(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 463 046 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
13.11.2019 Bulletin 2019/46

(21) Application number: **16729520.3**

(22) Date of filing: **07.06.2016**

(51) Int Cl.:
A61B 5/00 *(2006.01)* ***A61B 5/01*** *(2006.01)*
A61B 5/113 *(2006.01)* ***A61B 5/08*** *(2006.01)*
A61B 5/0205 *(2006.01)*

(86) International application number:
PCT/EP2016/062924

(87) International publication number:
WO 2017/211396 (14.12.2017 Gazette 2017/50)

(54) **SYSTEM AND METHOD FOR MEASURING LIFE PARAMETERS DURING SLEEP**

SYSTEM UND VERFAHREN ZUM MESSEN DER VITALZEICHEN WÄHREND DES SCHLAFES

SYSTÈME ET PROCÉDÉ DE MESURE DES PARAMÈTRES DE VIE PENDANT LE SOMMEIL

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **06.06.2016 PL 41741816**

(43) Date of publication of application:
10.04.2019 Bulletin 2019/15

(73) Proprietor: **Neuro Device Group Spolka Akcyjna
04-501 Warszawa (PL)**

(72) Inventors:
- **SOLUCH, Pawel
02-972 Warszawa (PL)**
- **ORZECHOWSKI, Mateusz
04-450 Warszawa (PL)**
- **ROGALA, Dominika
80-390 Gdansk (PL)**
- **WROTKOWSKI, Krzysztof
20-075 Lublin (PL)**
- **TAMON, Przemyslaw
01-957 Warszawa (PL)**
- **KSIEZOPOLSKI, Michal
05-074 Cisie (PL)**
- **GIERGIELEWICZ, Mariusz
01-307 Warszawa (PL)**

(74) Representative: **Kancelaria Eupatent.pl Sp. z.o.o
Ul. Kilinskiego 185
90-348 Lodz (PL)**

(56) References cited:
**US-A1- 2005 119 586 US-A1- 2013 331 723
US-A1- 2013 345 585**

- **JIN JIAYI ET AL: "A Home Sleep Apnea Screening Device With Time-Domain Signal Processing and Autonomous Scoring Capability", IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS, IEEE, US, vol. 9, no. 1, 1 February 2015 (2015-02-01), pages 96-104, XP011571113, ISSN: 1932-4545, DOI: 10.1109/TBCAS.2014.2314301 [retrieved on 2015-01-23]**

EP 3 463 046 B1

Description

TECHNICAL FIELD

[0001] The present invention relates to a system and method for measuring life parameters during sleep. In particular, the present invention relates to constant monitoring and evaluating of life parameters, as well as reporting detected abnormal events.

BACKGROUND

[0002] In medicine, monitoring is the observation of a disease, condition or one or more medical parameters over time. It can be performed by continuously measuring certain parameters by using a medical monitor (for example, by continuously measuring vital signs by a bedside monitor), and/or by repeatedly performing medical tests (such as blood glucose monitoring with a glucose meter). Transmitting data from a monitor to a distant monitoring station is known as telemetry or biotelemetry (source: Wikipedia).

[0003] For a typical person, there are three key aspects of monitoring life parameters during sleep. They refer to different abnormal conditions typically found in different age groups.

[0004] The first age group are children from 0 to 8 months of age. Apnea usually occurs during sleep and is primarily a disorder of premature infants. Babies born before 34 weeks of gestation do not have a fully developed central nervous system, and they often do not have adequate control of the breathing reflex.

[0005] The second group of interest are children from 6 months to 3 years of age. In this age range the key monitored parameter is body temperature. Children often suffer from rapidly developing infections with very high fever. Thus, it is crucial to monitor their life parameters.

[0006] The last target group are adults suffering from obstructive sleep apnea (OSA). OSA is the most common category of sleep-disordered breathing. The muscle tone of the body ordinarily relaxes during sleep, and at the level of the throat the human airway is composed of collapsible walls of soft tissue which can obstruct breathing during sleep. Mild occasional sleep apnea, such as many people experience during an upper respiratory infection, may not be important, but chronic severe obstructive sleep apnea requires treatment to prevent low blood oxygen (hypoxemia), sleep deprivation, and other complications (source: Wikipedia).

[0007] In case of adults, heart rate may also be measured as an additional life parameter to the aforementioned.

[0008] A US patent US6062216 discloses an apnea monitor and system for treatment includes a detector in a fixed console that projects a detection beam at a sleep surface. The detection beam is reflected off a patient on the surface and return light is analyzed to develop a signal which varies with external motion of the patient's upper body. The motion signals are then fed to a pattern recognizer which identifies breath signals and analyzes them to detect cessation or excessive pauses in breathing, and trigger an alarm or intervention to restore breathing regularity. The monitor includes a laser for generating radiation. The radiation is reflected from the patient and is directed onto a detector. The detector produces output signals corresponding to the impinging reflected light, which are processed by a control element to determine the change of movement, e.g., the breathing rate, of the patient. This method has a disadvantage of monitoring a patient externally. Thus, in case a patient changes positions during sleep or is covered with a thick quilt, the method is not reliable.

[0009] A US patent application US20030055348 discloses a method of determining a diagnostic measure of sleep apnea including the following steps: acquiring an electrocardiogram signal, calculating a set of RR intervals and electrocardiogram-derived respiratory signal from said electrocardiogram, and hence calculating a set of spectral and time-domain measurements over time periods including power spectral density, mean, and standard deviation. These measurements are processed by a classifier model which has been trained on a pre-existing data base of electrocardiogram signals to provide a probability of a specific time period containing apneic episodes or otherwise. These probabilities can be combined to form an overall diagnostic measure. The system also provides a system and apparatus for providing a diagnostic measure of sleep apnea. A disadvantage of this method is a complex equipment that may be inconvenient for a patient during sleep.

[0010] Further systems and methods for measuring life parameters during sleep by a device comprising an accelerometer are known from US 2013/345585 A1, US 2005/119586 A1, and US 2013/331723 A1, as well as from JIN JIAYI ET AL: "A Home Sleep Apnea Screening Device With Time-Domain Signal Processing and Autonomous Scoring Capability" (IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS, IEEE, US, vol. 9, no. 1, 1 February 2015, pages 96-104, ISSN: 1932-4545, DOI: 10.1109/TBCAS.2014.2314301).

[0011] It would be advantageous to provide a compact device with improved sleep apnea and temperature detection as well as evaluation.

