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(54) SYSTEM AND METHOD FOR TELEMETRICALLY MONITORING A TARGET OBJECT

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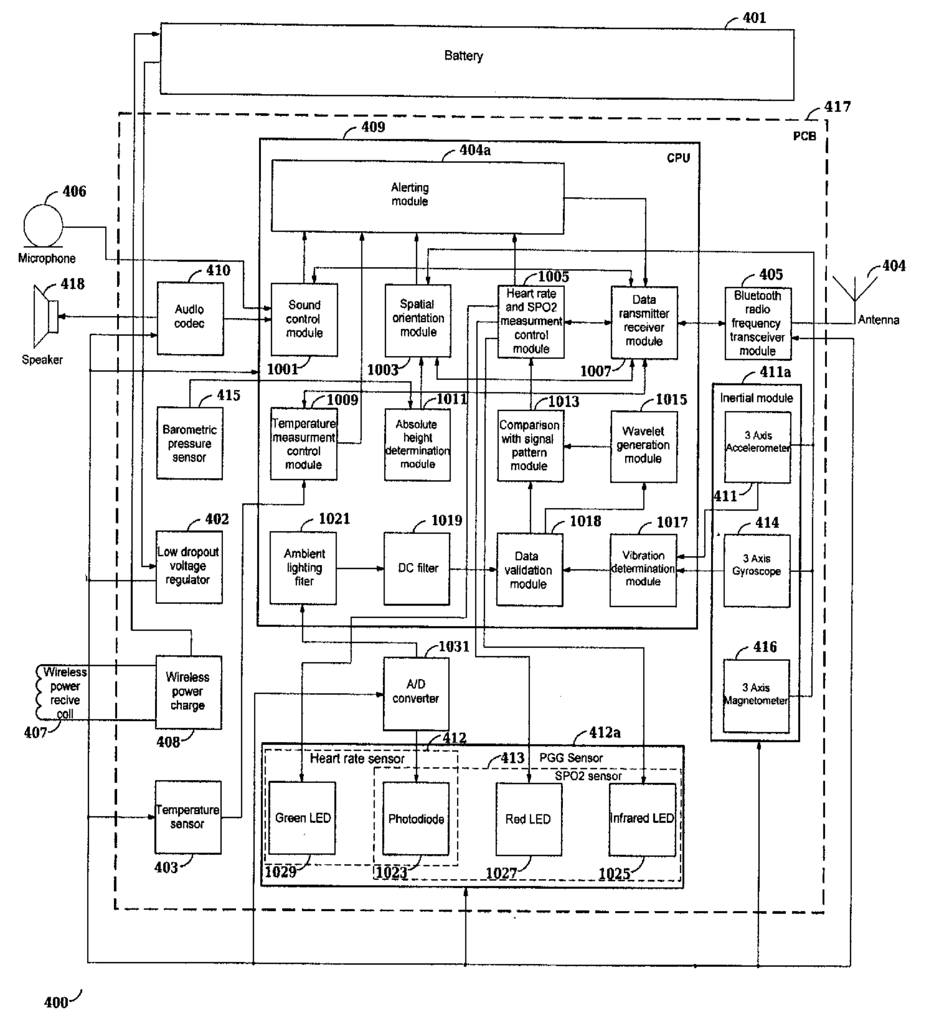
(57) **ABSTRACT**

A wearable telemetry device for monitoring a target object, for example, a baby, includes a strap and an enclosure that encloses components including a processor, sensors, an audio capture device, an output device, and a rechargeable power unit. The processor executes modules of the wearable telemetry device for receiving user input data from a user device, facilitating communication between the target object and the user device via a transceiver, activating and controlling the sensors, the audio capture device, and the output device based on the user input data, filtering sensor data, computing monitoring indexes by processing health parameters, motion, and/or position of the target object detected by the sensors, in accordance with threshold data, ambient audio signals received by the audio capture device, and/or the user input data, and generating and transmitting alert notifications based on the monitoring indexes to the target object, and/or the user device via the transceiver.



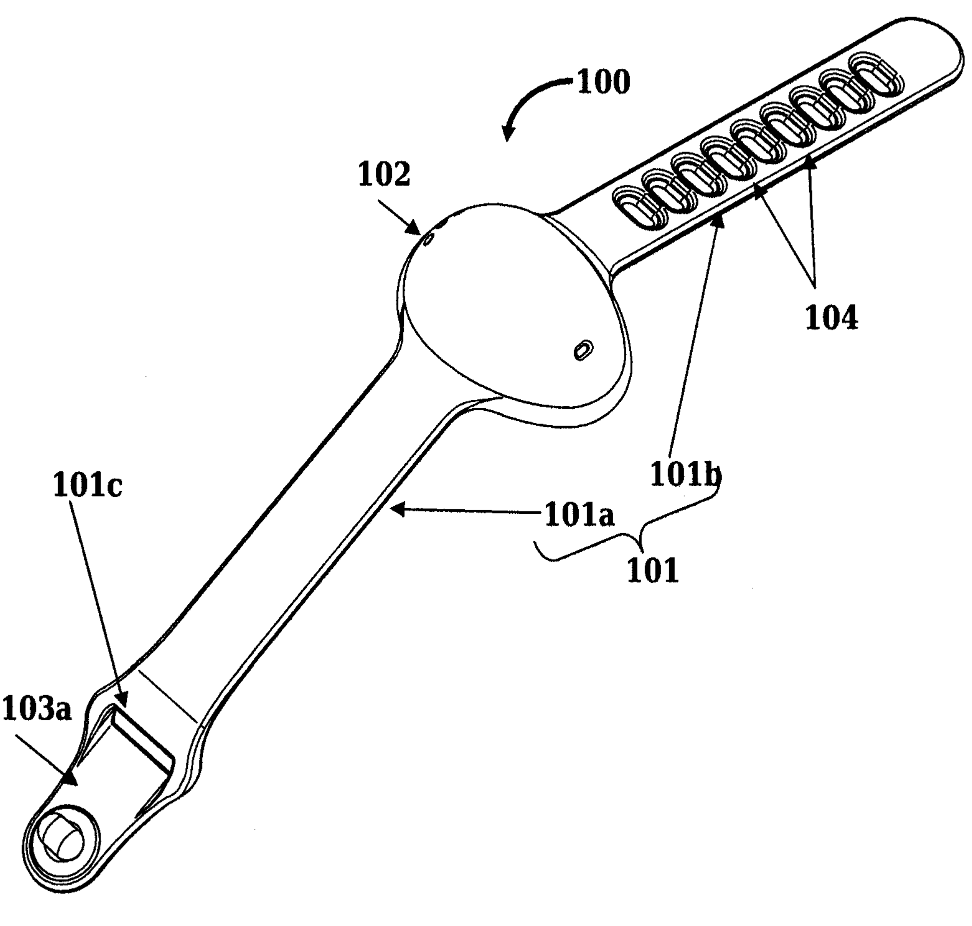


FIG. 1A

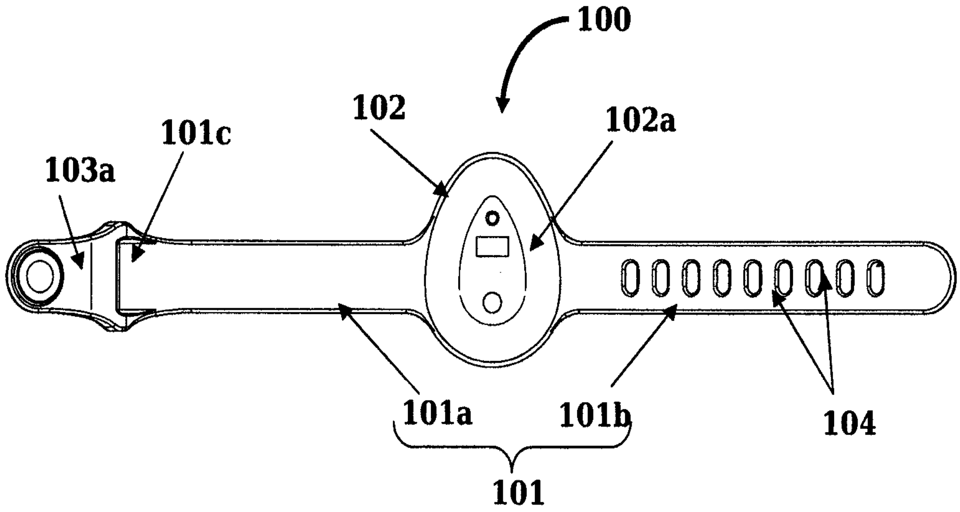


FIG. 1B

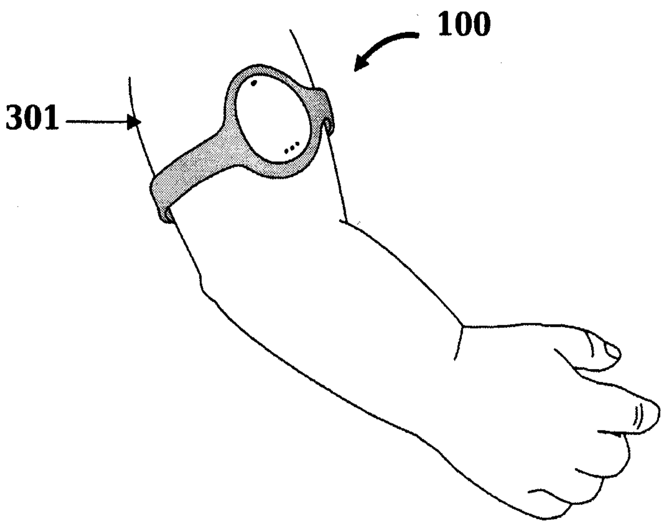


FIG. 2

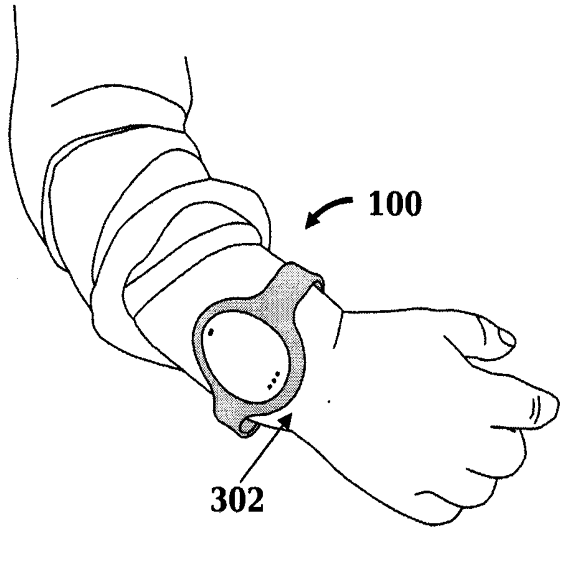


FIG. 3

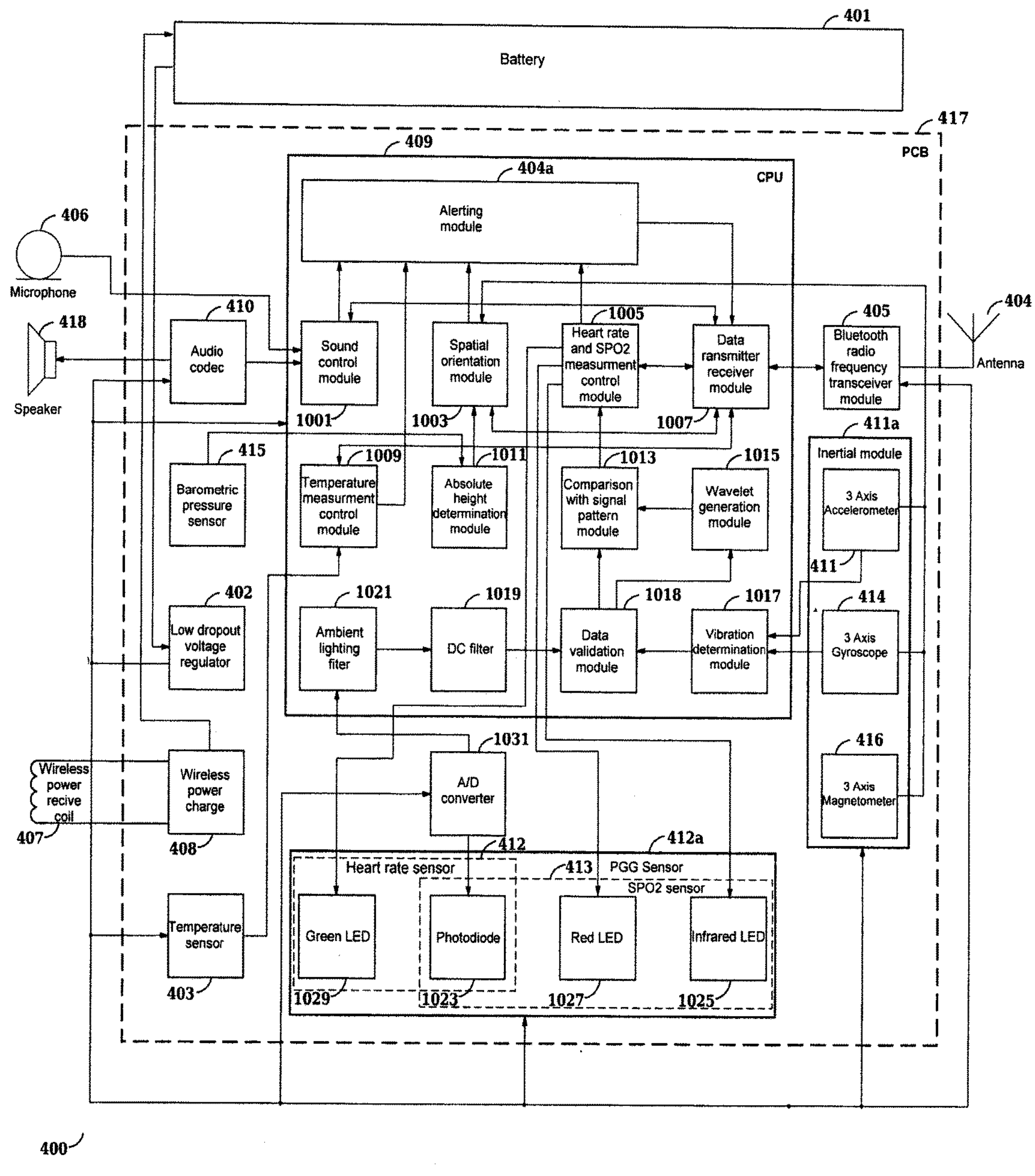

401
Battery
417
PCB
409
CPU
404a
Alerting module
406
Microphone
418
Speaker
410
Audio codec
Sound control module
1001
Spatial orientation module
1003
1005
Heart rate and SPO2 measurment control module
Data ransmitter receiver module
1007
405
Bluetooth radio frequency transceiver module
404
Antenna
415
Barometric pressure sensor
1009
Temperature measurment control module
1011
Absolute height determination module
1013
Comparison with signal pattern module
1015
Wavelet generation module
411a
Inertial module
3 Axis Accelerometer
411
402
Low dropout voltage regulator
1021
Ambient lighting fiter
1019
DC filter
1018
Data validation module
1017
Vibration determination module
414
3 Axis Gyroscope
416
3 Axis Magnetometer
1031
A/D converter
Wireless power recive coil
407
Wireless power charge
408
412
412a
Heart rate sensor
413
PGG Sensor
SPO2 sensor
Green LED
Photodiode
Red LED
Infrared LED
1029
1023
1027
1025
Temperature sensor
403
400

