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(54) DIETARY HABIT MANAGEMENT APPARATUS AND METHOD

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(57) **ABSTRACT**

A dietary habit management apparatus and method are provided. The dietary habit management apparatus includes a bio-signal acquirer configured to acquire a bio-signal of a user, and a processor configured to obtain a total peripheral resistance (TPR) reflected index, from the bio-signal that is acquired by the bio-signal acquirer, and determine whether the user has eaten food, based on the TPR reflected index.

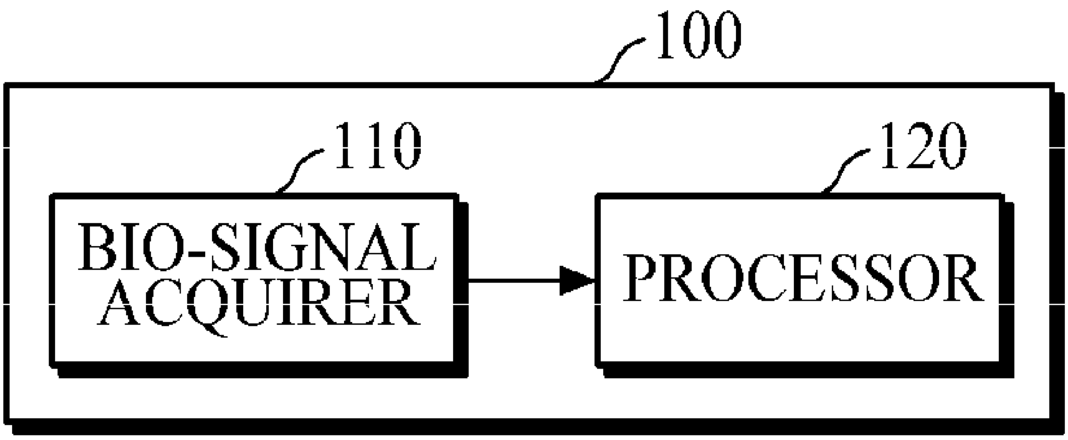


FIG. 1

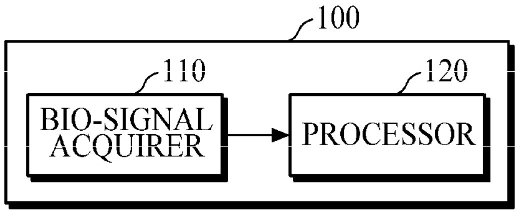


FIG. 2

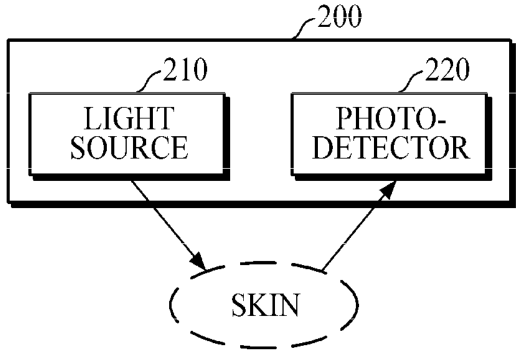


FIG. 3

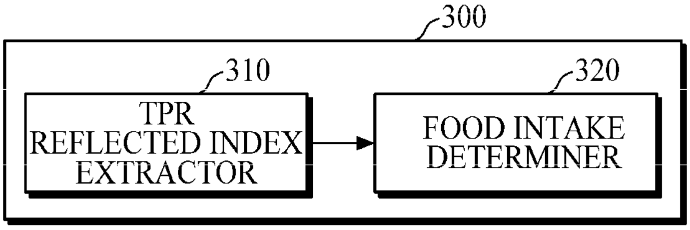

300
310
TPR
REFLECTED INDEX
EXTRACTOR
320
FOOD INTAKE
DETERMINER

FIG. 4

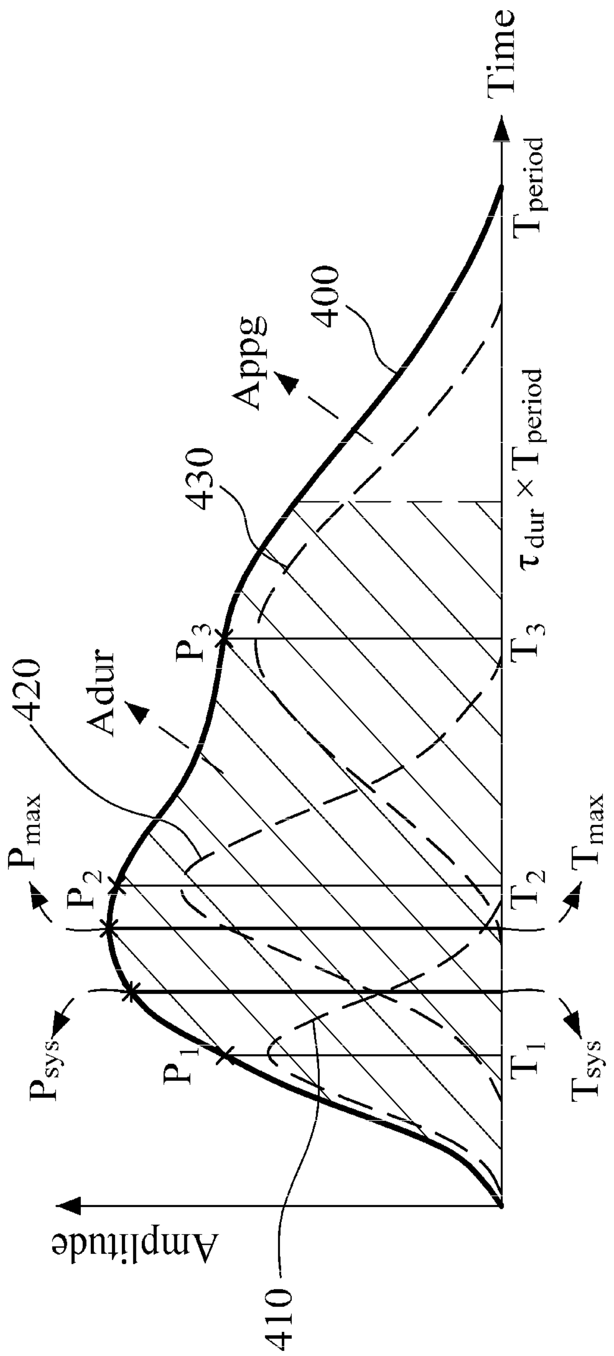

Time
Amplitude
T_period
Appg
400
τ_dur × T_period
430
P_3
T_3
Adur
420
P_max
P_2
T_2
T_max
P_sys
P_1
T_1
T_sys
410

