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(54) **ACTIVITY IDENTIFICATION USING AN OPTICAL HEART RATE MONITOR**

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(58) **Field of Classification Search**
None
See application file for complete search history.

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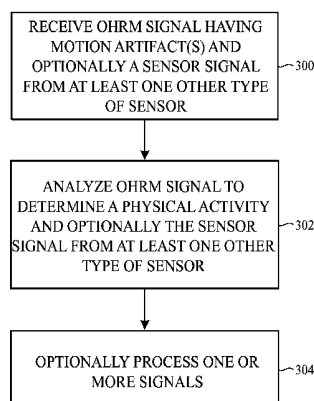
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(57) **ABSTRACT**

An electronic device that can be worn by a user can include a processing device and one or more optical heart rate monitors operatively connected to the processing device. The processing device can be adapted to receive a OHRM signal from at least one optical heart rate monitor. The OHRM signal includes one or more motion artifacts that are produced by a physical activity of the user. The processing device can be adapted to analyze the OHRM signal to determine the physical activity of the user.

18 Claims, 6 Drawing Sheets



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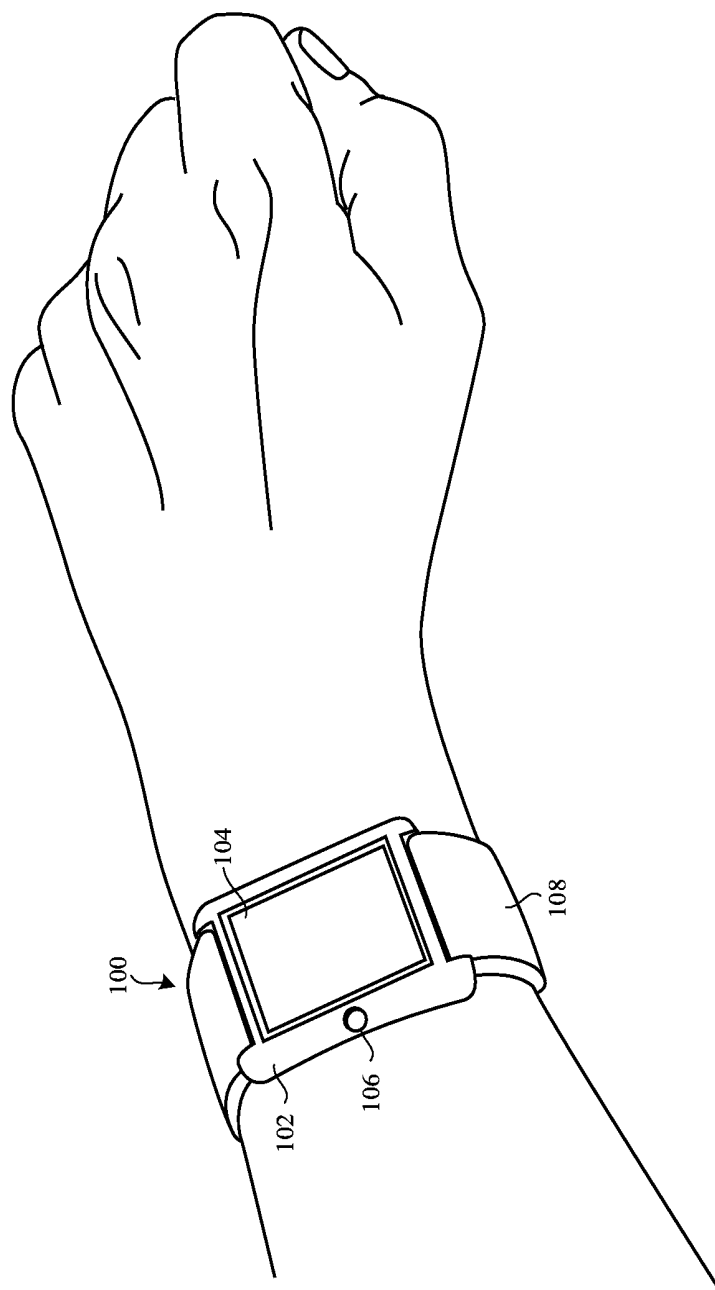