FIG. 4

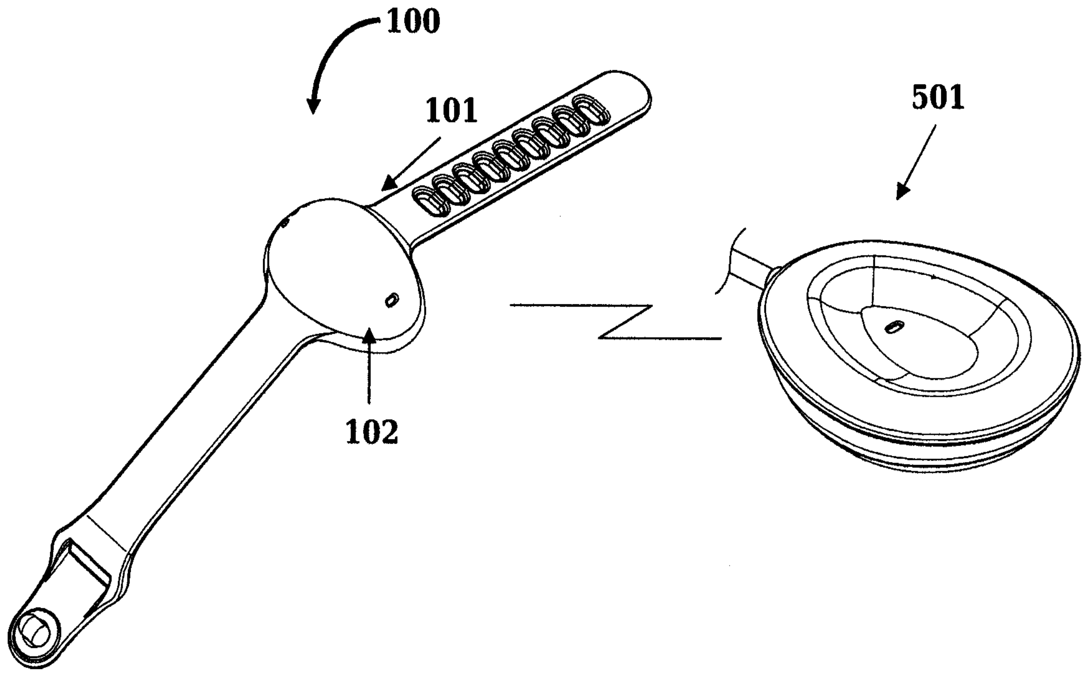


FIG. 5

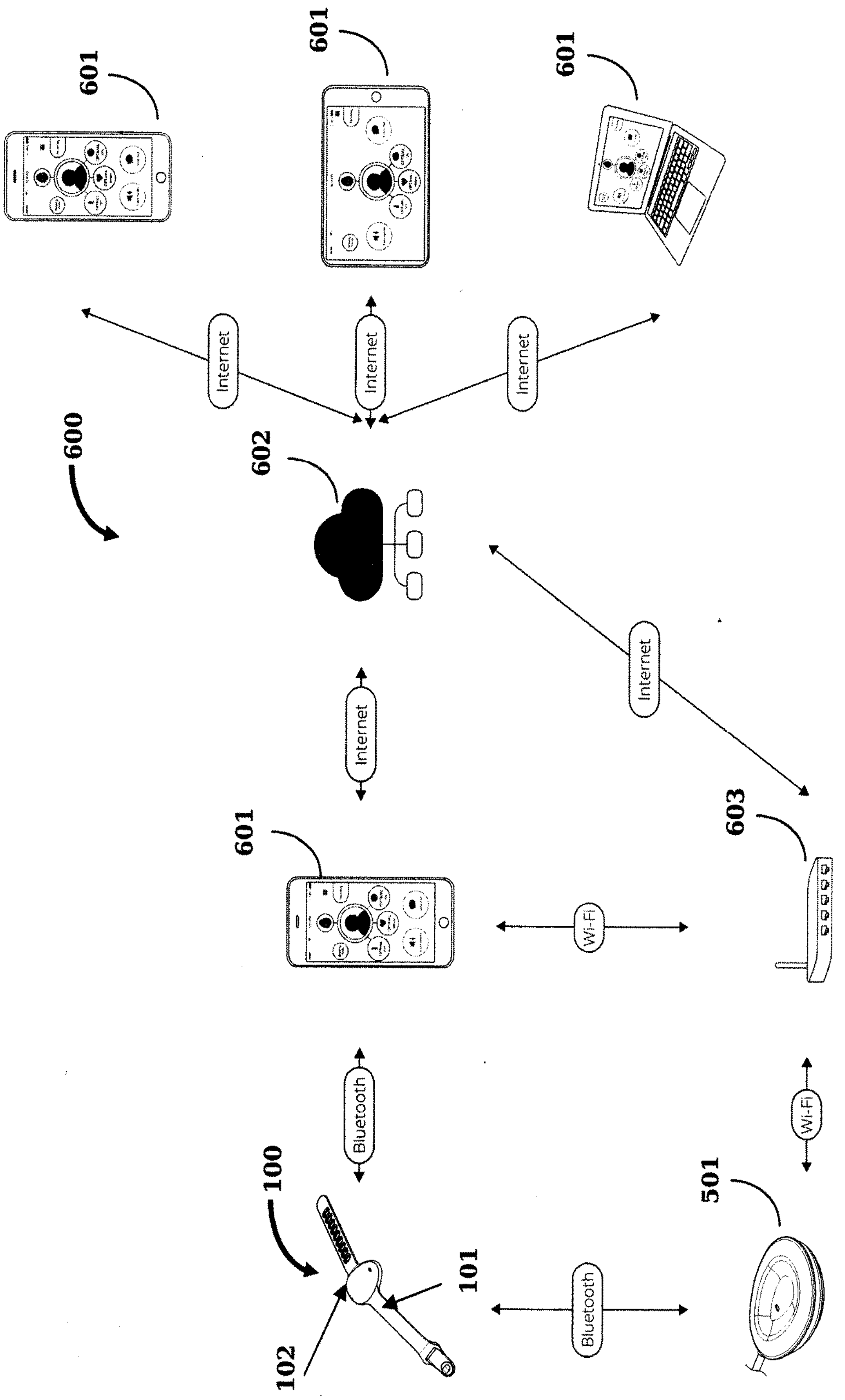
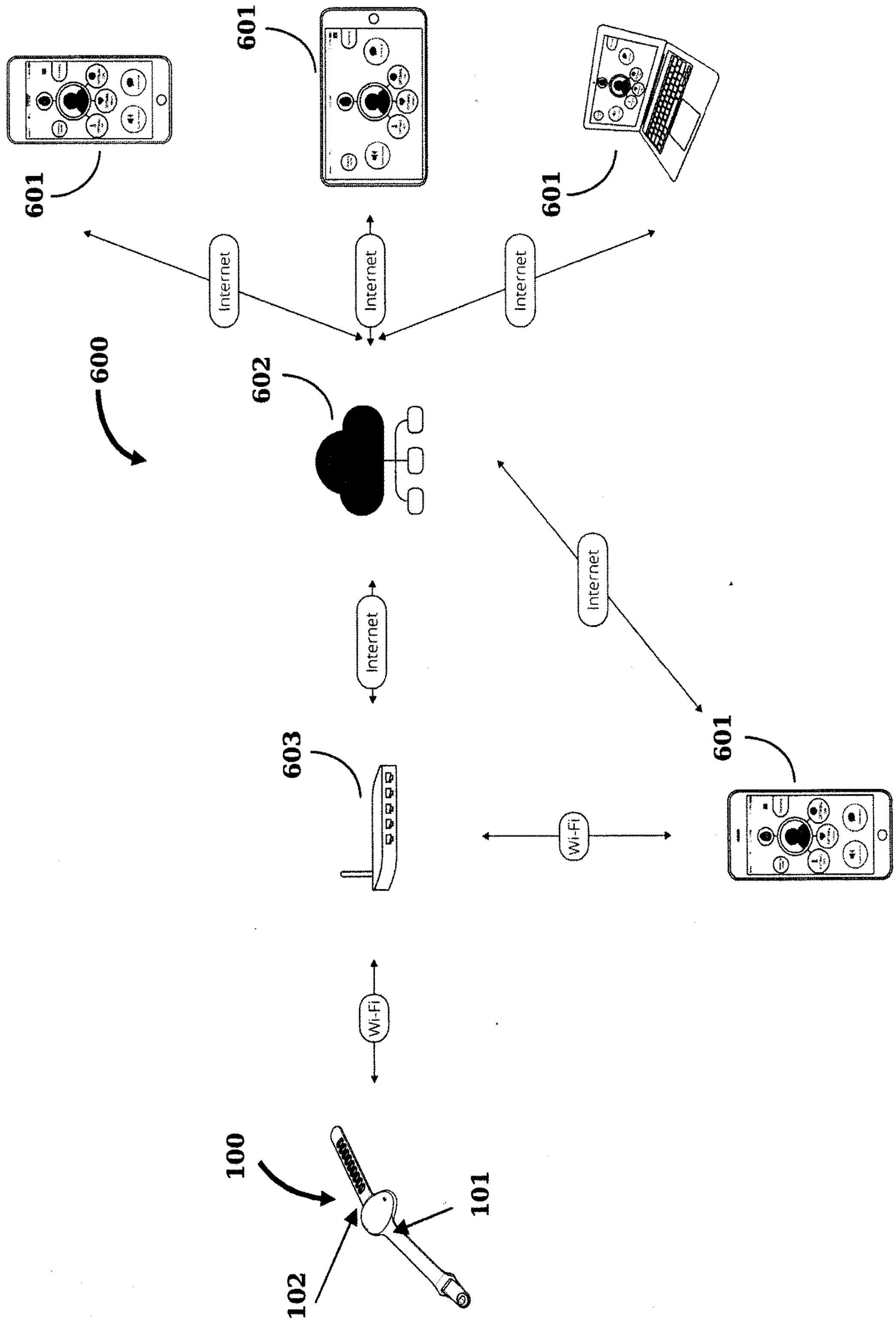

601
601
601
Internet
Internet
Internet
600
602
Internet
Internet
601
603
Wi-Fi
Bluetooth
Wi-Fi
100
101
102
Bluetooth
501

FIG. 6



600
601
601
601
601
602
603
Internet
Internet
Internet
Internet
Internet
Wi-Fi
Wi-Fi
100
101
102

