US 20190069786A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2019/0069786 A1

Perez-Camargo et al. (43) Pub. Date: Mar. 7, 2019

(54) HEART RATE DETECTION DEVICE AND RELATED SYSTEMS AND METHODS

(71) Applicant: **NESTEC SA**, Vevey (CH)

(72) Inventors: **Gerardo Perez-Camargo**, House Springs, MO (US); **Stuart Kyle Neubarth**, Sunnyvale, CA (US); **Mark Alan Donavon**, Troy, IL (US)

(21) Appl. No.: **16/113,310**

(22) Filed: **Aug. 27, 2018**

Related U.S. Application Data

(60) Provisional application No. 62/553,202, filed on Sep. 1, 2017.

Publication Classification

(51) Int. Cl.

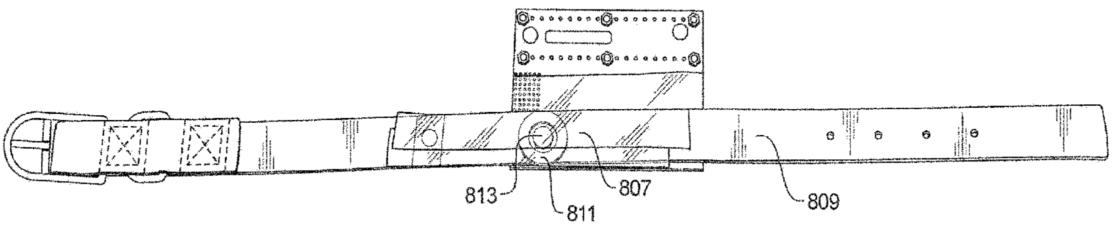
A61B 5/024	(2006.01)
G01D 5/241	(2006.01)
G01P 13/00	(2006.01)
A61B 5/00	(2006.01)
A61B 5/08	(2006.01)
A61B 5/0205	(2006.01)
A61B 5/0245	(2006.01)

(52) U.S. Cl.

CPC *A61B 5/02438* (2013.01); *G01D 5/2417* (2013.01); *G01P 13/00* (2013.01); *A61B 5/6822* (2013.01); *A61B 5/7207* (2013.01); *A61B 5/02405* (2013.01); *A61B 2503/40* (2013.01); *A61B 5/0205* (2013.01); *A61B 5/6831* (2013.01); *A61B 5/6805* (2013.01); *A61B 5/0245* (2013.01); *A61B 2562/0219* (2013.01); *A61B 5/742* (2013.01); *A61B 5/0816* (2013.01)

(57) ABSTRACT

Some embodiments can include a device for detecting heart rate. In a number of embodiments, the device can comprise at least one capacitive displacement sensor coupled to a strap. In many embodiments, the at least one capacitive displacement sensor can comprise two electrodes. In some embodiments, the two electrodes can comprise an outer transmitting electrode and an inner receiving electrode. In various embodiments, the at least one capacitive displacement sensor can detect a pulse by producing a signal associated with a distance change between a skin of a wearer of the device and the at least one capacitive displacement sensor. Other embodiments of related apparatuses, methods and systems are also provided.



800

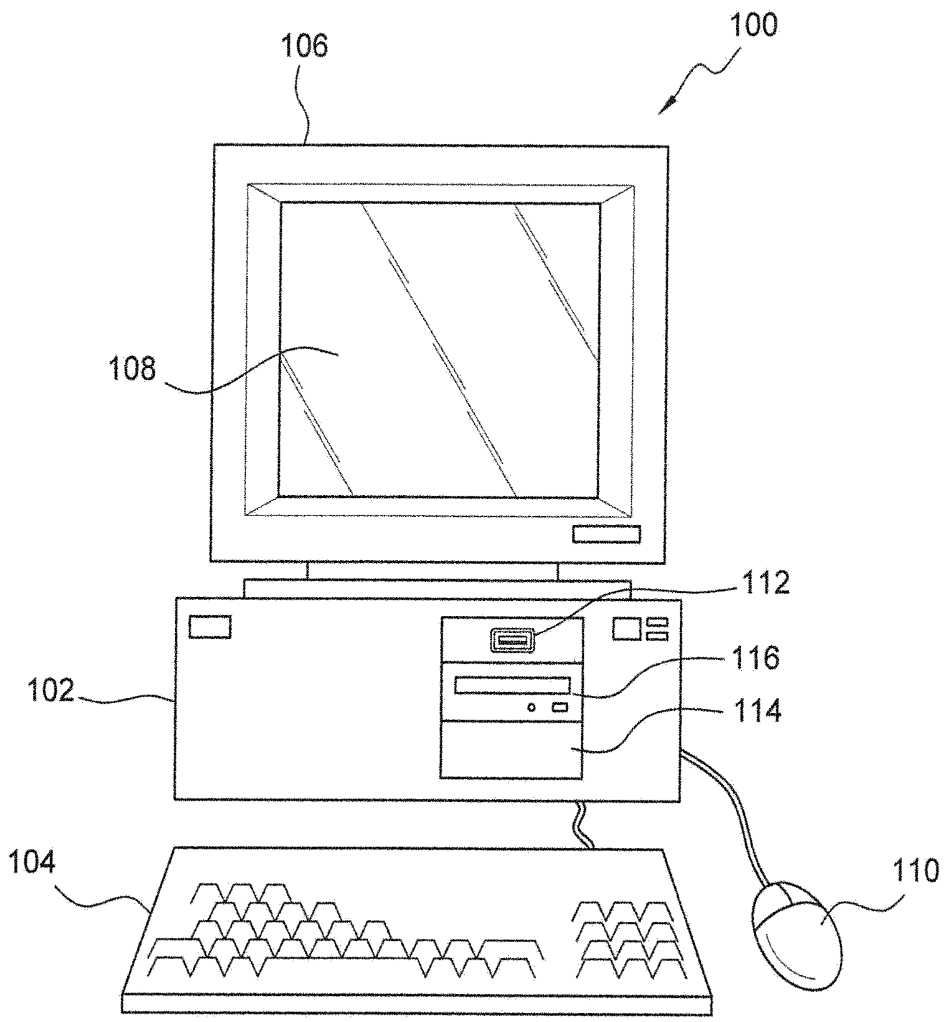


FIG. 1

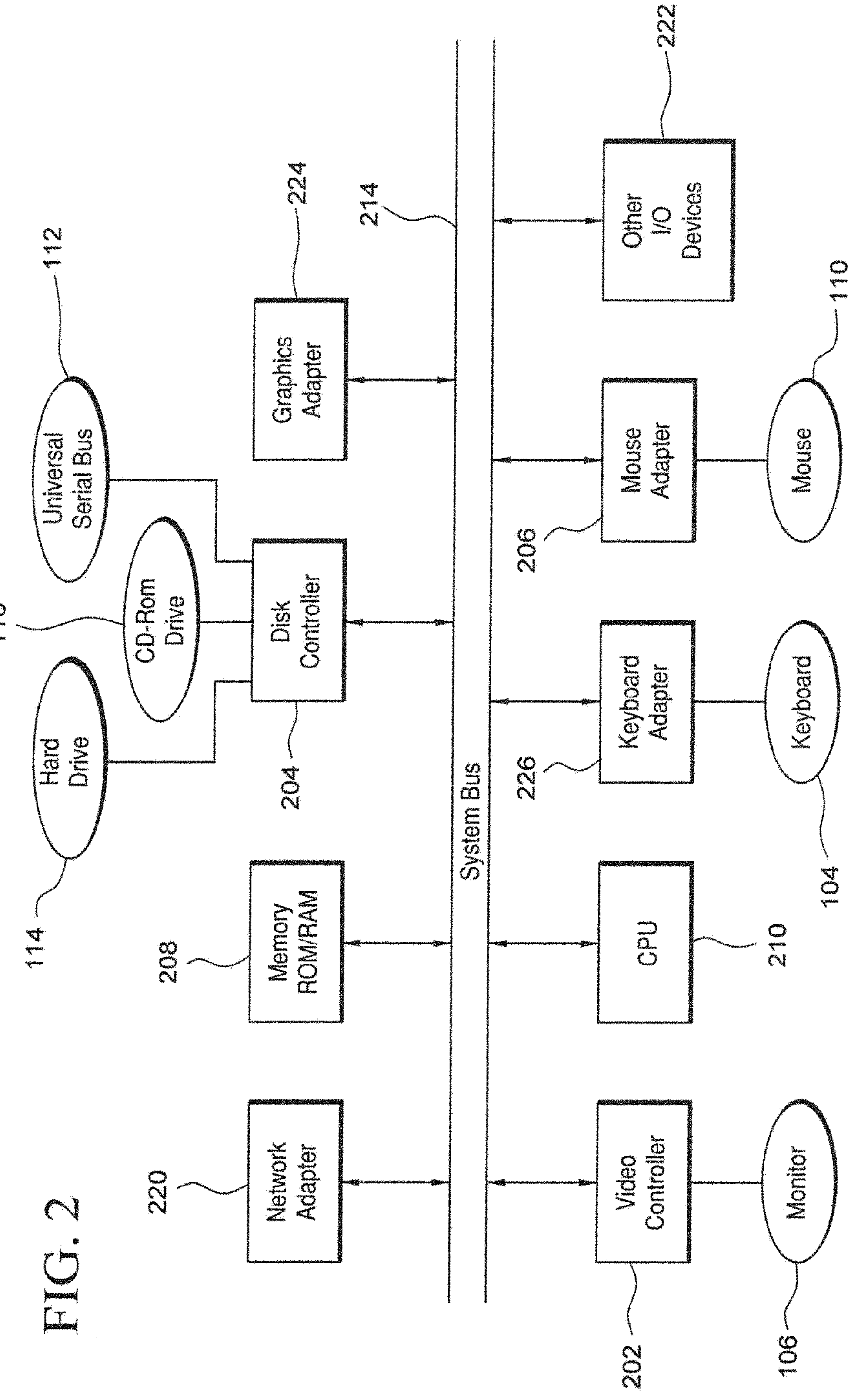

Network Adapter
220
Memory ROM/RAM
208
Hard Drive
114
CD-Rom Drive
116
Universal Serial Bus
112
Disk Controller
204
Graphics Adapter
224
214
System Bus
Video Controller
202
Monitor
106
CPU
210
Keyboard Adapter
226
Keyboard
104
Mouse Adapter
206
Mouse
110
Other I/O Devices
222