FIG. 1

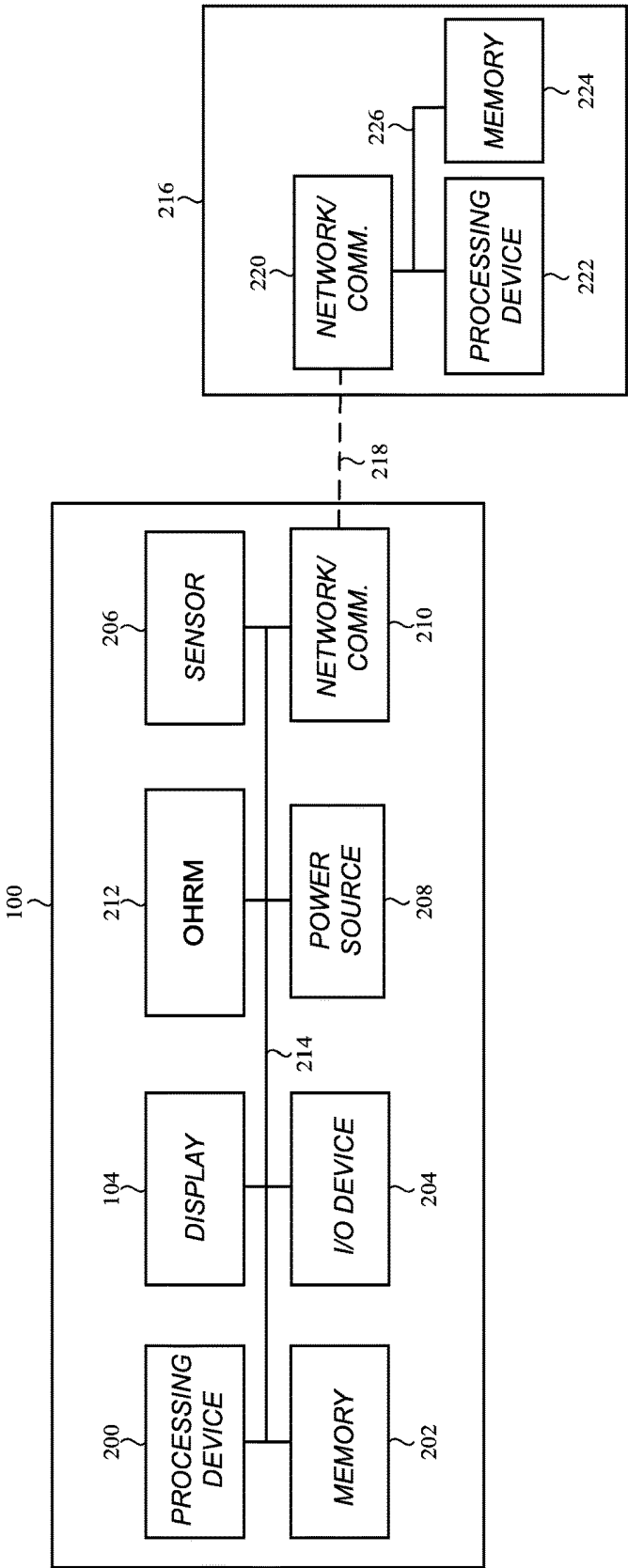
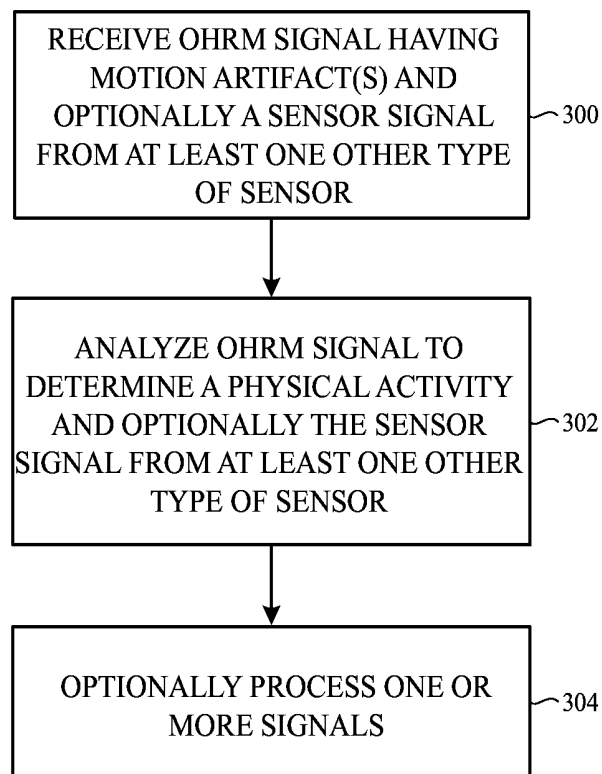