FIG. 7

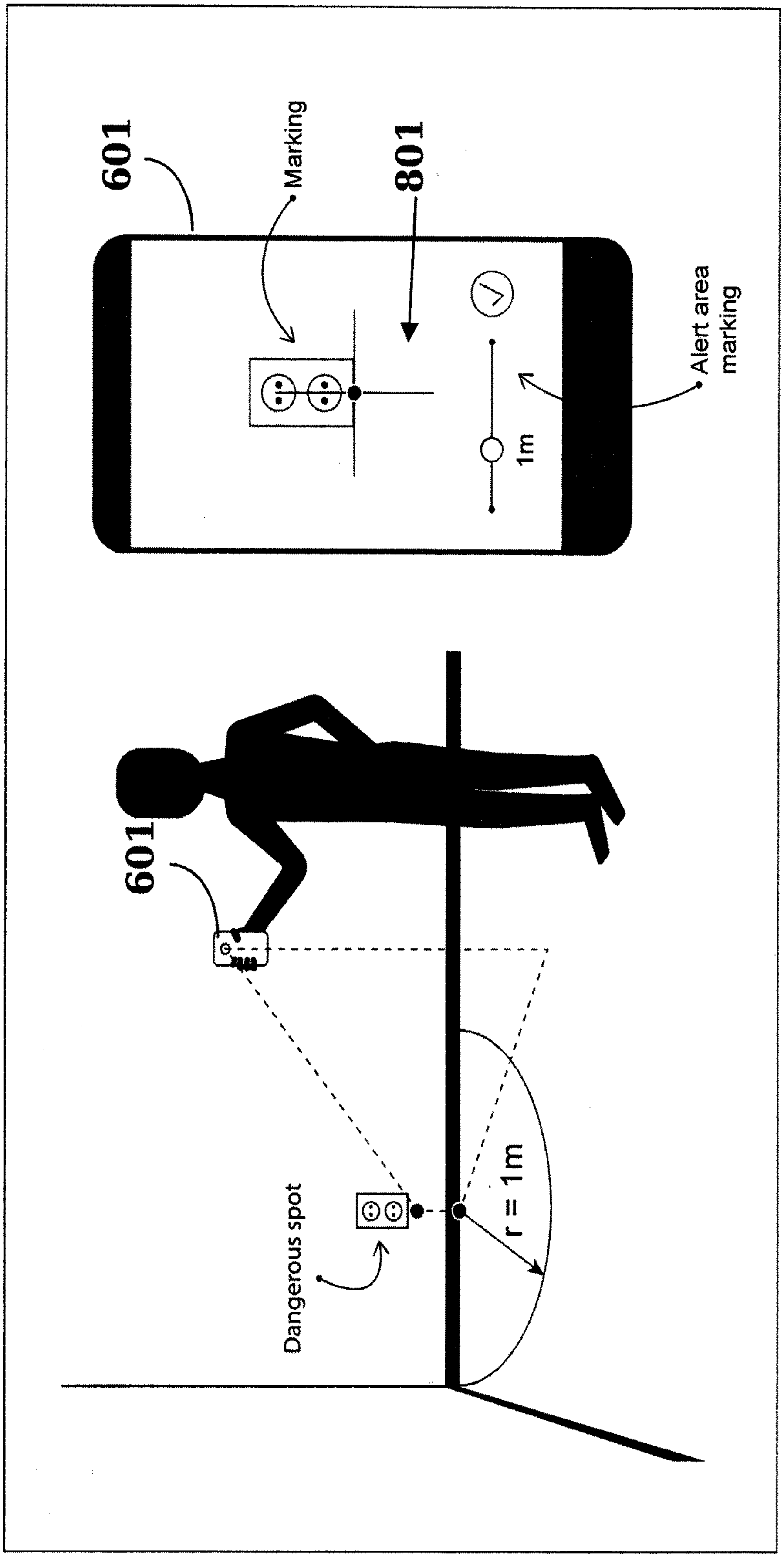

601
Marking
801
Alert area marking
1m
601
Dangerous spot
r = 1m

FIG. 8A

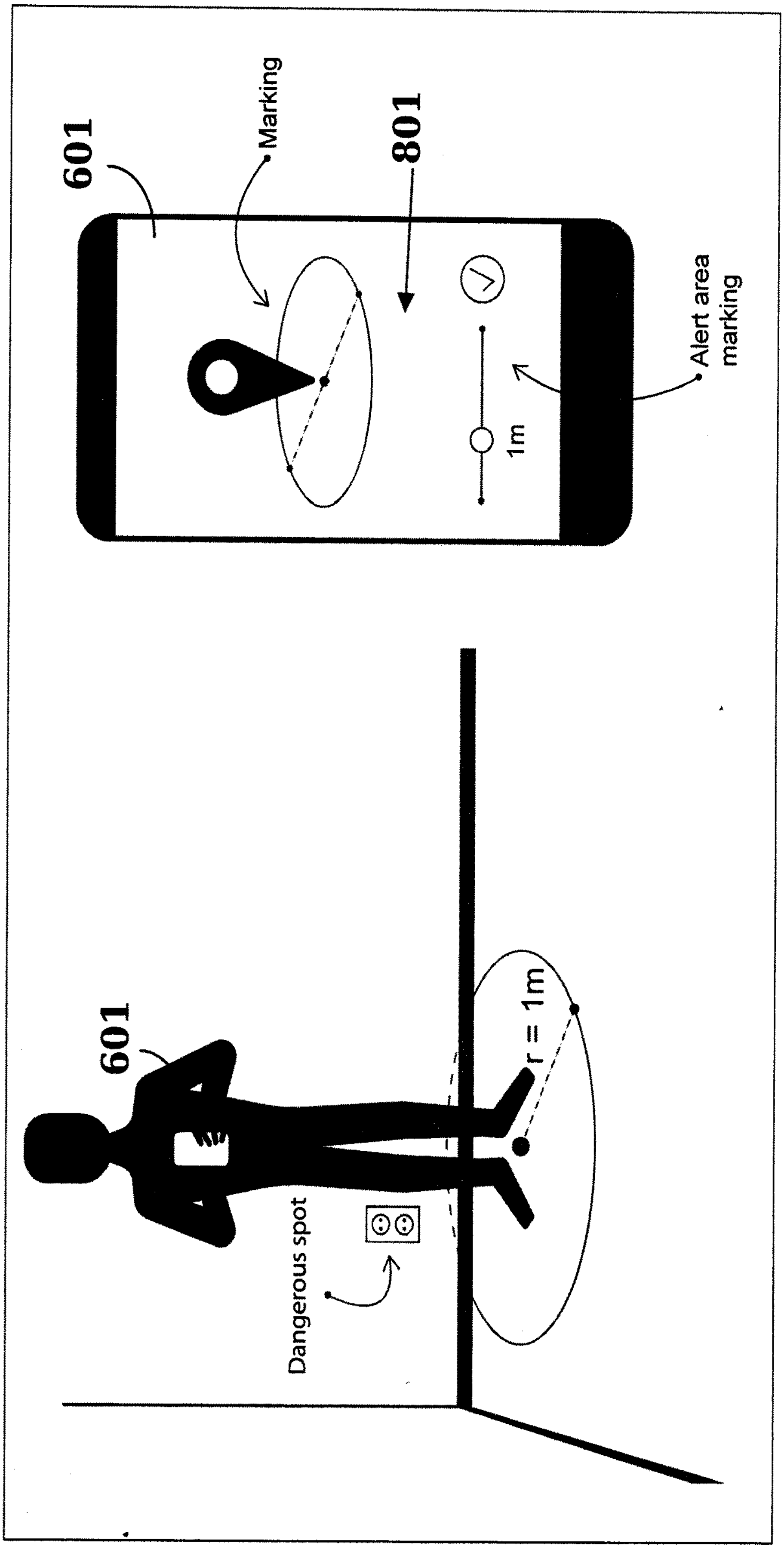

601
Marking
801
Alert area marking
1m
601
r = 1m
Dangerous spot

FIG. 8B

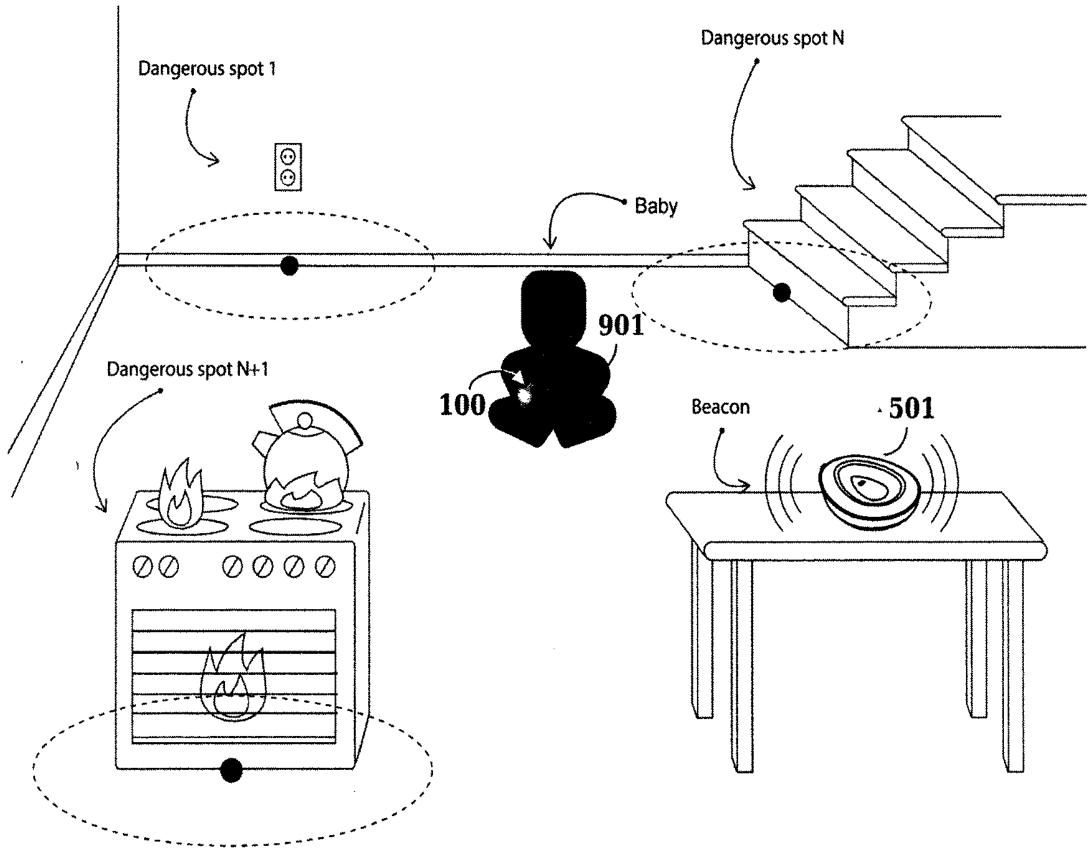

Dangerous spot 1
Dangerous spot N
Baby
901
Dangerous spot N+1
100
Beacon
501

FIG. 9

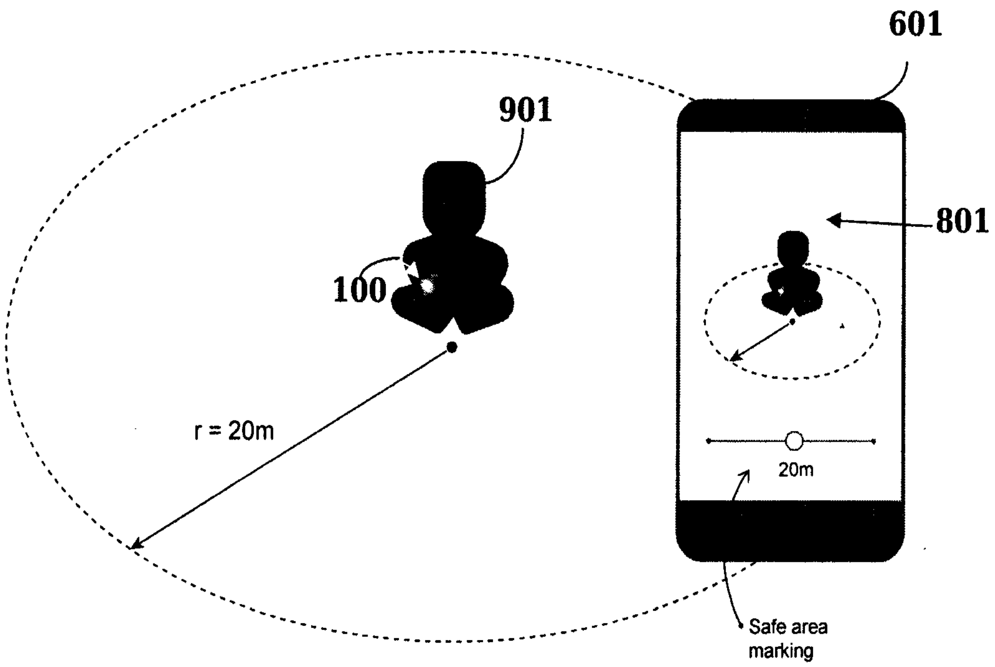


FIG. 10

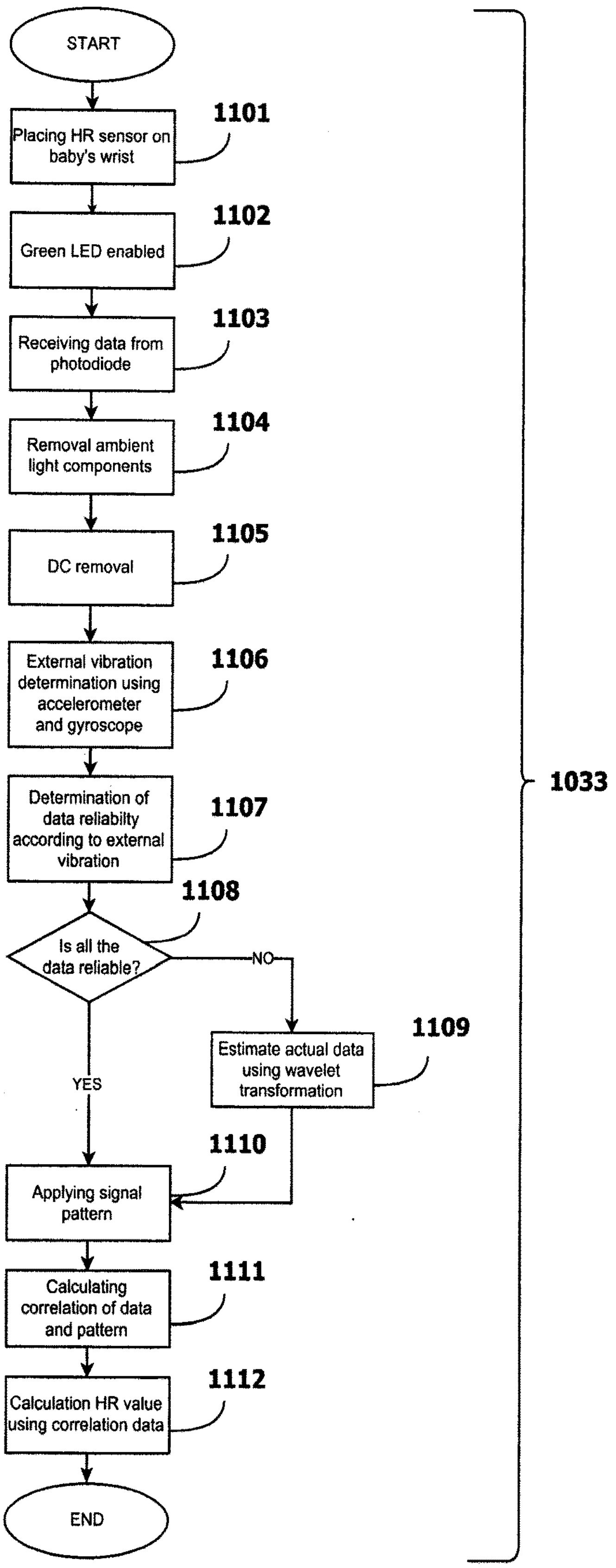

START
Placing HR sensor on baby's wrist
1101
Green LED enabled
1102
Receiving data from photodiode
1103
Removal ambient light components
1104
DC removal
1105
External vibration determination using accelerometer and gyroscope
1106
Determination of data reliabilty according to external vibration
1107
Is all the data reliable?
1108
NO
Estimate actual data using wavelet transformation
1109
YES
Applying signal pattern
1110
Calculating correlation of data and pattern
1111
Calculation HR value using correlation data
1112
END
1033

FIG. 11

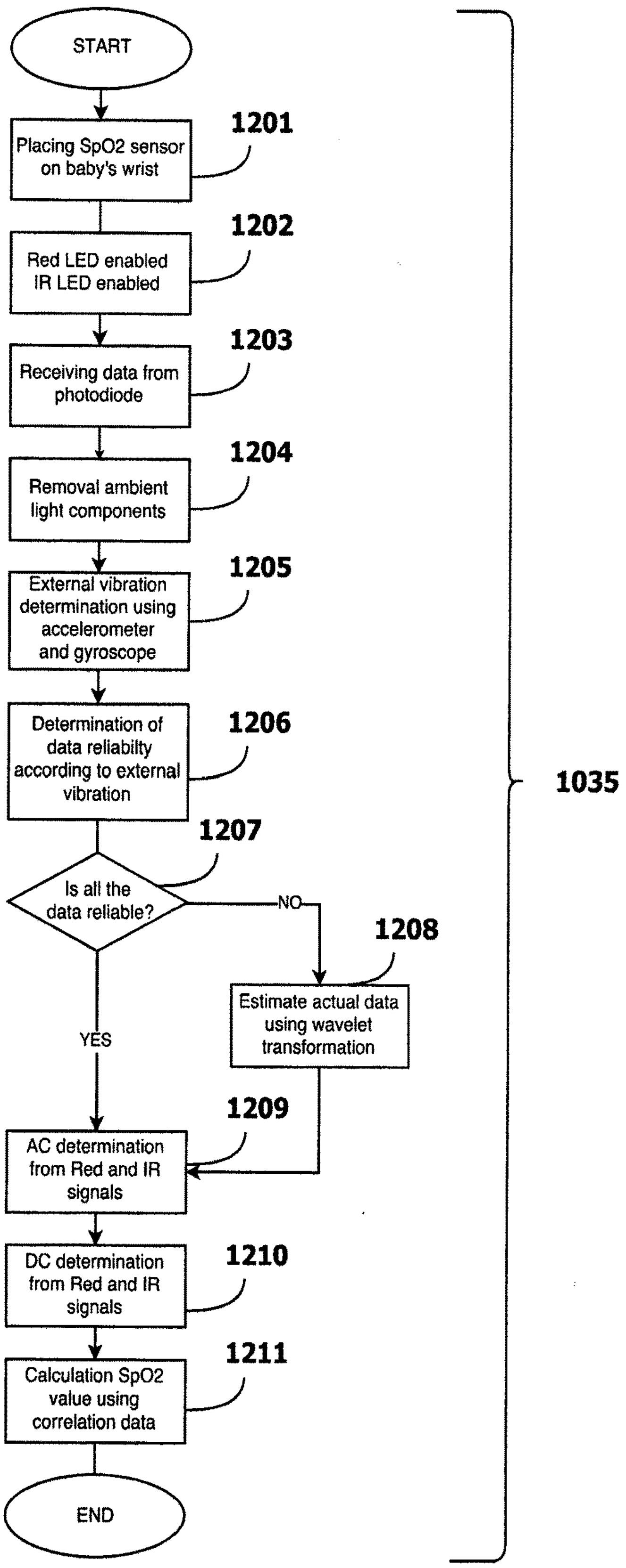

START
Placing SpO2 sensor on baby's wrist
1201
Red LED enabled IR LED enabled
1202
Receiving data from photodiode
1203
Removal ambient light components
1204
External vibration determination using accelerometer and gyroscope
1205
Determination of data reliabilty according to external vibration
1206
Is all the data reliable?
1207
NO
Estimate actual data using wavelet transformation
1208
YES
AC determination from Red and IR signals
1209
DC determination from Red and IR signals
1210
Calculation SpO2 value using correlation data
1211
END
1035

FIG. 12

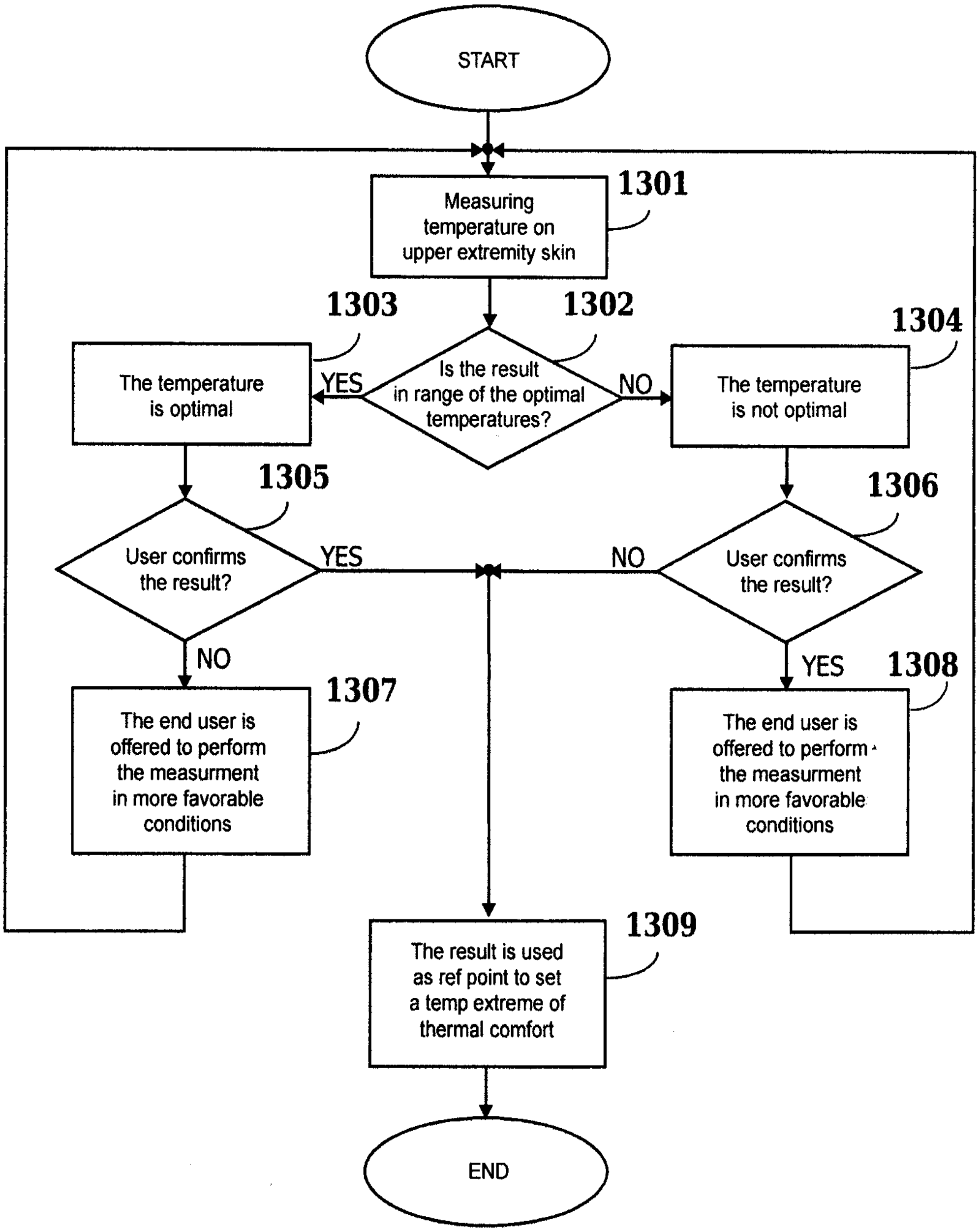

START
Measuring temperature on upper extremity skin
1301
1303
1302
1304
Is the result in range of the optimal temperatures?
YES
NO
The temperature is optimal
The temperature is not optimal
1305
1306
User confirms the result?
YES
NO
User confirms the result?
NO
YES
1307
1308
The end user is offered to perform the measurment in more favorable conditions
The end user is offered to perform the measurment in more favorable conditions
1309
The result is used as ref point to set a temp extreme of thermal comfort
END