FIG. 2

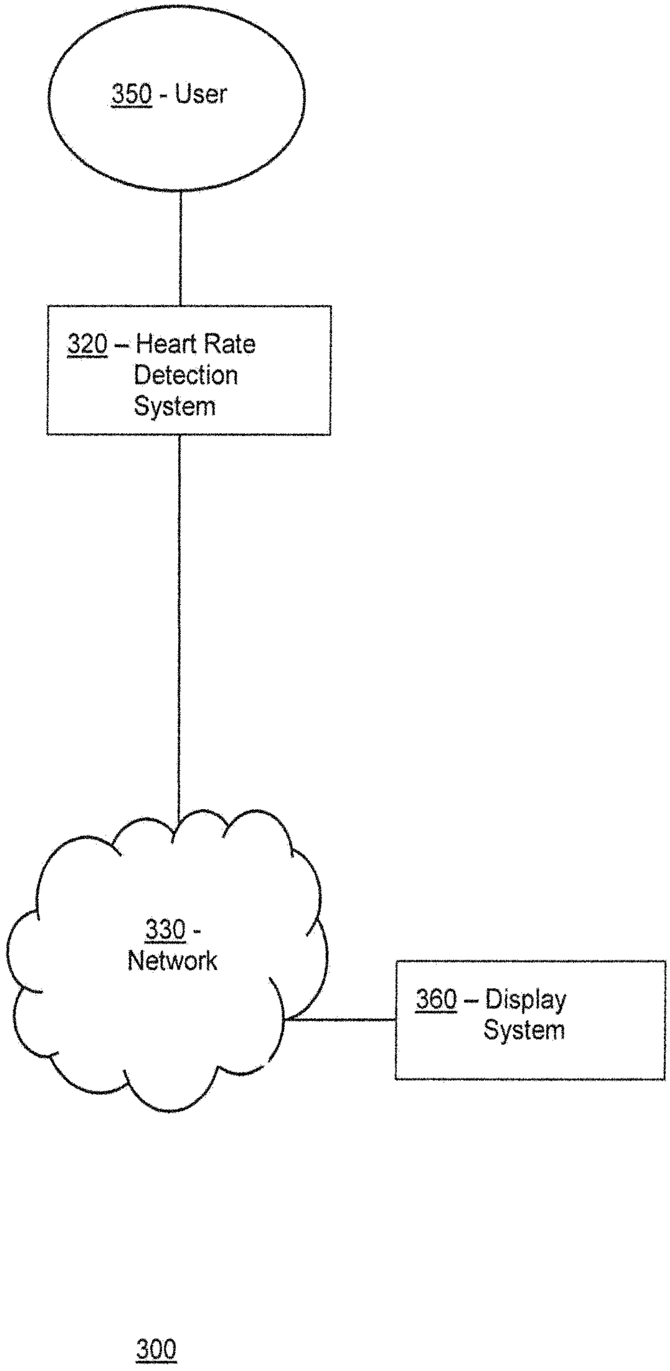

350 - User
320 – Heart Rate Detection System
330 - Network
360 – Display System
300

FIG. 3

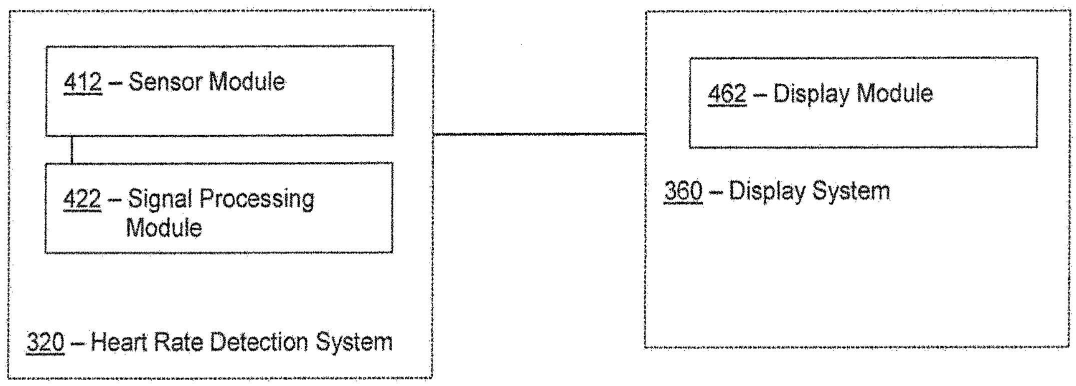

412 – Sensor Module
422 – Signal Processing Module
320 – Heart Rate Detection System
462 – Display Module
360 – Display System

FIG. 4

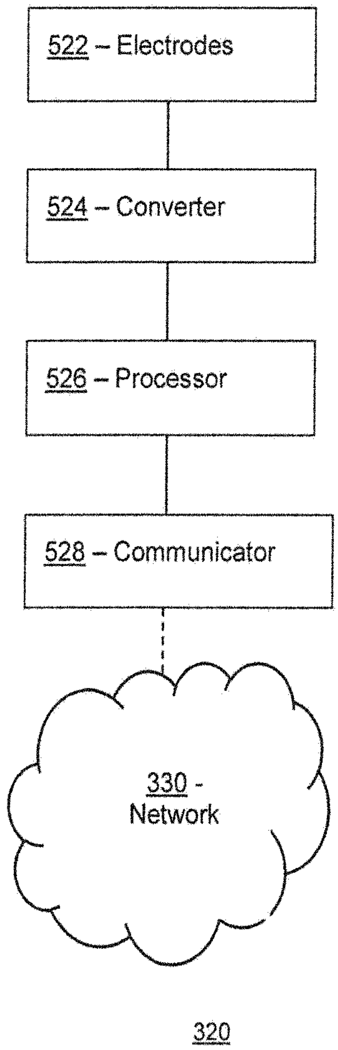

522 – Electrodes
524 – Converter
526 – Processor
528 – Communicator
330 - Network
320

FIG. 5

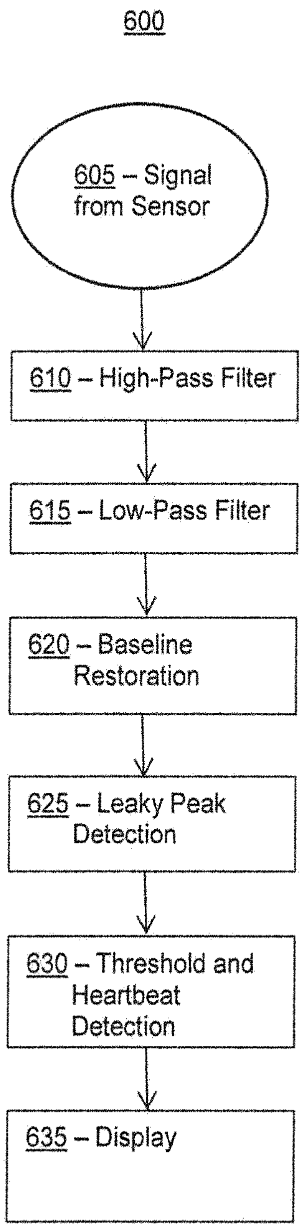

600
605 – Signal from Sensor
610 – High-Pass Filter
615 – Low-Pass Filter
620 – Baseline Restoration
625 – Leaky Peak Detection
630 – Threshold and Heartbeat Detection
635 – Display

FIG. 6

700

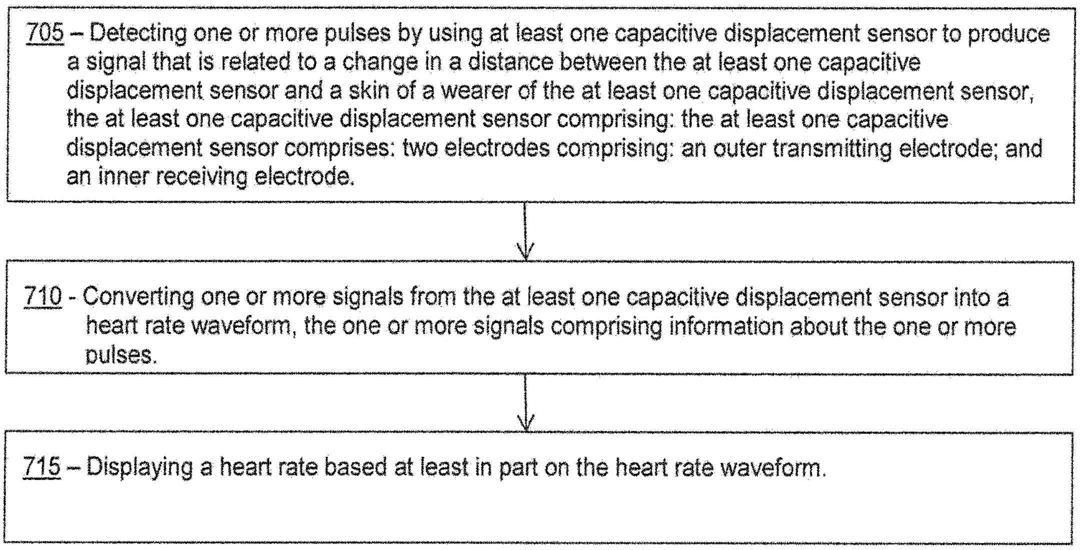
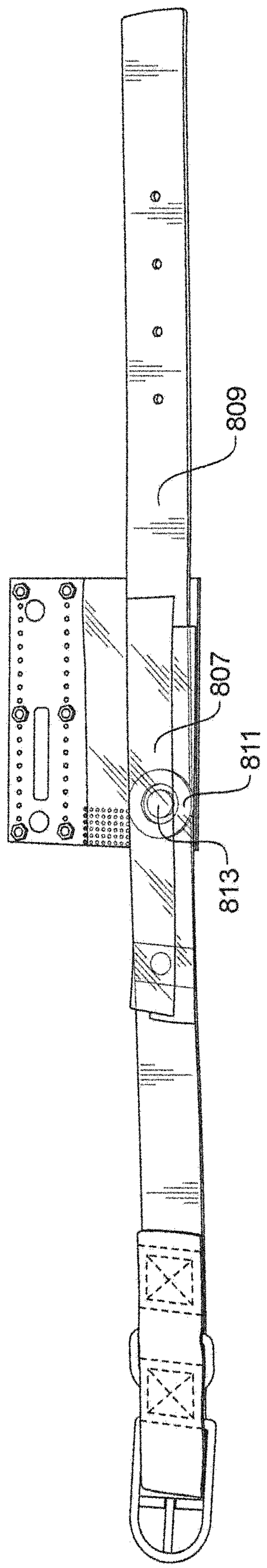

705 – Detecting one or more pulses by using at least one capacitive displacement sensor to produce a signal that is related to a change in a distance between the at least one capacitive displacement sensor and a skin of a wearer of the at least one capacitive displacement sensor, the at least one capacitive displacement sensor comprising: the at least one capacitive displacement sensor comprises: two electrodes comprising: an outer transmitting electrode; and an inner receiving electrode.
710 - Converting one or more signals from the at least one capacitive displacement sensor into a heart rate waveform, the one or more signals comprising information about the one or more pulses.
715 – Displaying a heart rate based at least in part on the heart rate waveform.