FIG. 5

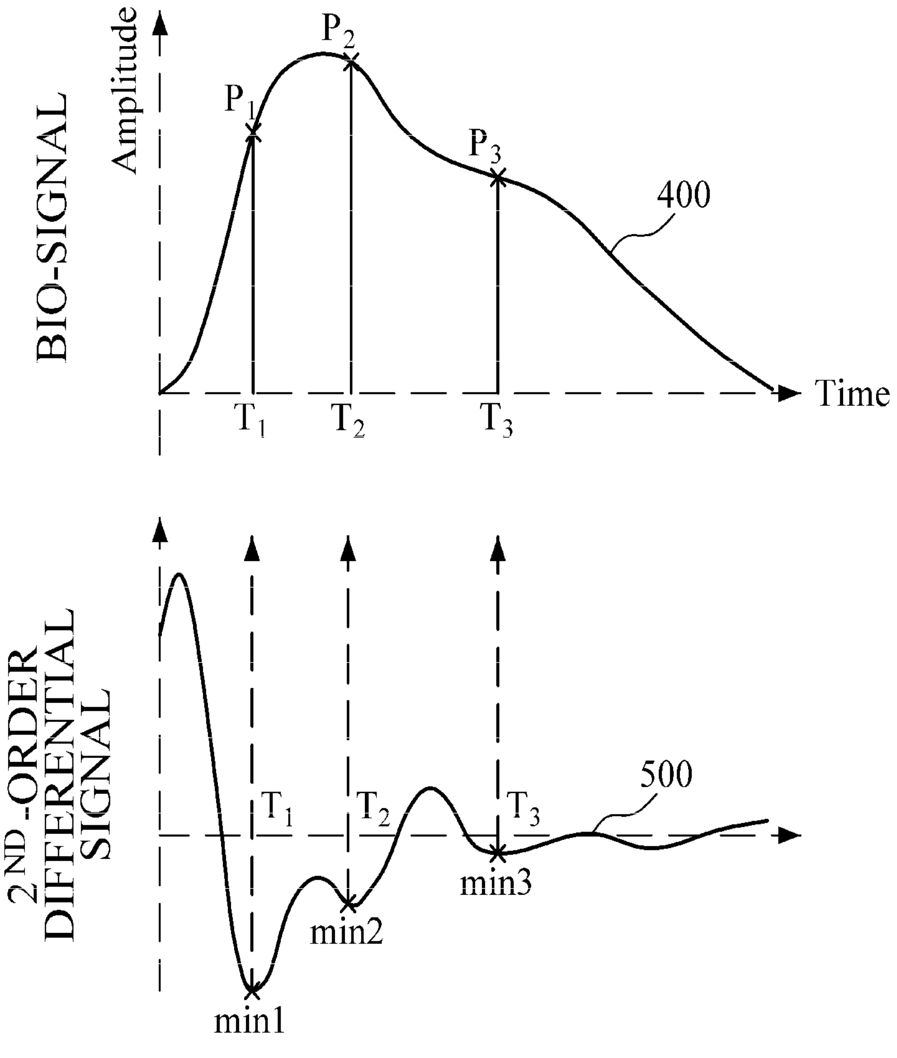
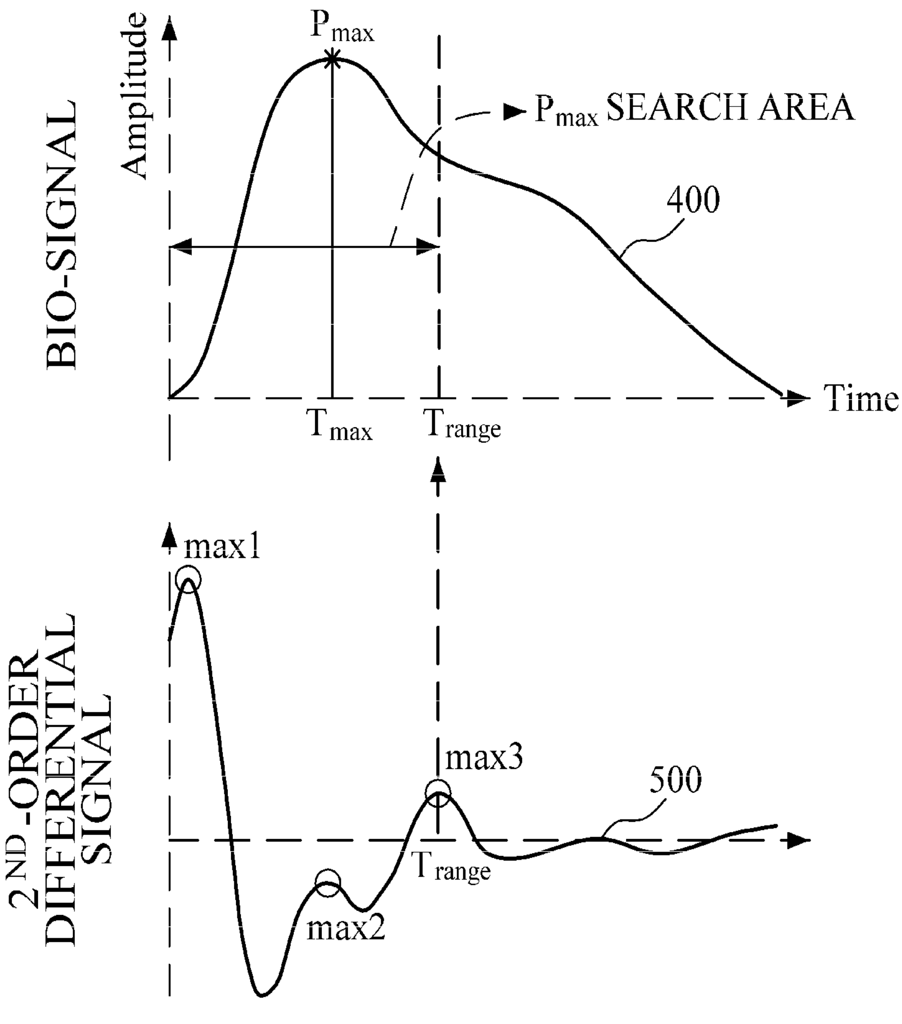

BIO-SIGNAL
Amplitude
P1
P2
P3
400
Time
T1
T2
T3
2ND-ORDER DIFFERENTIAL SIGNAL
T1
T2
T3
500
min1
min2
min3

FIG. 6



BIO-SIGNAL
Amplitude
Pmax
Pmax SEARCH AREA
400
Time
Tmax
Trange
2ND-ORDER DIFFERENTIAL SIGNAL
max1
max2
max3
500
Trange

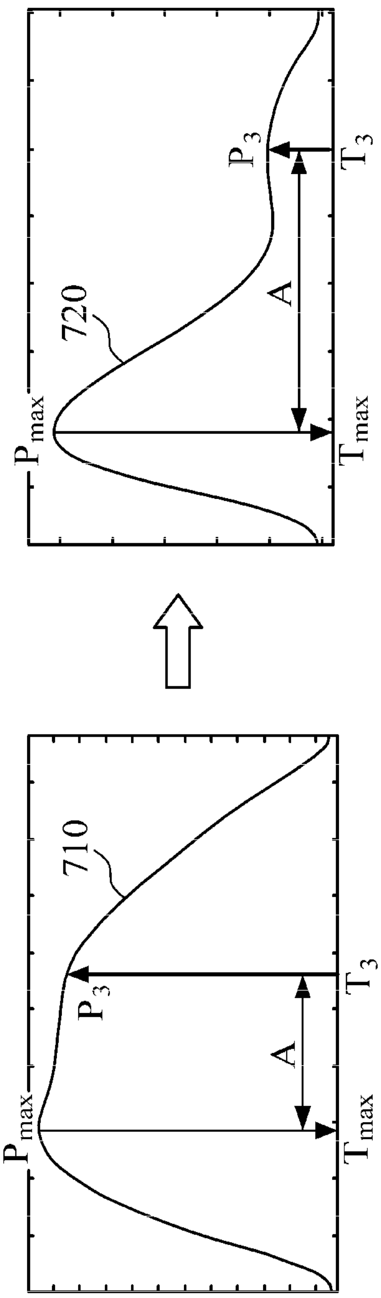


FIG. 7

FIG. 8

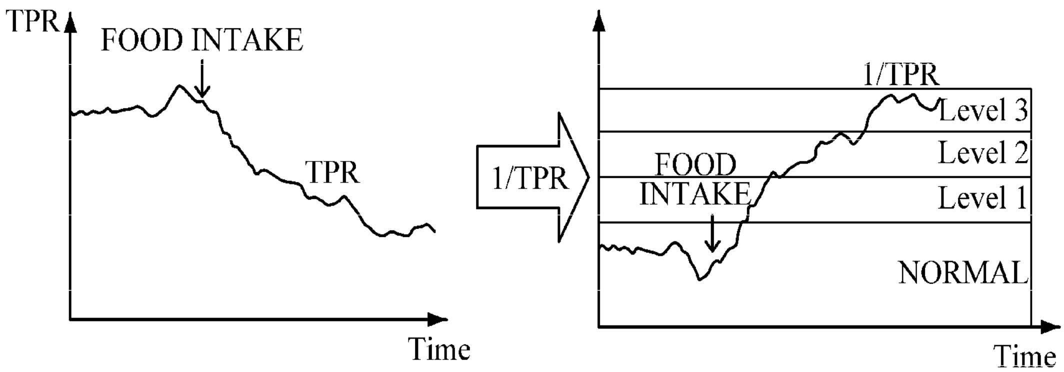

TPR
FOOD INTAKE
TPR
Time
1/TPR
1/TPR
Level 3
Level 2
FOOD
INTAKE
Level 1
NORMAL
Time

FIG. 9

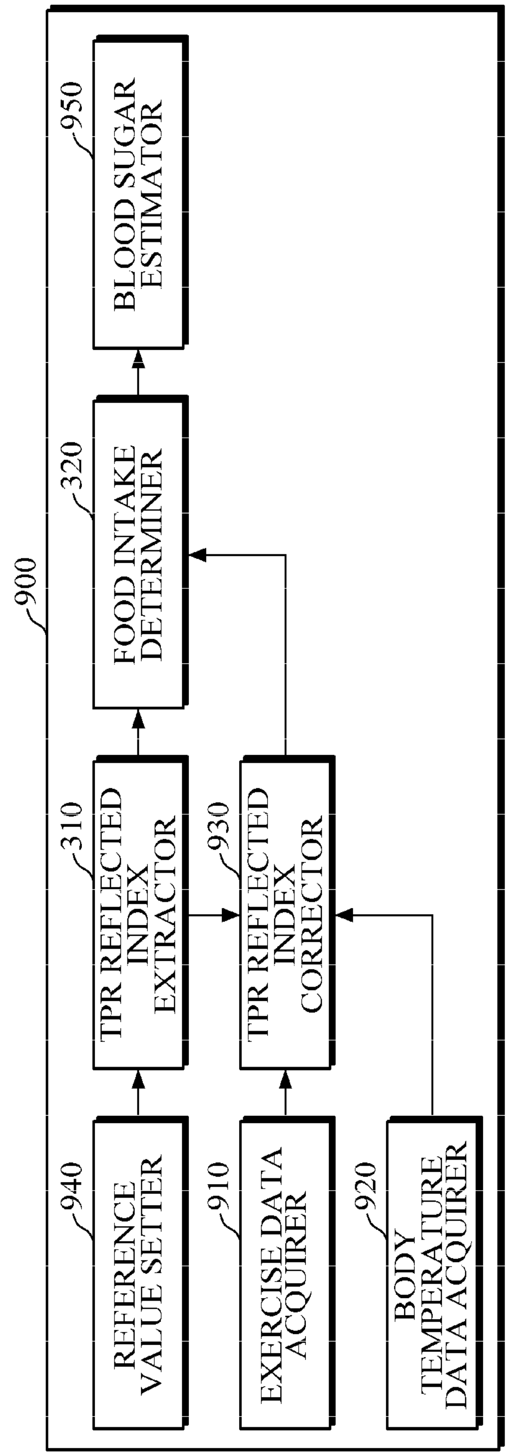

900
940
REFERENCE VALUE SETTER
910
EXERCISE DATA ACQUIRER
920
BODY TEMPERATURE DATA ACQUIRER
310
TPR REFLECTED INDEX EXTRACTOR
930
TPR REFLECTED INDEX CORRECTOR
320
FOOD INTAKE DETERMINER
950
BLOOD SUGAR ESTIMATOR