FIG. 13

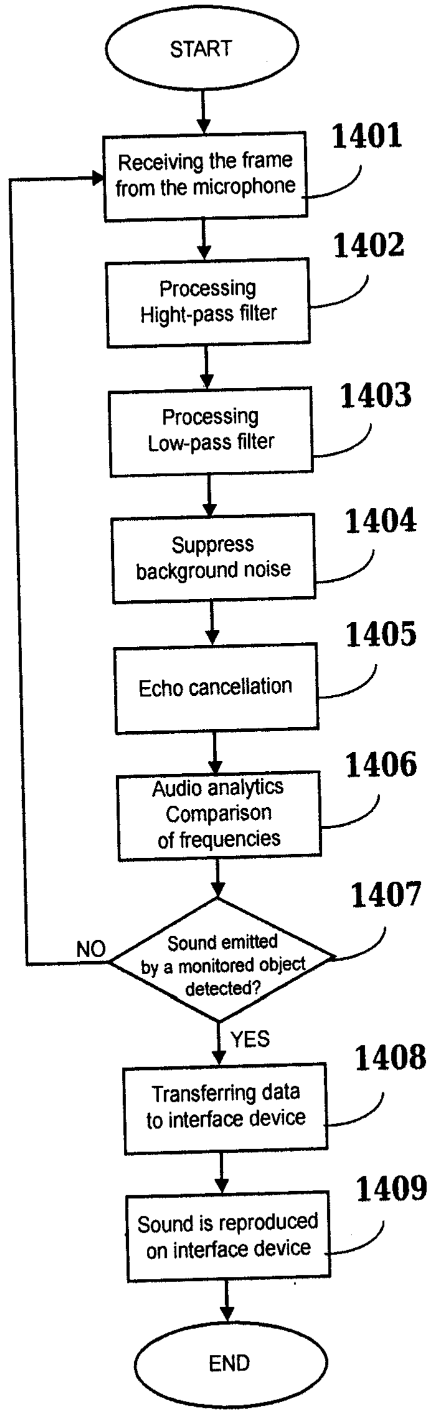

START
Receiving the frame from the microphone
1401
Processing Hight-pass filter
1402
Processing Low-pass filter
1403
Suppress background noise
1404
Echo cancellation
1405
Audio analytics Comparison of frequencies
1406
Sound emitted by a monitored object detected?
1407
NO
YES
Transferring data to interface device
1408
Sound is reproduced on interface device
1409
END

FIG. 14

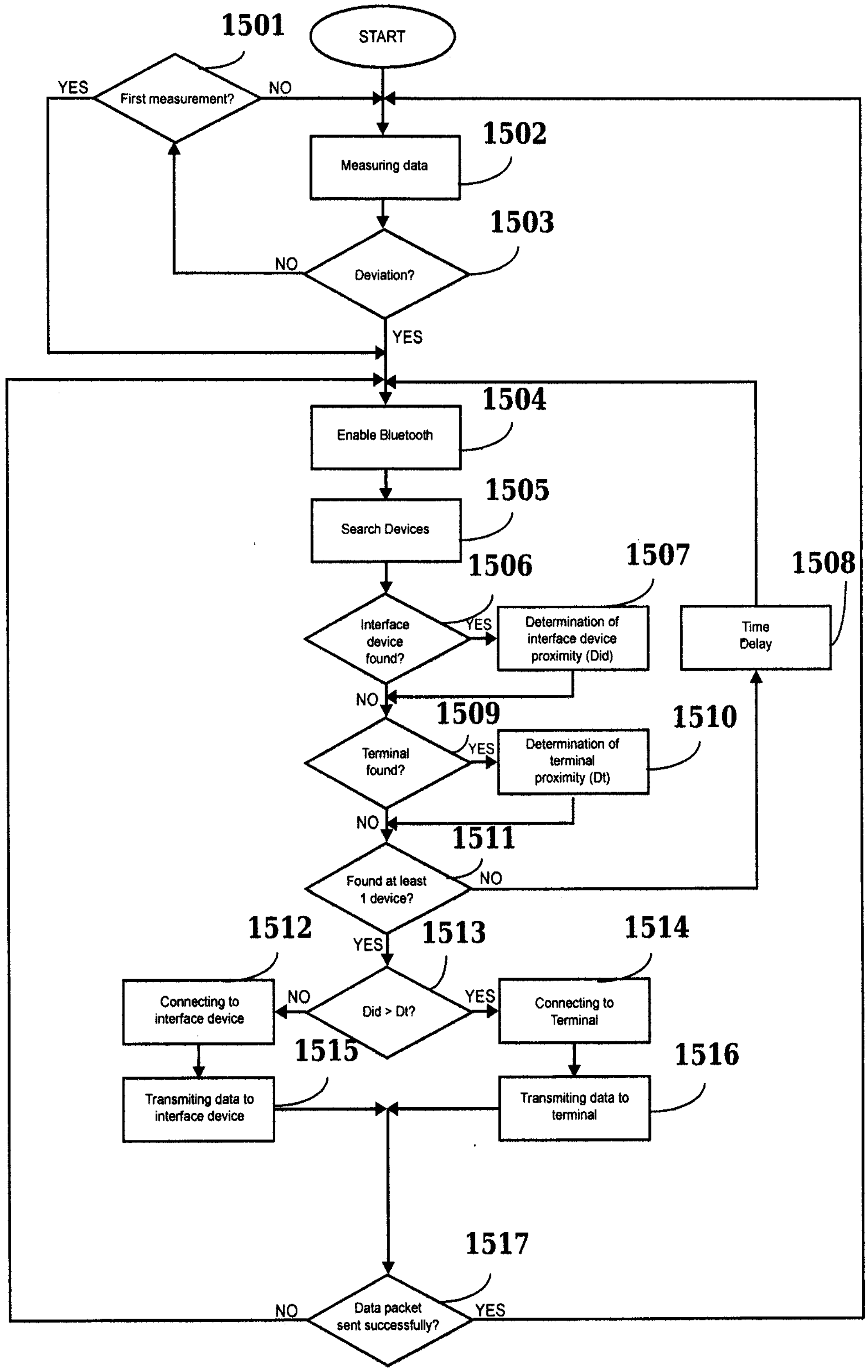

START
1501
First measurement?
YES
NO
1502
Measuring data
1503
Deviation?
NO
YES
1504
Enable Bluetooth
1505
Search Devices
1506
Interface device found?
YES
NO
1507
Determination of interface device proximity (Did)
1508
Time Delay
1509
Terminal found?
YES
NO
1510
Determination of terminal proximity (Dt)
1511
Found at least 1 device?
NO
YES
1512
Connecting to interface device
1513
Did > Dt?
NO
YES
1514
Connecting to Terminal
1515
Transmiting data to interface device
1516
Transmiting data to terminal
1517
Data packet sent successfully?
NO
YES

FIG. 15

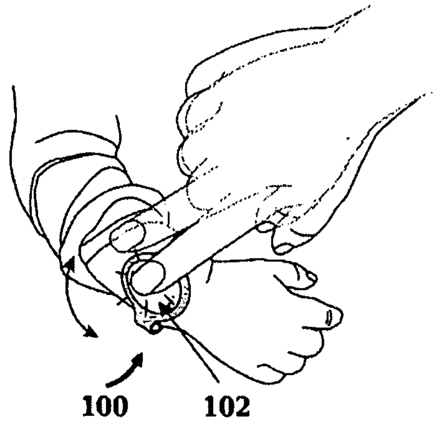

100
102

FIG. 17

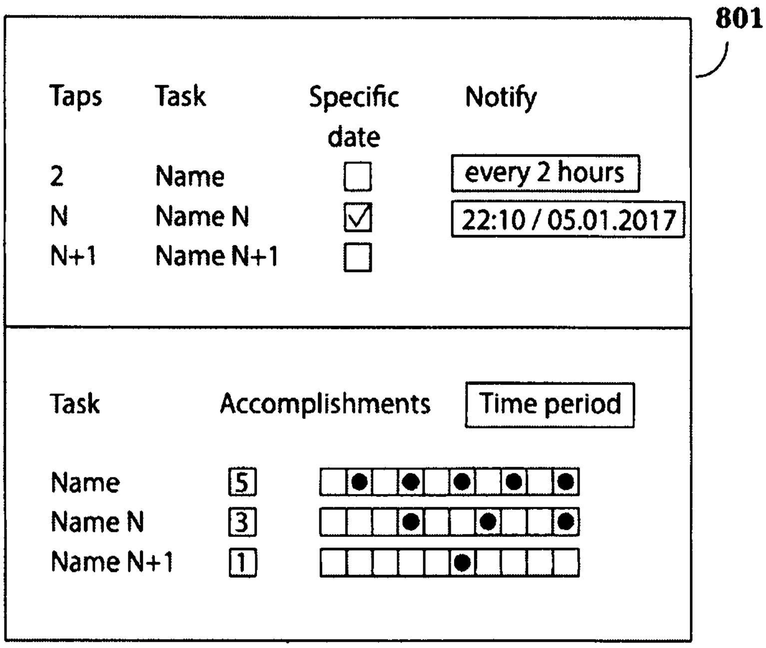

801
Taps
Task
Specific date
Notify
2
Name
every 2 hours
N
Name N
22:10 / 05.01.2017
N+1
Name N+1
Task
Accomplishments
Time period
Name
5
Name N
3
Name N+1
1

FIG. 18

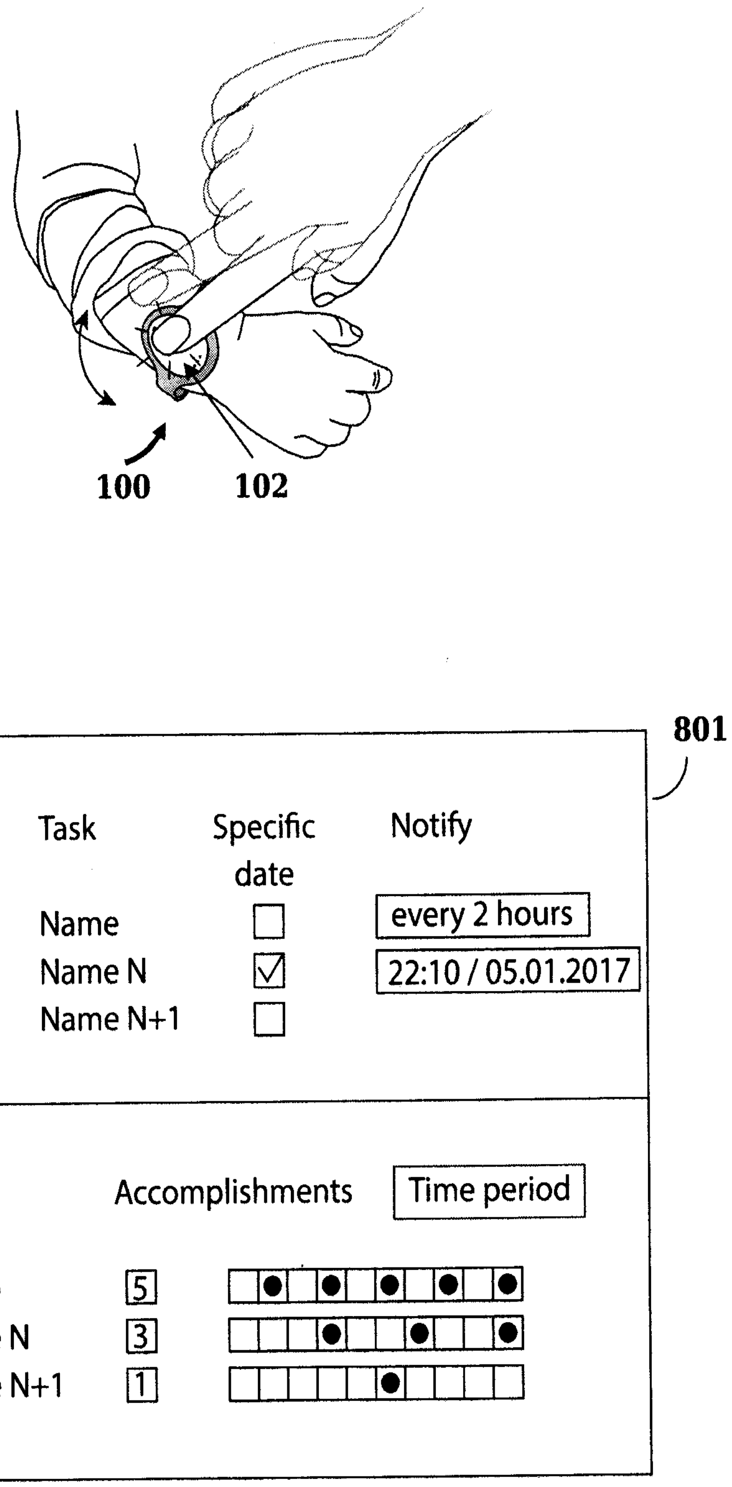

100
102
801
Taps
Task
Specific date
Notify
2
Name
every 2 hours
N
Name N
22:10 / 05.01.2017
N+1
Name N+1
Task
Accomplishments
Time period
Name
5
Name N
3
Name N+1
1

FIG. 17

SYSTEM AND METHOD FOR TELEMETRICALLY MONITORING A TARGET OBJECT

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The system and method disclosed herein, in general, relate to telemetry. More particularly, the system and method disclosed herein relate to a wearable telemetry device, and more specifically, to a system and method for monitoring a target object, for example, a baby.

Description of the Related Art

[0002] Systems and methods for telemetrically monitoring target objects, such as adult patients, children, babies, or infants are known in the art.

[0003] For example, U.S. Pat. No. 7,364,539 issued to M. Mackin on Apr. 29, 2008 discloses an infant warming apparatus for supporting an infant upon an infant bed. The apparatus has a sensor that is affixed to the skin of the infant to detect one or more physiological functions of the infant. A transmitter is located within the enclosure of the sensor which transmits the information detected by the physiological sensor to a receiver that is located on the infant care apparatus and which can then convert that information into a recognizable or usable medium. An alternative embodiment includes the transmitter located proximate to the infant within an infant scale located beneath the infant. The sensor is hardwired to the transmitter in the infant scale and signals relating to weight and/or a condition of the infant are transmitted by wireless telemetry to a monitor or other display device to display that information to the caregiver.

[0004] U.S. Pat. No. 9,028,405 issued on May 12, 2015 to Bao Tran discloses a system that includes a processor; a cellular Wi-Fi, or Bluetooth® transceiver coupled to the processor; an accelerometer or a motion sensor coupled to the processor; and a sensor coupled to the processor to sense mood, wherein text, image, sound, or video is rendered in response to the sensed mood. Among other parameters, the system controls and monitors a heart rate, a blood pressure, heart beat sounds, bio-electric impedance, etc. The system may also include an accelerometer to detect a dangerous condition such as a falling condition and to generate a warning when the dangerous condition is detected. An electrode or electrodes of the sensor mounted on the mobile telephone case may be used to contact the person's skin and capture bio-electrical signals, and the amplifier coupled to the electrodes, a processor coupled to the amplifier, and a screen coupled to the processor allow to display medical data such as images of the bio-electrical signals.