FIG. 2

**FIG. 3**

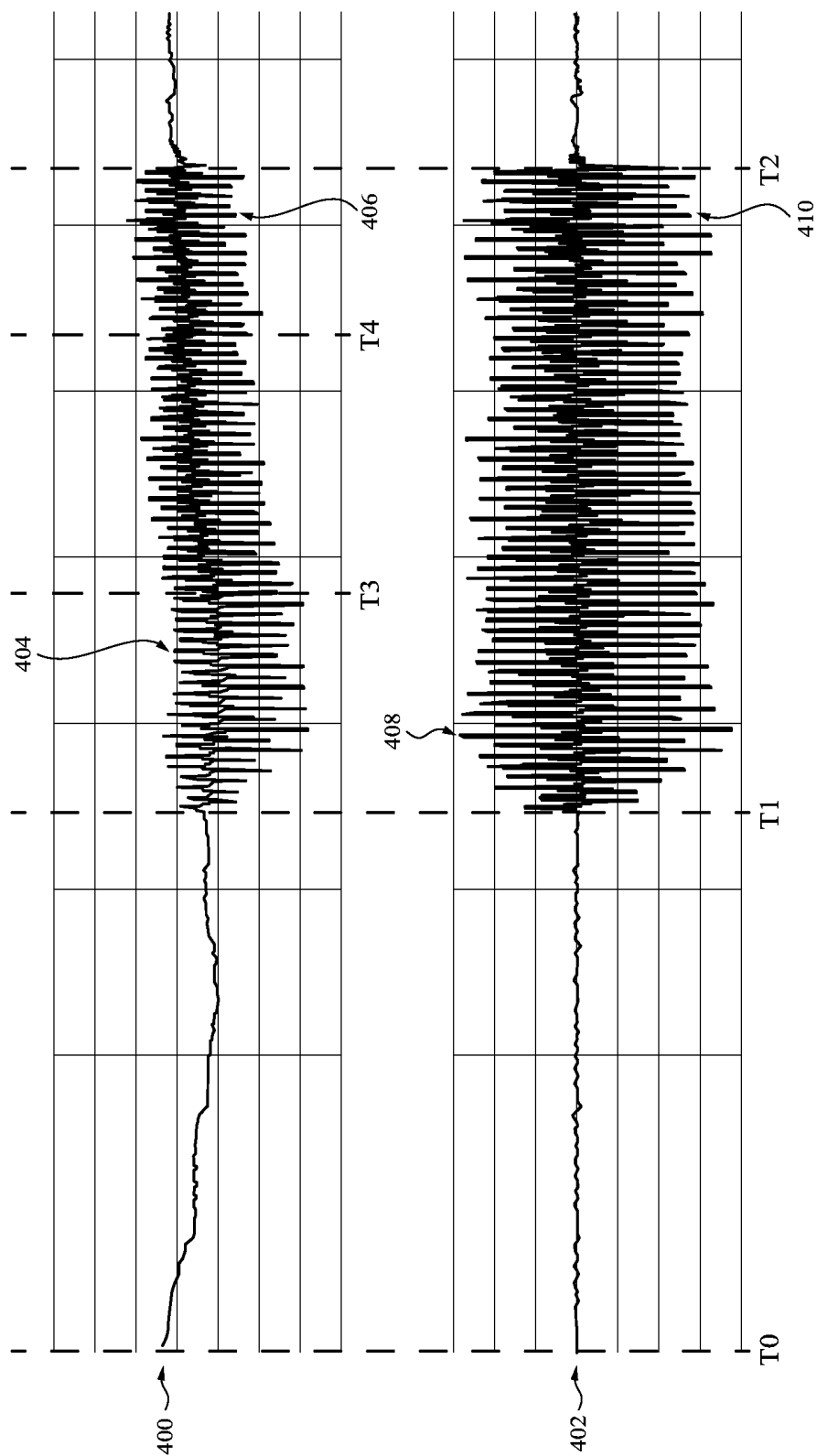


FIG. 4

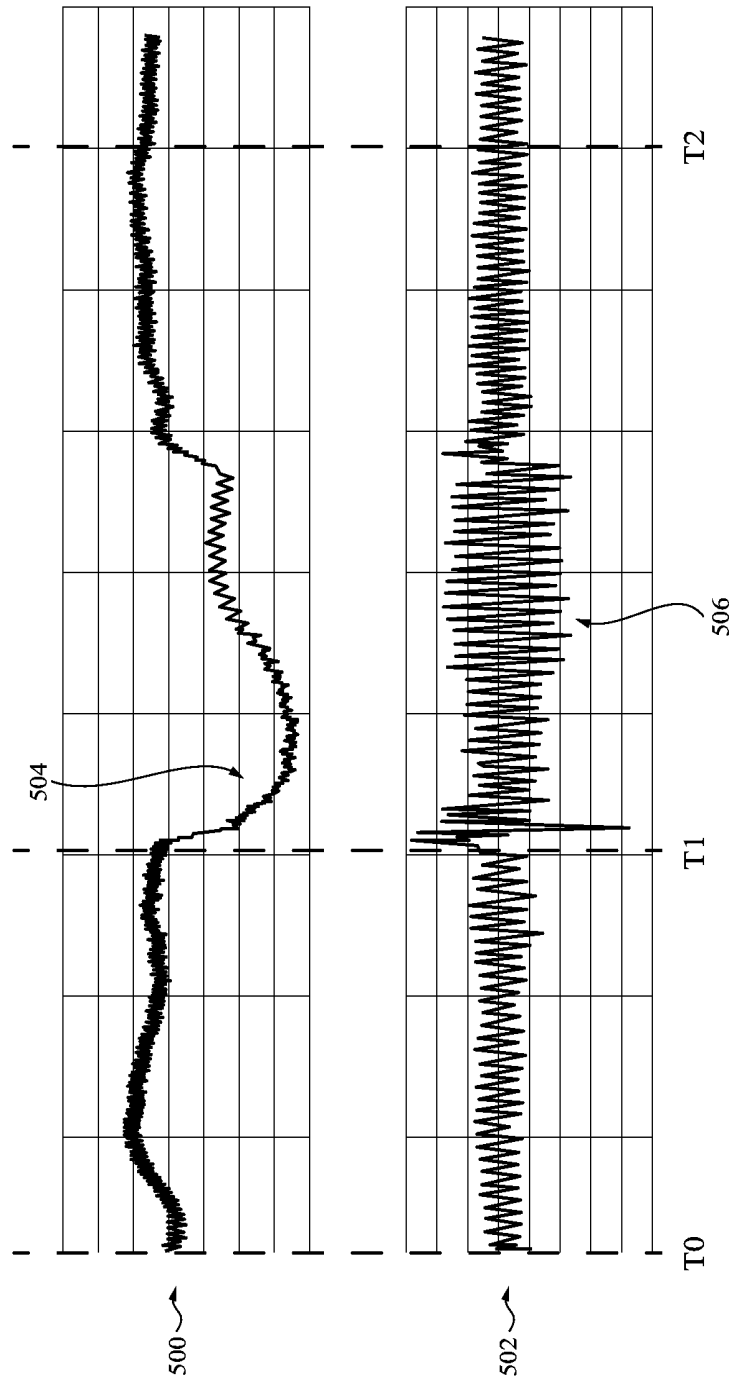
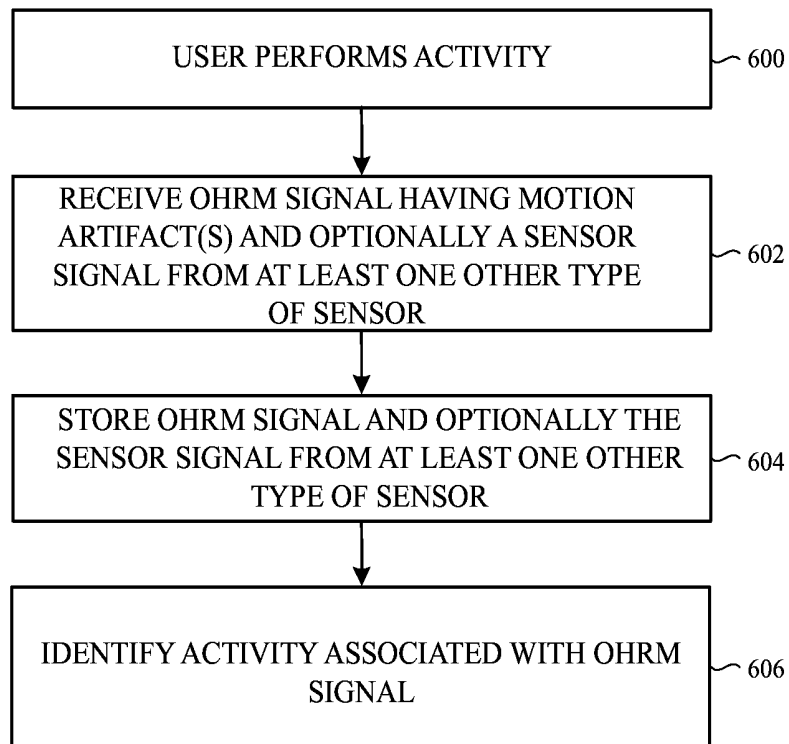


