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(54) **HEALTH MONITORING DEVICE**

(71) Applicant: **InfoBionic, Inc.**, Lowell, MA (US)

(72) Inventors: **Lev KORZINOV**, San Diego, CA (US); **Eric BAUMANN**, San Diego, CA (US)

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(57) **ABSTRACT**

A computer-implemented method for processing ECG data may include: receiving ECG data representing a plurality of heartbeats; analyzing the ECG data to determine whether each of the plurality of heartbeats is a normal heartbeat or an abnormal heartbeat; associating each of the abnormal heartbeats with an existing template or a new template; receiving input related to each new template, wherein the input includes either: a) a confirmation that the new template represents an abnormal heartbeat, or b) a reclassification of the new template as representing a normal heartbeat or a different abnormal heartbeat; and in response to the user input, updating a label of each of the heartbeats associated with each confirmed new template and each of the heartbeats associated with each reclassified new template.

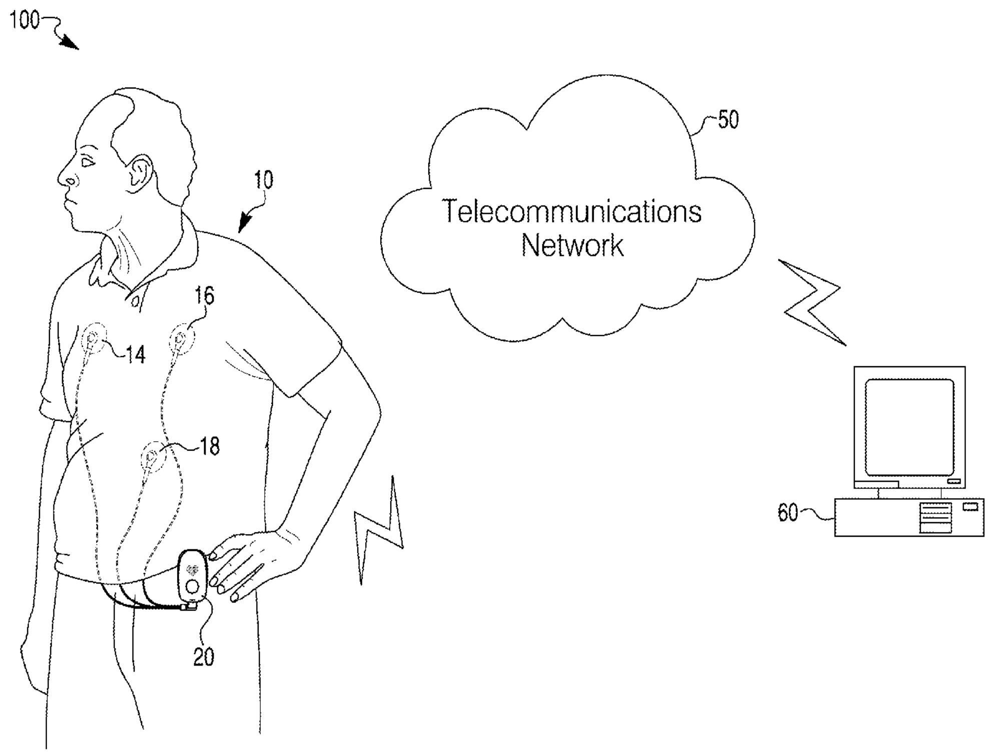


FIG. 1

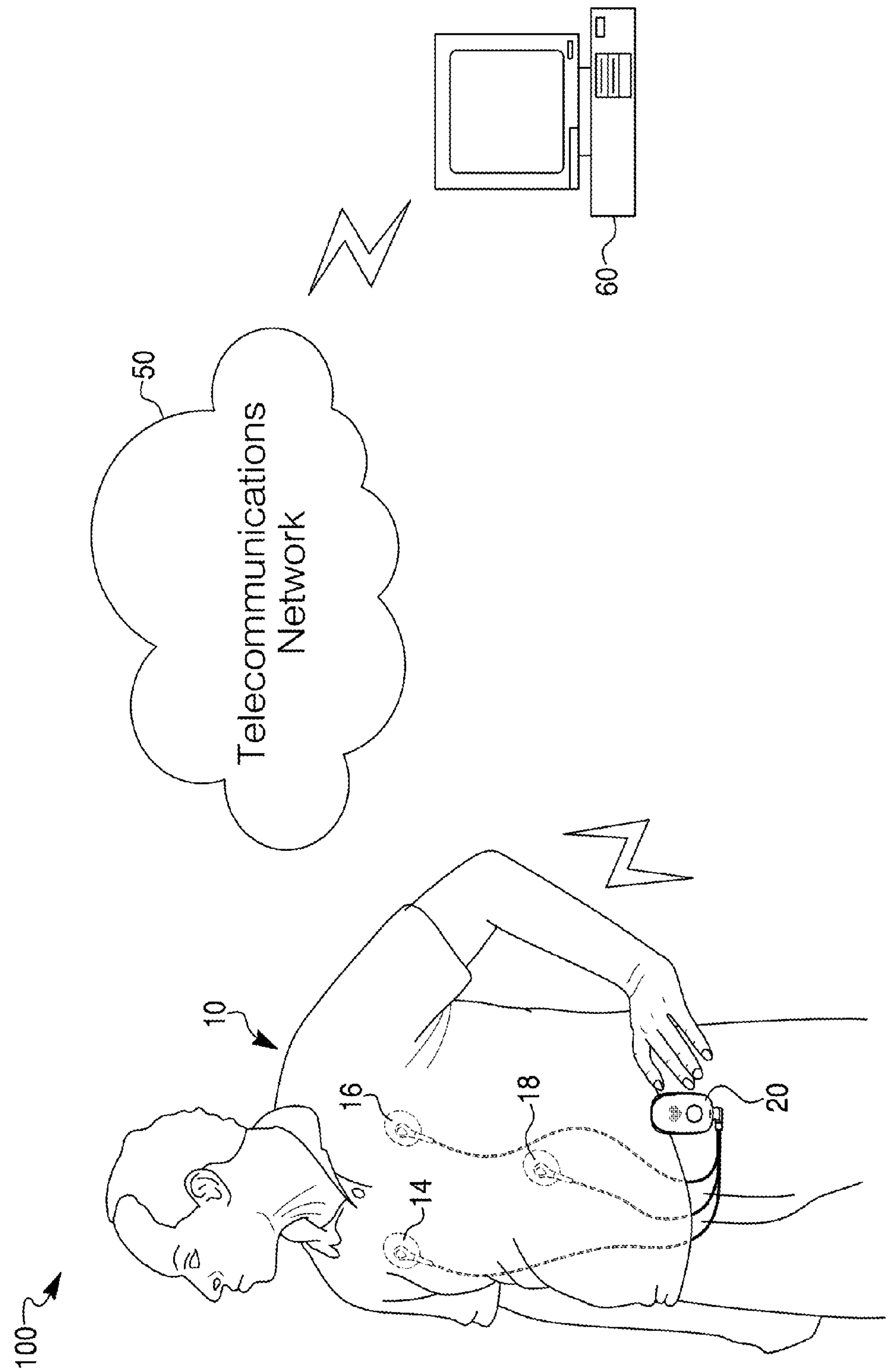


FIG. 2

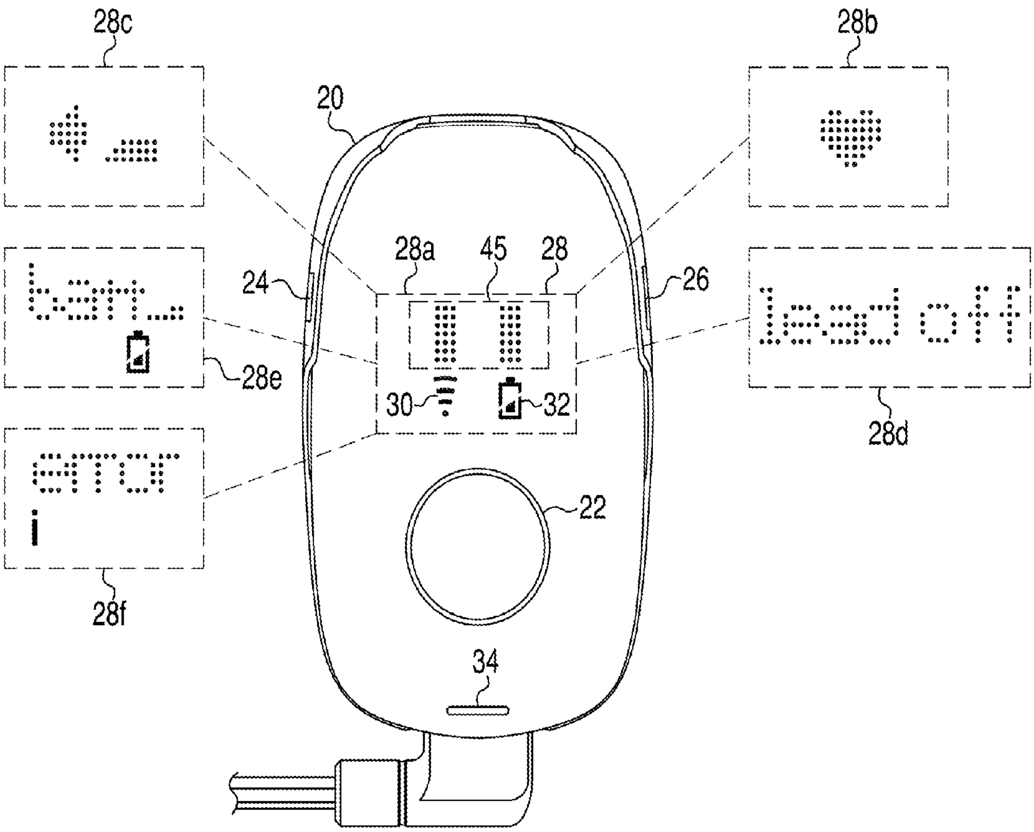


FIG. 3

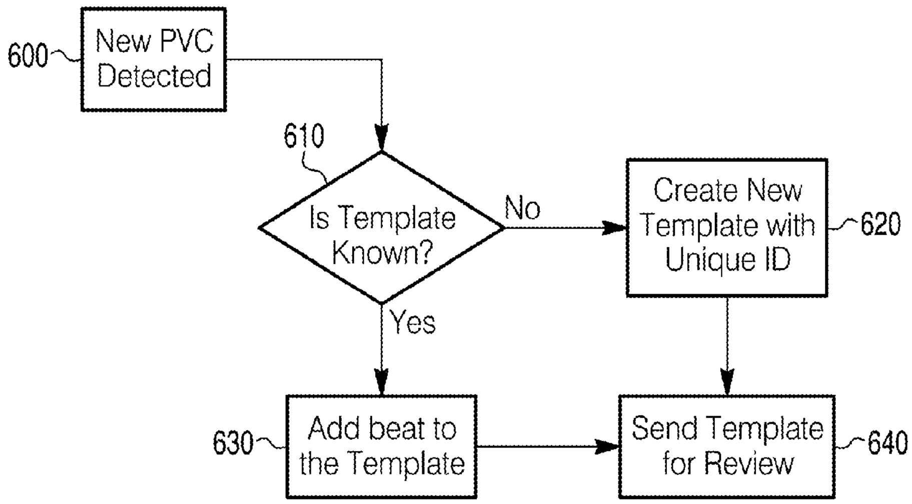
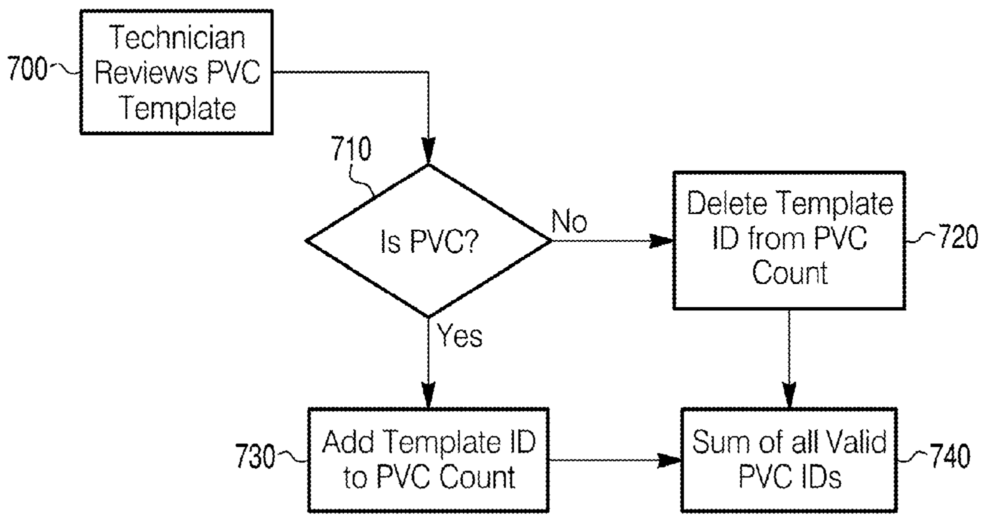

600
New PVC Detected
610
Is Template Known?
No
Create New Template with Unique ID
620
Yes
630
Add beat to the Template
Send Template for Review
640

FIG. 4


700
Technician Reviews PVC Template
710
Is PVC?
No
Delete Template ID from PVC Count
720
Yes
730
Add Template ID to PVC Count
Sum of all Valid PVC IDs
740

HEALTH MONITORING DEVICE

TECHNICAL FIELD

[0001] Various embodiments of the present disclosure relate to a device and systems and methods of using the device for health monitoring, and more particularly to a device and system and methods of using a device for physiologic data monitoring.

