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(72) Inventors:
• **MUKHOPADHYAY, SHALINI**
700160 Kolkata - West Bengal (IN)
• **GHOSE, AVIK**
700160 Kolkata - West Bengal (IN)
• **AHMED, NASIMUDDIN**
700160 Kolkata - West Bengal (IN)
• **PAL, ARPAN**
700160 Kolkata - West Bengal (IN)

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(74) Representative: **Goddar, Heinz J.**
Boehmert & Boehmert
Anwaltpartnerschaft mbB
Pettenkofenstrasse 22
80336 München (DE)

(54) **HEART RATE ESTIMATION TAKING MOBILITY STATES INTO ACCOUNT**

(57) The heart rate monitoring systems currently available are prone to mistaking heart rate variation (caused due to the user involving in the physical activity) as an abnormal variation, even though such variations are 'normal', and may even trigger a false alarm. Even the monitoring systems which consider mobility states of the user so as to filter out such variations caused due to user activities may fail to consider change in mobility states at the time of measuring the heart rate data, which may have direct impact on the heart rate variations. A system and a method for heart rate estimation are provided wherein data pertaining to transition between different mobility states is considered by the system to filter out variations due to the transition between mobility states of the user. Different types of such transitions are identified, and appropriate methods are executed to filter the estimated heart rate data.

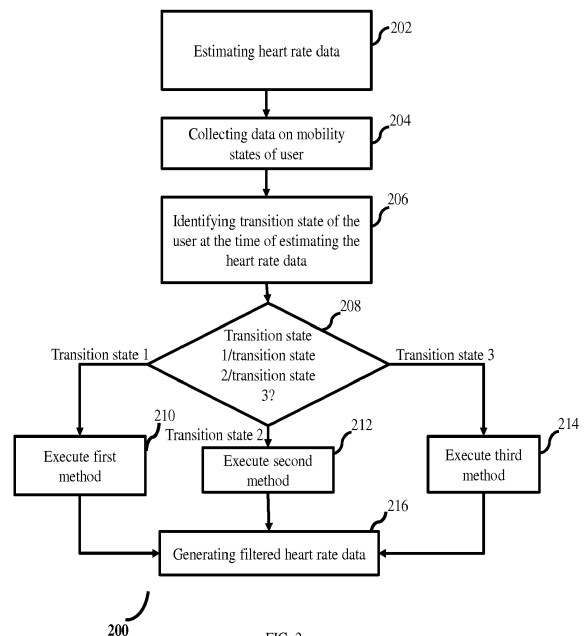


FIG. 2

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS AND PRIORITY

[0001] The present application claims priority to Indian complete specification (Title: SYSTEM AND METHOD FOR HEART RATE ESTIMATION USING A TRACKING MECHANISM) Application No. (201821040008), filed in India on October 23, 2018.

TECHNICAL FIELD

[0002] The disclosure herein generally relates to heart rate monitoring and estimation, and, more particularly, to a system and a method for improving the heart rate estimation based on a determined transition state of the user.

BACKGROUND

[0003] One important measurement performed by many of the health monitoring equipment(s) is heart rate measurement, as heart rate is a crucial health parameter which can be indicative of health status of a user being monitored. The heart rate is typically measured in beats per minute (BPM). Many electronic heart rate monitors (also referred to as 'monitors') for measuring heart rate are available in the market today. Such heart rate monitoring and estimation devices are available in different forms. Some popular forms are chest straps, and different types of (smart) wearable devices (examples include watches, rings, wristbands, chest straps, headbands, headphones, ear buds, clamps, clips, clothing, bags, shoes, glasses, goggles, hats, suits, necklace, attachments/patches/strips/pads which can adhere to a living being, accessories, portable devices, and so on).

[0004] Many of such monitors currently being used are automatic, which means these devices can monitor and estimate heart rate of the user without requiring user intervention. Some of such devices may also be configured to trigger certain actions when certain preset conditions are detected/met. For example, the condition detected maybe a sudden variation in heart rate, which could be indicative of a health issue of the user, and in that scenario, the action maybe triggering an alarm to notify the user, and/or any other person.

[0005] However, these heart rate monitors have certain disadvantage(s) that they are often not very accurate, due to a high amount of noise present in the signals provided by the sensors of these monitors. The noise may be caused due to various reasons. One such reason is the user being monitored involving in any physical activity. When the user is engaged in a physical activity such as walking, climbing, jogging and so on, such activities may cause heart rate of the user to rise, and it may be a normal process. However, a system that is configured to trigger an alarm in response to an abnormal

variation in the heart rate may still trigger the alarm upon detecting the variation in the heart rate, even though it was caused due to the user involving in the physical activity, which means the system triggered a false alarm.

5 Some of the existing systems handle such scenarios by monitoring and considering mobility states of the user at the time of measurement of the heart rate. The term 'mobility states' may refer to state of motion or state of rest. If detected mobility state of the user indicates that the user was in motion and/or was involved in any physical activity at a time an 'abnormal' spike in the value of heart rate of the user was detected, then the system may filter out the detected spike, which in turn eliminates chances of the system triggering a false alarm. However, such systems may fail to provide accurate results as the mobility state of a user may not be constant throughout the heart rate estimation.

SUMMARY

20 **[0006]** Embodiments of the present disclosure present technological improvements as solutions to one or more of the above-mentioned technical problems recognized by the inventors in conventional systems. For example, in one embodiment, a system for heart rate estimation is provided. The system includes a memory module; one or more communication interfaces; a heart rate estimation module, a post processing module, and one or more hardware processors coupled to the memory module via the one or more communication interfaces, wherein the one or more hardware processors are caused by the plurality of instructions to: estimate heart rate data of a user, via the heart rate estimation module, wherein the estimated heart rate is distributed among a plurality of time windows; collect data pertaining to a first mobility state and a second mobility state of the user, while estimating the heart rate data; process the estimated heart rate data and the data pertaining to the first mobility state and the second mobility state, comprising: (a) identifying a transition state of the user as one of a first transition state, a second transition state, or a third transition state, in terms of transition between the first mobility state and the second mobility state at the time of estimating the heart rate data; (b) filtering the estimated heart rate data, via the post processing module, based on the identified transition state of the user; and (c) generating the filtered heart rate data as output.