FIG. 7



800

FIG. 8

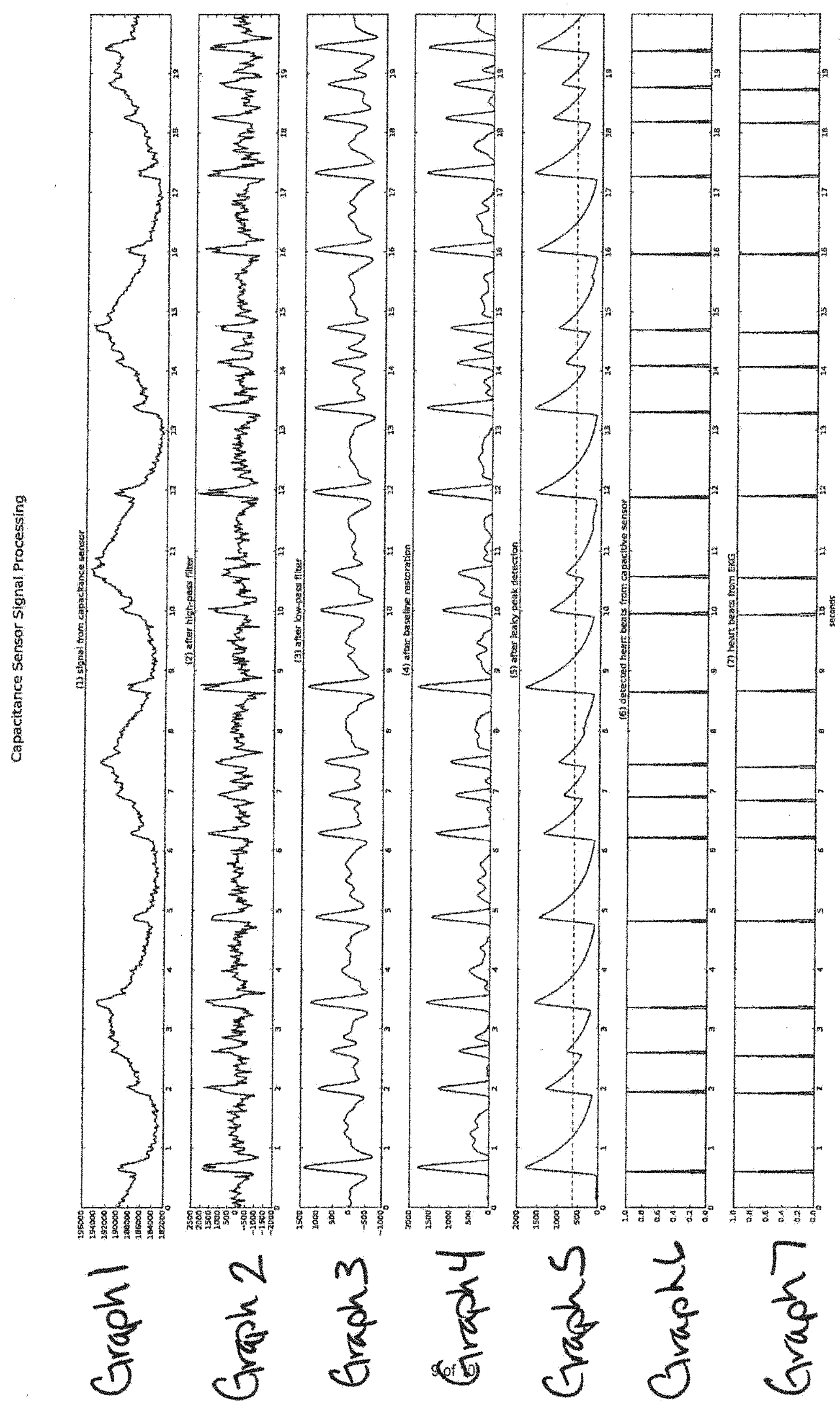

Capacitance Sensor Signal Processing
(1) signal from capacitance sensor
(2) after high-pass filter
(3) after low-pass filter
(4) after baseline restoration
(5) after leaky peak detection
(6) detected heart beats from capacitive sensor
(7) heart beats from EKG
seconds
Graph 1
Graph 2
Graph 3
Graph 4
Graph 5
Graph 6
Graph 7

FIG. 9

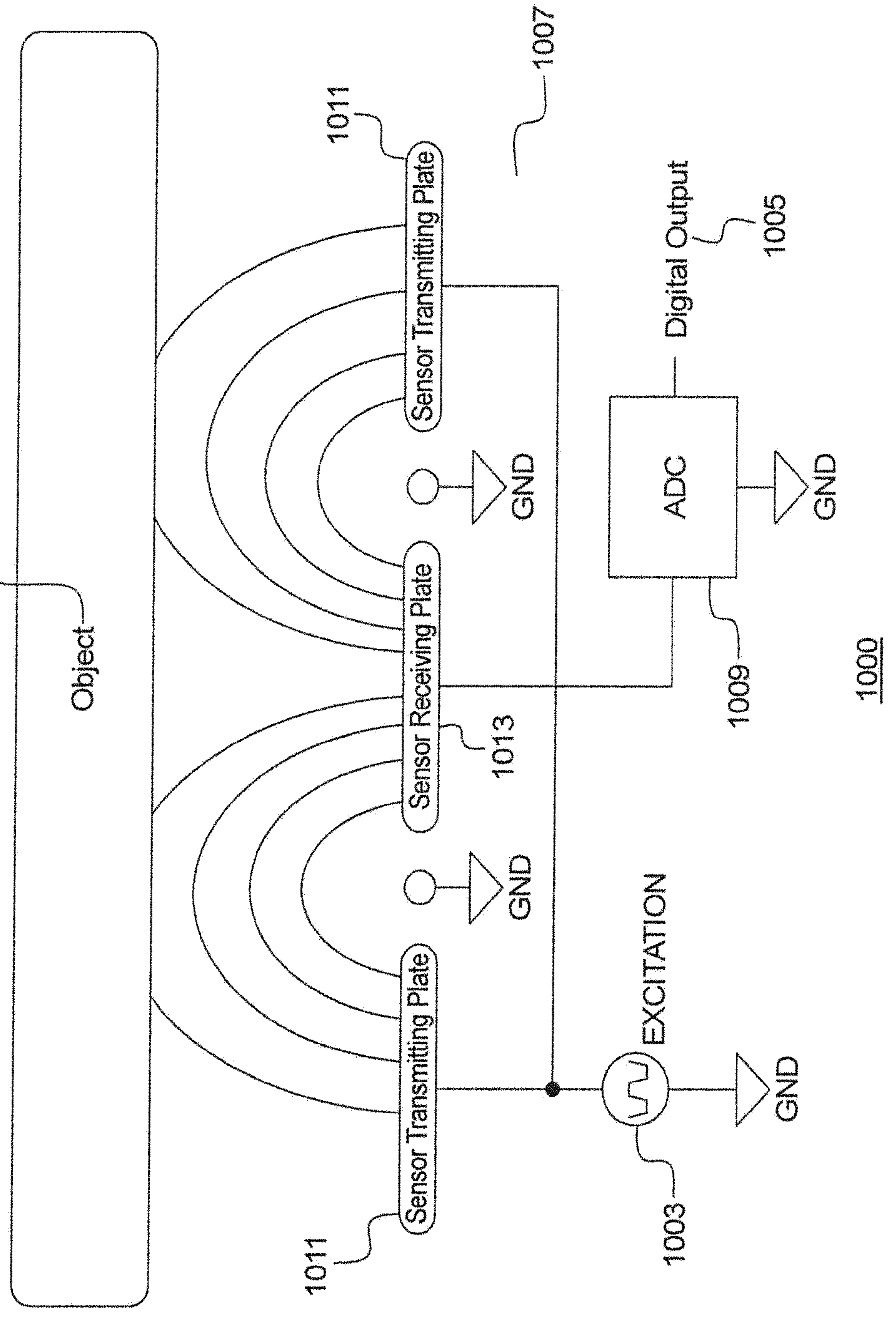

Object
1019
Sensor Transmitting Plate
1011
Sensor Receiving Plate
1013
Sensor Transmitting Plate
1011
1007
GND
GND
GND
GND
ADC
1009
Digital Output
1005
EXCITATION
1003
1000

FIG. 10

HEART RATE DETECTION DEVICE AND RELATED SYSTEMS AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 62/553,202 filed Sep. 1, 2017, the disclosure of which is incorporated herein by this reference.

TECHNICAL FIELD

[0002] This disclosure relates generally to devices for detecting heart rate, heart rate variability, heart beat-to-beat intervals, respiration rate, and breath-to-breath intervals, and relates more particularly to heart rate devices with at least one capacitive displacement sensor.

