(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 October 2015 (29.10.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/164077 A1

(51) International Patent Classification:
A61B 5/00 (2006.01) *A61B 5/01* (2006.01)
A61B 5/024 (2006.01) *A61B 5/05* (2006.01)
A61B 5/11 (2006.01) *A61B 5/0488* (2006.01)
A61B 5/0205 (2006.01)

(21) International Application Number:
PCT/US2015/024879

(22) International Filing Date:
8 April 2015 (08.04.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
14/262,449 25 April 2014 (25.04.2014) US

(71) Applicant: **CYBERONICS, INC.** [US/US]; CYBERONICS, INC., 100 Cyberonics Blvd., Houston, Texas 77058 (US).

(72) Inventor: **SABESAN, Shivkumar**; 100 Cyberonics Blvd., Houston, Texas 77058 (US).

(74) Agents: **SCOTT, Timothy, L.** et al.; Cyberonics, INC., 100 Cyberonics Blvd., Houston, Texas 77058 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: DETECTING SEIZURES BASED ON HEARTBEAT DATA

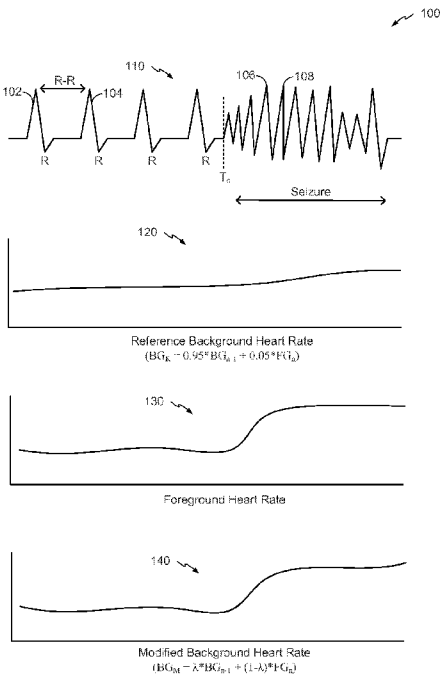

FIG. 1

(57) Abstract: A method includes receiving heartbeat data of a patient and receiving activity data of the patient. The activity data includes one or more activity values that are related to an activity level of the patient and that are measured independently of the heartbeat data. The method further includes determining a value of a weighting factor based on the activity data. The method also includes determining modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data. The method also includes detecting a seizure event based on the modified heartbeat data.

WO 2015/164077 A1

DETECTING SEIZURES BASED ON HEARTBEAT DATA

FIELD OF THE DISCLOSURE

[0001] The present disclosure is generally related to detecting seizures based on heartbeat data.

BACKGROUND

[0002] Advances in technology have led to the development of medical devices that can be implanted within a living organism, such as a human, to provide treatment or monitoring. For example, a medical device may detect when a seizure occurs in a patient. Early detection of a seizure may allow appropriate responsive action to be taken. Such actions may include sending an alert signal to the patient or a caregiver, initiating a treatment therapy, or taking remedial action such as making the patient and/or an environment around the patient safe. One way to detect seizures is by monitoring a heartbeat of the patient to determine whether the heartbeat increases beyond a threshold. However, other factors can also cause the heartbeat to increase beyond the threshold. Thus, seizure detection based on a heartbeat may be subject to a significant number of false positives.

SUMMARY

[0003] A medical device monitoring and/or providing therapy to a patient may detect and respond to seizures based on patient heartbeat data and based on patient activity data (including patient state data). The medical device may use a seizure detection algorithm that is capable of distinguishing between pathological changes in the detected heartbeat, which may indicate a seizure, and non-pathological changes in the detected heartbeat. The non-pathological changes may correspond to normal physiological functioning as opposed to a seizure. The non-pathological changes may be difficult to distinguish from the pathological changes based solely on information associated with the heartbeat.

[0004] For example, the patient's heartbeat may increase when a seizure event occurs (e.g., a pathological change). However, the patient's heartbeat may also change when the patient engages in a state of physical activity (such as running, jumping, exercising, swimming, etc.) or the patient assumes a state or changes to or from a state (such as initiating running, awaking from sleep, going to sleep, changing from healthy to sick, etc.). Other external factors may also cause the patient's heartbeat to increase. For example, a change in temperature may contribute to an increase in the patient's heartbeat. It may become difficult for the medical

device to determine whether an increase in the patient's heartbeat is due to a seizure, physical activity, or other external factors.

[0005] To address such concerns, the medical device may account for the physical activity and/or other external factors when determining whether or not a seizure event is indicated by heartbeat data. For example, the medical device may use an algorithm that detects whether or not a seizure event is present based on a background heart rate and a foreground heart rate. The foreground heart rate may correspond to a rate at which the patient's heart is beating at a present time, which can be the most-recent heart rate value obtained from the patient or be an average of several recent heart rate values that are adjacent to and include the most-recent heart rate value. The background heart rate may be a function of the foreground heart rate and a previously-determined background heart rate. For example, the algorithm may be expressed as $BG_n = \lambda*BG_{n-1} + (1-\lambda)*FG_n$, where BG_n is the background heart rate at the present time (n), BG_{n-1} is the previously-determined background heart rate, FG_n is the foreground heart rate at the present time (n), and λ is a weighting factor. The previously-determined background heart rate may correspond to an average heart rate during a moving period of time or time window (e.g., an average heart rate during a moving five minute time window that remains immediately prior to the present time), with the period of time or time window being selected to capture a sufficient number of stable heart beats to provide an average heart rate value that is representative of the patient's heart rate and not heavily influenced by any extremely-high or low single heart beat or grouping of heart beats. When a ratio of the foreground heart rate and the background heart rate at the present time exceeds a seizure detection threshold, the medical device may determine that a seizure event is present.

[0006] A value of the weighting factor may be based on physical activity and/or other external factors that affect heart rate. The weighting factor may be zero, one, or between zero and one. As can be appreciated, when the weighting factor is set at a high value that is at or close to one, the calculation of the background heart rate will be heavily influenced by the value of the previously determined-background heart rate, thus providing a background heart rate that is greatly dependent on a window of time corresponding to the time period assigned when determining the previously-determined heart rate. As can also be appreciated, when the weighting factor is set at a low value that is at or close to zero, the calculation of the background heart rate will be heavily influenced by the value of the foreground heart rate, thus

providing a background heart rate that is greatly dependent on an instant heart rate or recently-measured heart rate values. As can be further appreciated, when the weighting factor is set at a middle value that is at or close to 0.5, the calculation of the background heart rate will be equally influenced by the values of the previously-determined heart rate and the foreground heart rate, thus providing a background heart rate that is balanced in its dependence on previously-measured heart rate values and recently-measured heart rate values. As an illustrative non-limiting example, the value of the weighting factor may be approximately equal to 0.95 when the patient is in an idle state (e.g., sleep), which would provide a background heart rate that heavily depends (e.g., 95% dependence) on the previously-determined background heart rate and lightly depends (e.g., 5% dependence) on the foreground heart rate. When the patient is undergoing physical activity such as running on a treadmill, or the patient is subject to external factors that affect heart rate, the value of the weighting factor may be set to a lesser value than with the idle state, which will generate a background heart rate that is more dependent on the foreground heart rate than the previously-determined background heart rate, and/or generate a background heart rate that is based on a balancing of the foreground heart rate and the previously-determined heart rate. For example, when the value of the weighting factor is reduced from 0.95 to 0.50 when the patient leaves an idle state to undergo a particular physical activity, the background heart rate can be 50% dependent on the previously-determined background heart rate and 50% dependent on the foreground heart rate, thereby providing a background heart rate that accounts for a recent change in the heart rate due to the physical activity and accounts for the more-stable and longer-measured heart rate that was observed before the recent change in heart rate.