45 **[0007]** In another aspect, a method for heart rate estimation is provided. The method includes steps of: estimating heart rate data of a user, wherein the estimated heart rate is distributed among a plurality of time windows; collecting data pertaining to a first mobility state and a second mobility state of the user, while estimating the heart rate data; processing the estimated heart rate data and the data pertaining to the first mobility state and the second mobility state, comprising: (a) identifying a transition state of the user as one of a first transition state, a second transition state, or a third transition state, in

terms of transition between the first mobility state and the second mobility state while estimating the heart rate data; (b) filtering the estimated heart rate data based on the identified transition state of the user; and (f) generating the filtered heart rate data as output.

[0008] In yet another aspect, a non-transitory computer readable medium for heart rate estimation is provided. The non-transitory computer readable medium performs the heart rate estimation by: estimating heart rate data of a user, wherein the estimated heart rate is distributed among a plurality of time windows; collecting data pertaining to a first mobility state and a second mobility state of the user, while estimating the heart rate data; processing the estimated heart rate data and the data pertaining to the first mobility state and the second mobility state, comprising: (a) identifying a transition state of the user as one of a first transition state, a second transition state, or a third transition state, in terms of a transition between the first mobility state and the second mobility state while estimating the heart rate data; (b) filtering the estimated heart rate data based on the identified transition state of the user; and (f) generating the filtered heart rate data as output.

[0009] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles:

FIG. 1 illustrates an exemplary block diagram of a system for heart rate estimation, in accordance with some embodiments of the present disclosure.

FIG. 2 is a flow diagram depicting the steps involved in the process of heart rate estimation and filtering of estimated heart rate data using the system of FIG. 1, in accordance with some embodiments of the present disclosure.

FIG. 3 is a flow diagram depicting the steps involved in the process of filtering the estimated heart rate data by executing a first method using the system of FIG. 1, in accordance with some embodiments of the present disclosure.

FIG. 4 is a flow diagram depicting the steps involved in the process of filtering the estimated heart rate data by executing a second method using the system of FIG. 1, in accordance with some embodiments of the present disclosure.

FIG. 5 is a flow diagram depicting the steps involved in the process of filtering the estimated heart rate data by executing a third method using the system of FIG. 1, in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0011] Exemplary embodiments are described with reference to the accompanying drawings. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the spirit and scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope and spirit being indicated by the following claims.

[0012] Referring now to the drawings, and more particularly to FIG. 1 through FIG. 5, where similar reference characters denote corresponding features consistently throughout the figures, there are shown preferred embodiments and these embodiments are described in the context of the following exemplary system and/or method.

[0013] FIG. 1 illustrates an exemplary block diagram of a system for heart rate estimation, according to some embodiments of the present disclosure. In an embodiment, the system 100 includes one or more hardware processors 102, communication interface(s) or input/output (I/O) interface(s) 103, and one or more data storage devices or memory module 101 operatively coupled to the one or more hardware processors 102. The one or more hardware processors 102 can be implemented as one or more microprocessors, microcomputers, microcontrollers, digital signal processors, central processing units, state machines, graphics controllers, logic circuitries, and/or any devices that manipulate signals based on operational instructions. Among other capabilities, the processor(s) are configured to fetch and execute computer-readable instructions stored in the memory. In an embodiment, the system 100 can be implemented in a variety of computing systems, such as laptop computers, notebooks, hand-held devices, workstations, mainframe computers, servers, a network cloud and the like.

[0014] The communication interface(s) 103 can include a variety of software and hardware interfaces, for example, a web interface, a graphical user interface, and the like and can facilitate multiple communications within a wide variety of networks N/W and protocol types, including wired networks, for example, LAN, cable, etc., and wireless networks, such as WLAN, cellular, or satellite. In an embodiment, the communication interface(s) 103 can include one or more ports for connecting a number of devices to one another or to another server.

[0015] The memory module(s) 101 may include any computer-readable medium known in the art including, for example, volatile memory, such as static random access memory (SRAM) and dynamic random access memory (DRAM), and/or non-volatile memory, such as read only memory (ROM), erasable programmable

ROM, flash memories, hard disks, optical disks, and magnetic tapes. In an embodiment, one or more modules (not shown) of the system 100 can be stored in the memory 101.

[0016] The system 100, using the one or more hardware processors (also referred to as 'processors' throughout the specification) estimates heart rate of a user. The system 100 may use any of the existing heart rate estimation mechanisms for the purpose of estimating the heart rate. In another embodiment, the system 100 may be configured to track heart rate estimation being performed by any external system, and collect heart rate data estimated by the external system, as input, for further processing. For the purpose of processing the estimated heart rate data, the system 100 distributes the heart rate data into multiple time windows, in the order the heart rate data is estimated, and based on corresponding timestamp (matching the estimated heart rate data).

[0017] The system 100, along with the heart rate data, also collects data pertaining to at least two mobility states, of the user being monitored. For the purpose of explanation, two mobility states (a first mobility state and a second mobility state) are considered. The mobility states are 'a state of rest' and a 'state of motion'. Again, for the purpose of explanation, the 'state of rest' is termed as a 'first mobility state' and the 'state of motion' is termed as a 'second mobility state'. It is to be noted that in an alternate embodiment, the state of motion may be the first mobility state and the state of rest may be the second mobility state. The heart rate estimation process is explained in the specification by considering the 'state of rest' as the 'first mobility state' and the 'state of motion' as the second mobility state'.

[0018] Further, the system 100 considers heart rate data and mobility state data from two windows (a first window and a second window) of the plurality of time windows, at a time, for processing. During the processing, the system 100 identifies a transition state of the user between the first and second windows considered. In an embodiment, the system 100 identifies the transition state of the user, based on the data pertaining to the mobility states i.e. the transition state of the user represents/indicates presence or absence of change in mobility state of the user, between the first window and the second window. The system 100 identifies the transition state of the user as 'transition state 1 (also referred to as 'first transition state')' if the mobility state of the user changes from the first mobility state to the second mobility state, between the first and second windows. The system 100 identifies transition state of the user as 'transition state 2 (also referred to as 'second transition state')' if the mobility state of the user continues to be the first mobility state (in other words, the user continues to be in the first mobility state), between the first and second windows. The system 100 identifies transition state of the user as 'transition state 3 (also referred to as 'third transition state')' if the mobility state of the user changes

from the second mobility state to the first mobility state or if the user continues to be in the second mobility state, between the first and second windows. Based on the identified transition state of the user, the system 100 executes one of a first method, a second method, or a third method so as to filter the estimated heart rate data.

