

**TITLE: A SYSTEM AND METHOD FOR CALIBRATING READINGS
ASSOCIATED WITH PHYSIOLOGICAL PARAMETERS OF A USER**

FIELD OF THE INVENTION

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[0001] The present invention relates to accurately measuring one or more physiological parameters of a user. In particular, the present invention relates to calibration of readings associated with physiological parameters of a user for accurate measurement.

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BACKGROUND OF THE INVENTION

[0002] Sensors are used in multitude of applications ranging from automotive to medical devices. The wearable devices also include sensors that are commonly used for determination of physiological parameters of a user. However, sensor readings may be influenced by various external factors such as humidity, temperature, wind speed and solar radiation. Further, there may be variations between readings from identical sensors of the same make and/or model due to intrinsic physical imperfections inadvertently created during manufacture. Therefore, the sensor readings may be erroneous and inaccurate. Inaccurate sensor readings may cause serious consequences, especially when used for medical applications, such as treatment of the user. There are various conventionally available wearable devices that employ sophisticated sensors and complex logics for filtering out the external parameters and improve accuracy of reading of the physiological parameters of the user. However, the conventional wearable devices with the sophisticated sensors do not consider ambient parameters for determining accuracy of the readings provided by the wearable device and have reduced portability and usability for non-trained users.

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[0003] Thus, there is a need for a mechanism to make the readings of the physiological parameters of a user more accurate and precise by way of an automated calibration using ambient parameters.

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SUMMARY OF THE INVENTION

[0004] An embodiment of the present invention discloses, a system for calibrating readings associated with one or more physiological parameters of a user. The system comprises a wearable device to sense data associated with one or more physiological parameters of a user and one or more sensors positioned in proximity of the user to sense data associated with one or more ambient parameters of the user. The system also includes a sensor hub configured to receive sensed data from the wearable device and receive sensed data from the one or more sensors. The system further includes a data processing engine configured to correlate the sensed data from the wearable device and the sensed data from the one or more sensors by employing one or more machine learning models to determine a bias in the sensed data from the wearable device and calibrate the readings associated with one or more physiological parameters of the user based on the determined bias in the sensed data from the wearable device.

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[0005] In an embodiment of the present invention, the one or more physiological parameters of a user include core body temperature, oxygen saturation, blood pressure, glucose level, heart rate, activity and motion, and pulse rate. Further, the one or more sensors are at least one of: set of identical sensors and set of non-identical sensors. Furthermore, the one or more sensors include at least one of: one or more temperature sensors, one or more humidity sensors, one or more Passive Infrared based

motion sensors, one or more light sensors, one or more pressure sensors and one or more Magnetic Switch sensors.

[0006] In an embodiment of the present invention, the data processing engine is communicatively coupled to the sensor hub and is located one of: in proximity of the user, in remote location and cloud environment. Further, the wearable device communicates with the sensor hub via a first communication protocol and the one or more sensors communicate with the sensor hub via a second communication protocol.

[0007] In an embodiment of the present invention, the sensor hub is configured to detect occupancy of a space ambient to the user. Further, determine change in Received Signal Strength Indicator (RSSI) value of the sensed data received from the wearable device for a predetermined period of time upon detection of the presence of the user in the ambient space. Next, the sensor hub compares successively obtained RSSI value of the sensed data of the wearable device over a period of time to determine if the user is wearing the wearable device.

[0008] In an embodiment of the present invention, when the result of the comparison indicates that the sensed data of the wearable device and the sensed data of the one or more sensors are same for the predetermined period of time it is inferred that the wearable device is off the user's body and is measuring the ambient parameters of the user. Further, when the result of the comparison indicates that the sensed data of the wearable device and the sensed data of the one or more sensors have a predetermined difference for the predetermined period of time it is inferred that the wearable device is worn by the user and is measuring one or more physiological parameters of the user.

[0009] In an embodiment of the present invention, the data processing engine is also configured to create an annotated event timeline based on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable device with respect to user's body. The data processing engine is also configured to generate a transfer curve by employing one or more machine learning model on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable sensor and calibrate the readings associated with one or more physiological parameters of the user based on the transfer curve.

[0010] An embodiment of the present invention discloses, automated method to calibrate readings associated with one or more physiological parameters of a user. The automated method comprises sensing, by a wearable device, data associated with one or more physiological parameters of a user and sensing, by a one or more sensors positioned in proximity of the user, data associated with one or more ambient parameters of the user. The automated method further includes receiving the sensed data from the wearable device and receiving the sensed data from the one or more sensors. Next, correlating the sensed data from the wearable device and the sensed data from the one or more sensors by employing one or more machine learning models to determine a bias in the sensed data from the wearable device and calibrating the readings associated with one or more physiological parameters of the user based on the determined bias in the sensed data from the wearable device.

