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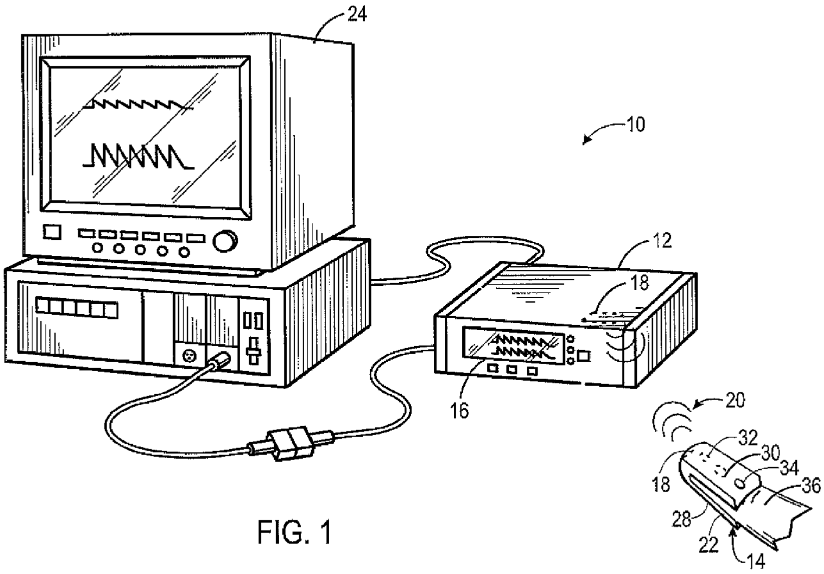

FIG. 1

(57) **Abstract**: Systems, methods, and devices for balancing power consumption and utility of medical sensors are provided. For example, a wireless medical sensor device may include a sensor, data processing circuitry, and wireless transmission circuitry. The sensor may be capable of obtaining a raw measurement from a patient, and the data processing circuitry may be capable of sampling the raw measurement to obtain values. Further, the data processing circuitry also may be capable of determining an update interval based at least in part on an update factor associated with a status of the patient, and the wireless transmission circuitry may be capable of wireless transmitting one of the values to an external wireless receiver at the update interval.

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SYSTEMS AND METHODS FOR BALANCING POWER CONSUMPTION AND UTILITY OF WIRELESS MEDICAL SENSORS

BACKGROUND

The present disclosure relates generally to medical sensors and, more particularly, to wireless medical sensors.

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.

Medical sensors are used in a variety of medical applications. For example, a plethysmographic sensor may provide such information as patient pulse rate, blood oxygen saturation, and/or total hemoglobin, or a respiration band may provide the respiration rate of a patient. Such medical sensors may communicate with a local patient monitor or a network using a communication cable. However, the use of communication cables may limit the range of applications available, as the cables may become prohibitively expensive at long distances and may physically tether a patient to a monitoring device, limiting patient range of motion. Though wireless medical sensors may transmit information without need of a communication cable, wireless medical sensors may employ large batteries that are cumbersome, uncomfortable to wear, and expensive.

SUMMARY

Certain aspects commensurate in scope with the originally claimed embodiments are set forth below. It should be understood that these aspects are presented merely to provide the reader with a brief summary of certain forms the embodiments might take and that these aspects are not intended to limit the scope of the presently disclosed subject matter. Indeed, the embodiments may encompass a variety of aspects that may not be set forth below.

Present embodiments relate to systems, methods, and devices for balancing power consumption and utility of medical sensors. For example, a wireless medical sensor device may include a sensor, data processing circuitry, and wireless transmission circuitry. The sensor may be capable of obtaining a raw measurement from a patient, and the data processing circuitry may be capable of sampling the raw measurement to obtain discrete values. Further, the data processing circuitry also may be capable of determining an update interval based at least in part on a predetermined update factor associated with a status of the patient, and the wireless transmission circuitry may be capable of wirelessly transmitting one of the discrete values to an external wireless receiver at the update interval.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of the presently disclosed subject matter may become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. 1 is a perspective view of a wireless medical sensor system, in accordance with an embodiment;

FIG. 2 is a block diagram of the system of **FIG. 1**, in accordance with an embodiment;

FIG. 3 is a flowchart describing an embodiment of a method for providing wireless medical sensor data using the system of **FIG. 1**, in accordance with an embodiment;

FIG. 4 is a schematic diagram of various factors that may be employed with the method of **FIG. 3**, in accordance with an embodiment;

FIG. 5 is a communication diagram schematically illustrating communication between a wireless medical sensor and a patient monitor of the system of **FIG. 1**, in accordance with an embodiment;

FIG. 6 is another communication diagram schematically illustrating communication between the wireless medical sensor and the patient monitor of the system of **FIG. 1**, in accordance with an embodiment;

FIG. 7 is a schematic diagram of parameters for controlling the system of **FIG. 1**, in accordance with an embodiment;

FIG. 8 is a flowchart describing an embodiment of a method for transmitting wireless sensor data at a context-based latency, in accordance with an embodiment;

FIG. 9 is a communication diagram illustrating communication between the wireless sensor and the patient monitor of the system of **FIG.1** while carrying out the method of **FIG. 8**, in accordance with an embodiment; and

FIG. 10 is a flowchart of an embodiment of a method for wirelessly transmitting medical data at a discrete context-based data transfer level, in accordance with an embodiment.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

One or more specific embodiments of the present disclosure 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.

Present embodiments may apply to a variety of wireless medical sensors, including photoplethysmographic sensors, temperature sensors, respiration bands, blood pressure sensors, ECG sensors, pulse transit time sensors, and so forth. Moreover, as disclosed herein, the particular data of interest that may be observed using a wireless medical sensor may similarly vary depending on the capabilities of each device. For example, a photoplethysmographic sensor may transmit data of interest that includes pulse rate, blood oxygen saturation, and/or total hemoglobin, and so forth. Because the embodiments presently disclosed may reduce the quantity of data to be transmitted wirelessly, the wireless medical sensors may expend less power and, accordingly, may employ smaller or less expensive batteries, which may be more comfortable to wear.

With the foregoing in mind, **FIG. 1** illustrates a perspective view of an embodiment of a wireless medical sensor system **10** that may efficiently transmit and/or receive medical sensor data, conserving power. Although the embodiment of the system **10** illustrated in **FIG. 1** relates to wireless photoplethysmography, 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 or alternatively, be configured to obtain a respiration rate, a patient temperature, an ECG, a blood pressure, and/or a pulse transit time, and so forth.

The system **10** may include a patient monitor **12** that communicates wirelessly with a wireless medical sensor **14**. The patient monitor **12** may include a display **16**, a wireless module **18** for transmitting and receiving wireless data, a memory, a processor, and various monitoring and control features. Based on sensor data received from the wireless medical sensor **14**, the patient monitor **12** may display patient measurements and perform various additional algorithms. For example, when the system **10** is configured for photoplethysmography, the patient monitor may perform pulse oximetry measurements, calculations, and control algorithms, based on the received wireless sensor data.

In the presently illustrated embodiment of the system **10**, the wireless medical sensor **14** is a photoplethysmographic sensor. As should be appreciated, however, the sensor **14** may be chosen to obtain any of a variety of medical measurements, such as a respiration rate, a patient temperature, an ECG, a blood pressure, and/or a pulse transit time, and so forth. Like the patient monitor **12**, the sensor **14** may also include a wireless module **18**. The wireless module **18** of the sensor **14** may establish wireless communication **20** with the wireless module **18** of the patient monitor **12** using any suitable protocol. By way of example, the wireless modules **18** may be capable of communicating using the IEEE 802.15.4 standard, and may be, for example, ZigBee, WirelessHART, or MiWi modules. Additionally or alternatively, the wireless modules **18** may be capable of communicating using the

Bluetooth standard or one or more of the IEEE 802.11 standards. As described further below, the wireless module **18** of the sensor **14** may transmit data of interest at an interval that depends on one or more factors relating to the context of its use. Thus, the wireless module **18** may not consume excessive power while the wireless medical sensor **14** provides medical data about a patient.

A sensor assembly or body **22** of the wireless medical sensor **14** may attach to patient tissue (e.g., a patient's finger, ear, forehead, or toe). In the illustrated embodiment, the sensor assembly **22** is configured to attach to a finger. The system **10** may also include a separate display feature **24** that is communicatively coupled with the patient monitor **12** to facilitate presentation of medical data, such as plethysmographic data. By way of example, the display feature **24** may display a plethysmogram, pulse oximetry information, non-invasive measurement of total hemoglobin, and/or related data.

The wireless medical sensor **14**, illustrated in the present embodiment as a photoplethysmographic sensor, may include an emitter **28** and a detector **30**. When attached to pulsatile tissue, the emitter **28** may transmit light at certain wavelengths into the tissue and the detector **30** may receive the light after it has passed through or is reflected by the tissue. The amount of light that passes through the tissue and other characteristics of light waves may vary in accordance with the changing amount of certain blood constituents in the tissue and the related light absorption and/or scattering. For example, the system **10** may emit light from two or more LEDs or other suitable light sources into the pulsatile tissue. The reflected or transmitted light may be detected with the detector **30**, such as a photodiode or photo-detector, after the light has passed through or has been reflected by the pulsatile tissue.

One or more additional medical sensors may also be present in the sensor **14**. In addition to the emitter **28** and the detector **30**, the sensor **14** may include an extraneous sensor **32** for monitoring a patient characteristic that may be extraneous to photoplethysmography. By way of example, the extraneous sensor **32** may include a temperature sensor to measure a current temperature at the pulsatile tissue site. This extraneous measurement may be used as a factor in determining a wireless data update rate, as discussed in greater detail below.

A button or switch **34** may enable a patient **36** or medical staff associated with the patient **36** to indicate an operating preference of the wireless medical sensor **14**. Such operating preferences may include a level of granularity of the medical data transferred, a request for raw photoplethysmographic data for a predetermined time, a change in the data of interest to be transferred, a preferred wavelength to be employed by the emitter **28**, and so forth. In one embodiment, the button or switch **34** may be a button that, when pressed, may instruct the sensor **14** that all raw data is to be transferred to the patient monitor **12**. In another embodiment, the button or switch **34** may be a switch with two or more settings to indicate that the data of interest is to be transferred at a discrete data transfer level (e.g., low, medium, or high). The selection of the button or switch **34** may also be used as a factor in determining the wireless data update rate of a measurement or sampling interval of a waveform, as discussed below.

FIG. 2 is a block diagram of an embodiment of the wireless medical sensor system **10** that may be configured to implement the techniques described herein. By way of example, embodiments of the system **10** may be implemented with any suitable medical sensor and patient monitor, such as those available from Nellcor Puritan Bennett LLC. The system **10** may include the patient monitor **12** and the sensor **14**, which may be configured to obtain, for example, a plethysmographic signal from patient tissue at certain predetermined wavelengths. The photoplethysmographic sensor **14** may be communicatively connected to the patient monitor **12** via wireless communication **20** (shown in **FIG. 1**). When the system **10** is operating, light from the emitter **28** may pass into the patient **36** and be scattered and detected by the detector **30**. The sensor **14** may include a microprocessor **38** connected to a bus **40**. Also connected to the bus **40** may be a RAM memory **42** and an optional ROM memory **44**. A time processing unit (TPU) **46** may provide timing control signals to light drive circuitry **48** which may control when the emitter **28** is illuminated, and if multiple light sources are used, the multiplexed timing for the different light sources. The TPU **46** may optionally also control the gating-in of signals from the detector **30** through an amplifier **50** and a switching circuit **52**. These signals may be sampled at the proper time, depending upon which of multiple light sources is illuminated, if multiple light sources are used. The received signal from the detector **30** may be passed through an amplifier **54**, a low pass filter **56**, and an analog-to-digital converter **58**.

