US 20080221399A1

(19) United States
(12) Patent Application Publication
Zhou et al.
(10) Pub. No.: US 2008/0221399 A1
(43) Pub. Date: Sep. 11, 2008

(54) **MONITOR FOR MEASURING VITAL SIGNS AND RENDERING VIDEO IMAGES**

(75) Inventors: **Zhou Zhou**, La Jolla, CA (US); **Marshal Singh Dhillon**, San Diego, CA (US); **Henk Visser**, San Diego, CA (US); **Matthew John Banet**, Del Mar, CA (US); **Andrew Stanley Terry**, San Diego, CA (US); **Kenneth Robert Hunt**, Vista, CA (US); **Adam Michael Fleming**, New York, NY (US)

Correspondence Address:
Triage Wireless, Inc.
Matthew John Banet
9444 Waples Street, Suite 280
SAN DIEGO, CA 92121 (US)

(73) Assignee: **TRIAGE WIRELESS, INC.**, San Diego, CA (US)

(21) Appl. No.: **11/682,177**

(22) Filed: **Mar. 5, 2007**

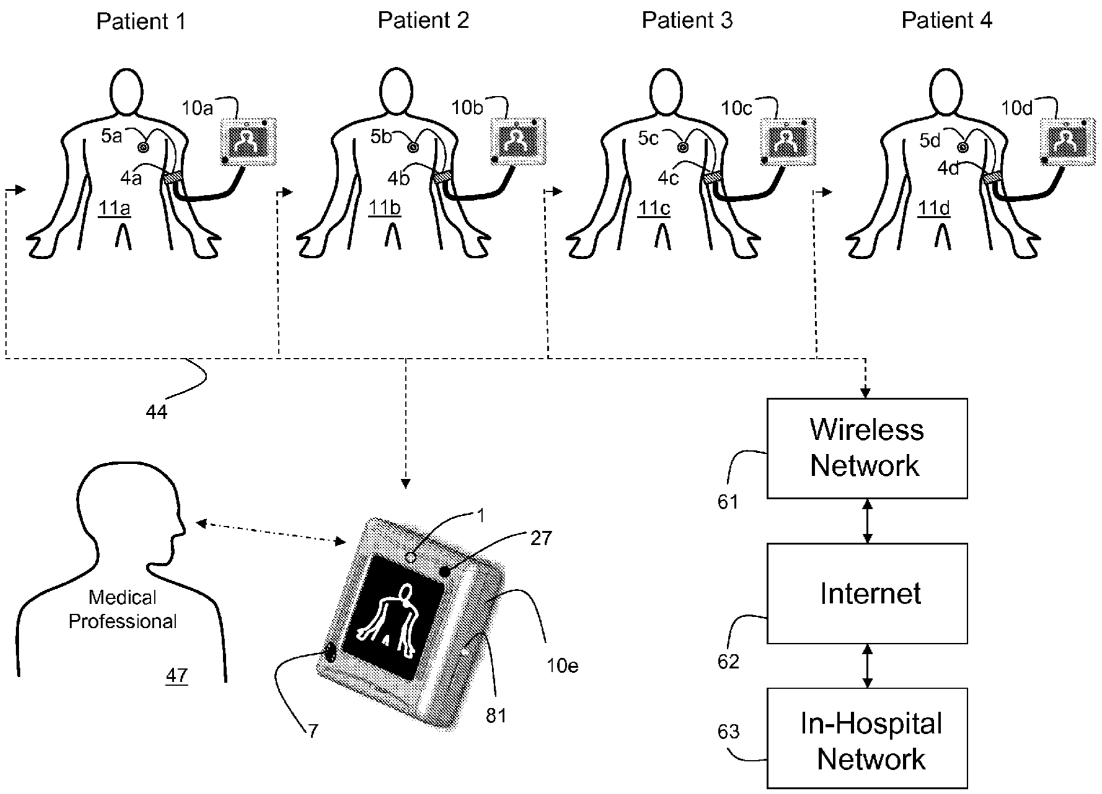
Publication Classification

(51) **Int. Cl.**
A61B 5/00 (2006.01)

(52) **U.S. Cl.** **600/301**

(57) **ABSTRACT**

The invention features a vital sign monitor that includes: 1) a sensor component that attaches to the patient and features an optical sensor and an electrical sensor that measure, respectively a first and second signal: and 2) a control component. The control component features: 1) an analog-to-digital converter configured to convert the first signal and second signal into, respectively, a first digital signal and a second digital signal; 2) a CPU configured to operate an algorithm that generates a blood pressure value by processing with an algorithm the first digital signal and second digital signal; 3) a display element; 4) a graphical user interface generated by computer code operating on the CPU and configured to render on the display element the blood pressure value; and 5) a software component that renders video images on the display element. To capture video and audio information, the device further includes both a digital camera and a microphone.