SUMMARY

[0012] There is disclosed a method and system for measuring life parameters during sleep according to the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] These and other objects of the invention presented herein, are accomplished by providing a system and method for measuring life parameters during sleep. Further details and features of the present invention, its nature and various advantages will become more apparent from the following detailed description of the preferred embodiments shown in a drawing, in which:

Fig. 1 presents a diagram of the system according to the present invention;
Fig. 2 presents a diagram of the method according to the present invention;
Fig. 3 presents a raw and filtered signal comparison;
Fig. 4 shows a signal waveform of breathing of a several-months-old child;
Fig. 5 presents a signal comprising the strong constant component; and
Fig. 6 presents signal monitoring and hysteresis modification (movement).

NOTATION AND NOMENCLATURE

[0014] Some portions of the detailed description which follows are presented in terms of data processing procedures, steps or other symbolic representations of operations on data bits that can be performed on computer memory. Therefore, a computer executes such logical steps thus requiring physical manipulations of physical quantities.

Usually these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a computer system. For reasons of common usage, these signals are referred to as bits, packets, messages, values, elements, symbols, characters, terms, numbers, or the like.

[0015] Additionally, all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Terms such as "processing" or "creating" or "transferring" or "executing" or "determining" or "detecting" or "obtaining" or "selecting" or "calculating" or "generating" or the like, refer to the action and processes of a computer system that manipulates and transforms data represented as physical (electronic) quantities within the computer's registers and memories into other data similarly represented as physical quantities within the memories or registers or other such information storage.

[0016] A computer-readable (storage) medium, such as referred to herein, typically may be non-transitory and/or comprise a non-transitory device. In this context, a non-transitory storage medium may include a device that may be tangible, meaning that the device has a concrete physical form, although the device may change its physical state. Thus, for example, non-transitory refers to a device remaining tangible despite a change in state.

[0017] As utilized herein, the term "example" means serving as a non-limiting example, instance, or illustration. As utilized herein, the terms "for example" and "e.g." introduce a list of one or more non-limiting examples, instances, or illustrations.

DETAILED DESCRIPTION

[0018] Fig. 1 presents a diagram of the system according to the present invention. The system is a temperature and breathing measuring device. Additionally, pulse may be measured, by detecting micro moves, and body moves may be monitored in order to detect sleep phases.

[0019] The system may be realized using dedicated components or custom made FPGA (Field-Programmable Gate Array) or ASIC (Application Specific Integrated Circuit) circuits. The system comprises a data bus 101 (e.g. 12C or similar) communicatively coupled to a memory 104. Additionally, other components of the system are communicatively coupled to the system bus 101 so that they may be managed by a controller 105.

[0020] The memory 104 may store computer program or programs executed by the controller 106 in order to execute steps of the method according to the present invention. Further, the memory 104 may store any temporary and final data produced by the controller.

[0021] The controller 105 may process the received data or may pass raw data to an external processing unit, preferably via a communication means 103 that may be wired or wireless (e.g. Bluetooth). Alternatively, the controller 105 may process the received data and transmit externally only signals on abnormal conditions, for example to a mobile phone.

[0022] The system may have several versions differing by the number and envisaged placement of temperature sensor(s). The division results from assumed ages of monitored persons as well as from the characteristics of the measured parameters. For example, it is best to measure temperature in an armpit while breathing is best measured at abdomen.

[0023] In a first embodiment, the system may comprise an external temperature sensor 106, preferably for positioning in an armpit.

[0024] In a second embodiment, the system may comprise at least one temperature sensor 102, preferably at the exterior of its casing, wherein a temperature sensor may measure ambient temperature or body temperature.

[0025] The temperature sensor may be TMP112AIDRLT offered by Texas Instruments. It is sufficiently precise, has 12-bit processing and digital communication capabilities.

[0026] Additionally, the present system comprises an accelerometer 107. An accelerometer is a device that measures proper acceleration ("g-force"). Proper acceleration is not the same as coordinate acceleration (rate of change of velocity). For example, an accelerometer at rest on the surface of the Earth will measure an acceleration g=9.81 m/s2 straight upwards. By contrast, accelerometers in free fall (falling toward the center of the Earth at a rate of about 9.81 m/s2) will measure zero.

[0027] Accelerometers have multiple applications in industry and science. Highly sensitive accelerometers are components of inertial navigation systems.

[0028] The controller 105 requests data from the accelerometer 107 and the temperature sensor(s). Then the data is processed and the results are stored. In case of detection of an abnormal condition, the controller 107 may be configured to signal an event that may be indicated by the system e.g. by a sound or a light indication, or be transmitted to an external device.

[0029] Lastly, the present system comprises a filters module 108 required for filtering of the accelerometer data. Details of such filtering have been presented with reference to Fig. 2.

[0030] Fig. 2 presents a diagram of the method according to the present invention. The method starts at step 201 from acquiring samples of data from the accelerometer 107. Samples may be gathered over a period of time in order to obtain a signal variable in time. Fig. 4 shows a signal waveform of breathing of a several-months-old child as sampled.

[0031] Preferably, the controller 105 reads data from the accelerometer 107 with a frequency of at least 50Hz (i.e. it reads data every 20 ms or more frequently) by using the data bus 101. These data denote acceleration values in all three accelerometer axes. Naturally, other sampling frequencies may be applied.

[0032] Analysis of the sampled signal is executed by using a method of detection of a maximum and minimum value with a moving hysteresis (time-based dependence of a system's output on present and past inputs).

[0033] Regarding the aforementioned maximum and minimum values, the present method applies a joint movement, of both the maximum and the minimum level of the hysteresis window (i.e. the maximum hysteresis and the minimum hysteresis parameters appropriately). This means that the width of the hysteresis is constant (i.e. the difference between the maximum hysteresis and the minimum hysteresis parameters is constant) but rather its placement on the Y axis changes.

[0034] The width of the hysteresis is system-specific and selected experimentally depending on e.g. the desired sensitivity of the system.

[0035] Increasing values received by the method, result in, after crossing a maximum hysteresis level, moving the hysteresis towards higher values. The maximum hysteresis value is at this point determined as the signal level while the minimum hysteresis value equals a difference between the signal level and a predefined hysteresis width.

[0036] The hysteresis width may be adapted to measurement conditions and is aimed at reducing interferences of noise. In particular, it is the aim of setting up the hysteresis width so that noise present, which does not exceed the hysteresis width, will not affect breathing detections.

[0037] A change of signal level monotonicity for example from a rising to a different monotonicity, will not immediately result in for example moving the hysteresis downwards on the Y axis. This will happen when the signal level crosses the current minimum hysteresis value. At this moment the minimum hysteresis value will be determined at the signal level while the maximum hysteresis value will be determined at the level equaling a sum of the signal level (filtered and combined data from accelerometer in 3 axes) and a predefined hysteresis width. A movement of the hysteresis towards the rising value followed by a movement towards the falling values will denote a breath.