[0007] Thus, physical activity and/or external factors may be used alone or in combination to determine the background heart rate by changing the value of the weighting factor based on the physical activity and/or external factors that affect heart rate. As a result, when the background heart rate is compared to the foreground heart rate to determine whether a seizure event is occurring, physical activity and/or external factors are taken into account.

[0008] In a particular embodiment, a method includes receiving heartbeat data of a patient and receiving activity data of the patient. The activity data can provide one or more activity values that are related to an activity level of the patient and that are independent of the heartbeat data. The method further includes determining a value of a weighting factor based on the activity

data. The method also includes determining modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data. The method also includes detecting a seizure event based on the modified heartbeat data.

[0009] In another particular embodiment, a medical device includes a first interface to receive heartbeat data of a patient and a second interface to receive activity data of the patient. The activity data includes one or more activity values that are related to an activity level of the patient and that are measured independently of the heartbeat data. The medical device also includes a processor to determine a value of weighting factor based on the activity data. The processor determines modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data. The processor also detects a seizure event based on the modified heartbeat data.

[0010] In another particular embodiment, a non-transitory computer readable medium stores instructions that are executable be a processor to cause the processor perform operations. The operations include receiving heartbeat data of a patient and receiving activity data of the patient. The activity data includes one or more activity values that are related to an activity level of the patient and that are measured independently of the heartbeat data. The operations further include determining a value of a weighting factor based on the activity data and determining modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data. The operations also include detecting a seizure event based on the modified heartbeat data.

[0011] The features, functions, and advantages that have been described can be achieved independently in various embodiments or may be combined in yet other embodiments, further details of which are disclosed with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a particular illustrative embodiment of a diagram illustrating heartbeat data modification based on activity data;

[0013] FIG. 2 is a particular embodiment of a system that is operable to detect a seizure event based on heartbeat data and activity data;

[0014] FIG. 3 is a block diagram of a particular embodiment of a medical device in communication with a patient that is operable to detect a seizure event based on heartbeat data and activity data; and

[0015] FIG. 4 is a flow chart of a particular embodiment of a method of detecting a seizure event based on heartbeat data and activity data.

DETAILED DESCRIPTION

[0016] FIG. 1 is a particular illustrative embodiment of a diagram 100 illustrating heartbeat data modification based on physical activity. The diagram 100 includes a first trace 110 illustrating an electrocardiogram of a patient, a second trace 120 illustrating a background heart rate of the patient which is derived from the first trace 110 and calculated using a fixed weighting factor, a third trace 130 illustrating a foreground heart rate of the patient which is derived from the first trace 110, and a fourth trace 140 illustrating a modified background heart rate of the patient which is derived from the first trace 110 and calculated using a weighting factor and adjusted based on activity data. The four traces 110, 120, 130, and 140 of diagram 100 are aligned with each other to provide identical x-axis representation of time and to provide similar y-axis representations of magnitude of the measured or calculated parameter.

[0017] The electrocardiogram illustrated in the first trace 110 may include a plurality of R waves. For example, the electrocardiogram may include a first R wave 102 and a second R wave 104. A time between respective points on the first R wave 102 and the second R wave 104 is an R-R interval. The first R wave 102 and the second R wave 104 may correspond to a first and second heartbeat, respectively, and the R-R interval may correspond to an amount of time that elapses between consecutive heartbeats (e.g., a heartbeat rate, also referred to as a "heart rate").

[0018] A faster heartbeat may result in a shorter R-R interval between consecutive heartbeats (e.g., R waves). For example, a third R wave 106 and a fourth wave 108 may have a shorter R-R interval than the R-R interval between the first and second R waves 102, 104. Thus, the patient's heart is beating at a faster rate at a time corresponding to the third and fourth R waves 106, 108 as opposed to a time corresponding to the first and second R waves 102, 104. As illustrated by the first trace 110, an increased rate of the patient's heartbeat (e.g., shorter R-R intervals) may be indicative of a seizure event. For example, the seizure event may begin at a critical time (T_c) when the rate of the patient's heartbeat exceeds a threshold level.

[0019] The background heart rate of the patient illustrated in the second trace 120 may be expressed as $BG_R = 0.95*BG_{n-1} + 0.05*FG_n$, where BG_R is a reference background heart rate

at the present time (n), BG_{n-1} is the previously-determined background heart rate, and FG_n is the foreground heart rate at the present time (n). The previously-determined background heart rate may be generated by taking an electrocardiogram over a particular time span and performing an infinite impulse response (IIR) operation on the electrocardiogram. For example, the previously-determined background heart rate may correspond to an IIR operation on an electrocardiogram spanning a five minute time period before the present time (n). In another example, the previously-determined background heart rate may correspond to an IIR operation on an electrocardiogram spanning a time period determined by a number of heart beats before the present time (n).

[0020] The foreground heart rate (FG_n) at the present time (n) is illustrated in the third trace 130. The foreground heart rate may be generated by taking an electrocardiogram over a time span corresponding to a most recent R-R interval. For example, the foreground heart rate may correspond to a current heart rate. When the current heart rate increases, a magnitude of the foreground heart rate increases. When the current heart rate decreases, the magnitude of the foreground heart rate decreases.

[0021] Referring back to the exemplary embodiment represented with second trace 120, ninety-five percent of the reference background heart rate is based on a heart rate spanning over a previous five minute period (e.g., the previously-determined background heart rate) and five percent of the reference background heart rate is based on the foreground heart rate illustrated in the third trace 130. Thus, when determining the reference background heart rate, the previously-determined background heart rate is weighted at a fixed rate (e.g., 0.95) and the foreground heart rate is weighted at a fixed rate (e.g., 0.05). When comparing the foreground heart rate illustrated in the third trace 130 to the reference background heart rate illustrated in the second trace 120, a ratio of the foreground heart rate and the reference background heart rate may be calculated, and the ratio may be compared to a seizure threshold and, when the threshold is exceeded, detect the occurrence of a seizure event at the critical time (T_c).

[0022] However, if the increased heart rate at the critical time (T_c) is associated with a physical activity of the patient as opposed to a seizure, then using the reference background heart rate in the second trace 120 may result in a false detection of a seizure event. For example, volitional motion or other non-seizure activity may increase heart rate, and the dominance of the previously-determined background heart rate (when, e.g., weighted at 95%)

in the calculation of the reference background heart rate and/or the ratio may result in a false indication of a seizure event. To reduce the likelihood of detecting a false seizure event, the modified background heart rate illustrated in the fourth trace 140 may be used along with the foreground heart rate illustrated in the third trace 130 to detect whether a seizure event is present.

[0023] For example, the modified background heart rate may factor in an activity level of the patient to account for the increased heart rate. The modified background heart rate may be expressed as $BG_M = \lambda*BG_{n-1} + (1-\lambda)*FG_n$, where BG_M is the modified background heart rate at the present time (n), BG_{n-1} is the previously-determined background heart rate, FG_n is the foreground heart rate at the present time (n), and λ is a weighting factor.

