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(54) **SYSTEM AND METHOD FOR EMERGENCY RESUSCITATION**

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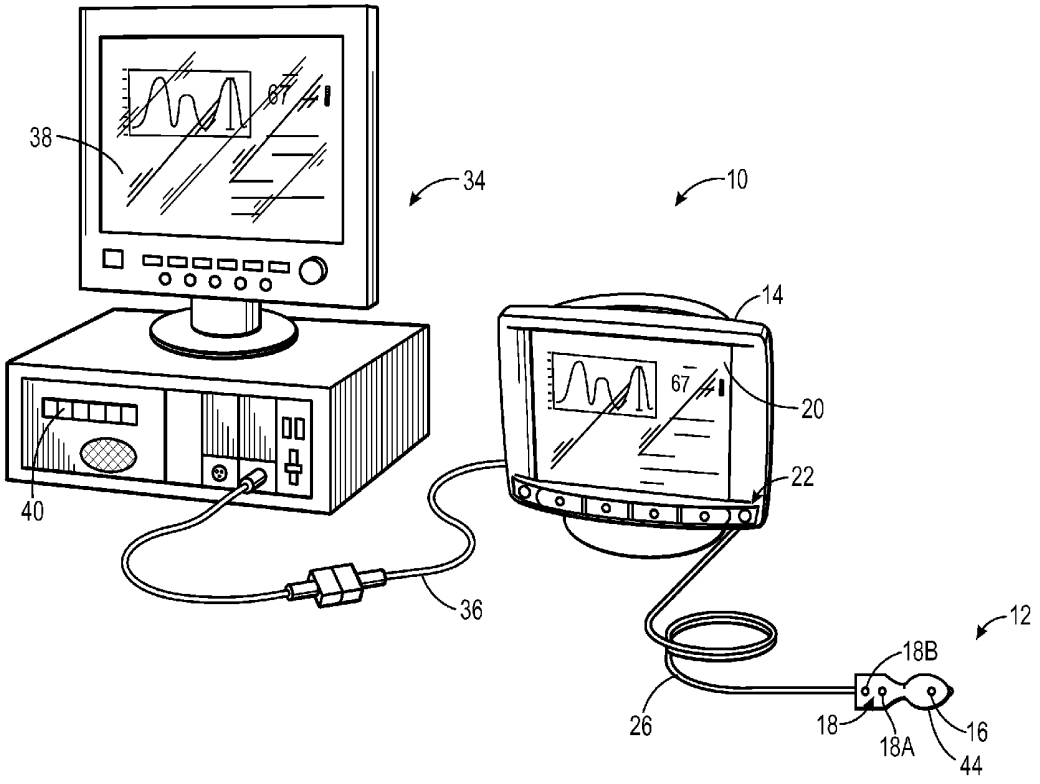
(57) **ABSTRACT**

According to various embodiments, a regional oximetry sensor may include a light emitting element configured to emit light, a light detector configured to receive the light and generate a signal based on the received light. The regional oximetry sensor, itself or in conjunction with a monitor, may enable communicating adjustments in the administration of CPR to a patient based on one or more characteristics (e.g., pulse amplitude or pulse rate) of the signal generated by the regional oximetry sensor.