[0038] Thus, the minimum and the maximum amplitude values are obtained after merging signals from the three accelerometer axes. Further, in case breathing is not detected i.e. accelerometer's signal amplitude is lower than a value of the hysteresis, a timer may be started. When the time without breath reaches a predefined threshold, for example 15 seconds, an abnormal event may be signaled.

[0039] The method detects a rising edge or a falling edge of the signal and appropriately corrects the hysteresis value as defined above.

[0040] A change of a monitored edge is present when the signal crosses hysteresis value appropriately separated (by a predefined threshold) from a previously stored minimum or maximum value.

[0041] For example, for a rising edge, a maximum value is constantly updated as well as the lower level of the hysteresis, which is a difference between the maximum value and the hysteresis width.

[0042] This is effected until the signal reaches a peak value and starts to fall. The lower level of hysteresis value will start to monitor the signal by appropriately decreasing the upper hysteresis value.

[0043] This approach does not report false positive results when significant surging is present e.g. due to movement of a monitored person.

[0044] This method has been selected based on a series of trials and results in nearly 100% correct detections of breathing patterns.

[0045] The next step of the method 202, is a low-pass and high-pass filtering of the signal. The signal comprises a strong constant (DC) component, which is a result of earth's gravity. Since the device should detect small differences in signals this strong constant component should be filtered. Fig. 5 presents a signal comprising the strong constant component.

[0046] After the strong constant component the highest concentration of components is present at discrete frequencies around 0,012, which translates to a real frequency of 0.6 Hz (the sampling frequency has been set at 50 Hz).

[0047] Research shows that breathing frequency of children of the age up to 3 years is within a range of between 0,3 Hz and 1 Hz. Thus frequencies above 1 Hz may be discarded as noise and interferences (e.g. heart motion).

[0048] Thus, the cut off frequencies of the band-pass filter are preferably set at from 0,2 Hz to 1,1 Hz. A band-pass filter may be configured as a difference between two low-pass filters.

[0049] Further, moving average filters have been applied: a first filtered averaging 16 samples and a second filter averaging the square number of samples of the first filter, i.e. 256 samples. Filters averaging more samples can be used as well.

[0050] The filter is a band-pass filter implemented as a difference of two moving averages having a different time window. The first moving average is used as a low-pass filter and is calculated over the latest 16 samples. The second moving average is calculated over 16 latest results of the first moving average (over successive sets of 16 samples), which after a subtraction serves as a high-pass filter. The operation of the filter results in decrease of influence of high frequency interferences and removal of a constant component from the signal as well as low frequencies.

[0051] The filtering is executed for signals from each axis wherein these signals are combined i.e. there is defined a sum of absolute values. From this moment onwards, these are the values used to calculate a hysteresis.

[0052] Fig. 3 presents a raw and filtered signal comparison. As may be seen, after filtration, spectral lines 0,2 Hz and 0,6 Hz are more clear, while the strong constant component has been removed.

[0053] After filtering in step 202 the signals of 3 axes are combined (a sum of absolute values) in step 203. Subsequently, at step 204 breathing is detected by finding local peaks in a signal waveform (minimums and maximums) with an application of an appropriate hysteresis, which allows for further filtering of interferences.

[0054] In case the method does not detect any acceleration condition, caused by chest movements, within e.g. 15 seconds, it signals an alarm event in step 205. Otherwise, if movements detected are too frequent (e.g. above 6 Hz), there may be signaled an alarm event on hyperactivity 206.

[0055] Fig. 6 presents signal monitoring and hysteresis modification (movement). At step 601 the method reads signal level i.e. filtered and combined data from accelerometer in 3 axes as previously described with respect to the two moving averages having a different time window. The Slope parameter value is initialized to 0 and a predefined hysteresis width (HYSTERESIS) is set up using the minimum and maximum hysteresis values.

[0056] Subsequently, at step 602, it is checked whether signal level is higher than the current maximum hysteresis value. In case it is (denoting a rising edge of the signal), the method proceeds to step 603 where the maximum hysteresis value is set to the signal level.

[0057] Subsequently, at step 604, the minimum hysteresis value is set to the maximum hysteresis value decreased by the predefined hysteresis width. Next, at step 605, it is checked whether a falling edge of the signal level has previously occurred (0 denotes that the signal level has been falling while a 1 denotes that signal level has been rising) and if it has, a flag (Slope) signaling the signal level edge is set to 1 in step 606 and breath detection is signaled in step 607. In other words, a breath detection is signaled when a transition from a falling edge to a rising edge is detected on the signal level.

[0058] Otherwise, when at step 602 signal level is higher than the current maximum hysteresis value, the method proceeds to step 608 where it is checked whether signal level is lower than the current maximum hysteresis value. In case it is (denoting a falling edge of the signal), the method proceeds to step 609 where the minimum hysteresis value is set to the signal level. Subsequently, at step 610, the maximum hysteresis value is set to the minimum hysteresis value increased by the predefined hysteresis width.

[0059] Next, at step 611, it is checked whether a rising edge of the signal level has previously occurred (1 denotes that the signal level has been rising while a 0 denotes that signal level has been falling) and if it has, a flag (Slope) signaling the signal level edge is set to 0 in step 612. In other words, a transition from a rising edge to a falling edge is detected on the signal level.

[0060] The aforementioned approach has an advantage that even if it there is noise present, which does not exceed the hysteresis width, the detection will not be impaired and the hysteresis will move accordingly until a rising edge is detected.

[0061] The aforementioned invention results in detection of sleep apnea condition and thus serves as a human being life parameters monitoring tool that may detect serious conditions. Therefore, the invention provides a useful, concrete and tangible result.

[0062] According to the present invention, data from an accelerometer are sampled, by a specially configured processing system, and processed in order to detect proper or abnormal breathing condition. Therefore, the machine or transformation test is fulfilled and that the idea is not abstract.

[0063] At least parts of the methods according to the invention may be computer implemented. Accordingly, the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit", "module" or "system".

[0064] Furthermore, the present invention may take the form of a computer program product embodied in any tangible medium of expression having computer usable program code embodied in the medium.

[0065] It can be easily recognized, by one skilled in the art, that the aforementioned method for measuring life parameters during sleep may be performed and/or controlled by one or more computer programs. Such computer programs are typically executed by utilizing the computing resources in a computing device. Applications are stored on a non-transitory medium. An example of a non-transitory medium is a non-volatile memory, for example a flash memory while an example of a volatile memory is RAM. The computer instructions are executed by a processor. These memories are exemplary recording media for storing computer programs comprising computer-executable instructions performing all the steps of the computer-implemented method according the technical concept presented herein.