BACKGROUND

[0002] Physiologic data may be used to monitor the health of a patient. For example, bioelectric signals (e.g., electrocardiogram or ECG signals) from the patient's heart may be used to monitor cardiac health. ECG is a recording of the electrical activity of the heart. During ECG monitoring, electrodes attached to a patient's skin are used to detect electrical activity of the heart over a period of time, and electrical impulses generated by the heart during each heartbeat are detected and recorded and/or displayed on a device. Analysis of the data reveals the cardiac health (e.g., rate and regularity of heartbeats, size and position of the chambers, the presence of any damage to the heart, effects of drugs or devices used to regulate the heart, etc.) of the patient.

[0003] Multiple electrodes (e.g., left arm (LA), right arm (RA), and left leg (LL) electrodes) may be attached to the patient's skin for ECG measurement. These electrodes may be combined into a number of pairs (e.g., three pairs LA-RA, LA-LL, and RA-LL), and voltage signals may be recorded across each pair. Each pair is known as a lead. Each lead looks at the heart from a different angle. Different types of ECG measurements can be referred to by the number of leads that are recorded (e.g., 3-lead, 5-lead, 12-lead ECG, etc.).

[0004] Many cardiac problems become noticeable only during physical activity (walking, exercise, etc.). An ambulatory electrocardiogram (ECG) continuously monitors the electrical activity of the heart while a patient does normal activities. Typically, a 12-lead or a 5-lead ECG is used for periodic ECG monitoring (e.g., at a doctor's office, etc.) and a 3-lead ECG is used for continuous ambulatory monitoring. In 3-lead monitoring, ECG data is collected using three electrodes