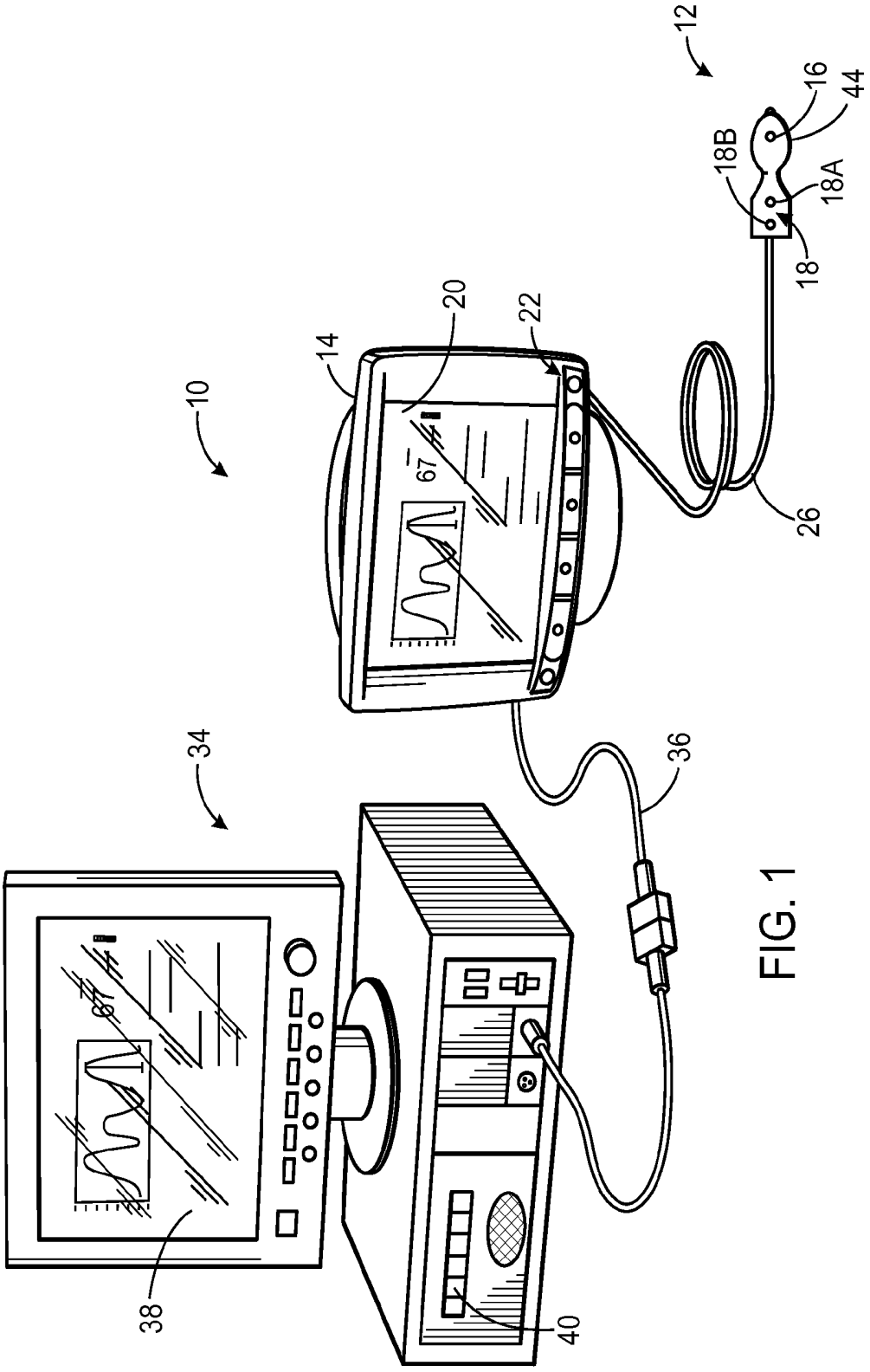


FIG. 1

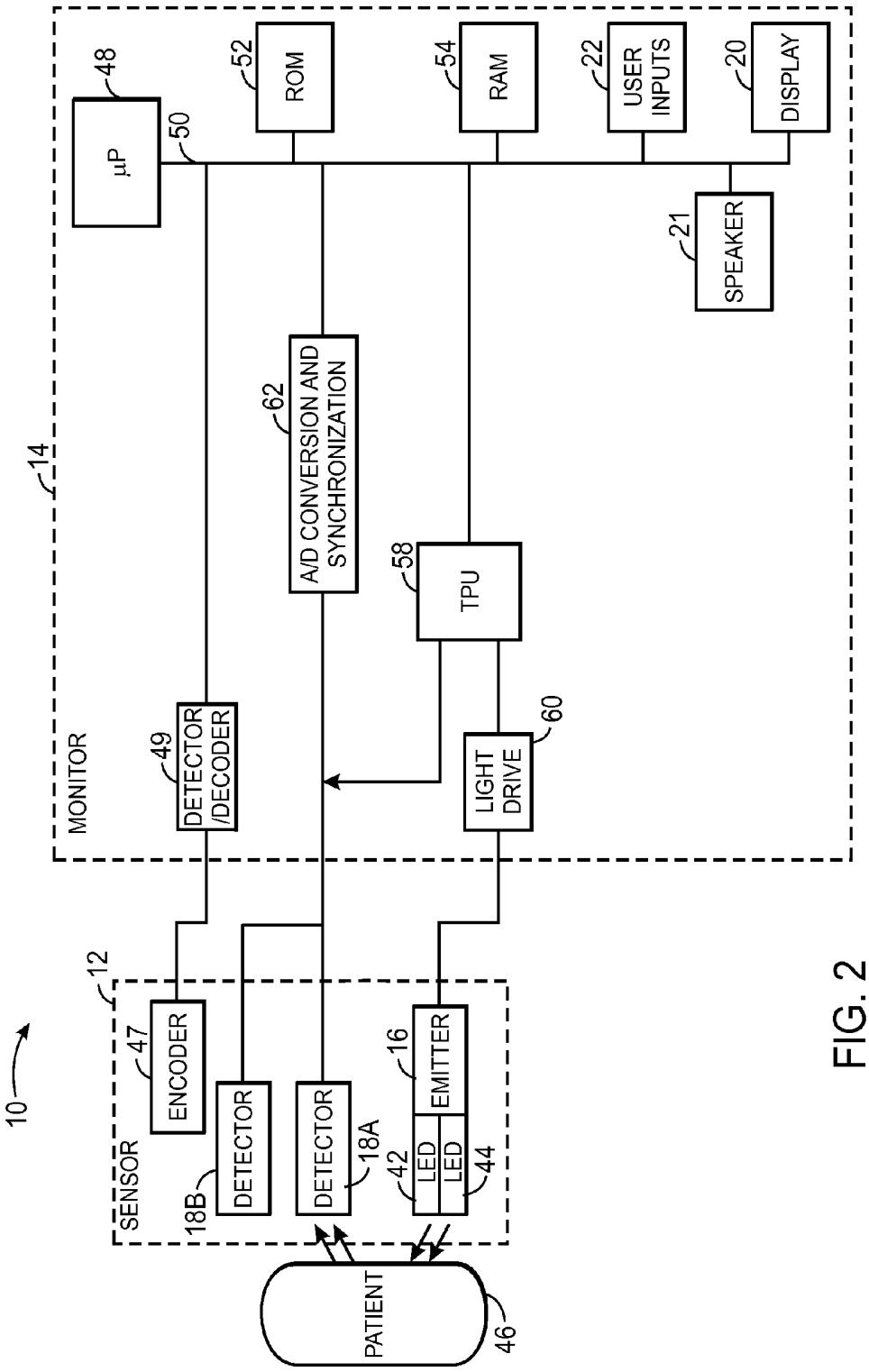

10
14
MONITOR
48
µP
50
52
ROM
54
RAM
22
USER INPUTS
20
DISPLAY
21
SPEAKER
62
A/D CONVERSION AND SYNCHRONIZATION
58
TPU
60
LIGHT DRIVE
49
DETECTOR /DECODER
12
SENSOR
47
ENCODER
18B
DETECTOR
18A
DETECTOR
16
EMITTER
42
LED
44
LED
PATIENT
46

FIG. 2

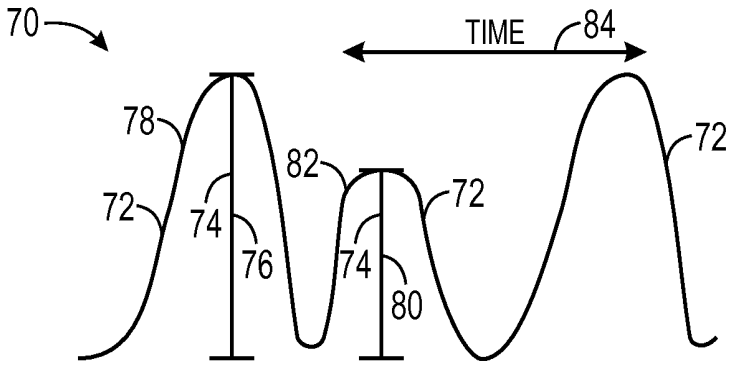

70
TIME
84
78
72
74
76
82
72
74
80
72

FIG. 3

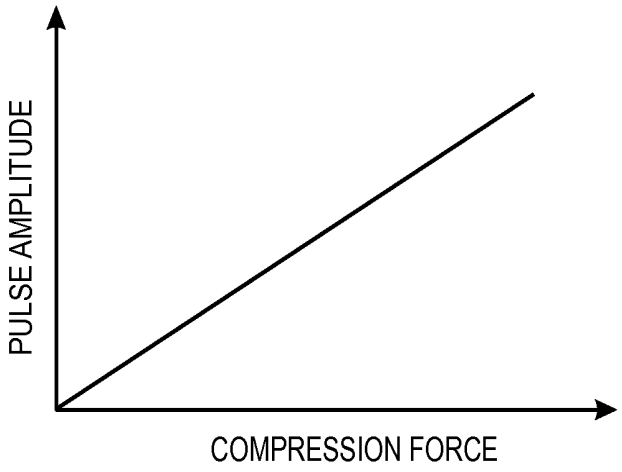

PULSE AMPLITUDE
COMPRESSION FORCE

FIG. 4

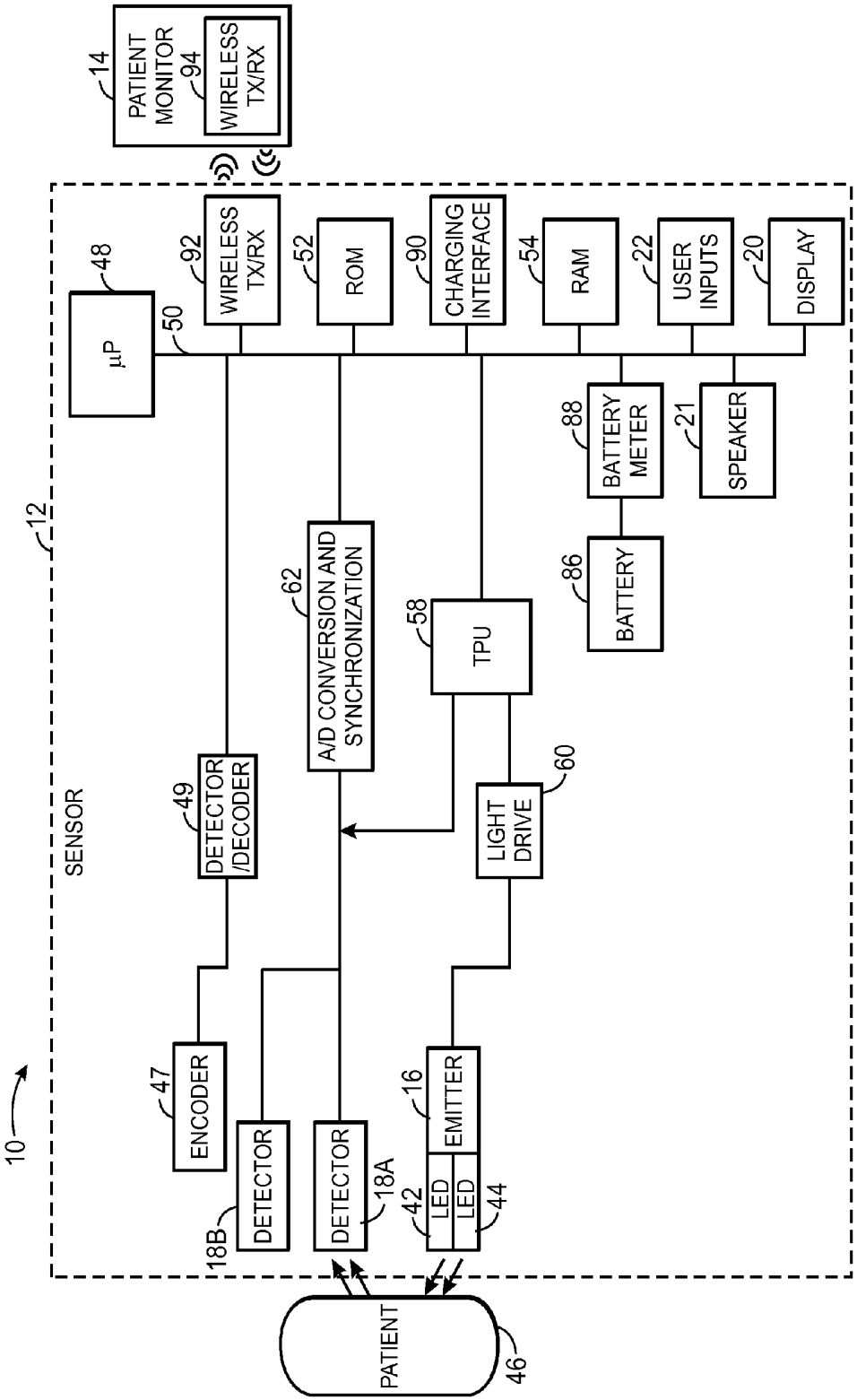

14
PATIENT MONITOR
94
WIRELESS TX/RX
12
SENSOR
48
μP
50
92
WIRELESS TX/RX
52
ROM
90
CHARGING INTERFACE
54
RAM
22
USER INPUTS
20
DISPLAY
88
BATTERY METER
21
SPEAKER
86
BATTERY
62
A/D CONVERSION AND SYNCHRONIZATION
58
TPU
60
LIGHT DRIVE
49
DETECTOR /DECODER
47
ENCODER
16
EMITTER
42
LED
44
LED
18A
DETECTOR
18B
DETECTOR
10
PATIENT
46