FIG. 10

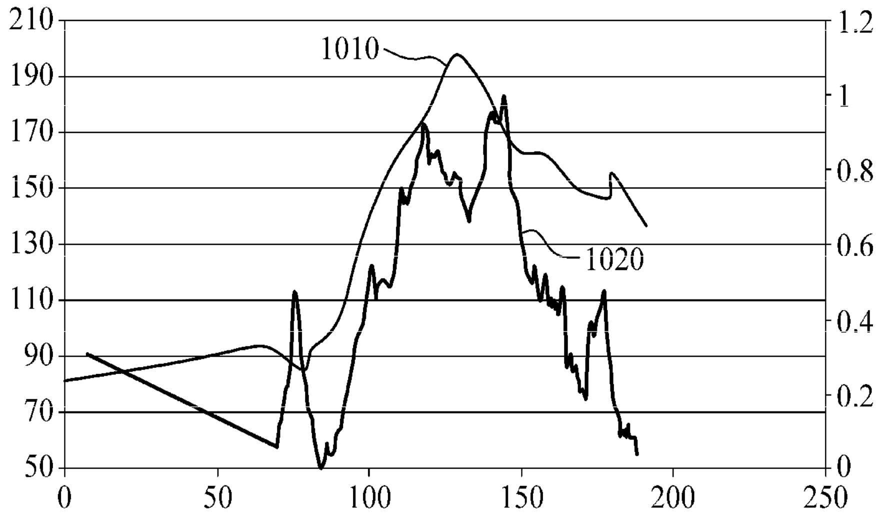

210
190
170
150
130
110
90
70
50
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
1010
1020

FIG. 11

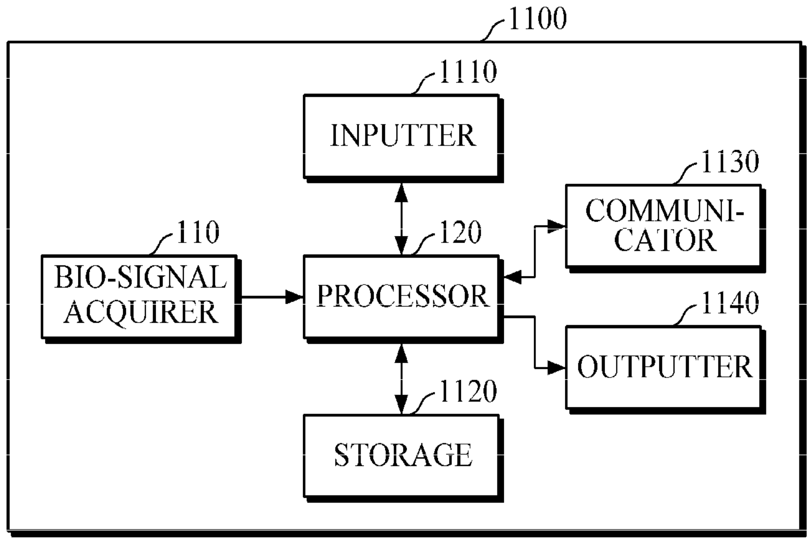

1100
1110
INPUTTER
1130
COMMUNI-
CATOR
110
120
BIO-SIGNAL
ACQUIRER
PROCESSOR
1140
OUTPUTTER
1120
STORAGE

FIG. 12

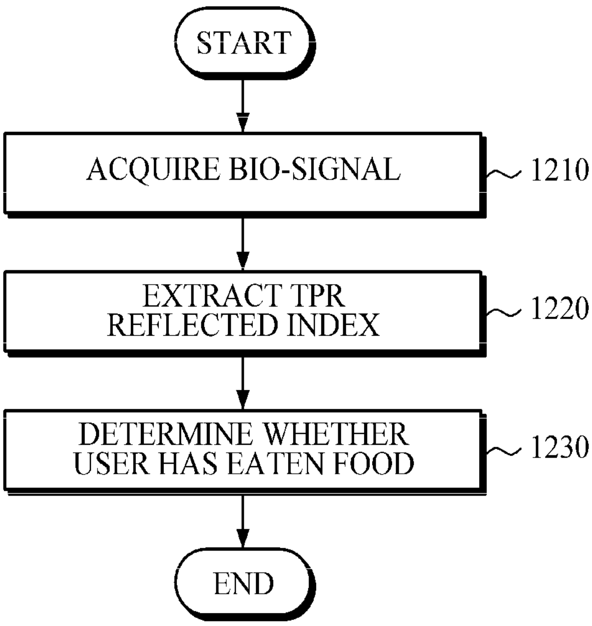
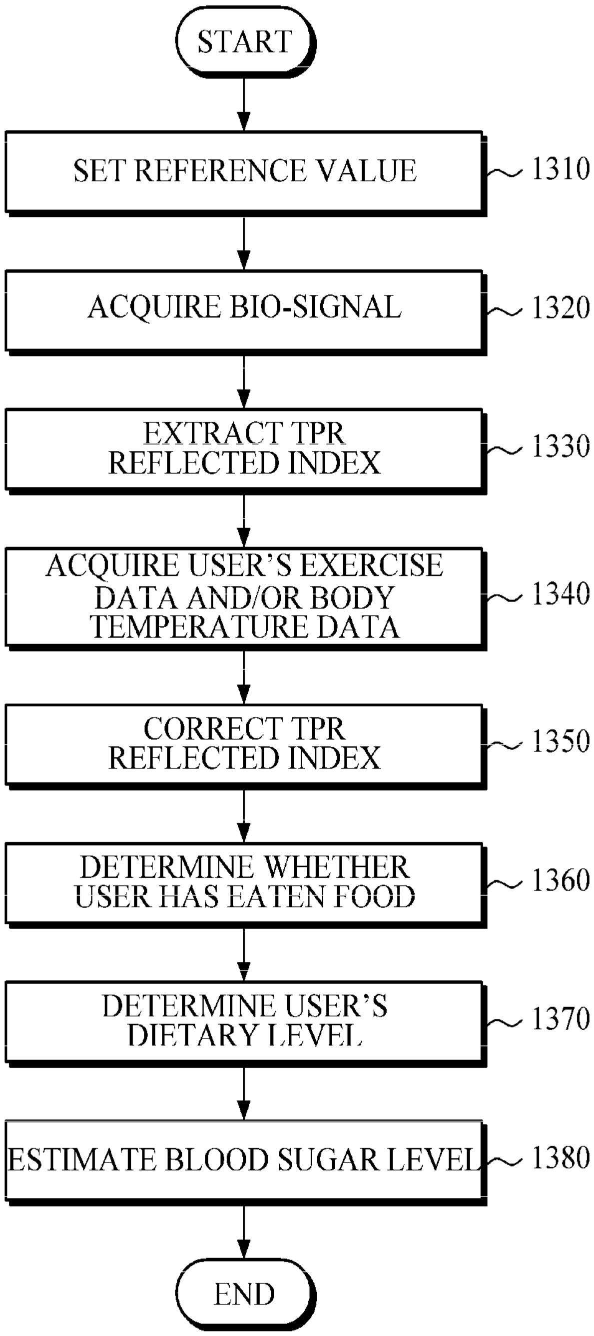

START
ACQUIRE BIO-SIGNAL
1210
EXTRACT TPR REFLECTED INDEX
1220
DETERMINE WHETHER USER HAS EATEN FOOD
1230
END

FIG. 13


START
SET REFERENCE VALUE
1310
ACQUIRE BIO-SIGNAL
1320
EXTRACT TPR REFLECTED INDEX
1330
ACQUIRE USER'S EXERCISE DATA AND/OR BODY TEMPERATURE DATA
1340
CORRECT TPR REFLECTED INDEX
1350
DETERMINE WHETHER USER HAS EATEN FOOD
1360
DETERMINE USER'S DIETARY LEVEL
1370
ESTIMATE BLOOD SUGAR LEVEL
1380
END

DIETARY HABIT MANAGEMENT APPARATUS AND METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from Korean Patent Application No. 10-2018-0014202, filed on Feb. 5, 2018, in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference for all purposes.

BACKGROUND

1. Field

[0002] Apparatuses and methods consistent with example embodiments relate to managing dietary habits, based on a bio-signal.