attached to the patient. The collected data is recorded in a monitor operatively coupled to the electrodes. The stored data is analyzed by a health care provider. In some cases, the monitor may transmit ECG data to a health care provider for analysis. Several types of monitors (e.g., Holter monitor, event monitors, mobile cardiovascular telemetry monitors, etc.) are known in the art. Some of these monitors store the data for subsequent analysis by a health care provider, while others transmit (real-time, periodically, or on demand) the collected ECG data to a remote site where it is analyzed.

SUMMARY

[0005] Embodiments of the present disclosure relate to, among other things, devices for physiologic data monitoring. Each of the embodiments disclosed herein may include one or more of the features described in connection with any of the other disclosed embodiments.

[0006] A computer-implemented method for processing ECG data may include: receiving, over an electronic network, ECG data, wherein the ECG data represents a plurality of heartbeats; analyzing the ECG data, by at least one processor, to determine whether each of the plurality of heartbeats is a normal heartbeat or an abnormal heartbeat; associating, by the at least one processor, each of the abnormal heartbeats with either only one of a plurality of existing templates or a new template; receiving, from a user, input related to each new template, wherein the input includes either: a) a confirmation that the new template represents an abnormal heartbeat, or b) a reclassification of the new template as representing a normal heartbeat or a different abnormal heartbeat; and in response to the user input, updating, by the at least one processor, a label of each of the heartbeats associated with each confirmed new template and each of the heartbeats associated with each reclassified new template.