The digital data may then be stored in a queued serial module (QSM) **60**, for later downloading to the RAM **42** as the QSM **60** fills up. Alternatively, the processor **38** may read the A/D converter after each sample, without the use of QSM **60**. In one embodiment, there may be multiple parallel paths of separate amplifier, filter and A/D converters for multiple light wavelengths or spectra received. This raw digital data may be further processed by the wireless medical sensor **14** into specific data of interest, such as pulse rate, blood oxygen saturation, and so forth. The data of interest may take up significantly less storage space than the raw data. For example, a raw 16-bit digital stream of photoplethysmographic data of between approximately 50 Hz or less to 2000 Hz or more (e.g., approximately 1211 Hz) may be sampled down to between approximately 10 Hz to 200 Hz (e.g., approximately 57.5 Hz), before being processed to obtain an instantaneous pulse rate at a given time, which may take up only approximately 8 bits.

In an embodiment, the sensor **14** may also contain an encoder **62** that provides signals indicative of the wavelength of one or more light sources of the emitter **28**, which may allow for selection of appropriate calibration coefficients for calculating a physiological parameter such as blood oxygen saturation. The encoder **62** may, for instance, be a coded resistor, EEPROM or other coding devices (such as a capacitor, inductor, PROM, RFID, parallel resonant circuits, or a colorimetric indicator) that may provide a signal to the processor **38** related to the characteristics of the photoplethysmographic sensor **14** that may allow the processor **38** to determine the appropriate calibration characteristics for the photoplethysmographic sensor **14**. Further, the encoder **62** may include encryption coding that prevents a disposable part of the photoplethysmographic sensor **14** from being recognized by a processor **38** that is not able to decode the encryption. For example, a detector/decoder **64** may be required to translate information from the encoder **62** before it can be properly handled by the processor **38**. In some embodiments, the encoder **62** and/or the detector/decoder **64** may not be present. Additionally or alternatively, the processor **38** may encode processed sensor data before transmission of the data to the patient monitor **12**.

In various embodiments, based at least in part upon the value of the received signals corresponding to the light received by detector **30**, the microprocessor **38** may calculate a physiological parameter of interest using various algorithms. These algorithms may utilize coefficients, which may be empirically determined, corresponding to, for example, the wavelengths of light used. These may be stored in the ROM **44** or in other nonvolatile memory **66** including flash or One-Time Programmable (OTP) memory. In a two-wavelength system, the particular set of coefficients chosen for any pair of wavelength spectra may be determined by the value indicated by the encoder **62** corresponding to a particular light source provided by the emitter **28**. For example, the first wavelength may be a wavelength that is highly sensitive to small quantities of deoxyhemoglobin in blood, and the second wavelength may be a complimentary wavelength. Specifically, for example, such wavelengths may be produced by orange, red, infrared, green, and/or yellow LEDs. Different wavelengths may be selected based on instructions from the patient monitor **12**, based preferences stored in a nonvolatile storage **66**, or depending on whether the button or switch **34** has been selected, as determined by the button or switch decoder **68** or automatically based on an algorithm executed by the processor **38**. The instructions from the patient monitor **12** may be transmitted wirelessly to the sensor **14** in the manner described below with reference to **FIG. 5**, and may be selected at the patient monitor **12** by a switch on the patient monitor **12**, a keyboard, or a port providing instructions from a remote host computer.

Nonvolatile memory **66** may store caregiver preferences, patient information, or various parameters, discussed below, which may be used in the operation of the sensor **14**. Software for performing the configuration of the sensor **14** and for carrying out the techniques described herein may also be stored on the nonvolatile memory **66**, or may be stored on the ROM **44**. The nonvolatile memory **66** and/or RAM **42** may also store historical values of various discrete medical data points. By way of example, the nonvolatile memory **66** and/or RAM **42** may store values of instantaneous pulse rate for every second or every heart beat of the most recent five minutes. These stored values may be used as factors in determining the wireless data update rate, as discussed in greater detail below.

A battery **70** may supply the wireless medical sensor **14** with operating power. By way of example, the battery **70** may be a rechargeable battery, such as a lithium ion or lithium polymer battery, or may be a single-use battery such as an alkaline or lithium battery. Due to the techniques described herein to reduce battery consumption, the battery **70** may be of a much lower capacity, and accordingly much smaller and/or cheaper, than a battery needed to power a similar wireless sensor that does not employ these techniques. A battery meter **72** may provide the expected remaining power of the battery **70** to the microprocessor **38**. The remaining battery life indicated by the battery meter **72** may be used as a factor in determining the wireless data update rate, as discussed in greater detail below.

The wireless medical sensor **14** may also include a movement sensor **74** that may sense when the patient **36** moves the sensor **14**. The movement sensor **74** may include, for example, a digital accelerometer that may indicate a state of motion of the patient **36**. Whether the patient is at rest or moving, as indicated by the movement sensor **74**, may also be used as a factor in determining the wireless data update rate, as discussed in greater detail below.

To conserve the amount of power used by the sensor **14**, the microprocessor **38** may vary the update rate at which data is transferred using the wireless module **18** to the patient monitor **12** using a variety of techniques, as described in greater detail below. The microprocessor **38** may carry out these techniques based on instructions stored in the RAM **42**, the ROM **44**, the nonvolatile memory **66**, or based on instructions received from the patient monitor **12**. Specifically, because the wireless module **18** may consume a substantial amount of power at times when a radio in the wireless module **18** is activated, the radio of the wireless module **18** may generally remain deactivated until data is to be transmitted. The microprocessor **38** may determine a portion of the total raw data that is obtained by the sensor **14** to be transmitted, as well as the specific times at which the portion of the data may be transmitted. During these times, the wireless module **18** may be temporarily activated. Because the wireless module **18** may only be in use at these specific times, less power may be consumed and the life of the battery **70** may be extended. In selecting which of the raw data to transmit and at which times, the microprocessor **38** may consider a variety of factors, including the significance of raw data currently being obtained from the patient **36** by the wireless medical sensor **14**. These various factors are described in greater detail below with reference to **FIG. 4**.

FIG. 3 is a flowchart describing an embodiment of a method for efficiently selecting and transmitting wireless data from the sensor **14** to the patient monitor **12**. The method described by the flowchart **74** may enable determination and transmission of a medically sufficient amount of data. Thus, the amount of data sent by the sensor **14** may be reduced as compared to simply transmitting all collected raw data. Accordingly, the amount of power consumed by the wireless module **18** may be reduced. Generally, the sensor **14** may transmit only certain data of interest (e.g., pulse rate, respiration rate, blood oxygen saturation, patient temperature, etc.) at determined intervals to the patient monitor **12**, rather than transmit a raw data stream. Based on various update factors, described below, the sensor **14** may increase or decrease the interval at which the data of interest are transmitted to the patient monitor **12**.

In a first step **76** of the flowchart **74**, the sensor **14** may receive a raw measurement stream, which may be processed by the microprocessor **38**. In certain embodiments, the sensor **14** may be a photoplethysmographic sensor configured to obtain a raw 16-bit digital stream of photoplethysmographic data sampled at between approximately 50 Hz or less to 2000 Hz or more (e.g., approximately 1211 Hz). After the data is sampled down to between approximately 10 Hz to 200 Hz (e.g., approximately 57.5 Hz), the microprocessor **38** may further parse the raw stream of data into discrete, meaningful points of data. For example, the microprocessor **38** may break a raw photoplethysmographic data stream into pulse rate, respiration rate data, blood oxygen saturation data, etc. Such discrete data may represent data of interest to be sent to the patient monitor **12**, or may be used as update factors in step **78**.

In step **78**, the microprocessor **38** of the sensor **14** may evaluate one or more update factors, which may represent various criteria for determining an appropriate quantity and rate of data to send to the patient monitor **12**. Any number of suitable update factors may considered, many of which may be described with reference to **FIG. 4** below. By way of example, in one embodiment, the microprocessor **38** may consider whether the data of interest (e.g., pulse rate, respiration rate, blood oxygen saturation, patient temperature, etc.) has remained stable over a recent historical period (e.g., 5 minutes) or whether any of the data of interest has changed beyond a predetermined threshold.

In step **80**, based on the evaluation of the update factors, the microprocessor **38** may determine an appropriate update interval at which to transmit the data of interest. The update interval may be relatively long if the update factors indicate that additional data would be largely superfluous, as may be the case if the patient **36** is very stable. By contrast, the update interval may be relatively short if the update factors indicate that additional data would be medically significant, as may be the case if the patient **36** experiences a rapid change, such as significantly increased or decreased pulse rate, respiration rate. In certain cases, the update interval may be determined to be so short that, rather than transmit only the data of interest to the patient monitor **12**, all raw data should be transmitted. The update interval may be any amount of time suitable to provide medically sufficient data to the patient monitor **12** as determined by the wireless medical sensor **14**, such as zero seconds (e.g., send raw data stream or a continuous stream of processed values) or periodically every 1 second, every few seconds, minutes, or hours as appropriate to the application. For example, the update interval may be approximately every 1 second, 2 seconds, 5 seconds, 10 seconds, 30 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 30 minutes, 1 hour, 2 hours, 5 hours, etc.

In step **82**, the microprocessor **38** may determine whether an amount of time equal to or greater than the determined update interval has passed since the data point of interest was last transmitted to the patient monitor **12**. If so, the microprocessor **38** may determine current values of the data of interest, which may then be transmitted wirelessly to the patient monitor **12**. Because the radio of the wireless module **18** may be activated only to transmit the data of interest at each update interval, the wireless module **18** may consume significantly less power when the update interval is comparatively long. In certain cases, if the update interval is determined to fall beneath a predetermined threshold (e.g., less than one second), the microprocessor **38** may instruct the wireless module **18** to transmit the stream of raw digital data for a predetermined period of time. Following step **82**, the process may return to step **76** and may repeat indefinitely.

As described above, the microprocessor **38** of the sensor **14** may evaluate a number of factors to determine the update interval. **FIG. 4** represents a schematic diagram **84** of many such update factors **86**. As should be appreciated, precisely which update factors **86** may be considered by the microprocessor **38** may be predetermined or may be selected by the microprocessor **38** based on the current condition of the patient **36** and/or the particular medical application for which the sensor **14** is being used.

One factor **88** of the update factors **86** may be the stability of the data of interest obtained by the sensor **14** for a recent historical period. As noted above, the sensor **14** may extract the data of interest (e.g., pulse rate, blood oxygen saturation, etc.) from a raw stream of data (e.g., a raw 16-bit digital stream of photoplethysmographic data sampled at between approximately 50 Hz or less to 2000 Hz or more (e.g., approximately 1211 Hz)). If the data of interest is within a predetermined variability threshold over a recent historical period (e.g., 5 minutes), the factor **88** may weigh in favor of a relatively longer update interval. If the data of interest varies beyond the predetermined variability threshold, the factor **88** may weigh in favor of a relatively shorter update interval. The factor **88** may trigger an immediate update when the data of interest is outside the expected variability, such as if a patient's heart rate suddenly changes from a range of 70 – 75 bpm to 120 bpm. In determining the update interval based at least in part on the factor **88**, the microprocessor **38** may further consider how much the data of interest has varied. For example, the greater the variability of the data of interest, the more the factor **88** may weigh in favor of a shorter update interval.