FIG. 5

**FIG. 6**

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ACTIVITY IDENTIFICATION USING AN OPTICAL HEART RATE MONITOR

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application No. 61/940,364, filed Feb. 14, 2014, entitled "Activity Identification Using An Optical Heart Rate Monitor," the entirety of which is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates generally to electronic devices, and more particularly to wearable electronic devices. Still more particularly, the present invention relates to determining a physical activity based on a signal received from at least one optical heart rate monitor.

BACKGROUND

Portable electronic devices can be used for performing a wide variety of tasks, and in some situations the electronic device can be worn on the body of a user. For example, a portable electronic device can be worn by a user on his or her wrist, arm, ankle, or leg. One example of such an electronic device is a wrist-worn activity monitor. The activity monitor can include a heart rate monitor, a position sensor (e.g., gyroscope), and/or a motion sensor (e.g., accelerometer). The activity monitor can determine the type of physical activity based on the signals received from the heart rate monitor and the sensor(s).

Some activities, however, involve little or no limb motion during the performance of the physical activity. For example, a user's arms can remain substantially still when the user is bicycling, walking or running while pushing a stroller, exercising on an elliptical trainer or stair machine while holding the handles or side railings, and performing low-impact activities such as push-ups, squats, or sit-ups. In these situations, it can be difficult, if not impossible, for a wrist-worn activity monitor to determine the type of physical activity the user is performing. The wrist-worn activity monitor may be unable to provide information to the user about the user's physical condition or his or her performance during the physical activity. For example, the wrist-worn activity monitor may not be able to present the user with the number of steps taken by the user or the number of calories expended during the physical activity.

SUMMARY

A signal produced by an optical heart rate monitor (OHRM) can include motion artifacts or noise that are introduced into the signal during physical activity. For example, motion of the body part wearing the OHRM, motion between the OHRM and the skin, and variations in blood flow caused by body movement (e.g., a physical activity of the user) can produce motion artifacts or noise in the signal produced by the OHRM. Embodiments described herein determine the type of physical activity performed by a user by analyzing the OHRM signal that includes one or more motion artifacts.

In one aspect, an electronic device can include a processing device and one or more OHRMs operatively connected to the processing device. The processing device may be adapted to receive an OHRM signal from at least one

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OHRM when the user performs a physical activity. The OHRM signal includes one or more motion artifacts that are produced by the physical activity, and the processing device can be adapted to analyze the OHRM signal to determine the physical activity of the user.

In another aspect, a method for determining a physical activity of a user wearing an electronic device that includes an OHRM can include receiving an OHRM signal from the OHRM and analyzing the OHRM signal to determine the physical activity of the user. The OHRM signal includes one or more motion artifacts that are produced while the user performs the physical activity.

In another aspect, a system can include an OHRM, one or more motion and/or position sensors, and a processing device operatively connected to the OHRM and the motion and/or position sensor(s). The processing device is adapted to receive an OHRM signal from the OHRM. The OHRM signal includes one or more motion artifacts that are produced by the physical activity of the user. The processing device can also be adapted to receive a sensor signal from at least one motion and/or position sensor. The processing device analyzes the OHRM signal and the sensor signal to determine a physical activity performed by the user. Additionally or alternatively, information regarding the activity can be provided to the user. For example, data such as a heart rate, the number of steps taken, cadence information, the intensity of the activity, calorie consumption, and/or the user's speed can be provided to the user.

In yet another aspect, an electronic device includes an OHRM. The electronic device can be calibrated to determine a physical activity of a user by receiving an OHRM signal that includes one or more motion artifacts when a user performs a particular physical activity, receiving an activity identifier, and associating the activity identifier to the OHRM signal. Subsequent OHRM signals can then be correlated to an activity based on the associated activity identifier, and the identified activity may be displayed or provided to the user.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are better understood with reference to the following drawings. The elements of the drawings are not necessarily to scale relative to each other. Identical reference numerals have been used, where possible, to designate identical features that are common to the figures.

FIG. 1 is a perspective view of one example of a wearable electronic device that includes one or more optical heart rate monitors;

FIG. 2 is an illustrative block diagram of the wearable electronic device **100** shown in FIG. 1;

FIG. 3 is a flowchart of a method for detecting a physical activity of a user wearing an electronic device that includes one or more optical heart rate monitors;

FIG. 4 depicts a first example of a photoplethysmograph signal with motion artifacts and a filtered photoplethysmograph signal;

FIG. 5 illustrates a second example of a photoplethysmograph signal with motion artifacts and a filtered photoplethysmograph signal; and

FIG. 6 is a flowchart of a method for calibrating a wearable electronic device to determine one or more activities of a user.

DETAILED DESCRIPTION

Embodiments described herein provide a wearable electronic device that includes one or more optical heart rate

monitors (OHRM). A signal received from at least one OHRM can include one or more motion artifacts or noise that is generated by movement of the user. Motion by the body part wearing the OHRM, motion between the OHRM and the skin, and variations in blood flow caused by body movement are example functions that can produce motion artifacts or noise in the signal output by an OHRM.

