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(54) **SLEEP APNEA DETECTION SYSTEM AND METHOD**

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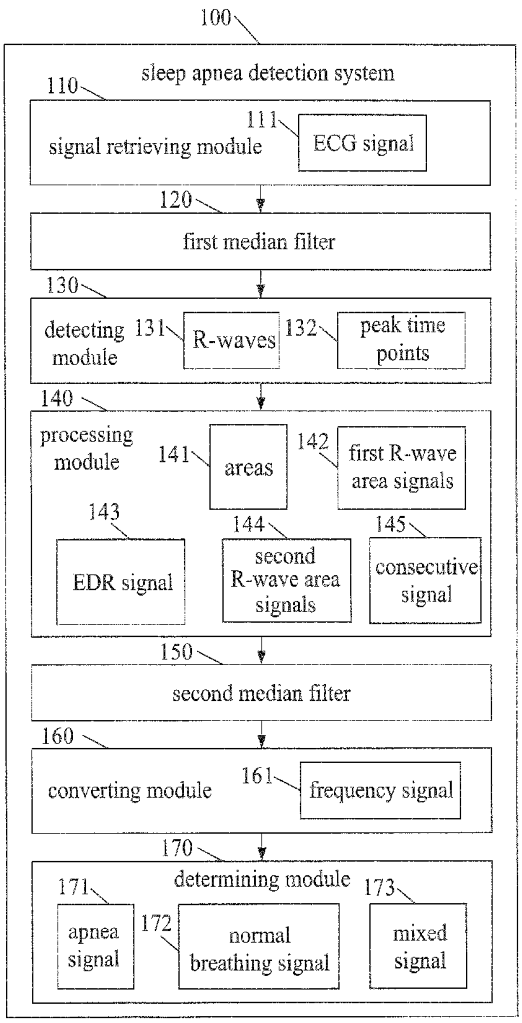
(57) **ABSTRACT**

The invention provides a sleep apnea detection system and method. The system includes a detecting module, a processing module, a converting module and a determining module. The detecting module detects a plurality of peak time points of R-waves in an ECG (electrocardiograph) signal. The processing module calculates areas of the R-waves at a predetermined time range based on the peak time points, so as to produce a plurality of first R-wave area signals based on the areas and generate an EDR (ECG Derived Respiration) signal based on the peak time points and the first R-wave area signals. The converting module converts the EDR signal to a frequency signal. The determining module determines whether a maximum peak frequency of the frequency signal is at a first frequency segment or a second frequency segment to determine the frequency signal being an apnea signal or a normal breathing signal.



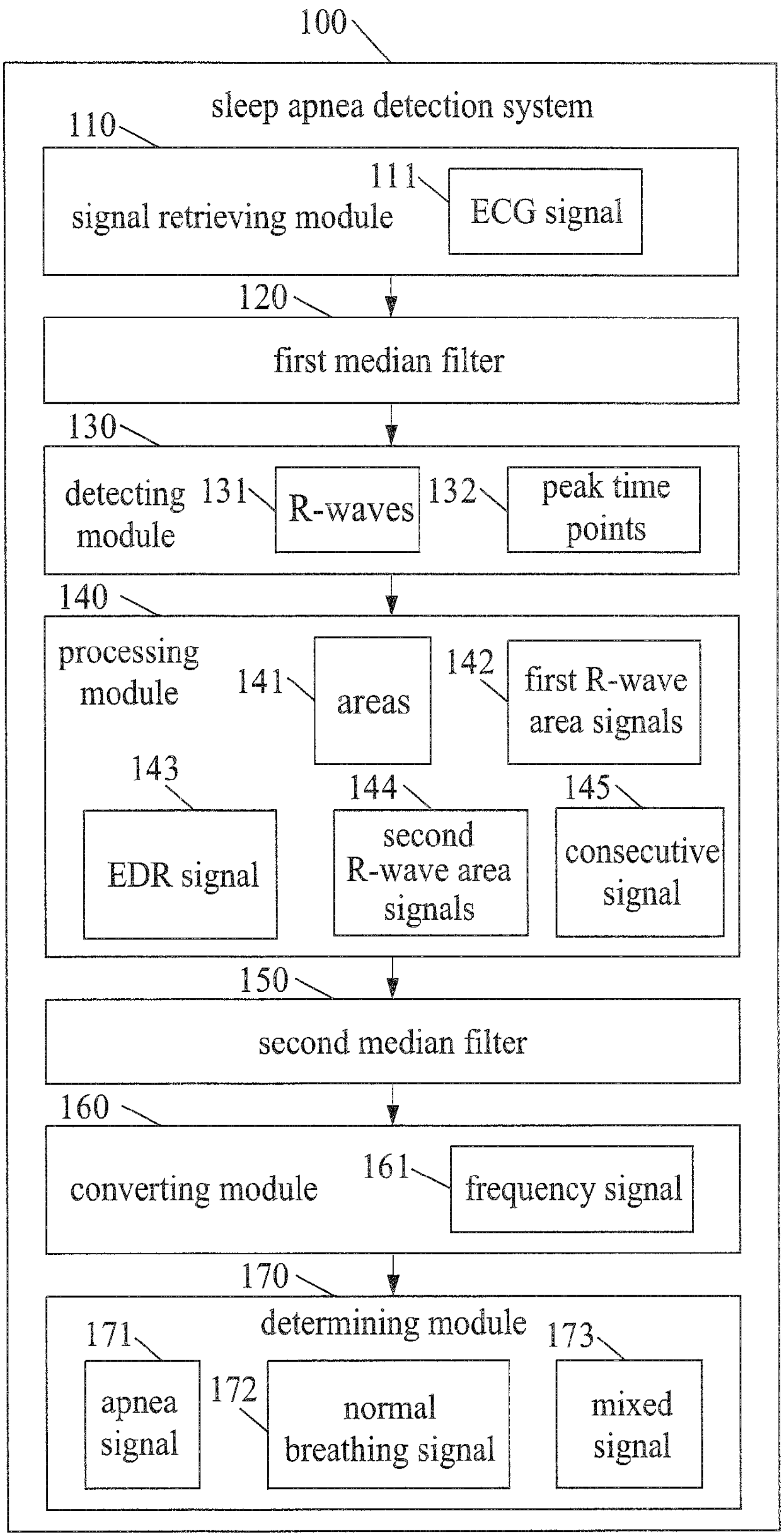

100
sleep apnea detection system
110
signal retrieving module
111
ECG signal
120
first median filter
130
detecting module
131
R-waves
132
peak time points
140
processing module
141
areas
142
first R-wave area signals
143
EDR signal
144
second R-wave area signals
145
consecutive signal
150
second median filter
160
converting module
161
frequency signal
170
determining module
171
apnea signal
172
normal breathing signal
173
mixed signal