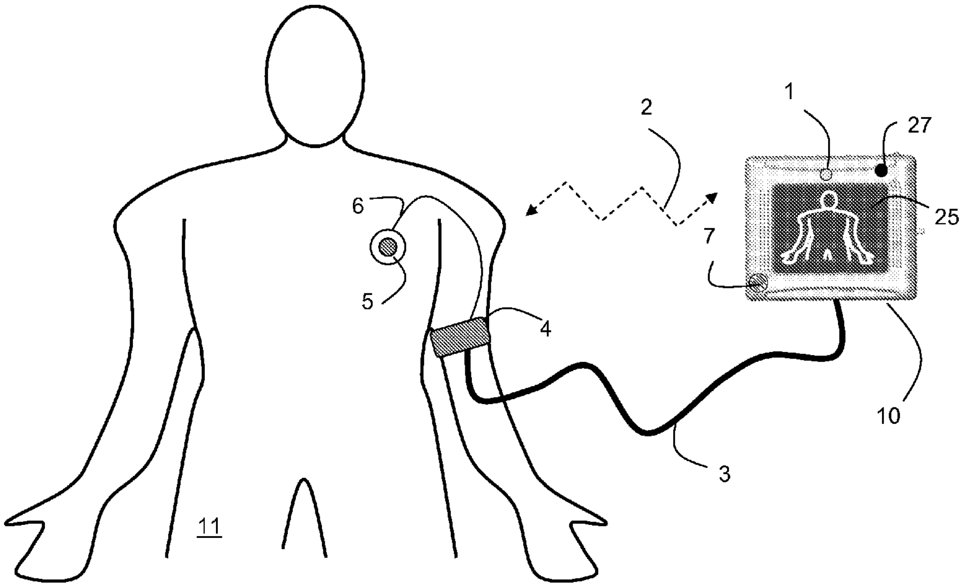


Fig. 1

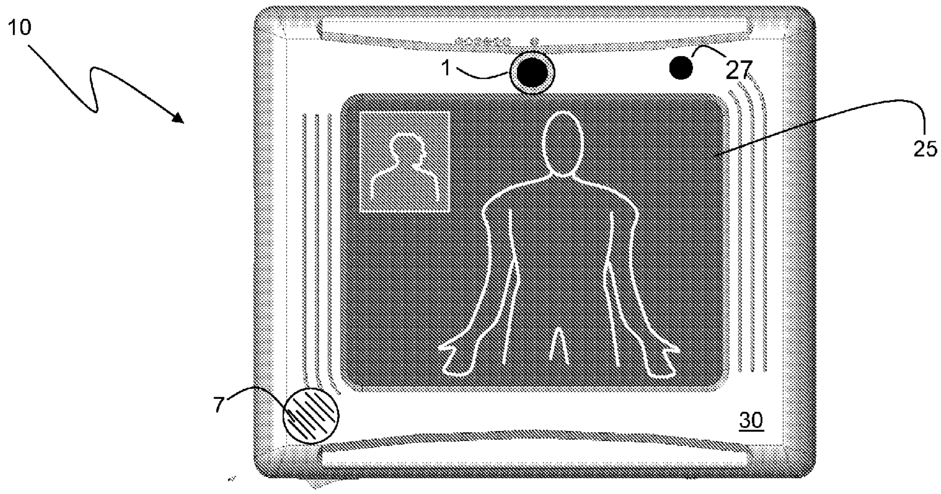


Fig. 2A

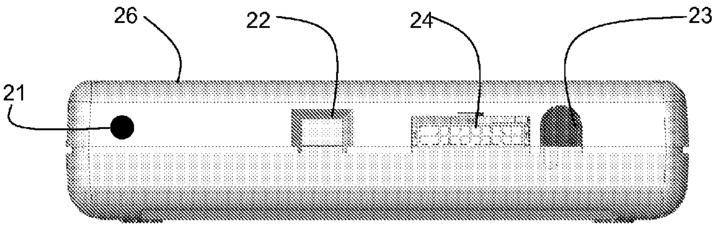


Fig. 2B

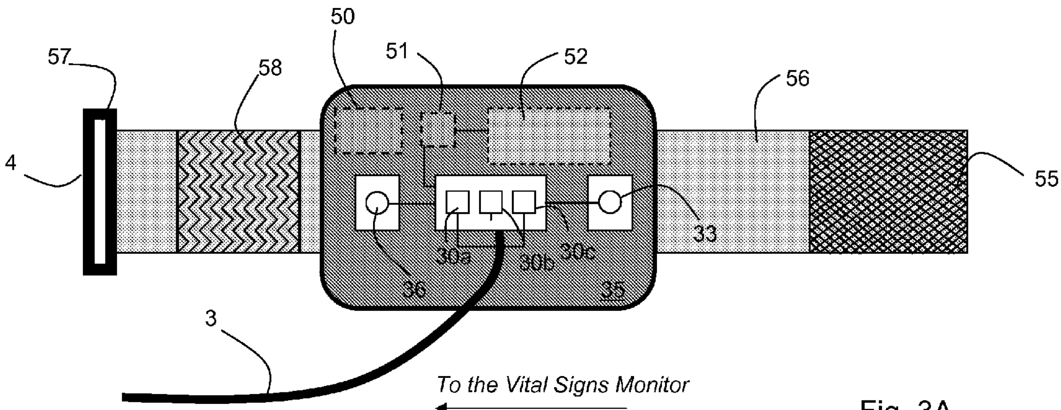


Fig. 3A

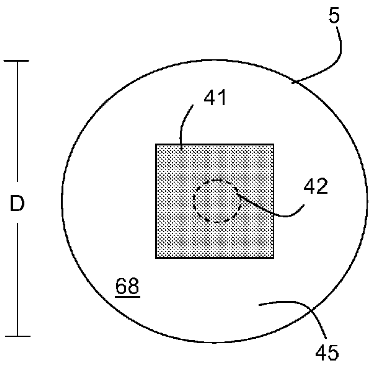


Fig. 3B

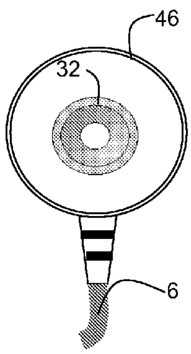


Fig. 3C

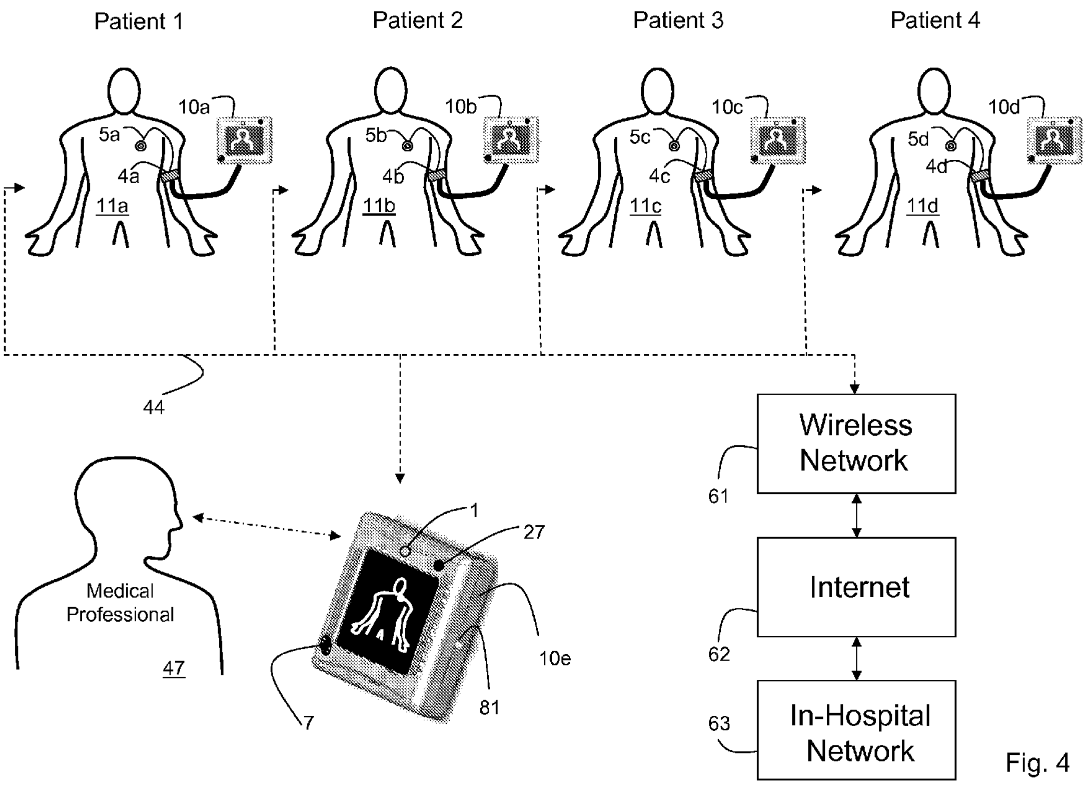

Patient 1
Patient 2
Patient 3
Patient 4
10a
5a
4a
11a
10b
5b
4b
11b
10c
5c
4c
11c
10d
5d
4d
11d
44
Medical
Professional
47
1
27
10e
81
7
Wireless
Network
61
Internet
62
In-Hospital
Network
63