[0019] FIG. 2 is a flow diagram depicting the steps involved in the process of heart rate estimation and filtering of estimated heart rate data, in accordance with some embodiments of the present disclosure. The system 100 initially estimates (202) heart rate data of a user being monitored. The system 100 further collects (204) data pertaining to mobility state of the user (mobility state data), at the same time the heart rate measurement is being performed. The system 100 distributes the heart rate data among a plurality of time windows, and then picks heart rate data and corresponding mobility state data from a first window and a second window of the plurality of time windows, at a time, for processing.

[0020] The system 100 identifies (206) transition state of the user, for the two windows being considered, based on the mobility state(s) of the user in the first window and the second window. The transition state of the user is identified as one of a transition state 1, transition state 2, or transition state 3. If the identified transition state is transition state 1, then the system 100 executes (210) a first method (explained in Fig. 3 description). If the identified transition state is transition state 2, then the system 100 executes (212) a second method (explained in Fig. 4 description). If the identified transition state is transition state 3, then the system 100 executes (214) a third method (explained in Fig. 5 description). By executing one of the first method, the second method, and the third method, the system 100 generates (216) a filtered heart rate data.

[0021] When the user's mobility state changes, there is a transition from rest to motion or motion to rest. In either case, due to movement, heart rate data of the user may vary. As change in heart rate is considered 'normal' while the mobility state of the user changes, by identifying the transition state and by executing appropriate method (first method or second method or third method), the system 100 applies appropriate correction to the estimated heart rate data. This in turn helps the system 100 to prevent triggering false alarms. In various embodiments, various steps in method 200 may be performed in the same order as depicted in FIG. 2 or in any appropriate alternate order when required. In another embodiment, one or more steps from FIG. 2 may be skipped.

[0022] FIG. 3 is a flow diagram depicting the steps involved in the process of filtering the estimated heart rate data by executing a first method using the system of FIG. 1, in accordance with some embodiments of the present disclosure.

[0023] In the first method, the system 100 checks (302) whether heart rate value in the second window lies between heart rate value in a first window and a first reference value. In an embodiment, the first reference value

equals summation of heart rate value in the first window and a heart rate change tolerance interval (also referred to as 'interval'). In an embodiment, the value of interval is set to 10. If the heart rate value in the second window lies between the heart rate value in the first window and the first reference value, then the system 100 resets (304) the value of interval to a first incremental value and subsequently generates (306) value of the filtered heart rate data as equal to heart rate data in the second window. In an embodiment, the first reference value equals summation of the interval and heart rate value in the first window. If the heart rate value in the second window does not lie between the heart rate value in the first window and the first reference value, then the system 100 generates (308) value of the filtered heart rate data as equal to summation of heart rate value in the first window and a second incremental value. In various embodiments, values of the interval, the first incremental value, and the second incremental value are decided/selected based on one or more known facts, and may be pre-configured or dynamically configured with the system 100. For example, the first incremental value and the second incremental value may be set to 10. In various embodiments, various steps in method 300 may be performed in the same order as depicted in FIG. 3 or in any appropriate alternate order when required. In another embodiment, one or more steps from FIG. 3 maybe skipped.

[0024] FIG. 4 is a flow diagram depicting the steps involved in the process of filtering the estimated heart rate using a second method, in accordance with some embodiments of the present disclosure. While executing the second method, the system 100 checks (402) whether the heart rate value in the second window lies between a second reference value and a third reference value. The second reference value equals summation of heart rate value in the second window and the interval. The third reference value equals difference between the heart rate value in the second window and the interval. If the heart rate value in the second window lies between a second reference value and a third reference value, then the system 100 resets the interval to a value equal to the first incremental value and subsequently generates (406) value of the filtered heart rate data as equal to the heart rate value in the second window. If the heart rate value in the second window does not lie between the second reference value and the third reference value, then the system 100 generates value of the filtered heart rate data (output of the system 100) as equal to the heart rate value in the first window, and subsequently increments the value of the interval by a third incremental value. In various embodiments, values of the first incremental value and the third incremental value may be decided/selected based on known facts, and may be pre-configured dynamically configured with the system 100. In various embodiments, various steps in method 400 may be performed in the same order as depicted in FIG. 4 or in any appropriate alternate order when required. In another embodiment, one or more steps from FIG. 4 maybe

skipped.

[0025] FIG. 5 is a flow diagram depicting the steps involved in the process of filtering the estimated heart rate using a third method, in accordance with some embodiments of the present disclosure. The system 100 checks (502) whether the heart rate value in the second window lies between the second reference value and the third reference value. If the heart rate value in the second window lies between the second reference value and the third reference value, then the system 100 resets the interval to a value equaling the first incremental value and subsequently generates the value of the filtered heart rate data as equal to the heart rate value in the second window. If the heart rate value in the second window does not lie between the second reference value and the third reference value, then the system 100 generates value of the filtered heart rate data as equal to the heart rate value in the first window, and subsequently increments the value of the interval by a value which is equal to first incremental value. In various embodiments, various steps in method 500 may be performed in the same order as depicted in FIG. 5 or in any appropriate alternate order when required. In another embodiment, one or more steps from FIG. 5 maybe skipped.

[0026] The written description describes the subject matter herein to enable any person skilled in the art to make and use the embodiments. The scope of the subject matter embodiments is defined by the claims and may include other modifications that occur to those skilled in the art. Such other modifications are intended to be within the scope of the claims if they have similar elements that do not differ from the literal language of the claims or if they include equivalent elements with insubstantial differences from the literal language of the claims.

[0027] The embodiments of present disclosure herein addresses unresolved problem of heart rate estimation by considering the transition states of the user. The embodiment, thus provides a system and a method which improves the heart rate estimation accuracy utilizing information pertaining to change mobility states of the user at the time the heart rate data is being estimated.

