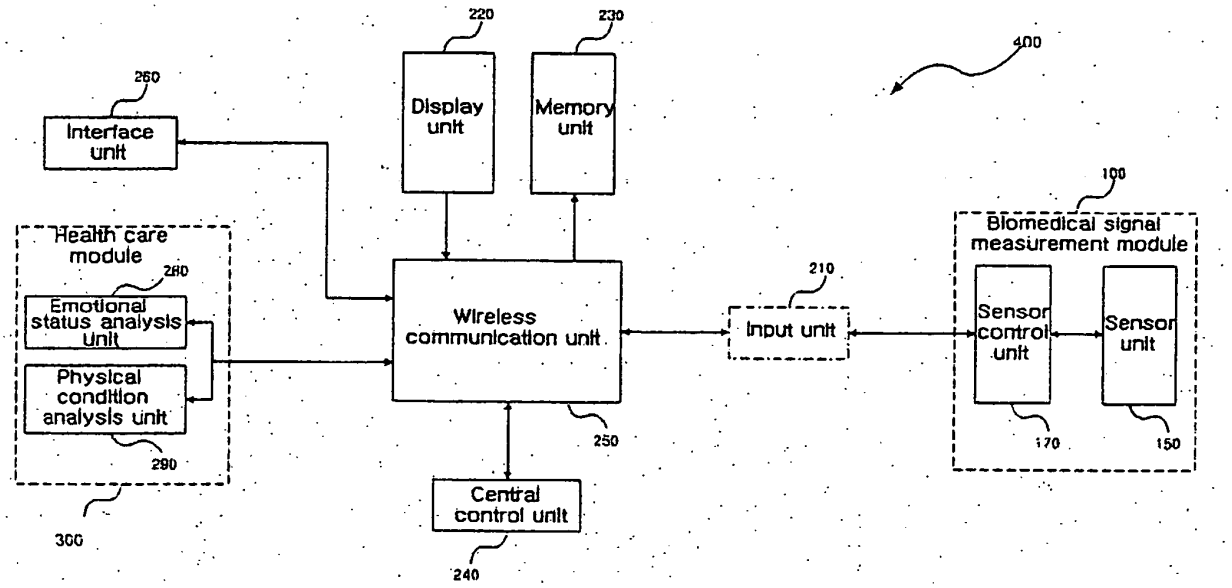

220
230
400
260
Display unit
Memory unit
Interface unit
100
Health care module
Biomedical signal measurement module
280
210
Emotional status analysis unit
Wireless communication unit
Input unit
Sensor control unit
Sensor unit
Physical condition analysis unit
250
170
150
290
Central control unit
300
240

FIG. 3

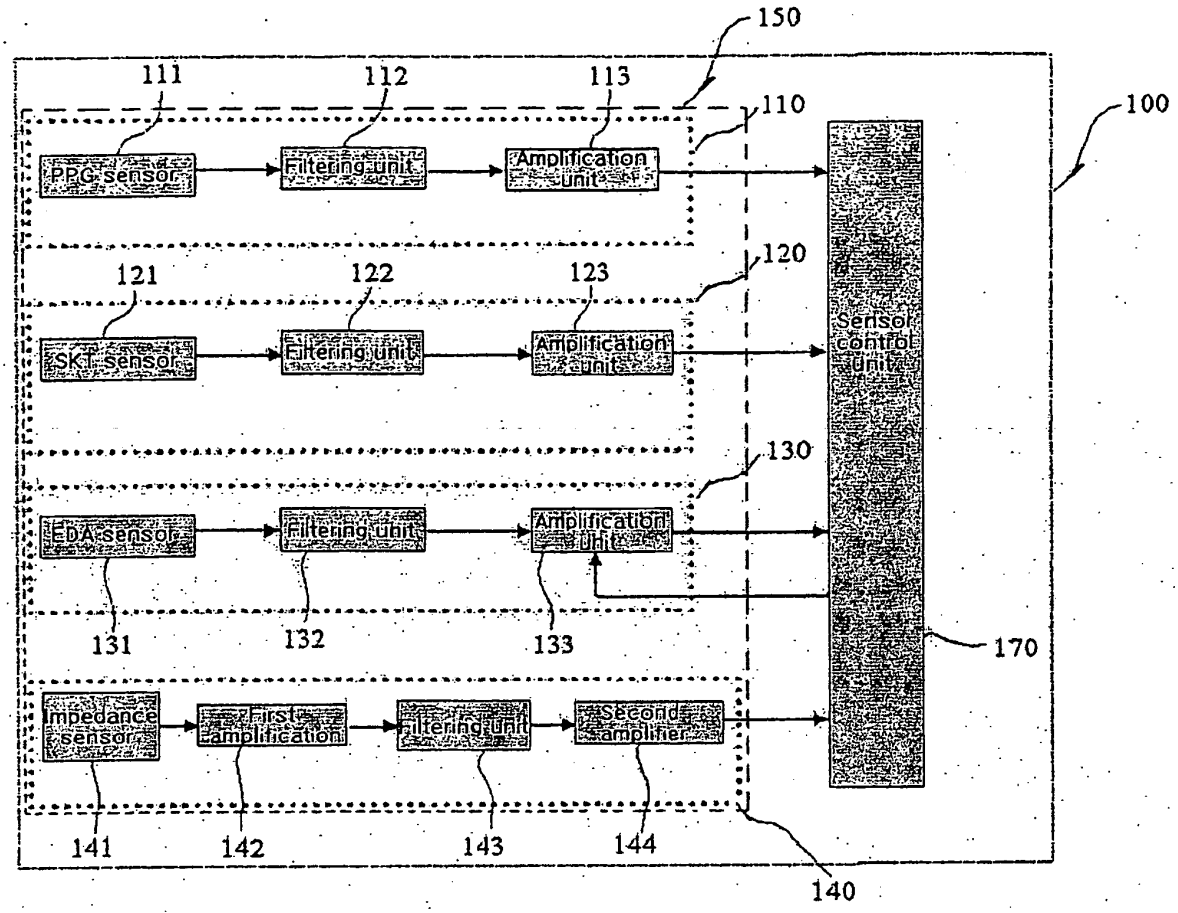

150
111
112
113
110
100
PPG sensor
Filtering unit
Amplification unit
120
121
122
123
SKT sensor
Filtering unit
Amplification unit
Sensor control unit
130
EDA sensor
Filtering unit
Amplification unit
131
132
133
170
Impedance sensor
First amplification
Filtering unit
Second amplifier
141
142
143
144
140

FIG. 4

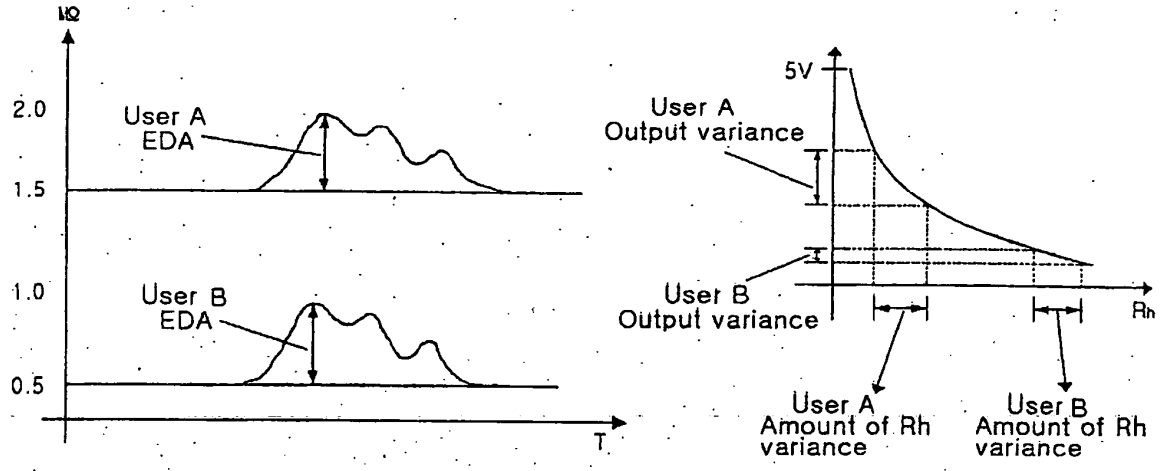

kΩ
2.0
1.5
1.0
0.5
User A
EDA
User B
EDA
T
5V
User A
Output variance
User B
Output variance
Rh
User A
Amount of Rh
variance
User B
Amount of Rh
variance

FIG. 5

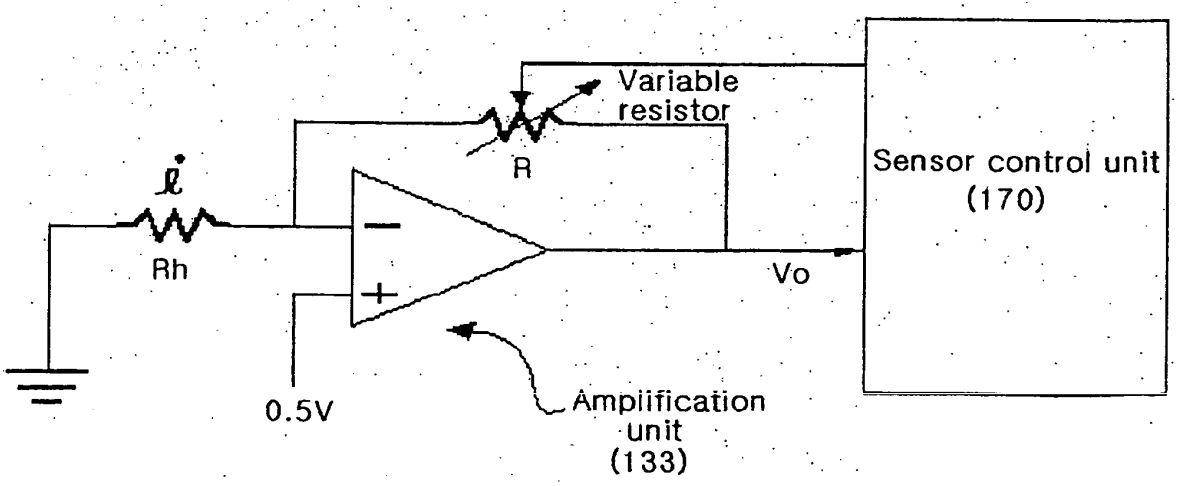

Variable
resistor
R
Rh
Vo
Sensor control unit
(170)
0.5V
Amplification
unit
(133)