[0024] A value of the weighting factor may be based on activity data. In a particular embodiment, the activity data includes accelerometer data, body temperature data, electromyography data, respiration data, perspiration data, impedance data, or a combination thereof. The activity data may include data obtained from an electroencephalography (EEG) sensor, an electrooculography (EOG) sensor, an electrocardiography (ECG) sensor, an electromyography (EMG) sensor, an accelerometer, or a combination thereof, as disclosed in contemporaneously-filed U.S. Patent Application Serial No. _____ (Attorney Docket Number 1000.321), entitled "DETECTING SEIZURES BASED ON HEARTBEAT DATA," which is hereby incorporated by reference as though fully set forth herein. In another particular embodiment, the activity data may correspond to one or more activity values that are related to an activity level of the patient. The activity values may be measured independently of the heart rate of the patient (e.g., measured independently of heartbeat data). The activity values may also be based on a state of the patient or a change of patient state, e.g., based on an activity state, a sleep state, or a change in the patient activity or sleep state. The activity values may also be related to measurements corresponding patient temperature, patient muscle activity, breathing rate, a skin response such as sweating, or combinations thereof. For example, activity data measured with an accelerometer may have a first activity value associated with running, activity data measured with a respiration sensor may have a second activity value associated with walking, activity data measured with an EEG sensor may have a third activity value associated with sleeping, etc. With regard to sleeping, the activity value may correspond to a sleep state of the patient so as to increase or decrease the weighting factor

when the patient is in a sleep state that, for example, exhibits reduced or increased body movements, when the patient transitions from one sleep state to another sleep state, when the patient moves or changes positions during sleep, and/or when the patient awakes from sleep, as disclosed in contemporaneously-filed U.S. Patent Application Serial No. _____ (Attorney Docket Number 1000.321), entitled "DETECTING SEIZURES BASED ON HEARTBEAT DATA," which is hereby incorporated by reference as though fully set forth herein. The value of the weighting factor may decrease as an activity level of the patient increases. As a non-limiting example, the value of the weighting factor may be approximately 0.95 when the activity corresponds to sleeping or to a sleep state, 0.75 when the activity corresponds to walking, and 0.50 when the activity corresponds to running. As the weighting factor decreases, the modified background heart rate becomes more dependent on the foreground heart rate (e.g., more dependent on a current heart rate of the patient) and less dependent on the previously-determined background heart rate. Thus, the modified background heart rate updates more quickly than the reference background heart rate when the patient is engages in activities that cause an immediate or foreseeable increase in heart rate.

[0025] The modified background heart rate may become increasingly similar to the foreground heart rate as the value of the weighting factor decreases. For example, the third trace 130 (e.g., the foreground heart rate) may become increasingly similar to the fourth trace 140 (e.g., the modified background heart rate) as the value of the weighting factor approaches zero. As a result, when comparing the foreground heart rate illustrated in the third trace 130 to the modified background heart rate illustrated in the fourth trace 140, a ratio of the foreground heart rate and the modified background heart rate may not exceed the seizure threshold at the critical time (T_c) when the increased heart rate is based on patient activity. Thus, using the modified background heart rate to detect a seizure event may yield fewer false positives.

[0026] Referring to FIG. 2, a system 200 that is operable to detect a seizure event based on heartbeat data and activity data is shown. The system 200 includes a patient-contacting medical device 202, which can be, for example, an implantable medical device or an external device fixed to the surface of a patient's skin. The medical device 202 includes a processor 206 that is coupled to a memory 204 and can also be coupled directly or wirelessly to a therapy delivery unit 212, which may be part of the medical device 202 (as illustrated in FIG. 2) or located external to the medical device 202.

[0027] The medical device 202 includes a first interface 208 that is coupled to receive heartbeat data 220 of a patient. The heartbeat data 220 may be generated from an electrode implanted within, or externally coupled to, the patient. The heartbeat data 220 of the patient may include electrocardiogram data. For example, the heartbeat data 220 may correspond to the electrocardiogram illustrated in the first trace 110 of FIG. 1. In a particular embodiment, the heartbeat data 220 is a numeric value indicating a most recent R-R interval or a signal corresponding to an electrocardiogram data trace. The first interface 208 may be configured to provide the heartbeat data 220 to the processor 206.

[0028] The medical device also includes a second interface 210 that is coupled to receive activity data 230 of the patient. The activity data 230 may be generated from a component (such as an accelerometer) within the medical device 202 (not shown in FIG. 2) or an external device such as an electrode implanted within, or externally coupled to, the patient as illustrated in FIG. 2. In a particular embodiment, the activity data 230 includes accelerometer data, body temperature data, electromyography data, perspiration data, impedance data, or a combination thereof. The activity data 230 may include one or more activity values that are related to an activity level of the patient. For example, a first activity value may be associated with running, a second activity value may be associated with walking, a third activity value may be associated with sleeping, etc. The activity values may be measured independently of the heartbeat data 220. In a particular embodiment, the activity data is a numeric value or signal indicating a measurement that is associated with the activity level of the patient. The second interface 210 may be configured to provide the activity data 230 to the processor 206.

[0029] The processor 206 may be configured to receive the heartbeat data 220 from the first interface 208 and to receive the activity data 230 from the second interface 210. The processor 206 may perform an IIR operation on the heartbeat data 220 (e.g., perform an IIR operation on the electrocardiogram data) to generate a background heart rate for spanning over a time period (e.g., a five minute time period). The processor 206 may also be configured to determine a value of a weighting factor based on the activity data 230.

[0030] The processor 206 may further be configured to determine modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data. Determining the modified heartbeat data may include determining a background heart rate based on a previously-determined background heart rate, a most recent R-R interval, and the weighting

factor. Determining the modified heartbeat data may also include determining a foreground heart rate based on a most recent R-R interval. For example, the modified heartbeat data may correspond to the modified background heart rate illustrated in the fourth trace 140 of FIG. 1 and may be expressed as $BG_M = \lambda*BG_{n-1} + (1-\lambda)*FG_n$, where BG_M is the modified heartbeat data (e.g., the modified background heart rate), BG_{n-1} is a previously-determined background heart rate, FG_n is a foreground heart rate at the present time (n), and λ is the weighting factor determined based on the activity data 230. Thus, the modified heartbeat data may be determined as a sum of a first value and a second value. The first value ($\lambda*BG_{n-1}$) may be the weighting factor times the previously-determined background heart rate, and the second value ($(1-\lambda)*FG_n$) may be one minus the weighting factor times the most recent R-R interval (e.g., the foreground heart rate).

[0031] In response to the activity data 230 indicating an increased activity level of the patient, the processor 206 is configured to determine the value of the weighting factor such that an effect of prior heartbeat data (BG_{n-1}) on the modified heartbeat data is decreased. As a non-limiting example, the value of the weighting factor may be approximately 0.95 when the activity corresponds to sleeping or a sleep state, 0.75 when the activity corresponds to walking, and 0.50 when the activity corresponds to running. Thus, the value of the weighting factor decreases as the activity level of the patient increases. As can be appreciated, the calculation of modified background heart rate and the weighting factor can be modified to provide the same operation described above, but configured so that the value of the weighting factor increases as the activity level of the patient increases.

[0032] The processor 206 may also be configured to detect an indication of noise in the heartbeat data 220. Noise may be detected via patterns in an electrocardiogram, such as the electrocardiogram illustrated in the first trace 110 of FIG. 1. For example, noise may be present if the detected heartbeat falls below a lower threshold or rises above an upper threshold. In a particular embodiment, the lower threshold is about 35 beats per minute (bpm) and the upper threshold is about 180 bpm. As another example, noise may be present if a beat-to-beat variability rises above an upper threshold or falls below a lower threshold. In a particular embodiment, the upper threshold may be about 115 percent and the lower threshold is about 65 percent.