[0007] A system for processing ECG data may include a data storage device that stores instructions for processing ECG data; and a processor configured to execute the instructions to perform a method including: receiving, over an electronic network, ECG data, wherein the ECG data represents a plurality of heartbeats; analyzing the ECG data to determine whether each of the plurality of heartbeats is a normal heartbeat or an abnormal heartbeat; associating each of the abnormal heartbeats with either only one of a plurality of existing templates or a new template; receiving, from a user, input related to each new template, wherein the input includes either: a) a confirmation that the new template represents an abnormal heartbeat, or b) a reclassification of the new template as representing a normal heartbeat or a different abnormal heartbeat; and in response to the user input, updating the labels of each of the heartbeats associated with each confirmed new template and each of the heartbeats associated with each reclassified new template.

[0008] A non-transitory computer-readable medium may store instructions that, when executed by a computer, cause the computer to perform a method for processing ECG data, the method including: receiving, over an electronic network, ECG data, wherein the ECG data represents a plurality of heartbeats; analyzing the ECG data, by at least one processor, to determine whether each of the plurality of heartbeats is a normal heartbeat or an abnormal heartbeat; associating, by the at least one processor, each of the abnormal heartbeats with either only one of a plurality of existing templates or a new template; receiving, from a user, input related to each new template, wherein the input includes either: a) a confirmation that the new template represents an abnormal heartbeat, or b) a reclassification of the new template as representing a normal heartbeat or a different abnormal heartbeat; and in response to the user input, updating, by the at least one processor, a label of each of the heartbeats associated with each confirmed new template and each of the heartbeats associated with each reclassified new templates.

[0009] A method, system, or non-transitory computer-readable medium for processing ECG data may additionally or alternatively include one or more of the following steps or features: the method does not include repeating the analyzing step; the method may further comprise totaling, by the at least one processor, the number of heartbeats associated with the confirmed new templates and the number of heartbeats associated with the new templates reclassified as a different abnormal heartbeat; the associating step may include comparing ECG data representing a heartbeat to at least one of the plurality of existing templates; the step of associating may include creating the new template for abnormal heartbeats having characteristics that differ by more than a predefined threshold from each of the existing templates; the step of associating an abnormal heartbeat with one of the plurality of existing templates may include associating the abnormal heartbeat with an existing template if the abnormal heartbeat has characteristics that differ by less than a predefined threshold from the existing template; the abnormal heartbeats may include premature ventricular contractions; the electronic network may include a wireless connection over a cellular network; and the receiving step may include receiving the ECG data from a monitor, and the monitor may be a portable device configured to be carried on a patient's body.

[0010] It may be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate exemplary embodiments of the present disclosure and together with the description, serve to explain the principles of the disclosure.

[0012] FIG. **1** illustrates an exemplary system for measuring ECG of a patient.

[0013] FIG. **2** illustrates an exemplary device used in the ECG measurement system of FIG. **1**.

[0014] FIGS. **3** and **4** illustrate steps in an exemplary process for detecting and classifying arrhythmias.

DETAILED DESCRIPTION

Overview of a System for Monitoring Physiologic Data

[0015] Embodiments of the present disclosure may include methods and systems for monitoring physiologic data of a patient. Various aspects of the present disclosure may be used in combination with, or include, one or more features disclosed in U.S. Pat. No. 8,478,418 (issued Jul. 2, 2013) and U.S. Pat. No. 8,620,418 (issued Dec. 31, 2013), each of which is incorporated by reference herein in its entirety. While an exemplary embodiment of measuring ECG data is described below, it should be noted that the current disclosure may be applied to the measurement of any physiologic data. For example, the disclosed systems and methods may be used to measure signals indicative of heart rate, activity level (e.g., physical mobility or movement), respiration rate, blood pressure (e.g., systolic and/or diastolic), blood oxygen saturation (SpO2), blood glucose or insulin level, pulse oximetry, impedance, body temperature, etc. Thus, the systems, devices, and methods described herein may acquire and process other types of physiologic data instead of or in addition to ECG data. It is also contemplated that, in some embodiments, the measured physiologic data may be used to determine a cardiac safety indicator such as QT prolongation, ST elevation, etc.

[0016] FIG. **1** is a schematic illustration of an exemplary system **100** for measuring ECG of a patient **10**. A plurality of electrodes **14**, **16**, **18** may be attached to the patient **10** to detect ECG signals. Although a three-electrode configuration is illustrated, electrodes may be placed to measure any number of leads (e.g., a 10 electrode, 12-lead configuration). In one example, the electrodes **14**, **16**, **18** acquire two leads (channels) of ECG data. The electrodes **14**, **16**, **18** detect (and in some cases amplify) tiny electrical changes on the skin that are caused when heart muscles depolarize during each heartbeat. At rest, each heart muscle cell has a negative charge (called the membrane potential) across its cell membrane. Decreasing this negative charge toward zero, via the influx of the positive cations (Na+ and Ca++) is called depolarization. Depolarization activates mechanisms in the cell that cause it to contract. During each heartbeat, a healthy heart will have an orderly progression of a wave of depolarization that is triggered by the cells in the sinoatrial node, spreads out through the atrium, passes through the atrioventricular node and then spreads all over the ventricles. The depolarization wave (or ECG data) is indicative of the overall rhythm of the heart and is detected as variations in voltage between the electrode pairs (e.g., between electrodes **14-16**, **14-18**, and **16-18**).

[0017] System **100** may include a monitor **20** operatively coupled to the electrodes **14**, **16**, **18**. Monitor **20** may be adapted to receive and store the ECG data from the electrodes **14**, **16**, **18** using standard connections known in the art (e.g., lead wires, an analog to digital converter, etc.). In one example, the lead wires connected to each electrode in FIG. **1** may include a resistor. If a patient is undergoing defibrillation, the resistor may prevent the monitor from diverting energy applied to the patient by the defibrillation device. The presence of resistors in the lead wires does not inhibit impedance tomography. In one example, the resistor in each lead wire may be 1000 ohms.