A second factor **90** of the update factors **86** may be an absolute value of the data of interest obtained by the sensor **14**. If the data of interest is within a predetermined acceptable range of values, the factor **90** may weigh in favor of a comparatively longer update interval. If the data of interest is higher or lower than the predetermined acceptable range of values, the factor **90** may weigh in favor of a comparatively shorter update interval. By way of example, if the data of interest includes a respiration rate, a predetermined acceptable range of values for an adult patient may be a range of 12 to 20 breaths per minute. A respiration rate less than 12 breaths per minute or greater than 20 breaths per minute may be evaluated by the microprocessor **38** as weighing in favor of a shorter update interval. In determining the update interval based at least in part on the factor **90**, the microprocessor **38** may further consider how much the absolute value of the data of interest varies beyond the predetermined acceptable range. For example, the more the data of interest varies from the predetermined acceptable range, the more the factor **90** may weigh in favor of a shorter update interval.

A third factor **92** of the update factors **86** may be the stability of extraneous sensor data or an absolute value of the extraneous sensor data. Extraneous sensor data may represent data not generally being transmitted as data of interest. By way of example, a current patient temperature may be extraneous sensor data when the data of interest is obtained from a photoplethysmographic measurement (e.g., pulse rate, blood oxygen saturation, etc.). Such extraneous sensor data may be obtained, for example, from an extraneous sensor **32** in the wireless medical sensor **14**. Like the factors **88** and/or **90**, if the extraneous sensor data exceeds a predetermined acceptable range of variability over a recent historical period, or if an absolute value of the extraneous sensor data exceeds a predetermined acceptable range of values, the factor **92** may weigh in favor of a shorter update interval. Similarly, if the extraneous sensor data remains within the predetermined acceptable range of variability over the recent historical period, or if the absolute value of the extraneous sensor data does not exceed the predetermined acceptable range of values, the factor **92** may weigh in favor of a longer update interval. By way of example, if the current patient temperature falls outside a predetermined acceptable range of values (e.g., a range of between 97.6 °F and 99.6 °F), the microprocessor **38** may interpret the factor **92** as weighing in favor of a shorter update interval for photoplethysmographic data of interest. Also like the factors **88** and/or **90**, in determining the update interval based at least in part on the factor **92**, the microprocessor **38** may further consider how much the extraneous sensor data has varied over time or how much the absolute value of the extraneous sensor data varies beyond the predetermined acceptable range. For example, the more the extraneous sensor data exceeds the predetermined acceptable range, the more the factor **92** may weigh in favor of a shorter update interval.

Express instructions received by the wireless medical sensor **14** from the patient monitor **12** may constitute a fourth factor **94** of the update factors **86**. As described below with reference to **FIG. 5**, in the course of wireless communication with the sensor **14**, the patient monitor **12** may transmit updates to sensor parameters in an acknowledgement, or ACK, packet. These sensor parameter updates from the patient monitor **12** may instruct the sensor **14** to send data at a particular interval, to send data in a continuous stream of raw data, or may provide other indications, such as a button press on the monitor **12**, which may be interrupted by the sensor **14** and used to determine the update interval. Certain parameters that may govern the operation of the wireless medical sensor **14** or that may weigh in favor of a shorter or longer update interval are described in greater detail below with reference to **FIG. 7**. To provide one example, by pressing a button on the patient monitor **12**, medical personnel may cause the patient monitor **12** to instruct the wireless medical sensor **14** to transmit the raw stream of data.

A fifth factor **96** of the update factors **86** may be a press of the button or switch **34** on the wireless medical sensor **14**. If the button or switch **34** is a single button and the button is pressed, the factor **96** may weigh in favor of a shorter update interval. Similarly, if the button or switch **34** is a switch with two or more settings (e.g., low, medium, high, etc.), the setting to which the button or switch **34** has been moved may correspondingly weigh in favor of shorter or longer update intervals, as appropriate. For example, because pressing the button or switch **34** may cause the factor **96** to weigh in favor of a shorter update interval, pressing the button or switch **34** may result in the transmission of the raw data stream from the sensor **14** to the patient monitor.

A sixth factor **98** of the update factors **86** may be the current location of the patient **36**, which may be supplied to the wireless medical sensor **14** via parameter updates from the patient monitor **12**. Because the amount of data from the wireless medical sensor **14** that should be supplied to the patient monitor **12** may vary depending on whether the patient **36** is in surgery, in recovery, or undergoing other tests, the current location of the patient **36** may be considered as one of the update factors **86**. Thus, if the patient **36** is currently located in a medical facility room where the patient **36** should be kept under especially close scrutiny, such as an operating room, the factor **98** may weigh in favor of a correspondingly shorter update interval. If the patient **36** is currently located in a medical facility room where the patient **36** may be kept under less scrutiny, such as a recovery room, the factor **98** may weigh in favor of a longer update interval. In determining the update interval based at least in part on the factor **98**, the microprocessor **38** may give different locations different weights in favor of a shorter or longer update interval. For example, if the current location is a testing room, such as a CT room, or an operating room, the factor **98** may weigh in favor of a comparatively shorter update interval. However, the factor **98** may weigh more heavily in favor of a shorter update interval if the current location of the patient **36** is the operating room. Similarly, the sensor **14** may be instructed to stop transmitting data or use a very long update internal if the patient **36** is located in close proximity to an instrument which is sensitive to wireless interference. In such a case, if the sensor **14** includes frequency hopping capabilities, the sensor **14** may select an alternate frequency or channel which does not interfere with nearby equipment or sensors located on other patients. In this way, data from a critically ill patient or patient in the operating room may be prioritized higher than patients who are relatively stable.

A seventh factor **100** of the update factors **86** may be the presence or the absence of a clinician proximate to the patient **36**, which may be supplied to the wireless medical sensor **14** via parameter updates from the patient monitor **12**. For example, if a clinician enters a room where the patient **36** is currently located, the factor **100** may weigh in favor of a comparatively shorter update interval. If the clinician exits the room, the factor **100** may weigh in favor of a comparatively longer update interval. In determining the update interval based at least in part on the factor **100**, the microprocessor **38** may weigh the factor **100** more heavily in favor of a shorter or longer update interval based on the number or patient assignment of clinicians present. For example, if a clinician that is not assigned to the patient **36** enters a room where the patient **36** is currently located, the factor **100** may not weigh as heavily in favor of a shorter update interval as when a clinician that is assigned to the patient **36** enters the room.

An eighth factor **102** of the update factors **86** may be the movement of the patient **36**, which may be indicated to the wireless medical sensor **14** via parameter updates from the patient monitor **12** or via the movement sensor **74**. If the patient **36** is currently moving, indicating that the patient **36** is not at rest or is being moved from one room to another, the factor **102** may weigh in favor of a comparatively shorter update interval. If the patient **36** is not currently moving, the factor **102** may weigh in favor of a comparatively longer update interval. Additionally, the amount of current patient movement may further affect the weight of the factor **102** in favor of a comparatively shorter or longer update interval. In another example, transmission of the heart rate of the patient **36** may be suppressed if an accelerometer of the movement sensor **74** detects excessive motion artifact and the calculated heart rate is less likely to be accurate than a previous value.

A ninth factor **104** of the update factors **86** may be an initialization status of the sensor **14**. For a predetermined period of time while the sensor is being initialized (e.g., 5 minutes), the update rate of the sensor **14** may be temporarily increased dramatically, such that the raw data stream is supplied to the patient monitor **12**. By supplying a raw data stream during the initialization of the sensor **14**, a clinician for other medical personnel may properly fit the sensor **14** to the patient **36**. In this way, the factor **104** may weigh very heavily in favor of a shorter update interval when the sensor **14** has recently been activated.

A tenth factor **106** of the update factors **86** may be a battery life of the wireless medical sensor **14**. If the battery **70** of the sensor **14** has more than a predetermined amount of remaining battery life, the factor **106** may weigh in favor of a comparatively shorter update interval. If the battery **70** has less than the predetermined amount of remaining battery life, the factor **106** may weigh in favor of a comparatively longer update interval. This factor **106** may also account for the transmit power required to send error-free data at the last update. For instance, when the patient **36** is relatively far from the receiver, more transmit power may be required, so less frequent updates may take place, especially at lower battery **70** reserves.

FIG. 5 is a schematic communication diagram **108** describing communication between the wireless medical sensor **14** and the patient monitor **12**. As shown in the communication diagram **108**, communication between the wireless medical sensor **14** and the patient monitor **12** may begin once the sensor **14** has obtained **110** the raw data stream and has evaluated **112** the one or more update factors **86**. Having determined the update interval based on the evaluation **112** of the update factors **86**, the sensor **14** may begin the process of transmitting the data of interest at the start of the next update interval.

Transmission of the data of interest from the sensor **14** to the patient monitor **12** may begin at the start of an update interval when the sensor **14** activates **114** a radio of the wireless module **18**. The sensor **14** may concurrently or subsequently sample **116** the current data of interest (e.g., pulse rate, blood oxygen saturation, etc.) from the raw data stream (e.g., a raw 16-bit digital stream of photoplethysmographic data sampled at 100 Hz). The sampled data of interest may be a much smaller quantity of data than the raw data stream, and may be, for example, a single 8-bit value. Additionally or alternatively, the sensor **14** may sample **116** the current data of interest from the raw data stream, optionally process the data, and packetize the data for transmission prior to powering up the radio of the wireless module **18**. Doing so may minimize the amount of time the radio of the wireless module **18** is active.

Thereafter, the wireless medical sensor **14** may wirelessly transmit **118** the data of interest to the patient monitor **12**. In addition to the data of interest, the sensor **14** may also transmit **118** other information regarding the sensor **14** status, such as remaining battery life. If reliable delivery is needed, the patient monitor **12** may reply **120** with a wireless acknowledgment packet, or ACK, which may also include one or more sensor parameter updates. The data contained in the parameter update of the ACK packet may instruct the sensor **14** to operate in a particular way, or may convey information regarding the update factors **86**, as described above.

Including the information part of the ACK packet may generally mean that the sensor **14** does not have to power a receiver of the wireless module **18** at other times.

Following the transmission **118** of the data of interest and optional reply **120** from the patient monitor **12**, the sensor **14** may deactivate **122** the radio of the wireless module **18**. Depending on the selected protocol, the sensor **14** may power up the transmitter of the wireless module **18** one more time to ACK any new instructions from the patient monitor **12**. For the remainder of the update interval, the wireless module **18** may consume only a minimal amount of power. Because the wireless module **18** does not continually consume power, the battery **70** of the sensor **14** may provide power for a longer amount of time or may be smaller than those of comparable sensors that do not perform the techniques disclosed herein. Until circumstances change, and the update factors indicate a different update interval, the data of interest may continue to be transmitted at the update interval, which may start again when the radio of the wireless module is again activated **124**.