2. Description of Related Art

[0003] As the food culture has become westernized, the numbers of obese patients and diabetes patients have been increasing, and the importance of controlling food and food portions has been emphasized as a treatment and prevention measure for those patients. In addition, in response to such an interest, diet-friendly restaurants have opened, helping customers' diet and meal portion control.

[0004] Most people today get an insufficient amount of exercise because they do not have spare time for exercise, and they often eat large amounts of meals, without a sufficient amount of exercise, which may lead to obesity or diabetes. In addition, with the modern diet including more high-calorie foods than in the past, one is more likely to become diabetic or obese.

SUMMARY

[0005] According to an aspect of an example embodiment, there is provided a dietary habit management apparatus including a bio-signal acquirer configured to acquire a bio-signal of a user, and a processor configured to obtain a total peripheral resistance (TPR) reflected index, from the bio-signal that is acquired by the bio-signal acquirer, and determine whether the user has eaten food, based on the TPR reflected index.

[0006] The bio-signal may be one of a pulse pressure signal, a photoplethysmogram (PPG) signal, an electrocardiogram (ECG) signal, an electromyogram (EMG) signal, and a ballistocardiogram (BCG) signal.

[0007] The processor may be further configured to extract at least one feature point, from the bio-signal, and obtain the TPR reflected index by combining features corresponding to the at least one feature point.

[0008] The TPR reflected index may include any one or any combination of $1/(T_3-T_1)$, $1/(T_3-T_{sys})$, $1/(T_3-T_{max})$, $1/(T_2-T_1)$, P_2/P_1, P_3/P_{max}, P_3/P_1, and $A_{ppg}/(P_{max}*A_{dur})$, where T_1 denotes a time of a peak point of a first component pulse constituting the bio-signal, T_2 denotes a time of a peak point of a second component pulse constituting the bio-signal, T_3 denotes a time of a peak point of a third component pulse constituting the bio-signal, T_{max} denotes a time of a peak point of the bio-signal in a first interval, T_{sys} denotes an intermediate time between T_1 and T_{max}, P_1 denotes an amplitude of the bio-signal at T_1, P_2 denotes an amplitude of the bio-signal at T_2, P_3 denotes an amplitude of the bio-signal at T_3, P_{max} denotes an amplitude of the bio-signal at T_{max}, A_{ppg} denotes a sum of amplitudes of the bio-signal of one period, and A_{dur} denotes a sum of amplitudes of the bio-signal in a second interval.

[0009] The processor may be further configured to obtain the TPR reflected index, based on a time delay of a plurality of bio-signals that is measured using a plurality of light sources that emits light of different wavelengths.

[0010] The processor may be further configured to compare the TPR reflected index or a reciprocal of the TPR reflected index, with a reference value, and determine whether the user has eaten food, based on a result of the TPR reflected index or a reciprocal of the TPR reflected index being compared with the reference value.

[0011] The processor may be further configured to set the reference value to be used in determining whether the user has eaten food, based on an instruction of the user or based on the TPR reflected index obtained in a fasting and resting state.

[0012] The processor may be further configured to determine a dietary level of the user, based on the TPR reflected index.

[0013] The processor may be further configured to acquire exercise data of the user, and correct the TPR reflected index, based on the exercise data.

[0014] The processor may be further configured to acquire body temperature data of the user, and correct the TPR reflected index, based on the body temperature.

[0015] The processor may be further configured to estimate a blood sugar level of the user, based on the TPR reflected index.

[0016] According to an aspect of another example embodiment, there is provided a method of managing dietary habits, the method including acquiring a bio-signal of a user, obtaining a total peripheral resistance (TPR) reflected index, from the bio-signal that is acquired, and determining whether the user has eaten food, based on the TPR reflected index.

[0017] The obtaining the TPR reflected index may include extracting at least one feature point, from the bio-signal, and obtaining the TPR reflected index by combining features corresponding to the at least one feature point.

[0018] The obtaining the TPR reflected index may include obtaining the TPR reflected index, based on a time delay of a plurality of bio-signals that is measured using a plurality of light sources that emits light of different wavelengths.

[0019] The determining of whether the user has eaten food may include comparing the TPR reflected index or a reciprocal of the TPR reflected index, with a reference value, and determining whether the user has eaten food, based on a result of the TPR reflected index or a reciprocal of the TPR reflected index being compared with the reference value.

[0020] The method may further include setting the reference value to be used in determining whether the user has eaten food, based on an instruction of the user or based on the TPR reflected index obtained in a fasting and resting state.

[0021] The method may further include determining a dietary level of the user, based on the TPR reflected index.

[0022] The method may further include acquiring exercise data of the user, and correcting the TPR reflected index, based on the exercise data.

[0023] The method may further include acquiring body temperature data of the user, and correcting the TPR reflected index, based on the body temperature data.

[0024] The method may further include estimating a blood sugar level of the user, based on the TPR reflected index.

[0025] Other features and aspects will be apparent from the following detailed description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The above and/or other aspects will be more apparent by describing certain example embodiments, with reference to the accompanying drawings, in which:

[0027] FIG. **1** is a block diagram illustrating a dietary habit management apparatus according to an example embodiment;

[0028] FIG. **2** is a block diagram illustrating a bio-signal acquiring apparatus according to an example embodiment;

[0029] FIG. **3** is a block diagram illustrating a processor according to an example embodiment;

[0030] FIG. **4** is a graph for describing a TPR reflected index;

[0031] FIG. **5** are graphs for describing a method of acquiring $P_n(P_1, P_2, P_3)$ and $T_n(T_1, T_2, T_3)$ of FIG. **4**;

[0032] FIG. **6** are graphs for describing a method of acquiring P_{max} and T_{max} of FIG. **4**;

[0033] FIG. **7** are graphs for showing examples of a PPG signal according to food intake;

[0034] FIG. **8** are graphs for showing an example of a change in TPR reflected index according to food intake;

[0035] FIG. **9** is a block diagram illustrating a processor according to another example embodiment;

[0036] FIG. **10** is a graph for describing a relationship between a TPR reflected index and a blood sugar level;

[0037] FIG. **11** is a block diagram illustrating a dietary habit management apparatus according to another example embodiment;

[0038] FIG. **12** is a flowchart illustrating a method of managing dietary habits according to an example embodiment; and

[0039] FIG. **13** is a flowchart illustrating a method of managing dietary habits according to another example embodiment.

DETAILED DESCRIPTION

[0040] Example embodiments are described in greater detail below with reference to the accompanying drawings.

[0041] In the following description, like drawing reference numerals are used for like elements, even in different drawings. The matters defined in the description, such as detailed construction and elements, are provided to assist in a comprehensive understanding of the example embodiments. However, it is apparent that the example embodiments can be practiced without those defined matters. Also, well-known functions or constructions are not described in detail because they would obscure the description with unnecessary detail.

[0042] In some alternative implementations, the functions/acts noted in the blocks may occur out of the order noted in the flowcharts. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

[0043] Terms described in below are selected by considering functions in the embodiment and meanings may vary depending on, for example, a user or operator's intentions or customs. Therefore, in the following embodiments, when terms are defined, the meanings of terms may be interpreted based on definitions, and otherwise, may be interpreted based on meanings recognized by those skilled in the art.

[0044] As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," or "includes" and/or "including" when used in this description, specify the presence of stated features, numbers, steps, operations, elements, components or combinations thereof, but do not preclude the presence or addition of one or more other features, numbers, steps, operations, elements, components or combinations thereof.

[0045] It will also be understood that the elements or components in the following description are discriminated in accordance with their respective main functions. In other words, two or more elements may be made into one element or one element may be divided into two or more elements in accordance with a subdivided function. Additionally, each of the elements in the following description may perform a part or whole of the function of another element as well as its main function, and some of the main functions of each of the elements may be performed exclusively by other elements. Each element may be realized in the form of a hardware component, a software component, and/or a combination thereof.

[0046] FIG. **1** is a block diagram illustrating a dietary habit management apparatus **100** according to an example embodiment. The dietary habit management apparatus **100** of FIG. **1** may be implemented as a software module or in the form of a hardware chip and may be mounted in an electronic device. In this case, the electronic device may include a mobile phone, a smartphone, a tablet computer, a notebook computer, a personal digital assistant (PDA), a portable multimedia player (PMP), a navigation terminal, an MP3 player, a digital camera, and a wearable device. The wearable device may include wearable devices of a wristwatch type, a wrist band type, a belt type, a necklace type, an ankle band type, a thigh band type, a forearm band type, and the like. However, the electronic device and the wearable device are not limited to the above examples.

[0047] Referring to FIG. **1**, the dietary habit management apparatus **100** may include a bio-signal acquirer **110** and a processor **120**.

[0048] The bio-signal acquirer **110** may acquire a bio-signal of a user. Here, the bio-signal may include, but not limited to, a pulse pressure signal, a photoplethysmogram (PPG) signal, an electrocardiogram (ECG) signal, an electromyogram (EMG) signal, a ballistocardiogram (BCG) signal, and the like.