FIG. 5

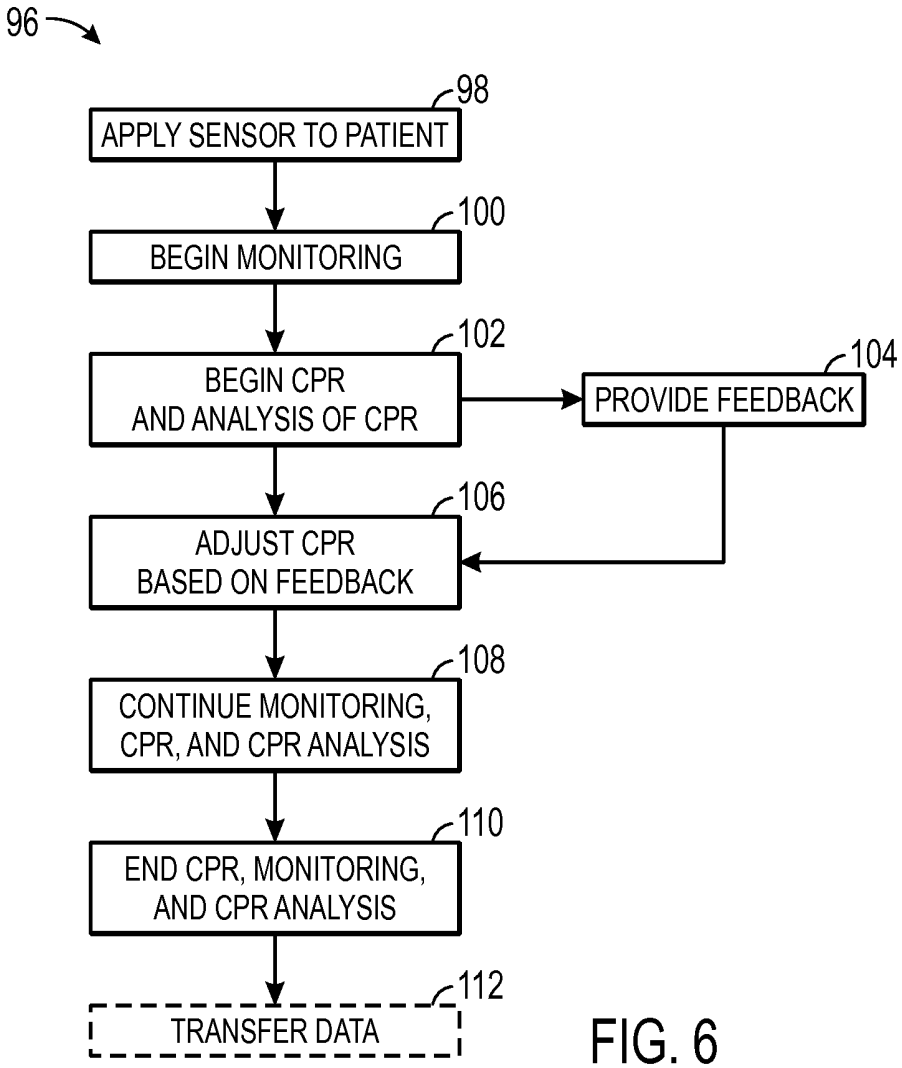

96
98
APPLY SENSOR TO PATIENT
100
BEGIN MONITORING
102
BEGIN CPR
AND ANALYSIS OF CPR
104
PROVIDE FEEDBACK
106
ADJUST CPR
BASED ON FEEDBACK
108
CONTINUE MONITORING,
CPR, AND CPR ANALYSIS
110
END CPR, MONITORING,
AND CPR ANALYSIS
112
TRANSFER DATA

FIG. 6

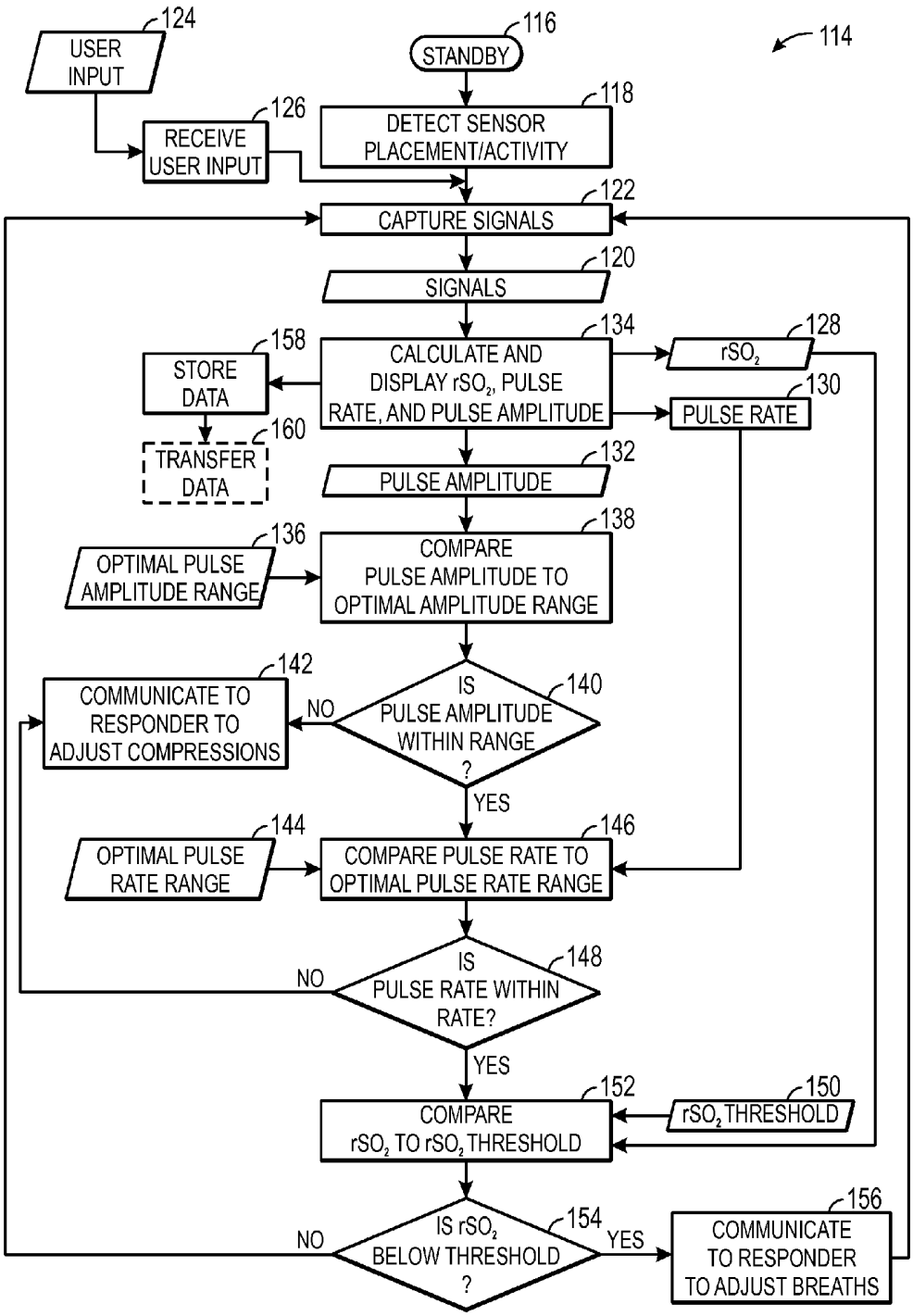

114
124
USER INPUT
116
STANDBY
126
RECEIVE USER INPUT
118
DETECT SENSOR PLACEMENT/ACTIVITY
122
CAPTURE SIGNALS
120
SIGNALS
158
STORE DATA
134
CALCULATE AND DISPLAY rSO2, PULSE RATE, AND PULSE AMPLITUDE
128
rSO2
130
PULSE RATE
160
TRANSFER DATA
132
PULSE AMPLITUDE
136
OPTIMAL PULSE AMPLITUDE RANGE
138
COMPARE PULSE AMPLITUDE TO OPTIMAL AMPLITUDE RANGE
142
COMMUNICATE TO RESPONDER TO ADJUST COMPRESSIONS
NO
IS PULSE AMPLITUDE WITHIN RANGE ?
140
YES
144
OPTIMAL PULSE RATE RANGE
146
COMPARE PULSE RATE TO OPTIMAL PULSE RATE RANGE
NO
IS PULSE RATE WITHIN RATE?
148
YES
152
COMPARE rSO2 TO rSO2 THRESHOLD
150
rSO2 THRESHOLD
NO
IS rSO2 BELOW THRESHOLD ?
154
YES
156
COMMUNICATE TO RESPONDER TO ADJUST BREATHS