[0066] While the invention presented herein has been depicted, described, and has been defined with reference to particular preferred embodiments, such references and examples of implementation in the foregoing specification do not imply any limitation on the invention. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader scope of the technical concept. The presented preferred embodiments are exemplary only, and are not exhaustive of the scope of the technical concept presented herein.

[0067] Accordingly, the scope of protection is not limited to the preferred embodiments described in the specification, but is only limited by the claims that follow.

Claims

1. A method for measuring life parameters during sleep by a device comprising an accelerometer attached to the body of a sleeping subject, the method comprising the steps of:

a) setting a hysteresis width having a maximum hysteresis value and a minimum hysteresis value;
b) reading (201), from the accelerometer (107), values of acceleration in three axes;
c) filtering (202) the values of acceleration in each of the three axes with a band-pass filter to obtain filtered acceleration signals;
d) combining (203) the filtered acceleration signals from each of the three axes to obtain a signal level;
e) checking (602) whether the signal level is higher than the current maximum hysteresis value and if so, setting (603) the maximum hysteresis value to the signal level and setting (604) the minimum hysteresis value to the maximum hysteresis value decreased by the hysteresis width; and
f) signaling (607) a breath detection when a transition from a falling edge to a rising edge is detected on the signal level (605, 606).

2. The method according to claim 1, comprising reading the values of acceleration in the three axes with a frequency of at least 50Hz.

3. The method according to any of previous claims, wherein when the signal level is lower than or equal the current maximum hysteresis value:

- checking (606) whether the signal level is lower than the current maximum hysteresis value and if so, setting (607) the minimum hysteresis value to the signal level and setting (608) the maximum hysteresis value to the minimum hysteresis value increased by the hysteresis width; and
- detecting (611) a transition from a rising edge to a falling edge on the signal level and setting a flag (612) indicating such detection.

4. The method according to any of previous claims, wherein the pass band of the band-pass filter is from 0,2 Hz to 1,1 Hz.

5. The method according to any of previous claims, wherein the filtering is effected by applying moving average filters.

6. The method according to claim 5, wherein the first moving average filter uses at least 16 samples while the second moving average filter uses at least 16 latest results of the first filter over the successive sets of at least 16 samples.

7. The method according to any of previous claims, wherein combining the filtered acceleration signals from each of the three axes comprises calculating a sum of absolute values of the filtered acceleration signals in each of the three axes.

8. The method according to any of previous claims, further comprising returning to step (b) after step (f) to repeat the method steps for at least one subsequent data sample.

9. A computer program comprising program code means for performing all the steps of the computer-implemented method according to any of claims 1-8 when said program is run on a computer coupled with an accelerometer.

10. A computer readable medium storing computer-executable instructions performing all the steps of the computer-implemented method according to any of claims 1-8 when executed on a computer coupled with an accelerometer.

11. A system for measuring life parameters during sleep, the system comprising:

- a data bus (101) communicatively coupled to a memory (104);
- an accelerometer (107) coupled to the data bus; and
a controller (105) configured to execute all the steps of the method according to any of claims 1-8.

Patentansprüche

1. Verfahren zum Messen der Vitalzeichen während des Schlafes durch eine Vorrichtung, umfassend einen am Körper eines schlafenden Subjekts angebrachten Beschleunigungsmesser, wobei das Verfahren die Schritte umfasst:

a) Einstellen einer Hysteresebreite mit einem maximalen Hysteresewert und einem minimalen Hysteresewert;
b) Ablesen (201), vom Beschleunigungsmesser (107) von Beschleunigungswerten in drei Achsen;
c) Filtern (202) der Beschleunigungswerte in jeder der drei Achsen mit einem Bandpassfilter, um gefilterte Beschleunigungssignale zu erhalten;
d) Kombinieren (203) der gefilterten Beschleunigungssignale von jeder der drei Achsen, um einen Signalpegel zu erhalten;
e) Kontrollieren (602), ob der Signalpegel höher als der aktuelle maximale Hysteresewert ist und falls ja, Einstellen (603) des maximalen Hysteresewerts auf den Signalpegel und Einstellen (604) des minimalen Hysteresewerts auf den maximalen Hysteresewert abzüglich der Hysteresebreite; und
f) Signalisieren (607) einer Atemdetektion, wenn ein Übergang von einer abfallenden Flanke zu einer ansteigenden Flanke auf dem Signalpegel (605, 606) detektiert wird.

2. Verfahren nach Anspruch 1, umfassend Ablesen der Beschleunigungswerte in den drei Achsen mit einer Frequenz von mindestens 50 Hz.

3. Verfahren nach einem der vorstehenden Ansprüche, wobei, wenn der Signalpegel kleiner oder gleich dem aktuellen maximalen Hysteresewert ist:

- Kontrollieren (606), ob der Signalpegel kleiner als der aktuelle maximale Hysteresewert ist und falls ja, Einstellen (607) des minimalen Hysteresewerts auf den Signalpegel und Einstellen (608) des maximalen Hysteresewerts auf den minimalen Hysteresewert zuzüglich der Hysteresebreite; und
- Detektieren (611) eines Übergangs von einer ansteigenden Flanke zu einer absteigenden Flanke auf dem Signalpegel und Einstellen einer Markierung (612), die eine solche Detektion anzeigt.

4. Verfahren nach einem der vorstehenden Ansprüche, wobei das Durchlassband des Bandpassfilters von 0,2 Hz bis 1,1 Hz reicht.

5. Verfahren nach einem der vorstehenden Ansprüche, wobei das Filtern durch Anwenden beweglicher Durchschnittsfilter bewirkt wird.

6. Verfahren nach Anspruch 5, wobei der erste bewegliche Durchschnittsfilter mindestens 16 Abtastungen verwendet, während der zweite bewegliche Durchschnittsfilter mindestens 16 aktuellste Ergebnisse des ersten Filters über die aufeinanderfolgenden Sätze von mindestens 16 Abtastungen verwendet.

7. Verfahren nach einem der vorstehenden Ansprüche, wobei das Kombinieren der gefilterten Beschleunigungssignale von jeder der drei Achsen das Berechnen einer Summe absoluter Werte der gefilterten Beschleunigungssignale in jeder der drei Achsen umfasst.

8. Verfahren nach einem der vorstehenden Ansprüche, ferner umfassend Zurückkehren zu Schritt (b) nach Schritt (f), um die Verfahrensschritte für mindestens eine nachfolgende Datenabtastung zu wiederholen.

9. Computerprogramm, umfassend Programmcodemittel zum Ausführen aller Schritte des computerimplementierten Verfahrens nach einem der Ansprüche 1 bis 8, wenn das Programm auf einem mit einem Beschleunigungsmesser gekoppelten Computer läuft.