FIG. 6

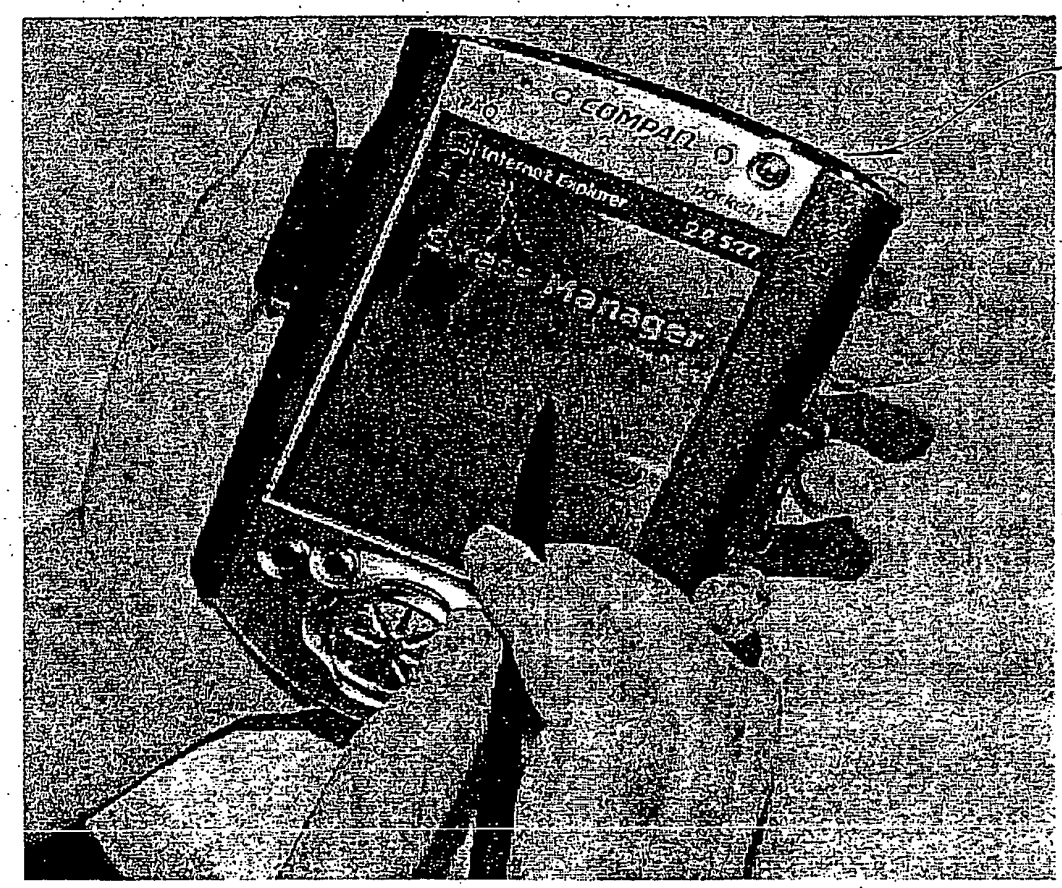


FIG. 7

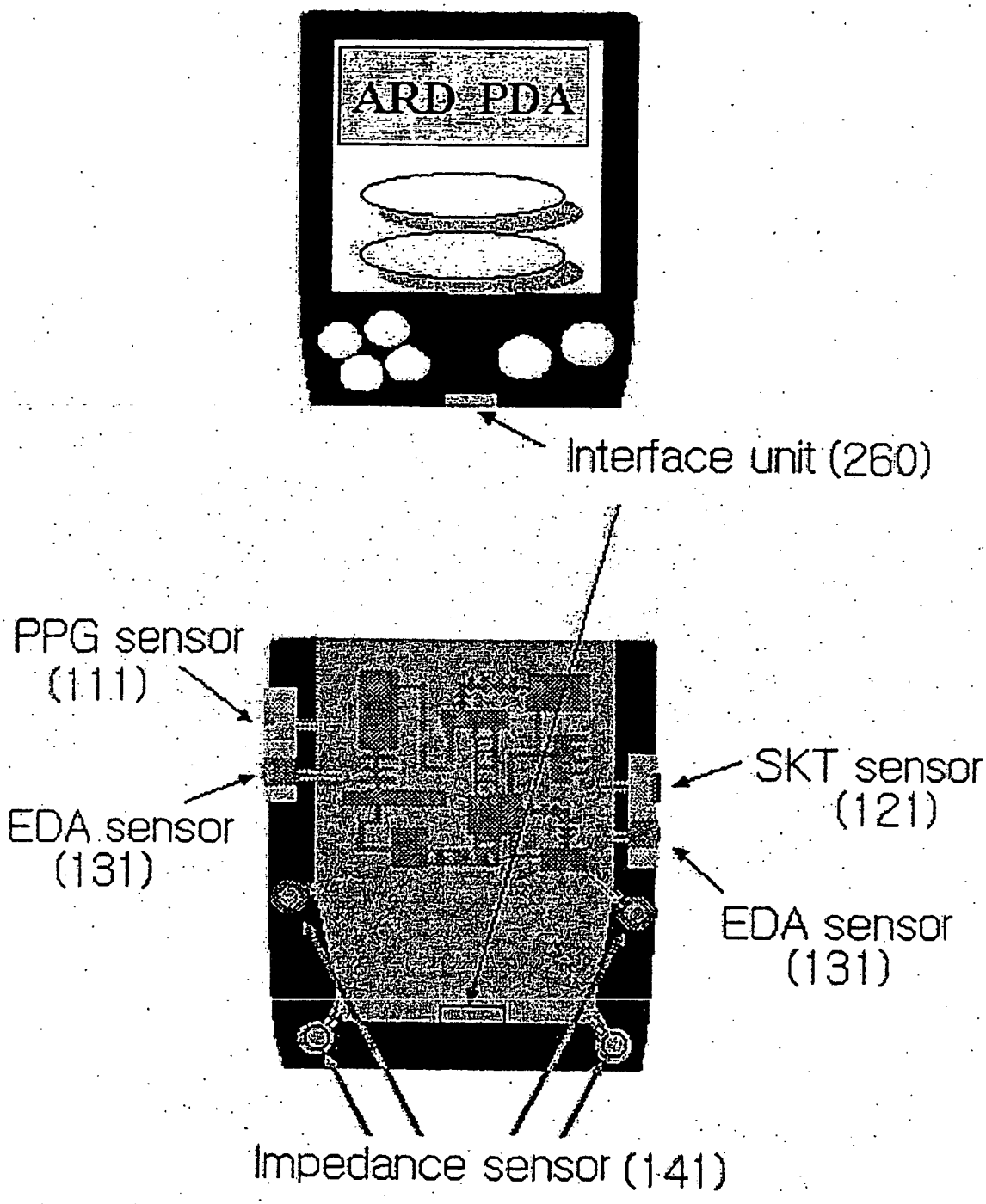

ARD PDA
Interface unit (260)
PPG sensor (111)
EDA sensor (131)
SKT sensor (121)
EDA sensor (131)
Impedance sensor (141)

FIG. 8

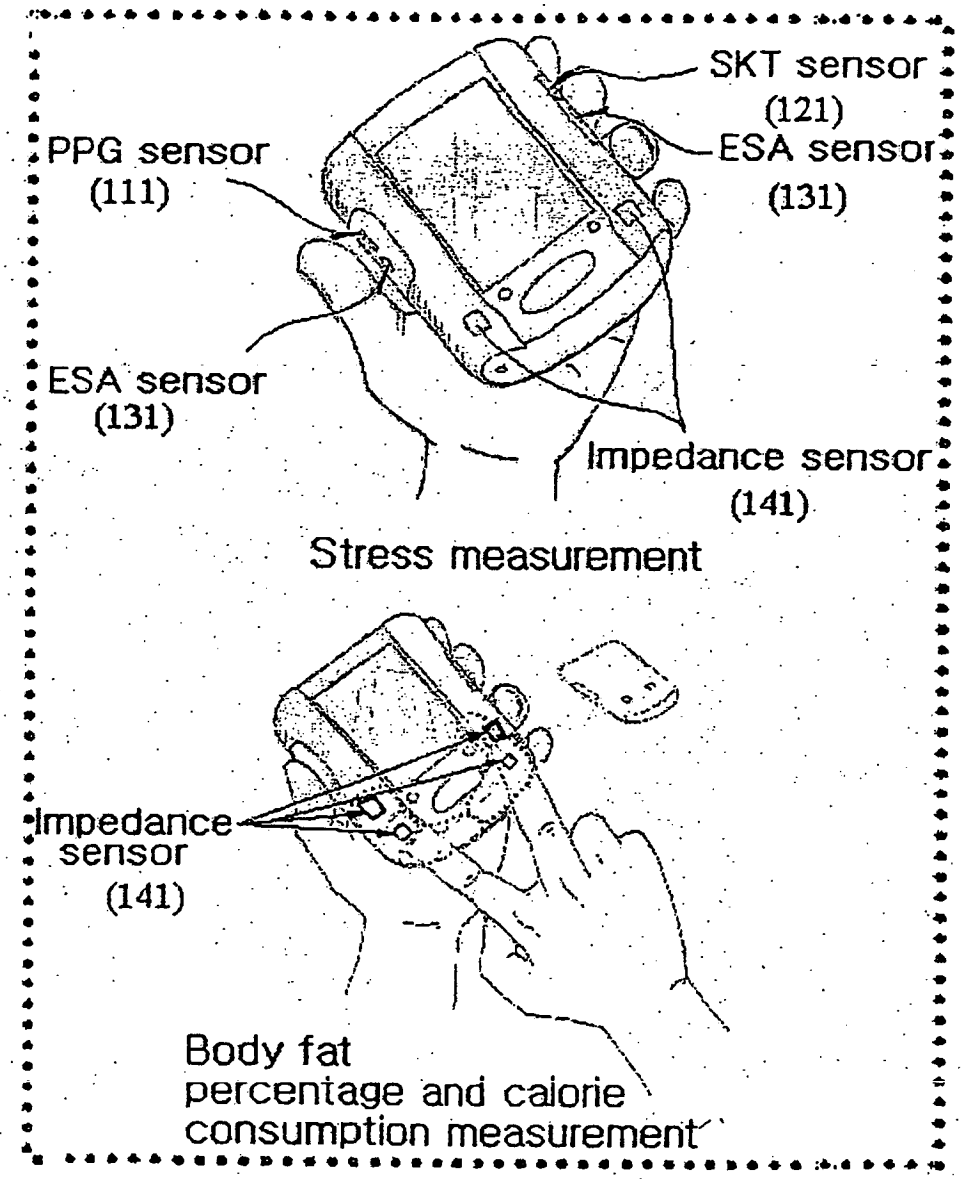

SKT sensor
(121)
PPG sensor
(111)
ESA sensor
(131)
ESA sensor
(131)
Impedance sensor
(141)
Stress measurement
Impedance
sensor
(141)
Body fat
percentage and calorie
consumption measurement