[0049] According to one embodiment, the bio-signal acquirer **110** may acquire a bio-signal of the user from an external device. In this case, the bio-signal acquirer **110** may use various communication technologies, such as Bluetooth, Bluetooth low energy (BLE), near field communication (NFC), wireless local area network (WLAN) communication, ZigBee communication, infrared data association (IrDA) communication, Wi-Fi direct (WFD) communication, ultra-wideband (UWB) communication, Ant+ communication, Wi-Fi communication, radio frequency identification (RFID) communication, third generation (3G) communication, fourth generation (4G) communication, fifth generation (5G) communication, and the like.

[0050] The external device is a device that measures or stores a bio-signal of a user, and may include, but not limited to, various sensors (e.g., a pulse pressure sensor, a PPG sensor, an ECG sensor, an EMG sensor, a BCG sensor, and the like), a digital TV, a desktop computer, a mobile phone, a smartphone, a tablet computer, a notebook computer, a PDA, a PMP, a navigation terminal, an MP3 player, a digital camera, a wearable device and the like.

[0051] According to another embodiment, the bio-signal acquirer **110** may include various sensors for sensing a bio-signal, by which the bio-signal acquirer **110** can directly acquire the user's bio-signal. In this case, the sensor may include a pulse pressure sensor, a PPG sensor, an ECG sensor, an EMG sensor, a BCG sensor, and the like.

[0052] The processor **120** may process various signals related to the operations of the dietary habit management apparatus **100**.

[0053] The processor **120** may control the bio-signal acquirer **110** to acquire the user's bio-signal at predetermined intervals or upon request of the user and may obtain or extract a total peripheral resistance (TPR) reflected index (hereinafter will be referred to as a "TPR reflected index") from the acquired bio-signal. In this case, the TPR reflected index may be an index in negative correlation or positive correlation with TPR. For example, the processor **120** may extract a TPR reflected index by extracting feature points from the bio-signal and combining features corresponding to the extracted feature points, or extract a TPR reflected index using a time delay between a plurality of bio-signals measured using a plurality of light sources that emit light of different wavelengths. In this case, the time delay is a time difference between the bio-signals and is obtained by extracting feature points that respectively correspond to the plurality of bio-signals and calculating the time difference between the extracted feature points.

[0054] The TPR reflected index will be described below in detail with reference to FIG. **4**.

[0055] In addition, the processor **120** may determine whether the user has eaten food by analyzing the extracted TPR reflected index. For example, the processor **120** may compare the TPR reflected index (when the TPR reflected index is in negative correlation with TPR) or the reciprocal of the TPR reflected index (when the TPR reflected index is in positive correlation with TPR) with a predetermined reference value and determine that the user has eaten food when the TPR reflected index or the reciprocal of the TPR reflected index is greater than the predetermined reference value.

[0056] FIG. **2** is a block diagram illustrating a bio-signal acquiring apparatus **200** according to an example embodiment. The bio-signal acquiring apparatus **200** of FIG. **2** may be one embodiment of the bio-signal acquirer **110** of FIG. **1**.

[0057] Referring to FIG. **2**, the bio-signal acquiring apparatus **200** may include a light source **210** and a photodetector **220**.

[0058] The light source **210** may emit light to the skin of a user. The light source **210** may include at least one light source formed by a light emitting diode (LED), a laser diode, or a phosphor.

[0059] According to one embodiment, each of the light sources may emit visible ray light, near infrared ray (NIR) light, or mid-infrared ray (MIR) light. However, the wavelength of the light emitted from each of the light sources may vary depending on the purpose of measurement or a target component to be analyzed. In addition, each of the light sources is not necessarily configured with a single light emitting structure, and may be formed as an array composed of a plurality of light emitting structures. In this case, each of the light sources may emit light of the same wavelengths or emit light of a different wavelength.

[0060] The light source **210** may further include various optical devices to allow light to be emitted to a desired position.

[0061] The photodetector **220** may receive light reflected or scattered from the skin of the user and acquire the user's bio-signal (e.g., PPG signal). The photodetector **220** may include one or more photodetectors formed by a photodiode, a photo transistor (PTr), or a charge-coupled device (CCD). The photodetector is not necessarily configured with a single device and may be formed as an array composed of a plurality of devices.

[0062] The numbers and arrangements of the light sources and the photodetectors may vary depending on the purpose of use of the bio-signal acquiring apparatus **200** and the size and the shape of the electronic device in which the bio-signal acquiring apparatus **200** is mounted.

[0063] FIG. **3** is a block diagram illustrating a processor **300** according to an example embodiment. The processor **300** of FIG. **3** may be one embodiment of the processor **120** of FIG. **1**.

[0064] Referring to FIG. **3**, the processor **300** may include a TPR reflected index extractor **310** and a food intake determiner **320** for determining whether a user has eaten food.

[0065] The TPR reflected index extractor **310** may extract a TPR reflected index from a bio-signal.

[0066] According to one embodiment, the TPR reflected index extractor **310** may extract one or more feature points by analyzing the bio-signal and extract a TPR reflected index by combining features corresponding to the one or more extracted feature points. In this case, the feature points may include a peak point of the bio-signal and an intermediate point of a peak point of each component pulse constituting the bio-signal and the peak point of the bio-signal, but these are an embodiment and aspects of the disclosure are not limited thereto.

[0067] According to another embodiment, the TPR reflected index extractor **310** may calculate a time delay between a plurality of bio-signals by analyzing the plurality of bio-signal, which are measured using a plurality of light sources that emit light of different wavelengths and extract a TPR reflected index on the basis of the calculated time delay. For example, the TPR reflected index extractor **310** may extract feature points corresponding to each other from the plurality of bio-signals and calculate a time delay between the plurality of bio-signals by computing a time difference between the extracted feature points. In addition, the TPR reflected index extractor **310** may extract the TPR reflected index using Equation 1 below.

$$\text{TPR reflected index}=a*T-b*k \quad (1)$$

[0068] Here, T denotes a time delay between a first bio-signal and a second bio-signal having a wavelength different from that of the first bio-signal, k denotes a heart-rate reflected index or a cardiac-output reflected index, and a and b may be scale constants. In this case, k may be obtained by analyzing the first bio-signal and/or the second bio-signal, or may be obtained by acquiring and analyzing another bio-signal. For example, the cardiac-output reflected index may be obtained by extracting one or more feature points from a bio-signal (the first bio-signal, the second bio-signal, or another bio-signal) and combining features (e.g., P_{max}/P_{area}, P_{max}/P_3, P_{sys}/P_3, P_1/P_3, P_2/P_3, and $1/T_{period}$, refer to FIG. **4**) corresponding to the one or more extracted feature points, and the heart-rate reflected index may be obtained by dividing the cardiac-output reflected index by a stroke volume.

[0069] The food intake determiner **320** may determine whether the user has eaten food by analyzing the TPR reflected index. According to one embodiment, the food intake determiner **320** may compare the TPR reflected index (when the TPR reflected index is in negative correlation with TPR) or the reciprocal of the TPR reflected index (when the TPR reflected index is in positive correlation with TPR) with a predetermined reference value and determine that the user has eaten food when the TPR reflected index or the reciprocal of the TPR reflected index is greater than the predetermined reference value.

[0070] The food intake determiner **320** may determine a dietary level of the user by analyzing the TPR reflected index. For example, the dietary level may be classified into a plurality of levels (e.g., a first level, a second level, and a third level) according to a value of the TPR reflected index (when the TPR reflected index is in negative correlation with TPR) or the reciprocal of the TPR reflected index (when the TPR reflected index is in positive correlation with TPR). In this case, the food intake determiner **320** may determine a level at which the user's TPR reflected index (when the TPR reflected index is in negative correlation with TPR) or the reciprocal of the TPR reflected index of the user (when the TPR reflected index is in positive correlation with TPR) is situated, and determine the user's dietary level according to the determined level. In this case, when the level is higher (e.g., the first level<the second level<the third level), the food intake determiner **320** may determine that the user has eaten higher-calorie food or higher glycemic index food.

[0071] FIG. **4** is a graph for describing a TPR reflected index, FIG. **5** are graphs for describing a method of acquiring $P_n(P_1, P_2, P_3)$ and $T_n(T_1, T_2, T_3)$ of FIG. **4**, and FIG. **6** are graphs for describing a method of acquiring P_{max} and T_{max} of FIG. **4**. In this case, it is assumed that a bio-signal is a PPG signal and the TPR reflected index is in positive correlation with TPR.

[0072] Referring to FIG. **4**, a waveform of a PPG signal **400** may be a summation of a propagation wave **410** propagating from the heart to peripheral parts of a body and reflection waves **420** and **430** returning from the peripheral parts of the body. That is, the PPG signal **400** may be a summation of three or more component pulses **410** to **430**. In this case, reference numeral **400** denotes the PPG signal of one period T_{period}, **410** denotes a first component pulse, **420** denotes a second component pulse, and **430** denotes a third component pulse. In addition, T_1 denotes the time of the peak point of the first component pulse **410**, P_1 denotes the amplitude of the PPG signal **400** at T_1, T_2 denotes the time of the peak point of the second component pulse **420**, P_2 denotes the amplitude of the PPG signal **400** at T_2, T_3 denotes the time of the peak point of the third component pulse **430**, P_3 denotes the amplitude of the PPG signal **400** at T_3, T_{max} denotes the time of the peak point of the PPG signal **400** in a predetermined interval, P_{max} denotes the amplitude of the PPG signal **400** at T_{max}, T_{sys} denotes the intermediate time between T_1 and T_{max} P_{sys} denotes the amplitude of the PPG signal **400** at T_{sys}, τ_{dur} denotes a setting factor ($0 \le \tau_{dur} \le 1$) (e.g., 0.7) of the system, A_{dur} denotes the sum of amplitudes of the PPG signal **400** between time 0 and $t_{dur}*T_{period}$, and A_{ppg} denotes the sum of amplitudes of the PPG signal of one period T_{period}.