BACKGROUND

[0003] Similar to the trends seen in human health and fitness monitoring technologies, products are rapidly emerging within the companion animal category leveraging existing and emerging technologies to acquire an individual animal's biometric and behavioral data that can then be translated into custom insights in the animal's current and predictive health. Emotions like fear or happiness affect in a non-voluntary manner how fast the heart beats (Heart Rate or HR) and the rhythm of the heart (time between beats or Heart Rate Variability or HRV). Detecting changes in HR and HRV helps provide information about the changes in emotional status in pets. Involved pet owners want to know about the well-being of their pets when they cannot be together. Pet owners might want to have remote information about the emotional status of their pets while at work or during travel. Pet owner can also have access to the pet's wellbeing while the pet is at the groomers, in a boarding kennel, or with a dog walker. Additionally, changes in HR and respiration can help detect changes in normal cardiac function and respiration, these changes can alert the pet owner of the need to take the pet to the veterinarian. The ability to acquire heart rate and heart rate variability data on a person or animal can offer a rich source of data to identify both current and predictive mood and health insights custom to the individual. While current technologies have been seen that enable heart rate and heart rate variability signal acquisition with accuracy on companion animals when at rest, motion or movement by the animal introduces noise artifacts into these signals which significantly reduce the accuracy and confidence available in the data. Therefore, there is a need for an approach to heart rate and heart rate signal acquisition that can significantly increase the confidence and accuracy in the data beyond the capability of other existing technologies.

SUMMARY OF THE INVENTION

[0004] This disclosure relates generally to devices for detecting heart rate, heart rate variability, heart beat-to-beat intervals, respiration rate, and breath-to-breath intervals. The disclosure relates more particularly to heart rate devices with at least one capacitive displacement sensor.

[0005] One embodiment comprises a the device for detecting a heart rate, the device comprising: at least one capacitive displacement sensor coupled to a strap, wherein the at least one capacitive displacement sensor comprises at least two electrodes, and the at least one capacitive displacement sensor detects a pulse by producing a signal associated with a distance change between a skin of a wearer of the device and the at least one capacitive displacement sensor.

[0006] Another embodiment comprises a system for determining a heart rate, the system comprising: at least one capacitive displacement sensor coupled to a strap, wherein the at least one capacitive displacement sensor comprises at least two electrodes and the at least one capacitive displacement sensor detects one or more pulses by producing a signal associated with a distance change between a skin of a wearer of the system and the at least one capacitive displacement sensor; and a signal processor receiving one or more signals from the at least one capacitive displacement sensor, the one or more signals comprising information about the one or more pulses, wherein the signal processor detects, from the information, one or more peak pulses of the one or more pulses and determines a heart rate waveform therefrom.

[0007] One other embodiment comprises a method for determining a heart rate comprising: detecting one or more pulses by using at least one capacitive displacement sensor to produce a signal that is related to a change in a distance between the at least one capacitive displacement sensor and a skin of a wearer of the at least one capacitive displacement sensor, the at least one capacitive displacement sensor comprising: two electrodes comprising an outer transmitting electrode; and an inner receiving electrode; and converting one or more signals from the at least one capacitive displacement sensor into a heart rate waveform, the one or more signals comprising information about the one or more pulses.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** illustrates a front elevation view of a computer system that is suitable for implementing at least part of a central computer system.

[0009] FIG. **2** illustrates a representative block diagram of exemplary elements included on the circuit boards inside a chassis of the computer system of FIG. **1**.

[0010] FIG. **3** illustrates a representative block diagram of a system, according to an embodiment.

[0011] FIG. **4** illustrates a representative block diagram of a portion of the system of FIG. **3**, according to an embodiment.

[0012] FIG. **5** illustrates a representative block diagram of another portion of the system of FIG. **3**, according to an embodiment.

[0013] FIG. **6** illustrates is a flowchart for a method, according to an embodiment.

[0014] FIG. **7** illustrates is a flowchart for a method, according to an embodiment.

[0015] FIG. **8** illustrates a heart rate detecting device, according to an embodiment.

[0016] FIG. **9** illustrates graphs of a data associated with an embodiment.

[0017] FIG. **10** illustrates a heart rate detecting device, according to another embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0018] For simplicity and clarity of illustration, the drawing figures illustrate the general manner of construction, and descriptions and details of well-known features and techniques may be omitted to avoid unnecessarily obscuring the present disclosure. Additionally, elements in the drawing figures are not necessarily drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help improve understanding of embodiments of the present disclosure. The same reference numerals in different figures denote the same elements.

[0019] The terms “first,” “second,” “third,” “fourth,” and the like in the description and in the claims, if any, are used for distinguishing between similar elements and not necessarily for describing a particular sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances such that the embodiments described herein are, for example, capable of operation in sequences other than those illustrated or otherwise described herein. Furthermore, the terms “include,” and “have,” and any variations thereof, are intended to cover a non-exclusive inclusion, such that a process, method, system, article, device, or apparatus that comprises a list of elements is not necessarily limited to those elements, but may include other elements not expressly listed or inherent to such process, method, system, article, device, or apparatus.

[0020] The terms “left,” “right,” “front,” “back,” “top,” “bottom,” “over”, “under,” and the like in the description and in the claims, if any, are used for descriptive purposes and not necessarily for describing permanent relative positions. It is to be understood that the teens so used are interchangeable under appropriate circumstances such that the embodiments of the apparatus, methods, and/or articles of manufacture described herein are, for example, capable of operation in other orientations than those illustrated or otherwise described herein.

[0021] The terms “couple,” “coupled,” “couples,” “coupling,” and the like should be broadly understood and refer to connecting two or more elements mechanically and/or otherwise. Two or more electrical elements may be electrically coupled together, but not be mechanically or otherwise coupled together. Coupling may be for any length of time, e.g., permanent or semi-permanent or only for an instant. “Electrical coupling” and the like should be broadly understood and include electrical coupling of all types. The absence of the word “removably,” “removable,” and the like near the word “coupled,” and the like does not mean that the coupling, etc. in question is or is not removable.

[0022] As defined herein, “approximately” can, in some embodiments, mean within plus or minus ten percent of the stated value. In other embodiments, “approximately” can mean within plus or minus five percent of the stated value. In further embodiments, “approximately” can mean within plus or minus three percent of the stated value. In yet other embodiments, “approximately” can mean within plus or minus one percent of the stated value.

[0023] Some embodiments can include a device for detecting heart rate. In a number of embodiments, the device can comprise at least one capacitive displacement sensor coupled to a strap. In many embodiments, the at least one capacitive displacement sensor can comprise two electrodes. In some embodiments, the two electrodes can comprise an outer transmitting electrode and an inner receiving electrode. In various embodiments, the at least one capacitive displacement sensor can detect a pulse by producing a signal associated with a distance change between a skin of a wearer of the device and the at least one capacitive displacement sensor.

[0024] Some embodiments comprise a system. In many embodiments, the system can comprise at least one capacitive displacement sensor coupled to a strap. In some embodiments, the at least one capacitive displacement sensor can comprises two electrodes. In some embodiments, the two electrodes comprise an outer transmitting electrode and an inner receiving electrode. In many embodiments, the at least one capacitive displacement sensor can detect a pulse by producing a signal associated with a distance change between a skin of a wearer of the device and the at least one capacitive displacement sensor. In many embodiments, the system can further comprise a signal processor receiving one or more signals from the at least one capacitive displacement sensor, the one or more signals comprising information about the one or more pulses, wherein the signal processor detects, from the information, one or more peak pulses of the one or more pulses and determines a heart rate waveform therefrom.

[0025] Some embodiments include a method. In some embodiments, a method can comprise detecting one or more pulses by using at least one capacitive displacement sensor to produce a signal that is related to a change in a distance between the at least one capacitive displacement sensor and a skin of a wearer of the at least one capacitive displacement sensor. In many embodiments, the at least one capacitive displacement sensor can comprise two electrodes. In some embodiments, the two electrodes can comprise an outer transmitting electrode and an inner receiving electrode. In some embodiments, the method can further comprise converting one or more signals from the at least one capacitive displacement sensor into a heart rate waveform, the one or more signals comprising information about the one or more pulses.

[0026] Turning to the drawings, FIG. **1** illustrates an exemplary embodiment of a computer system **100**, all of which or a portion of which can be suitable for (i) implementing part or all of one or more embodiments of the techniques, methods, and systems and/or (ii) implementing and/or operating part or all of one or more embodiments of the memory storage modules described herein. As an example, a different or separate one of a chassis **102** (and its internal components) can be suitable for implementing part or all of one or more embodiments of the techniques, methods, and/or systems described herein. Furthermore, one or more elements of computer system **100** (e.g., a monitor **106**, a keyboard **104**, and/or a mouse **110**, etc.) also can be appropriate for implementing part or all of one or more embodiments of the techniques, methods, and/or systems described herein. Computer system **100** can comprise chassis **102** containing one or more circuit boards (not shown), a Universal Serial Bus (USB) port **112**, a Compact Disc Read-Only Memory (CD-ROM) and/or Digital Video Disc (DVD) drive **116**, and a hard drive **114**. A representative block diagram of the elements included on the circuit boards inside chassis **102** is shown in FIG. **2**. A central processing unit (CPU) **210** in FIG. **2** is coupled to a system bus **214** in FIG. **2**. In various embodiments, the architecture of CPU **210** can be compliant with any of a variety of commercially distributed architecture families.

[0027] Continuing with FIG. **2**, system bus **214** also is coupled to a memory storage unit **208**, where memory storage unit **208** can comprise (i) volatile (e.g., transitory) memory, such as, for example, read only memory (ROM) and/or (ii) non-volatile (e.g., non-transitory) memory, such as, for example, random access memory (RAM). The non-volatile memory can be removable and/or non-removable non-volatile memory. Meanwhile, RAM can include dynamic RAM (DRAM), static RAM (SRAM), etc. Further, ROM can include mask-programmed ROM, programmable ROM (PROM), one-time programmable ROM (OTP), erasable programmable read-only memory (EPROM), electrically erasable programmable ROM (EEPROM) (e.g., electrically alterable ROM (EAROM) and/or flash memory), etc. The memory storage module(s) of the various embodiments disclosed herein can comprise memory storage unit **208**, an external memory storage drive (not shown), such as, for example, a USB-equipped electronic memory storage drive coupled to universal serial bus (USB) port **112** (FIGS. **1-2**), hard drive **114** (FIGS. **1-2**), a CD-ROM and/or DVD for use with a CD-ROM and/or DVD drive **116** (FIGS. **1-2**), floppy disk for use with a floppy disk drive (not shown), an optical disc (not shown), a magneto-optical disc (now shown), magnetic tape (not shown), etc. Further, non-volatile or non-transitory memory storage module(s) refer to the portions of the memory storage module(s) that are non-volatile (e.g., non-transitory) memory.