FIG. 1

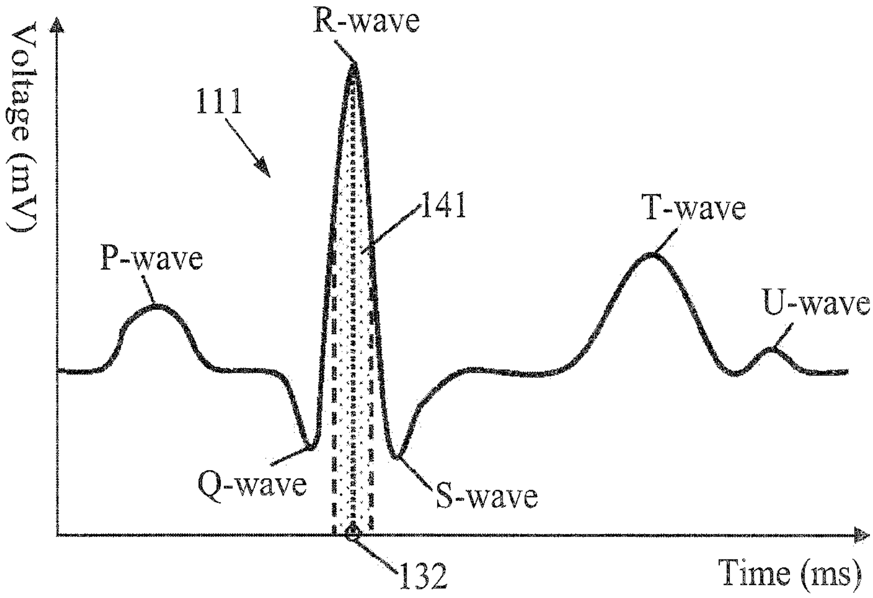

Voltage (mV)
R-wave
111
141
P-wave
T-wave
U-wave
Q-wave
S-wave
132
Time (ms)

FIG. 2

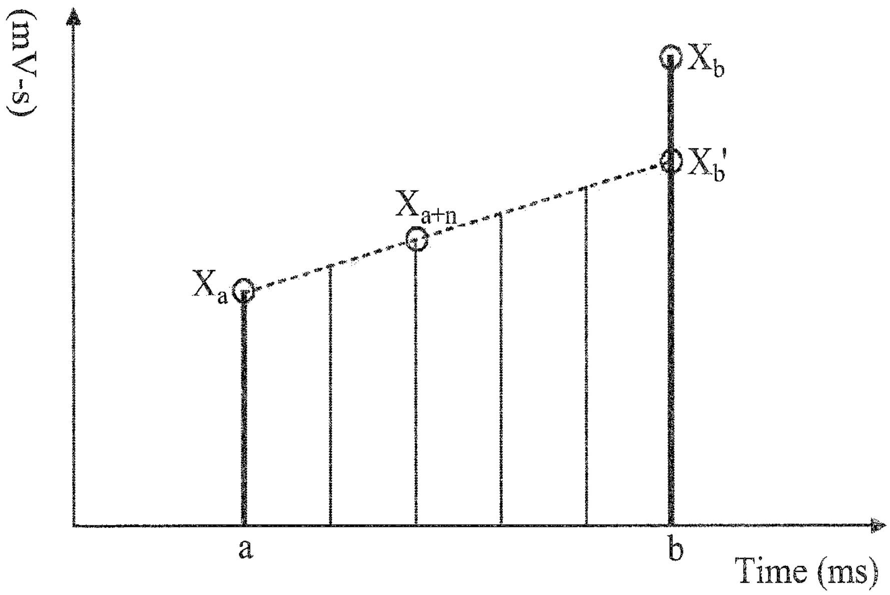

(mV-s)
X_b
X_b'
X_{a+n}
X_a
a
b
Time (ms)