[0005] U.S. Pat. No. 5,652,570 issued on Jul. 29, 1997 to R. Lepkofker discloses an interactive individual location and monitoring system includes a central monitoring system for maintaining health, location, and other data with respect to an individual. A watch unit carried by the individual receives medical and other information selected by and inputted directly from the individual. The watch unit broadcasts the medical and other information locally by radio in a region near the individual. Preferably, the present invention includes an embodiment which also monitors vital signs of a user. The pod unit includes a triaxial accelerometer for gathering acceleration data for transmission of the data to the central monitoring station for analysis at a later time. The central monitoring system broadcasts alerts and queries directed to the individual and the transponder pod unit receives and rebroadcasts the alerts and queries locally. The watch unit receives the alerts and queries, and the watch unit includes a vibratory annunciator which alerts the individual of an inquiry signal from the pod unit.

[0006] German Patent No DE 10352591 issued on Jun. 16, 2005 to Anja Falk, et al. discloses a device for monitoring vital parameters, especially of baby. The device, has wireless data transmission module; sensors, signal processing unit; transmission module and power supply unit which are integrated into a watch in miniaturized form. The device incorporates measurement of vital signs.

[0007] Although the list of such examples may be continued with reference to many other similar devices and methods, there is still enough room for improvement since in many cases such devices do not take into account automatic corrections of wrong data and do not convert data between various conversion protocols. Also, in a majority of cases, monitoring devices for individuals relate to adult patients or to infants whose motions are restricted by a bed or fencing. However, a baby who is about two years old is normally very mobile and requires extremely cautious watching. The baby's skin is thin, and this allows to obtain accurate measurement of vital parameters through skin contact. Nevertheless, the inventions relating to telemetric monitoring of children in this category are few in number and are still on a demand.

SUMMARY OF THE INVENTION

[0008] Disclosed herein is a wearable telemetry device and method for monitoring a target object, for example, a baby. The wearable telemetry device comprises a strap and an enclosure. The strap is wearable by the target object. The strap comprises a cavity positioned at a preconfigured location, for example, a central location of the strap. The enclosure is detachably positioned within the cavity of the strap. The enclosure encloses multiple telemetry device components therewith in. The telemetry device components comprise at least one processor, multiple sensors, an audio capture device, a non-transitory computer readable storage medium, an output device, and a rechargeable power unit. The sensors and the audio capture device are communicatively coupled to the processor. The sensors generate sensor data by detecting health parameters, and/or motion, and/or position of the target object. The audio capture device receives ambient audio signals. The non-transitory computer readable storage medium stores the generated sensor data, the received ambient audio signals, threshold data, preconfigured media data, and instructions defined by modules of the wearable telemetry device.

[0009] The processor of the wearable telemetry device is communicatively coupled to the non-transitory computer readable storage medium and operably coupled to a transceiver. The processor executes one or more computer program instructions defined by the modules of the wearable telemetry device. The modules of the wearable telemetry device comprise data communication modules, control modules, data processing modules, and an alerting module. The data communication module receives user input data from a monitoring application deployed on one or more user devices via the transceiver and facilitates communication between the target object and the user devices via the transceiver. The control module activates and controls operability and sensitivity of the sensors, and/or the audio capture device, and/or the output device based on the received user input data. The data processing module filters the sensor data generated by the activated sensors and computes monitoring indexes by processing the detected health parameters, and/or the motion, and/or the position of the target object from the filtered data in accordance with the threshold data, and/or the received ambient audio signals, and/or the received user input data. The alerting module generates alert notifications in multiple formats based on the computed monitoring indexes and transmits the generated alert notifications to the target object and/or the user devices via the transceiver. The output device is communicatively coupled to the processor and the transceiver via a codec. The output device plays the preconfigured media data and/or the data received from the processor and/or the transceiver via the codec. The rechargeable power unit is operably coupled to the processor, the transceiver, the sensors, the audio capture device, and the output device for powering the processor, the transceiver, the sensors, the audio capture device, and the output device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1**A exemplarily illustrate perspective views of a wearable telemetry device for monitoring a target object.

[0011] FIG. **1**B exemplarily illustrates a bottom view of the wearable telemetry device for monitoring a target object.

[0012] FIG. **2** exemplarily illustrates a perspective view of the wearable telemetry device positioned on an arm of a target object.

[0013] FIG. **3** exemplarily illustrates a perspective view of the wearable telemetry device positioned on a wrist of a target object.

[0014] FIG. **4** exemplarily illustrates a block diagram showing telemetry device components of the wearable telemetry device.

[0015] FIG. **5** exemplarily illustrates wireless communication between the wearable telemetry device and a base station.

[0016] FIG. **6** exemplarily illustrates a system for monitoring a target object, showing wireless communication between the wearable telemetry device, the base station, and multiple user devices.

[0017] FIG. **7** exemplarily illustrates a modification of the system for monitoring a target object, showing wireless communication between the wearable telemetry device and multiple user devices.

[0018] FIGS. **8**A-**8**B exemplarily illustrate configuration of dangerous spots in a region using a monitoring application deployed on a user device for monitoring a target object.

[0019] FIG. **9** exemplarily illustrates monitoring of a target object in an environment with dangerous spots identified using a monitoring application deployed on a user device.

[0020] FIG. **10** exemplarily illustrates monitoring of a target object in an environment with a safe area identified using a monitoring application deployed on a user device.

[0021] FIG. **11** exemplarily illustrates a flowchart comprising the steps of determining a heart rate of a target object using a heart-rate output data determination and a correlation block of the wearable telemetry device.

[0022] FIG. **12** exemplarily illustrates a flowchart comprising the steps of determining an oxygen saturation level in the blood of a target object using an output SPO2 value determination and correlation block of the wearable telemetry device.

[0023] FIG. **13** exemplarily illustrates a flowchart comprising the steps for determining a reference point to set a temperature extreme of thermal comfort of a target object using the wearable telemetry device worn by the target object.

[0024] FIG. **14** exemplarily illustrates a flowchart comprising the steps for reproducing sound of a target object on a user device using the wearable telemetry device worn by the target object.

[0025] FIG. **15** exemplarily illustrates a flowchart comprising the steps for initiating wireless transmission of sensor data to a user device or the base station proximal to the wearable telemetry device via a wireless communication protocol based on a deviation found in the sensor data.

[0026] FIG. **16** exemplarily illustrates a flowchart comprising the steps for transmitting alert notifications to a user device or the base station on determining a deviation of measured data from threshold data.

[0027] FIG. **17** exemplarily illustrates confirmation of task accomplishment by a user by tapping on the enclosure of the wearable telemetry device.

[0028] FIG. **18** exemplarily illustrates a screenshot that is provided by the monitoring application deployed on the user device for setting up tasks and tracking task accomplishment and that graphically represents user's experience.

DETAILED DESCRIPTION

[0029] FIG. **1**A exemplarily illustrates a perspective view of a wearable telemetry device **100** of the invention for monitoring a target object. As used herein, the term "target object" refers to an entity, for example, a child, e.g., a baby up to two years of age who is monitored using the wearable telemetry device **100**. The wearable telemetry device may have, e.g., the following dimensions: 13 mm×30 mm×22 mm. The wearable telemetry device **100** comprises a strap **101** and an enclosure **102**. The strap **101** is wearable by the target object, for example, on a wrist or an arm. The strap **101** comprises two parts **101***a* and **101***b*. The enclosure **102** encloses multiple telemetry device components disclosed in the detailed description below and shown schematically in FIG. **4**. The strap **101** may be embedded into the enclosure forming with the wearable telemetry device **100** an integral non-divisible structure. The wearable telemetry device **100** can be securely fastened on an arm or a wrist of the target object. The wearable telemetry device **100** further comprises a clasp **103***a* positioned on one end **101***c* of the part **101***a* of the strap **101** and openings **104** configured on the part **101***b* of the strap **101**. The clasp **103***a* on the part **101***a* of the strap **101** is constructed to engage and lock the openings **104** on the part **101***b* of the strap **101** to prevent, for example, a baby from unlocking the wearable telemetry device **100** without parental supervision. The wearable telemetry device **100** disclosed herein can be used indoors and outdoors.

[0030] FIG. **1**B exemplarily illustrates a bottom view of the wearable telemetry device **100** for monitoring parameters of the target object, for example, a baby. A bottom portion **102***a* of the enclosure **102** of the wearable telemetry device **100** is exposed for contact with the target object surface, for example, the skin of the baby for detecting health parameters of the baby. The parameters of the target object include "health parameters", which herein comprise vital signs, for example, heart rate, body surface temperature, blood oxygen level, blood pressure, breathing rate, etc. The wearable telemetry device **100** allows remote monitoring of the health parameters. The wearable telemetry device **100** is independent of stationary power sources.

[0031] The enclosure **102** is a sealed capsule containing the telemetry device components. The enclosure **102** is, for example, about 30 mm long and 25.4 inch wide. According to one aspect of the invention, the enclosure **102** encloses a set of miniature sensors for measuring health parameters, position, motion, etc., of the target object, and a transceiver that exchanges data with external devices. The enclosure **102** is configured, for example, as a durable, waterproof, and heat resistant enclosure with complete electronic isolation for ensuring safety of the target object. The enclosure **102** is made of soft, breathable, hypoallergenic, and eco-friendly materials for further ensuring safety of the target object. The enclosure **102** is made of, for example, sanitary rubber, polyvinyl chloride, a fluoroelastomer, etc. The enclosure **102** is securely fastened within the cavity of the strap **101** of the wearable telemetry device **100** illustrated in FIG. 1A.

[0032] FIG. **2** exemplarily illustrates a perspective view of the wearable telemetry device **100** positioned on an arm **301** of a target object, for example, a baby. According to one modification of the invention, dimensions of the wearable telemetry device **100** are configured for positioning the wearable telemetry device **100** on a limited area of the target object's body part, for example, the baby's arm **301** for measuring the baby's vital signs.

[0033] FIG. **3** exemplarily illustrates a perspective view of the wearable telemetry device **100** positioned on a wrist **302** of a target object, for example, a baby. According to one or several aspects of the invention, dimensions of the wearable telemetry device **100** are configured for positioning the wearable telemetry device **100** on a limited area of a target object's body part, for example, a baby's wrist **302**, as the wrist **302** is an optimal location for positioning the wearable telemetry device **100** for measuring the baby's vital signs.

[0034] FIG. **4** exemplarily illustrates a block diagram showing the telemetry device components **400** of the wearable telemetry device **100** exemplarily illustrated in FIGS. 1A-1B. The telemetry device components **400** are electronic components positioned within the enclosure **102** of the wearable telemetry device **100** exemplarily illustrated in FIGS. FIGS. **1A-1B** The telemetry device components **400** comprise at least one processor, for example, a central processing unit (CPU) **409**, a wireless communication unit, e.g., a Bluetooth® transceiver module **405**, multiple sensors, a codec, for example, an audio codec **410**, a self-contained power source which is a rechargeable power unit, for example, a battery **401**, a wireless power receiver coil **407**, a wireless power charge unit **408**, and a low dropout voltage regulator **402**. The CPU **409** is an element on which logic connections between other telemetry device components **400** are based. The CPU **409** is, for example, the ARM® Cortex®-M4 processor of ARM Limited. The transceiver **405** is communicatively coupled to an antenna **404**. The transceiver **405** performs radio wave exchange of data with external devices, for example, user devices. The transceiver **405** operates at a frequency of, for example, about 2.4 gigahertz (GHz) to about 2.4835 GHz. The transceiver **405** is configured to operate using a wireless communication protocol, for example, the Institute of Electrical and Electronics Engineers (IEEE) 802.15.1 Bluetooth® of Bluetooth Sig, Inc., or standard IEEE 802.11 Wi-Fi® of Wi-Fi Alliance Corporation. The transceiver **405** is, for example, a Bluetooth® 4.0 transceiver of Bluetooth Sig, Inc. The wearable telemetry device **100** implements software that enables connection and operation of the wearable telemetry device **100**, for example, in a home network and over Public Network Internet via the transceiver **405**. The transceiver **405**, the sensors, the audio codec **410**, the wireless power charge unit **408**, and the low dropout voltage regulator **402** are operably coupled to the CPU **409** on a multilayered printed circuit board (PCB) **417**. The multilayered PCB **417** serves as an assembly base for the telemetry device components **400** and conducts connections between the telemetry device components **400**. Modern means of designing and manufacturing are used to manufacture the multilayered PCB **417** and integrated circuits for the wearable telemetry device **100**.

[0035] The sensors are communicatively coupled to the central processing unit (CPU) **409**. The sensors generate sensor data by detecting health parameters, and/or motion, and/or position of a target object. The sensors comprise, for example, a temperature sensor **403**, a photoplethysmography sensor block **412*a*** that incorporates a pulse sensor **412** and an SpO2 sensor **413**, an inertial module **411*a*** that incorporates an accelerometer such as a 3-axis accelerometer **411**, a gyroscope such as a 3-axis gyroscope **414**, and a magnetometer **416**, a barometric pressure sensor **415**, etc., or any combination thereof. The temperature sensor **403** measures body surface temperature of the target object. According to one aspect of the invention, the wearable telemetry device **100** comprises two types of temperature sensors **403**, for example, a resistance thermometer and a pyrometer. The resistance thermometer operates based on a dependence of electric resistance of metals, alloys, and semiconductor materials on temperature. The pyrometer operates based on a change of power of a target object's thermal radiation in the spectra of infrared radiation and visible light. Depending on the configuration of the wearable telemetry device **100**, the wearable telemetry device **100** comprises the resistance thermometer and/or the pyrometer to increase accuracy of measurements. The temperature sensor **403** allows the wearable telemetry device **100** to perform an infrared non-invasive tracking of a thermal condition of the target object based on feedback of temperature fluctuations in the upper limbs of the target object. The wearable telemetry device **100** therefore provides useful information necessary to maintain a neutral thermal environment of the target object.

[0036] The pulse sensor **412**, also referred to as a "heart rate sensor", measures a heart rate of the target object, for example, based on a phenomenon that a light signal, when passing through tissues, acquires a pulsing nature due to a change of volume of an arterial bed with each heart contraction. The pulse sensor **412** performs an optical non-invasive method of measurement of the heart rate of the target object, adapts to individual peculiarities of the target object, and filters out false readings, thereby delivering stable and accurate data. The pulse sensor **412** allows the wearable telemetry device **100** to track the heart rate of the target object in real time. Depending on the configuration of the wearable telemetry device **100**, the wearable telemetry device **100** comprises one or more pulse sensors **412** to increase accuracy of measurements. The SpO2 sensor **413** measures a degree of oxygen in the blood of the target object based on the fact that absorption of light of different lengths by hemoglobin changes depending on its saturation with oxygen. The SpO2 sensor **413** performs an optical non-invasive method of measurement of oxygen levels in the blood of the target object, adapts to individual peculiarities of the target object, and filters out false readings, thereby delivering stable and accurate data. The SpO2 sensor **413** allows the wearable telemetry device **100** to expose immunodeficiency, heart disease, and respiratory problems. The wearable telemetry device **100** comprises one or more SpO2 sensors **413** to increase accuracy of measurements.

[0037] Tests were performed on the wearable telemetry device **100** to measure the accuracy of the sensors of the wearable telemetry device **100**. The tests were performed on two adults of ages 26 years and 27 years. The tests composed of 15 measurements of health parameters, for example, heart rate, blood oxygen level, and temperature over a span of 3 hours. Each measurement was compared with a reference value to identify any deviations. The wearable telemetry device **100** measured the temperature of the skin surface (t° C.) of each adult as shown below:

Adult 1						
Reference value (t° C.)	30.1	30.1	30	30.3	30.3	30.3
Wearable telemetry device (t° C.)	30	30	30	30.1	30.1	30.2
Δt	0.10	0.10	0.00	0.20	0.20	0.10

where Δt max=0.20 t° C., Δt min=−0.10 t° C., and Δt average=0.04 t° C.