[0033] In response to the detected noise in the heartbeat data 220 increasing, the processor 206 may determine the value of the weighting factor such that an effect of prior heartbeat data (BG_{n-1}) on the modified heartbeat data is decreased. For example, in response to the detected noise in the heartbeat data 220 increasing, the processor 206 may lower the value of the weighting factor so that the modified heartbeat data is more dependent on the foreground heart rate. In response to the detected noise in the heartbeat data decreasing, the processor 206 may determine the value of the weighting factor such that the effect of the prior heartbeat data (BG_{n-1}) on the modified heartbeat data is increased. For example, in response to the detected noise in the heartbeat data 220 decreasing, the processor 206 may raise the value of the weighting factor so that the modified heartbeat data is more dependent on the previously-determined background heart rate (BG_{n-1}).

[0034] The processor 206 may further be configured to detect a seizure event based on the modified heartbeat data. For example, the processor 206 may compare a ratio of the foreground heart rate and the modified background heart rate (e.g., the modified heartbeat data) to a seizure detection threshold. When the ratio exceeds the seizure detection threshold, the processor 206 may determine that a seizure event is present. When the ratio is below the seizure detection threshold, the processor 206 may determine that no seizure event is present. As explained with respect to FIG. 3, in response to detecting the seizure event, the processor 206 may be configured, for example, to provide a notification that a seizure is detected, to initiate a recording of the seizure event, and/or to cause the therapy delivery unit 212 to apply stimulation to tissue of the patient.

[0035] The memory 204 may include tangible, non-transitory, computer-readable media (e.g., one or more computer memory devices). The processor 206 may be implemented using a single-chip processor or using multiple processors. The memory 204 may include various memory devices, such as registers, cache, volatile memory, and non-volatile memory. For example, the memory 204 can include cache that is accessible by the processor 206 to rapidly retrieve and store data. As a non-limiting example, the memory 204 may store information corresponding to the previously-determined background heart rate (BG_{n-1}) and/or weighting factor values for different activities. In a particular embodiment, a look-up table, an algorithm, or a combination thereof, is stored in the memory 204 to determine the weighting factor values based on the activity data 230, the detected noise in the heartbeat data 220, or a

combination thereof. Examples of computer-readable media that the memory 204 may use include, but are not limited to: magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROM disks; magneto-optical media; and specially configured hardware devices such as application-specific integrated circuits (ASICs), programmable logic devices (PLDs), and ROM and RAM devices.

[0036] The memory 204 may also store instructions that are executable by the processor 206 to implement various functions. To illustrate, the instructions may be executable by the processor 206 to cause the processor to perform operations including receiving the heartbeat data 220 and receiving the activity data 230. The operations may also include determining the value of the weighting factor based on the activity data 230 and determining modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data 220. The instructions may also be executable by the processor 206 to cause the processor to detect the seizure event based on the modified heartbeat data. In a particular embodiment, the instructions are executable by the processor 206 to detect R waves in an electrocardiogram, R-R intervals in an electrocardiogram, noise in the heartbeat data 220, other information descriptive of a heartbeat, or a combination thereof.

[0037] Additionally or in the alternative, the medical device 202 may include dedicated hardware implementations, such as application specific integrated circuits, programmable logic arrays and other hardware devices, to implement one or more functions of the processor 206. Accordingly, the present disclosure encompasses software, firmware, and hardware implementations.

[0038] When the heartbeat data 220 is received as an electrocardiogram trace, the processor 206, or an application-specific integrated circuit (ASIC), may perform an IIR operation on an electrocardiogram trace to detect R waves and R-R intervals. The processor 206 (or ASIC) may determine a foreground heart rate by monitoring the timing between the most recent R waves in the electrocardiogram. The processor 206 may also determine the modified background heart rate based on prior heartbeat data stored in the memory 204, the foreground heart rate, and the weighting factor. For example, the prior heartbeat data may be based on heartbeat data 220 received during a five minute window prior to the heartbeat data 220 associated with the foreground heart rate. Activity data 230 associated with patient may be

provided to the processor 206 via the second interface 210 to determine the value of the weighting factor.

[0039] The processor 206 may detect whether a seizure event is present based on the heartbeat data 220 and the activity data 230. For example, the processor 206 may compare the ratio of the foreground heart rate and the modified background heart rate to the seizure detection threshold to determine whether the seizure event is present. In response to detecting the seizure event, the processor 206 may, for example, send a signal to provide a notification that a seizure is detected, to initiate a recording of the seizure event, and/or to the therapy delivery unit 212 to cause the therapy delivery unit 212 to stimulate a tissue of the patient.

[0040] Referring to FIG. 3, a block diagram of a particular embodiment of implantable medical device 202 within a patient is shown. The medical device 202 includes the memory 204, the processor 206, the first interface 208, the second interface 210, the therapy delivery unit 212, a heartbeat sensor 320, and an activity sensor 330.

[0041] The medical device 202 may be adapted to be surgically implanted in a patient 306 to detect a seizure event based on activity data 230 and heartbeat data 220, to provide therapy, to monitor one or more conditions, for another purpose, or any combination thereof. In a particular embodiment, the medical device 202 may be coupled to one or more electrodes 308 and may be adapted to deliver electrical stimulus to tissue 304 of the patient 306 via the electrodes 308. In a particular embodiment, the medical device 202 is an implantable nerve stimulation device. Examples of the implantable nerve stimulation device may include an implantable cranial nerve stimulation device, an implantable spinal cord stimulation device, etc. The electrodes 308 may be coupled to the medical device 202 and may be positioned proximate to or coupled to a nerve, such as a cranial nerve (e.g., the trigeminal nerve, the hypoglossal nerve, the vagus nerve or a branch of the vagus nerve).

[0042] The heartbeat sensor 320 may be configured to detect (e.g., sense) a heartbeat of the patient 306. For example, the heartbeat sensor 320 may be coupled to a nerve via the electrodes 308 to detect the heartbeat of the patient 306. In a particular embodiment, the heartbeat sensor 320 is an electrocardiogram (ESG) sensor. For example, based on the detected heartbeat, the heartbeat sensor 320 may generate electrocardiogram data and provide the electrocardiogram data to the processor 206. The electrocardiogram data may correspond to the electrocardiogram data illustrated by the first trace 110 of FIG. 1 and may indicate R

waves and R-R intervals of the detected heartbeat. The activity sensor 330 may be configured to detect an activity level of the patient 306. For example, the activity sensor 330 may be coupled to a nerve via the electrodes 308 to detect an activity level of the patient 308. Alternatively, the activity sensor 330 may include a device that detects other indications of activity, such as an amount of perspiration, a body temperature, breathing rate, etc.

[0043] As explained with reference to FIG. 2, the medical device 202 may include the therapy delivery unit 212 that is configured to control generation of treatment stimulus provided to the electrodes 308 to provide an electrical stimulus to the tissue 304. In another particular embodiment, the medical device 202 is an implantable drug pump. In another particular embodiment, the medical device 202 is an implantable sensor. Examples of an implantable sensor may include an electrocardiogram (ESG) sensor, an electromyogram (EEG) sensor, etc. Note that the term "patient" is used broadly to include any organism and is not intended to imply that the patient 306 is human; although the patient 306 is a human patient in one embodiment.

[0044] FIG. 4 is a flow chart of a particular embodiment of a method 400 of detecting a seizure event based on heartbeat data and activity data. For example, the method 400 may be performed by a medical device and the components thereof, such as the medical device 202, the memory 204, the processor 206, the first interface 208, the second interface 210, the therapy delivery unit 212 of FIGs. 2 and 3, or any combination thereof. The method 400 may be performed while monitoring for a seizure event in a patient, such as the patient 306 of FIG. 3.