10. Computerlesbares Medium, das computerausführbare Anweisungen speichert, die alle Schritte des computerimplementierten Verfahrens nach einem der Ansprüche 1 bis 8 ausführen, wenn sie auf einem mit einem Beschleunigungsmesser gekoppelten Computer ausgeführt werden.

11. System zum Messen der Vitalzeichen während des Schlafs, wobei das System umfasst:

- ein Datenbus (101), der kommunikativ mit einem Speicher (104) gekoppelt ist;
- einen Beschleunigungsmesser (107), der mit dem Datenbus gekoppelt ist;
und eine Steuerung (105), die konfiguriert ist, um alle Schritte des Verfahrens nach einem der Ansprüche 1 bis 8 auszuführen.

Revendications

1. Procédé de mesure de paramètres vitaux pendant le sommeil par un dispositif comprenant un accéléromètre attaché au corps d'un sujet en sommeil, le procédé comprenant les étapes de :

a) définition d'une largeur d'hystérésis ayant une valeur d'hystérésis maximum et une valeur

d'hystérésis minimum ;
b) lecture (201), depuis l'accéléromètre (107), de valeurs d'accélération sur trois axes ;
c) filtration (202) des valeurs d'accélération sur chacun des trois axes avec un filtre passe-bande pour obtenir des signaux d'accélération filtrés ;
d) combinaison (203) des signaux d'accélération filtrés depuis chacun des trois axes pour obtenir un niveau de signal ;
e) vérification (602) si le niveau de signal est supérieur à la valeur d'hystérésis maximum actuelle et, si c'est le cas, définition (603) de la valeur d'hystérésis maximum sur le niveau de signal et définition (604) de la valeur d'hystérésis minimum sur la valeur d'hystérésis maximum diminuée par la largeur d'hystérésis ; et
f) signalisation (607) d'une détection de respiration quand une transition depuis un front de descente vers un front de montée est détectée sur le niveau de signal (605, 606).

2. Procédé selon la revendication 1, comprenant la lecture des valeurs d'accélération sur les trois axes avec une fréquence d'au moins 50 Hz.

3. Procédé selon l'une quelconque des revendications précédentes, dans lequel quand le niveau de signal est inférieur ou égal à la valeur d'hystérésis maximum actuelle :

- vérification (606) si le niveau de signal est inférieur à la valeur d'hystérésis maximum actuelle et, si c'est le cas, définition (607) de la valeur d'hystérésis minimum sur le niveau de signal et définition (608) de la valeur d'hystérésis maximum sur la valeur d'hystérésis minimum augmentée par la largeur d'hystérésis ; et
- détection (611) d'une transition depuis un front de montée vers un front de descente sur le niveau de signal et définition d'un drapeau (612) indiquant une telle détection.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel la bande passante du filtre passe-bande est de 0,2 Hz à 1,1 Hz.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la filtration est effectuée en appliquant des filtres à moyenne mobile.

6. Procédé selon la revendication 5, dans lequel le premier filtre à moyenne mobile utilise au moins 16 échantillons tandis que le deuxième filtre à moyenne mobile utilise au moins 16 résultats les plus récents du premier filtre sur les ensembles successifs d'au moins 16 échantillons.

7. Procédé selon l'une quelconque des revendications précédentes, dans lequel la combinaison des signaux d'accélération filtrés depuis chacun des trois axes comprend le calcul d'une somme de valeurs absolues des signaux d'accélération filtrés sur chacun des trois axes.

8. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre le retour à l'étape (b) après l'étape (f) pour répéter les étapes de procédés pour au moins un échantillon de données ultérieur.

9. Programme informatique comprenant un moyen de codage de programme pour exécuter toutes les étapes du procédé mis en œuvre sur un ordinateur selon l'une quelconque des revendications 1 à 8 quand ledit programme est exécuté sur un ordinateur couplé à un accéléromètre.

10. Support lisible par un ordinateur stockant des instructions exécutables par un ordinateur exécutant toutes les étapes du procédé mis en œuvre sur un ordinateur selon l'une quelconque des revendications 1 à 8 quand il est exécuté sur un ordinateur couplé à un accéléromètre.

11. Système de mesure de paramètres vitaux pendant le sommeil, le système comprenant :

- un bus de données (101) couplé de manière communicante à une mémoire (104) ;
- un accéléromètre (107) couplé au bus de données ;
et une unité de commande (105) configurée pour exécuter toutes les étapes du procédé selon l'une quelconque des revendications 1 à 8.