Adult 2								
Reference value (t° C.)	30.6	30.8	30.9	31.1	31.1	31.2	31.1	31.1
Wearable telemetry device (t° C.)	30.7	30.8	30.9	31	31.1	31.2	31.1	31.2
Δt	0.00	0.00	0.10	0.00	0.00	0.00	−0.10	

where Δt max=0.20 t° C., Δt min=−0.10 t° C., and Δt average=0.04 t° C.

[0038] The wearable telemetry device **100** measured oxygen levels in the blood (%) of each adult as shown below:

Adult 1							
Reference, SpO2, %	96	97	96	98	99	96	96
Wearable telemetry device, SpO2, %	96.4	97.2	97	97.4	98.2	96.4	96.4
ΔSpO2	−0.4	−0.2	−1.0	0.6	0.8	−0.4	−0.4

where ΔSpO2 max=0.8%, ΔSpO2 min=−1%, and ΔSpO2 average=0.1%.

Adult 2							
Reference, SpO2, %	97	98	98	97	97	96	98
Wearable telemetry device, SpO2, %	97	97.4	97.4	97.3	97.2	96.2	97.4
ΔSpO2	0 0	0.6	0.6	−0.3	−0.2	−0.2	0.6

[0039] The wearable telemetry device **100** measured pulse in beats per minute (bpm) of each adult as shown below:

Adult 1							
SH-D1, P bpm	77	72	70	70	71	74	75
Wearable telemetry device, P bpm	74	71	70	69	73	76	72
ΔP	3	1	0	1	−2	−2	3

where ΔP max=3 bpm, ΔP min=−2 bpm, and ΔP average=0.5 bpm.

Adult 2							
SH-D1, P bpm	92	85	84	85	84	87	90
Wearable telemetry device, P bpm	89	83	85	85	86	85	91
ΔP	3	2	−1	0	−2	2	−1

where ΔP max=3 bpm, ΔP min=−2 bpm, and ΔP average=0.5 bpm.

[0040] The 3-axis accelerometer **411** measures a projection of an apparent acceleration, that is, the difference between a true acceleration of the target object and a gravitational acceleration. The 3-axis accelerometer **411** tracks physical activity and movement of the target object. The barometric pressure sensor **415** is used to determine the absolute height required to determine the spatial orientation. The 3-axis gyroscope **414** and the magnetometer **416** determine orientation of the target object, thereby determining motion and position of the target object to monitor and analyze activities performed by the target object.

[0041] According to one aspect of the invention, the wearable telemetry device **100** further comprises an analog-to-digital converter for digitizing the sensor data collected from the sensors, for example, in the form of electrical valued. The central processing unit (CPU) **409** converts the electrical values mathematically to a form perceived by a user, creates a data packet, and sends the data packet to the user device. According to another aspect of the invention, a monitoring application is deployed on the user device for performing the mathematical reduction of the measured electrical values to save the charge of the battery **401** of the wearable telemetry device **100**. According to another aspect of the invention, the telemetry device components **400** further comprise a protocol converter for converting between data transfer protocols.

[0042] The telemetry device components **400** further comprise an audio capture device, for example, a microphone **406**. The microphone **406** is communicatively coupled to the central processing unit (CPU) **409**. The microphone **406** receives ambient audio signals. The microphone **406** transforms sound to an analog electric signal. According to one or several aspects of the invention, the wearable telemetry device **100** transmits the analog electric signal from the microphone **406** to a direct interface user device using the transceiver **405**. In another embodiment, the microphone **406** transmits the analog electric signal to the CPU **409** for performing a programmatic analysis of the analog electric signal, removing parasitic noise from the analog electric signal, and then transmitting the analog electric signal to the user device using the transceiver **405**. The wearable telemetry device **100** implements a software protocol for online transmission of sound packets from the microphone **406**. In one modification, the wearable telemetry device **100** comprises a highly sensitive microphone **406** coupled with a self-learning algorithm to suppress extraneous noises to transfer only sounds emitted by the target object to the user device or to the CPU **409**.

[0043] The telemetry device components **400** further comprise an output device, for example, a speaker **418**. The speaker **418** is communicatively coupled to the central processing unit (CPU) **409** and the transceiver **405** via the audio codec **410**. The wearable telemetry device **100** implements a software protocol for online transmission of sound packets and a section in the front-end monitoring application for external devices, for example, user devices. This section of the front-end monitoring application enables control of the transmission of sound messages, playing of audio files from the memory of an external device, cloud resources, and other sources of audio Internet content. The speaker **418** transforms an electric analog signal to a sound wave. According to one aspect of the invention, the wearable telemetry device **100** comprises a miniature speaker **418** with a broad range of resonant frequencies to obtain high sound quality. The speaker **418** plays audio content, for example, from a flash memory of a remote user device or a remote interface device, for example, a smartphone, a tablet, a personal computer, a minicomputer, etc., using the transceiver **405**, or from a flash memory of a local memory unit of the wearable telemetry device **100**, or from a flash memory of a terminal device, for example, a base station using the transceiver **405**. The speaker **418** allows a user to listen to sounds or noise made by a target object or environment in real time. The speaker **418** plays the preconfigured media data and/or the data received from the CPU **409** and/or the transceiver **405** via the audio codec **410**. The audio codec **410** is used as an analog-to-digital converter of electric signals received from the microphone **406** and as a digital-to-analog converter for electric signals transmitted to the speaker **418**.

[0044] The battery **401** is an autonomous sustainable source of electric energy. The battery **401** is operably coupled to the central processing unit (CPU) **409**, the transceiver **405**, the sensors, for example, **403**, **412**, **413**, **415**, etc., the microphone **406**, and the speaker **418** for powering the CPU **409**, the transceiver **405**, the sensors, the microphone **406**, and the speaker **418**. The wearable telemetry device **100** transmits audio tracks made by the microphone **406** and information on current charge of the battery **401** in the form of data packets to the user device. The wireless power receiver coil **407** is a receiver for wireless transmission of electric energy from the base station as disclosed in the detailed description of FIG. **5**. The wireless power charge unit **408** drives the battery **401**, controls the process of collection of electric energy by the wireless power receiver coil **407**, and regulates a charging process of the battery **401**. The wireless power charge unit **408** in electrical communication with the wireless power receiver coil **407** allows charging of the battery **401** wirelessly. The voltage regulator **402** converts voltage from the battery **401** to a level required by one or more of the telemetry device components **400**. In one modification, the wearable telemetry device **100** further comprises circuit breakers (not shown) connected to each of the telemetry device components **400** for protecting the telemetry device components **400** from electrical damage, for example, by preventing overheating and/or bridging of the telemetry device components **400**.

[0045] In another modification, the wearable telemetry device **100** further comprises a non-transitory computer readable storage medium, for example, a memory unit for storing the sensor data generated by the sensors, the ambient audio signals received from the microphone **406**, threshold data, the preconfigured media data comprising, for example, audio data such as music, audio fairy tales, fables, poems, relaxing sounds, calming sounds, lullabies, etc., and instructions defined by modules of the wearable telemetry device **100**. In s, the wearable telemetry device **100** updates the audio data automatically based on the age of the target object. The central processing unit (CPU) **409** is communicatively coupled to the non-transitory computer readable storage medium and operably coupled to the transceiver **405**. The transceiver **405** receives data packets with settings and commands from the user device and transmits the data packets to the CPU **409** of the wearable telemetry device **100**. The CPU **409** executes the commands and one or more computer program instructions defined by the modules of the wearable telemetry device **100**, collects information from the sensors in the set mode, and controls operation of the speaker **418** and the microphone **406**.

[0046] The modules of the wearable telemetry device **100** comprise a data communication module, a control module, a data processing module, and an alerting module **404***a*. The data communication module receives user input data from the monitoring application deployed on one or more user devices via the transceiver **405** and facilitates communication between the target object and the user devices via the transceiver **405**. The user input data comprises, for example, modes for activating and controlling operability and sensitivity of the sensors, the microphone **406**, and the speaker **418**, safe areas, spots dangerous for the target object, tasks to be accomplished, customizations for alert notifications, etc. The monitoring application is configured, for example, as a mobile application or a desktop application. The monitoring application can be deployed on user devices that execute operating systems of different types, for example, the Android® operating system of Google Inc., the iOS operating system of Apple Inc., the Windows Phone® operating system of Microsoft Corporation, etc. The control module activates and controls operability and sensitivity of the sensors, and/or the microphone **406**, and/or the speaker **418** based on the received user input data. The control module activates and deactivates the microphone **406** and the speaker **418** based on instructions received from the user device via a graphical user experience presentation screen (GUI) provided by the monitoring application deployed on the user device. The control module receives a selection of modes of operation of the wearable telemetry device **100**, for example, the modes of operation of the sensors, and activates the sensors to measure one or more health parameters of the target object. The modes of operation comprise, for example, activation of the sensors for measurement and updating of the health parameters of the target object with a certain regularity, activation of the sensors for measurement and updating of the health parameters of the target object based on a measurement request received from the monitoring application deployed on the user device, and activation of the sensors for measurement and transmitting the health parameters of the target object to the user device in real time.

[0047] It can be seen from FIG. **4** that the CPU **409** incorporates a number of various program functional modules such as a sound control module **1001**, a spatial orientation module **1003**, a heart rate and SPO2 measurement control module **1005**, a data transmitter/receiver module **1007**, a temperature measurement control module **1009**, an absolute height determination module **1011**, a comparison with signal pattern module **1013**, a wavelength generation module **1015**, a vibration determination module **1017**, as well as a DC filter **1019**, an ambient lighting filter **1021**, an a data validation module **1018**. The sound control module **1001** is linked to the data/transmitter/receiver module **1007**, and the latter is connected to the antenna **404** via the Bluetooth® transceiver module **405**. The spatial orientation module **1003** is linked to the 3-axis accelerometer **411**, the 3-axis gyroscope **414**, and the 3-axis magnetometer **416** of the inertial module **411***a*. The PGG sensor block photoplethysmography **412***a* sensor unit is a combination of two sensors: a heart sensor **412** and a SPO2 sensor **413**. It also incorporates a photodiode **1023**, an infrared LED **1025**, a red LED **1027**, and a green LED **1029**. The photodiode **1023** is linked to the ambient light filter **1021** via an A/D converter **1031**. Other links and relationships between various sensors, modules, and units of the telemetry device components **400** are shown in FIG. **4**.

[0048] An example of a photoplethysmography sensor block that incorporates a red LED, a green LED, and photodiode is a sensor SFH 7050 of the Health Monitoring Series produced by OSRAM Opto Semiconductors GmbH (Germany).

[0049] When a light wave, emitted by the green LED, is reflected from the blood tissue (capillaries, blood vessels, etc.) at different stages of their contraction, this changes intensity of the transmitted light, and when the reflected light falls on the photodiode, the latter generates a current which is directly proportional to the light intensity and, hence, to variations/contractions of the blood vessels. The frequency of such variations/contractions corresponds to the heart rate of the target object. The effect of the extraneous ambient and/or artificial light is reduced or eliminated by means of appropriate filters. Pulse oximetry is based on the principle that O_2Hb and HHb differentially absorb red and near-infrared (IR) light. In case of the SPO2 sensor, red and infrared LEDs that emit light shining through a reasonably translucent skin of a baby are used. Oxygenated hemoglobin absorbs more infrared light and allows more red light to pass through. Deoxygenated (or reduced) hemoglobin absorbs more red light and allows more infrared light to pass through. Red light is in the range of 600-750 nm wavelength light band. Infrared light is in the range of 850-1000 nm wavelength light band. The photodetector receives the light that passes through the measuring site. The data processing module filters and processes the sensor data generated by the activated sensors and computes monitoring indices by processing the detected health parameters, the motion, and/or the position of the target object from the filtered and processed data in accordance with the threshold data, and/or the received ambient audio signals, and/or the received user input data. As used herein, "monitoring indexes" refers to health indexes, for example, an average heart rate, oxygen level in the blood, temperature, etc. The alerting module generates alert notifications in multiple formats, for example, audio alerts, video alerts, text messages, etc., based on the computed monitoring indexes and transmits the generated alert notifications to the target object via the wearable telemetry device **100** and/or the user devices via the Bluetooth® transceiver module **405**. For example, if temperature readings of a target object such as a baby deviate from a normal temperature, the alerting module alerts a user by generating and transmitting alert notifications, for example, in the form of a sound or a visual signal. The wearable telemetry device **100** implements remote firmware update technology that allows updating of the firmware of the wearable telemetry device **100** remotely.

[0050] FIG. **5** exemplarily illustrates wireless communication between the wearable telemetry device **100** and a base station **501**. According to one or several aspects of the invention, the rechargeable power unit, for example, the battery **401** exemplarily illustrated in FIG. **4**, of the wearable telemetry device **100** is operably coupled to the base station **501** to allow the base station **501** to wirelessly transmit power from an external power source to the battery **401** of the wearable telemetry device **100**. The base station **501** is implemented, for example, as an inductive charger station and operates with wireless communication technology, for example, Bluetooth 4.0 technology and a Wi-Fi® module. The base station **501** is a source of wireless transmission of electric energy for wirelessly charging the wearable telemetry device **100**. The wearable telemetry device **100** has to be charged regularly. The life of the battery **401** of the wearable telemetry device **100** is, for example, from about 48 hours to up to about 30 days without heavy use of the speaker **418** exemplarily illustrated in FIG. **4**. According to another aspect of the invention, the battery **401** of the wearable telemetry device **100** is charged wirelessly from the base station **501** by an inductive transmission of electric energy between two coils. The base station **501** is powered from the mains power supply. In another embodiment, the battery **401** of the wearable telemetry device **100** is charged by wired charging, for example, using a mains voltage converter.

[0051] FIG. **6** exemplarily illustrates a system **600** for monitoring a target object, showing wireless communication between the wearable telemetry device **100**, the base station **501**, and multiple user devices **601**, for example, a laptop, a smartphone, a tablet computer, etc. The wireless communication is implemented using a combination of wireless communication protocols, for example, a Bluetooth® communication protocol, a Wi-Fi® communication protocol, etc. In one modification, the wearable telemetry device **100** is combined with a converter of wireless communication protocols for converting between, for example, a Bluetooth® data transfer protocol and a Wi-Fi® data transfer protocol. As exemplarily illustrated in FIG. **6**, the wearable telemetry device **100** communicates with the base station

501 and one or more user devices 601, for example, via the Bluetooth® data transfer protocol. The wearable telemetry device 100 positioned on a forearm 301 or a wrist 302 exemplarily illustrated in FIGS. 3A-3B, of a target object, for example, a baby is configured to communicate with telemetry and multimedia systems. The wearable telemetry device 100 operates directly with a user device 601, for example, a smartphone using a Bluetooth® channel or a Wi-Fi® channel, provided there is a wireless network in the operation area. One or more user devices 601 can connect to the wearable telemetry device 100 using point-to-point and/or point-to-multipoint connections via one or more data transfer or wireless communication protocols. The base station 501 communicates with a router, for example, a Wi-Fi® router 603 via the Wi-Fi® data transfer protocol. The Wi-Fi® router 603 communicates with the user device 601 via the Wi-Fi® data transfer protocol, and with cloud resources 602 via a network, for example, the Internet. Multiple user devices 601 access the cloud resources 602 via the Internet. ' The wearable' telemetry device 100 enables remote communication between a target object and users in close proximity to the wearable telemetry device 100 through the monitoring application deployed on each of the user devices 601. Interchangeable connection protocols allow the wearable telemetry device 100 to interact with multiple user devices 601 at any distance while at least one device with an Internet connection, including the base station 501, is in a range of, for example, 100 meters.

[0052] FIG. 7 exemplarily illustrates an embodiment of the system 600 for monitoring a target object, showing wireless communication between the wearable telemetry device 100 and multiple user devices 601. As exemplarily illustrated in FIG. 7, the wearable telemetry device 100 communicates with the user device 601, for example, via a router, for example, a Wi-Fi® router 603 using the Wi-Fi® data transfer protocol. The Wi-Fi® router 603 and the user device 601 then access cloud resources 602 via a network, for example, the Internet. Multiple user devices 601 access the cloud resources 602 via the Internet.

