wearing many electrodes and sensors on a body in an environment different from home also causes stress and makes it difficult to sleep. Therefore, it is difficult to correctly test the usual sleep state.

[0006] In view of the above circumstances, the present invention provides a sleep and arousal determination system or the like that determines sleep and arousal with sufficiently high accuracy using a small number of wearing device.

Means for Solving Problems

[0007] According to an aspect of the present invention, a sleep and arousal determination system is provided. The sleep and arousal determination system comprises at least one processor configured to execute a program to cause each of the following steps to be performed: an acquisition step of acquiring a signal indicating acceleration of at least a part of the body of a user; and a determination step of determining sleep and arousal of the user based on a specific frequency component included in the signal indicating the acceleration and preset reference information.

[0008] According to such an aspect, it becomes possible to determine sleep and arousal with sufficiently high accuracy using a small number of wearing device.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. 1 is a diagram showing an overview of a configuration of a sleep and arousal determination system 1 according to the present embodiment.

FIG. 2 is a block diagram showing a hardware configuration of the sleep and arousal determination system 1 shown in FIG. 1.

FIG. 3 is a photograph showing an example of a wearable device 2.

FIG. 4 is a functional block diagram of a controller 33 in an information processing apparatus 3.

processing apparatus 3 may be configured as one unit. In other words, the information processing apparatus 3 may be a wearable device 2 that can be worn by a user on a part of body and further comprise an acceleration sensor 24, wherein the acceleration sensor 24 is configured to measure a three-dimensional acceleration vector v (x, y, z) of acceleration.

[0062] The bandwidth limitation unit 332 may be configured to limit the frequency component to the specific frequency component C using a band-pass filter instead of the high-pass filter HF. According to such a manner, the specific frequency component can be restricted to a preferred component, and the sleep and arousal of the user can be determined more robustly.

[0063] The order of activities A103 and A104 shown in FIG. 5 may be reversed. That is, the correction unit 334 may standardize and correct distribution of the frequency component of the acquired signal, and the bandwidth limitation unit 332 may limit the standardized frequency component to the specific frequency component C. According to such an approach, influence of frequency sensitivity that varies from apparatus to apparatus can be reduced and the sleep and arousal of the user can be determined more robustly.

[0064] In addition to the acceleration sensor 24 in the present embodiment, other sensor may be added as appropriate. For instance, SpO2 sensor, ambient light sensor, heart rate sensor, etc. may be added. An SpO2 sensor may be implemented to measure transcutaneous arterial blood oxygen saturation, and a result thereof may be additionally used to determine sleep and arousal. An ambient light sensor may be implemented to measure intensity of ambient light of a user, and a result thereof may be additionally used to determine sleep and arousal. A heart rate sensor may be implemented to measure heart rate of a user, and a result thereof may be additionally used to determine sleep and arousal.

[0065] In addition, the present invention may be provided in each of the following aspects.

[0066] (1) A sleep and arousal determination system, comprising at least one processor configured to execute a program to cause each of the following steps to be performed: an acquisition step of acquiring a signal

indicating acceleration of at least a part of the body of a user; and a determination step of determining sleep and arousal of the user based on a specific frequency component included in the signal indicating the acceleration and preset reference information.

[0067] (2) The sleep and arousal determination system according to (1), the processor configured to execute the program to cause following step to be performed: the bandwidth limitation step of limiting to the specific frequency component using a high-pass filter or a band-pass filter.

[0068] (3) The sleep and arousal determination system according to (1) or (2), the processor configured to execute the program further to cause following step to be performed: a correction step of standardizing and correcting distribution of frequency component of the data for determination.

[0069] (4) The sleep and arousal determination system according to (1) or (2), the processor configured to execute the program further to cause each of following steps to be performed: a correction step of standardizing and correcting distribution of frequency component of the acquired signal, and the bandwidth limitation step of limiting the standardized frequency component to the specific frequency component.

[0070] (5) The sleep and arousal determination system according to any one of (1) to (4), the processor configured to execute the program to cause following step to be performed: the acquisition step of acquiring the signal by analog-to-digital conversion of the acceleration with a bit rate of 8 bits or more.

[0071] (6) The sleep and arousal determination system according to any one of (1) to (5), wherein: the reference information is a learned model that is allowed to learn correlation between the specific frequency component and the sleep and arousal.

[0072] (7) The sleep and arousal determination system according to (6), wherein: the learned model is a learned model in which correlation between the specific frequency component and the sleep and arousal is learned by acquiring the signal at a sampling frequency of 5 Hz or higher.