[0018] In addition to the connection to electrodes **14**, **16**, **18**, the monitor **20** may be configured to communicate with one or more additional or alternative sensors via wired or wireless connections. Any combination of well-known physiological sensors may be coupled to the monitor **20**, such as SpO2 sensors, blood pressure sensors, heart electrodes (e.g., electrodes **14**, **16**, **18**), respiration sensors, movement and activity sensors, glucose monitors, and the like. Respiration data may be derived from ECG baseline data, as is known to those of skill in the art. In one example, the monitor **20** can connect to a sensor in a scale to receive information related to the patient's weight. Movement or activity may be sensed with appropriate accelerometers or gyroscopes, which may include micro electro-mechanical system (MEMS) devices. The one or more additional or alternative sensors may be connected to the monitor **20** via wires or optical cables or via a wireless link (e.g., Bluetooth, Wi-Fi, ZigBee, Z-wave, radio, etc.).

[0019] In one example, at least one type of sensor transmits data to the monitor **20** via a wired connection, and at least one type of sensor transmits data to the monitor **20** via a wireless connection. The patient **10** may press a button on the monitor **20** to wirelessly pair it with one or more of the sensors described above. In another example, a user may communicate with a monitor **20** via a web/mobile interface component to wirelessly pair the monitor **20** with selected sensors.

[0020] In some embodiments, monitor **20** may transfer at least a portion of the measured ECG data (or other physiologic data) to a remote analysis station **60** for analysis. Although analysis station **60** is illustrated as a computer (e.g., processor and memory), in general, analysis station **60** may include any collection of computational devices (e.g., one or more servers, databases, and computers networked together) and personnel. The term "processor" as used herein may include a central processing unit or a microprocessor. The ECG data from monitor **20** may be transferred to remote analysis station **60** over a wired connection, using a portable storage medium (transferable memory device, etc.), or wirelessly over a telecommunications network **50** (e.g., a cellular network, the Internet, a computer network, etc.). For example, monitor **20** may include a cellular modem, and the ECG data may be sent to the analysis station **60** via a cellular network. As used herein, the term "electronic network" may include any combination of wired and wireless communication technologies used to transmit information.

[0021] Analysis station **60** may analyze the ECG data to check the cardiac health of patient **10**. Any analysis methodology known in the art may be used to analyze the received data (e.g., a methodology described by Philip de Chazal, et al., in "Automatic Classification of Heartbeats Using ECG Morphology and Heartbeat Interval Features," IEEE Transactions on Biomedical Engineering, Vol. 51, No. 7, July, 2004). In some embodiments, monitor **20** may at least partially analyze the collected ECG data before it is transferred to analysis station **60**.

[0022] In some embodiments, monitor **20** may store the collected ECG data, and continuously transmit (directly or through an intermediate device) a subset of the data (e.g., data at a lower resolution, etc.) to the analysis station **60**. In one example, the subset of the data is transmitted at 100 samples per second, although it may be transmitted at 200 samples per second or at any other frequency. The analysis station **60** may analyze the received data to determine if it indicates an anomaly (e.g., an arrhythmia, an unexpected trend in the data, etc.). If an anomaly is indicated, analysis station **60** may request (i.e. transmit instructions) the monitor **20** for more data (e.g., data from the same time frame at a higher resolution, etc.). For example, if the initial data was transmitted at 100 samples per second, the second set of more detailed data may be transmitted at 200 samples per second. Upon receipt of this request, the monitor **20** may retrieve the requested data from memory and transmit it to the analysis station **60**. The analysis station **60** may then analyze the data (e.g., using a more rigorous analysis methodology) to confirm or refute the anomaly detected during the previous analysis. This analysis methodology is described in more detail in U.S. Pat. No. 8,478,418, which is incorporated by reference herein.

Monitor

[0023] FIG. **2** illustrates an exemplary embodiment of monitor **20**. Monitor **20** may include integrated circuits (microprocessor, memory, communication devices, etc.), visual displays (LED, LCD, etc.), and/or buttons that can be activated by the patient **10**. The integrated circuits of monitor **20** may enable processing of collected ECG data, and communication between monitor **20** and the analysis station **60**. The buttons may enable the patient **10** to trigger an activity (data collection, communication with analysis station **60**, record or mark an event, etc.), and the display may enable the monitor **20** and analysis station **60** to communicate with patient **10** (e.g., using text messages). In one embodiment, the monitor **20** may include dimensions of approximately 108 mm×67 mm×17 mm, although the monitor **20** may be any size that allows it to be portable with the patient.

[0024] Monitor **20** may be a portable device, sized and adapted to be kept in the possession (strapped, attached, placed in the pocket, etc.) of patient **10**. Such a portable monitor **20** may enable the patient **10** to go about the patient's daily activities while the monitor **20** records (and/or transfers, analyzes, etc.) ECG data. In the exemplary embodiment illustrated in FIG. **1**, monitor **20** is shown as a device attached by a connector (e.g., clipped) to the patient's belt. However, this is only exemplary, and other configurations are possible (e.g., the connector could allow the device to be worn around the patient's neck). In embodiments where electrodes **14**, **16**, **18** are connected by a wire to the monitor, monitor **20** may include a connector to receive the connecting wire. In embodiments where electrodes **14**, **16**, **18** are coupled wirelessly, monitor **20** may include a transceiver to communicate with a transceiver of electrodes **14**, **16**, **18**.