FIG. 6 is another schematic communication diagram **126** describing communication between the wireless medical sensor **14** and the patient monitor **12**, which may take place when the update factors **86** indicate that the raw data stream should be transmitted in its entirety. As shown in the communication diagram **126**, communication between the wireless medical sensor **14** and the patient monitor **12** may begin once the sensor **14** has obtained **128** the raw data stream and has evaluated **130** the one or more update factors **86**. Having determined that the update interval based on the evaluation **130** indicates that the raw data stream should be transmitted, the sensor **14** may begin the process of transmitting the raw data stream without waiting for the start of an update interval.

Transmission of the raw data stream from the sensor **14** to the patient monitor **12** may begin when the sensor **14** activates **132** a radio of the wireless module **18**. Thereafter, the wireless medical sensor **14** may wirelessly stream **134** the raw data to the patient monitor **12**. Communication during the streaming **134** of the raw data may include various replies from the patient monitor **12**. After a predetermined time, the sensor **14** may deactivate **136** the radio of the wireless module **18**, and the process may repeat until circumstances change and the update interval is increased. As noted below with reference to **FIGS. 8** and **9**, if latency can be tolerated, it may be more efficient to queue several raw samples and power up the radio of the wireless module **18** only periodically. For example, the sensor **12** may queue 100 ms to 1 minute of raw data before powering on the radio of the wireless module **18** for only a few hundred milliseconds to transmit the data.

As described above, the operation of the wireless medical sensor **14** may be governed by various sensor parameters. These sensor parameters may be occasionally updated by the patient monitor **12** via parameter updates in an acknowledgement packet, or ACK, as described above with reference to **FIG. 5**. **FIG. 7** is a diagram **138** that describes many such sensor parameters **140**.

A first parameter **142** of the sensor parameters **140** may be a specified update interval. The parameter **142** may predetermine the update interval at which the sensor **14** transmits the data of interest to the patient monitor **12**. If the parameter **142** sets a specific update interval, the parameter **142** may override the update interval determination that the sensor **14** may generally undertake, and the sensor **14** may employ the specified update interval.

A second parameter **144** of the sensor parameters **140** may be an indication to the sensor **14** that the raw data stream should be transmitted to the patient monitor **12** immediately. By way of example, a clinician may press a button on the patient monitor **12**, and the patient monitor **12** may indicate via parameter updates in the next ACK packet that the raw data stream is desired. Thus, upon receiving parameter updates with such an update to the parameter **144**, the wireless medical sensor **14** may begin to transmit the raw data stream to the patient monitor **12**.

A third parameter **146** of the sensor parameters **140** may be a specification that raw data should be sent at specific predetermined intervals and for specific durations. For example, the parameter **146** may specify that the raw data stream is to be sent every hour for one minute. Thus, the parameter **146** may instruct the sensor **14** to supplement the data of interest with the raw data.

A fourth parameter **148** of the sensor parameters **140** may be a specification of the predetermined variability threshold or the predetermined range of acceptable values, as may be employed by the update factors **88-92**. A fifth parameter **150** of the sensor parameters **140** may be a specification of the data of interest. For example, the parameter **150** may specify that the data of interest is pulse rate and/or blood oxygen saturation when the raw data is a photoplethysmographic data stream.

The sensor parameters **140** illustrated in the diagram **138** are intended to be exemplary and not exclusive. As such, it should be understood that the sensor parameters **140** may further include other data that may enable the wireless medical sensor **14** to effectively carry out the techniques disclosed herein. For example, the sensor parameters **140** may also include other data that indicate, for example, a current patient location or a current clinician location, which may be employed to weigh various update factors **86**.

FIG. 8 is a flowchart **152** of another embodiment of a method for efficiently selecting and transmitting wireless data from the sensor **14** to the patient monitor **12**. The method described by the flowchart **152** may enable determination and transmission of a medically sufficient amount of information by sampling the data of interest (e.g., pulse rate, respiration rate, blood oxygen saturation, patient temperature, etc.) at a sampling interval and thereafter transmitting the sampled data at a determined latency. Thus, the amount of data sent by the sensor **14** may be reduced, particularly as compared to simply transmitting all collected raw data, and the amount of power consumed by the wireless module **18** may be correspondingly reduced. Based on the various update factors, described in greater detail above, the sensor **14** may increase or decrease the sampling interval and/or latency that the data of interest are transmitted to the patient monitor **12**.

In a first step **154** of the flowchart **156**, the sensor **14** may receive a raw measurement stream, which may be processed by the microprocessor **38**. For example, in certain embodiments, the sensor **14** may be a photoplethysmographic sensor configured to obtain a raw 16-bit digital stream of photoplethysmographic data sampled at between approximately 50 Hz or less to 2000 Hz or more (e.g., approximately 1211 Hz). After the data is sampled down to between approximately

10 Hz to 200 Hz (e.g., approximately 57.5 Hz), the microprocessor **38** may further parse the raw stream of data into discrete, meaningful points of data. For example, the microprocessor **38** may break a raw photoplethysmographic data stream into pulse rate data, blood oxygen saturation data, etc. Such discrete data may represent data of interest to be sent to the patient monitor **12** or data for use in evaluating the update factors **86** in step **156**.

In step **156**, the microprocessor **38** of the sensor **14** may evaluate one or more update factors **86**, which may represent various criteria for determining an appropriate quantity and rate of data to send to the patient monitor **12**. Any number of suitable update factors may considered, many of which may be described with reference to **FIG. 4** above. By way of example, in one embodiment, the microprocessor **38** may consider whether the data of interest (e.g., pulse rate, respiration rate, blood oxygen saturation, patient temperature, etc.) has remained stable over a recent historical period (e.g., 5 minutes) or whether any of the data of interest has changed beyond a predetermined threshold.

In step **158**, based on the evaluation of the update factors **86** of step **156**, the microprocessor **38** may determine an appropriate sampling rate and latency at which to transmit the data of interest. The sampling rate and/or the latency may be relatively fast if the update factors **86** indicate that additional data would be medically significant, as may be the case if the patient **36** experiences a rapid change, such as significantly increased or decreased pulse rate, respiration rate, etc. By contrast, the sampling rate and/or the latency may be relatively slow if the update factors **86** indicate that additional data would be largely superfluous, as may be the case if the patient **36** is very stable. In certain cases, the sampling rate and/or the latency may be determined to be so fast that, rather than transmit only the data of interest to the patient monitor **12** at a given latency, all raw data should be transmitted immediately. The latency may be similar to the update interval, in that the latency may include any amount of time suitable to provide medically sufficient data to the patient monitor **12** as determined by the wireless medical sensor **14**, such as zero seconds (e.g., send raw data stream or a continuous stream of processed values) or periodically every 1 second, every few seconds, minutes, or hours as appropriate to the application. By way of example, the latency may be 1 second, 2 seconds, 5 seconds, 10 seconds, 30 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 30 minutes, 1 hour, 2 hours, 5 hours, etc.

In step **160**, the microprocessor **38** may continually sample the data of interest at the sampling rate determined in step **158**. The sampled data may be stored in the RAM **42** or nonvolatile memory **66**. The microprocessor **38** may also determine whether an amount of time equal to or greater than the determined latency has passed since the sampled data of interest were last transmitted to the patient monitor **12**. If so, the microprocessor **38** may cause the sampled data of interest stored in the RAM **42** or the nonvolatile memory **66** to be transmitted wirelessly to the patient monitor **12**. Because the radio of the wireless module **18** may be activated only to transmit the sampled data of interest at the determined latency, the wireless module **18** may consume significantly less power when the latency is comparatively long. In certain cases, if the latency is determined to fall beneath a predetermined threshold (e.g., less than one second), the microprocessor **38** may instruct the wireless module **18** to transmit the stream of raw digital data for a predetermined period of time. Following step **160**, the process may return to step **154** and may repeat indefinitely.

FIG. 9 is another schematic communication diagram **162** describing communication between the wireless medical sensor **14** and the patient monitor **12**. The communication described by the flowchart **162** may describe determination and transmission of a medically sufficient amount of data by sampling the data of interest (e.g., pulse rate, respiration rate, blood oxygen saturation, patient temperature, etc.) at a sampling interval and transmitting the sampled data at a determined latency. As shown in the communication diagram **162**, communication between the wireless medical sensor **14** and the patient monitor **12** may begin once the sensor **14** has obtained **164** the raw data stream and has evaluated **166** the one or more update factors **86**. Having determined the sampling rate and/or the latency based on the evaluation **166** of the update factors **86**, the sensor **14** may obtain multiple samples **168** of the data of interest at the determined sampling rate until the start of the next latency interval.

Transmission of the data of interest from the sensor **14** to the patient monitor **12** may begin when the determined latency has been reached and the sensor **14** activates **170** a radio of the wireless module **18**. The sensor **14** may wirelessly transmit **172** the multiple samples of the data of interest to the patient monitor **12**. In addition to the data of interest, the sensor **14** may also transmit **172** other information regarding the sensor **14** status, such as remaining battery life. The patient monitor **12** may reply **174** with a wireless acknowledgment packet, or ACK, which may also include one or more sensor parameter updates. The data contained in the parameter update of the ACK packet may instruct the sensor **14** to operate in a particular way, or may convey information regarding the update factors **86**, as described above.

Following the transmission **172** of the multiple samples of the data of interest and the reply **174** from the patient monitor **12**, the sensor **14** may deactivate **176** the radio of the wireless module **18**. For the remainder of the latency interval, the wireless module **18** may consume only a minimal amount of power and the microprocessor **38** may continue to evaluate the update factors **86** and obtain multiple samples **178** of the data of interest. Because the wireless module **18** does not continually consume power, the battery **70** of the sensor **14** may provide power for a longer amount of time or may be smaller than those of comparable sensors that do not perform the techniques disclosed herein. Until circumstances change, and the update factors **86** indicate a different sampling rate and/or latency, the multiple samples of the data of interest may continue to be transmitted at the latency, which may start again when the radio of the wireless module is again activated **180**.

FIG. 10 depicts a flowchart **182** describing an embodiment of a method for transmitting data at discrete levels. In a first step **184**, the sensor **14** may collect the stream of raw measurement data from the patient **36**. In a step **186**, various factors, such as the update factors **86** described above with reference to **FIG. 4**, may be evaluated by the sensor **14**. Based on the factors evaluated in step **186**, the sensor **14** may determine a discrete data rate transmission level in step **188**. In the embodiment of the flowchart **182**, the sensor **14** may select between three predetermined discrete data rate levels of “low,” “medium,” and “high.” Any suitable number of discrete data rate levels may be defined, and the number of discrete data rate levels may vary depending on the various update factors **86** considered in step **186**.

In a subsequent decision **190**, if the discrete data rate level is "high," the sensor **14** may, in step **192**, transmit the stream of raw measurement to the patient monitor **12** for a predetermined time. After the predetermined time has passed, step **192** may end and the process may flow to a decision **194**, at which the sensor **14** may evaluate whether circumstances informing the update factors **86** have changed. If circumstances remain the same, the process may return to the decision **190**, where, because the data rate level remains set to "high," the process may return to step **192**.

Returning to the decision **194**, if circumstances have changed, the update factors **86** may be evaluated again in step **186**, and a new data rate level may be determined in step **188**. If the data rate level is not "high," as determined in the decision **190**, the process may flow to a decision **196**. If the data rate level is "medium," the sensor **14** may transmit a sample of the data of interest at a medium update interval for a predetermined time. By way of example, the sensor **14** may transmit pulse rate measurements once every five seconds for one minute. After the predetermined time has passed, the process may flow to the decision **194** for reevaluation of circumstances.