[0053] Consider an example where a user, for example, a parent attaches the wearable telemetry device 100 to a baby's arm 301 or wrist 302 exemplarily illustrated in FIGS. 3A-3B, using the strap 101 of the wearable telemetry device 100. Using a setup panel on a graphical user interface provided by the monitoring application of the user device 601, the user selects one of the modes of operation of the wearable telemetry device 100 comprising, for example, the pulse or heart rate sensors 412, the SpO2 sensors 413, and the temperature sensors 403 exemplarily illustrated in FIG. 4. The modes of operation of the wearable telemetry device 100 comprise: Mode 1: Automatic reading of the sensors with a certain regularity; Mode 2: reading of the sensors on request of the user; and Mode 3: measuring and transmission of readings to the user device 601 in real time. Using the same user device 601, the user can enable or disable the microphone 406 of the wearable telemetry device 100 exemplarily illustrated in FIG. 4, to listen to or mute external sounds from the microphone 406, enable or disable audio playback by the speaker 418 of the wearable telemetry device 100 exemplarily illustrated in FIG. 4, and adjust the sensitivity of the microphone 406 and the speaker 418. The wearable telemetry device 100 enables playback of different types of media content comprising, for example, music, audio fairy tales, fables, poems, relaxing sounds, calming sounds, lullabies, etc., via the speaker 418. On performance of the above actions, the monitoring application on the user device 601 creates data packets instantly and transmits the created data packets to the wearable telemetry device 100. The monitoring application on the user device 601 transmits the data packets to the wearable telemetry device 100 by different methods. In one modification, data is transmitted directly between the wearable telemetry device 100 and the user device 601, for example, by the Bluetooth® data transfer protocol as exemplarily illustrated in FIG. 6. In another embodiment, the data is transmitted indirectly between the wearable telemetry device 100 and the base station 501, for example, by the Bluetooth® data transfer protocol and then by means of a home network segment, for example, the Wi-Fi® router 603 to the user device 601 as exemplarily illustrated in FIG. 6. In both embodiments above, in case of access of the user device 601 or the Wi-Fi® router 603 to the Internet, data is stored in the cloud resources 602 and is available to other user devices 601.

[0054] In another embodiment as exemplarily illustrated in FIG. 7, data is transmitted between the wearable telemetry device 100 and the user device 601 using an access point created in a Wi-Fi® operation area, for example, the Wi-Fi® router 603. In case of access of the user device 601 or the Wi-Fi® router 603 to the Internet, data can be stored in the cloud resources 602 and is made available to other user devices 601. The system 600 implements a packet exchange protocol that enables the system 600 to select a path to a user device 601 and the cloud resources 602 if there are no network elements. If there are several paths, the packet exchange protocol selects the shortest path.

[0055] FIGS. 8A-8B exemplarily illustrate configuration of dangerous spots 804 in a region using the monitoring application deployed On a user device 601 for monitoring a target object. A user marks dangerous spots 804 via a graphical user experience presentation screen (GUI) 801 provided by the monitoring application deployed on a user device 601 as exemplarily illustrated in FIGS. 8A-8B. The GUI 801 displays information and controls for use by the user.

[0056] FIGS. 9-10 exemplarily illustrate monitoring of a target object, for example, a baby 901 in an environment with dangerous spots 902*a*, 902*b*, and 902*c*. identified using the monitoring application deployed on a user device 601 as exemplarily illustrated in FIGS. 8A-8B. FIG. 9 exemplarily illustrates one more dangerous spot surrounding the baby 901. The wearable telemetry device 100 and, in modification of the device, one or more beacons track the baby's 901 movement and produce visual and sound notifications on the user device 601 if the baby 901 approaches any of these dangerous spots. The wearable telemetry device 100, in communication with the monitoring application deployed on the user device 601, performs the tracking using an inertial navigation system (INS). The base station 501 is used as a coordinate origin to mark the dangerous spots. The wearable telemetry device 100 monitors the position of the baby 901 to detect dangerous or potentially dangerous situations. The wearable telemetry device 100 tracks the baby 901 in a three-axis coordinate system relative to the coordinate origin based on metrics of the 3-axis accelerometer 411 and the 3-axis gyroscope 414 exemplarily illustrated in FIG. 4, as a part of the INS, and a compass such as the magnetometer 416 exemplarily illustrated in FIG. 4, and a barometer such as a barometric pressure sensor 415 exemplarily illustrated in FIG. **4**. According to one aspect of the invention, the wearable telemetry device **100** and the monitoring application of the user device **601**, as exemplarily illustrated in FIG. **10**, are used to mark the area around the baby's **901** current location and send visual and sound alert notifications to the user device **601** if the baby **901** leaves the marked area. Using the monitoring application on the user device **601**, the user resets coordinates of the wearable telemetry device **100** at a desired location and marks a "safe" area around the desired location.

[0057] FIG. **11** exemplarily illustrates a flowchart comprising the steps for determining a heart rate of a target object, for example, a baby **901** exemplarily illustrated in FIGS. **9-10**, using the heart-rate output data determination and correlation block **1033** of the wearable telemetry device **100** exemplarily illustrated in FIGS. **1A-1C**, worn by the baby **901**. The wearable telemetry device **100** is based on an optical non-invasive measurement technology. The method of measurement of heart rate is based on a phenomenon that light signal, when passing through tissues, acquires a pulsing nature due to a change of volume of an arterial bed with each heart contraction. A user, for example, a parent, places **1101** the wearable telemetry device **100** comprising the pulse sensor **412** exemplarily illustrated in FIG. **4**, or a heart rate sensor on the baby's **901** wrist **302** exemplarily illustrated in FIG. **3**B. The wearable telemetry device **100** enables **1102** a green light emitting diode (LED) based on instructions received from the user via the GUI provided by the monitoring application deployed on the user device **601** exemplarily illustrated in FIGS. **6-7**, for example, a smartphone. The wearable telemetry device **100** receives **1103** data comprising, for example, reflected light component, one or more ambient light components, direct current (DC) components, etc., from a photodiode of the wearable telemetry device **100**. The wearable telemetry device **100** filters the received data by removing **1104** ambient light components from the received data. The wearable telemetry device **100** also filters the received data by removing **1105** the DC components from the received data. The result data contains the change of light, absorbed by blood, and gives the information about blood pulsations. The wearable telemetry device **100** then determines **1106** external vibrations based on data analysis received from the 3-axis gyroscope **414** exemplarily illustrated in FIG. **4** and the 3-axis accelerometer **411** exemplarily illustrated in FIG. **4** from the baby's **901** wrist **302** exemplarily illustrated in FIG. **3**B. The wearable telemetry device **100** then determines **1107** the filtered HR data reliability based on the determined external vibrations and if the filtered HR data is not fully reliable **1108**, the wearable telemetry device **100** then excludes unreliable data and estimates **1109** actual data using wavelet transformation. The wearable telemetry device **100** applies **1110** the special signal pattern to the reliable data and estimated data and calculates the correlation **1111** of the pattern signal and data to do it more suitable for further calculations. The resultant correlation data is used by the wearable telemetry device **100** to calculate **1112** a monitoring index, for example, an average heart rate value. The wearable telemetry device **100** measures and monitors the baby's **901** heart rate with medical quality accuracy.

[0058] FIG. **12** exemplarily illustrates a flowchart comprising the steps for determining an oxygen saturation level in the blood of a target object, for example, a baby **901** exemplarily illustrated in FIGS. **9-10**, using the output SPO2 value, determination and correlation block **1035** of the wearable telemetry device **100** exemplarily illustrated in FIGS. **1A-1C**, worn by the baby **901**. The method of measurement of the oxygen level in the blood is based on the fact that the absorption of light of two different lengths by hemoglobin changes depending on the saturation level of oxygen in the blood. A user, for example, a parent, places **1201** the wearable telemetry device **100** comprising the oxygen saturation level (SpO2) sensor **413** exemplarily illustrated in FIG. **4**, on the baby's **901** wrist **302** exemplarily illustrated in FIG. **3**B. The wearable telemetry device **100** enables **1202** a red light emitting diode (LED) and an infrared (IR) LED based on instructions received from the user via a graphical user experience presentation screen (GUI) provided by the monitoring application deployed on a user device **601** exemplarily illustrated in FIGS. **6-7**, for example, a smartphone. The wearable telemetry device **100** receives **1203** a red signal and an infrared signal comprising alternating current (AC) components, direct current (DC) components, etc., from a photodiode. The wearable telemetry device **100** filters the received data by removing **1204** ambient light components from the received data. The wearable telemetry device **100** then determines **1205** external vibrations based on data analysis received from the 3-axis gyroscope **414** exemplarily illustrated in FIG. **4** and the 3-axis accelerometer **411** exemplarily illustrated in FIG. **4** from the baby's **901** wrist **302** exemplarily illustrated in FIG. **3**B. The wearable telemetry device **100** then determines **1206** the SpO2 data reliability based on the determined external vibrations and if the SpO2 data is not fully reliable **1207**, the wearable telemetry device **100** then excludes unreliable data and estimates **1208** actual data using wavelet transformation. The wearable telemetry device **100** determines **1209** an AC component of the received red signal and IR signal. The wearable telemetry device **100** determines **1210** a DC component of the received red signal and IR signal. The wearable telemetry device **100** calculates **1211** a monitoring index, for example, the value of SpO2 in the blood circulation. The calculations are based on determination of AC and DC ratio of red signal and IR signal. The wearable telemetry device **100** measures and monitors SpO2 indexes with medical quality accuracy. The wearable telemetry device **100** implements an optical non-invasive measurement technology.

[0059] FIG. **13** exemplarily illustrates a flowchart comprising the steps for determining a reference point to set a temperature extreme of thermal comfort of a target object, for example, a baby **901** exemplarily illustrated in FIGS. **9-10**, using the wearable telemetry device **100** exemplarily illustrated in FIGS. **1A-1C**, worn by the baby **901**. A user, for example, a parent places the wearable telemetry device **100** comprising the temperature sensor **403** exemplarily illustrated in FIG. **4**, on the baby's **901** wrist **302** exemplarily illustrated in FIG. **3**B. The temperature sensor **403** measures **1301** the temperature of the baby **901** on the skin of the baby's **901** upper extremity based on instructions received from the user via a graphical user experience presentation screen (GUI) provided by the monitoring application deployed on a user device **601** exemplarily illustrated in FIGS. **6-7**, for example, a smartphone.

[0060] The wearable telemetry device **100** determines **1302** whether the measured result is in the range of optimal temperatures. If the measured result is in the range of optimal temperatures, then the wearable telemetry device

100 renders **1303** the optimal temperature information to the user device **601** for confirmation. The wearable telemetry device **100** checks **1305** for user confirmation. If the wearable telemetry device **100** receives a user confirmation from the user device **601**, then the wearable telemetry device **100** uses **1309** the measured temperature result as a reference point to set a temperature extreme of thermal comfort. If the wearable telemetry device **100** does not receive a user confirmation from the user device **601**, then the wearable telemetry device **100** allows a user to perform the measurement **1307** in more favorable conditions and continues to measure **1301** the temperature. If the temperature measured is not in the range of the optimal temperatures, then the wearable telemetry device **100** renders **1304** the non-optimal temperature information to the user device **601** for confirmation and checks **1306** for user confirmation. If the wearable telemetry device **100** receives a user confirmation from the user device **601**, then the wearable telemetry device **100** allows the user to perform the measurement **1308** in more favorable conditions and continues to measure **1301** the temperature. If the wearable telemetry device **100** does not receive a user confirmation from the user device **601**, then the wearable telemetry device **100** uses **1309** the measured temperature result as a reference point to set a temperature extreme of thermal comfort. The wearable telemetry device **100** measures and monitors the baby's **901** thermal comfort to provide the user with data needed to maintain the baby's **901** neutral thermal environment. The measurement technology is based on a human physiological function, when vasoconstriction and vasodilatation vary blood flow to the baby's **901** hands and other extremities to control heat loss from the baby's **901** skin to the environment. As a result, cold hands indicate that the baby's **901** body is acting to retain heat, while warm hands indicate the baby's **901** body is acting to lose heat. The wearable telemetry device **100** implements an infrared temperature measurement technology and an algorithm comprising, for example, two main stages. For example, the first stage is initial measurement, which is made to determine the wrist **302** or forearm's **301** temperature extreme of thermal comfort state of the baby **901**. The second stage relates to consequent measurements, which are made to monitor temperature deviations affecting the baby's **901** thermal comfort.

[0061] FIG. **14** exemplarily illustrates a flowchart comprising the steps for reproducing sound of a target object, for example, a baby **901** exemplarily illustrated in FIGS. **9-10**, on a user device **601** exemplarily illustrated in FIGS. **6-7**, using the wearable telemetry device **100** exemplarily illustrated in FIGS. **1A-1C**, worn by the baby **901**. The wearable telemetry device **100** receives **1401** an ambient sound frame from the microphone **406** exemplarily illustrated in FIG. **4**, based on instructions received from the user via a graphical user experience presentation screen (GUI) provided by the monitoring application deployed on the user device **601**. The wearable telemetry device **100** processes **1402** the received sound frame using a high pass filter in the wearable telemetry device **100** to remove high frequency extraneous noise from the received sound frame. The wearable telemetry device **100** processes **1403** the high pass filtered sound frame using a low pass filter to remove low frequency extraneous noise from the sound frame. The wearable telemetry device **100** suppresses **1404** background noise from the low pass filtered sound frame.

[0062] The wearable telemetry device **100** performs echo cancellation **1405** on the background noise suppressed sound frame. The wearable telemetry device **100** performs an audio analytics comparison **1406** of frequencies of the echo cancelled sound frame to detect **1407** the sound emitted by the baby **901**. If the wearable telemetry device **100** detects the sound emitted by the baby **901**, then the wearable telemetry device **100** wirelessly transmits **1408** the detected data of the sound frame to the user device **601** to reproduce **1409** the sound of the baby **901** on the user device **601**, for example, via a Wi-Fi® communication protocol or a Bluetooth® communication protocol. If the wearable telemetry device **100** is unable to detect the sound emitted by the baby **901**, the wearable telemetry device **100** receives **1401** the sound frame again from the microphone **406** for further processing and detection. The wearable telemetry device **100** also performs programmatic analysis of the received sound frame from the microphone **406**. The wearable telemetry device **100** removes extraneous noise from the received sound frame to monitor the sound produced only by the baby **901**.

[0063] According to one aspect of the invention, the wearable telemetry device **100** tracks and analyzes a sleep pattern of the baby **901**. In this embodiment, the wearable telemetry device **100** performs an analysis on quality of sleep and stages of sleep. The wearable telemetry device **100** processes and analyses the data received from the microphone **406** and the 3-axis accelerometer **411** exemplarily illustrated in FIG. **4**. The wearable telemetry device **100** detects whether the baby **901** is awake and sends visual and sound alert notifications to the user device **601** to alert the user. Limiting the audio signal perception area of the microphone **406** by implementing a noise cancellation algorithm provides improved results. The microphone **406** is highly sensitive and implements an extraneous noise suppression technology. The microphone **406** is coupled with a self-learning algorithm to suppress extraneous noise to transfer sounds emitted by the baby **901** to the user device **601**. The wearable telemetry device **100** enables remote voice communication between the baby **901** and the user device **601**. The wearable telemetry device **100** implements interchangeable connection protocols for interaction with user devices **601** at any distance from the wearable telemetry device **100**, while at least one device, for example, the base station **501** is in a range of, for example, a 100 meters, thereby allowing users to communicate with the target object from any location at any time. The wearable telemetry device **100** reproduces a variety of audio content accessed through the user device **601**.

[0064] FIG. **15** exemplarily illustrates a flowchart comprising the steps for initiating wireless transmission of sensor data to a user device **601** exemplarily illustrated in FIGS. **6-7**, or the base station **501** exemplarily illustrated in FIG. **5**, proximal to the wearable telemetry device **100** exemplarily illustrated in FIGS. **1A-1C**, via a wireless communication protocol based on a deviation found in the sensor data. The delivery of data packets by the wearable telemetry device **100** depends upon the proximity of the base station **501** and the user device **601**. The wearable telemetry device **100** receives one or more sensor readings based on instructions received from the user via a graphical user experience presentation screen (GUI) provided by the monitoring application deployed on the user device **601**. The wearable telemetry device **100** checks **1501** whether a first measurement of the sensor data was made. If the first measurement was not made, the wearable telemetry device **100** measures **1502** the sensor data, for example, health parameters of the target object, and computes monitoring indexes from the measured sensor data. The wearable telemetry device **100** determines **1503** whether there are deviations of the computed monitoring indexes from the data measured previously. If a deviation is not found, the wearable telemetry device **100** determines **1501** whether the current measurement is the first measurement. If the current measurement is not the first measurement, then the wearable telemetry device **100** continues to measure **1502** the sensor data and check **1503** for a deviation. If the wearable telemetry device **100** finds a deviation or if the current measurement is the first measurement made by the wearable telemetry device **100**, the wearable telemetry device **100** is programmed to transmit the sensor data.