[0028] It is to be understood that the scope of the protection is extended to such a program and in addition to a computer-readable means having a message therein; such computer-readable storage means contain program-code means for implementation of one or more steps of the method, when the program runs on a server or mobile device or any suitable programmable device. The hardware device can be any kind of device which can be programmed including e.g. any kind of computer like a server or a personal computer, or the like, or any combination thereof. The device may also include means which could be e.g. hardware means like e.g. an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or a combination of hardware and software means, e.g. an ASIC and an FPGA, or at least one microprocessor and at least one memory with software modules located therein. Thus, the means can

include both hardware means and software means. The method embodiments described herein could be implemented in hardware and software. The device may also include software means. Alternatively, the embodiments may be implemented on different hardware devices, e.g. using a plurality of CPUs.

[0029] The embodiments herein can comprise hardware and software elements. The embodiments that are implemented in software include but are not limited to, firmware, resident software, microcode, etc. The functions performed by various modules described herein may be implemented in other modules or combinations of other modules. For the purposes of this description, a computer-usable or computer readable medium can be any apparatus that can comprise, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

[0030] The illustrated steps are set out to explain the exemplary embodiments shown, and it should be anticipated that ongoing technological development will change the manner in which particular functions are performed. These examples are presented herein for purposes of illustration, and not limitation. Further, the boundaries of the functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternative boundaries can be defined so long as the specified functions and relationships thereof are appropriately performed. Alternatives (including equivalents, extensions, variations, deviations, etc., of those described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternatives fall within the scope and spirit of the disclosed embodiments. Also, the words "comprising," "having," "containing," and "including," and other similar forms are intended to be equivalent in meaning and be open ended in that an item or items following any one of these words is not meant to be an exhaustive listing of such item or items, or meant to be limited to only the listed item or items. It must also be noted that as used herein and in the appended claims, the singular forms "a," "an," and "the" include plural references unless the context clearly dictates otherwise.

[0031] Furthermore, one or more computer-readable storage media may be utilized in implementing embodiments consistent with the present disclosure. A computer-readable storage medium refers to any type of physical memory on which information or data readable by a processor may be stored. Thus, a computer-readable storage medium may store instructions for execution by one or more processors, including instructions for causing the processor(s) to perform steps or stages consistent with the embodiments described herein. The term "computer-readable medium" should be understood to include tangible items and exclude carrier waves and transient signals, i.e., be non-transitory. Examples include random access memory (RAM), read-only memory (ROM), volatile memory, nonvolatile memory, hard drives, CD

ROMs, DVDs, flash drives, disks, and any other known physical storage media.

[0032] It is intended that the disclosure and examples be considered as exemplary only, with a true scope and spirit of disclosed embodiments being indicated by the following claims.

Claims

1. A method for heart rate estimation, the method comprising the steps of:

estimating heart rate data of a user, wherein the estimated heart rate is distributed among a plurality of time windows;
collecting data pertaining to a first mobility state and a second mobility state of the user, while estimating the heart rate data; and
processing the estimated heart rate data and the data pertaining to the first mobility state and the second mobility state, comprising:

identifying a transition state of the user as one of a first transition state, a second transition state, or a third transition state, in terms of transition between the first mobility state and the second mobility state while estimating the heart rate data;
filtering the estimated heart rate data based on the identified transition state of the user; and
generating a filtered heart rate data as output.

2. The method as claimed in claim 1, wherein the first mobility state is a state of rest and the second mobility state is a state of motion.

3. The method as claimed in claim 2, wherein the first transition state represents transition of user from the first mobility state to the second mobility state between a first window and a second window of the plurality of time windows, and wherein filtering the estimated heart rate data if the identified transition state is the first transition state, by executing a first method, comprises:

checking whether heart rate value in the second window of the plurality of time windows lies between heart rate value in the first window and a first reference value;

if the heart rate value in the second window lies between the heart rate value in the first window and the first reference value:

resetting value of 'interval' to a first incremental value; and

- generating the filtered heart rate data as equal to heart rate value in the second window; and
- if the heart rate value in the second window does not lie between the heart rate value in the first window and the first reference value:
generating the filtered heart rate data as equal to summation of heart rate value in the first window and a second incremental value.
4. The method as claimed in claim 2, wherein the second transition state represents the user continuing in the first mobility state between a first window and a second window of the plurality of time windows, wherein filtering the heart rate data if the identified transition state is the second transition state, by executing a second method, comprises:
checking whether the heart rate value in the second window lies between a second reference value and a third reference value;
- if the heart rate value in the second window lies between a second reference value and a third reference value:
resetting value of 'interval' to a first incremental value; and
generating the filtered heart rate data as equal to the heart rate value in the second window; and
- if the heart rate value in the second window does not lie between the second reference value and the third reference value:
generating the filtered heart rate data as equal to the heart rate value in the first window; and
increasing value of the interval by a value equal to a third incremental value.
5. The method as claimed in claim 2, wherein the third transition state represents transition of user from the second mobility state to the first mobility state or the user continuing in the second mobility state, between a first window and a second window of the plurality of time windows, wherein filtering the heart rate data if the identified transition state is the third transition state, by executing a third method, comprises:
checking whether the heart rate value in the second window lies between a second reference value and a third reference value;
- if the heart rate value in the second window lies between the second reference value and the third reference value:
- resetting value of 'interval' to a first incremental value; and
generating the filtered heart rate data as equal to the heart rate value in the second window; and
- if the heart rate value in the second window does not lie between the second reference value and the third reference value:
generating the filtered heart rate data as equal to the heart rate value in the first window; and
increasing value of the interval by the first incremental value.
6. A system (100) for heart rate estimation comprising:
a memory module (102) storing a plurality of instructions;
one or more communication interfaces (110); and
one or more hardware processors (104) coupled to the memory module (102) via the one or more communication interfaces (110), wherein the one or more hardware processors are caused by the plurality of instructions to:
estimate heart rate data of a user, via the heart rate estimation module (106), wherein the estimated heart rate is distributed among a plurality of time windows;
collect data pertaining to a first mobility state and a second mobility state of the user, while estimating the heart rate data; and
process the estimated heart rate data and the data pertaining to the first mobility state and the second mobility state, comprising:
identifying a transition state of the user as one of a first transition state, a second transition state, or a third transition state, in terms of a transition between the first mobility state and the second mobility state while estimating the heart rate data;
filtering the estimated heart rate data based on the identified transition state of the user, via the post processing module (108); and
generating a filtered heart rate data as output.
7. The system as claimed in claim 6, wherein the first mobility state is a state of rest and the second mobility state is a state of motion.
8. The system as claimed in claim 6, wherein the first