[0073] (8) The sleep and arousal determination system according to (7), wherein: the learned model is a learned model in which correlation between the specific frequency component and the sleep and arousal is learned by acquiring the signal at a sampling frequency of 25 Hz or

higher.

[0074] (9) The sleep and arousal determination system according to any one of (1) to (8), the processor configured to execute the program to cause following step to be performed: the determination step of specifying a feature quantity for each epoch defined by a predetermined time based on the data for determination, determining sleep and arousal of the user based on, among the epoch, the feature quantity of a desired epoch, the feature quantity of a recent epoch past the desired epoch in time series, and the reference information.

[0075] (10) A sleep and arousal determination method, comprising each step in the sleep and arousal determination system according to any one of (1) to (9).

[0076] (11) A non-transitory computer readable medium storing a program, wherein the program allows at least one computer to execute each step in the sleep and arousal determination system according to any one of (1) to (9).

Of course, the present invention is not limited thereto.

[0077] Finally, various embodiments of the present invention have been described, but these are presented as examples and are not intended to limit the scope of the invention. The novel embodiment can be implemented in various other forms, and various omissions, replacements, and changes can be made without departing from the abstract of the invention. The embodiment and its modifications are included in the scope and abstract of the invention and are included in the scope of the invention described in the claims and the equivalent scope thereof.

REFERENCE SIGNS LIST

[0078]

1: Sleep and arousal determination system
2: Wearable device
2a: Wearable device
2b: Wearable device
3: Information processing apparatus
20: Communication bus

CLAIMS

1. A sleep and arousal determination system, comprising at least one processor configured to execute a program to cause each of the following steps to be performed:

an acquisition step of acquiring a signal indicating acceleration of at least a part of the body of a user; and

a determination step of determining sleep and arousal of the user based on a specific frequency component included in the signal indicating the acceleration and preset reference information.

2. The sleep and arousal determination system according to claim 1, the processor configured to execute the program further to cause each of the following steps to be performed:

a bandwidth limitation step of limiting a frequency component included in the signal indicating the acceleration to the specific frequency component,

a transform step of Fourier transforming a signal configured of the specific frequency component to generate data for determination, and

the determination step of determining sleep and arousal of the user based on the data for determination and preset reference information.

3. The sleep and arousal determination system according to claim 2, the processor configured to execute the program to cause the following step to be performed:

the bandwidth limitation step of limiting to the specific frequency component using a high-pass filter or a band-pass filter.

4. The sleep and arousal determination system according to claim 2 or 3, the processor configured to execute the program further to cause the following step to be performed:

a correction step of standardizing and correcting distribution of frequency component of the data for determination.

5. The sleep and arousal determination system according to claim 2

or 3, the processor configured to execute the program further to cause each of the following steps to be performed:

a correction step of standardizing and correcting distribution of frequency component of the acquired signal, and

the bandwidth limitation step of limiting the standardized frequency component to the specific frequency component.

6. The sleep and arousal determination system according to any one of claims 1 to 5, the processor configured to execute the program to cause the following step to be performed:

the acquisition step of acquiring the signal by analog-to-digital conversion of the acceleration with a bit rate of 8 bits or more.

7. The sleep and arousal determination system according to any one of claims 1 to 6, wherein:

the reference information is a learned model that is allowed to learn correlation between the specific frequency component and the sleep and arousal.

8. The sleep and arousal determination system according claim 7, wherein:

the learned model is a learned model in which correlation between the specific frequency component and the sleep and arousal is learned by acquiring the signal at a sampling frequency of 5 Hz or higher.

9. The sleep and arousal determination system according to claim 8, wherein:

the learned model is a learned model in which correlation between the specific frequency component and the sleep and arousal is learned by acquiring the signal at a sampling frequency of 25 Hz or higher.

10. The sleep and arousal determination system according to any one of claims 1 to 9, the processor configured to execute the program to cause the following step to be performed:

the determination step of

specifying a feature quantity for each epoch defined by a

predetermined time based on the specific frequency component,

determining sleep and arousal of the user based on, among the epoch, the feature quantity of a desired epoch, the feature quantity of a recent epoch past the desired epoch in time series, and the reference information.

11. A sleep and arousal determination method, comprising each step in the sleep and arousal determination system according to any one of claims 1 to 10.

12. A non-transitory computer readable medium storing a program, wherein:

the program allows at least one computer to execute each step in the sleep and arousal determination system according to any one of claims 1 to 10.