FIG. 3

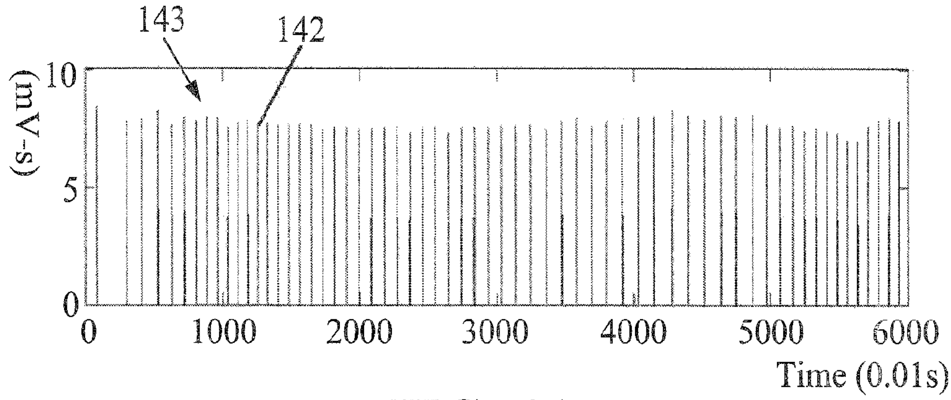


FIG. 4A

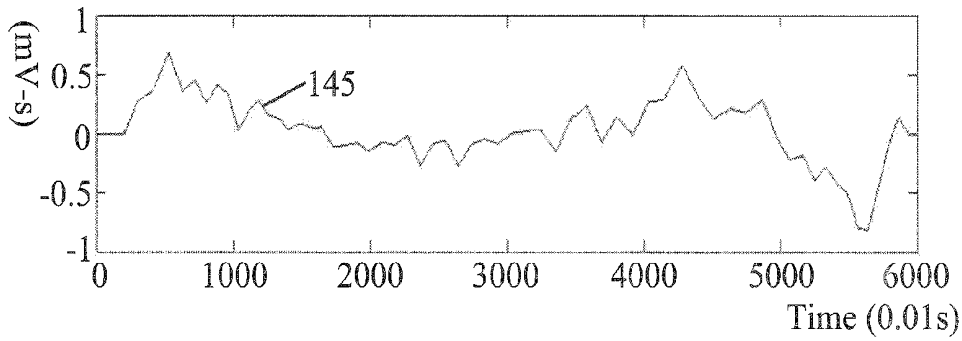


FIG. 4B

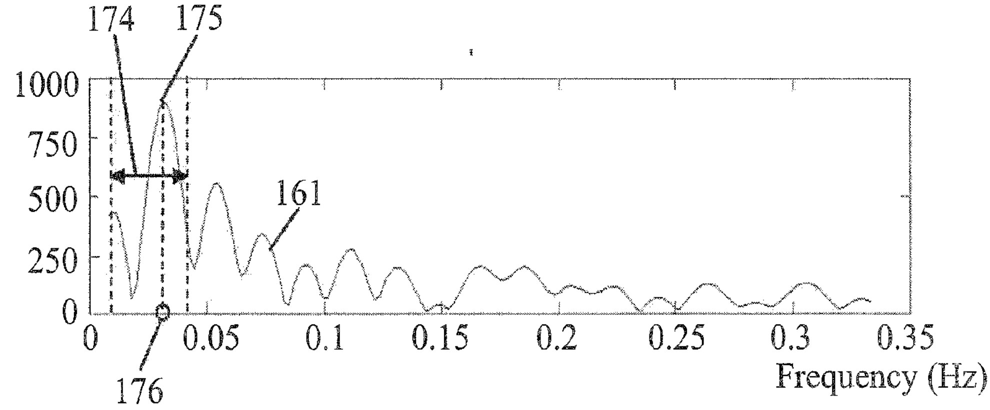


FIG. 4C

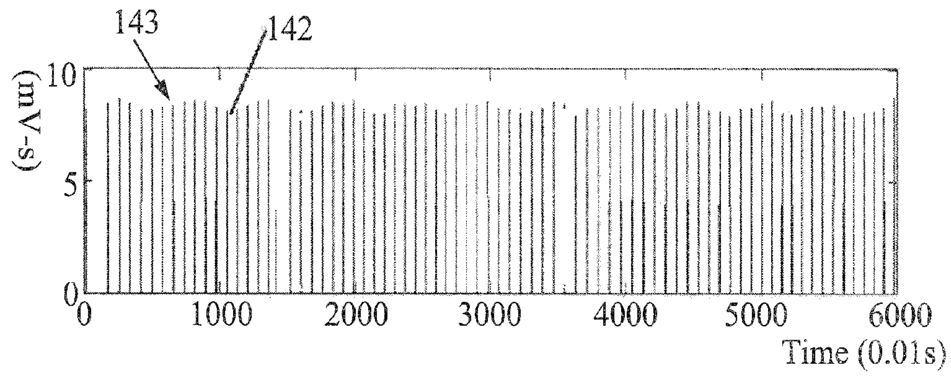


FIG. 5A

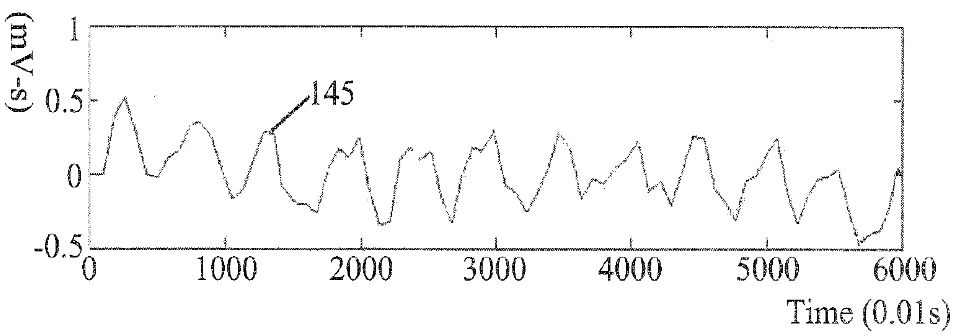


FIG. 5B

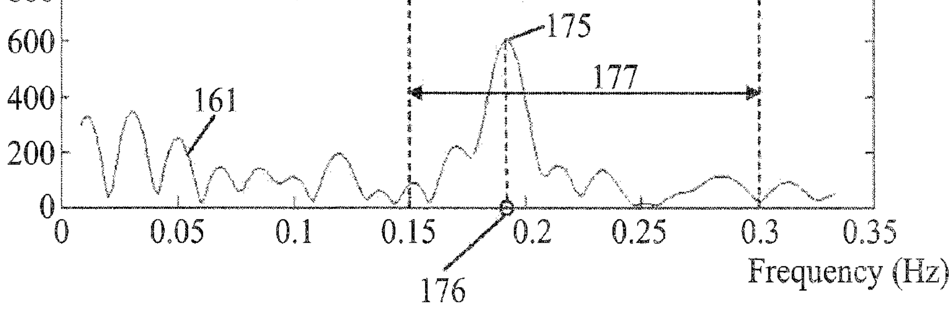


FIG. 5C

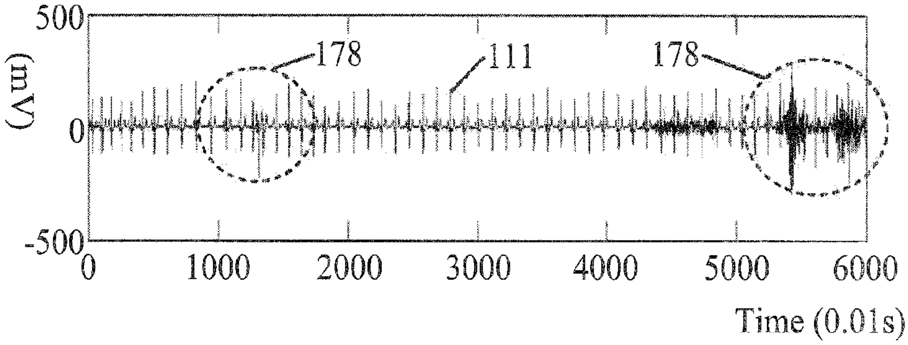


FIG. 6A

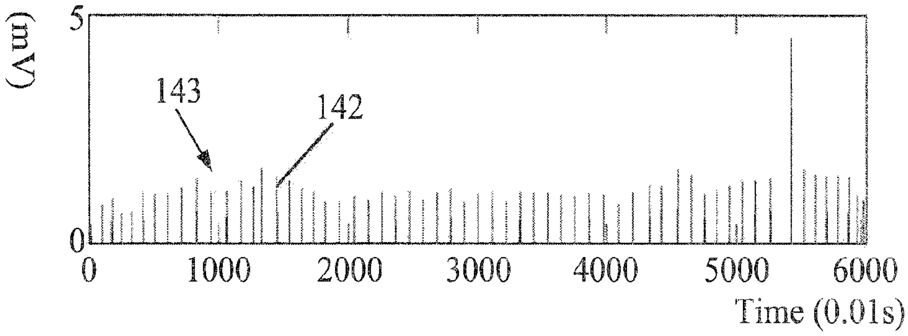