[0073] Within the PPG signal **400**, as T_3 or T_2 increases, the TPR reflected index may decrease, and as T_1, T_{sys}, or T_{max} increases, the TPR reflected index may increase. In addition, within the PPG signal **400**, as P_2, P_3, or A_{ppg} increases, the TPR reflected index may increase, and as P_1 or P_{max} increases, the TPR reflected index may decrease. For example, the TPR reflected index may include $1/(T_3-T_1)$, $1/(T_3-T_{sys})$, $1/(T_3-T_{max})$, $1/(T_2-T_1)$, P_2/P_1, P_3/P_{max}, P_3/P_1, $A_{ppg}/(P_{max}*A_{dur})$, and the like.

[0074] Although it is described in FIG. **4** that T_{sys} is the intermediate time between T_1 and T_{max} the disclosure is not limited thereto. That is, T_{sys} may be an arbitrary internally dividing point between T_1 and T_{max} or an arbitrary internally dividing point between T_1 and T_2.

[0075] Referring to FIG. **5**, $P_n(P_1, P_2, P_3)$, and $T_n(T_1, T_2, T_3)$ of FIG. **4** may be obtained based on a second-order differential signal **500** of the PPG signal **400**. When the second-order differential signal **500** is obtained from the PPG signal **400**, the second-order differential signal **500** includes a plurality of local minimum points min1, min2, and min3. When the local minimum points min1 to min3 included in the second-order differential signal **500** are arranged in a time-order sequence, the local minimum point min1 corresponds to T_1, the local minimum point min2 corresponds to T_2, and the local minimum point min3 corresponds to T_3. In addition, the amplitude of the PPG signal **400** at T_1 corresponds to P_1, the amplitude of the PPG signal **400** at T_2 corresponds to P_2, and the amplitude of the PPG signal **400** at T_3 corresponds to P_3.

[0076] Referring to FIG. **6**, P_{max} and T_{max} of FIG. **4** may be obtained based on the second-order differential signal **500** of the PPG signal **400**. When the second-order differential signal **500** is obtained from the PPG signal **400**, the second-order differential signal **500** includes a plurality of local maximum points max1, max2, and max3. When the local maximum points max1 to max3 included in the second-order differential signal **500** are arranged in a time-order sequence and the time corresponding to the third maximum point max3 is T_{range}, the time of the peak point of the PPG signal **400** in the range of $0 \le time \le T_{range}$ corresponds to T_{max} and the amplitude of the PPG signal **400** at T_{max} corresponds to P_{max}.

[0077] FIG. **7** are graphs for showing examples of a PPG signal according to food intake, and FIG. **8** are graphs for showing an example of a change in TPR reflected index according to food intake.

[0078] As shown in FIG. **7**, when a PPG signal **710** before food intake is compared with a PPG signal **720** after alcohol consumption, P3 decreases after food intake, and also A value (T_3-T_{max}) increases. That is, the A value (T_3-T_{max}) increases due to food intake, and as shown in FIG. **8**, the TPR reflected index (e.g., $1/(T_3-T_{max})$) decreases according to the food intake. This may be interpreted that the diameter of peripheral blood vessels increases and the blood flow increases.

[0079] Therefore, a dietary habit management apparatus (e.g., **100** in FIG. **1**) may monitor the TPR reflected index (e.g., $1/(T_3-T_{max})$) and determine that the user is eating food (alcohol) when the reciprocal of the TPR reflected index exceeds a predetermined reference value. In addition, when a dietary level is classified into a first level, a second level, and a third level, the dietary habit management apparatus (e.g., **100** in FIG. **1**) may determine the user's dietary level by identifying a level at which the reciprocal of the TPR reflected index is situated. In this case, the dietary habit management apparatus (e.g., **100** in FIG. **1**) may determine that the user has eaten higher calorie food or higher glycemic index food when the level is higher (e.g., first level<second level<third level). That is, as the level is increased from level 1 to level 3, it may be determined that the user has eaten higher calorie food or higher glycemic index food, and thereby it is possible to manage blood sugar level and calories, as well as dietary habits through storage of the number of meals and times of meals.

[0080] FIG. **9** is a block diagram illustrating a processor **900** according to another example embodiment. The processor **900** of FIG. **9** may be one embodiment of the processor **120** of FIG. **1**.

[0081] Referring to FIG. **9**, the processor **900** may include an exercise data acquirer **910**, a body temperature data acquirer **920**, a TPR reflected index extractor **310**, a TPR reflected index corrector **930**, a reference value setter **940**, a food intake determiner **320**, and a blood sugar estimator **950**. Here, the TPR reflected index extractor **310** and the food intake determiner **320** are the same as those described with reference to FIG. **3**, and hence detailed descriptions thereof will not be reiterated.

[0082] The exercise data acquirer **910** may acquire exercise data of a user.

[0083] According to one embodiment, the exercise data acquirer **910** may receive and acquire the user's exercise data from an external device. In this case, the exercise data acquirer **910** may use various communication technologies, such as Bluetooth, BLE, NFC, WLAN communication, ZigBee communication, IrDA communication, WFD communication, UWB communication, Ant+ communication, Wi-Fi communication, RFID communication, 3G communication, 4G communication, 5G communication, and the like.

[0084] The external device is a device that measures or stores user's exercise data and may include, but not limited to, various sensors (e.g., accelerator sensor, a gyro sensor, and the like), a digital TV, a desktop computer, a mobile phone, a smartphone, a tablet computer, a notebook computer, a PDA, a PMP, a navigation terminal, an MP3 player, a digital camera, a wearable device, and the like.

[0085] According to another embodiment, the exercise data acquirer **910** may include various sensors that sense the user's exercise data and directly obtain the user's exercise data through the various sensors. In this case, the sensors may include, but not limited to, an acceleration sensor, a gyro sensor, and the like.

[0086] The body temperature data acquirer **920** may acquire body temperature data of the user.

[0087] According to one embodiment, the body temperature data acquirer **920** may receive and acquire the user's body temperature data from an external device. In this case, the body temperature data acquirer **920** may use various communication technologies, such as Bluetooth, BLE, NFC, WLAN communication, ZigBee communication, IrDA communication, WFD communication, UWB communication, Ant+ communication, Wi-Fi communication, RFID communication, 3G communication, 4G communication, 5G communication, and the like.

[0088] The external device may be a device that measures or stores the user's body temperature data and may include, but not limited to, a temperature sensor, a digital TV, a desktop computer, a mobile phone, a smartphone, a tablet computer, a notebook computer, a PDA, a PMP, a navigation terminal, an MP3 player, a digital camera, a wearable device, and the like.

[0089] According to another embodiment, the body temperature data acquirer **920** may include a temperature sensor that senses the user's body temperature and may directly acquire the user's body temperature data using the temperature sensor.

[0090] The TPR reflected index corrector **930** may correct a TPR reflected index based on the user's exercise data and/or body temperature data.

[0091] The TPR reflected index is related to the expansion of the blood vessels, and hence may be affected not only by food intake but also by other factors, such as exercise intensity, body temperature, and the like.

[0092] According to one embodiment, the TPR reflected index corrector **930** may determine the amount of exercise of the user on the basis of the user's exercise data and increase or decrease the TPR reflected index according to the amount of exercise of the user. In this case, the specified increase or decrease amount of TPR reflected index may be determined using an exercise amount-TPR model that defines a relationship between the amount of exercise of the user and the TPR reflected index.

[0093] According to another embodiment, the TPR reflected index corrector **930** may increase or decrease the TPR reflected index according to the user's body temperature. In this case, the specified increase or decrease amount of TPR reflected index may be determined using a body temperature-TPR model that defines a relationship between the user's body temperature and the TPR reflected index.

[0094] The exercise amount-TPR model and the body temperature-TPR model may be constructed in advance using regression analysis or machine learning and be stored in the processor **900** or in an external database.

[0095] The reference value setter **940** may set a reference value to be used in determining whether the user has eaten food. For example, the reference value setter **940** may set the reference value according to a user's instruction or on the basis of the TPR reflected index extracted in a fasting and resting state. Here, the resting state may refer to a state in which the user is motionless or a state in which the user's exercise intensity is less than or equal to a predetermined threshold value.

[0096] The blood sugar estimator **950** may estimate a user's blood sugar level based on the TPR reflected index. For example, the blood sugar estimator **950** may estimate the user's blood sugar level using a TPR-blood sugar model that defines a relationship between the TPR reflected index and the blood sugar. In this case, the TPR-blood sugar model may be constructed in advance using regression analysis or machine learning and be stored in the processor **900** or in an external database.