FIG. 9

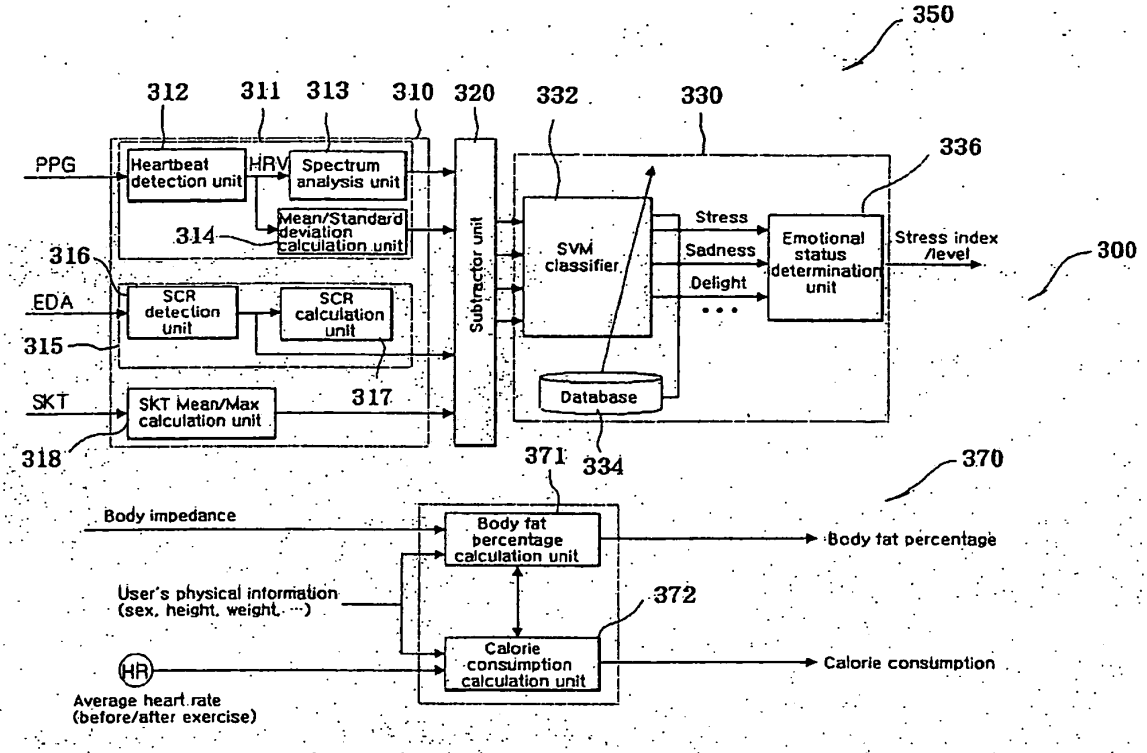

350
312
311
313
310
320
332
330
336
PPG
Heartbeat detection unit
HRV
Spectrum analysis unit
Mean/Standard deviation calculation unit
314
316
EDA
SCR detection unit
SCR calculation unit
315
317
SKT
SKT Mean/Max calculation unit
318
Subtractor unit
SVM classifier
Stress
Sadness
Delight
Emotional status determination unit
Stress index /level
300
Database
371
334
370
Body impedance
Body fat percentage calculation unit
Body fat percentage
User's physical information (sex, height, weight, ···)
372
HR
Average heart rate (before/after exercise)
Calorie consumption calculation unit
Calorie consumption

FIG. 10

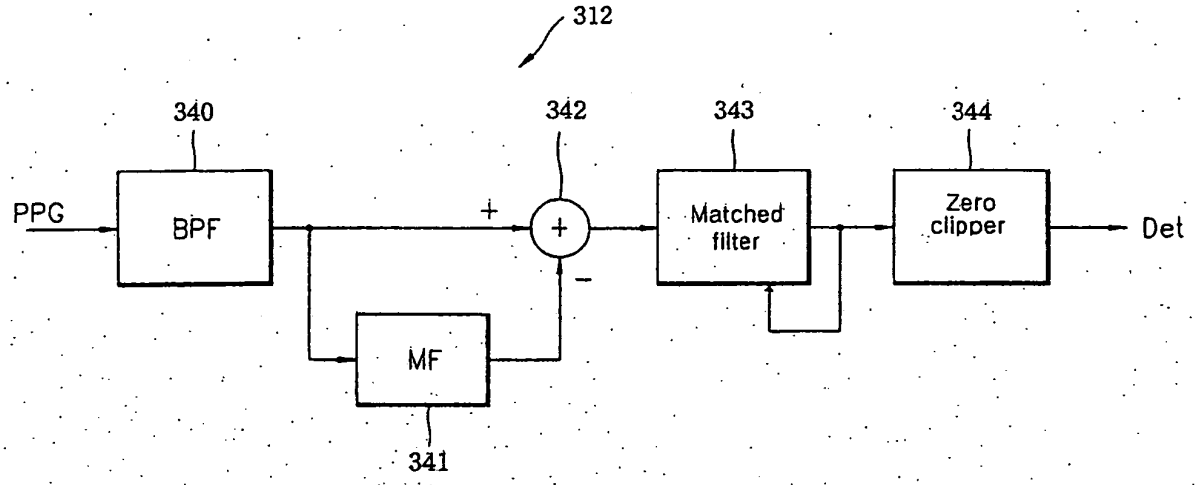

312
340
342
343
344
PPG
BPF
+
+
Matched filter
Zero clipper
Det
−
MF
341

FIG. 11

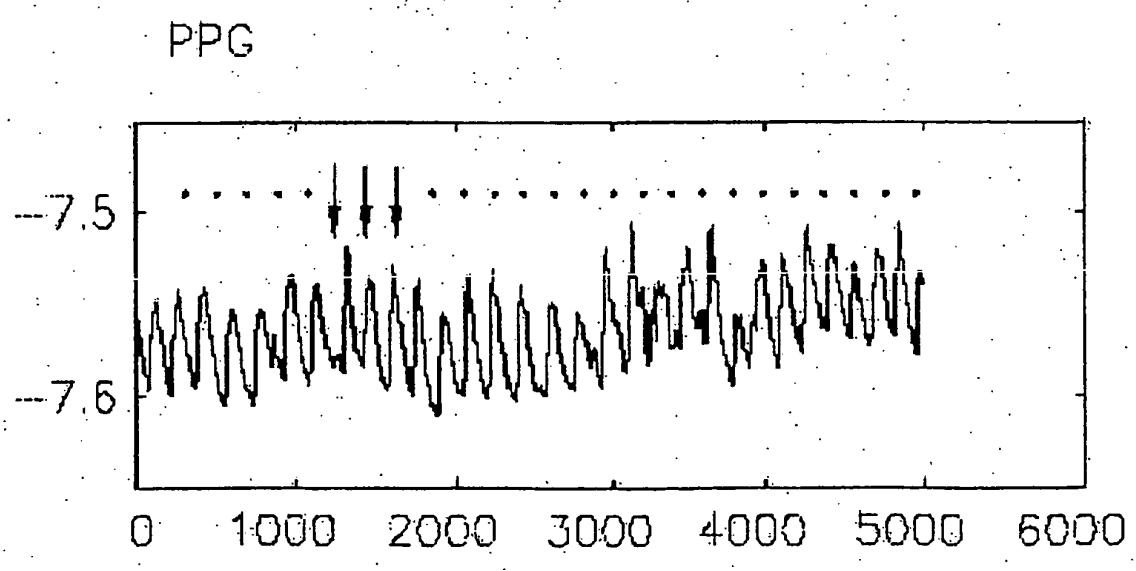

PPG
7.5
7.6
0
1000
2000
3000
4000
5000
6000

FIG. 12

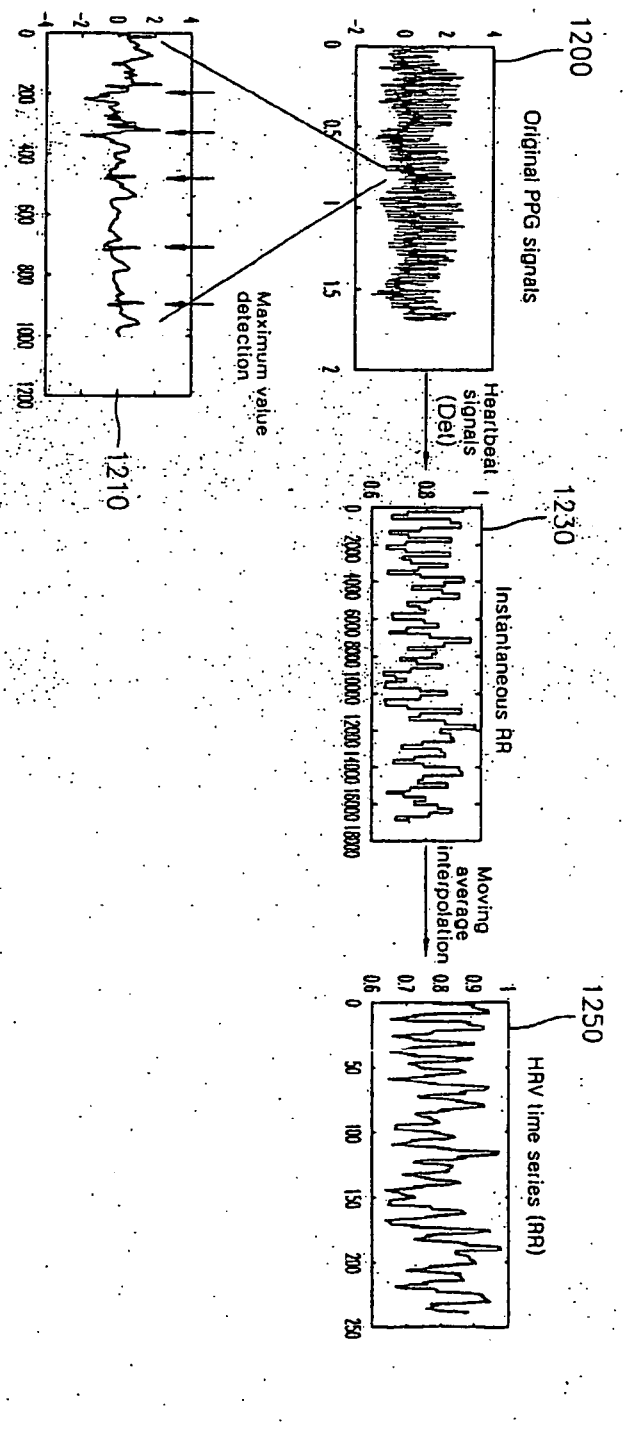

1200
Original PPG signals
Maximum value detection
1210
Heartbeat signals (Del)
1230
Instantaneous RR
Moving average interpolation
1250
HRV time series (RR)

FIG. 13

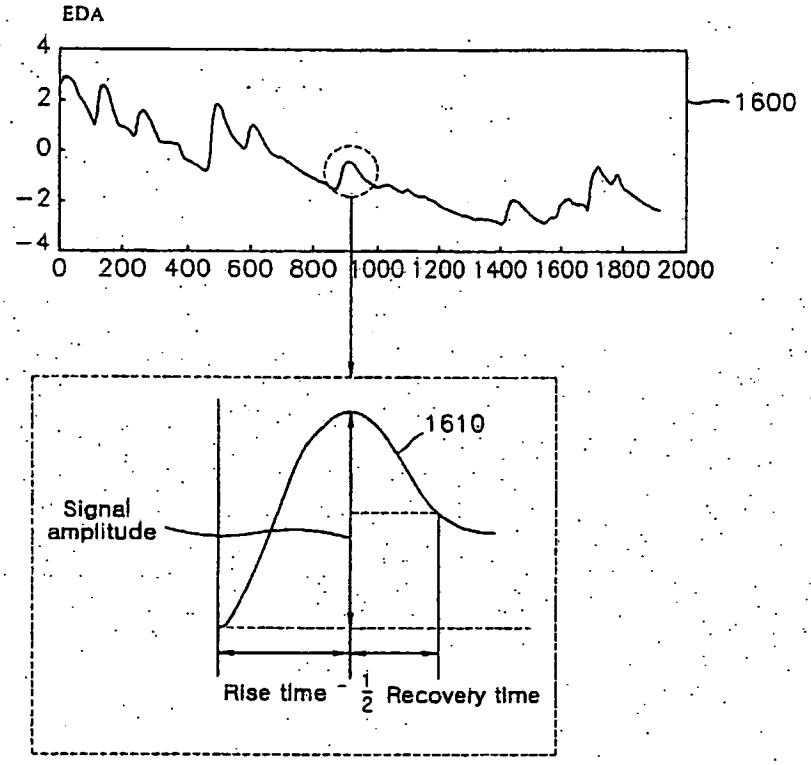

EDA
4
2
0
−2
−4
0 200 400 600 800 1000 1200 1400 1600 1800 2000
1600
1610
Signal amplitude
Rise time
1/2
Recovery time