Fig. 4

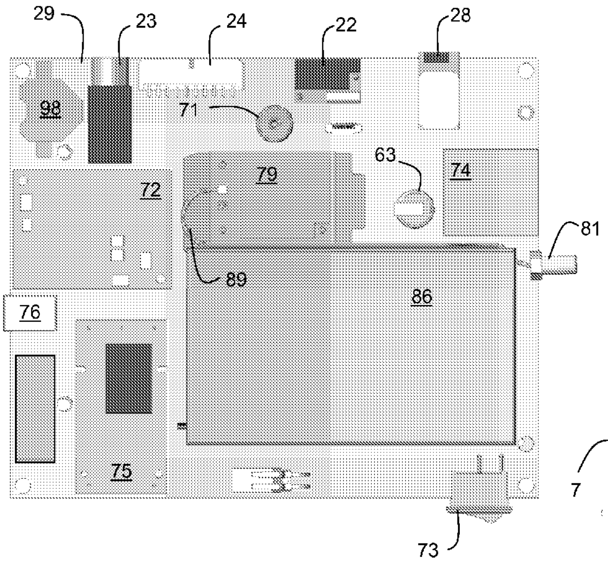

29
23
24
22
28
98
71
72
79
63
74
81
89
76
86
75
73

Fig. 5A

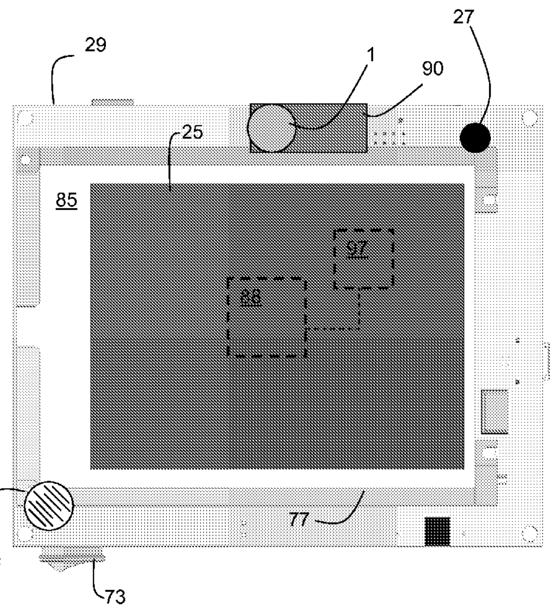

27
29
1
90
25
85
97
88
7
77
73

Fig. 5B

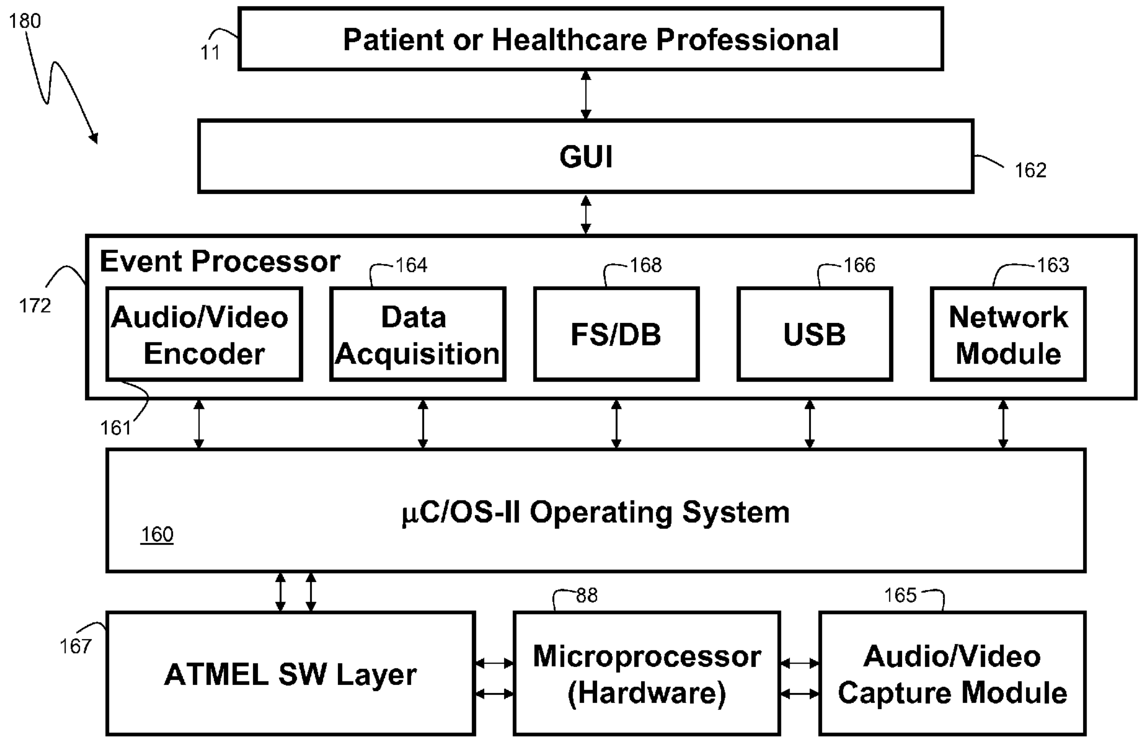

180
11
Patient or Healthcare Professional
GUI
162
Event Processor
172
164
168
166
163
Audio/Video Encoder
Data Acquisition
FS/DB
USB
Network Module
161
µC/OS-II Operating System
160
88
165
167
ATMEL SW Layer
Microprocessor (Hardware)
Audio/Video Capture Module

Fig. 6

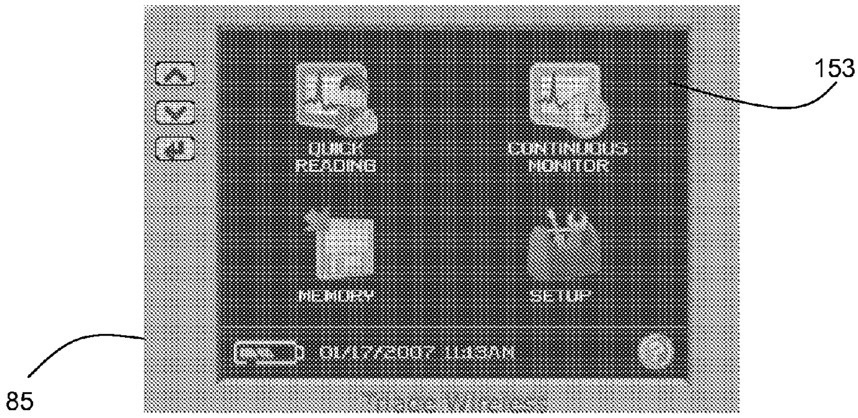

153
85
QUICK READING
CONTINUOUS MONITOR
MEMORY
SETUP
01/17/2007 11:15AM

Fig. 7A

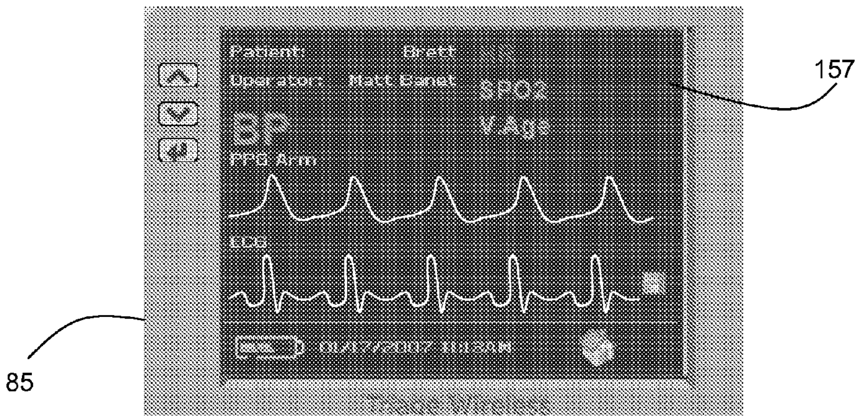

157
85
Patient: Brett
Operator: Matt Banet
SPO2
BP
V.Age
PPG Arm
ECG
01/17/2007 11:15AM

Fig. 7B

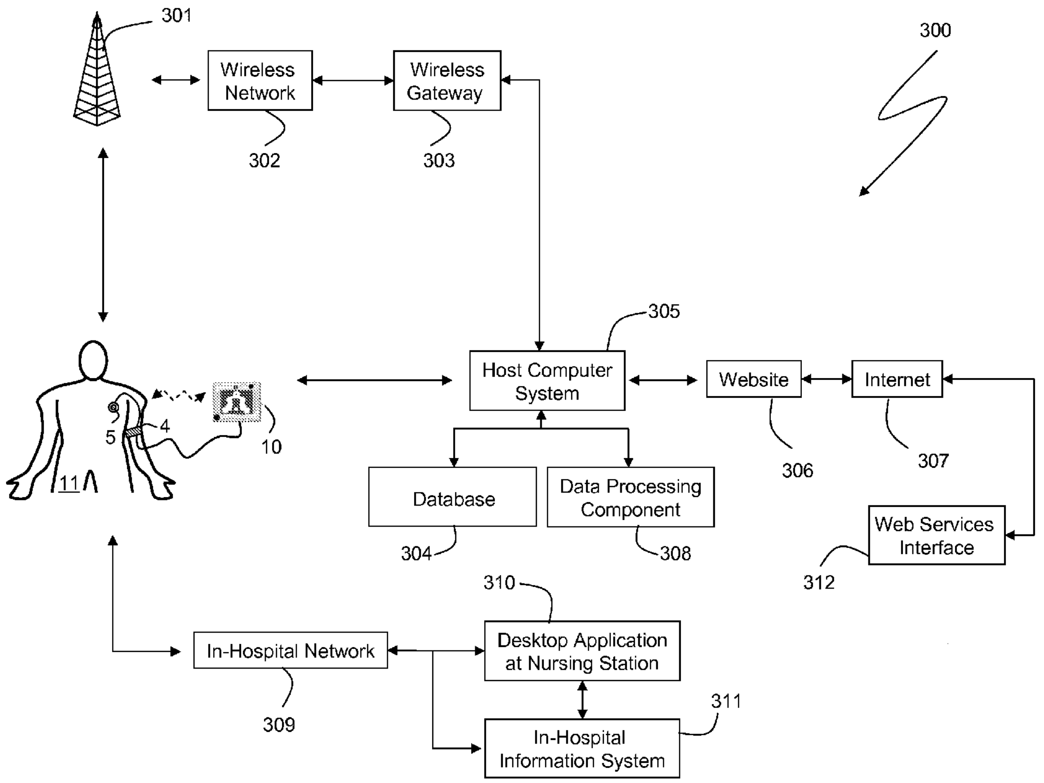

301
Wireless Network
302
Wireless Gateway
303
300
305
Host Computer System
Website
306
Internet
307
5
4
10
11
Database
304
Data Processing Component
308
Web Services Interface
312
310
Desktop Application at Nursing Station
In-Hospital Network
309
311
In-Hospital Information System

Fig. 8

MONITOR FOR MEASURING VITAL SIGNS AND RENDERING VIDEO IMAGES

CROSS REFERENCES TO RELATED APPLICATION

[0001] Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

BACKGROUND OF THE INVENTION

[0003] 1. Field of the Invention

[0004] The present invention relates to monitors for measuring vital signs, e.g. blood pressure, and rendering video images.