FIG. 7

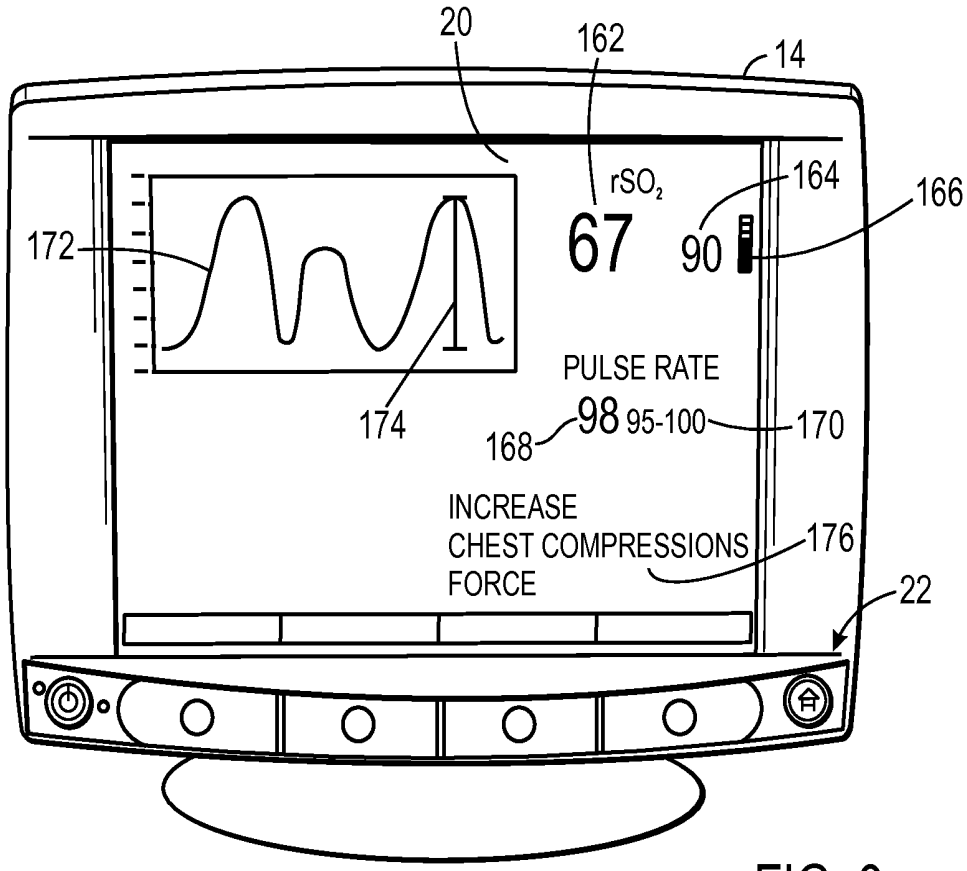

20
162
14
rSO2
164
166
172
67
90
PULSE RATE
174
98
95-100
170
168
INCREASE
CHEST COMPRESSIONS
FORCE
176
22

FIG. 8

SYSTEM AND METHOD FOR EMERGENCY RESUSCITATION

BACKGROUND

[0001] The present disclosure relates generally to emergency resuscitation and, more particularly, to sensors and/or monitors and/or algorithms configured to assist a person in performing emergency resuscitation.

[0002] This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

[0003] In many medical emergencies, a person's heart may stop pumping on its own. The person may need emergency resuscitation such as cardiopulmonary resuscitation (CPR) to sustain the life of the person by manually maintaining intact brain function. Typically, CPR involves manually pumping the chest (i.e., chest compressions) to force blood through the cardiovascular system to organs such as the brain. CPR also involves occasionally blowing oxygenated air (i.e., administered breaths or artificial respiration) into the lungs of the person so that oxygen may be absorbed into the bloodstream. However, the person administering the CPR, whether a trained emergency responder or a person with little training or experience in administering CPR, has little to no feedback as to the effectiveness of the CPR (e.g., quality of chest compressions or applied breaths) being administered. Consequently, the CPR may not be administered as effectively as possible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Advantages of the disclosed techniques may become apparent upon reading the following detailed description and upon reference to the drawings in which:

[0005] FIG. **1** is a front view of an embodiment of a monitoring system configured to be used with a sensor for regional saturation, in accordance with an aspect of the present disclosure;

[0006] FIG. **2** is a block diagram of the monitoring system of FIG. **1** (e.g., sensor coupled to monitor via wired connection), in accordance with an aspect of the present disclosure;

[0007] FIG. **3** is a graphical representation of a signal received from the sensor of FIG. **1**;

[0008] FIG. **4** is a graphical representation of compression force of administered chest compressions versus pulse amplitude of pulses of the signal received from the sensor;

[0009] FIG. **5** is a block diagram of the monitoring system of FIG. **1** (e.g., sensor wirelessly coupled to monitor), in accordance with an aspect of the present disclosure;

[0010] FIG. **6** is a process flow diagram of an embodiment of a method for using the monitoring system of FIG. **1**;

[0011] FIG. **7** is a process flow diagram of an embodiment of a method for determining the effectiveness of CPR administered to a patient using the monitoring system of FIG. **1**; and

[0012] FIG. **8** is a front view of an embodiment of a regional saturation monitor, in accordance with an aspect of the present disclosure.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0013] One or more specific embodiments of the present techniques will be described below. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0014] When introducing elements of various embodiments of the present disclosure, the articles "a," "an," and "the" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements. Additionally, it should be understood that references to "one embodiment" or "an embodiment" of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Also, as used herein, the term "over" or "above" refers to a component location on a sensor that is closer to patient tissue when the sensor is applied to the patient.

[0015] The present embodiments relate to emergency response kits (i.e., emergency response components described below provided or sold as a single unit for use in an emergency response) that may include a sensor and/or monitor to monitor one or more physiological characteristics (e.g., regional oxygen saturation (rSO_2)) of a patient (i.e., person receiving emergency resuscitation such as CPR). The sensors described herein may incorporate one or more emitters and one or more detectors for determining the level of blood oxygen saturation in a particular region, such as a cerebral or somatic region, which may be referred to as regional oximetry. In addition, characteristics or features of the signal acquired by the sensor from the patient may provide useful feedback related to the administration of the CPR. For example, these characteristics or features may include a pulse rate (e.g., frequency) and pulse amplitude of the signal that relate to the quality of administered chest compressions (e.g., appropriate location of chest compressions and/or strength of chest compressions), respectively. In addition, an rSO_2 value derived from the signal may be used to provide useful feedback related to the administration of the CPR. For example, the rSO_2 value may be related to the quality (e.g., effectiveness with regards to volume or frequency) of the breaths (i.e., artificial respiration) administered during the CPR. The sensor and/or monitor may compare a particular signal characteristic to a range (e.g., optimal range) or the rSO_2 value to a threshold to determine whether a component of the CPR needs to be altered (e.g., chest compressions and/or breaths). The optimal ranges may be based on characteristics of the patient (e.g., infant vs. adult, size of patient, age, etc.).

[0016] The feedback with regards to the administration of the CPR may be communicated from the sensor and/or monitor (e.g., via a speaker and/or a display). In certain embodiments, the sensor may communicate via a wired connection

(e.g., cable) or wirelessly with the monitor. Alternatively, the sensor may include some or all of the hardware (e.g., speaker, display, memory, processing device, etc.) and/or software to analyze the characteristics of the signals and to communicate any feedback (e.g., adjustments) to the person administering the CPR. It should be noted that CPR as described herein includes the components of administering chest compressions and artificial respiration. However, the techniques and systems described herein may also be utilized in conjunction with any type of CPR (e.g., CPR administered without artificial respiration). In addition, additional emergency response techniques may be utilized with CPR (e.g., defibrillation).

[0017] By way of example, an INVOS® cerebral/somatic sensor, such as an OxyAlert™ NIR sensor by Somanetics Corporation or a SomaSensor® by Somanetics Corporation, which may include one or more emitters and a pair of detectors for determining site-specific oxygen levels, may represent sensors used in the described techniques and systems. Example systems incorporating a sensor and/or monitor capable of performing regional oximetry and communicating real-time feedback (i.e., as the CPR is performed) related to the administration of CPR are discussed with respect to FIGS. **1**, **2**, and **4**. Example methods for using these systems and sensors are discussed with respect to FIGS. **5** and **6**.

[0018] With this in mind, FIG. **1** depicts an embodiment of a patient monitoring system **10** that may be used in conjunction with a medical sensor **12**. Although the depicted embodiments relate to sensors for use on a patient's head, it should be understood that, in certain embodiments, the features of the sensor **12** as provided herein may be incorporated into sensors for use on other tissue locations, such as the back, the stomach, the heel, the ear, an arm, a leg, or any other appropriate measurement site. In addition, although the embodiment of the patient monitoring system **10** illustrated in FIG. **1** relates to photoplethysmography or regional oximetry, the system **10** may be configured to obtain a variety of medical measurements with a suitable medical sensor. For example, the system **10** may additionally be configured to determine patient electroencephalography (e.g., a bispectral index), or any other desired physiological parameter such as water fraction or hematocrit.