[0025] In one embodiment, the monitor **20** may include an event button **22**, a wake button **24**, and a volume button **26**. A physician may press the event button **22** to activate the monitor **20** for patient use. Furthermore, the patient **10** may press the event button **22** if a symptom, such as the feeling caused by an arrhythmia, occurs. However, the monitor **20** may continuously record ECG data whether or not the patient presses the event button **22**. Information from the event button **22** may therefore serve to help confirm suspected arrhythmias or other irregular heart activity detected from the ECG data. The wake button **24** may be pressed by the patient **10** to display the current level of reception (e.g., via a cellular network), the battery level, and/or whether the electrodes **14**, **16**, **18** are adequately coupled to the patient **10**. Upon pressing the wake button **24**, a light **34** may be green if the electrodes are all adequately coupled to the patient or red if one or more of the electrodes is not adequately coupled to the patient. The volume button **26** may allow the patient **10** to adjust or mute the volume of alerts from the monitor **20**.

[0026] The monitor **20** may include a display **28**. The display **28** may include a plurality of LED lights and one or more icons underneath the outer casing of the monitor. The LED lights may form an LED matrix **45** (e.g., 24×7, 20×7, or any other suitable arrangement of lights). In one embodiment, when the lights are off, the display is either imperceptible or faintly visible. When one or more LED lights or icons are lit, however, the individual lights or icons may be visible through the portion of the outer casing of the monitor that overlays the display **28**. That portion of monitor **20** (a window over display **28**) may be made of a transparent or semi-transparent material, for example, translucent polycarbonate.

[0027] A variety of display patterns may appear on the display **28** at various times to provide information to the patient **10**. In FIG. **2**, for example, the display pattern **28*a*** may include a wireless icon **30** and a battery icon **32**, which each correspond to one or more columns (e.g., three) of LED lights. Display pattern **28*a*** may appear when the user (e.g., a physician, nurse, technician, patient, or any other person) presses the wake button **24**. The columns of LED lights may indicate the level of wireless service and the battery level, respectively. Display pattern **28*b*** may include an icon shaped like a heart, which may be displayed when the event button **22** is pressed. Display pattern **28*c*** may include a speaker and rows of LED lights, and may be displayed when the user changes the volume. The number of rows of LED lights may increase when the volume is raised and decrease when the volume is lowered. "Mute" may be spelled in LED lights next to a speaker icon when the sound is muted. When one or more electrodes is not connected to the patient **10**, the words "lead off" may scroll across the LED display, as shown in display pattern **28***d*. Alternatively, the words "lead" and "off" may alternate on the display **28**. Display pattern **28***e* may appear when the battery is low. The number of rows of LED lights that appear may correspond to the level of battery remaining. Furthermore, the battery icon may appear red to indicate low battery status. In a final example, display pattern **28***f* may appear if there is an error that requires user attention. The LED lights may be lit in any suitable pattern or may form any words to communicate to the patient **10**.

[0028] In other examples, display **28** may be separate from the monitor **20**. The separate display **28** could be a stand-alone display or could be a user's cell phone or other communication device. The monitor **20** may transmit information to the stand-alone display, cell phone, or other communication device via any type of wireless network.

[0029] The monitor **20** may include a rechargeable battery. In one example, the battery may operate for between 24 and 72 hours on a single charge. The battery may be removable from the monitor **20** and docked to an external charger.

[0030] The hardware of monitor **20** may include various components connected by general purpose input/outputs or by specialized connectors. The hardware may include any suitable microprocessor and other circuitry known to one of ordinary skill in the art for performing the various functions of the system described herein, such as analog-to-digital converters, device/component drivers, transceivers, and memory. The system software may receive ECG data for evaluation by an arrhythmia analysis algorithm, and any detected arrhythmias may be identified and presented for physician review. The system software may detect, for example, premature ventricular contractions (PVCs) from the ECG data, as will be described further below.

Method for Processing of ECG Data

[0031] FIGS. **3** and **4** illustrate an automated method for processing ECG data to detect arrhythmias, or abnormal heartbeats. Although an exemplary embodiment of detecting premature ventricular contractions (PVCs) is described, the method can be used to detect any type of irregular heartbeat. The illustrated method may require less computational resources and may process ECG datasets with greater speed than existing methods of processing ECG data to detect PVCs. PVC detection may play a role in diagnosing a variety of heart conditions, including: heart attack, high blood pressure, cardiomyopathy (including congestive heart failure), disease of heart valves (such as mitral valve prolapse), hypokalemia (low blood levels of potassium), hypomagnesemia (low blood levels of magnesium), and hypoxia (low amounts of oxygen in the blood). In addition, several PVCs in a row with a high heart rate could indicate a serious arrhythmia, such as ventricular tachycardia.

[0032] Automatic classification of PVCs presents a challenge. For example, a patient may have over 100,000 heartbeats every day. Even if an automatic process/algorithm is 99% accurate, about 1000 beats per day may be misclassified. Time-consuming human validation may then be required to correct misclassifications. Some existing classification processes may require an entire ECG data set to be processed twice—a first processing to detect suspected PVCs and a second processing after receiving user input related to the suspected PVCs.

[0033] A method for detecting and classifying PVCs may include receiving ECG input/data. In one example, the original ECG data may be sampled at 1024 samples per second, although any other sampling rate may be used (e.g., 2048, 512, 256, etc.). The ECG input may undergo appropriate filtering and processing steps to, for example, eliminate noise; reduce the data to a lower number of samples per second, such as 200 or 100; and/or detect the amplitudes and/or thresholds of beats. This information may be used to detect PVCs. For example, PVC beats may have a higher amplitude than normal beats, and beats may be classified as PVC if they have a threshold over a fixed reference threshold.