[0097] FIG. **10** is a graph for describing a relationship between a TPR reflected index and a blood sugar level. FIG.

10 is a graph showing a blood sugar level measurement result and a change in the TPR reflected index extracted from a PPT signal.

[0098] In the illustrated example, a blood sugar level **1010** shows a tendency to increase from the start of the meal (about 64 minutes) until 120 minutes and decrease since then. A reciprocal **1020** of the TPR reflected index (when the TPR reflected index is in positive correlation with TPR) also shows a tendency to increase and then decrease in a similar pattern as the blood sugar level **1010**.

[0099] FIG. **11** is a block diagram illustrating a dietary habit management apparatus **1100** according to another example embodiment. The dietary habit management apparatus of FIG. **11** may be implemented as a software module or in the form of a hardware chip and may be mounted in an electronic device. The electronic device may include, but not limited to, a mobile phone, a smartphone, a tablet computer, a notebook computer, a PDA, a PMP, a navigation terminal, an MP3 player, a digital camera, a wearable device and the like. The wearable device may include wearable devices of a wristwatch type, a wrist band type, a belt type, a necklace type, an ankle band type, a thigh band type, a forearm band type, and the like. However, the electronic device and the wearable device are not limited to the above examples.

[0100] Referring to FIG. **11**, the dietary habit management apparatus **1100** may include a bio-signal acquirer **110**, a processor **120**, an inputter **1110**, a storage **1120**, a communicator **1130**, and an outputter **1140**. Here, the bio-signal acquirer **110** and the processor **120** are the same those described with reference to FIGS. **1** to **10**, and thus detailed descriptions thereof will not be reiterated.

[0101] The inputter **1110** may receive various operation signals input by a user. According to one embodiment, the inputter **1110** may include a key pad, a dome switch, a resistive or capacitive touch pad, a jog wheel, a jog switch, a hardware (H/W) button, and the like. When a touch pad has a layered structure with a display, this structure may be referred to as a touch screen.

[0102] Programs or instructions for operations of the dietary habit management apparatus **1100** may be stored in the storage **1120** and data input to and output from the dietary habit management apparatus **1100** may also be stored in the storage **1120**. In addition, the storage **1120** may store bio-signal data acquired through the bio-signal acquirer **110**, TPR reflected index data extracted by the processor **120**, data about whether the user has eaten food and the dietary level, which is determined by the processor **120**, blood sugar level data of the user estimated by the processor **120**, and various models (e.g., an exercise-TPR model, a body temperature-TPR model, a TPR-blood sugar model, etc.).

[0103] The storage **1120** may include at least one type of storage media, such as a flash memory, a hard disk type memory, a multimedia card micro type memory, a card-type memory (e.g., SD or XD memory), random access memory (RAM), static random access memory (SRAM), read only memory (ROM), electrically erasable programmable read only memory (EEPROM), programmable read only memory (PROM), magnetic memory, and optical disk. In addition, the dietary habit management apparatus **1100** may operate an external storage medium, such as web storage providing a storage function of the storage **1120**.

[0104] The communicator **1130** may communicate with an external device. For example, the communicator **1130** may transmit the bio-signal data acquired through the bio-signal acquirer **110**, the TPR reflected index data extracted by the processor **120**, the data about whether the user has eaten food and the dietary level that is determined by the processor **120**, the blood sugar level data of the user estimated by the processor **120**, and various models (e.g., an exercise-TPR model, a body temperature-TPR model, a TPR-blood sugar model, etc.) to the external device, or receive a variety of data helpful to determine the food intake of the user and the dietary level and estimate the user's blood sugar level from the external device.

[0105] Here, the external device may be medical equipment that uses the data input by the user through the inputter **1110**, the bio-signal data acquired through the bio-signal acquirer **110**, the TPR reflected index data extracted by the processor **120**, the data about whether the user has eaten food and the dietary level that is determined by the processor **120**, the blood sugar level data of the user estimated by the processor **120**, and various models (e.g., an exercise-TPR model, a body temperature-TPR model, a TPR-blood sugar model, etc.), or a printer or display device to output a result. In addition, the external device may include, but not limited to, a digital TV, a desktop computer, a mobile phone, a smartphone, a tablet computer, a notebook computer, a PDA, a PMP, a navigation terminal, an MP3 player, a digital camera, a wearable device, and the like.

[0106] The communicator **1130** may communicate with the external device using various communication technologies, such as Bluetooth, BLE, NFC, WLAN communication, ZigBee communication, IrDA communication, WFD communication, UWB communication, Ant+ communication, Wi-Fi communication, RFID communication, 3G communication, 4G communication, 5G communication, and the like. However, these are examples, and aspects of the disclosure are not limited thereto.

[0107] The outputter **1140** may output the data input by the user through the inputter **1110**, the bio-signal data acquired through the bio-signal acquirer **110**, the TPR reflected index data extracted by the processor **120**, the data about whether the user has eaten food and the dietary level that is determined by the processor **120**, the blood sugar level data of the user estimated by the processor **120**, and the like. According to one embodiment, the outputter **1140** may output the data input by the user through the inputter **1110**, the bio-signal data acquired through the bio-signal acquirer **110**, the TPR reflected index data extracted by the processor **120**, the data about whether the user has eaten food and the dietary level that is determined by the processor **120**, the blood sugar level data of the user estimated by the processor **120**, and the like in any one or any combination of visual, audible, and tactile manners. To this end, the outputter **1140** may include a display, a speaker, a vibrator, and the like.

[0108] FIG. **12** is a flowchart illustrating a method of managing dietary habits according to an example embodiment. The method shown in FIG. **12** may be performed by the dietary habit management apparatus **100** of FIG. **1**.

[0109] Referring to FIGS. **1** and **12**, the dietary habit management apparatus **100** may acquire a user's bio-signal in operation **1210**. Here, the bio-signal may include, but not limited to, a pulse pressure signal, a PPG signal, an ECG signal, an EMG signal, a BCG signal, and the like.

[0110] For example, the dietary habit management apparatus **100** may acquire the user's bio-signal from an external device that measures or stores the user's bio-signal, or may include various sensors that sense the bio-signal and obtain the user's bio-signal through the various sensors.

[0111] The dietary habit management apparatus **100** may extract a TPR reflected index from the bio-signal in operation **1220**.

[0112] According to one embodiment, the dietary habit management apparatus **100** may extract one or more feature points by analyzing the bio-signal and extract the TPR reflected index by combining features corresponding to the one or more extracted feature points.

[0113] According to another embodiment, the dietary habit management apparatus **100** may calculate a time delay between a plurality of bio-signals by analyzing the plurality of bio-signal that are measured using a plurality of light sources that emit light of different wavelengths, and may extract a TPR reflected index on the basis of the calculated time delay. For example, the TPR reflected index extractor **310** may extract the TPR reflected index using Equation 1.

[0114] The dietary habit management apparatus **100** may determine whether the user has eaten food by analyzing the TPR reflected index in operation **1230**. According to one embodiment, the dietary habit management apparatus **100** may compare the TPR reflected index (when the TPR reflected index is in negative correlation with TPR) or the reciprocal of the TPR reflected index (when the TPR reflected index is in positive correlation with TPR) with a predetermined reference value and determine that the user has eaten food when the TPR reflected index or the reciprocal of the TPR reflected index is greater than the predetermined reference value.

[0115] FIG. **13** is a flowchart illustrating a method of managing dietary habits according to another example embodiment. The method shown in FIG. **13** may be performed by the dietary habit management apparatus **100** of FIG. **1**.

[0116] Referring to FIGS. **1** and **13**, the dietary habit management apparatus **100** may set a reference value to be used to determine whether the user has eaten food in operation **1310**. For example, the dietary habit management apparatus **10** may set the reference value according to a user's instruction or on the basis of the TPR reflected index extracted in a fasting and resting state. Here, the resting state may refer to a state in which the user is motionless or a state in which the user's exercise intensity is less than or equal to a predetermined threshold value.

[0117] The dietary habit management apparatus **100** may acquire a user's bio-signal in operation **1320**. For example, the dietary habit management apparatus **100** may acquire the user's bio-signal from an external device that measures or stores the user's bio-signal, or may include various sensors that sense a bio-signal and directly acquire the user's bio-signal through the various sensors.

[0118] The dietary habit management apparatus **100** may extract a TPR reflected index from the bio-signal in operation **1330**.

[0119] According to one embodiment, the dietary habit management apparatus **100** may extract one or more feature points by analyzing the bio-signal and extract the TPR reflected index by combining features corresponding to the one or more extracted feature points.

[0120] According to another embodiment, the dietary habit management apparatus **100** may calculate a time delay between a plurality of bio-signals by analyzing the plurality of bio-signal that are measured using a plurality of light sources that emit light of different wavelengths, and may extract a TPR reflected index on the basis of the calculated time delay. For example, the TPR reflected index extractor **310** may extract the TPR reflected index using Equation 1.

[0121] The dietary habit management apparatus **100** may acquire the user's exercise data and/or body temperature data in operation **1340**. For example, the dietary habit management apparatus **100** may acquire the user's exercise data and/or body temperature data from an external device that measures or stores the user's exercise data and/or body temperature data, or may include various sensors that sense the user's exercise data and/or body temperature data and directly acquire the user's exercise data and/or body temperature data through the various sensors.