Returning to the decision block **196**, if the data rate level is not "medium," and thus, is "low," step **200** may take place. In step **200**, the sensor **14** may transmit the data of interest at a low update rate for a predetermined period of time. For example, the sensor **14** may transmit pulse rate data once every thirty seconds for 5 minutes. Following the predetermined time, the circumstances may be reevaluated in the decision **194**.

While the embodiments set forth in the present 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 disclosure is not intended to be limited to the particular forms disclosed. The disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the following appended claims.

CLAIMS

What is claimed is:

1. A medical device comprising:

a medical sensor capable of obtaining a raw measurement from a patient;

data processing circuitry capable of sampling the raw measurement to obtain a plurality of values and capable of determining an update interval based at least in part on an update factor associated with a status of the patient; and

wireless transmission circuitry capable of wirelessly transmitting one of the plurality of values to an external wireless receiver at the update interval.

2. The device of claim 1, wherein the medical sensor comprises a photoplethysmographic sensor; a respirator band; a temperature sensor; a blood pressure sensor; an ECG sensor; or a pulse transit time sensor; or any combination thereof.

3. The device of claim 1, wherein the data processing circuitry is capable of determining the update interval based at least in part on the update factor associated with the status of the patient, wherein the update factor comprises a historical stability of the plurality of values; an absolute value of one of the plurality of values; a historical stability of a plurality of extraneous sensor values obtained from an extraneous medical sensor; an absolute value of an extraneous sensor value obtained from the extraneous medical sensor; an instruction from an external device; a button press or switch setting on the medical device; a current location of the patient; a current location of a clinician; a movement of the patient; an initialization status of the medical device; or a remaining battery life of the medical device; or any combination thereof.

4. The device of claim 1, comprising a button, wherein the wireless transmission circuitry is capable of transmitting the raw measurement to the external wireless receiver when the button is pressed.

5. The device of claim 1, comprising another medical sensor capable of obtaining another raw measurement of the patient, wherein the data processing circuitry is capable of sampling the other raw measurement to obtain a plurality of other values, wherein the data processing circuitry is capable of determining the update interval based at least in part on the update factor, and wherein the update factor comprises a historical stability of the plurality of other values or an absolute value of one of the plurality of extraneous sensor values.

6. The device of claim 1, wherein the wireless transmission circuitry is capable of transmitting the raw measurement to the external wireless receiver for a period of time when the determined update interval is beneath a threshold.

7. The device of claim 1, wherein the wireless transmission circuitry is capable transmitting a portion of the plurality of values to the external wireless receiver at the update interval.

8. The device of claim 1, comprising a memory device capable of storing at least a portion of the plurality of values, wherein the portion of the plurality of values have been obtained at an approximately constant sampling rate.

9. A method comprising:

obtaining, using a medical sensor, a raw measurement from a patient;

determining, using a processor, an update interval based at least in part on at least one update factor associated with a status of the patient; and

transmitting, using a wireless radio physically coupled to the medical sensor, a value obtained from the raw measurement to an external wireless receiver at the update interval.

10. The method of claim 9, wherein the obtained raw measurement comprises a pulse rate; a blood pressure saturation; a measure of total hemoglobin; a respiration rate; a temperature; an ECG; a blood pressure; or a pulse transit time; or any combination thereof.

11. The method of claim 9, wherein determining the update interval based at least in part on the at least one update factor associated with a status of the patient comprises evaluating the at least one update factor, wherein the at least one update factor comprises a historical stability of a plurality of values obtained from the raw measurement; an absolute value of one of the plurality of values; a historical stability of a plurality of extraneous sensor values obtained from an extraneous medical sensor; an absolute value of an extraneous sensor value obtained from the extraneous medical sensor; an instruction from an external device; a selection of a button or switch physically coupled to medical sensor; a current location of the patient; a current location of a clinician; a movement of the patient; an initialization status of the medical sensor; or a remaining battery life of a battery physically coupled to the medical sensor; or any combination thereof.

12. The method of claim 9, wherein the value is transmitted at the update interval only when the update interval is above a threshold.

13. The method of claim 12, comprising transmitting the raw measurement when the update interval is below a threshold.

14. The method of claim 9, comprising receiving an acknowledgement from the external wireless receiver, wherein the acknowledgement comprises data associated with the status of the patient.

15. A system comprising:

an electronic patient monitor capable of wirelessly receiving a measurement of a patient; and

a wireless medical sensor capable of obtaining a raw measurement from the patient, determining an update interval based at least in part on an update factor associated with a status of the patient, and wirelessly transmitting a value obtained from the raw measurement to the electronic patient monitor at the update interval.

16. The system of claim 15, wherein the electronic patient monitor is capable of wirelessly transmitting instructions to the wireless medical sensor.

17. The system of claim 15, wherein the electronic patient monitor is capable of wirelessly transmitting at least one sensor operating parameter to the wireless medical sensor.

18. The system of claim 15, wherein the wireless medical sensor is capable of determining the update interval based at least in part on a sensor operating parameter, wherein the operating parameter comprises a specified update interval; a specified indication that the raw data is to be transmitted immediately; a specified variability threshold of values obtained from the raw measurement; a specified range of acceptable values obtained from the raw measurement; a specified type of the value to be obtained from the raw measurement; a current location of the patient; a current location of a clinician; or any combination thereof.

19. The system of claim 15, wherein the wireless medical sensor is capable of wirelessly transmitting the raw measurement at a second update interval.

20. The system of claim 19, wherein the second update interval is defined by a sensor operating parameter.

21. The method of claim 15, wherein the wireless medical sensor is capable of wirelessly transmitting a remaining battery life of the wireless medical sensor to the electronic patient monitor when the value is transmitted.

22. A method comprising:

obtaining, using a medical sensor, a raw measurement from a patient;

determining, using a processor physically coupled to the medical sensor, a data rate level based at least in part on an update factor associated with a status of the patient; and

transmitting, using a wireless radio physically coupled to the medical sensor, a value obtained from the raw measurement to an external wireless receiver at an update interval, wherein the update interval is a value associated with the data rate level.

23. The method of claim 22, wherein determining the data rate level comprises selecting one of a plurality of levels.

24. The method of claim 22, wherein transmitting the value comprises transmitting, one at a time for a period of time, a plurality of values obtained from the raw measurement to the external wireless receiver at the update interval.