[0019] As noted, the system **10** includes the sensor **12** that is communicatively coupled to a patient monitor **14**. The sensor **12** may be reusable, entirely disposable, or include disposable portions. If the sensor **12** is reusable, it may include a disposable adhesive pad that may be replaced. Although only one sensor **12** is shown coupled to the monitor **14** in FIG. **1**, in other embodiments, two, three, four, or more sensors **12** may be coupled to the monitor **14**. For example, two sensors **12** may be used for cerebral oximetry and simultaneously two other sensors **12** used for somatic oximetry. As shown in FIG. **1**, the sensor **12** includes an emitter **16** and a pair of detectors **18**. The emitter **16** and detectors **18** of the sensor **12** are coupled to the monitor **14** via a cable **26** coupled to the monitor **14**. The cable **26** may interface directly with the sensor **12** and may include a plurality of conductors (e.g., wires). In certain embodiments, the sensor **12** may be configured to store patient-related data, such as historical regional oximetry data (e.g., rSO_2 values) and signal characteristics related to the administration of CPR.

[0020] The monitor **14** includes a monitor display **20** configured to display information regarding the physiological parameters monitored by the sensor **12**, information about the system, and/or alarm indications. In addition, the monitor display **20** may be configured to communicate information related to the CPR being administered to the patient. For example, information related to chest compressions (e.g., "change location of compressions", "compression too light", "compression too hard", "slow down compressions", "speed up compressions", etc.) and/or artificial respiration may be displayed on the display **20**. This information may relate to changing a location of the chest compressions, the amount of force applied during the chest compressions (e.g., too light, too hard, etc.), and/or the effectiveness of the administered breaths (e.g., an amount, frequency, etc.). The information may be displayed via text, images, and/or color-coded indicators. The monitor **14** may also include a speaker **21** to communicate information related to the CPR being administered to the patient. For example, the speaker **21** may communicate audible instructions (e.g., "change location of compressions", "compression too light", "compression too hard", "slow down compressions", "speed up compressions", etc.). In addition, the speaker **21** may emit a sound (e.g., beep) to reflect a detected pulse. In some embodiments, a pitch, tone, or other characteristic of the sound may be varied to indicate chest compressions are being administered too fast, too slow, or at a correct rate. The monitor **14** may include various input components **22**, such as knobs, switches, keys and keypads, buttons, touchscreen, etc., to provide for operation and configuration of the monitor **14**. The input components **22** may enable the inputting and/or adjusting of patient characteristics (e.g., patient age, size, condition, etc.), inputting that the sensor **12** has been applied to the patient, inputting a beginning and/or end of the administration of CPR to the patient, and/or inputting and/or adjusting ranges, values, and/or thresholds related to determining the effectiveness of the administered CPR (e.g., optimal pulse frequency range, optimal pulse rate range, optimal rSO_2 value, threshold, or range). In certain embodiments, the sensor **12** may include input components for inputting/and or adjusting this information. The monitor **14** also includes a processor that may be used to execute code, such as code for implementing various monitoring functionalities enabled by the sensor **12**. As discussed below, for example, the monitor **14** may be configured to process signals generated by the detectors **18** to estimate the amount of oxygenated vs. de-oxygenated hemoglobin in a monitored region of the patient (e.g., brain). In addition, the monitor **14** may be configured to relate the rSO_2 value to a component of the CPR (e.g., artificial respiration). Further, the monitor **14** may be configured to analyze the signals generated by the detectors **18** to relate signal characteristics (e.g., pulse rate and/or pulse frequency) to one or more components of the CPR (e.g., chest compressions). In some embodiments, the sensor **12** may include a processor that may be used to execute code stored in a memory of the sensor **12** to perform all or some of the functionalities described throughout related to calculating an rSO_2 value and/or analyzing signals characteristics related to one or more components of the CPR.

[0021] The monitor **14** may be any suitable monitor, such as an INVOS® System monitor available from Somanetics Corporation. Furthermore, to upgrade conventional operation provided by the monitor **14** to provide additional functions, the monitor **14** may be coupled to a multi-parameter patient monitor **34** via a cable **36** connected to a sensor input port. In addition to the monitor **14**, or alternatively, the multi-parameter patient monitor **34** may be configured to calculate physiological parameters and to provide a central display **38** for the

visualization of information from the monitor **14** and from other medical monitoring devices or systems. The multi-parameter monitor **34** includes a processor that may be configured to execute code. The multi-parameter monitor **34** may also include various input components **40**, such as knobs, switches, keys and keypads, buttons, touchscreen, etc., to provide for operation and configuration of the a multi-parameter monitor **34**. In addition, the monitor **14** and/or the multi-parameter monitor **34** may be connected to a network to enable the sharing of information with servers or other workstations (e.g., electronic medical records).

[0022] In certain embodiments, the sensor **12** may be a wireless sensor **12**. Accordingly, the wireless sensor **12** may establish a wireless communication with the patient monitor **14**, the multi-parameter patient monitor **34**, and/or network using any suitable wireless standard. By way of example, the wireless module may be capable of communicating using one or more of the ZigBee standard, WirelessHART standard, Bluetooth standard, IEEE 802.11x standards, or MiWi standard.

[0023] As provided herein, the sensor **12** may be configured to perform regional oximetry. Indeed, in one embodiment, the sensor **12** may be an INVOS® cerebral/somatic sensor available from Somanetics Corporation. In regional oximetry, by comparing the relative intensities of light received at two or more detectors, it is possible to estimate the blood oxygen saturation of hemoglobin in a region of a body. For example, a regional oximeter may include a sensor to be placed on a patient's forehead and may be used to calculate the oxygen saturation of a patient's blood within the venous, arterial, and capillary systems of a region underlying the patient's forehead (e.g., in the cerebral cortex). As illustrated in FIGS. **1-3**, the sensor **12** may include the emitter **16** and the two detectors **18**: one detector **18**A that is relatively "close" to the emitter **16** and another detector **18**B that is relatively "far" from the emitter **16**. Light intensity of one or more wavelengths may be received at both the "close" and the "far" detectors **18**A and **18**B. Thus, the detector **18**A may receive a first portion of light and the detector **18**B may receive a second portion of light. Each of the detectors **18** may generate signals indicative of their respective portions of light. For example, the resulting signals may be contrasted to arrive at a regional saturation value that pertains to additional tissue through which the light received at the "far" detector **18**B passed (tissue in addition to the tissue through which the light received by the "close" detector **18**A passed, e.g., the brain tissue) when it was transmitted through a region of a patient (e.g., a patient's cranium). Surface data from the skin and skull is subtracted out to produce a regional oxygen saturation (rSO_2) value for deeper tissues. In certain embodiments, the sensor **12** and/or monitor **14** may be configured to select the desired (e.g., strongest) signals from the signals provided by the detectors **18** for use in determining the rSO_2 value and/or analyzing the signal characteristics related to one or more components of the CPR being administered.

[0024] In certain embodiments, sensor **12** may be entirely or partially reusable and integrated with monitor **14** in a single unit possessing its own display and requiring no cable **26**. The integrated monitor would be a standalone unit, strapped to the head of the patient and in direct view of the operator. Such embodiment would present the advantages of greater mobility and reduced number of parts.

[0025] Turning to FIG. **2**, a simplified block diagram of the medical system **10** is illustrated in accordance with an embodiment. The sensor **12** may include optical components in the forms of the emitter **16** and detectors **18**. The emitter **16** and the detectors **18** may be arranged in a reflectance or transmission-type configuration with respect to one another. However, in embodiments in which the sensor **12** is configured for use on a patient's forehead, the emitter **16** and detectors **18** may be in a reflectance configuration. An emitter **16** may also be a light emitting diode, superluminescent light emitting diode, a laser diode, or a vertical cavity surface emitting laser (VCSEL). An emitter **16** and the detectors **18** may also include optical fiber sensing elements. Also, the emitter **16** may include two light emitting diodes (LEDs) **42** and **44** that are capable of emitting at least two wavelengths of light, e.g., red or near infrared light. In one embodiment, the LEDs **42** and **44** emit light in the range of 600 nm to about 1000 nm. In a particular embodiment, the one LED **42** is capable of emitting light at 730 nm and the other LED **44** is capable of emitting light at 810 nm. It should be understood that, as used herein, the term "light" may refer to one or more of ultrasound, radio, microwave, millimeter wave, infrared, visible, ultraviolet, gamma ray or X-ray electromagnetic radiation, and may also include any wavelength within the radio, microwave, infrared, visible, ultraviolet, or X-ray spectra, and that any suitable wavelength of light may be appropriate for use with the present disclosure.

[0026] In any suitable configuration of the sensor **12**, the detectors **18**A and **18**B may be an array of detector elements that may be capable of detecting light at various intensities and wavelengths. In one embodiment, light enters the detector **18** (e.g., detector **18**A or **18**B) after passing through the tissue of the patient **46**. In another embodiment, light emitted from the emitter **16** may be reflected by elements in the patient's tissue to enter the detector **18**. The detector **18** may convert the received light at a given intensity, which may be directly related to the absorbance and/or reflectance of light in the tissue of the patient **46**, into an electrical signal. That is, when more light at a certain wavelength is absorbed, less light of that wavelength is typically received from the tissue by the detector **18**, and when more light at a certain wavelength is reflected, more light of that wavelength is typically received from the tissue by the detector **18**. After converting the received light to an electrical signal, the detector **18** may send the signal to the monitor **14**, where physiological characteristics may be calculated based at least in part on the absorption and/or reflection of light by the tissue of the patient **46**.