[0122] The dietary habit management apparatus **100** may correct the TPR reflected index based on the user's exercise data and/or body temperature data in operation **1350**. For example, the dietary habit management apparatus **100** may determine the amount of exercise of the user on the basis of the user's exercise data, increase or decrease the TPR reflected index according to the amount of exercise of the user, or increase or decrease the TPR reflected index according to the body temperature of the user. In this case, the dietary habit management apparatus **100** may use an exercise amount-TPR model and/or a body temperature-TPR model.

[0123] The dietary habit management apparatus **100** may determine whether the user has eaten food by analyzing the TPR reflected index in operation **1360**. According to one embodiment, the dietary habit management apparatus **100** may compare the TPR reflected index (when the TPR reflected index is in negative correlation with TPR) or the reciprocal of the TPR reflected index (when the TPR reflected index is in positive correlation with TPR) with a predetermined reference value and determine that the user has eaten food when the TPR reflected index or the reciprocal of the TPR reflected index is greater than the predetermined reference value.

[0124] The dietary habit management apparatus **100** may determine a dietary level of the user by analyzing the TPR reflected index in operation **1370**. For example, the dietary level may be classified into a plurality of levels (e.g., a first level, a second level, and a third level) according to a value of the TPR reflected index (when the TPR reflected index is in negative correlation with TPR) or the reciprocal of the TPR reflected index (when the TPR reflected index is in positive correlation with TPR). In this case, the dietary habit management apparatus **100** may determine a level at which the user's TPR reflected index (when the TPR reflected index is in negative correlation with TPR) or the reciprocal of the TPR reflected index of the user (when the TPR reflected index is in positive correlation with TPR) is situated, and determine the user's dietary level according to the determined level. In this case, when the level is higher (e.g., the first level<the second level<the third level), the food intake determiner **320** may determine that the user has eaten higher-calorie food or higher glycemic index food.

[0125] The dietary habit management apparatus **100** may estimate a user's blood sugar level based on the TPR reflected index in operation **1380**. For example, the dietary habit management apparatus **100** may estimate the user's blood sugar level using the TPR-blood sugar model.

[0126] The current embodiments can be implemented as computer readable codes in a computer readable record medium. Codes and code segments constituting the computer program can be easily inferred by a skilled computer programmer in the art. The computer readable record medium includes all types of record media in which computer readable data are stored. Examples of the computer readable record medium include a ROM, a RAM, a CD-ROM, a magnetic tape, a floppy disk, and an optical data storage. Further, the record medium may be implemented in the form of a carrier wave such as Internet transmission. In addition, the computer readable record medium may be distributed to computer systems over a network, in which computer readable codes may be stored and executed in a distributed manner.

[0127] A number of examples have been described above. Nevertheless, it will be understood that various modifications may be made. For example, suitable results may be achieved if the described techniques are performed in a different order and/or if components in a described system, architecture, device, or circuit are combined in a different manner and/or replaced or supplemented by other components or their equivalents. Accordingly, other implementations are within the scope of the following claims.

What is claimed is:

1. A dietary habit management apparatus comprising:

a bio-signal acquirer configured to acquire a bio-signal of a user; and

a processor configured to:

obtain a total peripheral resistance (TPR) reflected index, from the bio-signal acquired by the bio-signal acquirer; and

determine whether the user has eaten food, based on the TPR reflected index.

2. The dietary habit management apparatus of claim **1**, wherein the bio-signal is one of a pulse pressure signal, a photoplethysmogram (PPG) signal, an electrocardiogram (ECG) signal, an electromyogram (EMG) signal, and a ballistocardiogram (BCG) signal.

3. The dietary habit management apparatus of claim **1**, wherein the processor is further configured to:

extract at least one feature point, from the bio-signal; and

obtain the TPR reflected index by combining features corresponding to the at least one feature point.

4. The dietary habit management apparatus of claim **3**, wherein the TPR reflected index comprises any one or any combination of $1/(T_3-T_1)$, $1/(T_3-T_{sys})$, $1/(T_3-T_{max})$, $1/(T_2-T_1)$, P_2/P_1, P_3/P_{max}, P_3/P_1, and $A_{ppg}/(P_{max}*A_{dur})$, where T_1 denotes a time of a peak point of a first component pulse constituting the bio-signal, T_2 denotes a time of a peak point of a second component pulse constituting the bio-signal, T_3 denotes a time of a peak point of a third component pulse constituting the bio-signal, T_{max} denotes a time of a peak point of the bio-signal in a first interval, T_{sys} denotes an intermediate time between T_1 and T_{max}, P_1 denotes an amplitude of the bio-signal at T_1, P_2 denotes an amplitude of the bio-signal at T_2, P_3 denotes an amplitude of the bio-signal at T_3, P_{max} denotes an amplitude of the bio-signal at T_{max}, A_{ppg} denotes a sum of amplitudes of the bio-signal of one period, and A_{dur} denotes a sum of amplitudes of the bio-signal in a second interval.

5. The dietary habit management apparatus of claim **1**, wherein the processor is further configured to obtain the TPR reflected index, based on a time delay of a plurality of bio-signals that is measured using a plurality of light sources that emits light of different wavelengths.

6. The dietary habit management apparatus of claim **1**, wherein the processor is further configured to:

compare the TPR reflected index or a reciprocal of the TPR reflected index with a reference value; and

determine whether the user has eaten food, based on a result of the TPR reflected index or a reciprocal of the TPR reflected index being compared with the reference value.

7. The dietary habit management apparatus of claim **6**, wherein the processor is further configured to set the reference value to be used in determining whether the user has eaten food, based on an instruction of the user or based on the TPR reflected index obtained in a fasting and resting state.

8. The dietary habit management apparatus of claim **1**, wherein the processor is further configured to determine a dietary level of the user, based on the TPR reflected index.

9. The dietary habit management apparatus of claim **1**, wherein the processor is further configured to:

acquire exercise data of the user; and

correct the TPR reflected index, based on the exercise data.

10. The dietary habit management apparatus of claim **1**, wherein the processor is further configured to:

acquire body temperature data of the user; and

correct the TPR reflected index, based on the body temperature data.

11. The dietary habit management apparatus of claim **1**, wherein the processor is further configured to estimate a blood sugar level of the user, based on the TPR reflected index.

12. A method of managing dietary habits, the method comprising:

acquiring a bio-signal of a user;

obtaining a total peripheral resistance (TPR) reflected index, from the bio-signal; and

determining whether the user has eaten food, based on the TPR reflected index.

13. The method of claim **12**, wherein the obtaining the TPR reflected index comprises:

extracting at least one feature point, from the bio-signal and

obtaining the TPR reflected index by combining features corresponding to the at least one feature point.

14. The method of claim **12**, wherein the obtaining the TPR reflected index comprises obtaining the TPR reflected index, based on a time delay of a plurality of bio-signals that is measured using a plurality of light sources that emits light of different wavelengths.

15. The method of claim **12**, wherein the determining whether the user has eaten food comprises:

comparing the TPR reflected index or a reciprocal of the TPR reflected index with a reference value; and

determining whether the user has eaten food, based on a result of the TPR reflected index or a reciprocal of the TPR reflected index being compared with the reference value.

16. The method of claim **15**, further comprising setting the reference value to be used in determining whether the user has eaten food, based on an instruction of the user or based on the TPR reflected index obtained in a fasting and resting state.

17. The method of claim **12**, further comprising determining a dietary level of the user, based on the TPR reflected index.

18. The method of claim **12**, further comprising:
- acquiring exercise data of the user; and
- correcting the TPR reflected index based on the exercise data.

19. The method of claim **12**, further comprising:
- acquiring body temperature data of the user; and
- correcting the TPR reflected index based on the body temperature data.

20. The method of claim **12**, further comprising estimating a blood sugar level of the user, based on the TPR reflected index.

* * * * *

专利名称(译)	饮食习惯管理装置和方法		
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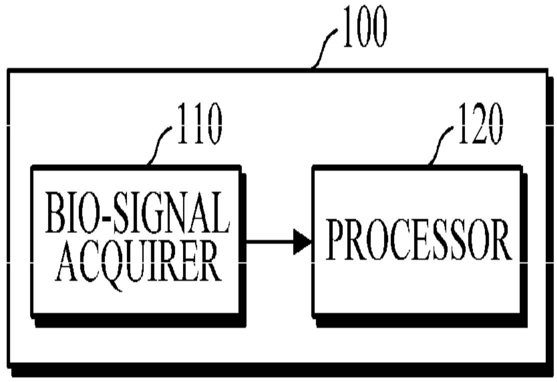
摘要(译)

提供了一种饮食习惯管理装置和方法。饮食习惯管理装置包括：生物信号获取器，被配置为获取用户的生物信号;以及处理器，被配置为从由生物信号获取的生物信号获得总外周电阻（TPR）反射指数。信号获取器，并根据TPR反射指数确定用户是否吃过食物。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BIO-SIGNAL ACQUIRER
PROCESSOR