25. The method of claim 24, wherein the period of time is a value associated with the data rate level.

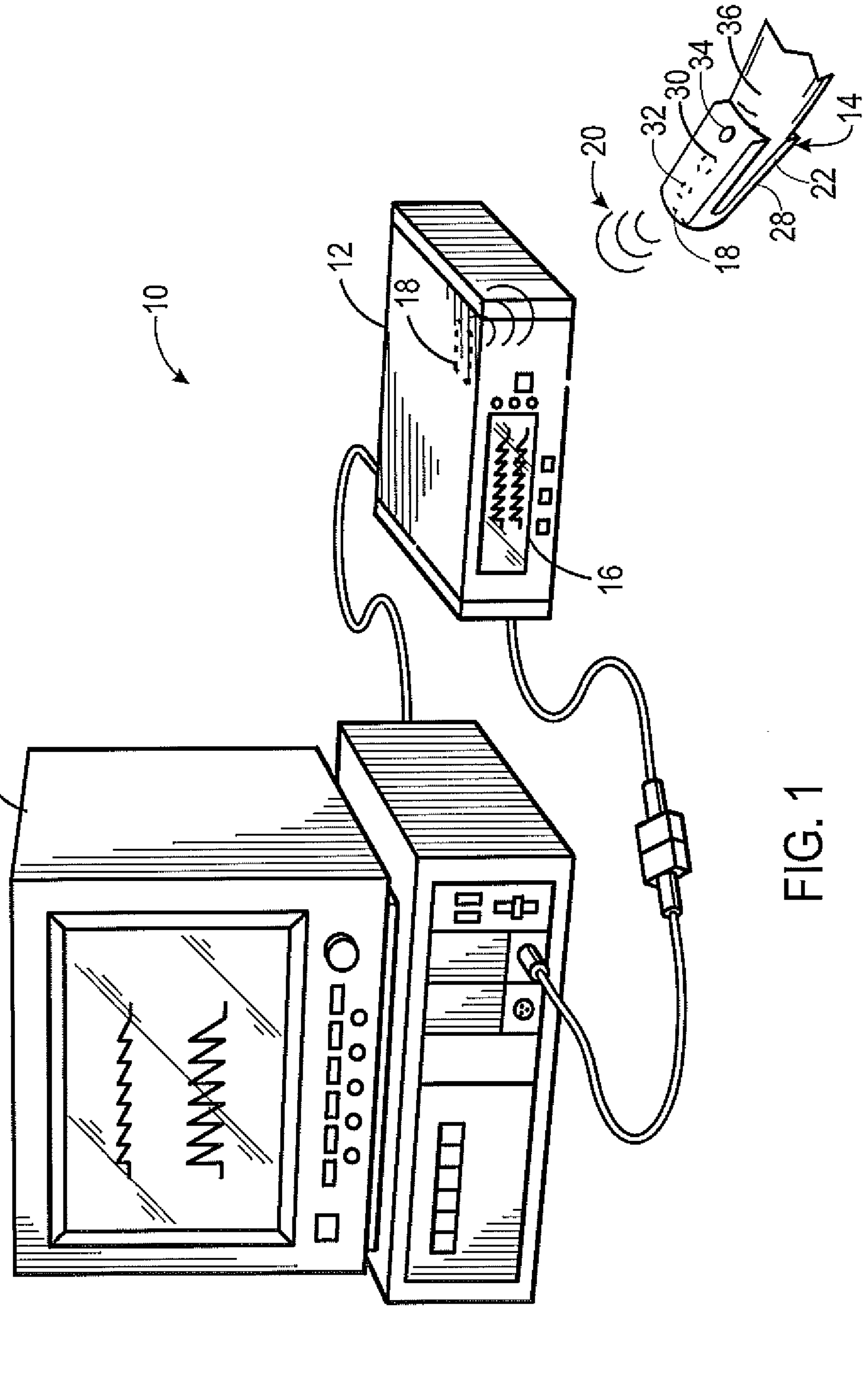


FIG. 1

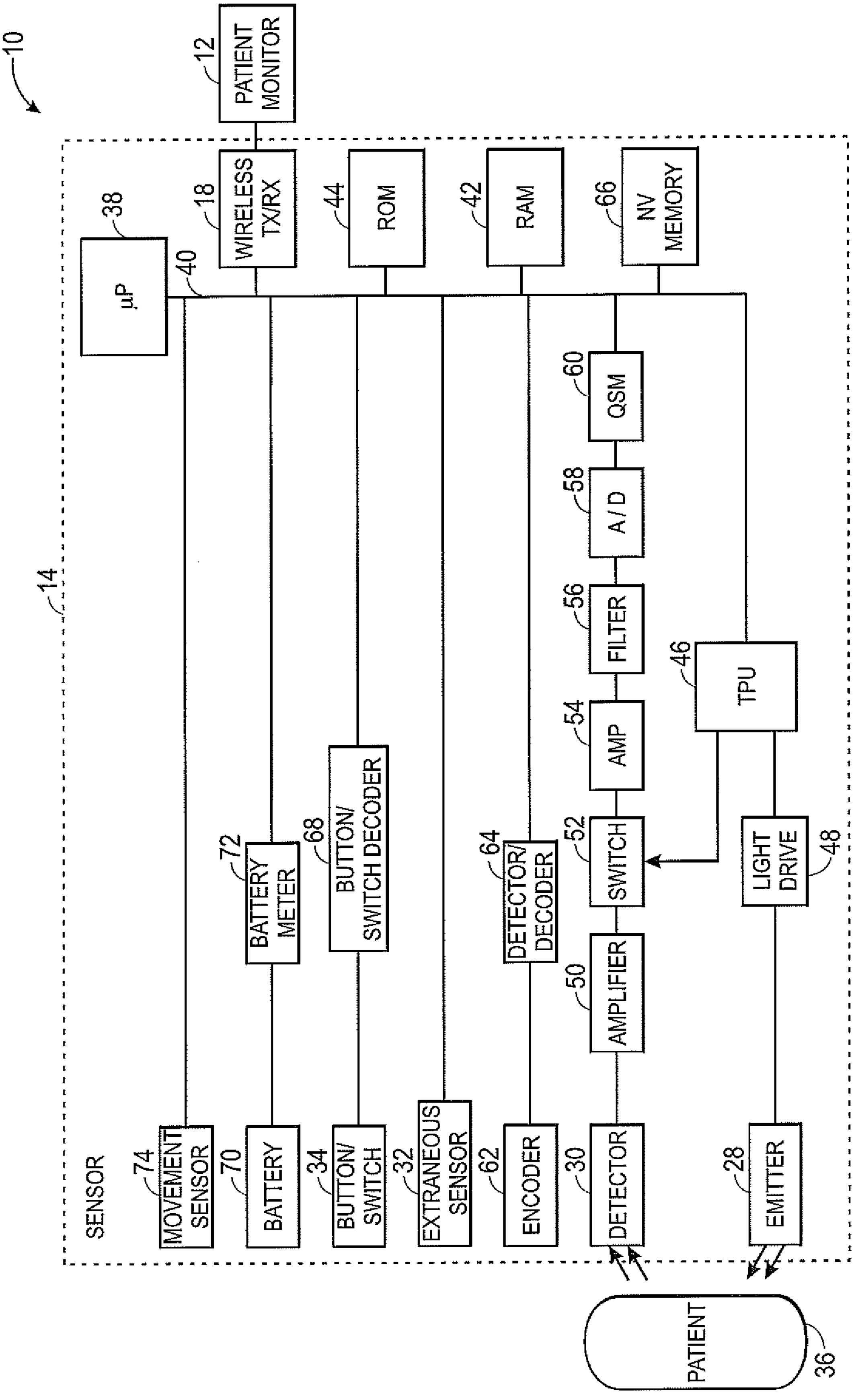

10
12
PATIENT MONITOR
14
SENSOR
18
WIRELESS TX/RX
38
µP
40
44
ROM
42
RAM
66
NV MEMORY
60
QSM
58
A / D
56
FILTER
46
TPU
54
AMP
52
SWITCH
48
LIGHT DRIVE
50
AMPLIFIER
72
BATTERY METER
68
BUTTON/ SWITCH DECODER
64
DETECTOR/ DECODER
74
MOVEMENT SENSOR
70
BATTERY
34
BUTTON/ SWITCH
32
EXTRANEOUS SENSOR
62
ENCODER
30
DETECTOR
28
EMITTER
PATIENT
36

FIG. 2

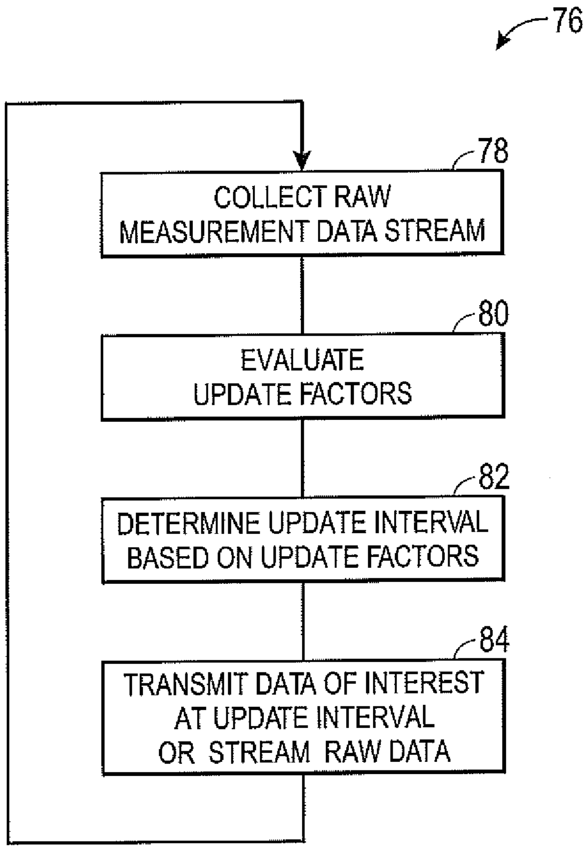

76
78
COLLECT RAW MEASUREMENT DATA STREAM
80
EVALUATE UPDATE FACTORS
82
DETERMINE UPDATE INTERVAL BASED ON UPDATE FACTORS
84
TRANSMIT DATA OF INTEREST AT UPDATE INTERVAL OR STREAM RAW DATA

FIG. 3

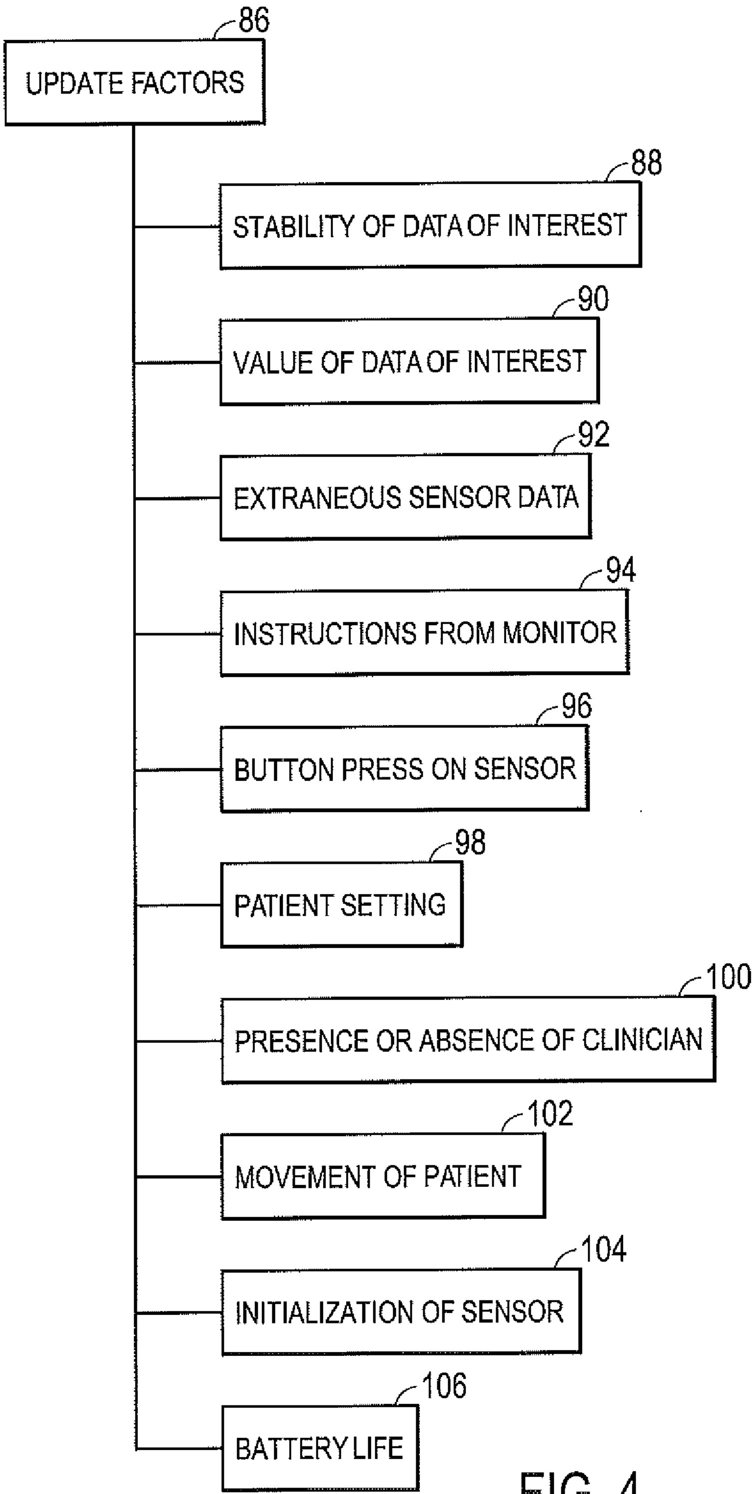
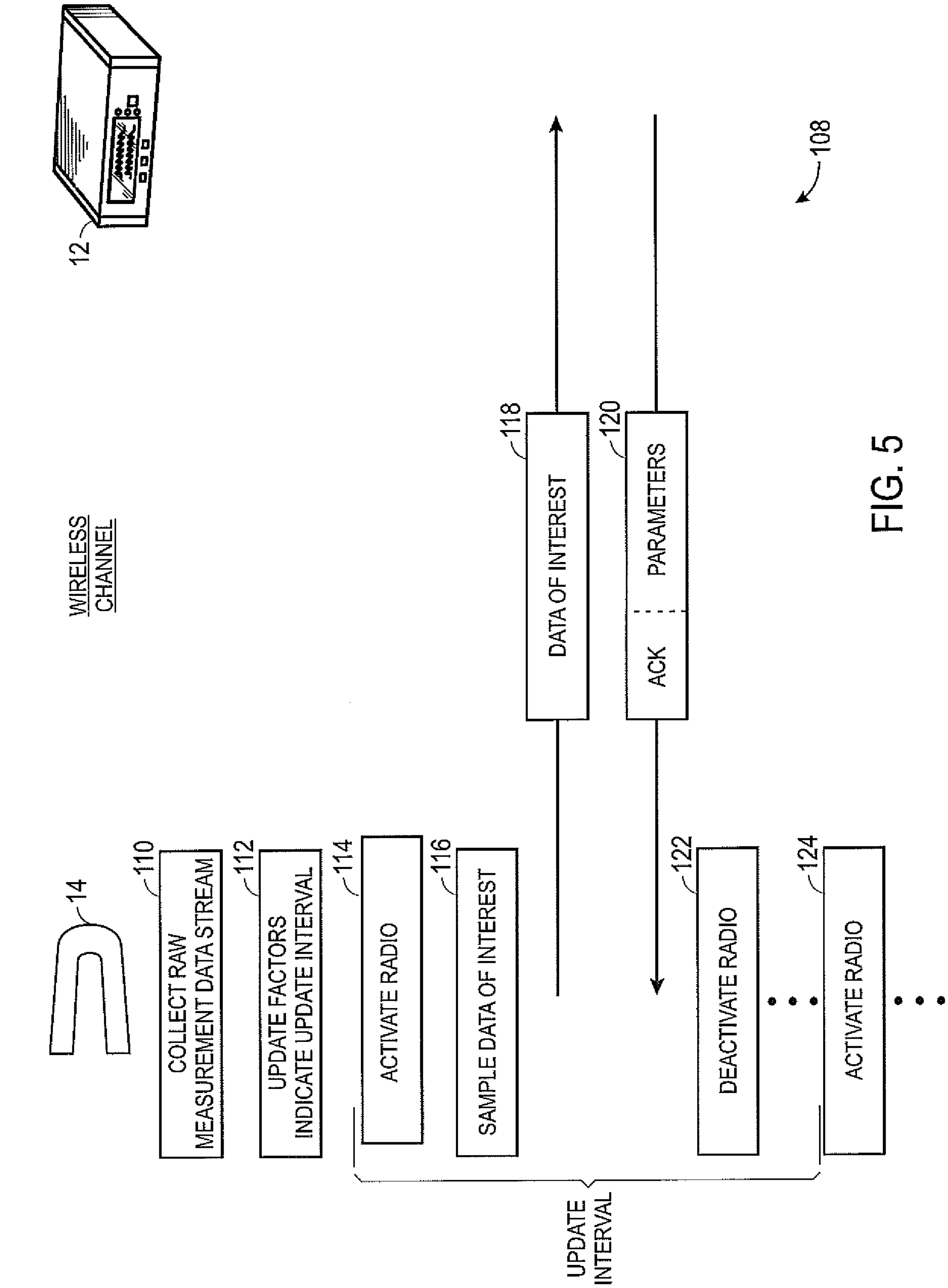