Embodiments described herein determine a physical activity of a user by analyzing an OHRM signal received from one or more OHRMs. The OHRM signal includes one or more motion artifacts that is produced by a physical activity of the user. One or more characteristics of the OHRM signal may be analyzed to determine the physical activity. For example, peak amplitudes, changes in amplitude, the distances between the peak amplitudes, time variations between peak amplitudes, the shape of the OHRM signal, and/or the frequency or frequency variations of the signal are characteristics of the OHRM signal that can be analyzed to identify the physical activity of the user.

In some embodiments, a signal produced by other types of sensors can be included in the analysis to determine the physical activity. As one example, a sensor signal from one or more motion and/or position sensors can be received and analyzed when determining a physical activity of the user. For example, when a user is mowing the lawn, a signal from an OHRM will include motion artifacts produced by the walking and/or pushing of the lawn mower. The OHRM signal can be analyzed to determine the user is mowing the lawn. Additionally, a signal from a gyroscope can detect turning position changes that indicate the user is mowing. Velocity determined from a signal received from a global positioning sensor can be consistent with the user's lawn mowing activity.

Referring now to FIG. 1, there is shown a perspective view of one example of a wearable electronic device that can include one or more optical heart rate monitors. Embodiments described herein include an electronic device **100** that is worn on a wrist of a user. But other embodiments can implement the electronic device differently, such as, for example, as a smart telephone, a gaming device, a digital music player, headphones or ear buds, a device that provides time, a health assistant, a fitness monitor, a medical device, and any other wearable electronic device. Additionally, the electronic device can be worn on any limb or other suitable body part (e.g., the head).

The wearable electronic device **100** includes an enclosure **102** at least partially surrounding a display **104** and one or more buttons **106** or input devices. The enclosure **102** can form an outer surface or partial outer surface and protective case for the internal components of the electronic device **100**, and may at least partially surround the display **104**. The enclosure **102** can be formed of one or more components operably connected together, such as a front piece and a back piece. Alternatively, the enclosure **102** can be formed of a single piece operably connected to the display **104**.

The display **104** can be implemented with any suitable technology, including, but not limited to, a multi-touch sensing touchscreen that uses liquid crystal display (LCD) technology, light emitting diode (LED) technology, organic light-emitting display (OLED) technology, organic electroluminescence (OEL) technology, or another type of display technology. At least one button **106** can take the form of a home button, which may be a mechanical button, a soft button (e.g., a button that does not physically move but still accepts inputs), an icon or image on a display or on an input

region, and so on. Further, in some embodiments, the button or buttons **106** can be integrated as part of a cover glass of the electronic device.

The wearable electronic device **100** can be permanently or removably attached to a band **108**. The band **108** can be made of any suitable material, including, but not limited to, leather, rubber or silicon, fabric, and ceramic. In the illustrated embodiment, the band is a wristband that wraps around the user's wrist. The wristband can include an attachment mechanism (not shown) to secure the band to the user's wrist. Example attachment mechanisms include, but are not limited to, a bracelet clasp, Velcro, and magnetic connectors. In other embodiments, the band can be elastic or stretchy such that it fits over the hand of the user and does not include an attachment mechanism.

FIG. 2 is an illustrative block diagram of the wearable electronic device **100** shown in FIG. 1. The electronic device **100** can include the display **104**, one or more processing devices **200**, memory **202**, one or more input/output (I/O) devices **204**, one or more sensors **206**, a power source **208**, a network communications interface **210**, and one or more optical heart rate monitors (OHRM) **212**. The display **104** may provide an image or video output for the electronic device **100**. The display may also provide an input surface for one or more input devices, such as, for example, a touch sensing device and/or a fingerprint sensor. The display **104** may be substantially any size and may be positioned substantially anywhere on the electronic device **100**.

The processing device **200** can control some or all of the operations of the electronic device **100**. The processing device **200** can communicate, either directly or indirectly, with substantially all of the components of the electronic device **100**. For example, a system bus or signal line **214** or other communication mechanisms can provide communication between the processing device(s) **200**, the memory **202**, the I/O device(s) **204**, the sensor(s) **206**, the power source **208**, the network communications interface **210**, and/or the OHRM(s) **212**. The one or more processing devices **200** can be implemented as any electronic device capable of processing, receiving, or transmitting data or instructions. For example, the processing device(s) **200** can each be a micro-processor, a central processing unit (CPU), an application-specific integrated circuit (ASIC), a digital signal processor (DSP), or combinations of such devices. As described herein, the term "processing device" is meant to encompass a single processor or processing unit, multiple processors, multiple processing units, or other suitably configured computing element or elements.

The memory **202** can store electronic data that can be used by the electronic device **100**. For example, a memory can store electrical data or content such as, for example, audio and video files, documents and applications, device settings and user preferences, timing signals, signals received from the one or more OHRMs and sensors, calibration signals, data structures or databases, and so on. The memory **202** can be configured as any type of memory. By way of example only, the memory can be implemented as random access memory, read-only memory, Flash memory, removable memory, or other types of storage elements, or combinations of such devices.

The one or more I/O devices **204** can transmit and/or receive data to and from a user or another electronic device. One example of an I/O device is button **106** in FIG. 1. The I/O device(s) **204** can include a display, a touch sensing input surface such as a trackpad, one or more buttons, one or more microphones or speakers, one or more ports such as a microphone port, and/or a keyboard.

The electronic device **100** may also include one or more sensors **206** positioned substantially anywhere on the electronic device **100**. The sensor or sensors **206** may be configured to sense substantially any type of characteristic, such as but not limited to, images, pressure or force, position, motion, speed, light, touch, heat, biometric data, and so on. For example, the sensor(s) **206** may be an image sensor, a gyroscope, an accelerometer, a global positioning sensor, a heat sensor, a light or optical sensor, a pressure transducer, a magnetometer, a health monitoring sensor, and so on.