[0045] The method 400 may include receiving heartbeat data of a patient, at 402. For example, in FIG. 2, the first interface 208 may be coupled to receive the heartbeat data 220 of a patient, such as the patient 306 of FIG. 3. The heartbeat data 220 of the patient 306 may include electrocardiogram data (e.g., an electrocardiogram trace). For example, the heartbeat data 220 may correspond to the electrocardiogram illustrated in the first trace 110 of FIG. 1. The first interface 208 may provide the heartbeat data 220 to the processor 206.

[0046] Activity data of the patient may be received, at 404. For example, in FIG. 2, the second interface 210 may be coupled to receive the activity data 230. The activity data 230 may include one or more activity values that are related to an activity level of the patient 306 and that are measured independently of the heartbeat data 220. In a particular embodiment,

the activity data 230 includes accelerometer data, body temperature data, electromyography data, perspiration data, impedance data, or a combination thereof. In a particular embodiment, the activity data 230 may be detected (e.g., sensed) by the activity sensor 330. Additionally or alternatively, the activity data 230 may be received wirelessly from one or more external sensors (not shown). The second interface 210 may provide the activity data 230 to the processor 206.

[0047] A value of a weighting factor may be determined based on the activity data, at 406. For example, in FIG. 2, the processor 206 may determine the value of the weighting factor such that an effect of prior heartbeat data on the modified heartbeat data is decreased in response to the activity data 230 indicating an increased activity level of the patient 306.

[0048] Modified heartbeat data may be determined by applying the weighting factor to at least a portion of the heartbeat data, at 408. For example, the processor 206 of FIG. 2 may determine the modified heartbeat data based on an algorithm, such as $BG_M = \lambda*BG_{n-1} + (1-\lambda)*FG_n$, where BG_M is the modified heartbeat data (e.g., the modified background heart rate), BG_{n-1} is a previously-determined background heart rate, FG_n is a foreground heart rate at the present time (n), and λ is the weighting factor determined based on the activity data. Thus, the modified heartbeat data may be determined as a sum of a first value and a second value. The first value ($\lambda*BG_{n-1}$) may be the weighting factor time the previously-determined background heart rate and the second value ($(1-\lambda)*FG_n$) may be one minus the weighting factor times the most recent R-R interval (e.g., the foreground heart rate).

[0049] A seizure event may be detected based on the modified heartbeat data, at 410. For example, the processor 206 of FIG. 2 may compare a ratio of the foreground heart rate and the modified background heart rate (e.g., the modified heartbeat data) to a seizure detection threshold. When the ratio exceeds the seizure detection threshold, the processor 206 may determine that a seizure event is present. When the ratio is below the seizure detection threshold, the processor 206 may determine that there is no seizure event present.

[0050] In a particular embodiment, the method 400 may include detecting an indication of noise in the heartbeat data. For example, the processor 206 of FIG. 2 may detect an indication of noise in the heartbeat data 220. The weighting factor may be further determined based on the indication of noise in the heartbeat data. For example, in response to the detected noise in the heartbeat data 220 increasing, the processor 206 may determine the value of the weighting

factor such that an effect of prior heartbeat data on the modified heartbeat data is decreased. Thus, in response to the detected noise in the heartbeat data 220 increasing, the processor 206 may lower the value of the weighting factor so that the modified heartbeat data is more dependent on the foreground heart rate. Alternatively, in response to the detected noise in the heartbeat data decreasing, the processor 206 may determine the value of the weighting factor such that the effect of the prior heartbeat data on the modified heartbeat data is increased. Thus, in response to the detected noise in the heartbeat data 220 decreasing, the processor 206 may raise the value of the weighting factor so that the modified heartbeat data is more dependent on the previously-determined background heart rate.

[0051] In a particular embodiment, the method 400 may include causing stimulation to be applied to tissue of the patient in response to detecting the seizure event. For example, the therapy delivery unit 212 of FIG. 3 may control generation of treatment stimulus provided to the electrodes 308 to provide an electrical stimulus to the tissue 304 in response to the processor 206 detecting the seizure event. In another particular embodiment, the method 400 may include generating a report regarding the detection of a seizure event, and may include the initiation of a recording of a detected seizure event.

[0052] The illustrations of the embodiments described herein are intended to provide a general understanding of the structure of the various embodiments. The illustrations are not intended to serve as a complete description of all of the elements and features of apparatus and systems that utilize the structures or methods described herein. Many other embodiments may be apparent to those of skill in the art upon reviewing the disclosure. Other embodiments may be utilized and derived from the disclosure, such that structural and logical substitutions and changes may be made without departing from the scope of the disclosure. For example, method steps may be performed in a different order than is shown in the figures or one or more method steps may be omitted. Accordingly, the disclosure and the figures are to be regarded as illustrative rather than restrictive.

[0053] Moreover, although specific embodiments have been illustrated and described herein, it should be appreciated that any subsequent arrangement designed to achieve the same or similar results may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all subsequent adaptations or variations of various embodiments.

Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the description.

[0054] The Abstract of the Disclosure is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, various features may be grouped together or described in a single embodiment for the purpose of streamlining the disclosure. This disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, the claimed subject matter may be directed to less than all of the features of any of the disclosed embodiments.

CLAIMS

What is claimed is:

1. A method comprising:

receiving heartbeat data of a patient;

receiving activity data of the patient, wherein the activity data includes one or more activity values that are related to an activity level of the patient and that are measured independently of the heartbeat data;

determining a value of a weighting factor based on the activity data;

determining modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data; and

detecting a seizure event based on the modified heartbeat data.

2. The method of claim 1, wherein determining the modified heartbeat data includes determining a background (BG) heart rate based on a previously-determined BG heart rate, a most recent R-R interval, and the weighting factor.

3. The method of claim 2, wherein the BG heart rate is determined as a sum of a first value and a second value, wherein the first value is the weighting factor times the previously-determined BG heart rate and the second value is one minus the weighting factor times the most recent R-R interval.

4. The method of claim 2, wherein determining the modified heartbeat data further includes determining a foreground (FG) heart rate based on one or more R-R intervals of the heartbeat data.

5. The method of claim 4, wherein detecting the seizure event comprises comparing a ratio of the FG heart rate and the BG heart rate to a seizure detection threshold.

6. The method of claim 1, wherein the heartbeat data of the patient includes electrocardiogram data.

7. The method of claim 6, wherein the electrocardiogram data indicates a timing related to a plurality of R-waves.

8. The method of claim 1, further comprising detecting an indication of noise in the heartbeat data, wherein the weighting factor is determined further based on the indication of noise in the heartbeat data.

9. The method of claim 8, wherein:

in response to detecting an increase in the noise in the heartbeat data, the value of the weighting factor is determined such that an effect of prior heartbeat data on the modified heartbeat data is decreased; and

in response to detecting a decrease in the noise in the heartbeat data, the value of the weighting factor is determined such that the effect of the prior heartbeat data on the modified heartbeat data is increased.

10. The method of claim 1, further comprising causing, in response to the detection of the seizure event, initiating at least one of a stimulation to tissue of the patient, a reporting of the occurrence of the seizure event, and a recording of the seizure event.

11. The method of claim 1, wherein the activity data includes accelerometer data, body temperature data, electromyography data, perspiration data, impedance data, or a combination thereof.