[0005] 2. Description of the Related Art

[0006] Pulse transit time ('PTT'), defined as the transit time for a pressure pulse launched by a heartbeat in a patient's arterial system, has been shown in a number of studies to correlate to both systolic and diastolic blood pressure. In these studies, PTT is typically measured with a conventional vital signs monitor that includes separate modules to determine both an electrocardiogram ('ECG') and pulse oximetry. During a PTT measurement, multiple electrodes typically attach to a patient's chest to determine a time-dependent ECG characterized by a sharp spike called the 'QRS complex'. This feature indicates an initial depolarization of ventricles within the heart and, informally, marks the beginning of the heartbeat and a pressure pulse that follows. Pulse oximetry is typically measured with a bandage or clothespin-shaped sensor that attaches to a patient's finger, and includes optical systems operating in both the red and infrared spectral regions. A photodetector measures radiation emitted from the optical systems and transmitted through the patient's finger. Other body sites, e.g., the ear, forehead, and nose, can also be used in place of the finger. During a measurement a microprocessor analyses red and infrared radiation measured by the photodetector to determine the patient's blood oxygen saturation level and a time-dependent waveform called a plethysmograph. Time-dependent features of the plethysmograph indicate both pulse rate and a volumetric change in an underlying artery (e.g., in the finger) caused by the propagating pressure pulse.

[0007] Typical PTT measurements determine the time separating a maximum point on the QRS complex (indicating the peak of ventricular depolarization) and a foot of the plethysmograph (indicating initiation of the pressure pulse). PTT depends primarily on arterial compliance, the propagation distance of the pressure pulse (closely approximated by the patient's arm length), and blood pressure. For a given patient, PTT typically decreases with an increase in blood pressure and a decrease in arterial compliance. Arterial compliance, in turn, typically decreases with age.

[0008] A number of issued U.S. patents describe the relationship between PTT and blood pressure. For example, U.S. Pat. Nos. 5,316,008; 5,857,975; 5,865,755; and 5,649,543 each describe an apparatus that includes conventional sensors that measure an ECG and plethysmograph, which are then processed to determine PTT.

[0009] Studies have also shown that a property called vascular transit time ('VTT'), defined as the time separating two plethysmographs measured from different locations on a patient, can correlate to blood pressure. Alternatively, VTT can be determined from the time separating other time-dependent signals measured from a patient, such as those measured with acoustic or pressure sensors. A study that investigates the correlation between VTT and blood pressure is described, for example, in 'Evaluation of blood pressure changes using vascular transit time', *Physiol. Meas.* 27, 685-694 (2006). U.S. Pat. Nos. 6,511,436; 6,599,251; and 6,723,054 each describe an apparatus that includes a pair of optical or pressure sensors, each sensitive to a propagating pressure pulse, that measure VTT. As described in these patents, a microprocessor associated with the apparatus processes the VTT value to estimate blood pressure.

[0010] In order to accurately measure blood pressure, both PTT and VTT measurements typically require a 'calibration' consisting of one and more conventional blood pressure measurements made simultaneously with the PTT or VTT measurement. The calibration accounts for patient-to-patient variation in arterial properties (e.g., stiffness and size). Calibration measurements are typically made with an auscultatory technique (e.g., using a pneumatic cuff and stethoscope) at the beginning of the PTT or VTT measurement; these measurements can be repeated if and when the patient undergoes any change that may affect their physiological state.

[0011] Other efforts have attempted to use a calibration along with other properties of the plethysmograph to measure blood pressure. For example, U.S. Pat. No. 6,616,613 describes a technique wherein a second derivative is taken from a plethysmograph measured from the patient's ear or finger. Properties from the second derivative are then extracted and used with calibration information to estimate the patient's blood pressure. In a related study, described in 'Assessment of Vasoactive Agents and Vascular Aging by the Second Derivative of Photoplethysmogram Waveform', *Hypertension.* 32, 365-370 (1998), the second derivative of the plethysmograph is analyzed to estimate the patient's 'vascular age' which is related to the patient's biological age and vascular properties.

[0012] A number of patents describe 'telemedicine' systems that collect vital signs, such as blood pressure, heart rate, pulse oximetry, respiratory rate, and temperature, from a patient, and then transmit them through a wired or wireless link to a host computer system. Representative U.S. patents include U.S. Pat. Nos. 6,416,471; 6,381,577; and 6,112,224. Some telemedicine systems, such as that described in U.S. Pat. No. 7,185,282, include separate video systems that collect and send video images of the patient along with the vital signs to the host computer system. In these systems separate monitors are typically used to measure vital signs and video images from the patient.

SUMMARY OF THE INVENTION

[0013] The present invention provides a portable patient monitor that measures vital signs (e.g. blood pressure) and renders video images on a high-resolution display. The video images, for example, can be images of the patient sent within or outside of the hospital. Alternatively, the images can be of family members or medical professionals sent to the patient. In both cases, the same monitor used to measure and display the patient's vital signs also collects and renders the video images.

[0014] The monitor measures one of the most important vital signs, blood pressure, with a cuffless, PTT-based measurement. Other vital signs, such as heart rate, pulse oximetry, respiratory rate, and temperature, are also measured. In addition, the monitor includes a microprocessor that engages a digital video recording camera, similar to a conventional 'web-camera', and a small digital audio microphone to record audio information. In general, the monitor additionally includes many features of a conventional personal digital assistant ('PDA'), such as a portable form factor, touchpanel, and an icon-driven graphical user interface ('GUI') rendered on a color, liquid crystal display ('LCD'). These features allow a user, preferably a healthcare professional or patient, to select different measurement modes, such as continuous, one-time, and 24-hour ambulatory modes, by simply tapping a stylus on an icon within the GUI. The monitor also includes several other hardware features commonly found in PDAs, such as short-range (e.g., Bluetooth® and WiFi®) and long-range (e.g., CDMA, GSM, IDEN) wireless modems, global positioning system ('GPS'), digital camera, and barcode scanner.

[0015] The monitor makes cuffless blood pressure measurements using a sensor pad that includes small-scale optical and electrical sensors. The sensor pad typically attaches to a patient's arm, just below their bicep muscle. A flexible nylon armband supports the sensor pad and has a form factor similar to a conventional wrap-around bandage. The sensor pad connects to a secondary electrode attached to the patient's chest. During operation, the sensor pad and secondary electrode measure, respectively, time-dependent optical and electrical waveforms that the microprocessor then analyzes as described in detail below to determine blood pressure and other vital signs. In this way, the sensor pad and secondary electrode replace a conventional cuff to make a rapid measurement of blood pressure with little or no discomfort to the patient.

[0016] Specifically, in one aspect, the invention features a vital sign monitor that includes: 1) a sensor component that attaches to the patient and features an optical sensor and an electrical sensor that measure, respectively a first and second signal: and 2) a control component. The control component features: 1) an analog-to-digital converter configured to convert the first signal and second signal into, respectively, a first digital signal and a second digital signal; 2) a CPU configured to operate an algorithm that generates a blood pressure value by processing with an algorithm the first digital signal and second digital signal; 3) a display element; 4) a graphical user interface generated by computer code operating on the CPU and configured to render on the display element the blood pressure value; and 5) a software component that renders video images on the display element. To capture video and audio information, the device further includes both a digital camera and a microphone.