The power source **208** can be implemented with any device capable of providing energy to the electronic device **100**. For example, the power source **208** can be one or more batteries or rechargeable batteries, or a connection cable that connects the remote control device to another power source such as a wall outlet. Additionally or alternatively, the power source **208** can include a wireless energy transfer device, such as an inductive energy receiver device.

The network communication interface **210** can facilitate transmission of data to or from other electronic devices. For example, a network communication interface can transmit electronic signals via a wireless and/or wired network connection. Examples of wireless and wired network connections include, but are not limited to, cellular, Wi-Fi, Bluetooth, IR, and Ethernet.

The one or more OHRMs **212** can each measure one or more physiological functions of the user wearing the wearable electronic device **100**. Each OHRM can be implemented as any suitable optical heart rate monitor. For example, in one embodiment, at least one OHRM is a reflective or transmissive photoplethysmograph (PPG) sensor. Illustrative measurements that a PPG sensor can measure include heart rate, the relative blood flow through a body part of a user, heart rate variability, and blood volume pulse. As will be described in more detail later, an OHRM signal or signals that includes one or more motion artifacts produced by a physical activity of a user is received from at least one OHRM and analyzed to identify and/or classify the physical activity of the user.

In some embodiments, the electronic device **100** can communicate with an external electronic device **216** using connection **218**. Connection **218** can be a wired or wireless connection. As one example, the connection can be a cellular, Wi-Fi, or Bluetooth connection. Alternatively, a physical connector cable can connect the wearable electronic device to the external electronic device. The external electronic device **216** can be any type of electronic device, such as a computing device. Example external electronic devices include, but are not limited to, a computer such as a laptop, a tablet computing device, a smart telephone, or another wearable electronic device.

The external electronic device can include a network communication interface **220** operably connected to a processing device **222** and a memory **224**. The processing device **222** can control some or all of the operations of the external electronic device **216** through bus **226**. Additionally or alternatively, the processing device **222** can control some or all of the operations of the wearable electronic device **100**.

It should be noted that FIGS. **1** and **2** are illustrative only. In other examples, an electronic device may include fewer or more components than those shown in FIGS. **1** and **2**. Additionally or alternatively, the wearable electronic device can be in communication with other external devices. For example, a wearable electronic device may be operatively connected to, or in communication with a separate display.

As another example, a wearable electronic device can access one or more signals or data that is stored in a memory separate from the wearable electronic device.

Additionally or alternatively, in some embodiments one or more components shown in the electronic device **100** can instead be included in the external electronic device **216**. For example, one or more sensors can be included in an external electronic device and the signal produced by the one or more sensors can be analyzed to determine a physical activity of the user. As one example, a user can wear the electronic device and carry a smart telephone at the same time. The wearable electronic device can be wirelessly paired to the smart telephone. A signal obtained from a global positioning sensor, a gyroscope, and/or an accelerometer in the smart telephone can be analyzed with an OHRM signal received from an OHRM in the electronic device to determine a physical activity of the user.

Referring now to FIG. **3**, there is shown a flowchart of a method for detecting a physical activity of a user wearing an electronic device that includes one or more OHRMs. Initially, a signal that includes motion artifacts is received from at least one OHRM at block **300**. For example, movement of the body part wearing the OHRM, motion between the OHRM and the skin, and variations in blood flow caused by body movement can produce motion artifacts in the signal produced by the OHRM.

Optionally, a signal can also be received from other types of sensors at block **300**. In one embodiment, a sensor signal can be received from a motion sensor and/or a position sensor. Examples of motion and position sensors include, but are not limited to, a gyroscope, an accelerometer, a global positioning sensor, a rotation vector sensor, a proximity sensor, and/or a magnetometer.

Next, as shown in block **302**, the OHRM signal is analyzed to determine a physical activity being performed by the user. For example, the OHRM signal can be analyzed by the processing device **200** and/or the processing device **222** shown in FIG. **2**. The analysis can identify a physical activity of the user. One or more characteristics of the OHRM signal having one or more motion artifacts may be analyzed to identify the physical activity of the user. For example, peak amplitudes, changes in amplitude, the distances between the peak amplitudes, time variations between peak amplitudes, the shape of the OHRM signal, and/or the frequency of the signal are characteristics of the OHRM signal that can be analyzed at block **302**.

Optionally, a signal received from one or more other sensors can be analyzed with the OHRM signal at block **302** to determine the physical activity of the user. For example, when a user is bicycling, a signal from an OHRM will include motion artifacts produced by body position changes occurring with each leg thrust. The OHRM signal can be analyzed to determine the user is bicycling. Additionally, a signal from a gyroscope can detect turning and changes in hand position that indicate the user is bicycling. The velocity determined from a signal received from a global positioning sensor can be consistent with the activity of bicycling. And if impacts or high frequency vibrations are detected by an accelerometer, it may be possible to classify the bicycling as mountain biking instead of bicycling on a road. Thus, one or more signals received from other types of sensors, such as motion and position sensors, can be used to determine the type of physical activity and/or to further classify the type of activity.

Next, as shown in block **304**, one or more of the signals can be processed to provide the user with additional information regarding the physical activity and/or his or her

performance. The one or more signals may include the OHRM signal (with or without motion artifacts). Additionally or alternatively, the one or more signals may include a signal from another type of sensor. As one example, the one or more signals can be processed to provide the user with information regarding their heart rate, the number of steps taken, cadence information, the intensity of the activity, calorie consumption, and/or the user's speed. The information can be provided in real time and/or provided after the user has completed the physical activity. In one embodiment, the additional information can be displayed to the user (e.g., on display 104 in FIG. 1).

Two examples of a PPG signal that includes motion artifacts and a filtered PPG signal for different activities are shown in FIGS. 4 and 5. FIG. 4 illustrates a PPG signal 400 that includes motion artifacts for a user wearing the electronic device 100 shown in FIG. 1 while standing and walking without any arm movement. In the illustrated embodiment, the filtered PPG signal 402 represents the heartbeats of the user. Between time T0 and T1 the user is standing still. Consequently, both the PPG signal 400 and the filtered PPG signal 402 are substantially flat during that time period.