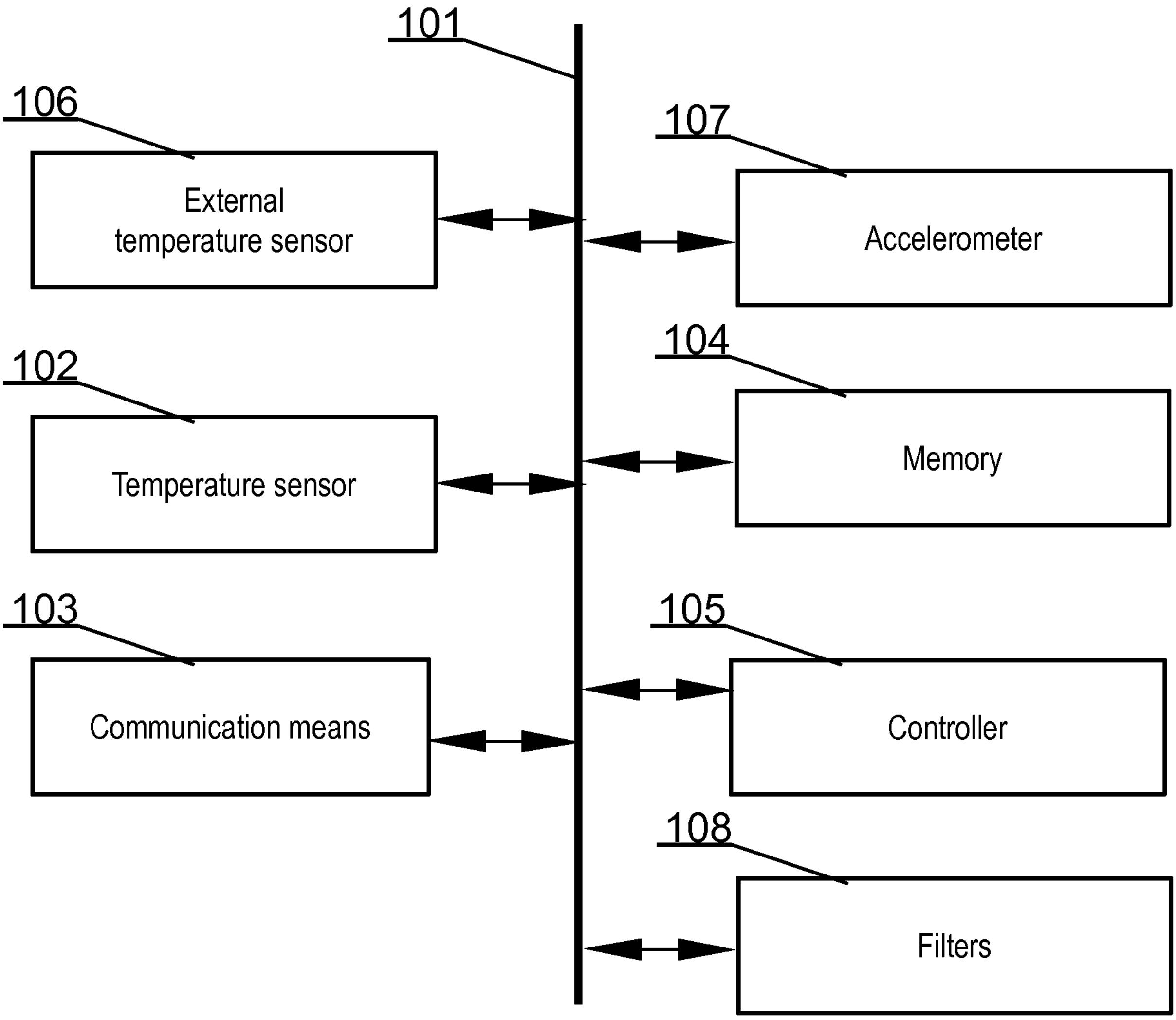

101
106
External
temperature sensor
107
Accelerometer
102
Temperature sensor
104
Memory
103
Communication means
105
Controller
108
Filters

Fig. 1

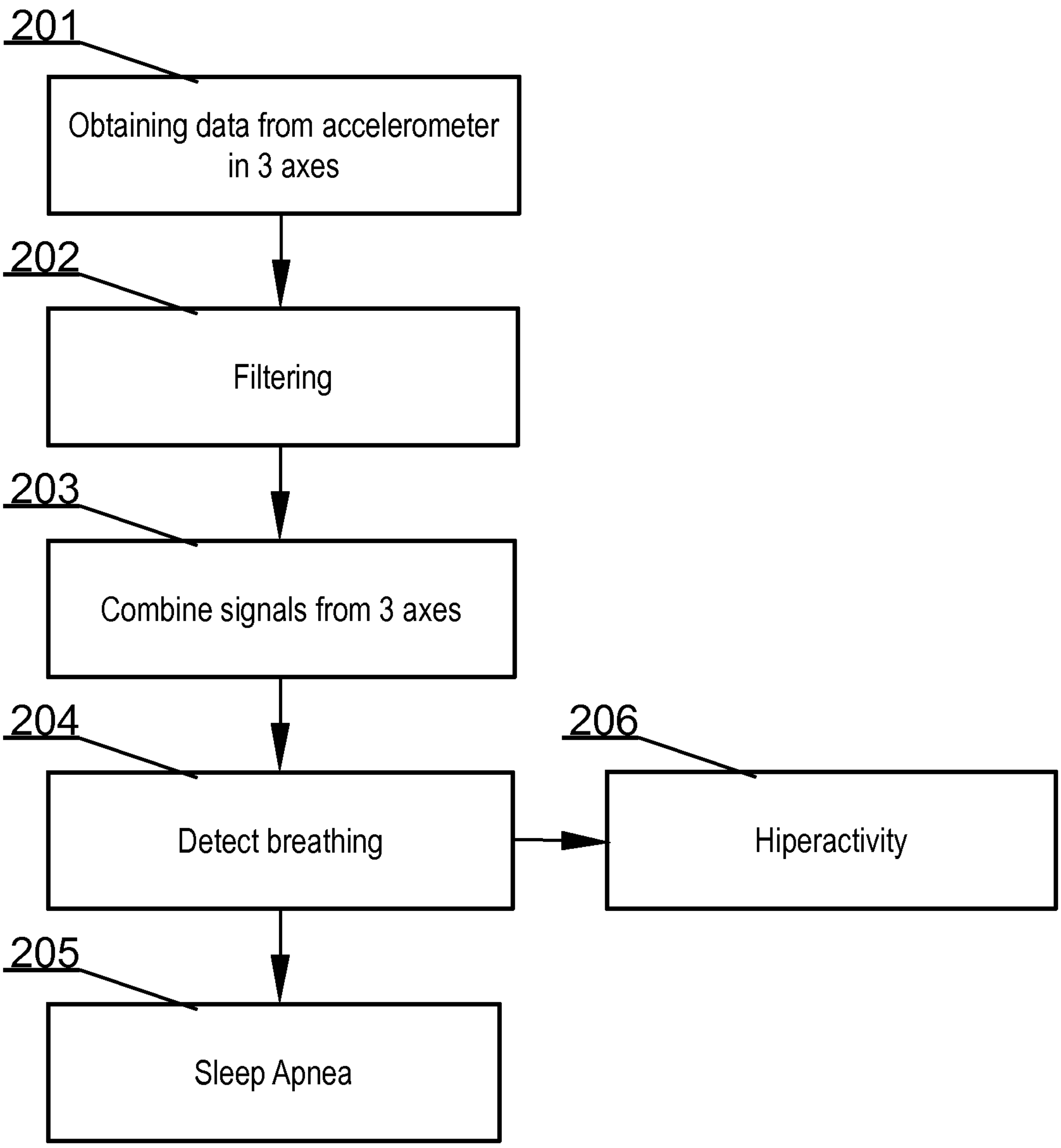

201
Obtaining data from accelerometer in 3 axes
202
Filtering
203
Combine signals from 3 axes
204
Detect breathing
206
Hiperactivity
205
Sleep Apnea