FIG. 6B

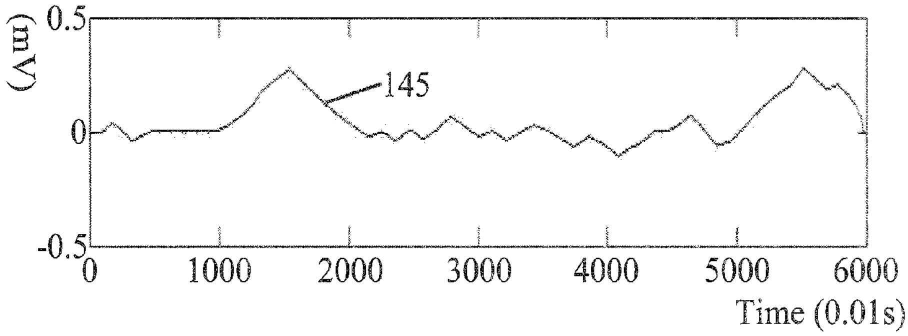


FIG. 6C

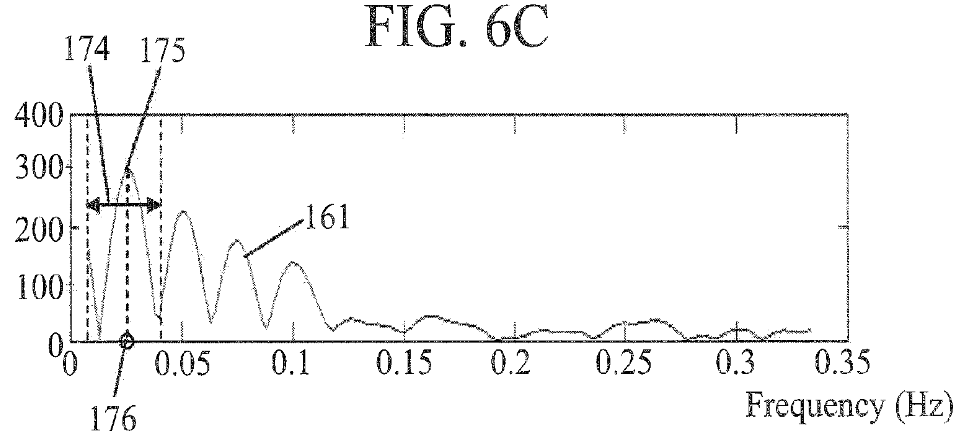


FIG. 6D

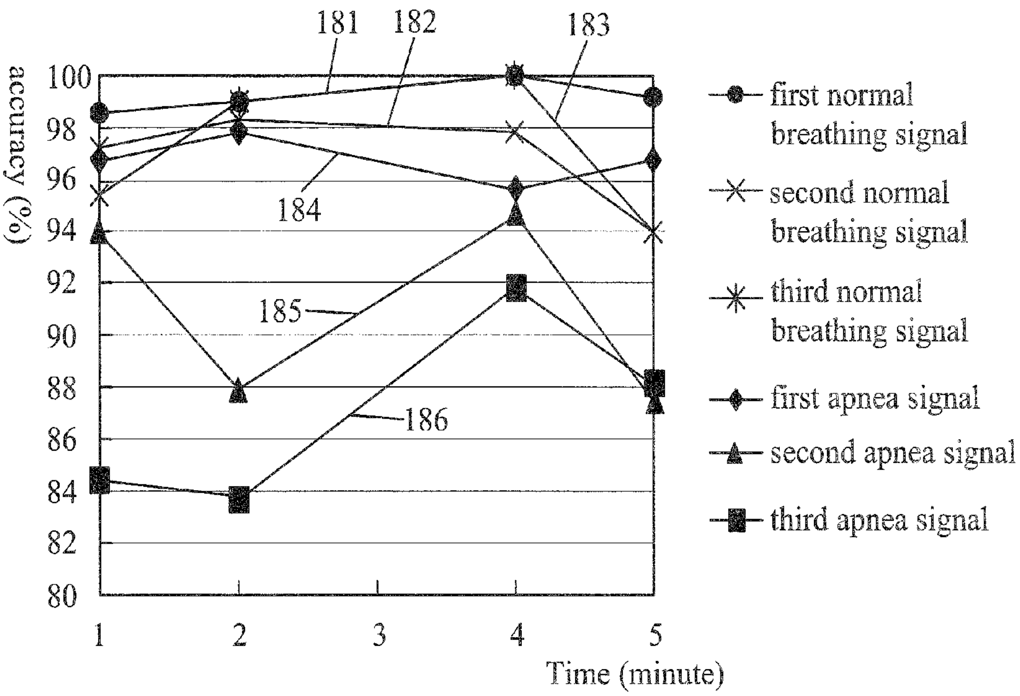

181
182
183
184
185
186
accuracy (%)
100
98
96
94
92
90
88
86
84
82
80
1
2
3
4
5
Time (minute)
first normal breathing signal
second normal breathing signal
third normal breathing signal
first apnea signal
second apnea signal
third apnea signal