FIG. 14

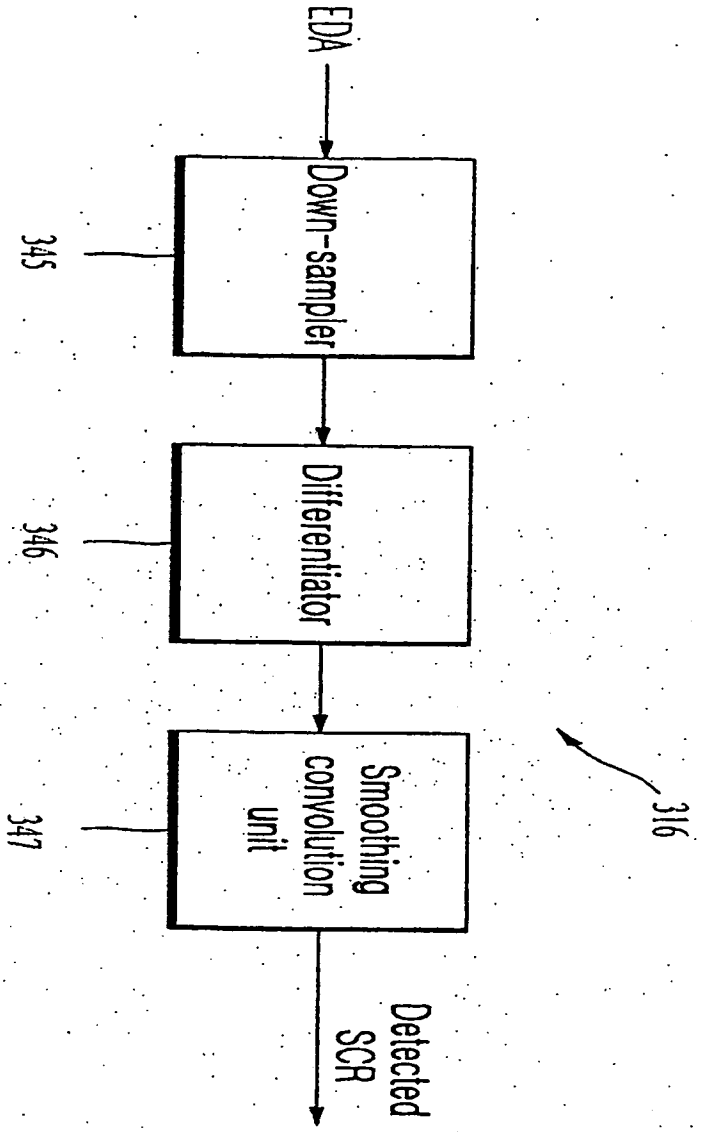

EDA
Down-sampler
345
Differentiator
346
Smoothing convolution unit
347
316
Detected SCR