[0028] In various examples, portions of the memory storage module(s) of the various embodiments disclosed herein (e.g., portions of the non-volatile memory storage module (s)) can be encoded with a boot code sequence suitable for restoring computer system **100** (FIG. **1**) to a functional state after a system reset. In addition, portions of the memory storage module(s) of the various embodiments disclosed herein (e.g., portions of the non-volatile memory storage module(s)) can comprise microcode such as a Basic Input-Output System (BIOS) operable with computer system **100** (FIG. **1**). In the same or different examples, portions of the memory storage module(s) of the various embodiments disclosed herein (e.g., portions of the non-volatile memory storage module(s)) can comprise an operating system, which can be a software program that manages the hardware and software resources of a computer and/or a computer network. The BIOS can initialize and test components of computer system **100** (FIG. **1**) and load the operating system. Meanwhile, the operating system can perform basic tasks such as, for example, controlling and allocating memory, prioritizing the processing of instructions, controlling input and output devices, facilitating networking, and managing files. Exemplary operating systems can comprise one of the following: (i) Microsoft® Windows® operating system (OS) by Microsoft Corp. of Redmond, Wash., United States of America, (ii) Mac® OS X by Apple Inc. of Cupertino, Calif., United States of America, (iii) UNIX® OS, and (iv) Linux® OS. Further exemplary operating systems can comprise one of the following: (i) the iOS® operating system by Apple Inc. of Cupertino, Calif., United States of America, (ii) the Blackberry® operating system by Research In Motion (RIM) of Waterloo, Ontario, Canada, (iii) the WebOS operating system by LG Electronics of Seoul, South Korea, (iv) the Android™ operating system developed by Google, of Mountain View, Calif., United States of America, (v) the Windows Mobile™ operating system by Microsoft Corp. of Redmond, Wash., United States of America, or (vi) the Symbian™ operating system by Accenture PLC of Dublin, Ireland.

[0029] As used herein, "processor" and/or "processing module" means any type of computational circuit, such as but not limited to a microprocessor, a microcontroller, a controller, a complex instruction set computing (CISC) microprocessor, a reduced instruction set computing (RISC) microprocessor, a very long instruction word (VLIW) microprocessor, a graphics processor, a digital signal processor, or any other type of processor or processing circuit capable of performing the desired functions. In some examples, the one or more processing modules of the various embodiments disclosed herein can comprise CPU **210**.

[0030] In the depicted embodiment of FIG. **2**, various I/O devices such as a disk controller **204**, a graphics adapter **224**, a video controller **202**, a keyboard adapter **226**, a mouse adapter **206**, a network adapter **220**, and other I/O devices **222** can be coupled to system bus **214**. Keyboard adapter **226** and mouse adapter **206** are coupled to keyboard **104** (FIGS. **1-2**) and mouse **110** (FIGS. **1-2**), respectively, of computer system **100** (FIG. **1**). While graphics adapter **224** and video controller **202** are indicated as distinct units in FIG. **2**, video controller **202** can be integrated into graphics adapter **224**, or vice versa in other embodiments. Video controller **202** is suitable for monitor **106** (FIGS. **1-2**) to display images on a screen **108** (FIG. **1**) of computer system **100** (FIG. **1**). Disk controller **204** can control hard drive **114** (FIGS. **1-2**), USB port **112** (FIGS. **1-2**), and CD-ROM drive **116** (FIGS. **1-2**). In other embodiments, distinct units can be used to control each of these devices separately.

[0031] Network adapter **220** can be suitable to connect computer system **100** (FIG. **1**) to a computer network by wired communication (e.g., a wired network adapter) and/or wireless communication (e.g., a wireless network adapter). In some embodiments, network adapter **220** can be plugged or coupled to an expansion port (not shown) in computer system **100** (FIG. **1**). In other embodiments, network adapter **220** can be built into computer system **100** (FIG. **1**). For example, network adapter **220** can be built into computer system **100** (FIG. **1**) by being integrated into the motherboard chipset (not shown), or implemented via one or more dedicated communication chips (not shown), connected through a PCI (peripheral component interconnector) or a PCI express bus of computer system **100** (FIG. **1**) or USB port **112** (FIG. **1**).

[0032] Returning now to FIG. **1**, although many other components of computer system **100** are not shown, such components and their interconnection are well known to those of ordinary skill in the art. Accordingly, further details concerning the construction and composition of computer system **100** and the circuit boards inside chassis **102** are not discussed herein.

[0033] Meanwhile, when computer system **100** is running, program instructions (e.g., computer instructions) stored on one or more of the memory storage module(s) of the various embodiments disclosed herein can be executed by CPU **210** (FIG. **2**). At least a portion of the program instructions, stored on these devices, can be suitable for carrying out at least part of the techniques and methods described herein.

[0034] Further, although computer system **100** is illustrated as a desktop computer in FIG. **1**, there can be examples where computer system **100** may take a different form factor while still having functional elements similar to those described for computer system **100**. In some embodiments, computer system **100** may comprise a single computer, a single server, or a cluster or collection of computers or servers, or a cloud of computers or servers. Typically, a cluster or collection of servers can be used when the demand on computer system **100** exceeds the reasonable capability of a single server or computer. In certain embodiments, computer system **100** may comprise a portable computer, such as a laptop computer. In certain other embodiments, computer system **100** may comprise a mobile electronic device, such as a smartphone. In certain additional embodiments, computer system **100** may comprise an embedded system.

[0035] Skipping ahead now in the drawings, FIG. **3** illustrates a representative block diagram of a system **300**, according to an embodiment. System **300** is merely exemplary and embodiments of the system are not limited to the embodiments presented herein. System **300** can be employed in many different embodiments or examples not specifically depicted or described herein. In some embodiments, certain elements or modules of system **300** can perform various methods and/or activities of those methods. In these or other embodiments, the methods and/or the activities of the methods can be performed by other suitable elements or modules of system **300**.

[0036] Generally, therefore, system **300** can be implemented with hardware and/or software, as described herein. In some embodiments, part or all of the hardware and/or software can be conventional, while in these or other embodiments, part or all of the hardware and/or software can be customized (e.g., optimized) for implementing part or all of the functionality of system **300** described herein.

[0037] In a number of embodiments, system **300** can comprise a heart rate detection system **320** and a display system **360**. In some embodiments, heart rate detection system **320** and display system **360** can each be a computer system **100** (FIG. **1**), as described above, and can each be a single computer, a single server, or a cluster or collection of computers or servers. In many embodiments, heart rate detection system **320** can comprise device **800** (FIG. **8**).

[0038] In many embodiments, heart rate detection system **320** and/or display system **360** can each comprise one or more input devices (e.g., one or more keyboards, one or more keypads, one or more pointing devices such as a computer mouse or computer mice, one or more touchscreen displays, a microphone, etc.), and/or can each comprise one or more display devices (e.g., one or more monitors, one or more touch screen displays, projectors, etc.). In these or other embodiments, one or more of the input device(s) can be similar or identical to keyboard **104** (FIG. **1**) and/or a mouse **110** (FIG. **1**). Further, one or more of the display device(s) can be similar or identical to monitor **106** (FIG. **1**) and/or screen **108** (FIG. **1**). The input device(s) and the display device(s) can be coupled to the processing module(s) and/or the memory storage module(s) of heart rate detection system **320** and/or display system **360** in a wired manner and/or a wireless manner, and the coupling can be direct and/or indirect, as well as locally and/or remotely. As an example of an indirect manner (which may or may not also be a remote manner), a keyboard-video-mouse (KVM) switch can be used to couple the input device(s) and the display device(s) to the processing module(s) and/or the memory storage module(s). In some embodiments, the KVM switch also can be part of heart rate detection system **320** and/or display system **360**. In a similar manner, the processing module(s) and the memory storage module(s) can be local and/or remote to each other.

[0039] In many embodiments, heart rate detection system **320** and/or display system **360** can be configured to communicate with one or more user computers (not shown). In some embodiments, heart rate detection system and/or display system **360** can communicate or interface (e.g. interact) with one or more customer computers through a network **330**. In some embodiments, network **330** can be an Internet, or an intranet that is not open to the public. Accordingly, in many embodiments, heart rate detection system **320** and/or display system **360** (and/or the software used by such systems) can refer to a back end of system **300** operated by an operator and/or administrator of system **300**, and user computers (and/or the software used by such systems) can refer to a front end of system **300** used by one or more user **350**, respectively. In these or other embodiments, the operator and/or administrator of system **300** can manage system **300**, the processing module(s) of system **300**, and/or the memory storage module(s) of system **300** using the input device(s) and/or display device(s) of system **300**.

[0040] Meanwhile, in many embodiments, heart rate detection system **320** and/or display system **360** also can be configured to communicate with one or more databases. The one or more databases can be stored on one or more memory storage modules (e.g., non-transitory memory storage module(s)), which can be similar or identical to the one or more memory storage module(s) (e.g., non-transitory memory storage module(s)) described above with respect to computer system **100** (FIG. **1**). Also, in some embodiments, for any particular database of the one or more databases, that particular database can be stored on a single memory storage module of the memory storage module(s), and/or the non-transitory memory storage module(s) storing the one or more databases or the contents of that particular database can be spread across multiple ones of the memory storage module(s) and/or non-transitory memory storage module(s) storing the one or more databases, depending on the size of the particular database and/or the storage capacity of the memory storage module(s) and/or non-transitory memory storage module(s).

[0041] The one or more databases can each comprise a structured (e.g., indexed) collection of data and can be managed by any suitable database management systems configured to define, create, query, organize, update, and manage database(s). Exemplary database management systems can include MySQL (Structured Query Language) Database, PostgreSQL Database, Microsoft SQL Server Database, Oracle Database, SAP (Systems, Applications, & Products) Database, and IBM DB2 Database.

[0042] Meanwhile, communication between heart rate detection system **320**, display system **360**, and/or the one or more databases can be implemented using any suitable manner of wired and/or wireless communication. Accordingly, system **300** can comprise any software and/or hardware components configured to implement the wired and/or wireless communication. Further, the wired and/or wireless communication can be implemented using any one or any combination of wired and/or wireless communication network topologies (e.g., ring, line, tree, bus, mesh, star, daisy chain, hybrid, etc.) and/or protocols (e.g., personal area network (PAN) protocol(s), local area network (LAN) protocol(s), wide area network (WAN) protocol(s), cellular network protocol(s), powerline network protocol(s), etc.).