86
UPDATE FACTORS
88
STABILITY OF DATA OF INTEREST
90
VALUE OF DATA OF INTEREST
92
EXTRANEOUS SENSOR DATA
94
INSTRUCTIONS FROM MONITOR
96
BUTTON PRESS ON SENSOR
98
PATIENT SETTING
100
PRESENCE OR ABSENCE OF CLINICIAN
102
MOVEMENT OF PATIENT
104
INITIALIZATION OF SENSOR
106
BATTERY LIFE

FIG. 4



12
WIRELESS CHANNEL
14
110
COLLECT RAW MEASUREMENT DATA STREAM
112
UPDATE FACTORS INDICATE UPDATE INTERVAL
114
ACTIVATE RADIO
116
SAMPLE DATA OF INTEREST
118
DATA OF INTEREST
120
ACK
PARAMETERS
122
DEACTIVATE RADIO
124
ACTIVATE RADIO
UPDATE INTERVAL
108

FIG. 5

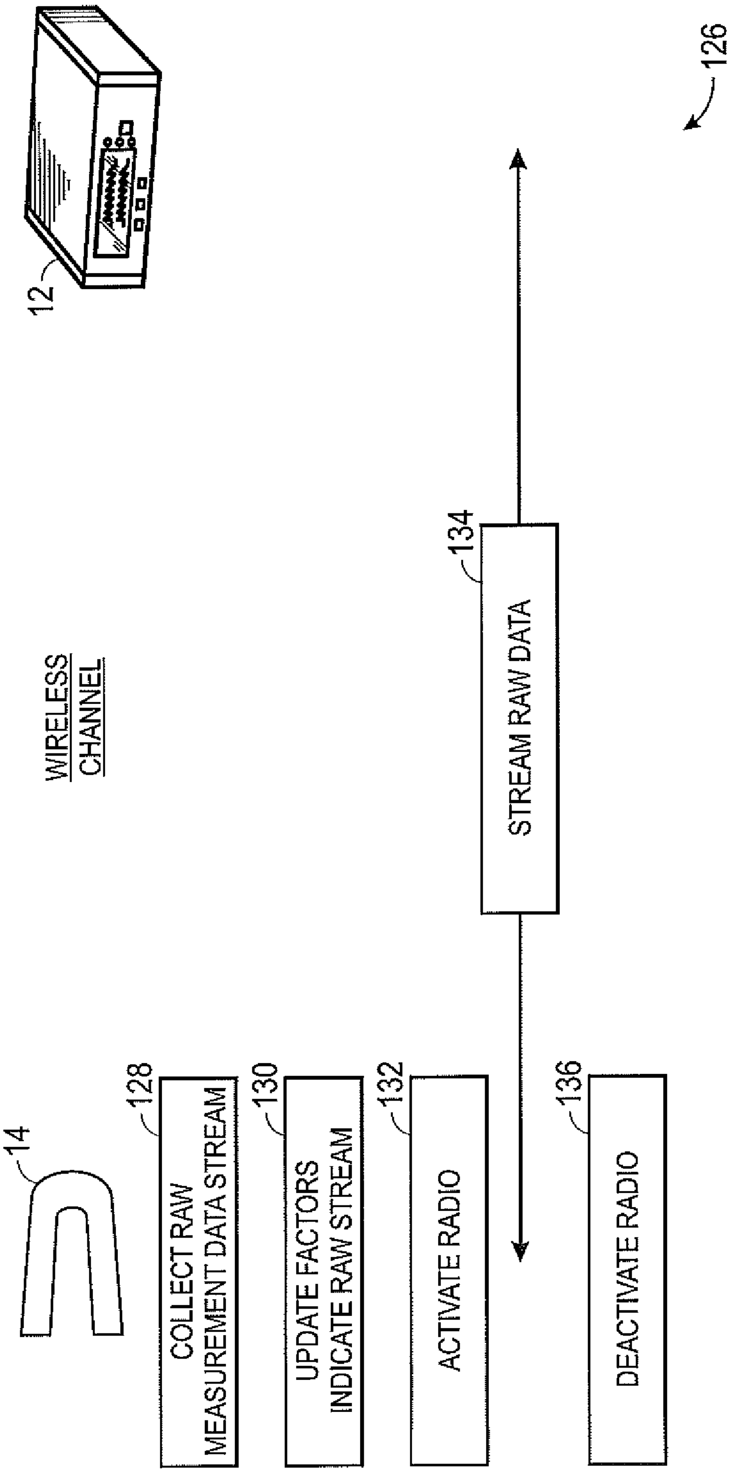

12
126
WIRELESS CHANNEL
134
STREAM RAW DATA
14
128
COLLECT RAW MEASUREMENT DATA STREAM
130
UPDATE FACTORS INDICATE RAW STREAM
132
ACTIVATE RADIO
136
DEACTIVATE RADIO

FIG. 6

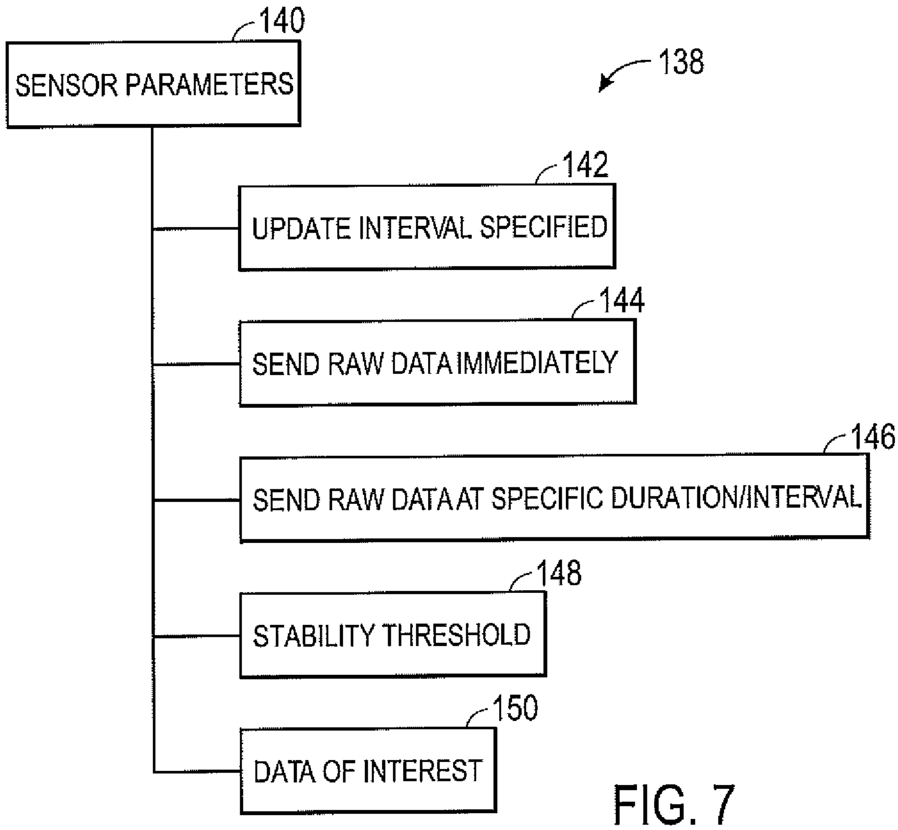

140
138
SENSOR PARAMETERS
142
UPDATE INTERVAL SPECIFIED
144
SEND RAW DATA IMMEDIATELY
146
SEND RAW DATA AT SPECIFIC DURATION/INTERVAL
148
STABILITY THRESHOLD
150
DATA OF INTEREST

FIG. 7

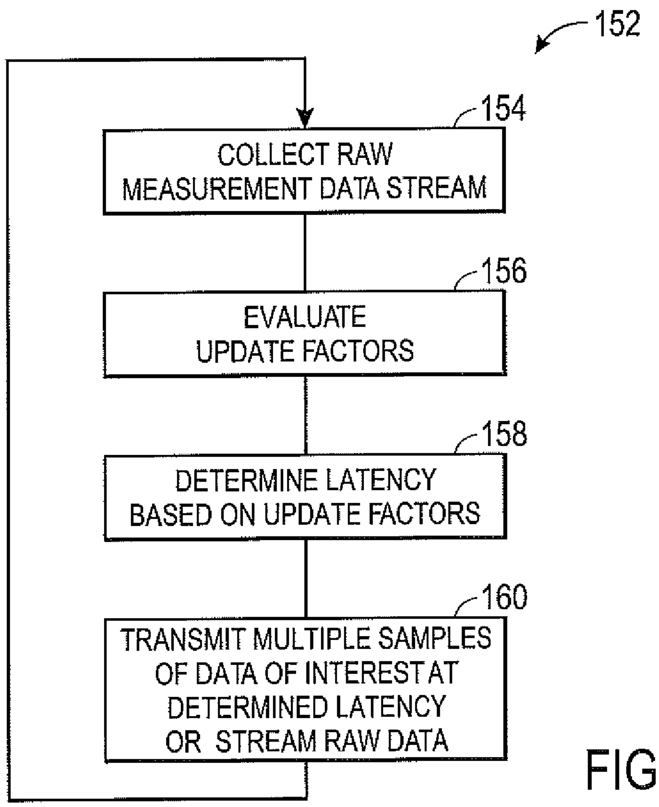

152
154
COLLECT RAW MEASUREMENT DATA STREAM
156
EVALUATE UPDATE FACTORS
158
DETERMINE LATENCY BASED ON UPDATE FACTORS
160
TRANSMIT MULTIPLE SAMPLES OF DATA OF INTEREST AT DETERMINED LATENCY OR STREAM RAW DATA