FIG. 7

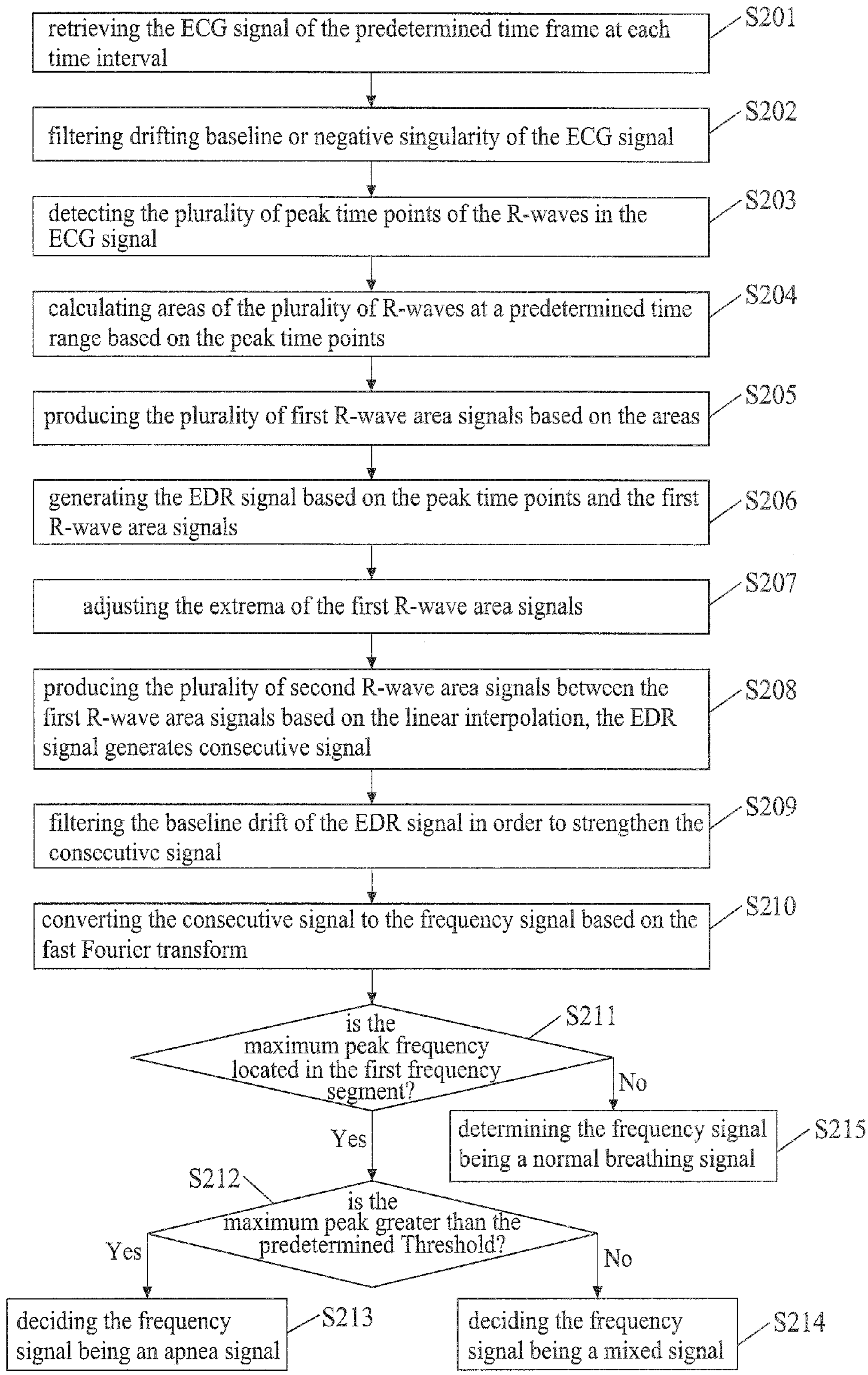

retrieving the ECG signal of the predetermined time frame at each time interval
S201
filtering drifting baseline or negative singularity of the ECG signal
S202
detecting the plurality of peak time points of the R-waves in the ECG signal
S203
calculating areas of the plurality of R-waves at a predetermined time range based on the peak time points
S204
producing the plurality of first R-wave area signals based on the areas
S205
generating the EDR signal based on the peak time points and the first R-wave area signals
S206
adjusting the extrema of the first R-wave area signals
S207
producing the plurality of second R-wave area signals between the first R-wave area signals based on the linear interpolation, the EDR signal generates consecutive signal
S208
filtering the baseline drift of the EDR signal in order to strengthen the consecutive signal
S209
converting the consecutive signal to the frequency signal based on the fast Fourier transform
S210
is the maximum peak frequency located in the first frequency segment?
S211
No
determining the frequency signal being a normal breathing signal
S215
Yes
S212
is the maximum peak greater than the predetermined Threshold?
Yes
No
deciding the frequency signal being an apnea signal
S213
deciding the frequency signal being a mixed signal
S214

FIG. 8

SLEEP APNEA DETECTION SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to a detection of sleep apnea, and more particularly, to a sleep apnea detection system and method.

[0003] 2. Description of Related Art

[0004] Sleep apnea is defined as having cessation in breathing, where each cessation could last from a few seconds to minutes, or shallow breaths during sleep. Sleep apnea can be classified into three types: central sleep apnea (CSA), obstructive picture of the occurrence and elapse time of apnea during sleep apnea (OSA), and mixed apnea.

[0005] Central sleep apnea results from the failure of brain to signal breathing command to the muscle, obstructive sleep apnea is caused by the limitation on air flow, which often results in snoring or choking during sleep, and mixed apnea is a combination of central sleep apnea and obstructive sleep apnea. Obstructive sleep apnea is the most common type of sleep apnea.

[0006] The current apnea detection systems such as that disclosed in U.S. 2003/0055348A1 is required to simultaneously determine an ECG (electrocardiograph) signal and an EDR (ECG derived respiration) signal, and detecting procedures and algorithms are more complex. For example, calculating PR (P-wave~R-wave) segment and power density of the ECG signal are required, and therefore the current apnea detection systems are not real-time detecting systems.

[0007] Furthermore, in US 2006/0079802A1, it is required to calculate the chest impedance and use devices such as an impedance sensor and a movement sensor.

[0008] Therefore, in order to solve the shortcomings of the above conventional technique, a simple detecting procedure, hardware, software, and algorithms for detecting the occurrence of the sleep apnea are provided.

SUMMARY OF THE INVENTION

[0009] The present invention provides a sleep apnea detection system and method. A plurality of peak time points of R-waves in an ECG (electrocardiograph) signal are first detected. Areas of the plurality of R-waves are calculated, and R-wave area signals are produced to generate an EDR signal. The maximum peak and frequency of the frequency signal are simultaneously determined, and then the frequency signal being an apnea signal, a normal breathing signal or a mixed signal is determined. Therefore, the real-time detection of the occurrence of the sleep apnea at a (within 1 minute) is achieved by simple detecting procedure, hardware, software, and algorithms without using additional detection instruments or manual interpretation. Hence, the diagnostic procedures are significantly reduced, and the detecting efficiency is improved by the present invention.

[0010] The invention provides a sleep apnea detection system comprising a detecting module, a processing module, a converting module and a determining module. The detecting module detects a plurality of peak time points of R-waves in an ECG (electrocardiograph) signal. The processing module calculates areas of the R-waves at a predetermined time range based on the peak time points, so as to produce a plurality of first R-wave area signals based on the areas and generate an EDR (ECG derived respiration) signal based on the peak time points and the first R-wave area signals. The converting module converts the EDR signal to a frequency signal. The determining module determines whether a maximum peak frequency of the frequency signal is at a first frequency segment or a second frequency segment to determine the frequency signal being an apnea signal or a normal breathing signal.

[0011] The invention also provides a method for detecting a sleep apnea, comprising detecting peak time points of a plurality of R-waves of a ECG signal; calculating areas of the plurality of R-waves at a predetermined time range based on the peak time points; producing a plurality of first R-wave area signals based on the areas; generating an EDR (ECG derived respiration) signal based on the peak time points and the plurality of first R-wave area signals; converting the EDR signal to a frequency signal; and determining whether a maximum peak frequency of the frequency signal is at a first frequency segment or a second frequency segment to determine the frequency signal being an apnea signal or a normal breathing signal.