Fig. 2

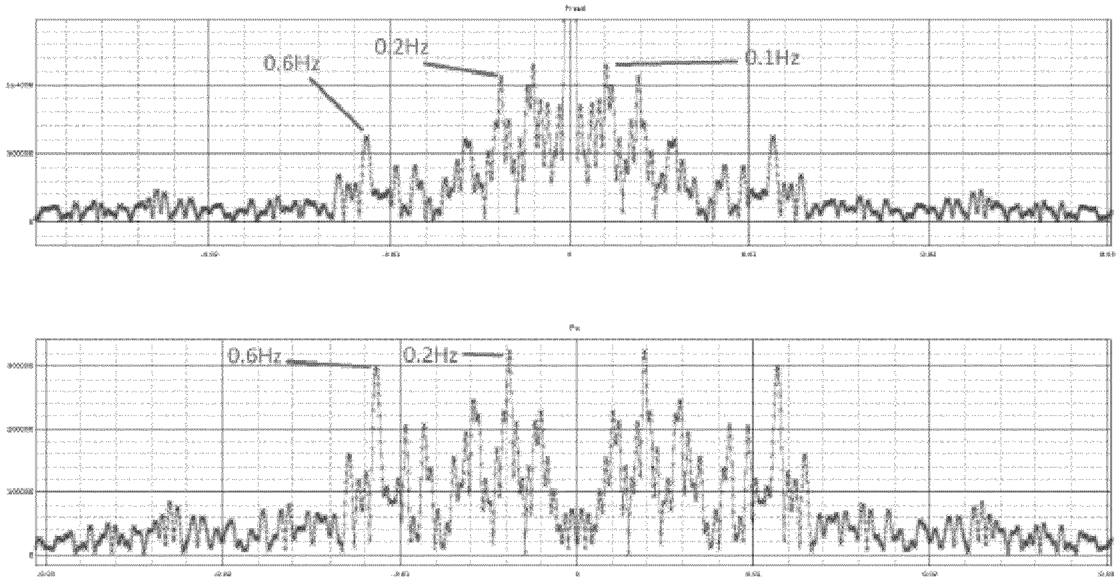


Fig. 3

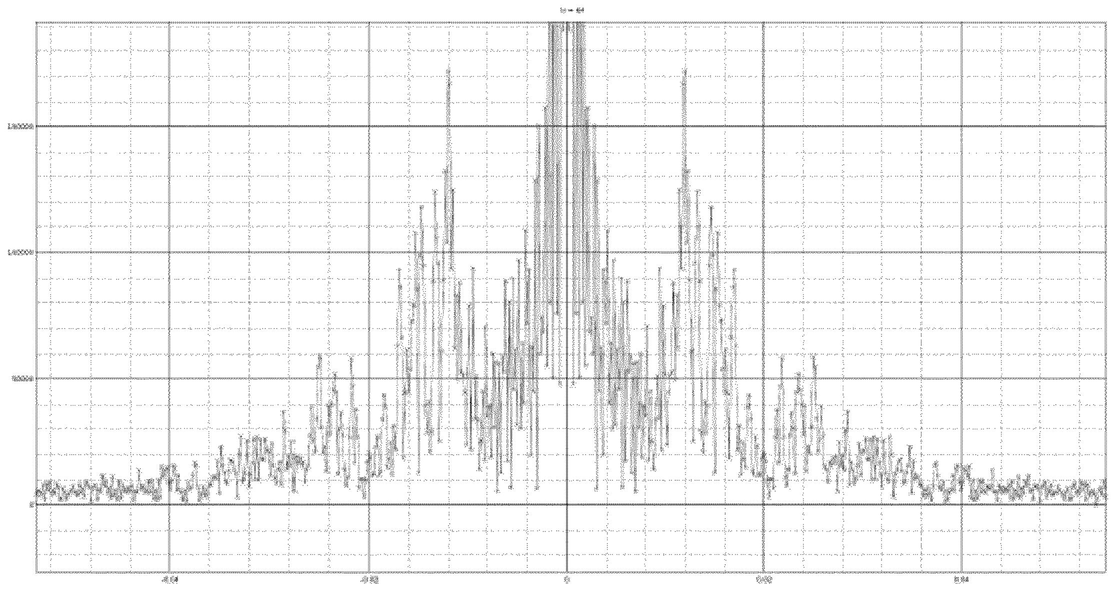


Fig. 4

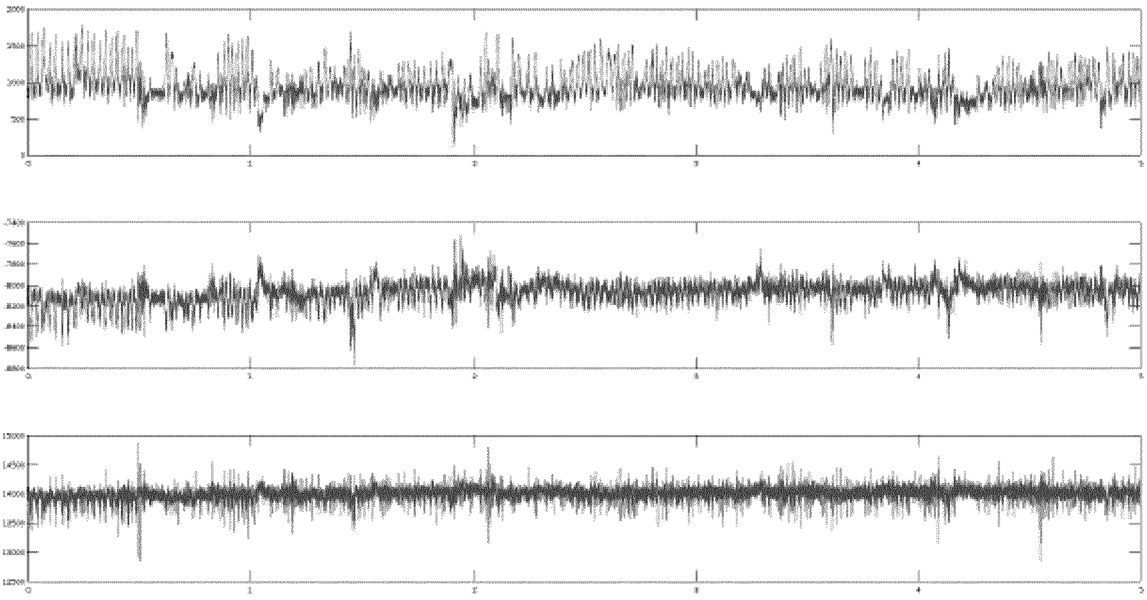
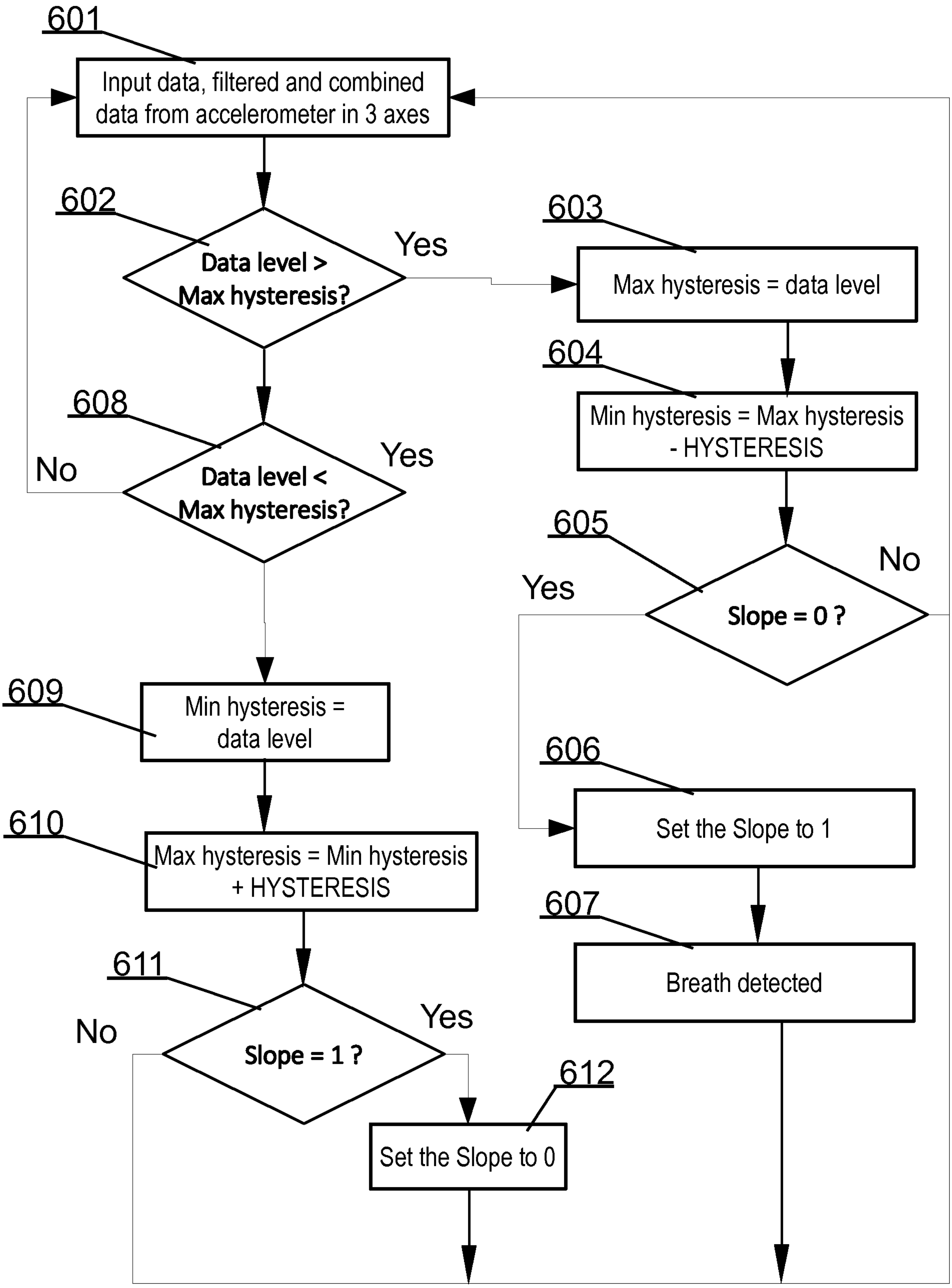