[0017] The monitor can include removable memory components for storing and transporting information. For example, these components can be a flash component or a synchronous dynamic random access memory (SDRAM) packaged in a removable module. The monitor can communicate with external devices through wireless modems that operate both short-range and long-range wireless protocols. Specifically, these modems may operate on: 1) a wide-area wireless network based on protocols such as CDMA, GSM, or IDEN; and, 2) a local-area wireless network based on protocols such as 802.11, 802.15, or 802.15.4. These protocols allow the monitor to communicate with an external computer, database, or in-hospital information system.

[0018] In embodiments, to generate the optical signal, an optical sensor within the sensor pad irradiates a first region with a light source (e.g. an LED), and then detects radiation reflected from this region with a photodetector. The signal from the photodetector passes to an analog-to-digital converter, where it is digitized so that it can be analyzed with the microprocessor. The analog-to-digital converter can be integrated directly into the microprocessor, or can be a stand-alone circuit component. Typically, in order to operate in a reflection-mode geometry, the radiation from the light source has a wavelength in a 'green' spectral region, typically between 520 and 590 nm. Alternatively, the radiation can have a wavelength in the infrared spectral region, typically between 800 and 1100 nm. In preferred embodiments the light source and the light detector are included in the same housing or electronic package. In embodiments, an additional optical sensor can be attached to the patient's finger and connected to the sensor pad through a thin wire. This optical sensor can be used to make conventional pulse oximetry measurements, and may additionally measure a plethysmograph that can be analyzed for the blood pressure measurement.

[0019] To generate the electrical signal, electrical sensors (e.g. electrodes) within the sensor pad and secondary electrode detect first and second electrical signals. The electrical signals are then processed (e.g. with a multi-stage differential amplifier and band-pass filters) to generate a time-dependent electrical waveform similar to an ECG. The sensor pad typically includes a third electrode, which generates a ground signal or external signal that is further processed to, e.g., reduce noise-related artifacts in the electrical signal.

[0020] In embodiments, the electrodes within the sensor pad are typically separated by a distance of at least 2 cm. In other embodiments, the electrodes include an Ag/AgCl material (e.g., an Ag/AgCl paste sintered to a metal contact) and a conductive gel. Typically a first surface of the conductive gel contacts the Ag/AgCl material, while a second surface is temporarily covered with a protective layer. The protective layer prevents the gel from drying out when not in use, and typically has a shelf life of about 24 months. In still other embodiments, the electrodes are made from a conductive material such as conductive rubber, conductive foam, conductive fabric, and metal.

[0021] During a measurement, the monitor makes a cuffless, non-calibrated measurement of blood pressure using PTT and a correction that accounts for the patient's arterial properties (e.g., stiffness and size). This correction, referred to herein as a 'vascular index' ('VI'), is calculated according to one of two methods. In the first method, the VI is determined by analyzing the shape of the plethysmograph, measured at either the brachial or the finger artery. In this method, in order to accurately extract features from the shape of the plethysmograph, this waveform is typically first passed through a mathematical filter based on Fourier Transform (called the 'Windowed-Sinc Digital Filter') and then analyzed by taking its second derivative. In the second method, the VI is estimated from the VTT measured between the patient's brachial and finger arteries. In both cases, the VI is used in combination with the patient's biological age to estimate their arterial properties. These properties are then used to 'correct' PTT and thus calculate blood pressure without the need for an external calibration (e.g., without input of an auscultatory measurement).

[0022] The invention has a number of advantages. In general, the monitor combines all the data-analysis features and form factor of a conventional PDA with the monitoring capabilities of a conventional vital sign monitor. This results in an easy-to-use, flexible monitor that performs one-time, continuous, and ambulatory measurements both in and outside of a hospital. And because it lacks a cuff, the monitor measures blood pressure in a simple, rapid, pain-free manner. Measurements can be made throughout the day with little or no inconvenience to the user. Moreover, measurements made with the sensor pad can be wirelessly transmitted to an external monitor. This minimizes the wires connected to the patient, thereby making them more comfortable in a hospital or at-home setting.

[0023] These and other advantages are described in detail in the following description, and in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. **1** is a schematic view of a monitor for measuring vital signs and rendering video images according to the invention that connects to a pad sensor on a patient's arm and an electrode on the patient's chest;

[0025] FIGS. **2**A and **2**B show, respectively, front and top views of the monitor of FIG. **1**;

[0026] FIG. **3**A is a schematic top view of the pad sensor of FIG. **1** which includes optical sensors, electrodes, and a clasping arm-band;

[0027] FIG. **3**B is a schematic top view of a two-piece electrode combined in a non-disposable sensor housing attached to a disposable patch;

[0028] FIG. **3**C is a schematic top view of a snap connector that connects to the two-piece electrode of FIG. **3**B;

[0029] FIG. **4** shows a semi-schematic view of multiple body-worn monitors of FIG. **1** connected to a central conferencing system in, e.g., a hospital setting;

[0030] FIGS. **5**A and **5**B show, respectively, bottom and top views of a circuit board within the monitor of FIG. **1**;

[0031] FIG. **6** shows a schematic view of an embedded software architecture used in the monitor of FIG. **1**;

[0032] FIGS. **7**A and **7**B show screen captures taken from a color LCD of FIG. **5**B that features an icon-driven GUI; and

[0033] FIG. **8** shows a schematic view of an Internet-based system used to send information from the monitor of FIG. **1** to both the Internet and an in-hospital information system.

DETAILED DESCRIPTION OF THE INVENTION

[0034] FIGS. **1**, **2**A, and **2**B show a monitor **10** for measuring vital signs and rendering video images according to the invention that features a digital video camera **1**, digital audio microphone **27**, speaker **7**, and GUI rendered on a LCD/touch panel **25**. The monitor **10** includes a sensor pad **4** that connects to a patient **11** to measure vital signs such as blood pressure, heart rate, respiratory rate, pulse oximetry, and temperature as described in more detail below. Using the GUI, which is shown in more detail in FIGS. **6**A and **6**B, and LCD/touch panel **25**, a health care professional can activate the digital video camera **1**, audio microphone **27**, and speaker **7** to exchange audio and video information with the patient through an in-hospital or nationwide wireless network (using, e.g., an antenna **21**) or the Internet (using an Ethernet connector, not shown in the figure). In addition, using the GUI the patient can view images of family members during a stay in the hospital. With the same GUI the health care professional can select different vital sign measurement modes, e.g. one-time, continuous, and 24-hour ambulatory mode.

[0035] A plastic housing **30** surrounds the monitor **10** to protect its internal components. The monitor **10** additionally includes a barcode reader **22** to optically scan patient information encoded, e.g., on a wrist-worn barcode. A first port **23** receives an external thermometer that measures a patient's esophageal temperature. A second multi-pin port **24** optionally connects to the pad sensor **4** so that these components can connect in a wired mode. The monitor **10** is lightweight by design, and is preferably hand-held to easily position the camera **1** for recording and viewing. In addition, the monitor **10** mounts to stationary objects within the hospital, such as beds and wall-mounted brackets, through mounting holes on its back panel **26**.

[0036] As shown in FIGS. **3**A and **3**B, the monitor **10** measures vital signs with a pad sensor **4** that attaches to the patient's arm and to a secondary electrode **5**. The pad sensor **4** and secondary electrode **5** measure optical and electrical waveforms that are used in an algorithm, described below, to determine blood pressure. During use, the pad sensor **4** wraps around the patient's arm using a VELCRO® belt **56**. The belt **56** connects to a nylon backing material **35**, which supports three optical sensors **30***a-c* and two electrodes **36**, **33**. The belt **56** buckles through a D-ring loop **57** and secures to the patient's arm using VELCRO® patches **55**, **58**. The pad sensor **4** can connect to the monitor **10** using a coaxial cable **3**, or alternatively through a short-range wireless transceiver **50**. An analog-to-digital converter **51** within the pad sensor **4** converts analog optical and electrical waveforms to digital ones, which a processor **52** then analyses to determine blood pressure. The secondary electrode **5** connects to the monitor **10** through an electrical lead **6**.