transition state represents transition of user from the first mobility state to the second mobility state between a first window and a second window of the plurality of time windows, and wherein the system filters the heart rate data by executing a first method, if the identified transition state is the first transition state, by:

checking whether heart rate value in a second window of the plurality of time windows lies between heart rate value in a first window of the plurality of time windows and a first reference value;

if the heart rate value in the second window lies between the heart rate value in the first window and the first reference value:

resetting value of 'interval' to first incremental value; and
generating the filtered heart rate data as equal to heart rate value in the second window; and

if the heart rate value in the second window does not lie between the heart rate value in the first window and the first reference value:

generating the filtered heart rate data as equal to summation of heart rate value in the first window and second incremental value.

- 9. The system as claimed in claim 6, wherein the second transition state represents the user continuing in the first mobility state between a first window and a second window of the plurality of time windows, wherein the system filters the heart rate data by executing a second method, if the identified transition state is the second transition state, by: checking whether the heart rate value in the second window lies between a second reference value and a third reference value;

if the heart rate value in the second window lies between a second reference value and a third reference value:

resetting value of 'interval' to a first incremental value; and
generating the filtered heart rate data as equal to the heart rate value in the second window;

if the heart rate value in the second window does not lie between a second reference value and a third reference value:

generating the filtered heart rate data as equal to the heart rate value in the first window; and
increasing value of the interval by a value

equal to a third incremental value.

- 10. The system as claimed in claim 6, wherein the third transition state represents transition of user from the second mobility state to the first mobility state or the user continuing in the second mobility state, between a first window and a second window of the plurality of time windows, wherein the system filters the heart rate data by executing a third method, if the identified transition state is the third transition state, by: checking whether the heart rate value in the second window lies between the second reference value and the third reference value;

if the heart rate value in the second window lies between the second reference value and the third reference value:

resetting value of 'interval' to a first incremental value; and
generating the filtered heart rate data as equal to the heart rate value in the second window; and

if the heart rate value in the second window does not lie between the second reference value and the third reference value:

generating the filtered heart rate data as equal to the heart rate value in the first window; and
increasing value of the interval by a first incremental value.

- 11. One or more non-transitory machine readable information storage mediums comprising one or more instructions which when executed by one or more hardware processors cause:

estimating heart rate data of a user, wherein the estimated heart rate is distributed among a plurality of time windows;
collecting data pertaining to a first mobility state and a second mobility state of the user, while estimating the heart rate data; and
processing the estimated heart rate data and the data pertaining to the first mobility state and the second mobility state, comprising:

identifying a transition state of the user as one of a first transition state, a second transition state, or a third transition state, in terms of transition between the first mobility state and the second mobility state while estimating the heart rate data;
filtering the estimated heart rate data based on the identified transition state of the user; and

- generating a filtered heart rate data as output.
12. The one or more non-transitory machine readable information storage mediums of claim 11, wherein the first mobility state is a state of rest and the second mobility state is a state of motion. 5
13. The one or more non-transitory machine readable information storage mediums of claim 12, wherein the first transition state represents transition of user from the first mobility state to the second mobility state between a first window and a second window of the plurality of time windows, and wherein filtering the estimated heart rate data if the identified transition state is the first transition state, by executing a first method, comprises: 10
- checking whether heart rate value in the second window of the plurality of time windows lies between heart rate value in the first window and a first reference value; 20
- if the heart rate value in the second window lies between the heart rate value in the first window and the first reference value: 25
- resetting value of 'interval' to a first incremental value; and
- generating the filtered heart rate data as equal to heart rate value in the second window; and 30
- if the heart rate value in the second window does not lie between the heart rate value in the first window and the first reference value: 35
- generating the filtered heart rate data as equal to summation of heart rate value in the first window and a second incremental value.
14. The one or more non-transitory machine readable information storage mediums of claim 12, wherein the second transition state represents the user continuing in the first mobility state between a first window and a second window of the plurality of time windows, wherein filtering the heart rate data if the identified transition state is the second transition state, by executing a second method, comprises: 40
- checking whether the heart rate value in the second window lies between a second reference value and a third reference value; 45
- if the heart rate value in the second window lies between a second reference value and a third reference value: 50
- resetting value of 'interval' to a first incremental value; and 55
- generating the filtered heart rate data as

- equal to the heart rate value in the second window; and
- if the heart rate value in the second window does not lie between the second reference value and the third reference value:
- generating the filtered heart rate data as equal to the heart rate value in the first window; and
- increasing value of the interval by a value equal to a third incremental value.
15. The one or more non-transitory machine readable information storage mediums of claim 12, wherein the third transition state represents transition of user from the second mobility state to the first mobility state or the user continuing in the second mobility state, between a first window and a second window of the plurality of time windows, wherein filtering the heart rate data if the identified transition state is the third transition state, by executing a third method, comprises: 5
- checking whether the heart rate value in the second window lies between a second reference value and a third reference value; 10
- if the heart rate value in the second window lies between the second reference value and the third reference value: 15
- resetting value of 'interval' to a first incremental value; and
- generating the filtered heart rate data as equal to the heart rate value in the second window; and 20
- if the heart rate value in the second window does not lie between the second reference value and the third reference value: 25
- generating the filtered heart rate data as equal to the heart rate value in the first window; and
- increasing value of the interval by the first incremental value. 30