FIG. 15

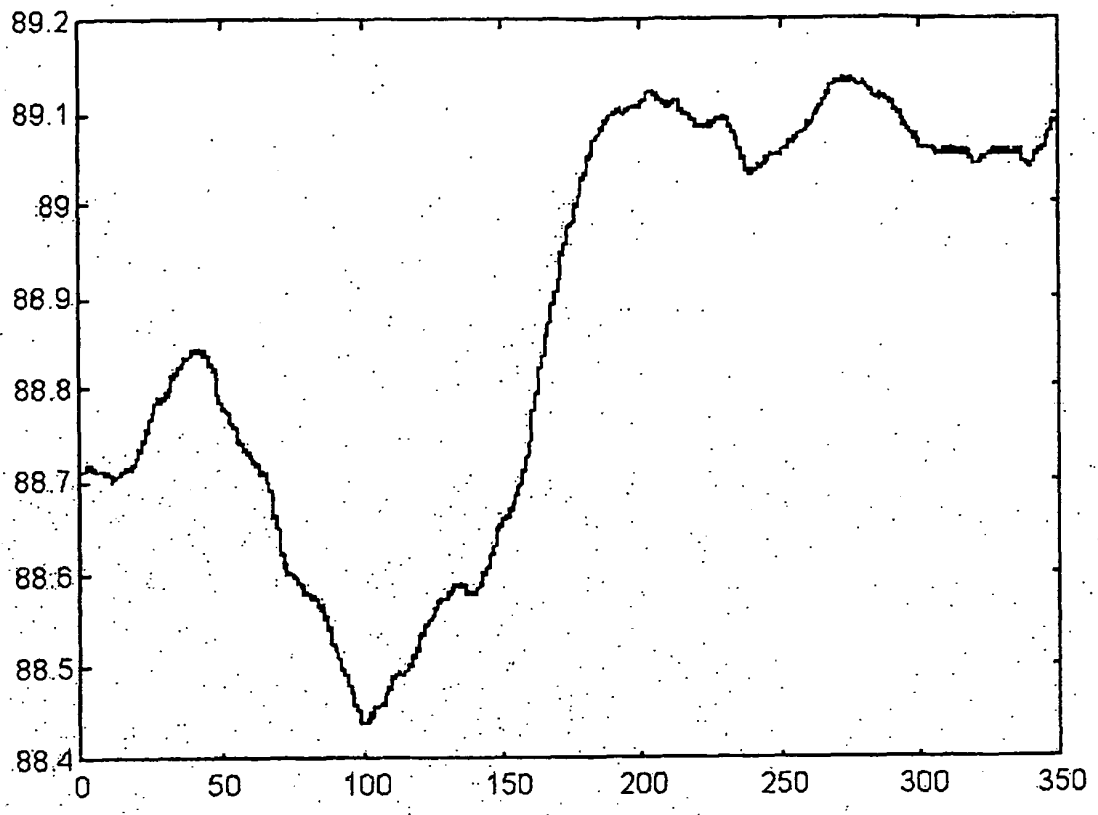

89.2
89.1
89
88.9
88.8
88.7
88.6
88.5
88.4
0
50
100
150
200
250
300
350

FIG. 16

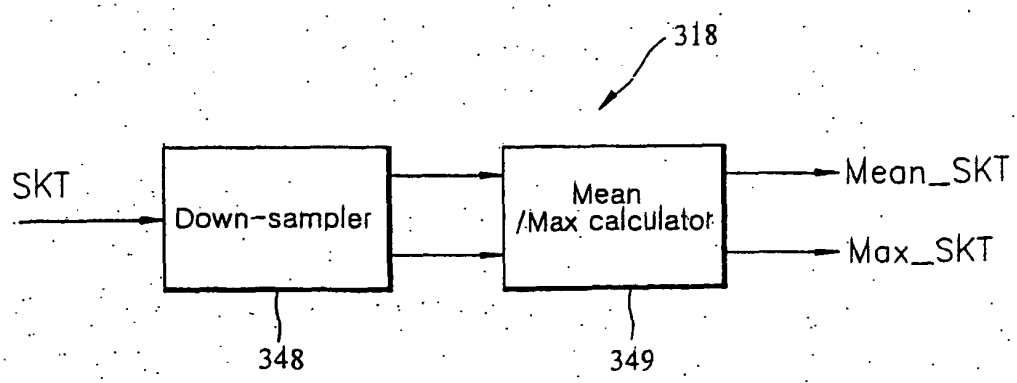

318
SKT
Down-sampler
Mean
/Max calculator
Mean_SKT
Max_SKT
348
349

FIG. 17a

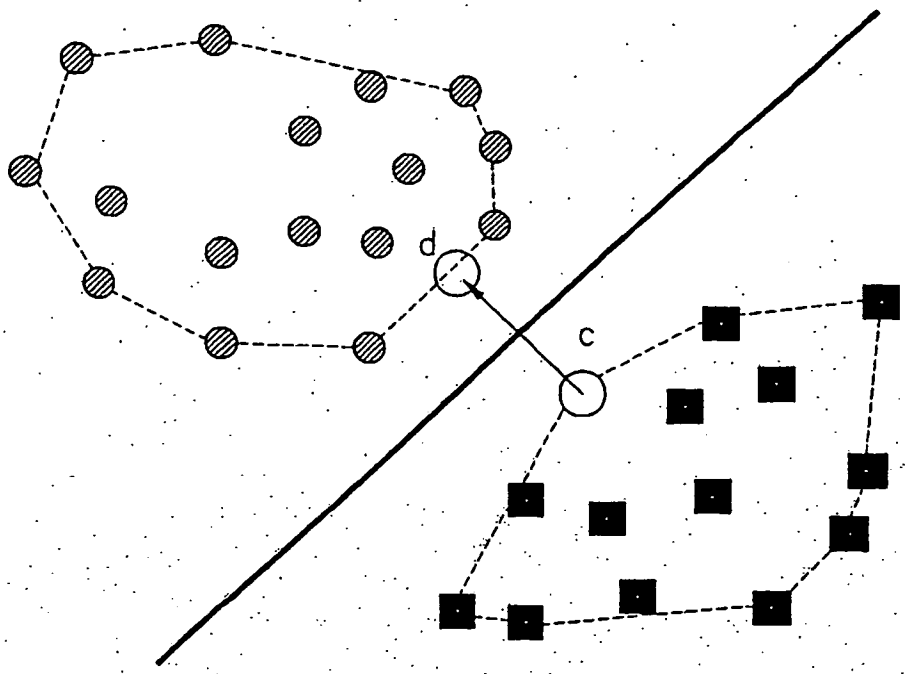


FIG. 17b

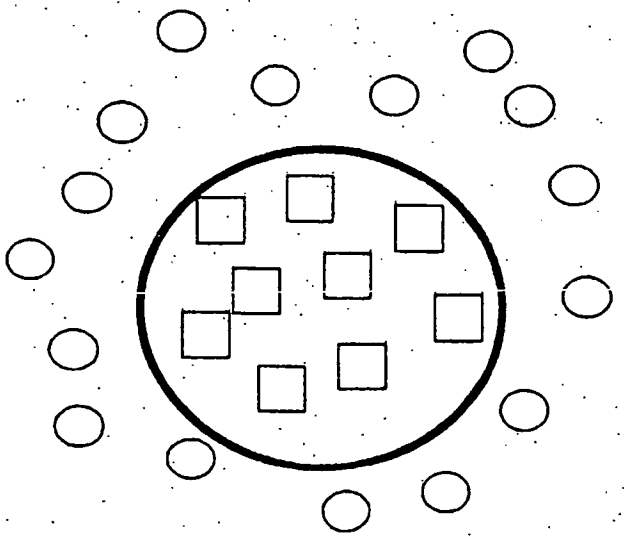


FIG. 18

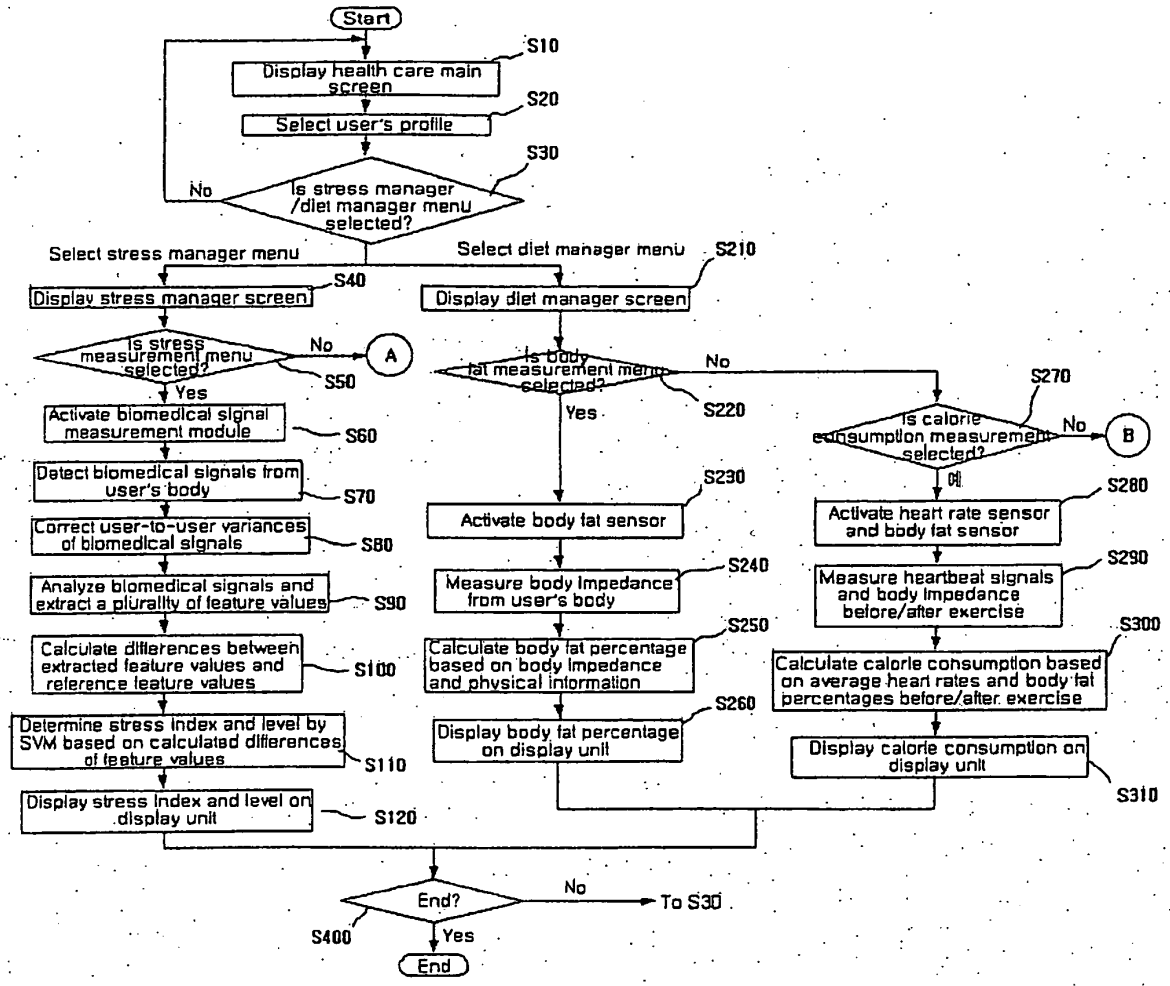

Start
S10
Display health care main screen
S20
Select user's profile
S30
No
Is stress manager /diet manager menu selected?
Select stress manager menu
Select diet manager menu
S210
S40
Display stress manager screen
Display diet manager screen
Is stress measurement menu selected?
No
A
S50
Yes
Activate biomedical signal measurement module
S60
Detect biomedical signals from user's body
S70
Correct user-to-user variances of biomedical signals
S80
Analyze biomedical signals and extract a plurality of feature values
S90
Calculate differences between extracted feature values and reference feature values
S100
Determine stress index and level by SVM based on calculated differences of feature values
S110
Display stress index and level on display unit
S120
Is body fat measurement menu selected?
No
S220
Yes
S230
Activate body fat sensor
S240
Measure body impedance from user's body
S250
Calculate body fat percentage based on body impedance and physical information
S260
Display body fat percentage on display unit
S270
Is calorie consumption measurement selected?
No
B
Yes
S280
Activate heart rate sensor and body fat sensor
S290
Measure heartbeat signals and body impedance before/after exercise
S300
Calculate calorie consumption based on average heart rates and body fat percentages before/after exercise
Display calorie consumption on display unit
S310
End?
No
To S30
S400
Yes
End

FIG. 19

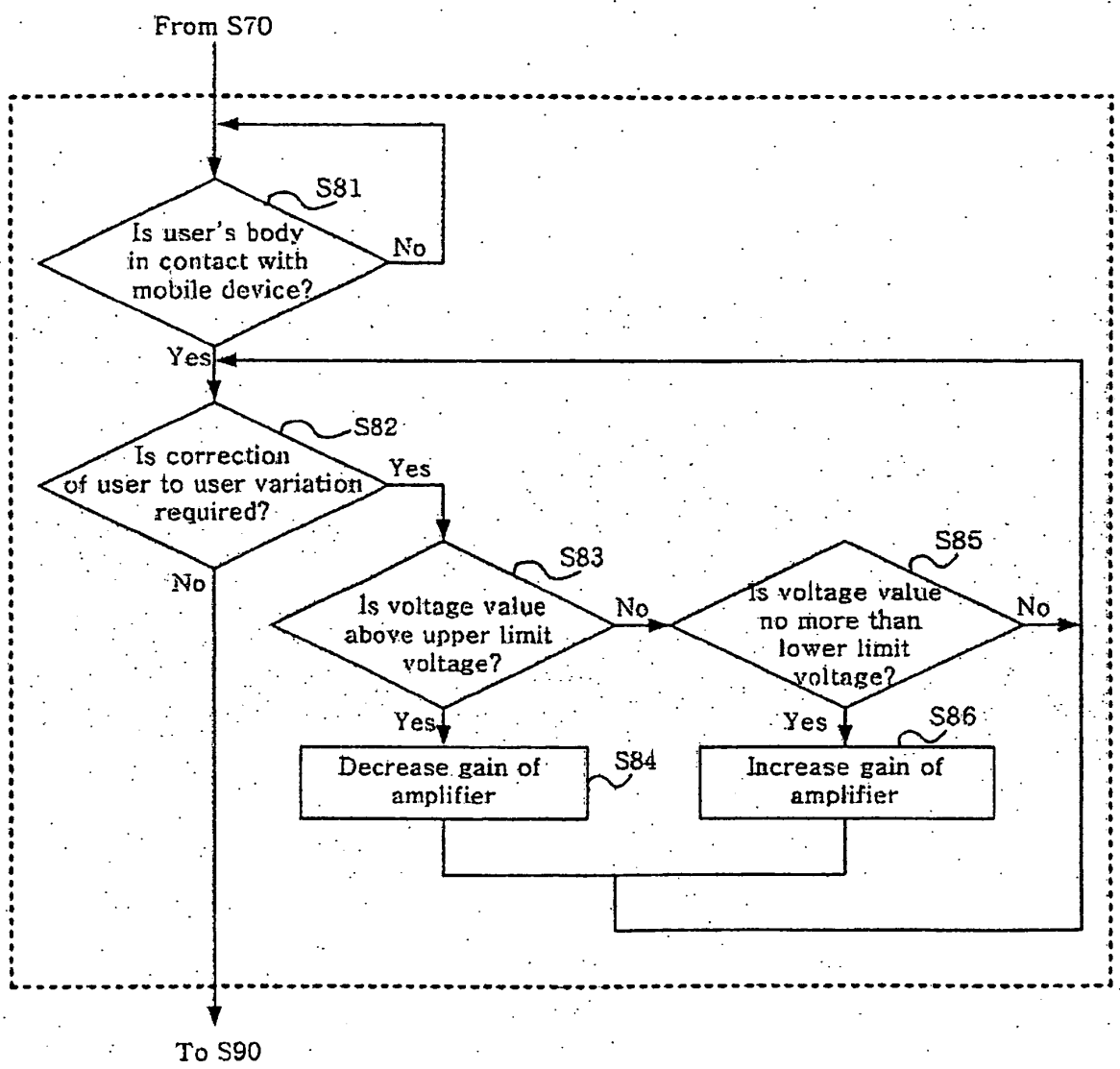

From S70
S81
Is user's body in contact with mobile device?
No
Yes
S82
Is correction of user to user variation required?
Yes
No
S83
Is voltage value above upper limit voltage?
No
S85
Is voltage value no more than lower limit voltage?
No
Yes
Yes
S84
Decrease gain of amplifier
S86
Increase gain of amplifier
To S90