[0037] To reduce the effects of ambient light, the pad sensor **4** covers the optical sensors **30***a-c* mounted in the middle of the nylon backing **35**. Each optical sensor **30***a-c* includes light-emitting diodes (LED) that typically emit green radiation (λ=520-570 nm), photodetectors that measure reflected optical radiation which varies in intensity according to blood flow in underlying capillaries, and an internal amplifier. Such a sensor is described in the following co-pending patent application, the entire contents of which are incorporated herein by reference: VITAL SIGN MONITOR FOR CUFFLESSLY MEASURING BLOOD PRESSURE WITHOUT USING AN EXTERNAL CALIBRATION (U.S. Ser. No. 11/______; filed February __, 2007). A preferred optical sensor is model TRS1755 manufactured by TAOS, Inc. of Plano, Tex.

[0038] The pad sensor **4** connects to the secondary electrode **5**, shown in FIGS. **3**B and **3**C, which is similar to a conventional ECG electrode. The electrode **5** features a disposable, sterile foam backing **68** that supports an Ag/AgCl-coated male electrical lead **42** in contact with an impedance-matching solid gel **41**. An adhesive layer **45** coats the foam backing **68** so that it sticks to the patient's skin. During use, the male electrical lead **42** snaps into a female snap connector **32** attached to a secondary electrode connector **46**. The shielded cable **6** connects the secondary electrode **5** to the pad sensor **4** described above. In a preferred embodiment, electrodes **33**, **36** measure, respectively, a positive signal and ground signal, while the secondary electrode **5** measures a negative signal. An electrical amplifier in the monitor **10** then processes the positive, negative, and ground signals to generate an electrical waveform, described in detail below, that is similar to a single-lead ECG.

[0039] The monitor **10** can also process pulse oximetry measurements typically made by attaching a conventional pulse oximeter sensor to the patient's finger. Determining pulse oximetry in this way is a standard practice known in the art, and is described, for example, in U.S. Pat. No. 4,653,498 to New, Jr. et al., the contents of which are incorporated herein by reference.

[0040] In addition to those methods described above, a number of additional methods can be used to calculate blood pressure from the optical and electrical waveforms. These are described in the following co-pending patent applications, the contents of which are incorporated herein by reference: 1) CUFFLESS BLOOD-PRESSURE MONITOR AND ACCOMPANYING WIRELESS, INTERNET-BASED SYSTEM (U.S. Ser. No. 10/709,015; filed Apr. 7, 2004); 2) CUFFLESS SYSTEM FOR MEASURING BLOOD PRESSURE (U.S. Ser. No. 10/709,014; filed Apr. 7, 2004); 3) CUFFLESS BLOOD PRESSURE MONITOR AND ACCOMPANYING WEB SERVICES INTERFACE (U.S. Ser. No. 10/810,237; filed Mar. 26, 2004); 4) CUFFLESS BLOOD PRESSURE MONITOR AND ACCOMPANYING WIRELESS MOBILE DEVICE (U.S. Ser. No. 10/967,511; filed Oct. 18, 2004); 5) BLOOD PRESSURE MONITORING DEVICE FEATURING A CALIBRATION-BASED ANALYSIS (U.S. Ser. No. 10/967,610; filed Oct. 18, 2004); 6) PERSONAL COMPUTER-BASED VITAL SIGN MONITOR (U.S. Ser. No. 10/906,342; filed Feb. 15, 2005); 7) PATCH SENSOR FOR MEASURING BLOOD PRESSURE WITHOUT A CUFF (U.S. Ser. No. 10/906,315; filed Feb. 14, 2005); 8) PATCH SENSOR FOR MEASURING VITAL SIGNS (U.S. Ser. No. 11/160,957; filed Jul. 18, 2005); 9) WIRELESS, INTERNET-BASED SYSTEM FOR MEASURING VITAL SIGNS FROM A PLURALITY OF PATIENTS IN A HOSPITAL OR MEDICAL CLINIC (U.S. Ser. No. 11/162,719; filed Sep. 9, 2005); 10) HAND-HELD MONITOR FOR MEASURING VITAL SIGNS (U.S. Ser. No. 11/162,742; filed Sep. 21, 2005); 11) SYSTEM FOR MEASURING VITAL SIGNS USING AN OPTICAL MODULE FEATURING A GREEN LIGHT SOURCE (U.S. Ser. No. 11/307,375; filed Feb. 3, 2006); 12) BILATERAL DEVICE, SYSTEM AND METHOD FOR MONITORING VITAL SIGNS (U.S. Ser. No. 11/420,281; filed May 25, 2006); 13) SYSTEM FOR MEASURING VITAL SIGNS USING BILATERAL PULSE TRANSIT TIME (U.S. Ser. No. 11/420,652; filed May 26, 2006); 14) BLOOD PRESSURE MONITOR (U.S. Ser. No. 11/530,076; filed Sep. 8, 2006); and 15) TWO-PART PATCH SENSOR FOR MONITORING VITAL SIGNS (U.S. Ser. No. 11/558,538; filed Nov. 10, 2006).

[0041] FIG. **4** shows how a first monitor **10***e* associated with a medical professional **47** operates in a hospital environment to collect vital sign information from four separate monitors **10***a-d*, each associated with a separate pad sensor **4***a-d* and electrode **5***a-d*, and patient **11***a-d*. Each patient **11***a-d*, for example, is typically located in a unique hospital room. The medical professional **47** uses the first monitor **10***e* to make 'virtual rounds' by capturing video, audio, and vital sign information from each patient **11***a-d*. During this process, the digital video camera **1**, digital audio microphone **27**, and speaker **7** from the first monitor **10***e* captures video and audio information from the medical professional **47** and transmits this to the monitors **10***a-d* associated with each patient **11***a-d*. Likewise, the four separate monitors **10***a-d* capture video and audio information, along with vital signs, from the four patients **11***a-d* and transmit this information to the medical professional's monitor **10***e*. The monitors **10***a-e* typically communicate through a short-range wireless connection **44** (using, e.g. a Bluetooth® or 802.11-based transceiver), described further in FIGS. **5**A and **5**B. Once vital sign information is collected from each patient **11***a-d*, the device **10***e* formats the data accordingly and sends it using an antenna **81** through a nation-wide wireless network **61** to a computer system on the Internet **62**. The computer system then sends the information through the Internet **62** to an in-hospital network **63** (using, e.g., a frame-relay circuit or VPN). From there, the information is associated with the patient's medical records, and can be accessed at a later time by the medical professional.

[0042] FIGS. **5**A and **5**B show a circuit board **29** mounted within the monitor for measuring vital signs and rendering video images as described above. A rechargeable lithium-ion battery **86** (manufacturer: Varta Microbattery; part number: 3P/PLF 503562 C PCM W) powers each of the circuit elements and is controlled by a conventional on/off switch **73**. A smaller back-up battery **98** is used to power volatile memory components. All compiled computer code that controls the monitor's various functions runs on a high-end microprocessor **88**, typically an ARM **9** (manufacturer: Atmel; part number: AT91SAM9261-CJ), that is typically a 'ball grid array' package mounted underneath an LCD display **85**. Before being processed by the microprocessor **88**, analog signals from the optical and electrical sensors pass through a connector **24** to the analog-to-digital converter **97**, which is typically a separate integrated circuit (manufacturer: Texas Instruments; part number: ADS8344NB) that digitizes the waveforms with 16-bit resolution. Such high resolution is typically required to adequately process the optical and electrical waveforms, as described in more detail below. The microprocessor **88** also controls a pulse oximetry circuit **72** including a connector (not shown in the figure) that connects to an external pulse oximetry finger sensor. To measure temperature, a probe containing a temperature-sensitive sensor (e.g. a thermistor) connects through a stereo jack-type connector **24**, which in turn connects to the analog-to-digital converter **97**. During operation, the temperature-sensitive sensor generates an analog voltage that varies with the temperature sensed by the probe. The analog voltage passes to the analog-to-digital converter **97**, where it is digitized and sent to the microprocessor **88** for comparison to a pre-determined look-up table stored in memory. The look-up table correlates the voltage measured by the temperature probe to an actual temperature.