[0011] In an embodiment of the present invention, the one or more physiological parameters of a user include core body temperature, oxygen saturation, blood pressure, glucose level, heart rate, activity and motion, and pulse rate. Further, the

one or more sensors are at least one of: set of identical sensors and set of non-identical sensor. Furthermore, the one or more sensors include at least one of: one or more temperature sensors, one or more humidity sensors, one or more Passive-Infrared based motion sensors, one or more light sensors, one or more pressure sensors and one or more Magnetic Switch sensors.

[0012] In an embodiment of the present invention, the automated method further includes detecting occupancy of a space ambient to the user. Further, determining change in Received Signal Strength Indicator (RSSI) value of the sensed data received from the wearable device for a predetermined period of time upon detection of the presence of the user in the ambient space and comparing the successively obtained RSSI value of the sensed data of the wearable device over a period of time to determine if the user is wearing the wearable device.

[0013] In an embodiment of the present invention, when the result of the comparison indicates that the sensed data of the wearable device and the sensed data of the one or more sensors are same for the predetermined period of time, inferring that the wearable device is off the user's body and measuring the ambient parameters of the user. Further, when the result of the comparison indicates that the sensed data of the wearable device and the sensed data of the one or more sensors have a predetermined difference for the predetermined period of time inferring that the wearable device is worn by the user and measuring one or more physiological parameters of the user.

[0014] In an embodiment of the present invention, the automated method also includes creating an annotated event timeline based on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable device with respect to the

user's body. Further, generating a transfer curve by employing one or more machine learning model on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable sensor.

5 Furthermore, calibrating the readings associated with one or more physiological parameters of the user based on the transfer curve.

[0015] An embodiment of the present invention discloses, a
10 computer program product comprising at least one computer-readable storage medium having computer-executable program code stored therein. The computer executable program code comprising instructions that when executed by a processor, cause the processor to sense, by a wearable device, data associated with
15 one or more physiological parameters of a user and sense, by a one or more sensors positioned in proximity of the user, data associated with one or more ambient parameters of the user. Further, receive the sensed data from the wearable device and receive the sensed data from the one or more sensors.
20 Furthermore, correlate the sensed data from the wearable device and the sensed data from the one or more sensors by employing one or more machine learning models to determine a bias in the sensed data from the wearable device and calibrate the readings associated with one or more physiological parameters of the user
25 based on the determined bias in the sensed data from the wearable device.

[0016] In an embodiment of the present invention, the computer program product comprises instructions to detect
30 occupancy of a space ambient to the user, determine change in Received Signal Strength Indicator (RSSI) value of the sensed data received from the wearable device for a predetermined period of time upon detection of the presence of the user in the ambient space, and compare the successively obtained RSSI

value of the sensed data of the wearable device over a period of time to determine if the user is wearing the wearable device.

[0017] In an embodiment of the present invention, the
5 computer program product comprises instructions to infer that
the wearable device is off the user's body and measuring the
ambient parameters of the user, when the result of the comparison
indicates that the sensed data of the wearable device and the
10 sensed data of the one or more sensors are same for the
predetermined period of time. Further, infer that the wearable
device is worn by the user and measuring one or more
physiological parameters of the user, when the result of the
comparison indicates that the sensed data of the wearable device
and the sensed data of the one or more sensors have a
15 predetermined difference for the predetermined period of time.

[0018] In an embodiment of the present invention, the
computer program product comprises instructions to create an
annotated event timeline based on the received sensed data from
20 the wearable device, received sensed data from the one or more
sensors and determined position of the wearable device with
respect to the user's body. Further, generate a transfer curve
by employing one or more machine learning model on the received
sensed data from the wearable device, received sensed data from
25 the one or more sensors and determined position of the wearable
sensor. Furthermore, calibrate the readings associated with one
or more physiological parameters of the user based on the
transfer curve.

30 **[0019]** Thus, the present invention provides the automated
mechanism for calibrating readings associated with one or more
physiological parameters of a user. Since the automated
mechanism uses ambient parameters for calibration of the
readings of the wearable device this improves accuracy of the

readings and reduces probability of error in the readings of the wearable devices. Further, the implementation of the machine learning models for continuous calibration ensure an automated and periodic detection and correction of errors in the readings of the wearable device. Furthermore, the inclusion of the position of the wearable device with respect to user's body as one of the factor for calibration enhances the accuracy of the calibration of the readings. Accordingly, the present invention calibrates the readings of the wearable device automatically in an automated manner based on ambient parameters of the user.