FIG. 20

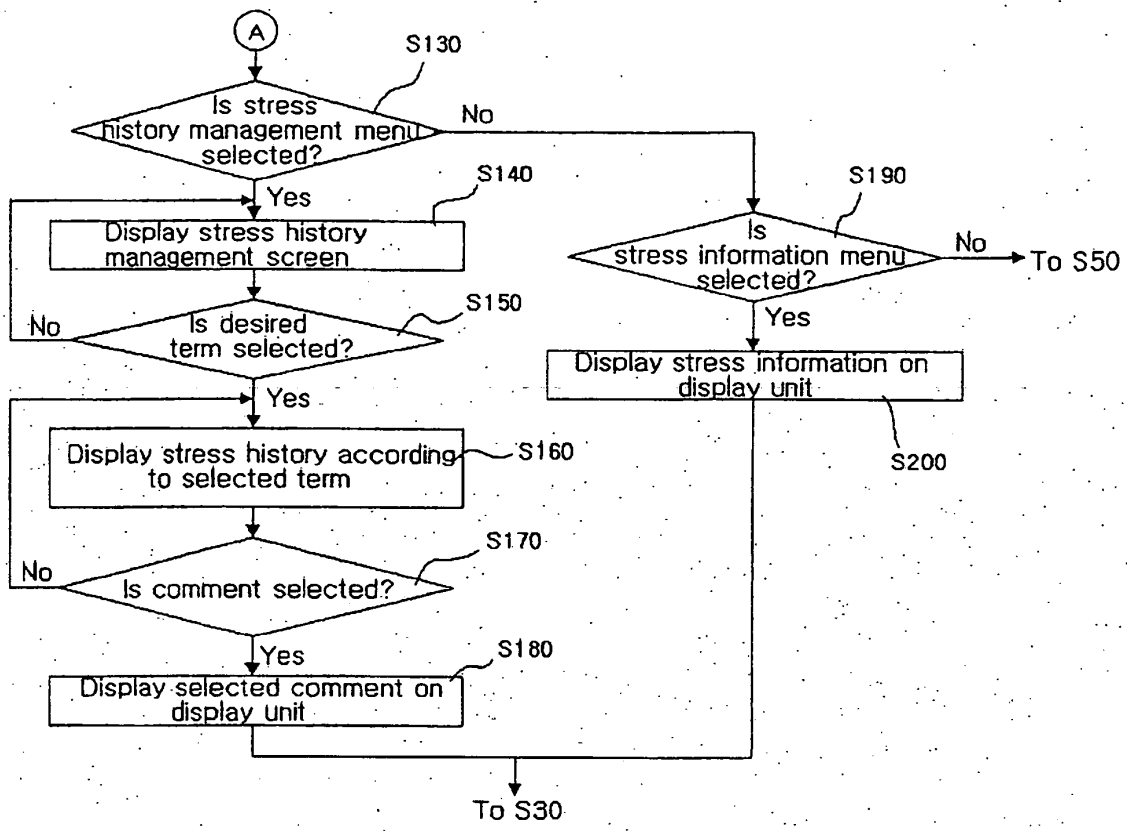

A
S130
Is stress history management menu selected?
No
Yes
S140
Display stress history management screen
S150
No
Is desired term selected?
Yes
Display stress history according to selected term
S160
S170
No
Is comment selected?
Yes
S180
Display selected comment on display unit
To S30
S190
Is stress information menu selected?
No
To S50
Yes
Display stress information on display unit
S200

FIG. 21

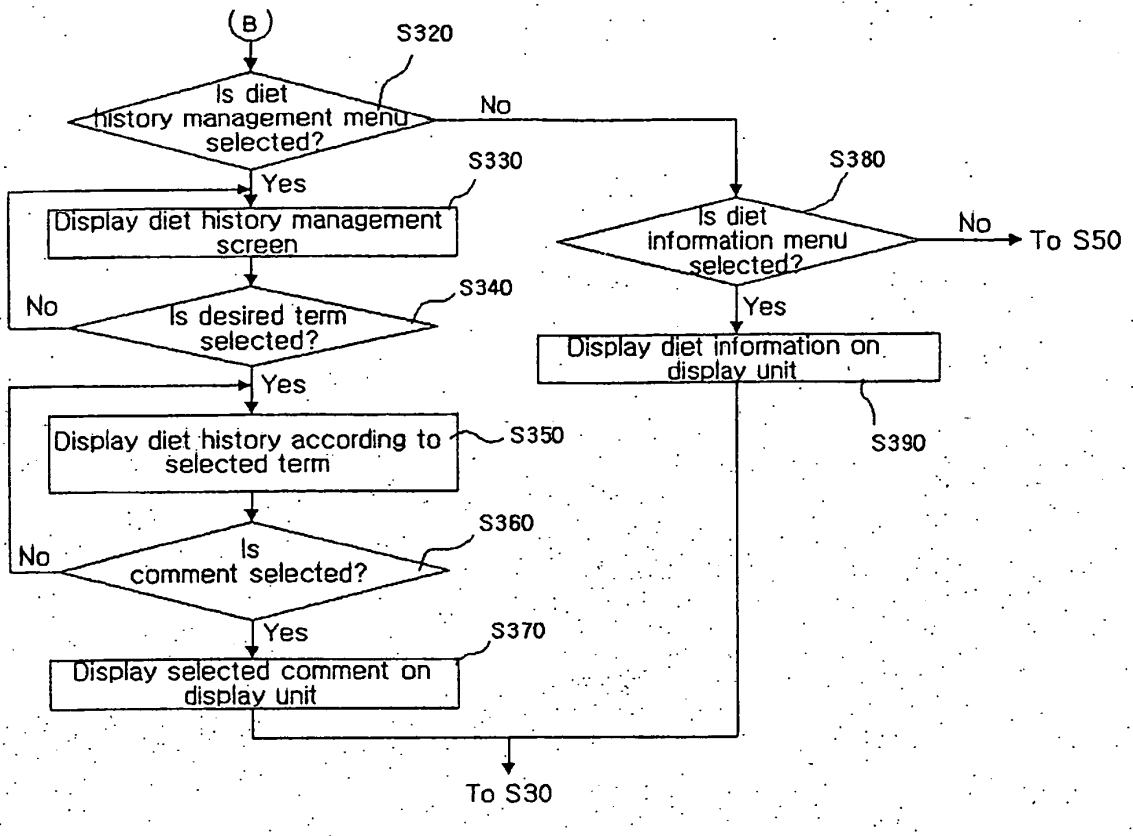

B
S320
Is diet history management menu selected?
No
Yes
S330
Display diet history management screen
S340
No
Is desired term selected?
Yes
Display diet history according to selected term
S350
S360
No
Is comment selected?
Yes
S370
Display selected comment on display unit
To S30
S380
Is diet information menu selected?
No
To S50
Yes
Display diet information on display unit
S390

FIG. 22

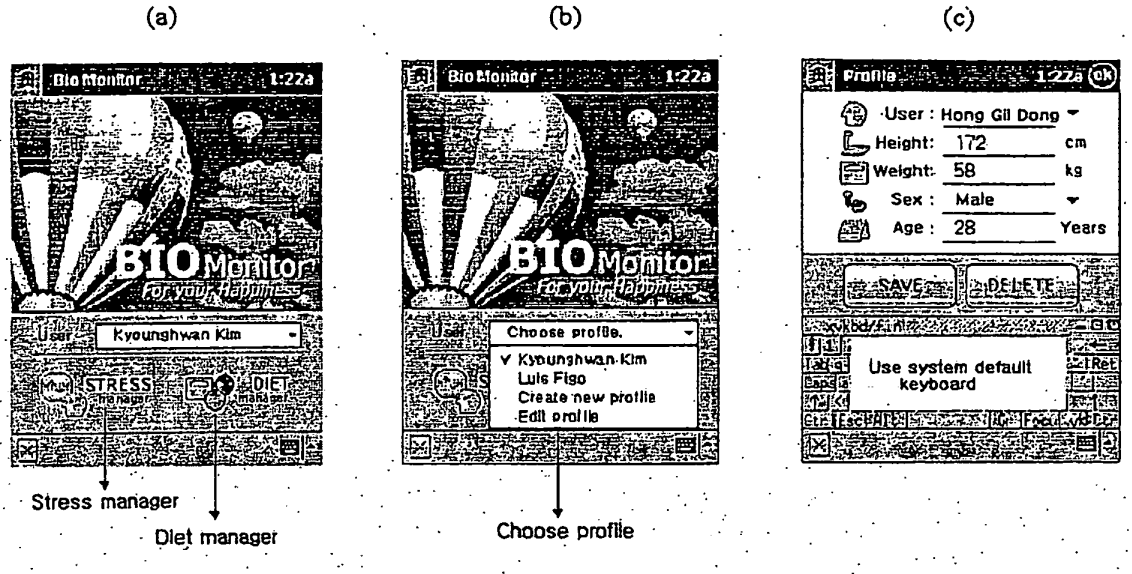

(a)
(b)
(c)
Bio Monitor
1:22a
BIO Monitor
For your Happiness
User
Kyounghwan Kim
STRESS
DIET
Stress manager
Diet manager
Choose profile.
Kyounghwan Kim
Luis Figo
Create new profile
Edit profile
Choose profile
Profile
1:22a
ok
User : Hong Gil Dong
Height: 172 cm
Weight: 58 kg
Sex : Male
Age : 28 Years
SAVE
DELETE
Use system default keyboard

FIG. 23a

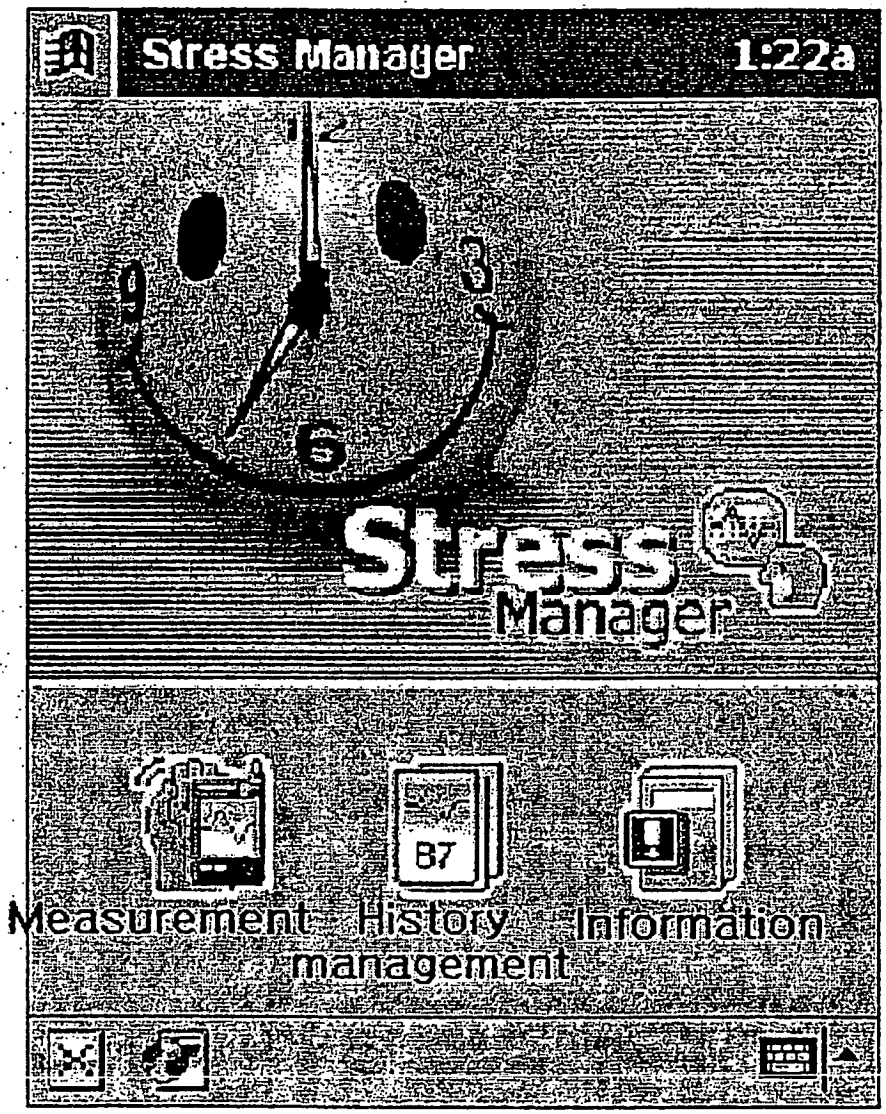

Stress Manager
1:22a
Stress
Manager
B7
Measurement
History management
Information