Fig. 5



601
Input data, filtered and combined data from accelerometer in 3 axes
602
Data level > Max hysteresis?
Yes
603
Max hysteresis = data level
604
Min hysteresis = Max hysteresis - HYSTERESIS
605
Slope = 0 ?
Yes
No
606
Set the Slope to 1
607
Breath detected
608
Data level < Max hysteresis?
Yes
No
609
Min hysteresis = data level
610
Max hysteresis = Min hysteresis + HYSTERESIS
611
Slope = 1 ?
Yes
No
612
Set the Slope to 0

Fig. 6

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6062216 A **[0008]**
- US 20030055348 A **[0009]**
- US 2013345585 A1 **[0010]**
- US 2005119586 A1 **[0010]**
- US 2013331723 A1 **[0010]**

Non-patent literature cited in the description

- A Home Sleep Apnea Screening Device With Time-Domain Signal Processing and Autonomous Scoring Capability. **JIN JIAYI et al.** IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS. IEEE, 01 February 2015, vol. 9, 96-104 **[0010]**

专利名称(译)	睡眠期间检测生命体征的方法和方法		
公开(公告)号	EP3463046B1	公开(公告)日	2019-11-13
申请号	EP2016729520	申请日	2016-06-07
[标]发明人	SOLUCH PAWEL ORZECHOWSKI MATEUSZ ROGALA DOMINIKA WROTKOWSKI KRZYSZTOF TAMON PRZEMYSLAW KSIEZOPOLSKI MICHAL GIERGIELEWICZ MARIUSZ		
发明人	SOLUCH, PAWEL ORZECHOWSKI, MATEUSZ ROGALA, DOMINIKA WROTKOWSKI, KRZYSZTOF TAMON, PRZEMYSLAW KSIEZOPOLSKI, MICHAL GIERGIELEWICZ, MARIUSZ		
IPC分类号	A61B5/00 A61B5/01 A61B5/113 A61B5/08 A61B5/0205		
CPC分类号	A61B5/01 A61B5/02055 A61B5/0816 A61B5/0826 A61B5/113 A61B5/4818 A61B5/7207 A61B5/746 A61B2562/0219		
优先权	2016417418 2016-06-06 PL		
其他公开文献	EP3463046A1		
外部链接	Espacenet		

摘要(译)

一种用于通过包括连接至睡眠对象的身体的加速度计的设备来测量睡眠期间的生活参数的方法。该方法包括：（a）设置具有最大磁滞值和最小磁滞值的磁滞宽度；（b）从加速度计读取三个轴上的加速度值；（c）用带通滤波器对三个轴的每一个的加速度值进行滤波，以获得滤波后的加速度信号；（d）组合滤波后的加速度信号以获得信号电平；（e）检查信号电平是否高于当前最大磁滞值，如果是，则将最大磁滞值设置为信号电平，并将最小磁滞值设置为最大磁滞值，该最大磁滞值减小了磁滞宽度；（f）当检测到从下降沿到上升沿的转变时发出呼吸检测信号。

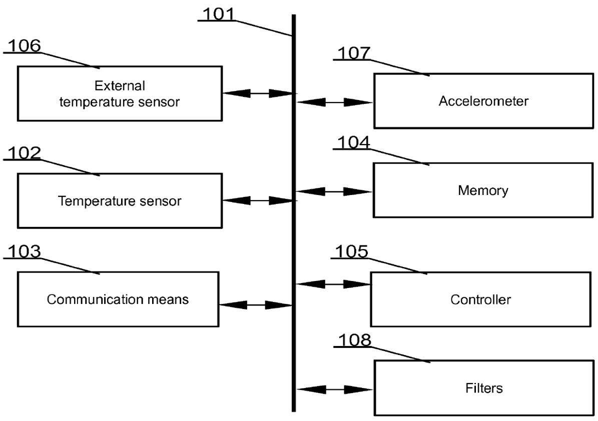


Fig. 1