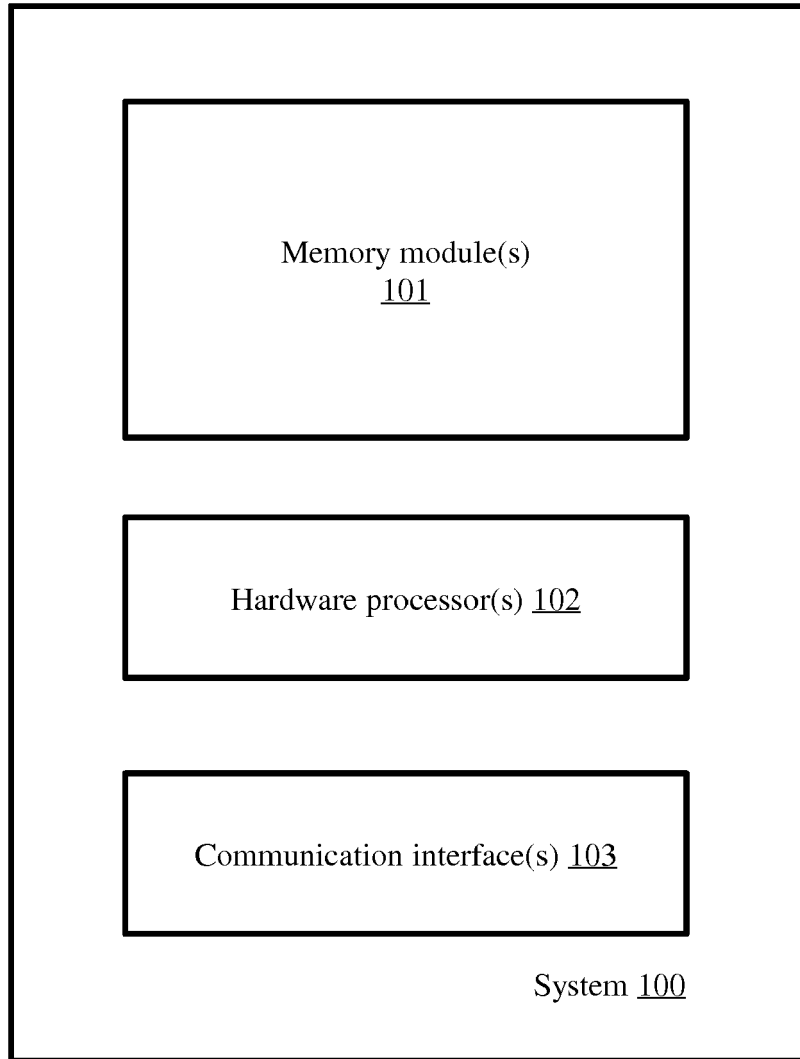


Fig. 1

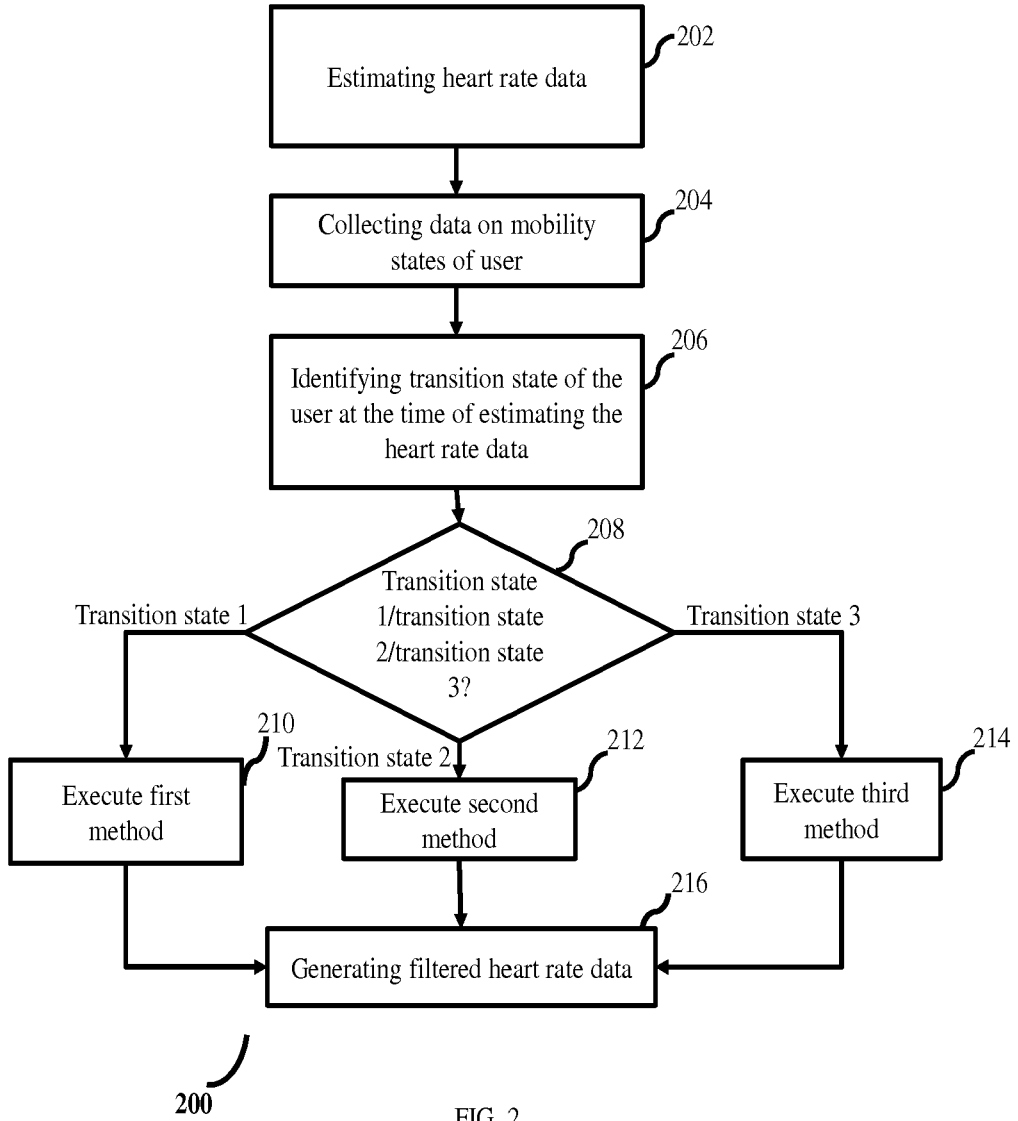
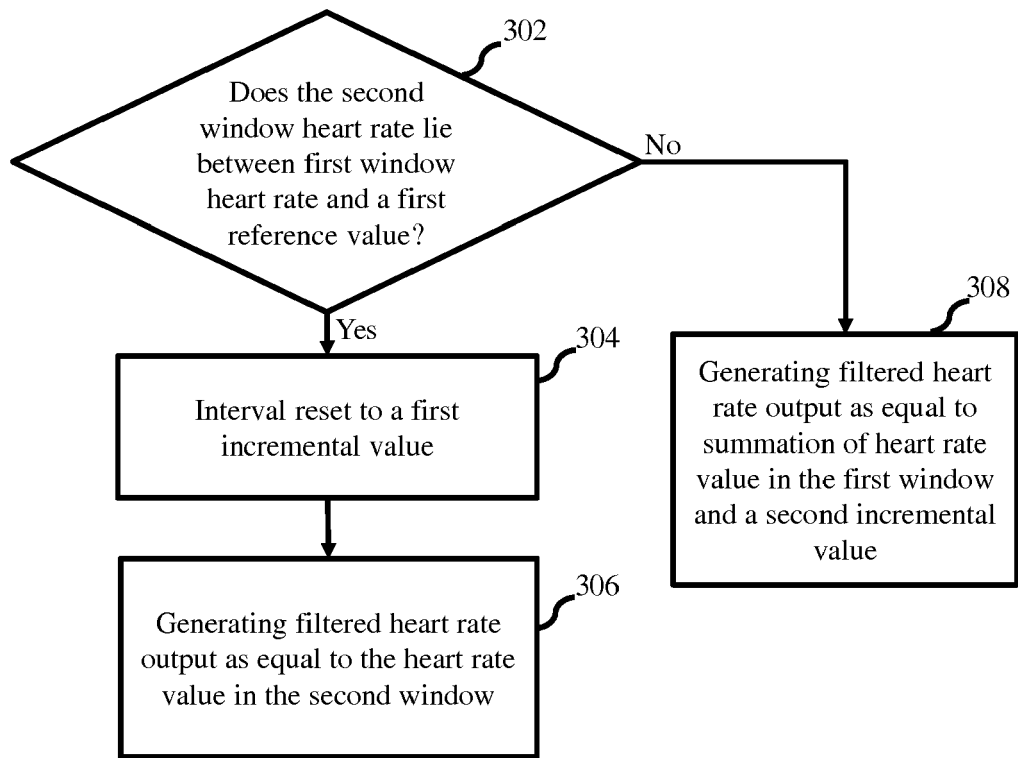