[0034] Detected heartbeats may be labeled or classified as either: a) normal, or b) PVC. The PVC beats may be provided with a PVC template ID corresponding to their morphology (e.g., the duration and amplitude of the various waves/intervals/complexes). A PVC "template" is, for example, a representation of a suspected PVC beat that is derived from (e.g., is an average of) the characteristics of a plurality of suspected PVC beats having a similar morphology. Each template may therefore be associated with a plurality of beats having a certain morphology. Each template may have a unique template ID. Each patient **10** may have a plurality of different PVC templates, with each template corresponding to beats having a certain morphology.

[0035] FIG. **3** illustrates an exemplary method for determining whether to create a new PVC template. The method begins at step **600** with a suspected PVC beat that was detected, as described above. In step **610**, the morphology of the suspected PVC may be compared to stored, previously-existing PVC templates (if there are any) to determine whether a template for the suspected PVC is known. The previously-existing PVC templates may be templates that were developed from earlier-processed heartbeats from the same patient. Additionally or alternatively, the previously-existing PVC templates may be based on known morphologies of PVCs, based on, for example, a population of patients. If the difference between the suspected PVC and the existing templates is above a certain threshold, a new PVC template may be created for the suspected PVC (step **620**). In one example, the threshold may be 5% in absolute differences between one or more of the characteristics that define the morphology of a heartbeat (e.g., the duration and amplitude of the various waves/intervals/complexes). However, if the morphology of the suspected PVC is similar to an existing template (e.g., below a certain threshold), the PVC beat may be added to the existing template (step **630**). In step **640**, the templates are sent to a user for review.

[0036] FIG. **4** illustrates a method for user review of PVC templates. In step **700**, the user reviews a PVC template. The user then determines whether the template is a PVC (step **710**) and provides input to the hardware/software that analyzes the ECG data to determine arrhythmias. In one example, the user may complete step **710** by reviewing the information from the template, such as the duration and amplitude of various waves/intervals/complexes (e.g., the QRS complex), and determining whether the heartbeat is irregular when compared to the patient's normal heartbeat. Additionally or alternatively, the user might compare the information from the template to other known information about irregular heartbeats. If the user determines that the template does not represent a PVC, the template ID may be deleted from the PVC count (step **720**), along with all beats associated with that template ID. Furthermore, the labels associated with each heartbeat corresponding to the deleted PVC template may be updated to indicate that the heartbeats are not PVCs. However, if the user determines that the template does represent a PVC, the template ID may be added to the PVC count (step **730**). In other words, if the template ID is confirmed as a PVC by the user, all beats associated with the template ID may be confirmed and added to the PVC count, and the labels associated with each confirmed heartbeat may be updated to indicate that the heartbeats are PVCs. The beats associated with all of the valid PVC template IDs may then be added to determine the total PVC count.

[0037] Accordingly, the ECG data may be processed once to detect potential PVCs. The remaining steps of the PVC processing method may then rely on the beat labels (e.g., normal or PVC with a template ID), which may be about 200 times smaller in data size compared to the original ECG data. Because the process of FIG. **4** relies on beat labels and eliminates the need for all of the ECG data to be reprocessed to classify and total PVCs based on the user's input, the process can be carried out more efficiently than previously existing classification methods.

[0038] At the end of a pre-defined interval (e.g., a day), the total number of PVC beats may be calculated. In one example, if the total number is more than a predefined threshold (e.g., 100), the PVC statistics may be displayed by one or more of the monitor **20** or by a device used by the clinician for review.

[0039] While principles of the present disclosure are described herein with reference to illustrative embodiments for particular applications, it should be understood that the disclosure is not limited thereto. Those having ordinary skill in the art and access to the teachings provided herein will recognize additional modifications, applications, embodiments, and substitution of equivalents all fall within the scope of the embodiments described herein. Accordingly, the invention is not to be considered as limited by the foregoing description.

1. A computer-implemented method for processing ECG data, comprising:

receiving, over an electronic network, ECG data, wherein the ECG data represents a plurality of heartbeats;

analyzing the ECG data, by at least one processor, to determine whether each of the plurality of heartbeats is a normal heartbeat or an abnormal heartbeat;

associating, by the at least one processor, each of the abnormal heartbeats with at least one template of: a) a plurality of existing templates, or b) a new template;

receiving, from a user, input related to each new template, wherein the input includes either: a) a confirmation that the new template represents an abnormal heartbeat, or b) a reclassification of the new template as representing a normal heartbeat or a different abnormal heartbeat;

in response to the user input, updating, by the at least one processor, a label of each of the heartbeats associated with each confirmed new template representing an abnormal heartbeat and each of the heartbeats associated with each reclassified new template; and

determining, by the at least one processor, a number of confirmed abnormal heartbeats, wherein confirmed abnormal heartbeats include each heartbeat associated with each confirmed new template representing an abnormal heartbeat and each heartbeat associated with each new template reclassified as a different abnormal heartbeat, wherein the processor determines the number of confirmed abnormal heartbeats using data contained in the labels associated with the confirmed abnormal heartbeats.

2. The method of claim **1**, wherein the method does not include repeating the analyzing step.

3. (canceled)

4. The method of claim **1**, wherein the associating step includes comparing ECG data representing a heartbeat to at least one of the plurality of existing templates.

5. The method of claim **1**, wherein the step of associating includes creating the new template for abnormal heartbeats having characteristics that differ by more than a predefined threshold from each of the existing templates.

6. The method of claim **1**, wherein the step of associating an abnormal heartbeat with one of the plurality of existing templates includes associating the abnormal heartbeat with an existing template if the abnormal heartbeat has characteristics that differ by less than a predefined threshold from the existing template.