The user is walking in place without any substantial arm movement between the time period T1 and T2. After time T1, the PPG signal 400 includes appreciable positive and negative amplitude peaks 404, 406. Similarly, the filtered PPG signal 402 includes appreciable positive and negative amplitude peaks 408, 410. Each walking step can cause a peak amplitude in the filtered PPG signal 402 that is larger than in the PPG signal 400. At time T2, the user stops walking and begins standing still again and the PPG signal 400 and the filtered PPG signal 402 are substantially flat.

One or more characteristics of the PPG signal 400 can be analyzed to determine if the user is standing or walking. In some embodiments, the peak-to-peak distances and/or the frequencies of the peak amplitudes in the PPG signal may correlate to a physical activity. Additionally or alternatively, the shape of the PPG signal over a given time period can be analyzed to determine the type of physical activity the user is performing (i.e., walking in this illustrated embodiment). The given time period can be any period of time (or multiple periods of time) that occur during the PPG signal. For example, the given time period can be the period between time T1 and time T2, or the given time period can be one or more subset time periods between time T1 and time T2. As one example, the period between time T3 and time T4 can be analyzed to determine the physical activity of the user. Additionally or alternatively, the period between time T0 and time T4 can be analyzed.

In some embodiments, the values of the peak amplitudes and/or the distances between positive peak amplitudes and negative peak amplitudes over a given time period can be considered when determining the physical activity of the user. Additionally or alternatively, characteristics of the OHRM signal not described herein can be analyzed to determine the physical activity performed by the user.

FIG. 5 depicts a second example of a PPG signal 500 that includes motion artifacts and a filtered PPG signal 502 for a user wearing the electronic device shown in FIG. 1 while standing and squatting. Once again, the filtered PPG signal 502 represents the heartbeats of the user. The user is standing between time T0 and time T1, squatting between time T1 and time T2, and standing again after time T2. Squatting can cause a reduction in intensity 504 in the PPG signal and the heart rate can increase 506 when the user is in the squat

position. As described earlier, one or more characteristics of the PPG signal can be analyzed to determine that the user is standing and/or squatting.

The OHRM signal and motion artifacts shown in FIG. 4 differs from the OHRM signal and motion artifacts in FIG. 5. Thus, physical activities can have distinct OHRM signals and motion artifacts, allowing an OHRM signal to be used to identify a specific physical activity of a user. In some embodiments, a user may calibrate a wearable electronic device by storing OHRM signals for a variety of different activities the user wants the electronic device to be able to identify.

Referring now to FIG. 6, there is shown a flowchart of a method for calibrating a wearable electronic device to determine one or more activities of a user. Initially, the user performs the physical activity he or she wants an electronic device to be able to detect using an OHRM signal (block 600). An OHRM signal that is based on the type of physical activity that is being performed is then received at block 602. The OHRM signal includes one or more motion artifacts that is produced by the physical activity of the user. Optionally, a sensor signal from one or more other types of sensors (e.g., motion and/or position sensors) can also be received at block 602. For example, a signal from a gyroscope and/or an accelerometer can be received at block 602.

The OHRM signal having one or more motion artifacts and optionally a signal from one or more other sensors can be stored in memory. As one example, the OHRM signal can be stored in memory 202 or memory 224 shown in FIG. 2. Other embodiments can store data and/or characteristics of the OHRM signal and/or motion artifacts rather than the signal itself at block 604. Likewise, a signal and/or data and/or characteristics of the sensor signal that is received from one or more other sensors can be stored in the memory at block 604.

Next, as shown in block 606, the physical activity associated with the OHRM signal is identified and stored. An activity identifier can be received and associated with the OHRM signal. In one embodiment, the user can input an activity identifier using an input device included in the wearable electronic device. As one example, the user can input an activity identifier using a keyboard displayed on a touchscreen. In another embodiment, the user can speak the activity identifier and a voice recognition function can input the activity identification. In other embodiments, the activity identifier can be received from an external electronic device.

Subsequent OHRM signals that include one or more motion artifacts can then be correlated to an activity based on the associated activity identifier, and the identified activity may be displayed or provided to the user.

The method shown in FIG. 6 can be performed for each physical activity the user wants identified using an OHRM signal that includes motion artifacts. Other embodiments can perform the method differently. Some blocks can be omitted, new blocks added, and/or some of the blocks can be performed in a different order. For example, in some embodiments, an OHRM signal associated with a particular physical activity that is stored in memory can be updated or replaced with a newly captured OHRM signal associated with the same physical activity. A stored OHRM signal can be updated or replaced periodically, at select times, or each time the user performs the activity. In embodiments that store data and/or characteristics of the OHRM signal, the data and/or characteristics can be updated or replaced periodically, at select times, or each time the user performs the physical activity. As one example, a running average of a given OHRM signal can be maintained by updating the

current OHRM signal for a particular activity with newly received OHRM signals that are determined to represent the same activity. As described previously, the OHRM signal or signals include one or more motion artifacts that is produced by the physical activity of the user.

Various embodiments have been described in detail with particular reference to certain features thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the disclosure. And even though specific embodiments have been described herein, it should be noted that the application is not limited to these embodiments. In particular, any features described with respect to one embodiment may also be used in other embodiments, where compatible. Likewise, the features of the different embodiments may be exchanged, where compatible.