Exemplary PAN protocol(s) can comprise Bluetooth, Zigbee, Wireless Universal Serial Bus (USB), Z-Wave, etc.; exemplary LAN and/or WAN protocol(s) can comprise Institute of Electrical and Electronic Engineers (IEEE) 802.3 (also known as Ethernet), IEEE 802.11 (also known as WiFi), etc.; and exemplary wireless cellular network protocol(s) can comprise Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS), Code Division Multiple Access (CDMA), Evolution-Data Optimized (EV-DO), Enhanced Data Rates for GSM Evolution (EDGE), Universal Mobile Telecommunications System (UMTS), Digital Enhanced Cordless Telecommunications (DECT), Digital AMPS (IS-136/Time Division Multiple Access (TDMA)), Integrated Digital Enhanced Network (iDEN), Evolved High-Speed Packet Access (HSPA+), Long-Term Evolution (LTE), WiMAX, etc. The specific communication software and/or hardware implemented can depend on the network topologies and/or protocols implemented, and vice versa. In many embodiments, exemplary communication hardware can comprise wired communication hardware including, for example, one or more data buses, such as, for example, universal serial bus(es), one or more networking cables, such as, for example, coaxial cable(s), optical fiber cable(s), and/or twisted pair cable(s), any other suitable data cable, etc. Further exemplary communication hardware can comprise wireless communication hardware including, for example, one or more radio transceivers, one or more infrared transceivers, etc. Additional exemplary communication hardware can comprise one or more networking components (e.g., modulator-demodulator components, gateway components, etc.)

[0043] Turning ahead in the drawings, FIG. **8** illustrates a device **800** for detecting heart rate. In many embodiments, device **800** can comprise at least one capacitive displacement sensor **807** coupled to a strap **809**. In some embodiments, strap **809** can comprise at least one of a harness, a belt, a vest, a collar, or a garment. In some embodiments, strap **809** can be configured to be worn over the skin of an animal (e.g., a vest worn by a dog). In many embodiments, at least one capacitive displacement sensor **807** can comprise two electrodes. In some embodiments, the at least one capacitive displacement sensor can comprise more than two electrodes. In many embodiments, the two electrodes can comprise an outer transmitting electrode **811** and an inner receiving electrode **813**. In some embodiments, the two electrodes can comprise a first electrode configured to transmit one or more signals and a second electrode configured to receive one or more signals. In some embodiments, outer transmitting electrode **811** and inner receiving electrode **813** can be concentric. In some embodiments, outer transmitting electrode **811** and inner receiving electrode **813** can be concentric circles. In other embodiments, outer transmitting electrode **811** and inner receiving electrode **813** can be linear with their geometric centers aligned together. In various embodiments, device **800** can comprise more than one capacitive displacement sensors that can be placed at approximately equidistant intervals across strap **809**. In some embodiments, at least one capacitive displacement sensor **807** can further comprise a ground electrode. In a number of embodiments, at least one capacitive displacement sensor **807** can comprise at least one outer transmitting electrode **811** and more than one inner receiving electrode **813**.

[0044] In many embodiments, at least one capacitive displacement sensor **807** can detect a pulse by producing a signal associated with a distance change between a skin of a wearer of the device and the at least one capacitive displacement sensor. In some embodiments, at least one capacitive displacement sensor **807** can detect a heart rate, a heart beat-to-beat interval, a respiration rate, and/or a breath-to-breath interval by producing a signal associated with a distance change between a skin of a wearer (e.g., user **350** (FIG. **3**) or a pet of user **350** (FIG. **3**)) of device **800** and at least one capacitive displacement sensor **807**. In some embodiments, the wearer can be a dog or a cat, or other similar pet and/or animal. In some embodiments, heart rate variability can be determined by measuring a time between heartbeats of the wearer of device **800**. As discussed further below, in many embodiments, a processor (e.g., processor **526** (FIG. **5**) can be used to process the signal produced by at least one capacitive displacement sensor **807** in order to extract information associated with the heart rate and/or breathing of the wearer (e.g. user **350** (FIG. **3**)) (e.g., heart rate, heart beat-to-beat interval, respiration rate, and/or breath-to-breath interval).

[0045] In many embodiments, the at least one capacitive displacement sensor can measure the change in a distance between the at least one capacitive displacement sensor and a skin of a wearer of the at least one capacitive displacement sensor by capacitive proximity sensing. Turning to FIG. **10**, device **1000** can be a heart rate detection device. In some embodiments, device **1000** can be similar to device **800** (FIG. **8**). In many embodiments, device **1000** can comprise at least one capacitive displacement sensor **1007**. In many embodiments, at least one capacitive displacement sensor **1007** can comprise at least one outer transmitting electrode **1011** and at least one inner receiving electrode **1013**. In many embodiments, outer transmitting electrode **1011** can be similar to outer transmitting electrode **811** (FIG. **8**) and inner transmitting electrode **1013** can be similar to inner transmitting electrode **813** (FIG. **8**).

[0046] In some embodiments, a power source can supply AC excitation voltage **1003** applied to outer transmitting electrode **1011**. In some embodiments, a capacitance to digital converter can comprise the power source for AC excitation voltage **1003** and an analog-to-digital converter **1009**. In many embodiments, the capacitance resolution of the capacitance to digital converter can be approximately 164 femtofarads. In various embodiments, power consumption of the capacitance to digital converter can be approximately 700 microamps at 3.3 volts. In many embodiments, inner receiving electrode **1013** can receive a signal from outer transmitting electrode **1011** due to capacitive coupling between outer transmitting electrode **1011** and inner receiving electrode **1013**. As an object **1019** (e.g., skin of the wearer or user raised during a heart beat or pulse) approaches outer transmitting electrode **1011** of device and inner receiving electrode **1013**, capacitive coupling can shunt the signal away from inner receiving electrode **1013**. In many embodiments, the shunting of the signal away from inner receiving electrode **1013** can cause the signal amplitude to be reduced. In a number of embodiments, a signal can be produced based at least in part on a change in distance due in part to the shunting of the signal away from inner receiving electrode **1013**. In some embodiments, the change in distance can be approximately 0.01 centimeter (cm) to approximately 3 cm. In some embodiments, a pulse of the carotid artery can cause dilation of the surface of the artery, which can result in an approximately 0.01 cm raise on a skin of an animal. In many embodiments, the change of distance can depend at least in part on a size of the animal, a breed of the animal, and/or a type of coat of the animal. In many embodiments, the signal produced can be converted into a digital output signal **1005**.

[0047] Returning to FIG. **8**, in a number of embodiments, at least one capacitive displacement sensor **807** can be placed at a neck of a wearer (e.g., user **350** (FIG. **3**)) and approximate to a carotid artery of the wearer (e.g., user **350** (FIG. **3**)). In many embodiments, at least one capacitive displacement sensor **807** does not touch a skin of the wearer. In many embodiments, at least one capacitive displacement sensor **807** is a non-contact displacement sensor. In some embodiments, at least one capacitive displacement sensor **807** can be placed at a chest of the wearer (e.g., user **350** (FIG. **3**)).

[0048] In various embodiments, device **800** can further comprise an array of capacitive sensors. In many embodiments, the array of capacitive sensors can comprise at least one capacitive displacement sensor **807**. In some embodiments, the array of capacitive sensors can comprise at least two capacitive displacement sensors. In some embodiments, the array of capacitive sensors can comprise a linear array. In some embodiments, the array of capacitive sensors can comprise a 2-dimensional array (e.g., on an inside surface of a vest).

[0049] In many embodiments, device **800** can further comprise one or more one or more inertial sensors. In some embodiment, the one or more inertial sensors can sense motion caused by a movement of the wearer (e.g., user **350** (FIG. **3**)) of the device. In some embodiments, the movement of the wearer (e.g., user **350** (FIG. **3**)) can be associated with the wearer walking, running, or any other body motion that is not associated with breathing. In some embodiments, at least a portion of the one or more inertial sensors can be co-located with at least one capacitive displacement sensor **807**. As an example, in some embodiments, at least one capacitive displacement sensor **807** and the at least the portion of the one or more inertial sensors can be located on a left side of the chest of the wearer (e.g., user **350** (FIG. **3**)), and/or another portion of the one or more inertial sensors and a different capacitive displacement sensor can be located on a right side of the chest of the wearer (e.g., user **350** (FIG. **3**)) to balance the weight of the strap across the wearer.

[0050] Turning back to heart rate detection system **320** in FIG. **5**, in many embodiments, the output signal from at least one capacitive displacement sensor **807** (FIG. **8**) can be a waveform. In many embodiments, the waveform can comprise information associated with the heart rate and/or breathing of the wearer (e.g. user **350** (FIG. **3**)) (e.g., heart rate, heart beat-to-beat interval, respiration rate, and/or breath-to-breath interval). In some embodiments, heart rate detection system **320** can comprise one or more electrodes **522** (e.g., outer transmitting electrode **811** and inner receiving electrode **813** (FIG. **8**)), converter **524**, processor **526**, and communicator **528**.

[0051] In some embodiments, heart rate detection system **320** (FIG. **5**) can process the signal produced by at least one capacitive displacement sensor **807** (FIG. **8**) according to a method **600** (FIG. **6**). Discussing FIGS. **6** and **9** together, in many embodiments, method **600** can process the signal produced by at least one capacitive displacement sensor **807** (FIG. **8**).

[0052] FIG. **9** illustrates **7** graphs representing approximately 20 seconds of data captured by at least one capacitive displacement sensor **807** (FIG. **8**). In many embodiments, the output signal from the at least one capacitive displacement sensor **807** (FIG. **8**) comprises a digital (e.g., numeric) representation of a capacitance value sensed by the electrodes (e.g., outer transmitting electrode **811** and inner receiving electrode **813** (FIG. **8**) as sent in activity **605** (FIG. **6**). This output signal can be raw or unprocessed and comprises information related to the breathing and heart beats of the dog. Graph **1** in FIG. **9** illustrates the output of activity **605**.