[0027] In certain embodiments, the medical sensor **12** may also include an encoder **47** that may provide signals indicative of the wavelength of one or more light sources of the emitter **16**, which may allow for selection of appropriate calibration coefficients for calculating a physical parameter such as blood oxygen saturation. The encoder **47** may, for instance, include a coded resistor, an electrically erasable programmable read only memory (EEPROM), or other coding device (such as a capacitor, inductor, programmable read only memory (PROM), RFID, parallel resident currents, or a colorimetric indicator) that may provide a signal to a microprocessor **48** related to the characteristics of the medical sensor **12** to enable the microprocessor **48** to determine the appropriate calibration characteristics of the medical sensor **12**. Further, the encoder **47** may include encryption coding that prevents a disposable part of the medical sensor **12** from being recognized by a microprocessor **48** unable to decode the encryption. For example, a detector/decoder **49** may translate information from the encoder **47** before the proces-

sor **48** can properly handle it. In some embodiments, the encoder **47** and/or the detector/decoder **48** may not be present.

[0028] In certain embodiments, the sensor **12** may include circuitry that stores patient-related data (e.g., rSO_2) and provides the data when requested. The circuitry may be included in the encoder **47** or in separate memory circuitry within the sensor **12**. Examples of memory circuitry include, but are not limited to, a random access memory (RAM), a FLASH memory, a PROM, an EEPROM, a similar programmable and/or erasable memory, any kind of erasable memory, a write once memory, or other memory technologies capable of write operations. In one embodiment, patient-related data, such as the rSO_2 values, trending data, or patient monitoring parameters, may be actively stored in the encoder **47** or memory circuitry.

[0029] Returning to FIG. **2**, signals from the detector **18** and/or the encoder **47** may be transmitted to the monitor **14**. By way of example, the monitor **14** shown in FIG. **2** may be an INVOS® System monitor **14** available from Somanetics Corporation. The monitor **14** may include one or more processors **48** coupled to an internal bus **50**. Also connected to the bus **50** may be a ROM memory **52**, a RAM memory **54**, and the display **20**. A time processing unit (TPU) **58** may provide timing control signals to light drive circuitry **60**, which controls when the emitter **16** is activated, and if multiple light sources are used, the multiplexed timing for the different light sources. The received signal from the detector **18** may be passed through analog-to-digital conversion and synchronization **62** under the control of timing control signals from the TPU **58**. Specifically, the signal may undergo synchronized demodulation and optionally amplification and/or filtering. For example, the LEDs **42** and **44** may be driven out-of-phase, sequentially and alternatingly with one another (i.e., only one of the LEDs **42** and **44** being driven during the same time interval) such that the detector **18** receives only resultant light spectra emanating from one LED at a time. Demodulation **62** of the signal enables the data associated with the LEDs **42** and **44** to be distinguished from one another. After demodulation, the digital data may be downloaded to the RAM memory **54**.

[0030] In some embodiments, the processor **48** may determine the placement of the sensor **12** on the patient **46** by detecting activity using various algorithms (e.g., "sensor off" algorithms, pulse detection algorithms, etc.). Alternatively, the processor **48** may be configured to receive user input via the input components **22** that indicate the placement of the sensor **12** on the patient **46**. In addition, the processor **48** may be configured to receive user input via the input components **22** that indicate the beginning and/or end of the administration of the CPR to the patient **46**.

[0031] In an embodiment, based at least in part upon the received signals corresponding to the light received by detector **18**, the processor **48** may calculate the oxygen saturation (e.g., regional oxygen saturation) using various algorithms. These algorithms may use coefficients, which may be empirically determined. For example, algorithms relating to the distance between an emitter **16** and various detector elements in a detector **18** may be stored in the ROM memory **52** and accessed and operated according to processor **48** instructions.

[0032] In addition, the processor **48** may select the strongest signal received from the detectors **18** (e.g., from a shallow detector or a deep detector) for calculating the oxygen saturation and further analysis of the signal. For example, the processor **48** may analyze characteristics of the signal and relate them to components of the CPR presently being administered to the patient **46** using various algorithms. Specifically, the processor **48** may calculate the pulse amplitude and/or pulse rate of the signal and relate these to the chest compressions administered to the patient **46**. FIG. **3** provides an example of a signal **70** obtained from the sensor **12**. The signal **70** includes multiple pulses **72**. Each pulse **72** includes a pulse amplitude **74** (i.e., peak to peak amplitude for the pulse **72**). The pulse amplitude **74** may be linearly related to the force applied during the chest compression (see FIG. **4**) and/or the effectiveness of the chest compression (e.g., location of the chest compression). For example, a stronger chest compression may result in a larger pulse amplitude **74** (see pulse amplitude **76** for pulse **78** in FIG. **3**) relative to the pulse amplitude **74** from a weaker chest compression (see pulse amplitude **80** for pulse **82** in FIG. **3**). Similarly, a chest compression administered in the wrong location (e.g., off-center) may result in a smaller pulse amplitude **74** (see pulse amplitude **80** for pulse **82** in FIG. **3**) than a pulse amplitude **74** from a chest compression administered in the proper location (see pulse amplitude **76** for pulse **78** in FIG. **3**). FIG. **3** also illustrates the pulse rate (i.e., frequency) of the signal **70** (i.e., the number of pulses **72** within a defined period of time **84**). Generally the frequency of the detected pulse (i.e., signal **70**) may be the same as the frequency of the chest compressions administered during the CPR. Returning to FIG. **2**, the processor **48** may be configured to relate the rSO_2 value to a component of the CPR (e.g., artificial respiration).

[0033] Further, the processor **48** may be configured to compare the rSO_2 value and characteristics of the signal to threshold values and/or ranges and communicate information related to the administered CPR (e.g., via the speaker **21** and/or display **20** as described above) based on these comparisons. For example, the processor **48**, via the speaker **21** and/or display **20**, may communicate to the person administering the CPR to adjust one or more components of the CPR (e.g., chest compressions and/or artificial respiration). The processor **48** may compare the rSO_2 value to a threshold value to determine if the rSO_2 value is lower than the threshold value and communicate to the person administering the CPR to adjust (e.g., increase or decrease) the frequency and/or intensity of breaths administered during the CPR if the rSO_2 value is lower than the threshold value. An rSO_2 value below the threshold value may be indicative that the brain of the patient **46** is not receiving enough oxygen. Alternatively, the processor **48** may be configured to determine if the rSO_2 value falls within an optimal range. The processor **48** may also keep track of the number of compressions administered and communicates when artificial respiration should be administered. The processor **48** may also compare the pulse amplitude of the signal to a pulse amplitude range (e.g., optimal pulse amplitude range) and communicate (e.g., via the speaker **21** and/or display **20** as described above) to the person administering the CPR to adjust chest compressions administered during the CPR if the pulse amplitude is not within the pulse amplitude range. The pulse amplitude range may be based on a nominal value determined through empirical data or inputted by a user. Additionally, the processor **48** may be configured to compare the pulse rate of the signal to a pulse rate range (e.g., optimal pulse rate range) and to communicate (e.g., via the speaker **21** and/or display **20** as described above) to the person administering the CPR to adjust chest compressions administered during the CPR if the pulse rate is not within the pulse rate range. The pulse rate range may be based

on a recommended pulse rate (e.g., **100** compressions per minute). The pulse amplitude range and pulse rate range may be stored within the ROM memory **52**. In addition, the user may adjust and/or enter a desired pulse amplitude range and pulse rate range. Alternatively, the user may input patient characteristics (e.g., age, size, etc.) and the processor **48** may be configured to adjust the pulse amplitude range and the pulse rate range based on these patient characteristics. Alternatively, the processor **48** may detect the type of sensor that is in use (e.g. adult, pediatric, infant) and adjust the target amplitudes, rates and ranges based on the patient population for the selected sensor.

[0034] Furthermore, one or more functions of the monitor **14** may also be implemented directly in the sensor **12** as illustrated in FIG. **5**. The sensor **12** in FIG. **5** includes the components of the monitor **14** shown in FIG. **2**. However, the sensor **12**, in certain embodiments, may include only some of these components. For example, in some embodiments, the sensor **12** may includes the processor **48** capable of calculating the physiological characteristics (e.g., rSO_2 value) from the signals obtained from the patient **46**. In addition, the processor **48** is capable of analyzing characteristics of the signals with regard to one or more components of CPR being administered to the patient **46** and communicating information (e.g., via display **20** and/or speaker **21**) related to the CPR as described above. A battery **86** may supply the sensor **12** with operating power. By way of example, the battery **86** may be a rechargeable battery, such as lithium ion or lithium polymer battery, or may be a single-use battery such as alkaline or lithium battery. A battery meter **88** may provide the expected remaining power of the battery **86** to a user and/or to the microprocessor **48**. In certain embodiments, the sensor **12** includes a charging interface that enables the sensor **12** to be coupled to the monitor **14** or a charger to charge the battery **86**. In accordance with the present techniques, the sensor **12** may be configured to provide desired contact between the patient **46** and the detector **18**, and/or the emitter **16**. The sensor **12** may have varying levels of processing power, and may output data in various stages (e.g., during and/or after the administered CPR) to the monitor **14** or other device or network, either wirelessly (e.g., via wireless transceiver **92** of the sensor **12** and wireless transceiver **94** of the monitor **14**) or via the cable **26**. For example, in some embodiments, the data output to the monitor **14** may be analog signals, such as detected light signals (e.g., oximetry signals or regional saturation signals), or processed data.