FIG. 8

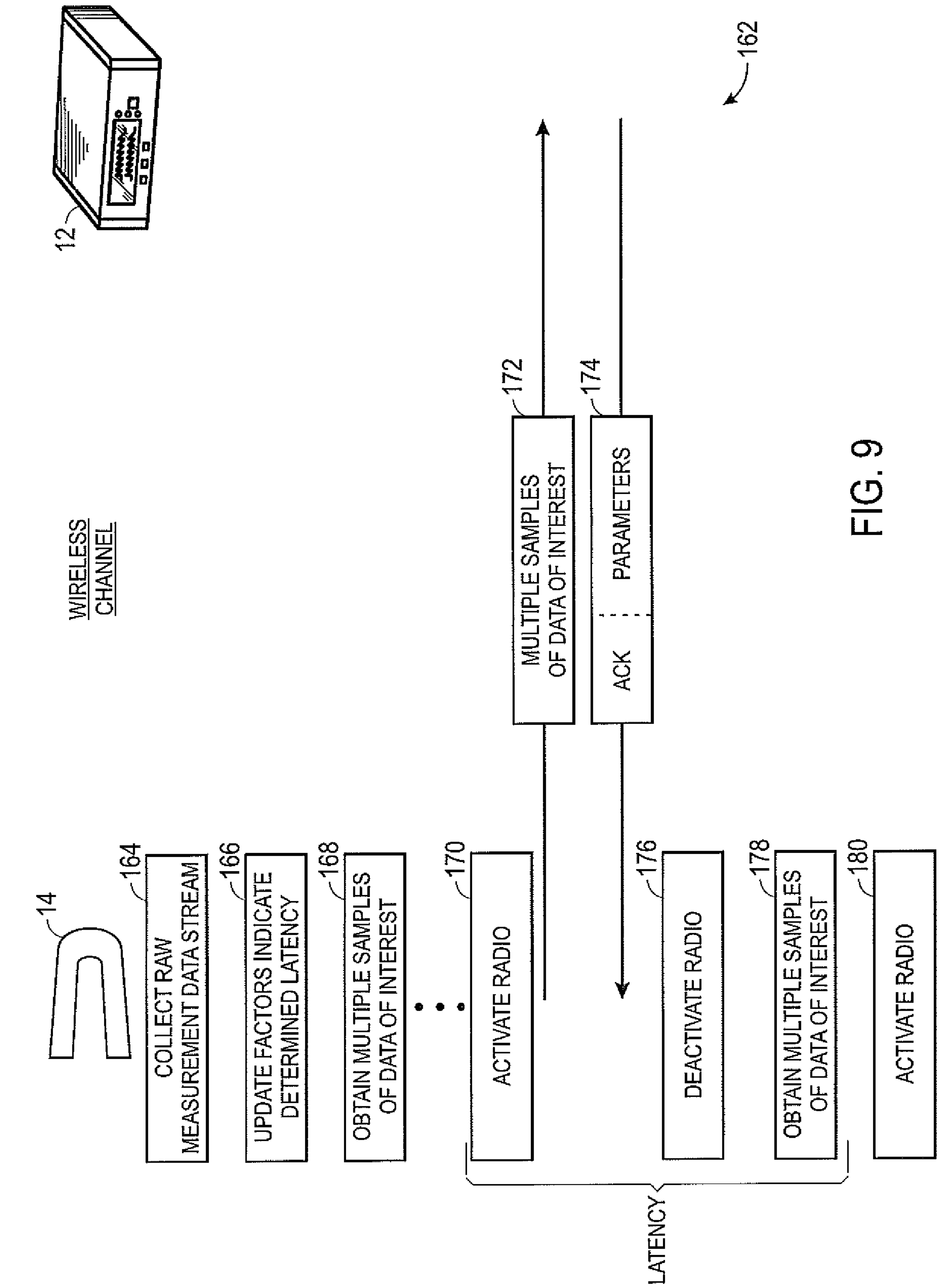

12
14
162
WIRELESS CHANNEL
COLLECT RAW MEASUREMENT DATA STREAM
164
UPDATE FACTORS INDICATE DETERMINED LATENCY
166
OBTAIN MULTIPLE SAMPLES OF DATA OF INTEREST
168
ACTIVATE RADIO
170
MULTIPLE SAMPLES OF DATA OF INTEREST
172
ACK
PARAMETERS
174
DEACTIVATE RADIO
176
OBTAIN MULTIPLE SAMPLES OF DATA OF INTEREST
178
ACTIVATE RADIO
180
LATENCY

FIG. 9

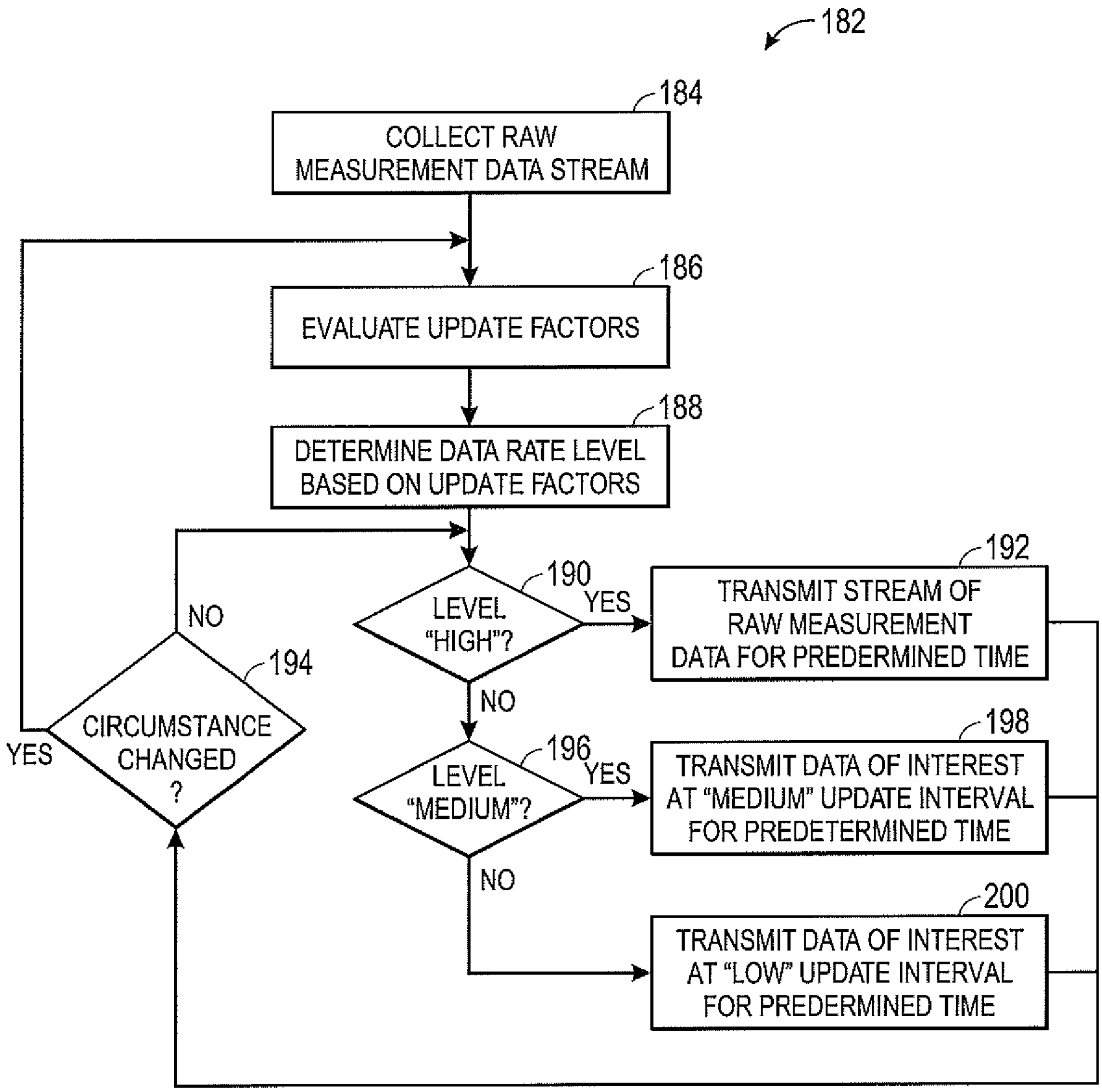

182
184
COLLECT RAW MEASUREMENT DATA STREAM
186
EVALUATE UPDATE FACTORS
188
DETERMINE DATA RATE LEVEL BASED ON UPDATE FACTORS
190
LEVEL "HIGH"?
YES
NO
192
TRANSMIT STREAM OF RAW MEASUREMENT DATA FOR PREDERMINED TIME
196
LEVEL "MEDIUM"?
YES
NO
198
TRANSMIT DATA OF INTEREST AT "MEDIUM" UPDATE INTERVAL FOR PREDETERMINED TIME
200
TRANSMIT DATA OF INTEREST AT "LOW" UPDATE INTERVAL FOR PREDERMINED TIME
194
CIRCUMSTANCE CHANGED ?
YES
NO

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/041847

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B5/0205
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/030260 A1 (ARX JEFFREY A VON [US] VON ARX JEFFREY A [US]) 12 February 2004 (2004-02-12) paragraph [0034] - paragraph [0038]	1-25
X	US 2008/110261 A1 (RANDALL KEVIN S [US] ET AL) 15 May 2008 (2008-05-15) paragraph [0047] - paragraph [0049] paragraph [0181] - paragraph [0182] claims 1-13	1-25
A	US 2006/202816 A1 (CRUMP CINDY [US] ET AL) 14 September 2006 (2006-09-14) paragraph [0041]	15,21

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 October 2010	22/10/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bengtsson, Johan

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2010/041847

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004030260 A1	12-02-2004	AU 2003256886 A1	25-02-2004
		EP 1526893 A2	04-05-2005
		JP 4546243 B2	15-09-2010
		JP 2005535391 T	24-11-2005
		WO 2004014484 A2	19-02-2004
US 2008110261 A1	15-05-2008	WO 2008060438 A2	22-05-2008
US 2006202816 A1	14-09-2006	WO 2006099120 A2	21-09-2006

专利名称(译)	用于平衡无线医疗传感器的功耗和效用的系统和方法		
公开(公告)号	EP2464277A1	公开(公告)日	2012-06-20
申请号	EP2010738070	申请日	2010-07-13
[标]申请(专利权)人(译)	内尔科尔普里坦贝内特公司		
申请(专利权)人(译)	NELLCOR PURITAN BENNETT LLC		
当前申请(专利权)人(译)	COVIDIEN LP		
[标]发明人	LISOGURSKI DANIEL MCKENNA EDWARD		
发明人	LISOGURSKI, DANIEL MCKENNA, EDWARD		
IPC分类号	A61B5/00 A61B5/0205		
CPC分类号	A61B5/0002 A61B5/0205 A61B5/02416 A61B5/1455 A61B2560/0209		
优先权	12/538696 2009-08-10 US		
外部链接	Espacenet		

摘要(译)

提供了用于平衡医疗传感器的功耗和效用的系统，方法和设备。例如，无线医疗传感器设备可以包括传感器，数据处理电路和无线传输电路。传感器可以能够从患者获得原始测量值，并且数据处理电路器能够对原始测量值进行采样以获得值。此外，数据处理电路还能够至少部分地基于与患者的状态相关联的更新因子来确定更新间隔，并且无线传输电路能够将这些值中的一个无线传输到外部。更新间隔的无线接收器。