[0043] After calculating vital signs, the microprocessor **88** displays them on the LCD **85** (manufacturer: EDT; part number: ER05700NJ6*B2), which additionally includes a touch panel **25** on its outer surface, and a backlight **77** underneath. An LCD control circuit **75** includes a high-voltage power supply that powers the backlight, and an LCD controller that processes signals from the touch panel **25** to determine which coordinate of the LCD **85** was contacted with the stylus. The microprocessor **88** runs software that correlates coordinates generated by the LCD controller with a particular icon and ultimately to software functions coded into the microprocessor **88**.

[0044] Information can be transferred from the monitor to an external device using both wired and wireless methods. For wired transfer of information, the circuit board **29** includes a universal serial bus (USB) connector **76** that connects directly to another device (e.g. a personal computer), and a removable SD flash memory card **74** that functions as a removable storage medium for large amounts (e.g., 1 GByte and larger) of information. For wireless transfer of information, the circuit board **29** includes a short-range Bluetooth® transceiver **28** that sends information over a range of up to 30 meters (manufacturer: BlueRadios; part number: BR-C40A). The Bluetooth® transceiver **28** can be replaced with a wireless transceiver that operates on a wireless local-area network, such as a WiFi® transceiver (manufacturer: DPac; part number: WLNB-AN-DP101). For long-range wireless transfer of information, the circuit board **29** includes a CDMA modem **79** (manufacturer: Wavecom; part number: Wismo Quik WAV Q2438F) that connects through a thin, coaxial cable **89** to an external antenna **81**. The CDMA modem **79** can be replaced with a comparable long-range modem, such as one that operates on a GSM or IDEN network.

[0045] The circuit board **29** includes a barcode scanner **22** (manufacturer: Symbol; part number: ED-95S-I100R) that can easily be pointed at a patient to scan their wrist-worn barcode. The barcode scanner **22** typically has a range of about 5-10 cm. Typically the barcode scanner **22** includes an internal, small-scale microprocessor that automatically decodes the barcode and sends it to the microprocessor **88** through a serial port for additional processing.

[0046] A small-scale, noise-making piezoelectric beeper **71** connects to the microprocessor **88** and sounds an alarm when a vital sign value exceeds a pre-programmed level. A small-scale backup battery **63** powers a clock (not shown in the figure) that sends a time/date stamp to the microprocessor **88**, which then includes it with each stored data file.

[0047] The digital video camera **1** (e.g., Firewire Camera) and digital video frame capture circuit board **90** are positioned in the top-center of the circuit board **29**. A digital audio microphone **27** and speaker **7** are positioned, respectively, on the top-right and bottom-left portion of the circuit board **29**. Once recorded using the video camera **1** and microphone **27**, video and audio information are digitally encoded and relayed to the microprocessor **88** for broadcast through short-range Bluetooth® transceiver **28** to another monitor **10***a-e*, stored on the SD flash memory card **74**, and/or sent to an external database.

[0048] FIG. **6** shows a schematic drawing of a software architecture **180** that runs on the above-described microprocessor. The software architecture **180** allows the patient or healthcare professional to operate the GUI **162** to measure vital signs and operate all the electrical components shown in FIGS. **5**A and **5**B. The software architecture **180** is based on an operating system **160** called the μC/OS-II (vendor: Micrium) which is loaded onto the microprocessor and operates in conjunction with software libraries (vendor: Micrium) for the GUI **162**. Using the digital microphone and video camera, the patient or healthcare professional records raw audio and video using an audio/video capture **165** module. The audio/video capture module **165** is allocated to the microprocessor **88**, described above, using ATMEL software layer **167** to process and store the captured data. The audio and video data, in turn, are encoded using the audio and video encoder **161** and allocated to the event processor **172** for recall using the GUI **162** or distribution over a network using a network module **163**. A USB **166** library (vendor: Micrium) operates the transfer of stored patient vital signs data through a USB cable to external devices. A Microsoft Windows™-compatible FAT32 embedded file management system database (FS/DB) **168** is a read-write information-allocation library that stores allocated patient information, audio and video capture and allows retrieval of information through the GUI **162**. These libraries are compiled along with proprietary data acquisition code **164** library that collects digitized waveforms and temperature readings from the analog-to-digital converter and stores them into RAM. The event processor **172** is coded using the Quantum Framework (QF) concurrent state machine framework (vendor: Quantum Leaps). This allows each of the write-to libraries for the GUI **162**, USB **166**, file system **168**, and data acquisition **162** to be implemented as finite state machines ('FSM'). This process is described in detail in the co-pending patent application 'HAND-HELD VITAL SIGNS MONITOR', U.S. Ser. No. 11/470,708, filed Sep. 7, 2006, the contents of which are incorporate herein by reference.

[0049] FIGS. **7**A and **7**B show screen captures of first and second software interfaces **153**, **157** within the GUI that run on the LCD **85**. Referring to FIG. **7**A, the first software interface **153** functions as a 'home page' and includes a series of icons that perform different functions when contacted through the touch panel. The home page includes icons for 'quick reading', which takes the user directly to a measurement screen similar to that shown in the second software interface **157**, and 'continuous monitor', which allows the user to enter patient information (e.g. the patient's name and biometric information) before taking a continuous measurement. Information for the continuous measurement is entered either directly using a soft, on-screen QWERTY touch-keyboard, or by using the barcode scanner. Device settings for the continuous measurement, e.g. alarm values for each vital sign and periodicity of measurements, are also entered after clicking the 'continuous monitor' icon. The home page additionally includes a 'setup' icon that allows the user to enter their information through either the soft keyboard or barcode scanner. Information can be stored and recalled from memory using the 'memory' icon. The '?' icon renders graphical help pages for each of the above-mentioned functions.

[0050] The second software interface **157** shown in FIG. **7**B is rendered after the user initiates the 'quick reading' icon in first software interface **153** of FIG. **6**A. This interface shows the patient's name (entered using either the soft keyboard or barcode scanner) and values for their systolic and diastolic blood pressure, heart rate, pulse oximetry, and temperature. The values for these vital signs are typically updated every few seconds. In this case the second software interface **157** shows an optical waveform measured with one of the optical sensors, and an electrical signal measured by the electrical sensors. These waveforms are continually updated on the LCD **85** while the sensor is attached to the patient.

[0051] Both the first **153** and second **157** software interfaces **157** include smaller icons near a bottom portion of the LCD **85** that correspond to the date, time, and remaining battery life. The 'save' icon (indicated by an image of a floppy disk) saves all the current vital sign and waveform information displayed measured by the monitor to an on-board memory, while the 'home' icon (indicated by an image of a house) renders the first software interface **153** shown in FIG. **7**A.

[0052] FIG. **8** shows an example of a computer system **300** that operates in concert with the monitor **10** and sensors **4**, **5** to measure and send information from a patient **11** to an host computer system **305**, and from there to an in-hospital information system **311**. When the patient is ambulatory, the monitor **10** can be programmed to send information to a website

306 hosted on the Internet. For example, using an internal wireless modem, the monitor 10 sends vital signs and video/audio information through a series of towers 301 in a nation-wide wireless network 302 to a wireless gateway 303 that ultimately connects to a host computer system 305. The host computer system 305 includes a database 304 and a data-processing component 308 for, respectively, storing and analyzing data sent from the monitor 10. The host computer system 305, for example, may include multiple computers, software systems, and other signal-processing and switching equipment, such as routers and digital signal processors. The wireless gateway 303 preferably connects to the wireless network 302 using a TCP/IP-based connection, or with a dedicated, digital leased line (e.g., a VPN, frame-relay circuit or digital line running an X.25 or other protocols). The host computer system 305 also hosts the web site 306 using conventional computer hardware (e.g. computer servers for both a database and the web site) and software (e.g., web server, application server, and database software).

[0053] To view information remotely, the patient or medical professional can access a user interface hosted on the web site 306 through the Internet 307 from a secondary computer system such as an Internet-accessible home computer. The computer system 300 may also include a call center, typically staffed with medical professionals such as doctors, nurses, or nurse practitioners, whom access a care-provider interface hosted on the same website 306.