FIG. 23b

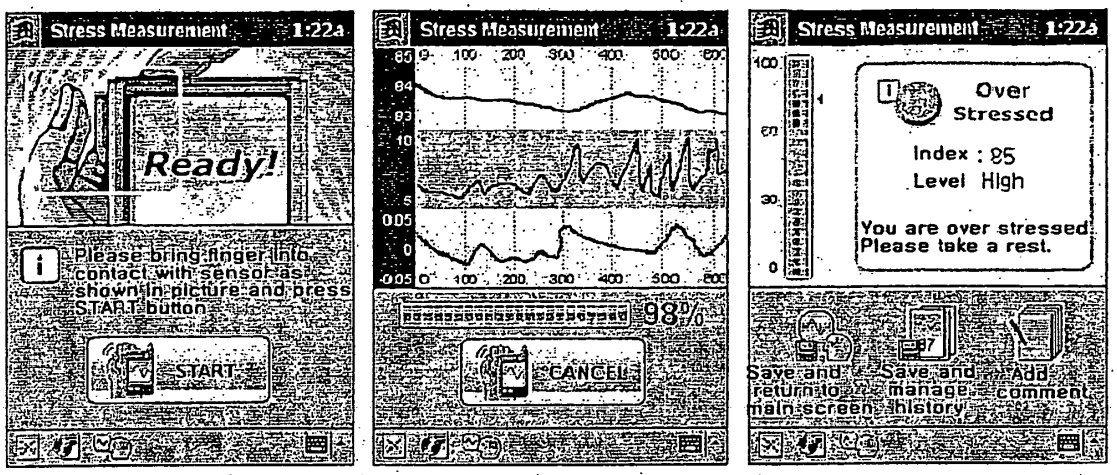


FIG. 23c

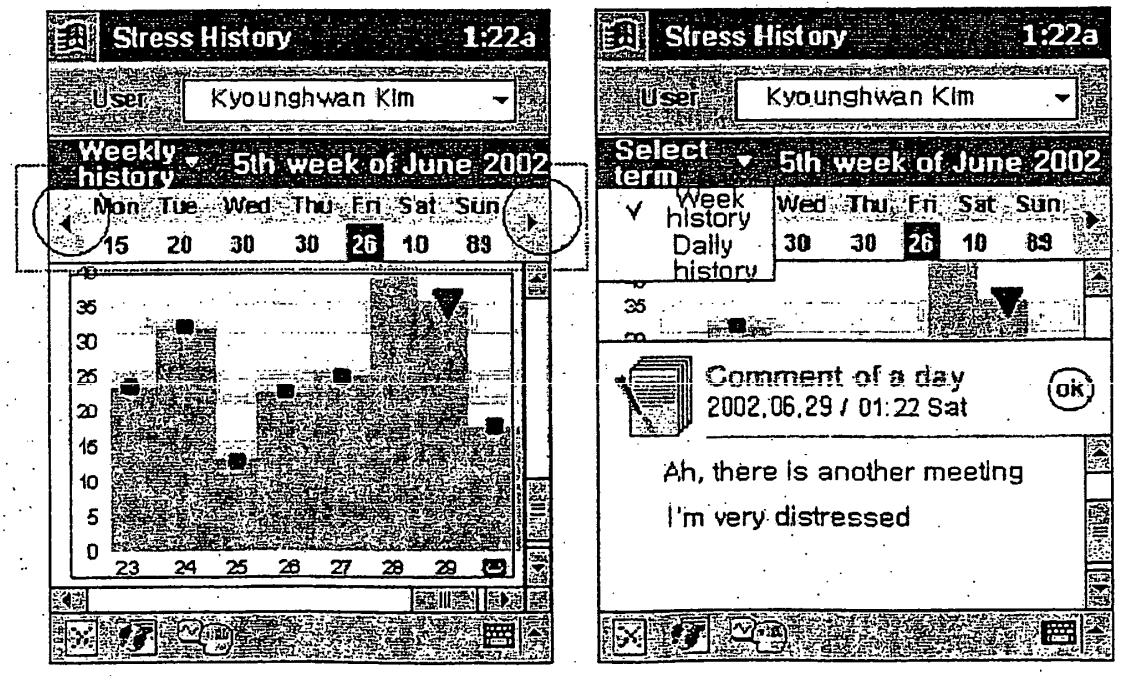


FIG. 23d

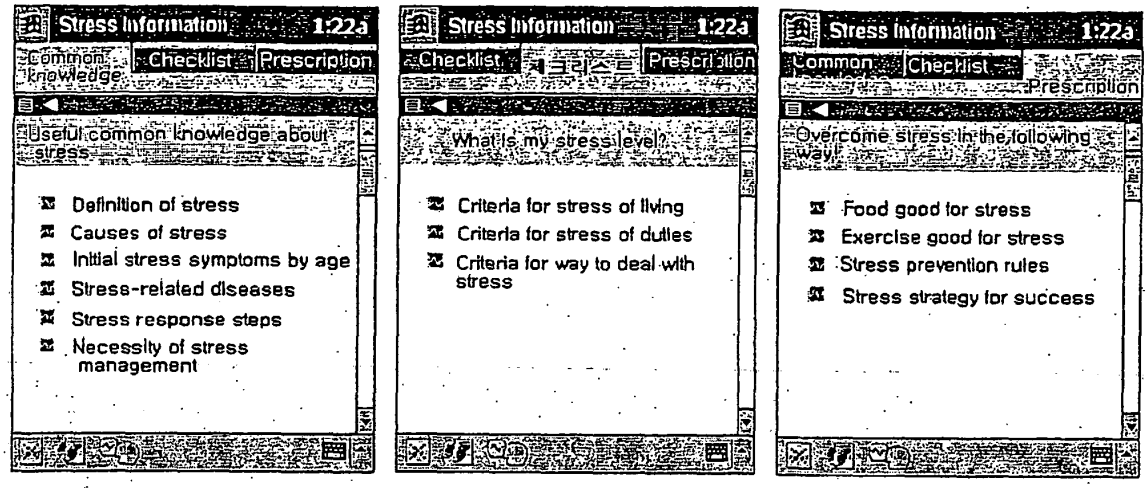

Stress Information 1:22a
Common knowledge
Checklist
Prescription
Useful common knowledge about stress
Definition of stress
Causes of stress
Initial stress symptoms by age
Stress-related diseases
Stress response steps
Necessity of stress management
Stress Information 1:22a
Checklist
체크리스트
Prescription
What is my stress level?
Criteria for stress of living
Criteria for stress of duties
Criteria for way to deal with stress
Stress Information 1:22a
Common
Checklist
Prescription
Overcome stress in the following way!
Food good for stress
Exercise good for stress
Stress prevention rules
Stress strategy for success

FIG. 24a

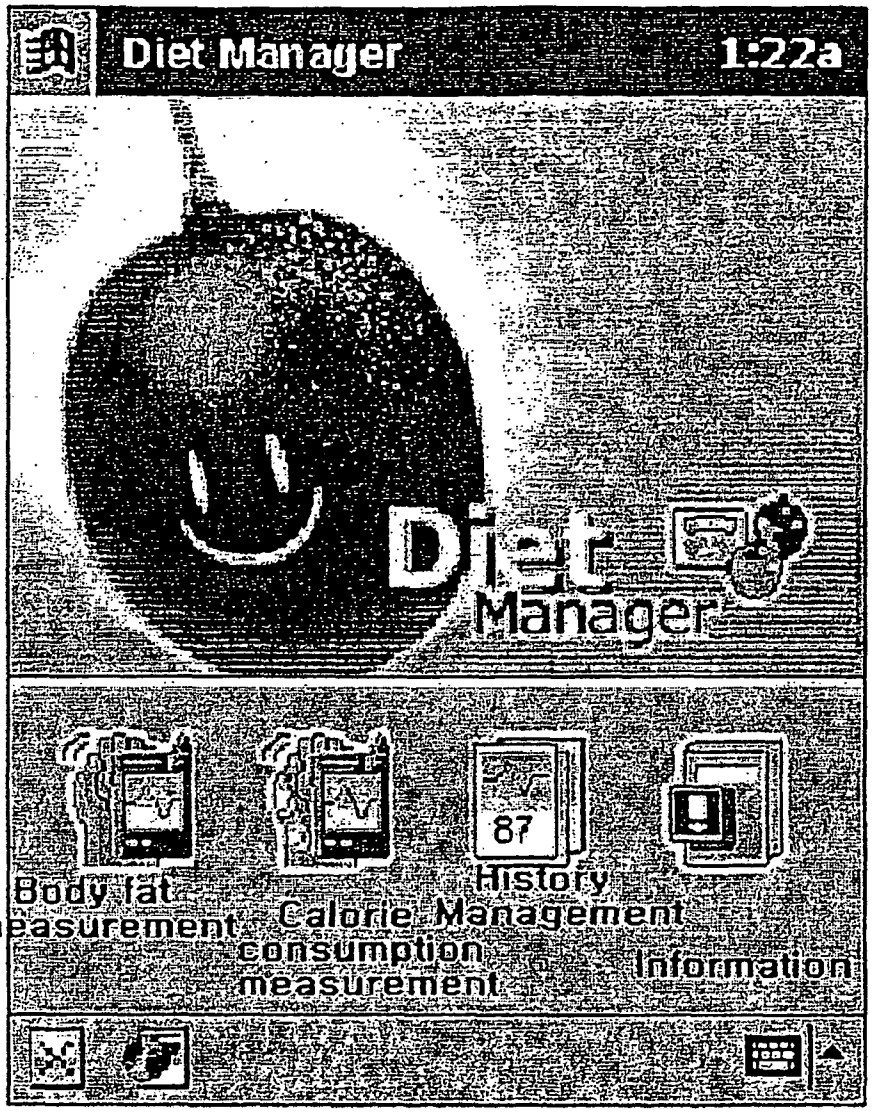

Diet Manager
1:22a
Diet
Manager
87
Body fat
measurement
Calorie
consumption
measurement
History
Management
Information