What is claimed is:

1. A method for determining a type of physical activity being performed by a user wearing an electronic device that includes a photoplethysmograph (PPG) sensor, the method comprising:

receiving, by a processing device, an optical heart rate monitor (OHRM) signal from the PPG sensor;

analyzing, by the processing device, the OHRM signal to detect one or more signal characteristics of the OHRM signal;

analyzing, by the processing device, the one or more signal characteristics to detect repeated motion artifacts that are produced by the type of physical activity being performed by the user;

based on the repeated motion artifacts:

determining, by the processing device, the type of physical activity being performed by the user;

identifying a time period in which the determined type of physical activity is being performed by the user; and

determining, by the processing device and using the repeated motion artifacts during the identified time period, at least one of a number of steps taken by the user during the type of physical activity or a calorie consumption by the user during the type of physical activity; and

providing, to the user, information regarding the type of physical activity and at least one of the number of steps taken by the user during the type of physical activity or the calorie consumption by the user during the type of physical activity.

2. The method as in claim 1, further comprising:

receiving a sensor signal from at least one other type of sensor; and

analyzing the sensor signal when determining the type of physical activity being performed by the user.

3. The method as in claim 1, wherein analyzing the OHRM signal comprises analyzing at least one amplitude peak in the OHRM signal during a given time period.

4. The method as in claim 1, wherein analyzing the OHRM signal comprises analyzing a shape of the OHRM signal during a given time period.

5. The method as in claim 1, wherein analyzing the OHRM signal comprises analyzing a frequency of the OHRM signal during a given time period.

6. The method as in claim 1, wherein the electronic device comprises a device that provides time.

7. The method as in claim 1, wherein the electronic device comprises a health assistant.

8. An electronic device wearable by a user, comprising: a photoplethysmograph (PPG) sensor; and

processing device that is operatively connected to the PPG sensor and adapted to:

receive an optical heart rate monitor (OHRM) signal from the PPG sensor;

analyze the OHRM signal to detect one or more signal characteristics of the OHRM signal;

analyze the one or more signal characteristics to detect repeated motion artifacts that are produced by a type of physical activity being performed by a user;

based on the repeated motion artifacts, determine the type of physical activity being performed by the user;

identify a time period in which the determined type of physical activity is being performed by the user; and determine, using the repeated motion artifacts during the identified time period, at least one of a number of steps taken by the user during the type of physical activity or a calorie consumption by the user during the type of physical activity; and

provide, to the user, information regarding the type of physical activity and at least one of the number of steps or the calorie consumption.

9. The electronic device as in claim 8, further comprising a memory adapted to store one or more OHRM signals that each represent a particular type of physical activity.

10. The electronic device as in claim 8, wherein the processing device analyzes the OHRM signal by analyzing at least one amplitude peak in the OHRM signal during a given time period.

11. The electronic device as in claim 8, wherein the processing device analyzes the OHRM signal by analyzing a shape of the OHRM signal during a given time period.

12. The electronic device as in claim 8, wherein the processing device analyzes the OHRM signal by analyzing a frequency of the OHRM signal during a given time period.

13. The electronic device as in claim 8, wherein the electronic device comprises a health assistant.

14. The electronic device as in claim 8, wherein the electronic device comprises a device that provides time.

15. A system, comprising:

a photoplethysmograph (PPG) sensor;

a motion or position sensor; and

a processing device operatively connected to the PPG sensor and the motion or position sensor, wherein the processing device is adapted to:

receive from the PPG sensor an OHRM signal;

determine one or more signal characteristics of the OHRM signal;

analyze the one or more signal characteristics to detect repeated motion artifacts that are produced by a type of physical activity being performed by a user;

determine the type of physical activity being performed by the user based on the repeated motion artifacts; receive a sensor signal from the motion or position sensor;

analyze the sensor signal to further categorize the type of physical activity being performed by the user;

identify, based on the repeated motion artifacts, a time period in which the determined type of physical activity is being performed by the user;

determine, using the repeated motion artifacts during the identified time period, at least one of a number of steps taken by the user during the type of physical activity or a calorie consumption by the user during the type of physical activity; and

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provide, to the user, information regarding the type of physical activity and at least one of the number of steps or the calorie consumption.

16. The system as in claim 15, wherein the system comprises a wearable electronic device.

17. The system as in claim 16, wherein the PPG sensor and the processing device are included in a wearable electronic device and the motion or position sensor is included in an external electronic device communicably connected to the PPG sensor.

18. A method for operating a wearable electronic device for determining a type of physical activity being performed by a user, the wearable electronic device including a photoplethysmograph (PPG) sensor, the method comprising:

receiving, by a processing device, an optical heart rate monitor (OHRM) signal from the PPG sensor when a user performs a particular type of physical activity;
determining first signal characteristics of the OHRM signal;
detecting first motion artifacts that are produced by the particular type of physical activity based on the first signal characteristics;
receiving an activity identifier from a user of the wearable electronic device;
associating the activity identifier to the OHRM signal to associate the particular type of physical activity to the OHRM signal;

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storing, in a memory of the wearable electronic device, the activity identifier and the OHRM signal;

determining a subsequently received a OHRM signal is associated with the particular type of physical activity, by:

determining second signal characteristics of the subsequently received OHRM signal;

detecting second motion artifacts based on the second signal characteristics; and

comparing the second motion artifacts with the first motion artifacts;

identifying, based on the second motion artifacts, a time period in which the particular type of physical activity is being performed by the user;

determining, using the second motion artifacts during the identified time period, at least one of a number of steps taken by the user during the particular type of physical activity or a calorie consumption by the user during the particular type of physical activity; and

providing, to the user, information regarding the type of physical activity associated with the subsequently received OHRM and at least one of the number of steps or the calorie consumption; and

updating the stored OHRM signal with the subsequently received OHRM signal, the updating comprising maintaining a running average of the OHRM signal associated with the particular type of physical activity.

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摘要(译)

可由用户佩戴的电子设备可包括处理设备和可操作地连接到处理设备的一个或多个光学心率监视器。处理设备可以适于从至少一个光学心率监测器接收OHRM信号。OHRM信号包括由用户的身体活动产生的一个或多个运动伪影。处理设备可以适于分析OHRM信号以确定用户的身体活动。