[0035] As discussed above, the monitoring system **10** (e.g., sensor **12** and/or monitor **14**) enable the analysis of physiological parameters (e.g., rSO_2 value) and/or signal characteristics to determine if the presently administered CPR needs to be adjusted, while also providing feedback with regard to one or more components of the CPR (e.g., chest compressions and/or artificial respiration). FIG. **6** generally illustrates a method **96** for utilizing the system **10** for this purpose. The method **96** begins with a responder (e.g., the person administering the CPR) applying the sensor **12** to the patient **46** (block **98**). Monitoring of the physiological parameters (e.g., rSO_2) may then begin (block **100**). As described above, the sensor **12** may detect activity by utilizing algorithms that detect a physiological signal or "sensor off" algorithms. The detected activity may trigger the sensor **12** and/or monitor **14** to begin monitoring. Alternatively, the input component **22** (e.g., actuation device) may be actuated on the sensor **12** and/or monitor **14** to mark the beginning of the monitoring. The responder may then begin administering CPR and the system **10** may begin analysis of the CPR (block **102**). Alternatively, the responder may begin CPR before the application of the sensor, at which time the sensor **12** and monitor **14** immediately assesses the status of the ongoing CPR. Analysis of the CPR may be started by the responder providing an indication to the sensor **12** and/or monitor **14** (e.g., via actuation of the input component **22**). The sensor **12** and/or monitor **14** may provide feedback (e.g., via display **20** and/or speaker **21**) to the provider based on the rSO_2 value and analyzed signal characteristics as described above (block **104**). The feedback may confirm the proper administration of the CPR, provide an analysis of the CPR, and/or provide adjustments for the administration of the CPR. The responder may then adjust the CPR based on the feedback (block **106**). The monitoring, CPR, and CPR analysis may continue (block **108**) until the termination of these activities (block **110**). For example, the input component **22** (e.g., actuation device) may be actuated on the sensor **12** and/or monitor **14** to mark the ending of the monitoring, CPR, and CPR analysis. Following the ending of these activities, in embodiments where the sensor **12** functions as a standalone unit (i.e., conducts the CPR analysis and communicates feedback), data (e.g., patient's physiological data, CPR analysis data, etc.) may be transferred to the monitor **14** or a network (block **112**). Alternatively, in embodiments where the monitor **14** performs the CPR analysis and communicates the feedback, the data may be transferred to the network or another system (e.g., electronic medical records).

[0036] FIG. **7** provides a method **114** that illustrates the functionality of the monitoring system **10** in greater detail. The method **114** may begin with the sensor **12** applied to the patient functioning in a standby mode **116**. In the standby mode **116**, the sensor **12** may detect sensor placement or activity by utilizing algorithms that detect a physiological signal or "sensor off" algorithms (block **118**). The detected activity may trigger the sensor **12** to begin capturing signals **120** (block **122**). After application of the sensor **12**, either prior to and/or after beginning to the capture the signals **120**, the sensor **12** and/or monitor may receive user input **124** (block **126**) (e.g., via the input component **22**). For example, the placement of the sensor **12** and beginning the capture of signals may be indicated via user input **124**. In addition, the beginning and ending of the administration of the CPR may be indicated via user input **124**. Further, patient data (e.g., age, size, condition, etc.), threshold values, and/or ranges may be provided via user input **124**. As described above, in certain embodiments, the sensor **12** and/or monitor **14** may select the strongest signal from among the signals **120** for subsequent analysis. The sensor **12** and/or monitor **14** may calculate and display from the signal **120** the rSO_2 value **128**, pulse rate **130**, and pulse amplitude **132** on the display **20** (block **134**). The sensor **12** and/or monitor **14** may compare the pulse amplitude **132** to an optimal pulse amplitude range **136** (block **138**). Based on this comparison, the sensor **12** and/or monitor **14** may determine whether the pulse amplitude **132** of the signal **120** is within the optimal pulse amplitude range **138** (block **140**). If the pulse amplitude **132** is outside the optimal pulse amplitude range **138**, the sensor **12** and/or monitor **14** may communicate (e.g., via display **20** and/or speaker **21**) to the responder to adjust the chest compressions (e.g., location or amount of force applied) (block **142**). If the pulse amplitude **132** is within the optimal pulse amplitude range **138**, the sensor **12** and/or monitor **14** may

compare the pulse rate **130** to an optimal pulse rate range **144** (e.g., 98 to 102 pulses/min, 96 to 104 pulses/min, 90 to 110 pulses/min, etc.) (block **146**). In certain embodiments, the sensor **12** and/or monitor **14** may compare the pulse rate **130** to a threshold (e.g., minimum or maximum threshold for pulse rate). Based on this comparison, the sensor **12** and/or monitor **14** may determine whether the pulse rate **130** of the signal **120** is within the optimal pulse rate range **144** (block **148**). If the pulse rate **130** is outside the optimal pulse rate range **144**, the sensor **12** and/or monitor **14** may communicate (e.g., via display **20** and/or speaker **21**) to the responder to adjust the chest compressions (e.g., location or amount of force applied) (block **142**). If the pulse rate **130** is within the optimal pulse rate range **144**, the sensor **12** and/or monitor **14** may compare the rSO_2 value **128** to an rSO_2 threshold **150** (block **152**). Based on this comparison, the sensor **12** and/or monitor **14** may determine whether the rSO_2 value **128** is below the rSO_2 threshold **150**. If the rSO_2 value **128** is below the rSO_2 threshold **150**, the sensor **12** and/or monitor **14** may communicate (e.g., via display **20** and/or speaker **21**) to the responder to adjust the breaths (e.g., amount and/or frequency) (block **156**). If the rSO_2 value **128** is at or above the rSO_2 threshold **150**, the sensor **12** continues capturing signals **120** and the sensor **12** and/or monitor **14** continue analyzing the signals **120**. Although, the above method **114** discusses the analysis of pulse amplitude, pulse rate, and rSO_2 in a particular order, these steps may be performed in any order and/or simultaneously. The method **114** may also include storing the data acquired (e.g., rSO_2 value, pulse amplitude, pulse rate, analyses of the rSO_2 value and signals characteristics, patient characteristics, etc.) on the memory of the sensor **12** and/or monitor **14** (block **158**). In certain embodiments, the stored data may be transferred (block **160**) during and/or after the CPR and CPR analysis. For example, in embodiments where the sensor **12** functions as a standalone unit (i.e., conducts the CPR analysis and communicates feedback), data (e.g., patient's physiological data, CPR analysis data, etc.) may be transferred to the monitor **14** or a network. Alternatively, in embodiments where the monitor **14** performs the CPR analysis and communicates the feedback, the data may be transferred to the network or another system (e.g., electronic medical records).

[0037] As described above, feedback with regard to the CPR may be communicated via display **20** of the monitor **14**, for example, as illustrated in FIG. **8**. It should be noted that a similar (although smaller) display **20** may be present on the sensor **12**. In the arrangement shown in FIG. **8**, the output from the sensor **12** is processed to provide an rSO_2 value or other such quantified value **162**. In addition, a threshold rSO_2 value **164** and/or an indicator **166** illustrating the rSO_2 value relative to the rSO_2 threshold value on the display **20**. Also, a pulse rate or frequency **168** along with a pulse rate range **170** may be shown on the display **20**. In certain embodiments, a graphical representation **172** of the signal may be shown along with an indicator **174** for pulse amplitude. Suggested adjustments, directions, and other information **176** based on the analysis of the signal characteristics and the rSO_2 value may be shown on the screen. This information **176** may be shown in the form of text (as shown in FIG. **8**), images, diagrams, symbols, or any other form to communicate the information **176** to the responder. The rSO_2 value **162**, pulse rate **168**, pulse amplitude indicator **174**, and/or information **176** may be displayed or highlighted in different colors to (e.g., red, green, yellow, etc.) to indicate a state of that particular value or information. For example, an acceptable pulse rate, pulse amplitude, or non-urgent information (e.g., "Maintain Rate of Chest Compressions") may be colored green, while unacceptable values or suggested adjustments may be colored red (e.g., "Increase Chest Compression Force"). As a result, information related to the CPR may be conveyed via the display **20**, along with speaker **21** as described above, instantaneously to the responder to facilitate effective CPR administration.