FIG. 2



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FIG. 3

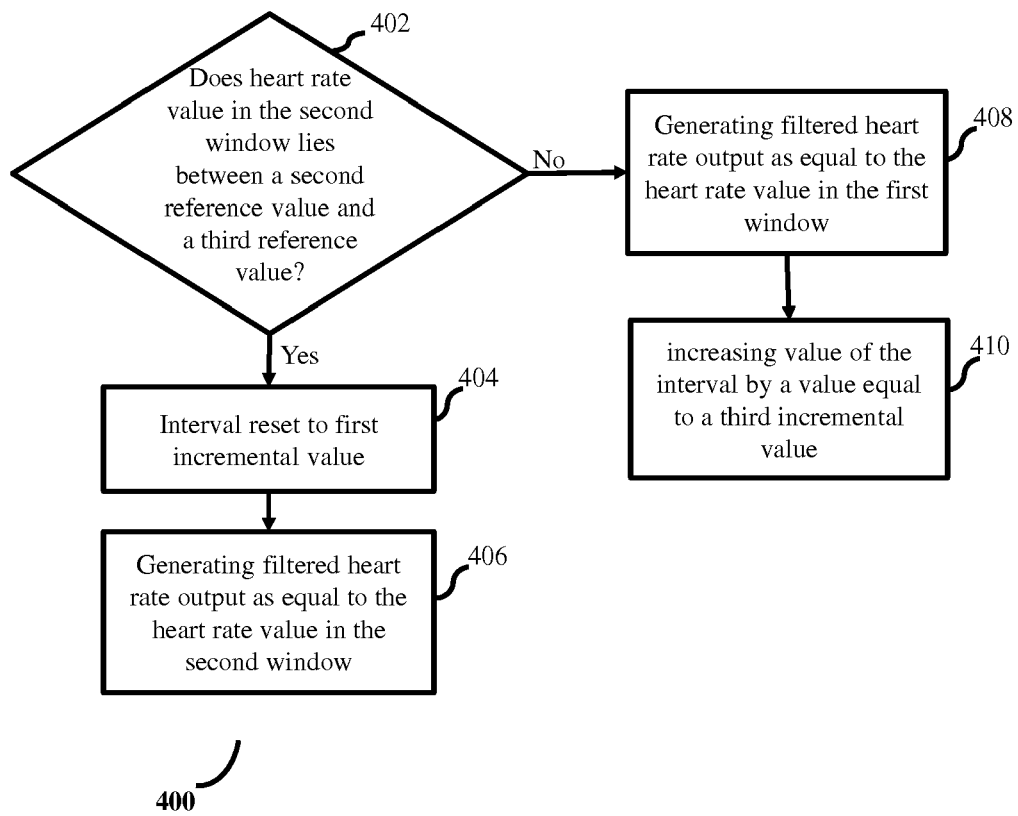


FIG. 4

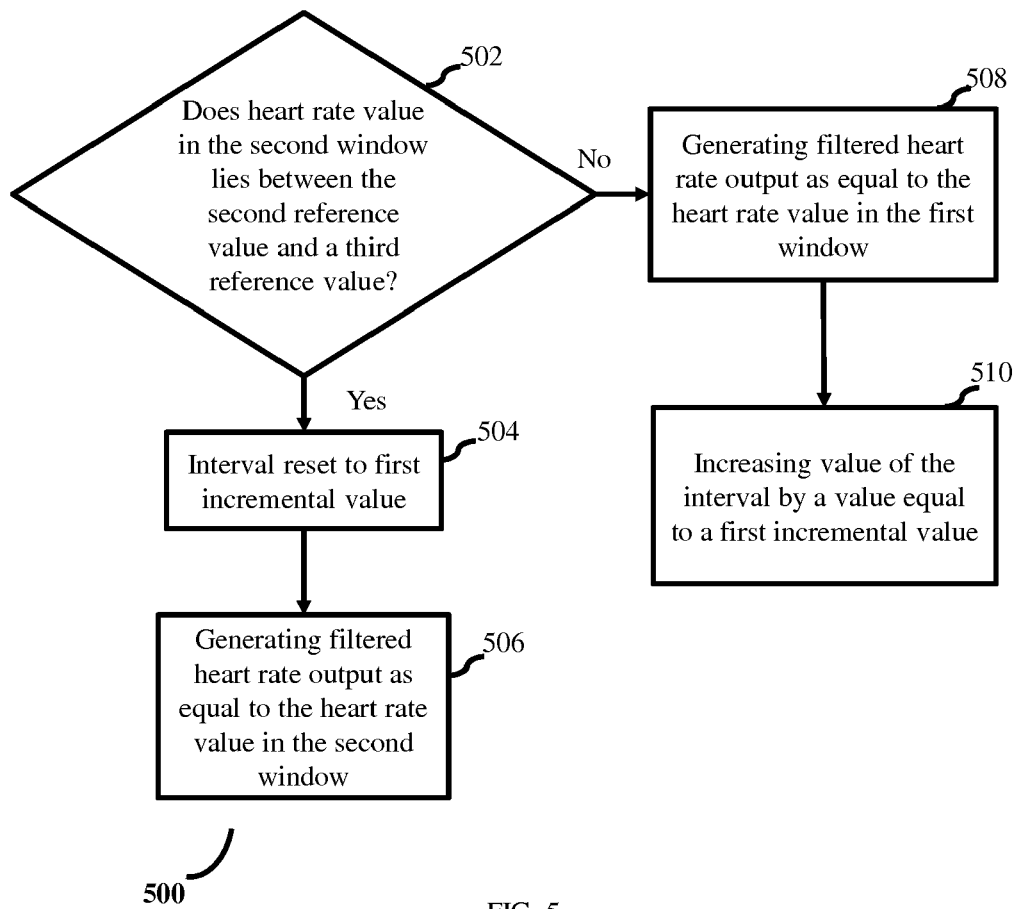


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 19 16 0241

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2017/164851 A1 (TAKAHASHI YUSUKE [JP]) 15 June 2017 (2017-06-15) * figures 8,9 * * paragraphs [0094], [0096] - [0099], [0100] - [0104], [0127] - [0138] * -----	1-15	INV. A61B5/024 A61B5/11 A61B5/00
X	EP 3 330 972 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 6 June 2018 (2018-06-06) * figure 10 * * paragraphs [0097] - [0100], [0158] - [0168] * -----	1-15	
X	US 2018/199837 A1 (AUMER MICHAEL EDWARD [US] ET AL) 19 July 2018 (2018-07-19) * paragraphs [0007], [0011] - [0012], [0019], [0072] - [0075], [0077] - [0078]; figures 4-6 * -----	1-15	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			A61B
Place of search		Date of completion of the search	Examiner
The Hague		22 August 2019	Albrecht, Ronald
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03/02 (P04C01)

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ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 19 16 0241