[0053] Turning back in the drawings, FIG. **6** illustrates a flow chart for a method **600**, according to an embodiment. Method **600** is merely exemplary and is not limited to the embodiments presented herein. Method **600** can be employed in many different embodiments or examples not specifically depicted or described herein. In some embodiments, the heart rate detecting device **800** (FIG. **8**) and/or device **1000** (FIG. **10**) can be used in association with method **600**. In some embodiments, the activities of method **600** can be performed in the order presented. In other embodiments, the activities of method **600** can be performed in any suitable order. In still other embodiments, one or more of the activities of method **600** can be combined or skipped. In many embodiments, system **300** (FIG. **3**) can be suitable to perform method **600** and/or one or more of the activities of method **600**. In these or other embodiments, one or more of the activities of method **600** can be implemented as one or more computer instructions configured to run at one or more processing modules and configured to be stored at one or more non-transitory memory storage modules **412**, **422**, and/or **462** (FIG. **4**). Such non-transitory memory storage modules can be part of a computer system such as heart rate device system **320** (FIGS. **3** & **4**) and/or display system **360** (FIGS. **3** & **4**). The processing module(s) can be similar or identical to the processing module(s) described above with respect to computer system **100** (FIG. **1**).

[0054] In many embodiments, method **600** can comprise an activity **610** of filtering the signal from activity **605** with a high-pass filter. In some embodiments, the high-pass filter can comprise a cutoff frequency of approximately 1 Hertz (Hz). In many embodiments, activity **610** can remove slow-moving signals, such as signals caused by respiration, in order to remove an offset from the data produced by activity **605**. Graph **2** (FIG. **9**) illustrates the output of activity **610**.

[0055] In various embodiments, method **600** further can comprise an activity **615** of filtering the signal through a low-pass filter. In many embodiments, activity **615** can comprise removing high-frequency noise by using the low-pass filter. In some embodiments, a cutoff frequency of the low-pass filter can be approximately 10 Hz. Graph **3** (FIG. **9**) illustrates the output of activity **615**. In some embodiments, the sequence of activities **610** and **615** is reversed.

[0056] In a number of embodiments, method **600** further can comprise an activity **620** of processing the signal to restore a baseline. In some embodiments, activity **620** can comprise processing the signal to set a numeric baseline of zero. In various embodiments, activity **620** can use a baseline restoration (e.g., DC-restoration) algorithm. In some embodiments, the following algorithm (in PYTHON code) can be used, wherein y_bp is the input signal and y_dcr is the output signal:

```
#dc restore
baseline = np.zeros(len(y__bp))
y__dcr = np.zeros(len(y__bp))
dcr = np.mean(y__bp)
decay__rate = 0.96
for i in range(len(y__bp)):
        if (y__bp[i] < dcr):
                dcr = y__bp[i]
        baseline[i] = dcr
        y__dcr[i] = y__bp[i] - dcr
        dcr = dcr*decay__rate
```

[0057] In some embodiments, this processing can emphasize one or more peaks in the signal that can be due to heartbeats. Graph **4** (FIG. **9**) illustrates the output of activity **620**.

[0058] In a number of embodiments, method **600** further can comprise an activity **625** to detect one or more heart beats and reject noise by processing the signal with a "leaky peak detection" algorithm. In many embodiments, following algorithm (in PYTHON code) can be used, where y_dcr is the input and y_pdl is the output:

```
#peak detection, leaky
pd__decay = 0.96
pdl = min(y__dcr)
y__pdl = np.zeros(len(y__dcr))
for i in range(len(y__pdl)):
        if (y__dcr[i] > pdl):
                pdl = y__dcr[i]
        y__pdl[i] = pdl
        pdl = pdl*pd__decay
```

[0059] Graph **5** (FIG. **9**) illustrates the output of activity **625**.

[0060] In some embodiments, method **600** also can comprise activity **630** of determining a threshold and detecting a heartbeat. In many embodiments, to detect heart beats from the signal of graph **5** (FIG. **9**), activity **630** can comprise determining a threshold value as the average of the signal. The threshold value can be shown as the dashed line in graph **5** (FIG. **9**). In many embodiments, a heart beat can be detected when the signal has a rising edge that crosses the threshold value (e.g., dashed line). Graph **6** (FIG. **9**) illustrates the output of activity **630**. As shown in graph **6** (FIG. **9**), each vertical spike indicates a detected heartbeat. The signal in graph **6** (FIG. **9**) can be used to measure beat-to-beat variation. In some embodiments, activity **600** also can comprise activity **635** of displaying the heart beat.

[0061] In many embodiments, to verify that the heart beat detecting device (e.g. device **800** (FIG. **8**) is correctly detecting heart beats from the user (e.g., user **350** (FIG. **3**), one or more heart beats from an electrocardiogram based (EKG-based) heart rate monitor can be collected simultaneously with the capacitive signal. The one or more heart beats recorded from the EKG-based monitor are illustrated in graph **7** (FIG. **9**). In the case of this approximately 20-second data set, the heart beat timing detected by the heart beat detecting device (e.g. device **800** (FIG. **8**) in graph **6** corresponds to the heart beat timing from the EKG-based monitor in graph **7** (FIG. **9**).

[0062] Turning ahead in the drawings, FIG. **7** illustrates a flow chart for a method **700**, according to an embodiment. Method **700** is merely exemplary and is not limited to the embodiments presented herein. Method **700** can be employed in many different embodiments or examples not specifically depicted or described herein. In some embodiments, the heart rate detecting device **800** (FIG. **8**) can be used in association with method **700**. In some embodiments, the activities of method **700** can be performed in the order presented. In other embodiments, the activities of method **700** can be performed in any suitable order. In still other embodiments, one or more of the activities of method **700** can be combined or skipped. In many embodiments, system **300** (FIG. **3**) can be suitable to perform method **700** and/or one or more of the activities of method **700**. In these or other embodiments, one or more of the activities of method **700** can be implemented as one or more computer instructions configured to run at one or more processing modules and configured to be stored at one or more non-transitory memory storage modules **412**, **422**, and/or **462** (FIG. **4**). Such non-transitory memory storage modules can be part of a computer system such as heart rate device system **320** (FIGS. **3** & **4**) and/or display system **360** (FIGS. **3** & **4**). The processing module(s) can be similar or identical to the processing module(s) described above with respect to computer system **100** (FIG. **1**).

[0063] In many embodiments, method **700** can comprise an activity **705** of detecting one or more pulses by using at least one capacitive displacement sensor to produce a signal that is related to a change in a distance between the at least one capacitive displacement sensor and a skin of a wearer of the at least one capacitive displacement sensor. In many embodiments, the at least one capacitive displacement sensor can comprise two electrodes comprising an outer transmitting electrode (e.g. outer transmitting electrode **811** (FIG. **8**)) and an inner receiving electrode (e.g., inner receiving electrode **813** (FIG. **8**)). In some embodiments, the at least one capacitive displacement sensor can be similar to at least one capacitive displacement sensor **807** (FIG. **8**). In various embodiments, the at least one capacitive displacement sensor can be attached to a strap (e.g., strap **809** (FIG. **8**)). In some embodiments, the two electrodes can comprise a first electrode configured to transmit one or more signals and a second electrode configured to receive one or more signals. In some embodiments, the outer transmitting electrode and the inner receiving electrode can be concentric. In some embodiments, the outer transmitting electrode and the inner receiving electrode can be concentric circles. In some embodiments, the outer transmitting electrode and the inner receiving electrode can be linear. In various embodiments, the heart beat detecting device (e.g., device **800** (FIG. **8**)) can comprise more than one capacitive displacement sensors that can be placed at approximately equidistant intervals across the strap. In some embodiments, the at least one capacitive displacement sensor can further comprise a ground electrode. In a number of embodiments, the at least one capacitive displacement sensor can comprise at least one outer transmitting electrode and more than one inner receiving electrode.

[0064] In one embodiment, one electrode could be a ground electrode, such as a metal wire that goes all the way around the collar or the collar itself if the collar were made of an electrically conductive material or a fabric with electrically conducive fibers in it. In this embodiment, the active electrode would be a metal patch located on the inside of the collar with an insulator separating it from the main collar strap ground electrode.

[0065] In another embodiments, the capacitance between the electrodes is not sensed by making one electrode transmit and the other receive. One common way to do this is to make the capacitance of one electrode relative to ground (or the strap) part of an oscillator's resonant circuit. When this is done, the frequency of the oscillation changes as the capacitance between the electrode and ground changes. The oscillator's output then goes to a frequency to voltage converter to get a signal that would look basically the same as that from an AD7746-based sensor. This single-electrode capacitive sensing technique is the principle of the well-known "Theremin" musical instrument, where extremely small changes in capacitance between the "antenna" (a single electrode) and ground affect the pitch of an audio oscillator.

[0066] In many embodiments, activity **705** can comprise applying an alternating current (AC) excitation voltage to the outer transmitting electrode as shown in FIG. **10** and discussed above. In some embodiments, detecting the one or more pulses can further comprise using an array of capacitive displacement sensors, the array of capacitive displacement sensors comprising the at least one capacitive displacement sensor. In many embodiments, the array of capacitive sensors can comprise at least one capacitive displacement sensor. In some embodiments, the array of capacitive sensors can comprise at least two capacitive displacement sensors. In some embodiments, the array of capacitive sensors can comprise a linear array. In some embodiments, the array of capacitive sensors can comprise a 2-dimensional array (e.g., on an inside surface of a vest).

[0067] In a number of embodiments, method **700** also can comprise an activity **710** of converting one or more signals from the at least one capacitive displacement sensor into a heart rate waveform, the one or more signals comprising information about the one or more pulses. In many embodiments, activity **710** can be similar to method **600** (FIG. **6**). In some embodiments, method **700** can further comprise an activity of detecting a motion caused by a movement of the wearer of the at least one capacitive displacement sensor by using one or more inertial sensors. In some embodiments, method **700** can further comprise an activity of filtering the heart rate waveform by removing data related to the motion caused by the movement of the wearer of the at least one capacitive displacement sensor. In some embodiments, method **700** also can comprise an activity **715** of displaying a heart rate based at least in part on the heart rate waveform.

[0068] Returning to FIG. **4**, FIG. **4** illustrates a block diagram of a portion of system **300** comprising heart rate detection system **320** and/or display system **360**, according to the embodiment shown in FIG. **3**. Each of heart rate detection system **320** and/or display system **360** are merely exemplary and are not limited to the embodiments presented herein. Each of heart rate detection system **320** and/or display system **360** can be employed in many different embodiments or examples not specifically depicted or described herein. In some embodiments, certain elements or modules of heart rate detection system **320** and/or display system **360** can perform various procedures, processes, and/or acts. In other embodiments, the procedures, processes, and/or acts can be performed by other suitable elements or modules.