[0054] Alternatively, when the patient is in the hospital, the monitor can be programmed to send information to an in-hospital information system 311 (e.g., a system for electronic medical records). In this case, the monitor 10 sends information through an in-hospital wireless network 309 (e.g., an internal WiFi® network) that connects to a desktop application running on a central nursing station 310. This desktop application 310 can then connect to an in-hospital information system 311. These two applications 310, 311, in turn, can additionally connect with each other. Alternatively, the in-hospital wireless network 309 may be a network operating, e.g. a Bluetooth®, 802.11a, 802.11b, 802.1g, 802.15.4, or 'mesh network' wireless protocols that connects directly to the in-hospital information system 311. In these embodiments, a nurse or other medical professional at a central nursing station can quickly view the vital signs of the patient using a simple computer interface.

[0055] Other embodiments are also within the scope of the invention. For example, software configurations other than those described above can be run on the monitor to give it a PDA-like functionality. These include, for example, Micro C OS®, Linux®, Microsoft Windows®, embOS, VxWorks, SymbianOS, QNX, OSE, BSD and its variants, e.g. FreeDOS, FreeRTOX, LynxOS, or eCOS and other embedded operating systems. In other embodiments, the monitor can connect to an Internet-accessible website to download content, e.g. calibrations, text messages, and information describing medications, from an associated website. As described above, the monitor 10 can connect to the website using both wired (e.g. USB port) or wireless (e.g. short or long-range wireless transceivers) means.

[0056] The above-described monitor may be used for in-home monitoring. In this case, the patient may video conference with a healthcare professional (i.e. physician, nurse, or pharmacist) from the comfort of their home or while traveling using the wireless or Internet-based technology, described above. The health care professional may access real-time vital signs information or vital signs information that has been stored over a period of time (e.g., an hour, day, week, or up to months).

[0057] Still other embodiments are within the scope of the following claims.

I claim as my invention:

1. A device for monitoring a patient's vital signs, comprising:

a sensor component that attaches to the patient and comprises an optical sensor and an electrical sensor that measure, respectively, a first and second signal;

an analog-to-digital converter configured to convert the first signal and second signal into, respectively, a first digital signal and a second digital signal;

a control component comprising:

a CPU configured to operate an algorithm that generates a blood pressure value by processing with an algorithm the first digital signal and second digital signal,

a display element,

a graphical user interface generated by computer code operating on the CPU and configured to render on the display element the blood pressure value, and,

a software component that renders video images on the display element.

2. The device of claim **1**, wherein the control component further comprises a digital camera.

3. The device of claim **1**, wherein the control component further comprises a microphone.

4. The device of claim **1**, wherein the control component further comprises a touch panel connected to the display element.

5. The device of claim **4**, wherein the control component further comprises a touch panel controller in electrical communication with the CPU and the touch panel.

6. The device of claim **4**, wherein the graphical user interface further comprises a plurality of icons, each corresponding to a different operation on the device.

7. The device of claim **6**, wherein the CPU comprises compiled computer code configured to render video images when an icon is addressed through the touch panel.

8. The device of claim **1**, wherein the compiled computer code further comprises a video driver.

9. The device of claim **6**, wherein the CPU comprises compiled computer code configured to play audio information when an icon is addressed through the touch panel.

10. The device of claim **9**, wherein the compiled computer code further comprises an audio driver.

11. The device of claim **1**, wherein the control component further comprises a wireless modem.

12. The device of claim **11**, wherein the control component further comprises a wireless modem in electrical communication with the CPU, the wireless modem configured to receive video information over a wireless interface and provide the video information to the CPU.

13. The device of claim **11**, wherein the control component further comprises a wireless modem configured to operate on a wide-area wireless network.

14. The device of claim **13**, wherein the control component further comprises a wireless modem configured to operate on a CDMA, GSM, or IDEN wireless network.

15. The device of claim **11**, wherein the control component further comprises a wireless modem configured to operate on a local-area wireless network.

16. The device of claim **15**, wherein the control component further comprises a wireless modem configured to operate on a local-area network based on a protocol selected from: 802.11, 802.15, 802.15.4.

17. A device for monitoring a patient's vital signs, comprising:

a body-worn component that attaches to the patient and comprises:

a sensor that measures at least one vital sign,

a microprocessor that receives and processes the at least one vital sign from the sensor, and

a first short-range wireless transceiver in electrical communication with the microprocessor that wirelessly transmits the at least one vital sign;

a control component comprising:

a second short-range wireless transceiver that receives the at least one vital sign from the first short-range wireless transceiver,

a CPU configured to receive and process the at least one vital sign,

a display element,

a graphical user interface generated by computer code operating on the CPU and configured to render on the display element the at least one vital sign, and,

a software component that renders video images on the display element.

18. The device of claim **17**, further comprising a digital camera.

19. The device of claim **17**, further comprising a microphone.

20. The device of claim **17**, further comprising a touch panel connected to the display element.

21. The device of claim **20**, further comprising a touch panel controller in electrical communication with the CPU and the touch panel.

22. The device of claim **20**, wherein the graphical user interface further comprises a plurality of icons, each corresponding to a different operation on the device.

23. The device of claim **22**, wherein the CPU comprises compiled computer code configured to render video images when an icon is addressed through the touch panel.

24. The device of claim **17**, wherein the compiled computer code further comprises a video driver.

25. The device of claim **22**, wherein the CPU comprises compiled computer code configured to play audio information when an icon is addressed through the touch panel.

26. The device of claim **25**, wherein the compiled computer code further comprises an audio driver.

27. A device for monitoring a patient's vital signs, comprising:

a body-worn component that attaches to the patient and comprises:

a sensor that measures at least one vital sign,

a microprocessor that receives and processes the at least one vital sign from the sensor, and

a first short-range wireless transceiver in electrical communication with the microprocessor that wirelessly transmits the at least one vital sign;

a control component comprising:

a second short-range wireless transceiver that receives the at least one vital sign from the first short-range wireless transceiver,

a CPU configured to receive and process the at least one vital sign,

a display element,

a graphical user interface generated by computer code operating on the CPU and comprising a first and second icon, the graphical user interface configured to render on the display element the at least one vital sign when the first icon is addressed, and,

a software component that renders real-time video and audio information on the display element when the second icon comprised by the graphical user interface is addressed.

* * * * *

patsnap

专利名称(译)	用于测量生命体征和渲染视频图像的监视器		
公开(公告)号	US20080221399A1	公开(公告)日	2008-09-11
申请号	US11/682177	申请日	2007-03-05
[标]申请(专利权)人(译)	TRIAGE WIRELESS		
申请(专利权)人(译)	TRIAGE WIRELESS , INC.		
当前申请(专利权)人(译)	SOTERA WIRELESS , INC.		
[标]发明人	ZHOU ZHOU DHILLON MARSHAL SINGH VISSER HENK BANET MATTHEW JOHN TERRY ANDREW STANLEY HUNT KENNETH ROBERT FLEMING ADAM MICHAEL		
发明人	ZHOU, ZHOU DHILLON, MARSHAL SINGH VISSER, HENK BANET, MATTHEW JOHN TERRY, ANDREW STANLEY HUNT, KENNETH ROBERT FLEMING, ADAM MICHAEL		
IPC分类号	A61B5/00		
CPC分类号	A61B5/021 A61B5/02125 A61B5/0022 A61B5/02141 A61B5/002 A61B5/0261 G16H40/67		
外部链接	Espacenet USPTO		

摘要(译)

本发明的特征在于一种生命体征监测器，其包括：1）传感器部件，其附接到患者并且具有光学传感器和电传感器，其分别测量第一和第二信号：和2）控制部件。控制部件的特征在于：1）模数转换器，被配置为将第一信号和第二信号分别转换为第一数字信号和第二数字信号; 2）CPU，被配置为通过利用算法处理第一数字信号和第二数字信号来操作生成血压值的算法; 3）显示元件; 4）由在CPU上运行的计算机代码生成的图形用户界面，用于在显示元件上呈现血压值; 5）在显示元件上呈现视频图像的软件组件。为了捕获视频和音频信息，该设备还包括数码相机和麦克风。