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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22-08-2019

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US 2017164851 A1	15-06-2017	JP 2017104382 A US 2017164851 A1	15-06-2017 15-06-2017
EP 3330972 A1	06-06-2018	CN 108078561 A EP 3330972 A1 KR 20180057868 A US 2018140204 A1	29-05-2018 06-06-2018 31-05-2018 24-05-2018
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REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	确定心律并考虑运动情况		
公开(公告)号	EP3643226A1	公开(公告)日	2020-04-29
申请号	EP2019160241	申请日	2019-03-01
申请(专利权)人(译)	塔塔咨询服务有限公司		
当前申请(专利权)人(译)	塔塔咨询服务有限公司		
[标]发明人	MUKHOPADHYAY SHALINI GHOSE AVIK AHMED NASIMUDDIN PAL ARPAN		
发明人	MUKHOPADHYAY, SHALINI GHOSE, AVIK AHMED, NASIMUDDIN PAL, ARPAN		
IPC分类号	A61B5/024 A61B5/11 A61B5/00		
CPC分类号	A61B5/024 A61B5/1123 A61B5/721 A61B5/725 A61B5/11 A61B5/7207		
审查员(译)	ALBRECHT, RONALD		
外部链接	Espacenet		

摘要(译)

当前可用的心率监测系统易于将心率变化（由于用户参与体育活动而引起）误认为是异常变化，即使这种变化是“正常的”，甚至可能会触发错误警报。甚至考虑用户移动性状态以滤除由于用户活动引起的这种变化的监视系统，也可能在测量心率数据时未考虑移动性状态的变化，这可能直接影响心率变化。提供了一种用于心率估计的系统和方法，其中系统考虑与不同移动性状态之间的转变有关的数据，以过滤出由于用户的移动性状态之间的转变而引起的变化。识别不同类型的这种过渡，并执行适当的方法以过滤估计的心率数据。

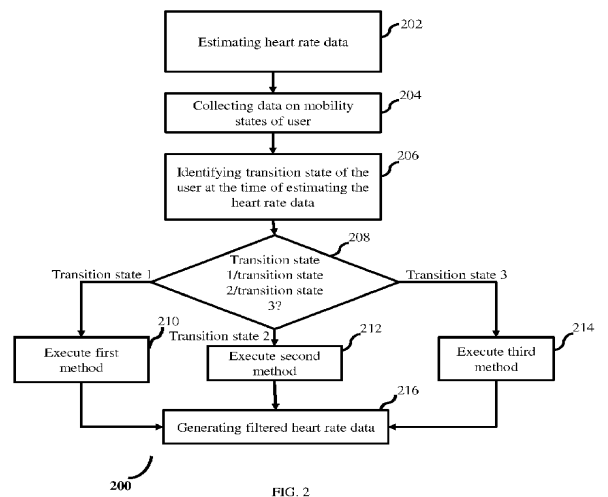


FIG. 2