12. The method of claim 1, wherein, in response to the activity data indicating an increased activity level of the patient, the value of the weighting factor is determined such that an effect of prior heartbeat data on the modified heartbeat data is decreased.

13. A medical device comprising:

a first interface to receive heartbeat data of a patient;

a second interface to receive activity data of the patient, wherein the activity data includes one or more activity values that are related to an activity level of the patient and that are measured independently of the heartbeat data; and

a processor configured to:

determine a value of a weighting factor based on the activity data;

determine modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data; and

detect a seizure event based on the modified heartbeat data.

14. The medical device of claim 13, wherein determining the modified heartbeat data includes determining a background (BG) heart rate based on a previously-determined BG heart rate, a most recent R-R interval, and the weighting factor.

15. The medical device of claim 14, wherein the BG heart rate is determined as a sum of a first value and a second value, wherein the first value is the weighting factor times the previously-determined BG heart rate and the second value is one minus the weighting factor times the most recent R-R interval.

16. The medical device of claim 14, wherein determining the modified heartbeat data further includes determining a foreground (FG) heart rate based on one or more R-R intervals of the heartbeat data, wherein the seizure event is detected by comparing a ratio of the FG heart rate and the BG heart rate to a seizure detection threshold.

17. The medical device of claim 13, wherein the processor is configured to detect an indication of noise in the heartbeat data, wherein in response to the noise in the heartbeat data increasing, the processor determines the value of the weighting factor such that an effect of prior heartbeat data on the modified heartbeat data is decreased, and wherein, in response to the noise in the heartbeat data decreasing, the processor determines the value of the weighting factor such that the effect of the prior heartbeat data on the modified heartbeat data is increased.

18. The medical device of claim 13, wherein the processor, in response to the detection of the seizure event, provides a signal to at least one of stimulation device disposed to provide stimulation to tissue of the patient, a signal indicating the occurrence of the seizure event, and a signal initiating the recording of the seizure event.

19. The medical device of claim 13, wherein activity data includes accelerometer data, body temperature data, electromyography data, perspiration data, impedance data, or a combination thereof.

20. The medical device of claim 13, wherein, in response to the activity data indicating an increased activity level of the patient, the processor determines the value of the weighting factor such that an effect of prior heartbeat data on the modified heartbeat data is decreased.

21. A non-transitory computer-readable medium storing instructions that are executable by a processor to cause the processor to perform operations including:

receiving heartbeat data of a patient;

receiving activity data of the patient, wherein the activity data includes one or more activity values that are related to an activity level of the patient and that are measured independently of the heartbeat data;

determining a value of a weighting factor based on the activity data;

determining modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data; and

detecting a seizure event based on the modified heartbeat data.

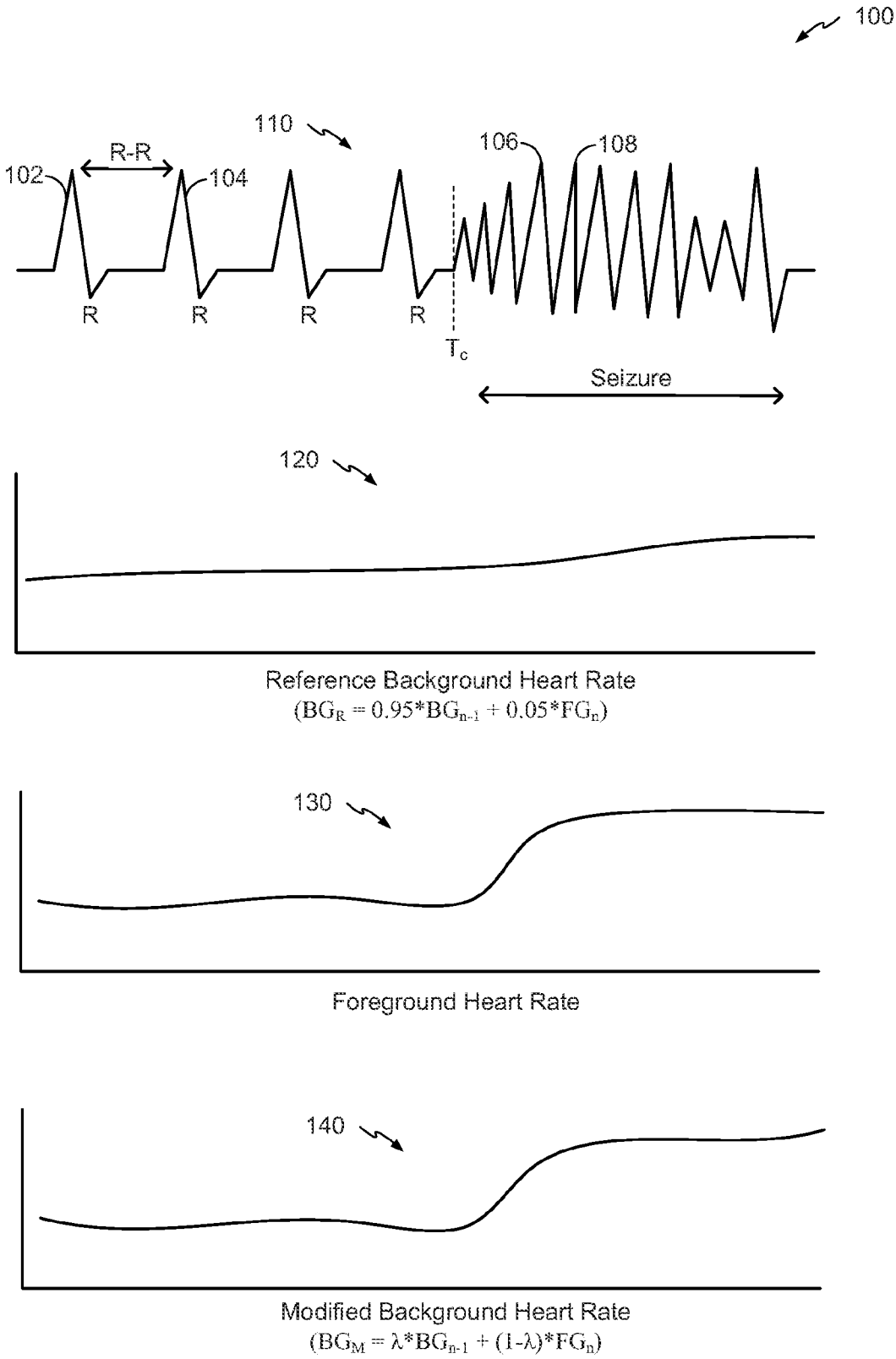
100
110
R-R
102
104
106
108
R
R
R
R
T_c
Seizure
120
Reference Background Heart Rate
($BG_R = 0.95*BG_{n-1} + 0.05*FG_n$)
130
Foreground Heart Rate
140
Modified Background Heart Rate
($BG_M = \lambda*BG_{n-1} + (1-\lambda)*FG_n$)