7. The method of claim **1**, wherein the abnormal heartbeats include premature ventricular contractions.

8. The method of claim **1**, wherein the electronic network includes a wireless connection over a cellular network.

9. The method of claim **1**, wherein the receiving step includes receiving the ECG data from a monitor, and wherein the monitor is a portable device configured to be carried on a patient's body.

10. A system for processing ECG data, comprising:

a data storage device that stores instructions for processing ECG data; and

a processor configured to execute the instructions to perform a method including:

receiving, over an electronic network, ECG data, wherein the ECG data represents a plurality of heartbeats;

analyzing the ECG data to determine whether each of the plurality of heartbeats is a normal heartbeat or an abnormal heartbeat;

associating each of the abnormal heartbeats with at least one template of: a) a plurality of existing templates, or b) a new template;

receiving, from a user, input related to each new template, wherein the input includes either: a) a confirmation that the new template represents an abnormal heartbeat, or b) a reclassification of the new template as representing a normal heartbeat or a different abnormal heartbeat;

in response to the user input, updating a label of each of the heartbeats associated with each confirmed new template representing an abnormal heartbeat and each of the heartbeats associated with each reclassified new template; and

determining a number of confirmed abnormal heartbeats, wherein confirmed abnormal heartbeats include each heartbeat associated with each confirmed new template representing an abnormal heartbeat and each heartbeat associated with each new template reclassified as a different abnormal heartbeat, wherein the processor determines the number of confirmed abnormal heartbeats using data contained in the labels associated with the confirmed abnormal heartbeats.

11. The system of claim **10**, wherein the method performed by the processor does not include repeating the analyzing step.

12. (canceled)

13. The system of claim **10**, wherein the step of associating includes comparing ECG data representing a heartbeat to at least one of the plurality of existing templates.

14. The system of claim **10**, wherein the step of associating includes creating the new template for abnormal heartbeats having characteristics that differ by more than a predefined threshold from each of the existing templates.

15. The system of claim **10**, wherein the step of associating an abnormal heartbeat with one of the plurality of existing templates includes associating the abnormal heartbeat with an existing template if the abnormal heartbeat has characteristics that differ by less than a predefined threshold from the existing template.

16. The system of claim **10**, wherein the abnormal heartbeats include premature ventricular contractions.

17. A non-transitory computer-readable medium storing instructions that, when executed by a computer, cause the computer to perform a method for processing ECG data, the method including:

receiving, over an electronic network, ECG data, wherein the ECG data represents a plurality of heartbeats;

analyzing the ECG data, by at least one processor, to determine whether each of the plurality of heartbeats is a normal heartbeat or an abnormal heartbeat;

associating, by the at least one processor, each of the abnormal heartbeats with at least one template of: a) a plurality of existing templates, or b) a new template;

receiving, from a user, input related to each new template, wherein the input includes either: a) a confirmation that the new template represents an abnormal heartbeat, or b) a reclassification of the new template as representing a normal heartbeat or a different abnormal heartbeat;

in response to the user input, updating, by the at least one processor, a label of each of the heartbeats associated with each confirmed new template representing an abnormal heartbeat and each of the heartbeats associated with each reclassified new templates; and

determining, by the at least one processor, a number of confirmed abnormal heartbeats, wherein confirmed abnormal heartbeats include each heartbeat associated with each confirmed new template representing an abnormal heartbeat and each heartbeat associated with each new template reclassified as a different abnormal heartbeat, wherein the processor determines the number of confirmed abnormal heartbeats using data contained in the labels associated with the confirmed abnormal heartbeats.

18. The method of claim **17**, wherein the method does not include repeating the analyzing step.

19. (canceled)

20. The method of claim **17**, wherein the associating step includes comparing ECG data representing a heartbeat to at least one of the plurality of existing templates.

21. The method of claim **17**, wherein the step of associating includes creating the new template for abnormal heartbeats having characteristics that differ by more than a predefined threshold from each of the existing templates.

22. The method of claim **17**, wherein the step of associating an abnormal heartbeat with one of the plurality of existing templates includes associating the abnormal heartbeat with an existing template if the abnormal heartbeat has characteristics that differ by less than a predefined threshold from the existing template.

23. The method of claim **17**, wherein the abnormal heartbeats include premature ventricular contractions.

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专利名称(译)	健康监测装置		
公开(公告)号	US20170311830A1	公开(公告)日	2017-11-02
申请号	US15/143016	申请日	2016-04-29
申请(专利权)人(译)	INFOBIONIC INC.		
当前申请(专利权)人(译)	INFOBIONIC INC.		
[标]发明人	KORZINOV LEV BAUMANN ERIC		
发明人	KORZINOV, LEV BAUMANN, ERIC		
IPC分类号	A61B5/04 H04L12/26 H04B1/3827 A61B5/0408 A61B5/00 H04W4/00		
CPC分类号	A61B5/04012 A61B5/0006 A61B5/0022 H04W4/005 H04L43/04 H04B1/385 A61B5/0408 A61B5/02405 A61B5/02438 A61B5/04085 A61B5/0468 A61B5/6801 A61B5/7203 A61B5/7246 A61B5/7264 A61B5/7282 A61B5/7475 A61B2560/0431 G16H50/20 H04W4/70		
其他公开文献	US9968274		
外部链接	Espacenet USPTO		

摘要(译)

用于处理ECG数据的计算机实现的方法可以包括：接收表示多个心跳的ECG数据;分析ECG数据以确定多个心跳中的每一个是正常心跳还是异常心跳;将每个异常心跳与现有模板或新模板相关联;接收与每个新模板相关的输入，其中输入包括：a）新模板表示异常心跳的确认，或b）新模板重新分类为表示正常心跳或不同异常心跳;并且响应于用户输入，更新与每个确认的新模板相关联的每个心跳的标签以及与每个重新分类的新模板相关联的每个心跳。