BRIEF DESCRIPTION OF DRAWINGS

[0012] The invention can be more fully understood by reading the following detailed description of the preferred embodiments, with reference made to the accompanying drawings, wherein

[0013] FIG. **1** is a schematic block diagram of a sleep apnea detection system according to the present invention;

[0014] FIG. **2** is a waveform diagram showing ECG signal according to the present invention;

[0015] FIG. **3** is a schematic diagram showing second R-wave area signals produced between first R-wave area signals using a linear interpolation according to the present invention;

[0016] FIG. **4**A is a waveform diagram of generating EDR signal based on the first R-wave area signals of first embodiment according to the present invention;

[0017] FIG. **4**B is a waveform diagram of the EDR signal of FIG. **4**A generating consecutive signal according to the present invention;

[0018] FIG. **4**C is a waveform diagram showing the consecutive signal of FIG. **4**B converted to frequency signal and determined as an apnea signal according to the present invention;

[0019] FIG. **5**A is a waveform diagram showing that the EDR signal is generated based on the first R-wave area signals according to the second embodiment of the present invention;

[0020] FIG. **5**B is a waveform diagram of the EDR signal of FIG. **5**A generating consecutive signal according to the present invention;

[0021] FIG. **5**C is a waveform diagram showing the consecutive signal of FIG. **5**B converted to frequency signal and determined as a normal breathing signal according to the present invention;

[0022] FIG. **6**A is a waveform diagram of the ECG signal having noise according to the third embodiment of the present invention;

[0023] FIG. **6**B is a waveform diagram showing that the EDR signal is generated based on the first R-wave area signals produced by the ECG signal of FIG. **6**A according to the present invention;

[0024] FIG. **6**C is a waveform diagram of the EDR signal of FIG. **6**B generating consecutive signal according to the present invention;

[0025] FIG. 6D is a waveform diagram showing the consecutive signal of FIG. 6C converted to frequency signal and determined as a mixed signal according to the present invention;

[0026] FIG. 7 is a schematic diagram of accuracy in relation to the normal breathing signal and the apnea signal at different time length according to the present invention; and

[0027] FIG. 8 illustrates a schematic flow chart of a sleep apnea detecting method according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0028] The following illustrative embodiments are provided to illustrate the disclosure of the present invention, these and other advantages and effects can be apparently understood by those in the art after reading the disclosure of this specification. The present invention can also be performed or applied by other different embodiments. The details of the specification may be on the basis of different points and applications, and numerous modifications and variations can be devised without departing from the spirit of the present invention.

[0029] FIG. **1** illustrates a schematic block diagram of a sleep apnea detection system according to the present invention. As shown in FIG. **1**, the sleep apnea detection system **100** uses the impact of the expansion or reduction of the chest caused by breathing on the ECG signal **111**, calculates areas **141** of the R-waves **131** and generates the EDR signal **143**. Then, the judgment is performed in response to the modulation of the EDR signal **143** according to the more intense chest movement resulting from airway obstruction caused by sleep apnea.

[0030] Since the chest movement caused by the airway obstruction is relatively longer in cycle and larger in amplitude than the general normal breathing, it can be determined by determining the frequency signal **161** of the EDR signal **143** whether the sleep apnea occurs.

[0031] The sleep apnea detection system **100** may detect the OSA, the CSA, or the mixed type of apnea, and may include a signal retrieving module **110**, a first median filter **120**, a detecting module **130**, a processing module **140**, a second median filter **150**, a converting module **160** and a determining module **170**.

[0032] The signal retrieving module **110** is used for retrieving the ECG signal **111** of the predetermined time frame at each time interval, for example, retrieving the ECG signal **111** of 1 minute at every 15 seconds. The signal retrieving module **110** may be a signal retrieving program, a signal retrieving software or a signal receiving module.

[0033] The first median filter **120** is used for filtering drifting baseline or drifting baseline or negative singularity of the ECG signal **111**.

[0034] The detecting module **130** is used for detecting a plurality of peak time points **132** of the R-waves **131** in the ECG signal **111** based on a wavelet transform detecting method. The wavelet transform detecting method uses the quadratic spline for a mother wavelet function. The detecting module **130** may be a detector, a detecting program or a detecting software.

[0035] The processing module **140** is used for calculating areas **141** of the plurality of R-waves **131** at a predetermined time range based on the peak time points **132** to produce a plurality of first R-wave area signals **142** based on the areas **141** and generate the EDR signal **143** based on the peak time points **132** and the first plurality of R-wave area signals **142**. The processing module **140** may be a processor, a processing program or a processing software.

[0036] The processing module **140** may also adjust extrema of the plurality of first R-wave area signals **142** and produce a plurality of second R-wave area signals **144** between the plurality of first R-wave area signals **142** based on a linear interpolation, such that the EDR signal **143** generates a consecutive signal **145**.

[0037] The second median filter **150** is used for filtering the drifting baseline of the EDR signal **143** to strengthen the consecutive signal **145**.

[0038] The converting module **160** is used for converting the EDR signal **143** to a frequency signal **161** based on a fast Fourier transform (FFT) method. The converting module **160** may be a converting program, a converting software, a converter or a processor.

[0039] The determining module **170** is used for determining whether a maximum peak frequency of the frequency signal **161** is at a first frequency segment or a second frequency segment so as to determine the frequency signal **161** being an apnea signal **171** or a normal breathing signal **172**

[0040] When the maximum peak frequency is located at the first frequency segment, the determining module **170** further compares the maximum peak with a predetermined threshold. When the maximum peak is greater than the threshold, the determining module **170** determines that the frequency signal **161** is a apnea signal **171**, and when the maximum peak is less than the threshold, the determining module **170** determines that the frequency signal **161** is a mixed signal **173**, which is the normal breathing signal with noise. When the maximum peak frequency is located in the second frequency segment, the determining module **170** determines that the frequency signal **161** is the normal breathing signal **172**. The determining module **170** may be a determining program or a processor.

[0041] FIG. **2** illustrates a waveform diagram relating to ECG signal according to the present invention. As shown in FIG. **2**, the single pulse wave of the ECG signal **111** is divided into P wave, Q wave, R-wave S-wave, T wave and U wave, wherein the R-wave has a maximum peak.

[0042] As shown in FIGS. **1** and **2**, the detecting module **130** is used for detecting a plurality of peak time points **132** of the R-waves **131** in the ECG signal **111** based on a wavelet transform detecting method. The wavelet transform detecting method uses the quadratic spline for a mother wavelet function.

[0043] The processing module **140** is used for calculating areas **141** of the plurality of R-waves **131** at a predetermined time range based on the peak time points **132**. For example, an integration is carried out on the R-waves **131** based on the peak time points **132** before or after the time of 50 ms to calculate the areas **141** of the R-waves **131**.

[0044] FIG. **3** illustrates a schematic diagram of producing second R-wave area signals between first R-wave area signals using a linear interpolation according to the present invention.

[0045] As shown in FIG. **3**, the extrema of the plurality of first R-wave area signals (such as X_a, X_b) is adjusted first. For example, the extrema of the first R-wave area signals X_b is adjusted as follows:

$$(1-\alpha)X_a,$$

$$X_b \geqq (1+\alpha)X_a$$

$$X_b' = X_b,$$

$$(1+\alpha)X_a > X_b > (1-\alpha)X_a$$

$$(1+\alpha)X_a,\ X_b \leqq (1-\alpha)X_a$$

wherein X_a is the first R-wave area signal, X_b is the next first R-wave area signal, X_b' is the adjusted first R-wave area signal. a is the peak time point of the first R-wave area signals X_a, and b is the peak time point of the first R-wave area signals X_b. α is an adjustment value, such as 0.05 or other value.