FIG. 1

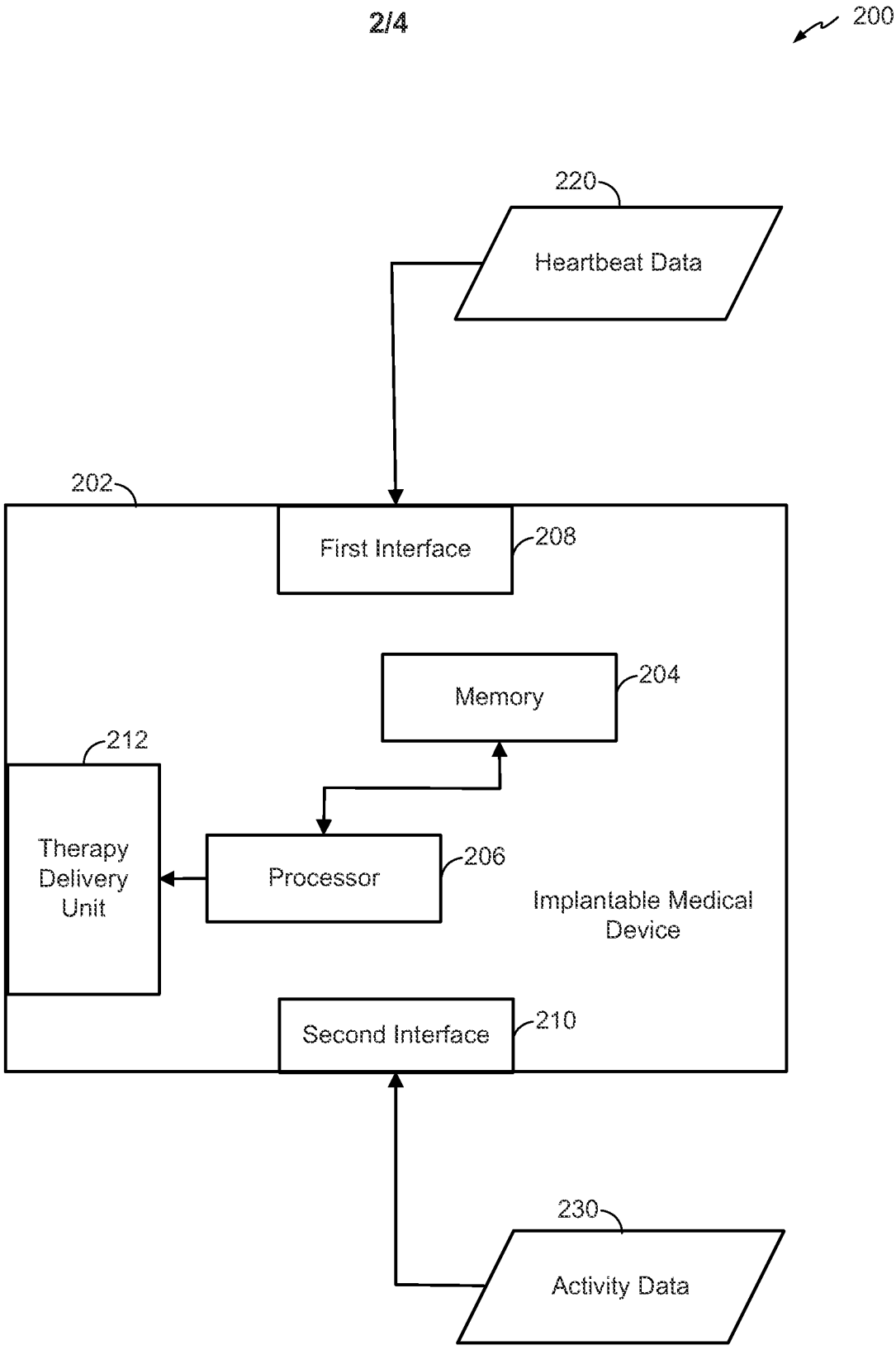
200
220
Heartbeat Data
202
First Interface
208
Memory
204
212
Therapy Delivery Unit
Processor
206
Implantable Medical Device
Second Interface
210
230
Activity Data

FIG. 2

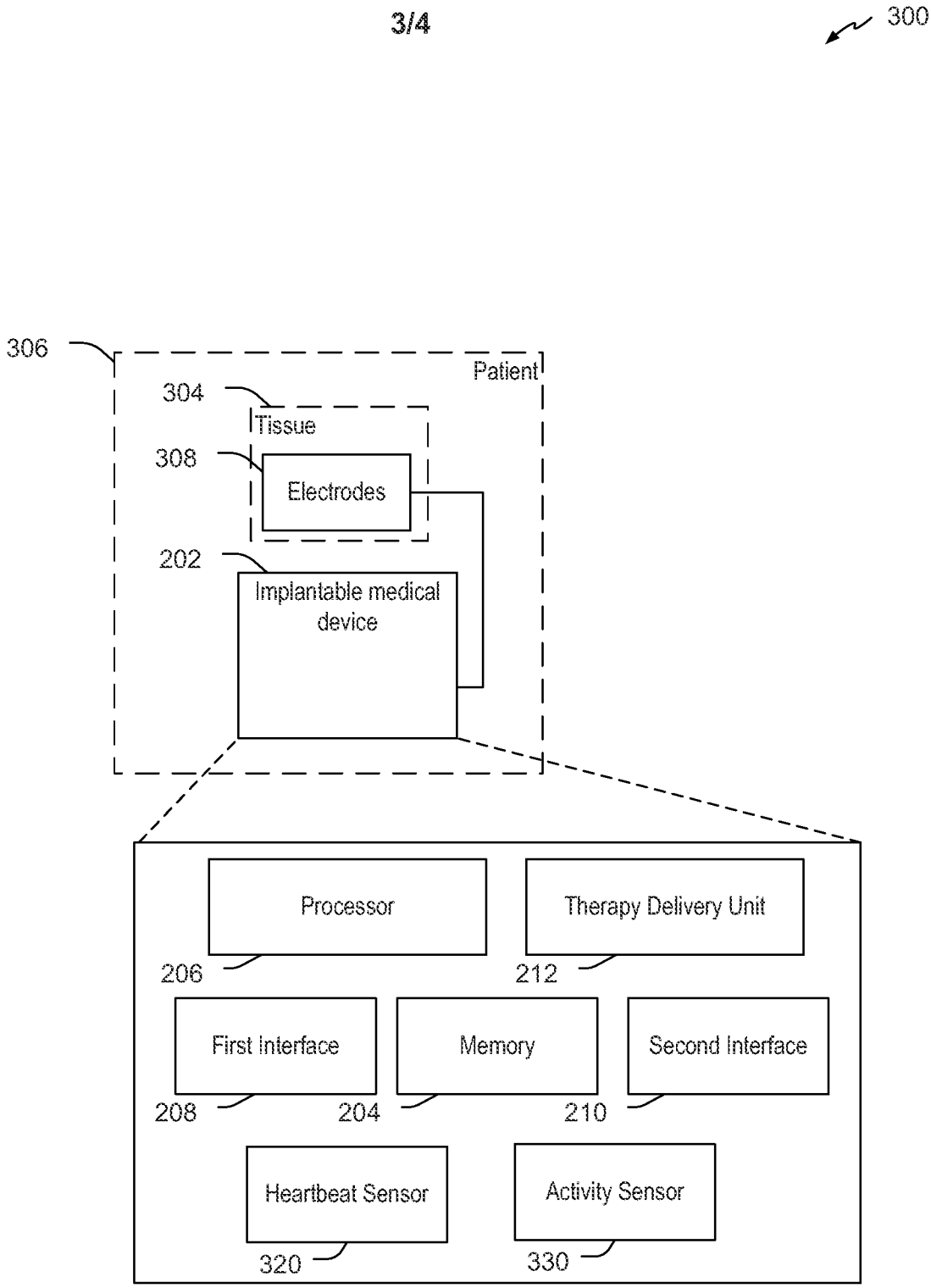
300
306
Patient
304
Tissue
308
Electrodes
202
Implantable medical device
Processor
206
Therapy Delivery Unit
212
First Interface
208
Memory
204
Second Interface
210
Heartbeat Sensor
320
Activity Sensor
330