FIG. 24b

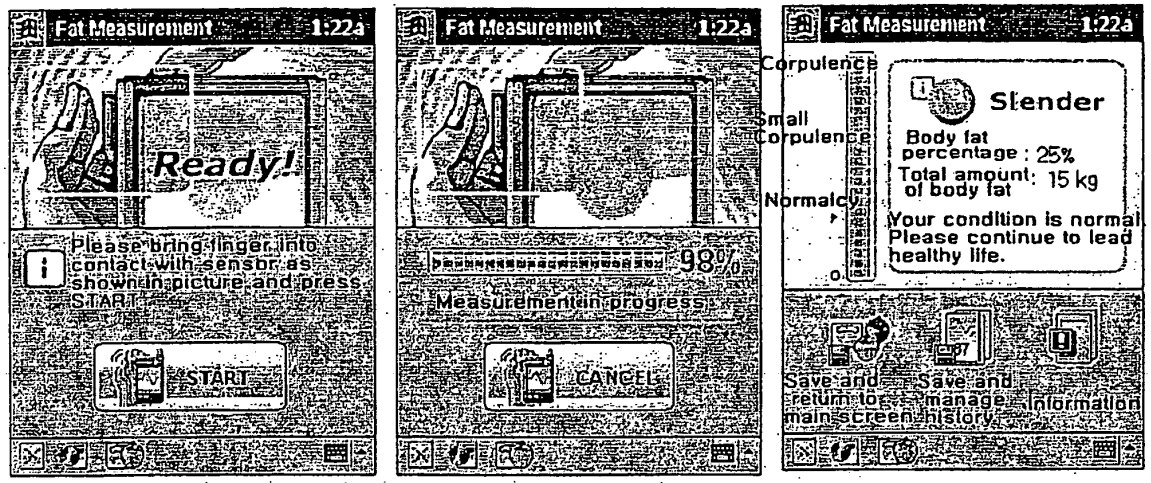


FIG. 24c

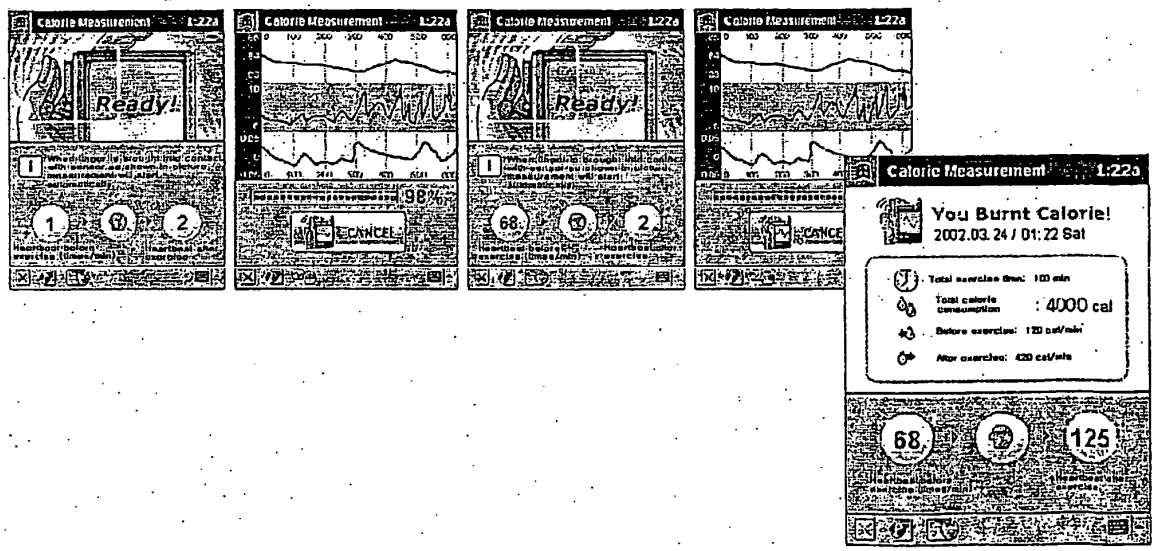


FIG. 24d

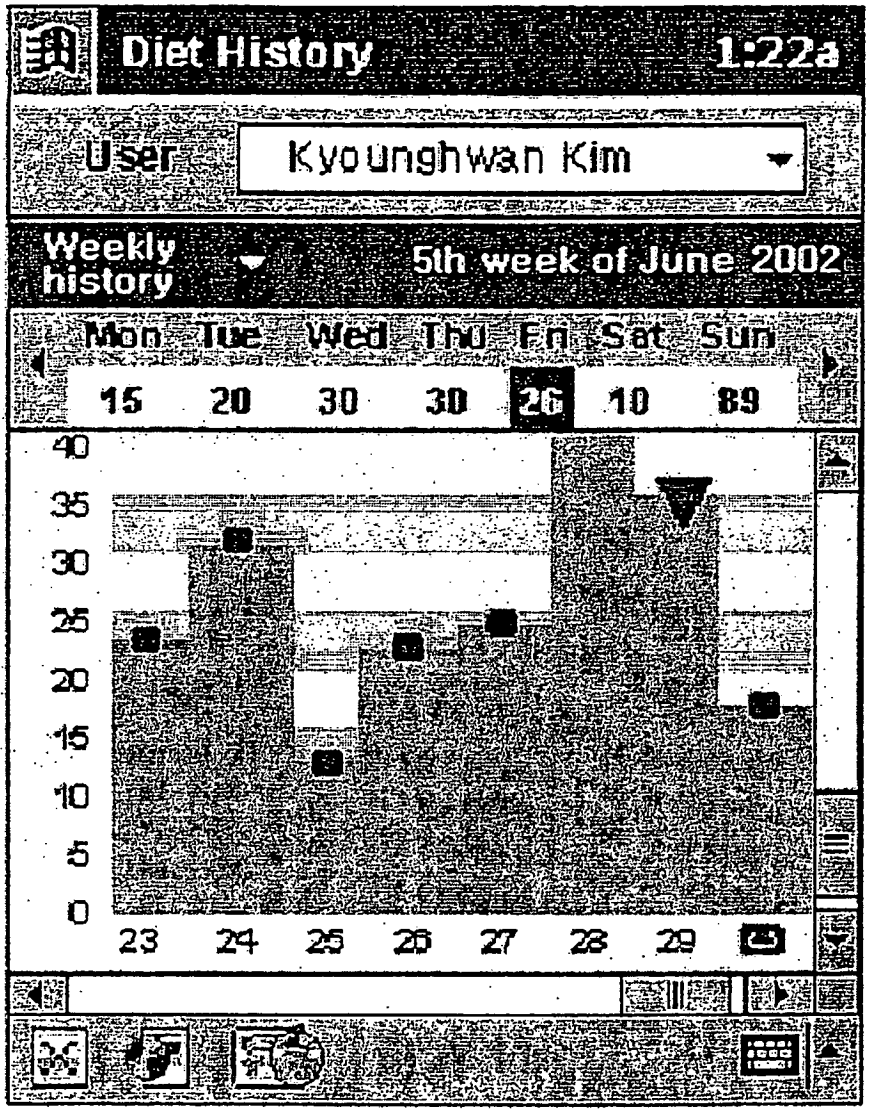
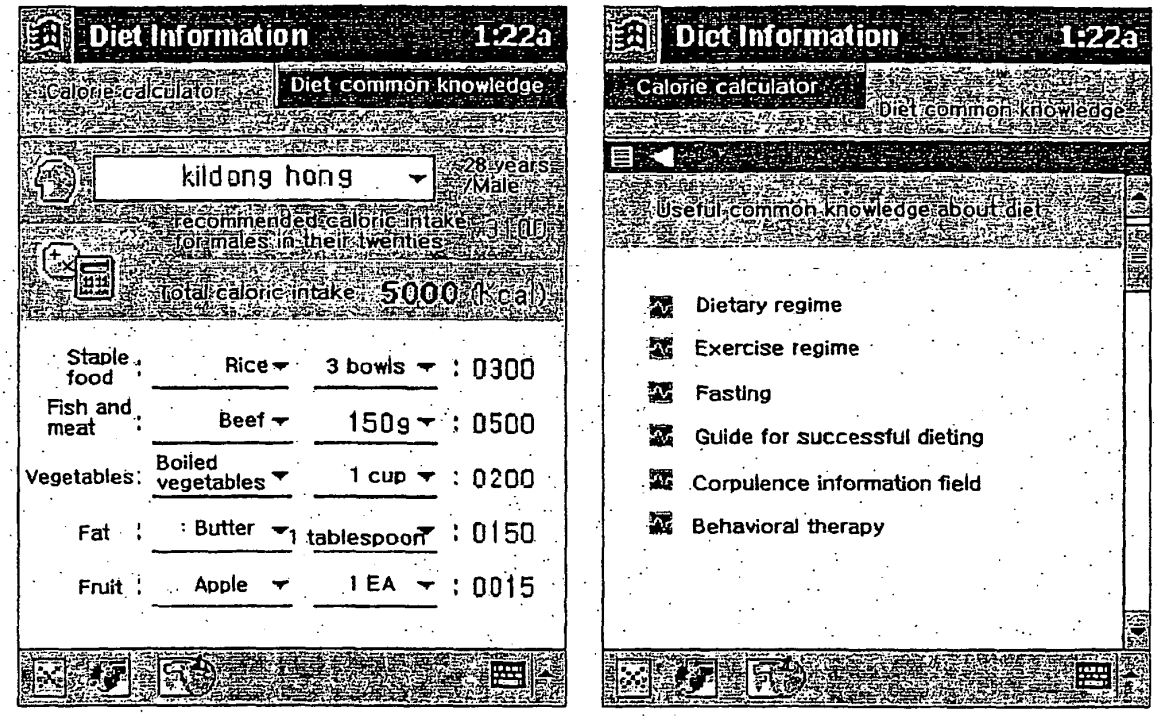

Diet History
1:22a
User
Kyounghwan Kim
Weekly history
5th week of June 2002
Mon Tue Wed Thu Fri Sat Sun
15 20 30 30 26 10 09
40
35
30
25
20
15
10
5
0
23 24 25 26 27 28 29

FIG. 24e


Diet Information
1:22a
Calorie calculator
Diet common knowledge
kildong hong
28 years
Male
recommended caloric intake
for males in their twenties
Total caloric intake 5000 (Kcal)
Staple food : Rice 3 bowls : 0300
Fish and meat : Beef 150g : 0500
Vegetables : Boiled vegetables 1 cup : 0200
Fat : Butter 1 tablespoon : 0150
Fruit : Apple 1 EA : 0015
Diet Information
1:22a
Calorie calculator
Diet common knowledge
Useful common knowledge about diet
Dietary regime
Exercise regime
Fasting
Guide for successful dieting
Corpulence information field
Behavioral therapy

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- EP 1027860 A1 **[0006]**
- WO 0233846 A1 **[0006]**
- WO 02060380 A2 **[0007]**
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- **R. D. BERGER.** An efficient algorithm for the spectral analysis of heart rate variability. *IEEE Trans. Biomed. Eng.,* 1986, vol. 33 **[0085]**
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- **V. VAPNIK.** An overview of statistical learning theory. *IEEE Transactions on neural network,* 1999, vol. 10 (5), 988-999 **[0105]**

专利名称(译)	用于基于生物医学信号的移动医疗保健的装置和方法		
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优先权	1020020061582 2002-10-09 KR		
其他公开文献	EP1407713A1		
外部链接	Espacenet		

摘要(译)

技术领域本发明涉及能够执行生物医学信号测量的移动设备和使用该移动设备的保健方法。本发明的一个目的是提供一种移动设备，该移动设备能够通过使用安装有生物医学信号测量模块的手持移动设备检查用户的健康状态来有效地为用户执行健康保健功能，该手持移动设备可以用作两者。移动设备以及在必要时测量用户的情绪状态和身体状况，以及使用该移动设备的保健方法。为了实现上述目的，本发明的移动设备包括生物医学信号测量模块（100），用于检测来自用户身体的生物医学信号，通过各自的信号对检测到的生物医学信号进行分类并输出分类信号;以及用于基于从生物医学信号测量模块（100）输入的生物医学信号和用户的身体信息来分析用户的情绪状态（280）和身体状况（290）的健康护理模块（300）。