[0046] For example, when α is 0.05, the above formula means that when the first R-wave area signal Xb is greater than or equal to 1.05 times of the first R-wave area signal X_a, the first R-wave area signal X_b' is equal to 0.95 times of the first R-wave area signals X_a, for lowering the extrema of the first R-wave area signal X_b.

[0047] Conversely, when the first R-wave area signals X_b is less than or equal to 0.95 times of the first R-wave area signals X_a, the first R-wave area signals X_b' is equal to 1.05 times of the first R-wave area signals X_a, for raising the extrema of the first R-wave areas signal X_b.

[0048] Furthermore, when the first R-wave area signals X_b is ranged from 0.95 to 1.05 times of the first R-wave area signals X_a, the first R-wave area signals X_b' is equal to the first R-wave area signal X_b, for maintaining the extrema of the first R-wave area signals X_b unchanged.

[0049] Therefore, the present invention avoids drastic change of the first R-wave area signals (such as X_a, X_b) interfering the detect results, and then focuses on the trend of the EDR signal.

[0050] After the extrema of the first R-wave area signals X_b is completely adjusted, the plurality of second R-wave area signals X_{a+n} are produced between the first R-wave area signals X_a and X_b based on the linear interpolation, and then the EDR signal generates consecutive signal. The formula of linear interpolation is as follows:

$$X_{a+n}=X_a+(X_b'-X_a)*n/(b-a),\ n=1,2,\ldots,b-a$$

wherein X_{a+n} is the nth second R-wave area signal counted from the first R-wave area signals X_a, X_a is the first R-wave area signal, X_b' is the adjusted first R-wave area signal, a is the peak time points of the first R-wave area signal X_a, b is the peak time points of the first R-wave area signal X_b, and n is a positive integer.

[0051] FIG. **4**A illustrates a waveform diagram of generating EDR signal based on the first R-wave area signals according to the first embodiment of the present invention. FIG. **4**B illustrates a waveform diagram of the EDR signal of FIG. **4**A generating consecutive signal according to the present invention. FIG. **4**C illustrates a waveform diagram showing the consecutive signal of FIG. **4**B converted to frequency signal and determined being an apnea signal according to the present invention.

[0052] As shown in FIG. **4**A, as FIG. **2**, the areas **141** of the plurality of R-waves of the ECG signal **111** are calculated, a plurality of first R-wave area signals **142** are produced based on the areas **141**, and the EDR signal **143** is generated based on the wave peak time points **132** and the first R-wave area signals **142** of the R-waves.

[0053] As shown in FIG. **4**B, the extrema of the plurality first R-wave area signals **142** in FIG. **4**A is adjusted, a plurality of second R-wave area signals (not shown) between the first R-wave area signals **142** are produced based on the linear interpolation, and the EDR signal **143** generates the consecutive signal **145**.

[0054] As shown in FIG. **4**C, the consecutive signal **145** is converted to a frequency signal **161**, and it is determined whether the frequency **176** of the maximum peak **175** of the frequency signal **161** is in the first frequency segment **174** or the second frequency segment (not shown) in order to determine the frequency signal **161** being the apnea signal or the normal breathing signal.

[0055] In the first embodiment, the frequency **176** of the maximum peak **175** of the frequency signal **161** is approximately 0.03 Hz, and is located in the first frequency segment **174**, i.e. frequency of 0.01 to 0.04 Hz; and the maximum peak **175** is approximately 900, and more than the predetermined threshold (such as 400). It is thus determined that the frequency signal **161** is the apnea signal.

[0056] FIG. **5**A illustrates a waveform diagram of generating EDR signal based on the first R-wave area signals according to the second embodiment of the present invention. FIG. **5**B illustrates a waveform diagram of the EDR signal of FIG. **5**A generating consecutive signal according to the present invention. FIG. **5**C illustrates a waveform diagram showing the consecutive signal of FIG. **5**B converted to the frequency signal and determined being a normal breathing signal according to the present invention.

[0057] The generation of the EDR signal, the consecutive signal and the frequency signal in the second embodiment is the same as that in the first embodiment of FIGS. **4**A to **4**C, and is thus not repeatedly described. The differences of the second embodiment from the first embodiment are illustrated as follows.

[0058] In FIG. **5**C, the frequency **176** of the maximum peak **175** of the frequency signal **161** is approximately 0.19 Hz, and is located in the second frequency segment **177**, i.e. frequency of 0.15 to 0.3 Hz. It is determined that the frequency signal **161** is the normal breathing signal.

[0059] FIG. **6**A illustrates a waveform diagram of the ECG signal having noise according to the third embodiment of the present invention. FIG. **6**B illustrates a waveform diagram of generating the EDR signal based on the first R-wave area signals produced by the ECG signal of FIG. **6**A according to the present invention. FIG. **6**C illustrates a waveform diagram of the EDR signal of FIG. **6**B generating consecutive signal according to the present invention. FIG. **6**D illustrates a waveform diagram showing the consecutive signal of FIG. **6**C converted to frequency signal and determined being a mixed signal according to the present invention.

[0060] The generation of the EDR signal, the consecutive signal and the frequency signal in the third embodiment is the same as that in the first embodiment of FIGS. **4**A to **4**C. and it is thus not repeatedly described. The differences of the third embodiment from the second embodiment are illustrated as follows.

[0061] In FIG. **6**A, the ECG signal **111** has a noise **178**.

[0062] In FIG. **6**D, the frequency **176** of the maximum peak **175** of the frequency signal **161** is approximately 0.03 Hz, and is located in the first frequency segment **174**, i.e. frequency of 0.01 to 0.04 Hz. It is determined that the frequency signal **161** may be the apnea signal.

[0063] However, due to the ECG signal **111** has the noise **178**, when the frequency signal **161** is determined as the apnea signal or the normal breathing signal, it needs to determine whether the maximum peak **175** is greater than a predetermined threshold (eg, **400**). If so, the frequency signal **161** is determined as the apnea signal. If not, the maximum peak **175** is less than the threshold, and it is determined that the frequency signal **161** is a mixed signal, which is the normal breathing signal with the noise.

[0064] FIG. **7** illustrates a schematic diagram of accuracy in relation to the normal breathing signal and the apnea signal at different time length according to the present invention.

[0065] As shown, accuracy **181** of the first Normal breathing signal, accuracy **182** of the second normal breathing signal, accuracy **183** of the third normal breathing signal, accuracy **184** of first apnea signal, accuracy **185** of second apnea signal and accuracy **186** of third apnea signal are respectively detected at different time length. No matter the time length is 1 minute, 2 minutes, 4 minutes, or 5 minutes, accuracy of the detection result is more than 80%. The accuracy of the detection result is not affected by the length of time.