[0065] The wearable telemetry device **100** enables **1504** a Bluetooth® communication protocol therewithin to transmit the measured sensor data. The wearable telemetry device **100** enables the Bluetooth® communication protocol to initiate transfer of the measured sensor data only when a deviation is detected. The wearable telemetry device **100** searches **1505** for devices to pair with for transmitting the measured sensor data. The wearable telemetry device **100** checks **1506** whether an interface device, that is, a user device **601** is found. If a user device **601** is found, then the wearable telemetry device **100** determines **1507** the proximity of the user device **601** from the wearable telemetry device **100** and checks **1509** for the presence of a terminal, that is, the base station **501**. If the base station **501** is found, then the wearable telemetry device **100** determines **1510** the proximity of the base station **501** from the wearable telemetry device **100**. The wearable telemetry device **100** checks **1511** whether at least one device is found. If the user device **601** and the base station **501** are not found, the wearable telemetry device **100** waits for a predetermined time delay **1508**, enables **1504** the Bluetooth® communication protocol again, and continues to search **1505** for the user device **601** and the base station **501**.

[0066] If the wearable telemetry device **100** finds at least one of the user device **601** and the base station **501**, the wearable telemetry device **100** compares **1513** the proximity of the user device **601** from the wearable telemetry device **100** with the proximity of the base station **501** from the wearable telemetry device **100**. If the proximity of the user device **601** with respect to the wearable telemetry device **100** is greater than the proximity of the base station **501** with respect to the wearable telemetry device **100**, then the wearable telemetry device **100** connects **1514** to the base station **501** and transmits **1516** the measured sensor data to the base station **501**. If the proximity of the user device **601** with respect to the wearable telemetry device **100** is lesser than the proximity of the base station **501** with respect to the wearable telemetry device **100**, then the wearable telemetry device **100** connects **1512** to the user device **601** and transmits **1515** the measured sensor data to the user device **601**. The wearable telemetry device **100** determines the device closest to the wearable telemetry device **100** to decrease electromagnetic radiation (EMR) during transmission of the measured sensor data. On transmitting the measured sensor data, the wearable telemetry device **100** determines **1517** whether the measured sensor data has been sent successfully. If the wearable telemetry device **100** sends the measured sensor data successfully, the wearable telemetry device **100** continues with the measurement of the sensor data. If the wearable telemetry device **100** did not send the measured sensor data successfully, the wearable telemetry device **100** enables **1504** the Bluetooth® communication protocol again to search **1505** for devices for transmitting the measured sensor data. The wearable telemetry device **100** substantially or completely removes potentially harmful EMR and electromagnetic frequencies (EMF) during the use of the wearable telemetry device **100**. As a result of a combination of autonomous operation and a data exchange algorithm, the wearable telemetry device **100** does not emit high or chronic electromagnetic radiation. The wearable telemetry device **100** combines the autonomous operation, the data exchange algorithm, and a Bluetooth® low energy (BLE) technology. The BLE technology is enabled only if there is sensitive data that requires the user's attention. The monitoring application deployed on the user device **601** displays the measured sensor data sent by the wearable telemetry device **100**, for example, as a visual representation on the graphical user interface on the user device **601**.

[0067] FIG. **16** exemplarily illustrates a flowchart comprising the steps for transmitting alert notifications to a user device **601** exemplarily illustrated in FIGS. **6-7**, or the base station **501** exemplarily illustrated in FIG. **5**, on determining a deviation of measured data from threshold data. The wearable telemetry device **100** exemplarily illustrated in the FIGS. **1A-1C**, measures **1601** health parameters of a target object, for example, a baby **901** exemplarily illustrated in FIGS. **9-10**. The wearable telemetry device **100** checks **1602** for deviations in the measured data with respect to the threshold data. If deviations are not found, the wearable telemetry device **100** continues to measure **1601** the health parameters of the baby **901**. If deviations are found, the wearable telemetry device **100** generates and transmits **1603** visual and sound alerts to an interface device, that is, the user device **601**. The wearable telemetry device **100** waits for a predetermined time delay **1604** after transmitting the visual and sound alerts to the user device **601**. The wearable telemetry device **100** checks **1605** whether the visual and sound alerts have been delivered to the user device **601** successfully. If the visual and sound alerts have been delivered successfully, the wearable telemetry device **100** continues to measure **1601** the health parameters of the baby **901**. If the visual and sound alerts have not been delivered successfully, the wearable telemetry device **100** generates and transmits **1606** a sound alert to a terminal, that is, to the base station **501**. The wearable telemetry device **100** waits for a predetermined time delay **1607** after transmitting the sound alert to the base station **501**. The wearable telemetry device **100** checks **1608** whether the sound alert has been delivered successfully. If the sound alert has been delivered successfully, the wearable telemetry device **100** continues to measure **1601** the health parameters of the baby **901**.

[0068] If the sound alert has not been delivered to the base station **501** successfully, the wearable telemetry device **100** generates and transmits **1609** a sound alert to the wearable telemetry device **100**. After a predetermined time delay **1610** after generating the sound alert, the wearable telemetry device **100** checks **1611** whether the sound alert has been delivered successfully. If the sound alert has been delivered successfully, the wearable telemetry device **100** continues to measure **1601** the health parameters of the baby **901**. If the sound alert has not been delivered successfully, the wearable telemetry device **100** generates **1603** visual and sound alerts in the user device **601**. The method disclosed herein implements a 3-stage notification delivery system to guarantee emergency alert delivery to the user. If an emergency alert cannot be delivered to the monitoring application deployed on the user device **601** under certain circumstances or if the emergency alert was missed by the user, an alert sound is played on the base station **501**. If the base station **501** cannot play the alert sound, the sound alert is produced on the wearable telemetry device **100**. The monitoring application on the user device **601** allows a user to customize the alert notifications, assign an emergency alert status, and enable or disable the alert notifications for certain events via the graphical user interface.

[0069] FIG. **17** exemplarily illustrates confirmation of task accomplishment by a user by tapping on the enclosure **102** of the wearable telemetry device **100**. In a modification of the device of the invention, the wearable telemetry device **100** disclosed herein allows updating tasks. A user may tap the enclosure **102** of the wearable telemetry device **100** with a predetermined number of taps to confirm a task accomplishment on the user device **601** exemplarily illustrated in FIGS. **6-7**. The device generates a sound via the speaker **418** to confirm that the event accomplishment was tracked after the device surface is tapped.

[0070] FIG. **18** exemplarily illustrates a user experience screenshot **801** provided by the monitoring application deployed on a user device **601** exemplarily illustrated in FIGS. **6-7**, for setting up tasks and tracking accomplishment of the tasks. A user can use the wearable telemetry device **100** exemplarily illustrated in FIGS. **1A-1C** and FIG. **17**, to set up tasks. The user adds a task and assigns the number of taps on the enclosure **102** of the wearable telemetry device **100** exemplarily illustrated in FIG. **17**, for the added task via the GUI **801** on the user device **601**. The taps are needed to identify an accomplished task. The user can select a notification time from options, for example, periodical or a specific time and date via the GUI **801**. The user can perform a task accomplishment confirmation by tapping on the enclosure **102** of the wearable telemetry device **100**. To track the accomplished tasks, the GUI **801** displays a table with tasks, number of accomplishments, a timeline for the accomplishment of tasks for a selected period of time, etc., as exemplarily illustrated in FIG. **18**. The GUI **801** displays the required information and controls. The monitoring application is the front-end application that provides the GUI **801** and is configured, for example, as an application for a smartphone, as an application for user device **601** such as a tablet computer, a personal computer, etc., as a web page, etc. The monitoring application enables simultaneous operation of several user devices **601** and collection of information on a state of health of several target objects, for example, children at any instance of time.

[0071] Thus, it has been shown that, even though some components of the wearable telemetry device of the invention are known per se, a combined use of all telemetric components of the system of the invention with comprehensive and interrelated data obtained from these components about vital signs, spatial orientation, and motions of the target object produce a novel and synergistic effect.

[0072] The foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the method and the wearable telemetry device **100** disclosed herein. While the method and the wearable telemetry device **100** have been described with reference to various modifications, it is understood that the words, which have been used herein, are words of description and illustration, rather than words of limitation. Furthermore, although the method and the wearable telemetry device **100** have been described herein with reference to particular means, materials, and embodiments, the method and the wearable telemetry device **100** are not intended to be limited to the particulars disclosed herein; rather, the method and the wearable telemetry device **100** extend to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims. Those skilled in the art, having the benefit of the teachings of this specification, may affect numerous modifications thereto and changes may be made without departing from the scope and spirit of the method and the wearable telemetry device **100** disclosed herein in their aspects. For example, a target object is not necessarily a baby and may be an adult clinical patient, an in-house senior citizen suffering from Alzheimer's disease, or the like. The wearable telemetry device **100** may be attached to the body of a target object not necessarily with a bracelet but may be adhesively attached to the skin at any other part of the body.

What is claimed is:

1. A system for telemetrically monitoring a target object, which is a human being, the system comprising:

a wearable telemetry device for monitoring a target object comprising an enclosure that contains telemetry device components, a strap for detachably attaching and securing the wearable telemetry device to the target object in a position that provides contact of the enclosure with a target object surface and in a position in which the multiple telemetry device components detect target object parameters; and

at least one user device;

wherein the multiple telemetry device components produce sensor data and comprise: at least one processor, a self-contained power source, an audio input and an audio output connected to the at least one processor, an antenna connected to the at least one processor and to the user device via wireless communication units, an inertial block connected to the at least one processor, a PGG sensor block, a temperature sensor, a heart-rate output data determination and correlation block that is defined by a green LED and a photodiode, and an output SPO2 value determination and correlation block that is defined by a red LED, an infrared LED, and said photodiode, the heart-rate output data determination and correlation block and the output SPO2 value determination and correlation block each incorporating a function of checking reliability of the obtained sensor data and values, estimating an actual data by using a wavelet transformation, obtaining a corrected data, and calculating values by using the corrected data.

2. The system according to claim **2**, wherein the human being is a baby, the enclosure is integrally connected to the strap, and wherein the strap has means for securing the wearable telemetry device on the wrist/arm of the baby.

3. The system according to claim **2**, wherein the self-contained power source is a rechargeable battery and wherein the system is further comprising a base station which is powered from an external power source and has a wireless power charger which is inductively connected to the rechargeable battery.

4. The system according to claim **3**, wherein the at least one processor comprises a plurality of modules comprising a sound control module connected to the audio input and an audio output, a spatial orientation module connected to the inertial block, a heart rate and SPO2 measurement control module connected to the PGG sensor block, a data transmitter/receiver module connected to the antenna via a wireless communication unit, a temperature measurement control module connected to the temperature sensor, an absolute height determination module connected to the spatial orientation module, a wavelet generation module, an ambient light filter, a DC filter, a data validation module, a vibration determination module, and an alerting module that generates alert notifications in multiple formats and transmits the generated alert notifications to the target object and/or the user devices via the wireless communication unit.

5. The system according to claim **4** wherein the inertial block comprises a 3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer, and wherein the wireless communication units comprise a Bluetooth® transceiver module.

6. The system according to claim **4**, further comprising a barometric sensor connected to the absolute height determination module.

7. The system according to claim **5**, further comprising a barometric sensor connected to the absolute height determination module.

8. The system according to claim **3**, further comprising means for initiating wireless transmission of the sensor data to the user device or the base station proximal to the wearable telemetry device via a wireless communication unit based on a deviation found in the sensor data, said means for initiating wireless transmission comprising a Bluetooth® transceiver module that is enabled in case of deviation of the data obtained from the sensors, a search device connectable to the wireless communication unit and/or the user device, and a terminal on the base station.

9. The system according to claim **1**, wherein the user device comprises a device selected from the group consisting of a laptop, a smartphone, a tablet, and a computer, the user device comprising a monitoring application that has means for sending commands to the multiple telemetry device components via the wireless communication unit for marking a "safe" area around the target object and a user experience presentation screen.

10. The system according to claim **5**, wherein the user device comprises a device selected from the group consisting of a laptop, a smartphone, a tablet, and a computer, the user device comprising a monitoring application that has means for sending commands to the multiple telemetry device components via the Bluetooth® transceiver module.

11. A method for telemetrically monitoring a target object, which is a human being, the method comprising the steps of:

providing a system comprising a wearable telemetry device for monitoring a target object comprising: an enclosure that contains telemetry device components, a device for attaching and securing the enclosure to the target object in contact with a target object surface in a position in which the multiple telemetry device components detect target object parameters and position, a wireless communication unit; and at least one user device, wherein the at least one user device is provided with means for detecting proximity of the target object and to dangerous spots, and with an alert module that generates alert notifications in multiple formats and transmits the generated alert notifications to the target object and/or the at least one user device;

attaching the wearable telemetry device to the target object by using the device for attaching and securing the enclosure to the target object;

telemetrically monitoring the target object parameters and the position relative to the dangerous spots by generating sensor data and for calculating data relating to health parameters of the target object comprising heart rate data, SpO2 value data, blood pressure, breathing rate, surface temperature of the target object, motion, and/position of the target object;

generating alert notifications in the alert notification module in multiple formats based on the calculated data;

constantly checking reliability of the calculated data; and

wirelessly transmitting the generated alert notifications to the target object and/or the user devices via a wireless communication unit to the user device;

wherein the step of constantly checking reliability of the calculated data comprises:

estimating the heart rate data obtained on the basis of green LED signals by using wavelet transformation, applying a signal pattern, and calculating a correlation data for the heart rate and a pattern;

estimating the SpO2 value data by using wavelet transformation,

determining AC by using signals obtained from red LED and infrared LED and obtaining a correlated data;

calculating the SpO2 value using the correlated data;

searching for the user device and/or base station; and

wirelessly transmitting the correlated data to the user device and/or to the base station.

12. The method according to claim **11**, wherein the human being is a baby and the device for attaching and securing the enclosure to a target object in contact with a target object surface is strap attachable to the baby's wrist/arm in contact with the baby's skin.

13. The method according to claim **12**, wherein the enclosure is integrally connected to the strap.

14. The method according to claim **13**, wherein if the user device and/or the base station are not found, the wearable telemetry device waits for a predetermined time delay, assumes wireless communication with the user device and/or the base station, and continues to search for the user device and the base station.

15. The method according to claim **11**, wherein the correlated data is transmitted directly between the wearable telemetry device and the user device via the wireless communication unit.

16. The method according to claim **11**, wherein the correlated data is transmitted indirectly between the wearable telemetry device and the base station via a wireless communication unit and then by means of a home network segment to the user device.

17. The method according to claim **13**, wherein the wireless communication unit is a Bluetooth® transceiver module and wherein the correlated data is transmitted directly between the wearable telemetry device and the user device via a Bluetooth® data transfer protocol.

18. The method according to claim **13**, wherein the correlated data is transmitted indirectly between the wearable telemetry device and the base station by the Bluetooth® transceiver module and then by means of a home network segment to the user device.

19. The method according to claim **16**, wherein in case of access of the user device or the home network segment to the Internet, the correlated data is stored in cloud resources and is available to other user devices.

20. The method according to claim **14**, comprising the step of providing a user device with a monitoring application that comprises a user experience presentation screen.

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专利名称(译)	用于遥测目标对象的系统和方法		
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摘要(译)

一种用于监视目标对象（例如婴儿）的可穿戴遥测设备，包括带和包围组件的外壳，所述组件包括处理器，传感器，音频捕获设备，输出设备和可再充电电源单元。处理器执行可穿戴遥测设备的模块，用于从用户设备接收用户输入数据，促进目标对象与用户设备之间经由收发器的通信，激活和控制传感器，音频捕获设备和输出设备基于用户输入数据，过滤传感器数据，通过根据阈值数据，由音频捕获设备接收的环境音频信号处理健康参数，运动和/或传感器检测到的目标对象的位置来计算监控指标，和/或者用户输入数据，并且基于监控索引生成并向目标对象和/或用户设备经由收发器发送警报通知。