[0069] In many embodiments, heart rate detection system **320** can comprise non-transitory memory storage modules **412** and **422**, and display module can comprise a non-transitory memory storage module **462**. Memory storage module **412** can be referred to as a sensor module **412**, and memory storage module **422** can be referred to as a signal processing module **422**. Memory storage module **462** can be referred to as a display module **462**.

[0070] In many embodiments, sensor module **412** can store computing instructions configured to run on one or more processing modules and perform one or more acts related to sensing. In various embodiments, sensor module **412** can store computing instructions configured to run on one or more processing modules and perform one or more acts of methods **700** (FIG. **7**) (e.g., activity **705** (FIG. **7**)) or one or more acts of method **600** (FIG. **6**) (e.g., activity **605** (FIG. **6**)). In some embodiments, signal processing module **422** can store computing instructions configured to run on one or more processing modules and perform one or more acts of method **700** (FIG. **7**) (e.g., activity **710** (FIG. **7**) and/or activities **610**, **615**, **620**, and/or **625** (FIG. **6**)).

[0071] In some embodiments, display module **462** can store computing instructions configured to run on one or more processing modules and perform one or more acts of method **700** (FIG. **7**) (e.g., activity **715** (FIG. **7**)) or one or more acts of method **600** (FIG. **6**) (e.g., activity **635** (FIG. **6**)).

[0072] Although a heart rate detection device and related systems and methods has been described above, it will be understood by those skilled in the art that various changes may be made without departing from the spirit or scope of the disclosure. Accordingly, the disclosure of embodiments is intended to be illustrative of the scope of the disclosure and is not intended to be limiting. It is intended that the scope of the disclosure shall be limited only to the extent required by the appended claims. For example, to one of ordinary skill in the art, it will be readily apparent that any element of the figures in FIGS. **1-9** may be modified, and that the foregoing discussion of certain of these embodiments does not necessarily represent a complete description of all possible embodiments. For example, one or more of the activities of the FIGS. **6-7** may include different activities and/or be performed by many different modules, in many different orders.

[0073] In another embodiment, the invention provides a magnetic field sensor, such as ST micro LSM303 3-axis compass integrated circuit, mounted with the capacitative sensor. The 3-axis compass signals can also be used to detect a dog's motion. The information about the dog's motion can be used to identify and remove motion artifacts in the capacitative sensor signal.

[0074] Replacement of one or more claimed elements constitutes reconstruction and not repair. Additionally, benefits, other advantages, and solutions to problems have been described with regard to specific embodiments. The benefits, advantages, solutions to problems, and any element or elements that may cause any benefit, advantage, or solution to occur or become more pronounced, however, are not to be construed as critical, required, or essential features or elements of any or all of the claims, unless such benefits, advantages, solutions, or elements are stated in such claim.

[0075] Moreover, embodiments and limitations disclosed herein are not dedicated to the public under the doctrine of dedication if the embodiments and/or limitations: (1) are not expressly claimed in the claims; and (2) are or are potentially equivalents of express elements and/or limitations in the claims under the doctrine of equivalents.

What is claimed is:

1. A device for detecting a heart rate, the device comprising at least one capacitive displacement sensor coupled to a strap, wherein the at least one capacitive displacement sensor comprises at least two electrodes, and the at least one capacitive displacement sensor detects a pulse by producing a signal associated with a distance change between a skin of a wearer of the device and the at least one capacitive displacement sensor.

2. The device of claim **1**, wherein the at least one capacitive displacement sensor comprises a transmitting electrode and a receiving electrode.

3. The device of claim **2**, wherein the transmitting electrode and the receiving electrode are in concentric arrangement or linear arrangement.

4. The device of claim **1**, wherein the strap comprises at least one of a harness; a belt; a vest; or a collar.

5. The device of claim **1**, further comprising an array of capacitive displacement sensors, the array of capacitive displacement sensors comprising the at least one capacitive displacement sensor.

6. The device of claim **4**, wherein the array of capacitive displacement sensors comprises at least two capacitive displacement sensors.

7. The device of claim **5**, wherein the at least two capacitive displacement sensors are placed at equidistant intervals across the strap.

8. The device of claim **1**, further comprising one or more inertial sensors, wherein the one or more inertial sensors sense motion caused by a movement of the wearer of the device.

9. The device of claim **1**, wherein the at least one capacitive displacement sensor is placed at a neck of the wearer and proximate to a carotid artery of the wearer.

10. A system for determining a heart rate, the system comprising:

i) at least one capacitive displacement sensor coupled to a strap, wherein the at least one capacitive displacement sensor comprises at least two electrodes and the at least one capacitive displacement sensor detects one or more pulses by producing a signal associated with a distance change between a skin of a wearer of the system and the at least one capacitive displacement sensor; and

ii) a signal processor receiving one or more signals from the at least one capacitive displacement sensor, the one or more signals comprising information about the one or more pulses, wherein the signal processor detects, from the information, one or more peak pulses of the one or more pulses and determines a heart rate waveform therefrom.

11. The system of claim **10**, wherein the at least one capacitive displacement sensor comprises a transmitting electrode; and a receiving electrode.

12. The system of claim **10**, wherein the transmitting electrode and the receiving electrode are in concentric arrangement or linear arrangement.

13. The system of claim **10**, wherein the strap comprises at least one of a harness; a belt; a vest; or a collar.

14. The system of claim **10**, further comprising: an array of capacitive displacement sensors, the array of capacitive displacement sensors comprising the at least one capacitive displacement sensor.

15. The system of claim **14**, wherein: the array of capacitive displacement sensors comprises at least two capacitive displacement sensors.

16. The system of claim **15**, wherein: the at least two capacitive displacement sensors are placed at equidistant intervals across the strap.

17. The system of claim **10**, further comprising: one or more inertial sensors, wherein the one or more inertial sensors sense motion caused by a movement of the wearer of the device.

18. The system of claim **10**, wherein: the at least one capacitive displacement sensor is placed at a neck of the wearer and approximate to a carotid artery of the wearer.

19. A method for determining a heart rate comprising:

detecting one or more pulses by using at least one capacitive displacement sensor to produce a signal that is related to a change in a distance between the at least one capacitive displacement sensor and a skin of a wearer of the at least one capacitive displacement sensor, the at least one capacitive displacement sensor comprising:

two electrodes comprising:

an outer transmitting electrode; and

an inner receiving electrode; and

converting one or more signals from the at least one capacitive displacement sensor into a heart rate waveform, the one or more signals comprising information about the one or more pulses.

20. The method of claim **19**, wherein: the outer transmitting electrode and the inner receiving electrode are concentric.

21. The method of claim **19**, wherein: at least one capacitive displacement sensor is attached to a strap; and the strap comprises at least one of: a harness; a belt; a vest; or a collar.

22. The method of claim **19**, wherein: detecting the one or more pulses further comprises using an array of capacitive displacement sensors, the array of capacitive displacement sensors comprising the at least one capacitive displacement sensor.

23. The method of claim **22**, wherein: the array of capacitive displacement sensors comprises at least two capacitive displacement sensors.

24. The method of claim **23**, wherein: the at least two capacitive displacement sensors are placed at equidistant intervals across the strap.

25. The method of claim **19**, further comprising:

detecting a motion caused by a movement of the wearer of the at least one capacitive displacement sensor by using one or more inertial sensors; and

filtering the heart rate waveform by removing data related to the motion caused by the movement of the wearer of the at least one capacitive displacement sensor.

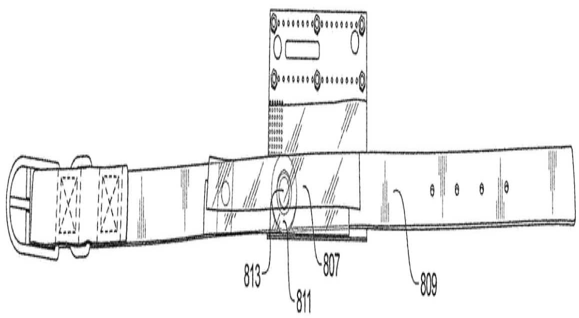
26. The method of claim **19**, wherein: the at least one capacitive displacement sensor is placed at a neck of the wearer and approximate to a carotid artery of the wearer.

* * * * *

专利名称(译)	心率检测装置及相关系统和方法		
公开(公告)号	[US20190069786A1](US20190069786A1)	公开(公告)日	2019-03-07
申请号	US16/113310	申请日	2018-08-27
[标]申请(专利权)人(译)	雀巢产品技术援助有限公司		
申请(专利权)人(译)	NESTEC SA		
当前申请(专利权)人(译)	NESTEC SA		
[标]发明人	PEREZ CAMARGO GERARDO NEUBARTH STUART KYLE DONAVON MARK ALAN		
发明人	PEREZ-CAMARGO, GERARDO NEUBARTH, STUART KYLE DONAVON, MARK ALAN		
IPC分类号	A61B5/024 G01D5/241 G01P13/00 A61B5/00 A61B5/08 A61B5/0205 A61B5/0245		
CPC分类号	A61B5/02438 G01D5/2417 G01P13/00 A61B5/6822 A61B5/7207 A61B5/02405 A61B5/0816 A61B5/0205 A61B5/6831 A61B5/6805 A61B5/0245 A61B2562/0219 A61B5/742 A61B2503/40 A61B5/02444 A61B5/05 A61B2562/0214 A61B2562/043 A61B2562/046		
优先权	62/553202 2017-09-01 US		
外部链接	Espacenet USPTO		

摘要(译)

一些实施例可包括用于检测心率的装置。在许多实施例中，该装置可包括耦合到带子的至少一个电容位移传感器。在许多实施例中，至少一个电容位移传感器可包括两个电极。在一些实施例中，两个电极可包括外部发射电极和内部接收电极。在各种实施例中，至少一个电容位移传感器可以通过产生与装置的佩戴者的皮肤和至少一个电容位移传感器之间的距离变化相关联的信号来检测脉冲。还提供了相关装置，方法和系统的其他实施例。



800