[0066] In other words, the present invention can be used as the real-time detection of sleep apnea, wherein the ECG signal is detected for 1 minute every 15 seconds, so as to real-time determine whether the patient has the sleep apnea.

[0067] FIG. **8** illustrates a schematic flow chart of a sleep apnea detecting method according to the present invention. As shown, the sleep apnea detecting method may include the following steps:

[0068] In step S**201**, the signal retrieving module retrieves the ECG signal of the predetermined time frame at each time interval. For example, the signal retrieving module retrieves the ECG signal for 1 minute at every 15 seconds. The procedure then goes to step S**202**.

[0069] In step S**202**, the first median filter filters drifting baseline or drifting baseline or negative singularity of the ECG signal. The procedure then goes to step S**203**.

[0070] In step S**203**, the detecting module detects the plurality of peak time points of the R-waves in the ECG signal. The procedure then goes to step S**204**.

[0071] In step S**204**, the processing module calculates areas of the plurality of R-waves at a predetermined time range. The procedure then goes to step S**205**.

[0072] In step S**205**, the processing module produces the plurality of first R-wave area signals based on the areas. The procedure then goes to step S**206**.

[0073] In step S**206**, the processing module generates the EDR signal based on the peak time points and the first R-wave area signals. The procedure then goes to step S**207**.

[0074] In step S**207**, the processing module adjusts the extrema of the first R-wave area signals. The procedure then goes to step S**208**.

[0075] In step S**208**, the processing module produces the plurality of second R-wave area signals between the first R-wave area signals based on the linear interpolation, and the EDR signal generates a consecutive signal. The procedure then goes to step S**209**.

[0076] In step S**209**, the second median filters the baseline drift of the EDR signal in order to strengthen the consecutive signal. The procedure then goes to step S**210**.

[0077] In step S**210**, the converting module converts the consecutive signal to the frequency signal based on the fast Fourier transform. The procedure then goes to step S**211**.

[0078] In step S**211**, the determining module determines whether the maximum peak frequency of the frequency signal is located in the first frequency segment. If so, the procedure then goes to step S**212**. If not, the maximum peak frequency is located in the second frequency segment, and the first frequency segment is less than the second frequency segment. The procedure then goes to step S**215**.

[0079] In step S**212**, the determining module determines whether the maximum peak is greater than the predetermined threshold. If so, the procedure then goes to step S**213**.

[0080] If not, the procedure then goes to step S**214**.

[0081] In step S**213**, the determining module determines the frequency signal being an apnea signal.

[0082] In step S**214**, the determining module determines the frequency signal being a mixed signal, namely the normal breathing signal with noise.

[0083] In step S**215**, the determining module determines the frequency signal being a normal breathing signal.

[0084] The foregoing descriptions of the detailed embodiments are only illustrated to disclose the features and functions of the present invention and not restrictive of the scope of the present invention. It should be understood to those in the art that all modifications and variations according to the spirit and principle in the disclosure of the present invention should fall within the scope of the appended claims.

What is claimed is:

1. A sleep apnea detection system, comprising:

a detecting module for detecting a plurality of peak time points of R-waves in an ECG (electrocardiograph) signal;

a processing module for calculating areas of the plurality of R-waves at a predetermined time range based on the peak time points to produce a plurality of first R-wave area signals based on the areas and generate an EDR (ECG derived respiration) signal based on the peak time points and the first plurality of R-wave area signals;

a converting module for converting the EDR signal to a frequency signal; and

a determining module for determining whether a maximum peak frequency of the frequency signal is at a first frequency segment or a second frequency segment to determine the frequency signal being an apnea signal or a normal breathing signal.

2. The sleep apnea detection system of claim **1**, further comprising a signal retrieving module for retrieving the ECG signal of the predetermined time frame at each time interval.

3. The sleep apnea detection system of claim **1**, further comprising a first median filter for filtering drifting baseline or negative singularity of the ECG signal.

4. The sleep apnea detection system of claim **1**, wherein the processing module further adjusts extrema of the plurality of first R-wave area signals and produces a plurality of second R-wave area signals between the plurality of first R-wave area signals based on a linear interpolation, such that the EDR signal generates a consecutive signal.

5. The sleep apnea detection system of claim **4**, further comprising a second median filter for filtering the drifting baseline of the EDR signal to strengthen the consecutive signal, wherein the converting module converts the consecutive signal to the frequency signal based on a fast Fourier transform method.

6. The sleep apnea detection system of claim **1**, when the maximum peak frequency is located at the first frequency segment, the determining module further compares the maximum peak with a predetermined threshold, when the maximum peak is greater than the threshold, the determining module determines that the frequency signal is a apnea signal, and when the maximum peak is less than the threshold, the determining module determines that the frequency signal is a mixed signal.

7. The sleep apnea detection system of claim **1**, wherein the first frequency segment is less than the second frequency segment, when the maximum peak frequency is located at the second frequency segment, the determining module determines that the frequency signal is the normal breathing signal.

8. A method for detecting a sleep apnea, comprising:

(1) detecting peak time points of a plurality of R-waves of an ECG signal;

(2) calculating areas of the plurality of R-waves at a predetermined time range based on the peak time points;

(3) producing a plurality of first R-wave area signals based on the areas;

(4) generating an EDR (ECG derived respiration) signal based on the peak time points and the plurality of first R-wave area signals;

(5) converting the EDR signal to a frequency signal; and

(6) determining whether a maximum peak frequency of the frequency signal is at a first frequency segment or a second frequency segment to determine the frequency signal being an apnea signal or a normal breathing signal.

9. The method of claim **8**, prior to step (1) further comprising:

(0-1) retrieving the ECG signal of a predetermined time frame at each time interval.

10. The method of claim **9**, after step (0-1) further comprising: (0-2) filtering drifting baseline or negative singularity of the ECG signal.

11. The method of claim **8**, wherein step (5) further comprises:

(5-1) adjusting extrema of the plurality of first R-wave area signals; and

(5-2) producing a plurality of second R-wave area signals between the plurality of first R-wave area signals based on a linear interpolation, such that the EDR signal generates a consecutive signal.

12. The method of claim **11**, wherein after step (5-2) further comprises:

(5-3) filtering the drifting baseline of the EDR signal to strengthen the consecutive signal; and

(5-4) converting the consecutive signal to the frequency signal based on a fast Fourier transform method.

13. The method of claim **8**, when it is determined in step (6) that the maximum peak frequency is located at the first frequency segment, further comprising:

(6-1) comparing the maximum peak with a predetermined threshold; and

(6-2) determining the frequency signal being an apnea signal when the maximum peak is greater than the threshold, and determining the frequency signal being a mixed signal when the maximum peak is less than the threshold.

14. The method of claim **8**, wherein when it is determined in step (6) that the maximum peak frequency is located at the second frequency segment, the frequency signal is determined as the normal breathing signal.

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