[0038] In another embodiment, the monitor **14** could be a small handheld monitor including the display **20** and the speaker **21**. However, the handheld monitor may display information in a manner understood by non-medically trained people. In other words, the handheld monitor may not display an rSO_2 value, pulse rate, graphs, or other items useful to medically trained people. Instead, the handheld monitor may display basic information (e.g., where to apply the sensor, how to conduct CPR, etc.) to the person providing the CPR as well as feedback to adjust the CPR (e.g., speed up compressions, give breath, etc.) via the display **20** and/or speaker **21**. The feedback may include adjusting a pitch, tone, or other characteristic of the sounds emitted by the speaker **21** as described above. In addition, the handheld monitor may provide audible instructions via the speaker **21** and/or visible instructions via the display **20** as to how to apply the sensor **12**, how to use the sensor **12** and/or monitor **14**, and/or how to conduct the CPR. In some embodiments, the handheld monitor may include pictures or cards attached to illustrate how to apply the sensor **12** (e.g., where to place the sensor, how to use the sensor **12** and/or monitor **14**, and/or how to conduct the CPR. The handheld monitor may include a sturdy outer case (e.g., rugged molded plastic shell cover) to protect the handheld monitor from fluid ingress. In certain embodiments, the handheld monitor may include default values (e.g., thresholds or ranges) set for the optimal pulse amplitude and/or pulse rate. In certain embodiments, the user may input patient characteristics (e.g., age, size, etc.) and the handheld monitor may be configured to select the pulse amplitude range, the pulse rate range, and/or the type of CPR to be administered (e.g., using heel of one hand for child, using two fingers for infant, using heels of both hands for adult, etc.) based on these patient characteristics. Alternatively, the handheld monitor may detect the type of sensor that is in use (e.g. adult, pediatric, infant) and select the type of CPR, target amplitudes, target rates, and/or target ranges based on the patient population for the selected sensor.

[0039] While the disclosure may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the embodiments provided herein are not intended to be limited to the particular forms disclosed. Rather, the various embodiments may cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the following appended claims.

What is claimed is:

1. An emergency resuscitation kit, comprising:

a regional oximetry sensor configured to be applied to a patient, comprising:

a light emitting element configured to emit light;

at least one light detector configured to receive the light and to generate a signal based on the received light; and

a monitor configured to receive the signal from the regional oximetry sensor, to analyze one or more characteristics of the signal to determine if cardiac pulmonary resuscitation (CPR) received by the patient needs to be adjusted, and to communicate to a person administering the CPR to adjust one or more components of the CPR based on the analysis.

2. The emergency resuscitation kit of claim **1**, wherein analyzing one or more characteristics of the signal comprises determining a regional oxygen saturation value based on the received signal, and wherein the monitor is configured to communicate to the person administering the CPR to adjust the one or more components of the CPR based on the regional oxygen saturation value.

3. The emergency resuscitation kit of claim **3**, wherein analyzing one or more characteristics of the signal further comprises comparing the regional oxygen saturation value to a threshold value to determine if the regional oxygen saturation value is lower than the threshold value, and wherein the one or more components of the CPR comprise breaths or other means of artificial respiration administered during the CPR to the patient.

4. The emergency resuscitation kit of claim **1**, wherein the one or more characteristics of the signal comprise a pulse amplitude of the signal, and wherein analyzing the one or more characteristics comprises comparing the pulse amplitude of the signal to a pulse amplitude range to determine if the pulse amplitude is within the pulse amplitude range, and wherein the one or more components of the CPR comprise compressions administered during the CPR to the patient.

5. The emergency resuscitation kit of claim **1**, wherein the one or more characteristics of the signal comprise a pulse rate of the signal, and wherein analyzing the one or more characteristics comprises comparing the pulse rate of the signal to a pulse rate range to determine if the pulse rate is within the pulse raterange, and wherein the one or more components of the CPR comprise chest compressions administered during the CPR to the patient.

6. The emergency resuscitation kit of claim **1**, wherein the regional oximetry sensor comprises a plurality of light detectors configured to receive the light and to generate a respective plurality of signals based on the received light, and wherein the monitor is configured to receive the plurality of signals from the regional oximetry sensor and to select from among the plurality of signals the desired signals for analyzing the one or more characteristics.

7. The emergency resuscitation kit of claim **1**, wherein the monitor is configured to automatically detect application of the regional oximetry sensor on the patient.

8. The emergency resuscitation kit of claim **1**, wherein the one or more characteristics of the signal comprise a regional oxygen saturation value, a pulse amplitude, or a pulse rate, and wherein the analysis comprises comparing to a regional oxygen saturation threshold value, a pulse amplitude range, or a pulse rate range, respectively.

9. The emergency resuscitation kit of claim **8**, wherein the monitor is configured to adjust one or more of the regional oxygen saturation threshold value, the pulse amplitude range, or the pulse rate range based on a user input related to patient characteristics.

10. The emergency resuscitation kit of claim **8**, wherein the monitor is configured to adjust one or more of the regional oxygen saturation threshold value, the pulse amplitude range, or the pulse rate range based on predefined values associated with a patient population that corresponds to a sensor type of the regional oximetry sensor applied to the patient.

11. The emergency resuscitation kit of claim **1**, wherein the monitor is further configured to provide audible feedback to the person administering the CPR indicating whether the CPR needs to be adjusted.

12. The emergency resuscitation kit of claim **11**, wherein the one or more characteristics comprise a pulse rate of the patient, wherein the analysis comprises comparing the pulse rate to a pulse rate range, wherein the one or more components of the CPR comprise chest compressions, and wherein the audible feedback comprises a sound that indicates whether to adjust the chest compressions.

13. The emergency resuscitation kit of claim **12**, wherein the sound changes in pitch to indicate to the person to increase or decrease a rate of administration of the chest compressions.

14. A regional oximetry sensor configured to be applied to a patient for use during administration of cardiac pulmonary resuscitation (CPR) to the patient, comprising:

a light emitting element configured to emit light;

a light detector configured to receive the light and generate a signal based on the received light; and

a processing device configured to receive the signal from the light detector, to analyze one or more characteristics of the signal to determine if the CPR administered to the patient needs to be adjusted, and to communicate to a person administering the CPR to adjust one or more components of the CPR based on the analysis.

15. The sensor of claim **14**, wherein the processing device is configured to receive an input that the patient is receiving CPR, and wherein the regional oximetry sensor comprises an actuation device configured to receive the input.

16. The sensor of claim **15**, wherein the actuation device comprises a knob, switch, key, keypad, button, or touchscreen.

17. The sensor of claim **14**, wherein analyzing one or more characteristics of the signal comprises determining a regional oxygen saturation value based on the received signal, and wherein the processing device is configured to communicate to the person administering the CPR to adjust the one or more components of the CPR based on the regional oxygen saturation value.

18. The sensor of claim **17**, wherein analyzing one or more characteristics of the signal further comprises comparing the regional oxygen saturation value to a threshold value to determine if the regional oxygen saturation value is lower than the threshold value, and wherein the one or more components of the CPR comprise breaths or other means of artificial respiration administered during the CPR to the patient.

19. The sensor of claim **14**, wherein the one or more characteristics of the signal comprise a pulse amplitude of the signal, and wherein analyzing the one or more characteristics comprises comparing the pulse amplitude of the signal to a pulse amplitude range to determine if the pulse amplitude is within the pulse amplitude range, and wherein the one or more components of the CPR comprise chest compressions administered during the CPR to the patient.

20. The sensor of claim **14**, wherein the one or more characteristics of the signal comprise a pulse rate of the signal, and analyzing the one or more characteristics comprises comparing the pulse rate of the signal to a pulse rate range to determine if the pulse rate is within the pulse rate range, and

wherein the one or more components of the CPR comprise chest compressions administered during the CPR to the patient.

21. The sensor of claim **14**, wherein the processing device is configured to automatically detect application of the regional oximetry sensor on the patient.

22. The sensor of claim **14**, wherein the regional oximetry sensor comprises a display, and the processing device is configured to communicate to the person administering the CPR to adjust one or more components of the CPR via the display.

23. A regional oximetry monitor, comprising:

an interface for receiving a signal from a regional oximetry sensor applied to a patient receiving cardiac pulmonary resuscitation (CPR); and

a processing device configured analyze a pulse amplitude and a pulse rate of the signal to determine if the received CPR needs to be adjusted, and to communicate to a person administering the CPR to adjust the chest compressions administered during the CPR to the patient based on the pulse amplitude or pulse rate.

24. The monitor of claim **23**, wherein the processing device is configured to determine a regional oxygen saturation value based on the received signal and to communicate to the person administering the CPR to adjust breaths administered during the CPR to the patient if the regional oxygen saturation value is lower than a threshold value.

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专利名称(译)	用于紧急复苏的系统和方法		
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当前申请(专利权)人(译)	COVIDIEN LP		
[标]发明人	HAYMAN SARAH SILVEIRA PAULO E X ANDERSON JILL KLOMHAUS PINTO YU JUNG		
发明人	HAYMAN, SARAH SILVEIRA, PAULO E.X. ANDERSON, JILL KLOMHAUS PINTO, YU-JUNG		
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摘要(译)

根据各种实施例，区域血氧测定传感器可包括配置成发光的发光元件，配置成接收光并基于接收的光产生信号的光检测器。区域血氧测定传感器本身或与监视器结合，可以基于由区域血氧测定传感器产生的信号的一个或多个特征（例如，脉冲幅度或脉冲速率）来实现CPR对患者的管理中的调整。