FIG. 3

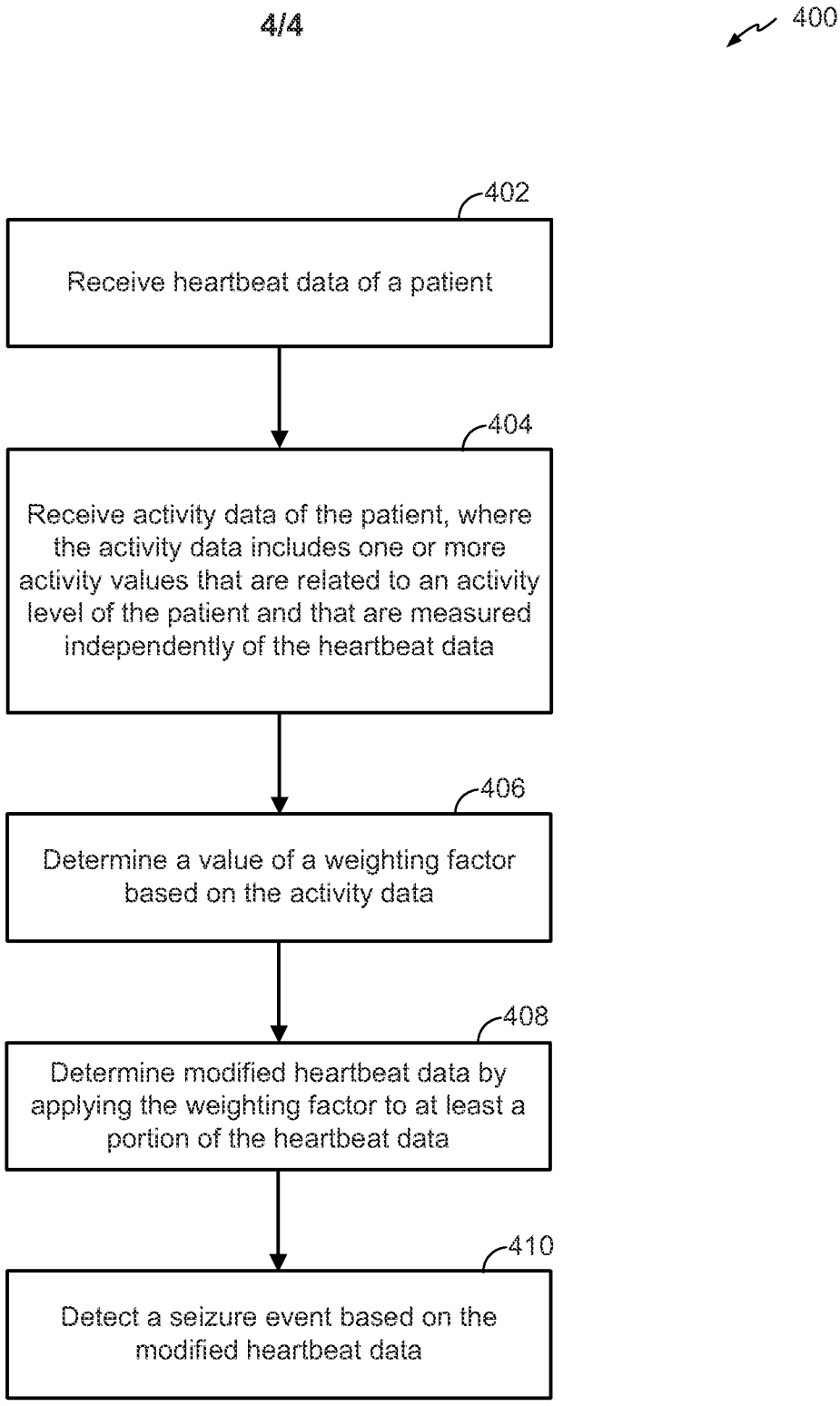
400
402
Receive heartbeat data of a patient
404
Receive activity data of the patient, where the activity data includes one or more activity values that are related to an activity level of the patient and that are measured independently of the heartbeat data
406
Determine a value of a weighting factor based on the activity data
408
Determine modified heartbeat data by applying the weighting factor to at least a portion of the heartbeat data
410
Detect a seizure event based on the modified heartbeat data

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/024879

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B5/024 A61B5/11
ADD. A61B5/0205 A61B5/01 A61B5/05 A61B5/0488

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/072425 A2 (KONINKL PHILIPS ELECTRONICS NV [NL]; PHILIPS CORP [US]; AARTS RONALD M) 28 June 2007 (2007-06-28) page 2, lines 13, 14, 24 page 3, lines 3, 5, 20, 22 page 6, line 22 figures 1, 2, 6	13-15, 17,19-21
X	WO 2013/056099 A1 (FLINT HILLS SCIENT LLC [US]; OSORIO IVAN [US]; LYUBUSHIN ALEXEY [RU];) 18 April 2013 (2013-04-18) paragraphs [0043], [0064], [0084], [0121], [0149] figure 3	13-15, 17-19,21

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 June 2015	25/06/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Meyer, Wolfgang

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/024879

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/270096 A1 (OSORIO IVAN [US] ET AL) 3 November 2011 (2011-11-03) paragraphs [0038], [0063], [0084], [0145], [0201], [0206], [0256], [0260] figures 2A, 2B	13-18,21
A	EP 2 030 565 A1 (MEDICALGORITHMICS SP Z O O [PL]) 4 March 2009 (2009-03-04) equation (15)	14-16
A	US 2011/270346 A1 (FREI MARK [US] ET AL) 3 November 2011 (2011-11-03) paragraphs [0211] - [0214]	17
A	US 2012/277605 A1 (COLBORN JOHN C [US]) 1 November 2012 (2012-11-01) the whole document	13-21
A	US 2008/269631 A1 (DENISON TIMOTHY J [US] ET AL) 30 October 2008 (2008-10-30) the whole document	13-21
A	US 2012/116183 A1 (OSORIO IVAN [US]) 10 May 2012 (2012-05-10) the whole document	13-21

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/024879

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 1-12
because they relate to subject matter not required to be searched by this Authority, namely:

Claims 1-12 have not been searched, because they are defining mental acts or comprising diagnostic methods performed on the human body and thus fail to comply with Rule 39.1(iii) and 39.1(iv) PCT

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/024879

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2007072425 A2	28-06-2007	CN 101340846 A	07-01-2009
		EP 1965696 A2	10-09-2008
		JP 2009519803 A	21-05-2009
		US 2008319281 A1	25-12-2008
		WO 2007072425 A2	28-06-2007
WO 2013056099 A1	18-04-2013	US 2013096393 A1	18-04-2013
		WO 2013056099 A1	18-04-2013
US 2011270096 A1	03-11-2011	US 2011270096 A1	03-11-2011
		US 2014046203 A1	13-02-2014
EP 2030565 A1	04-03-2009	EP 2030565 A1	04-03-2009
		US 2009171227 A1	02-07-2009
		US 2015018700 A1	15-01-2015
US 2011270346 A1	03-11-2011	US 2011270346 A1	03-11-2011
		US 2014378851 A1	25-12-2014
US 2012277605 A1	01-11-2012	EP 2701583 A1	05-03-2014
		US 2012277605 A1	01-11-2012
		WO 2012148467 A1	01-11-2012
US 2008269631 A1	30-10-2008	NONE	
US 2012116183 A1	10-05-2012	NONE	