BRIEF DESCRIPTION OF DRAWINGS

[0020] The present invention is described by way of embodiments illustrated in the accompanying drawings wherein:

[0021] Figure 1 is a block diagram illustrating a system for calibrating readings associated with one or more physiological parameters of a user in accordance with an embodiment of the present invention;

[0022] Figure 2 illustrates an exemplary annotated event timeline in accordance with an embodiment of the present invention;

[0023] Figure 3 is a flowchart illustrating an automated method for calibrating readings associated with one or more physiological parameters of a user in accordance with an embodiment of the present invention; and

[0024] Figure 4 illustrates an exemplary computer system in which various embodiments of the present invention may be implemented.

DETAILED DESCRIPTION OF DRAWINGS

[0025] The following disclosure is provided in order to enable a person having ordinary skill in the art to practice the invention. Exemplary embodiments are provided only for illustrative purposes and various modifications will be readily apparent to persons skilled in the art. The general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Also, the terminology and phraseology used is for the purpose of describing exemplary embodiments and should not be considered limiting. Thus, the present invention is to be accorded the widest scope encompassing numerous alternatives, modifications and equivalents consistent with the principles and features disclosed. For the purpose of clarity, details relating to technical material that is known in the technical fields related to the invention have not been described in detail so as not to unnecessarily obscure the present invention.

[0026] Figure 1 is a block diagram illustrating a system 100 for calibrating readings associated with one or more physiological parameters of a user in accordance with an embodiment of the present invention. In an example, the system 100 may be deployed, without any limitation, for medical care and treatment of patients, where the user may be understood as a patient. Further, the system 100 may include a wearable device 102, one or more sensors 104, a sensor hub 106 and a backend system 108. In an embodiment of the present invention, the wearable device 102, the one or more sensors 104 and the sensor hub 106 may be located in ambient space of the user, as illustrated by the block 128. Further, the backend system 108 may be located at a remote location with respect to the block 128 that is remote to the ambient space where the wearable device

102, the one or more sensors 104 and the sensor hub 106 may be located.

[0027] Further, the wearable device 102 may comprise one or more sensors configured to sense data associated with one or more physiological parameters of a user. In an exemplary embodiment of the present invention, the wearable device 102 may include, without any limitation, a temperature sensor, a heart rate sensor, a blood pressure sensor, an oxygen sensor, or any combination thereof. Further, the one or more physiological parameters of the user may be, without any limitation, core body temperature, oxygen saturation, blood pressure, glucose level, heart rate, activity and motion, and pulse rate or any combination thereof.

[0028] The one or more sensors 104 may be positioned in the ambient space to sense ambient parameters. In an embodiment of the present invention, the one or more sensors 104 may be understood as a set of identical sensors, a set of non-identical sensors or a combination thereof. In an exemplary embodiment of the present invention, the one or more sensors 104 may include, without any limitation, one or more temperature sensors 104a, one or more humidity sensors 104b, one or more Passive Infrared based motion sensors 104c, one or more light sensors 104d, one or more pressure sensors 104e and one or more Magnetic Switch sensors 104f as door contact sensors or any combination thereof. The one or more temperature sensors 104a may sense temperature of the ambient space. The one or more humidity sensors 104b may sense humidity or moisture level in the ambient space. The one or more Passive Infrared based motion sensors 104c may sense motion in the ambient space and assist in determination of occupancy in the ambient space. The one or more pressure sensors 104e may sense air pressure inside the ambient space. The one or more light sensors 104d may be used to measure lux levels in

ambient space. Further, one or more door contact sensors 104f may be used to detect whether doors and windows in proximity of the user are open or close.

5 **[0029]** In an embodiment of the present invention, the sensor hub 106 may include a receiver 112, a transmitter 114 and an inferencing engine 116. The wearable device 102 may communicate with the receiver 112 of the sensor hub 106 via a first communication protocol and the one or more sensors 104 may
10 communicate with the sensor hub 106 via a second communication protocol. In an exemplary embodiment of the present invention, the first communication protocol may be Bluetooth protocol and the second communication protocol may be Zigbee protocol. Accordingly, the wearable device 102 may be communicatively
15 coupled with Bluetooth transceiver to send the sensed data to the sensor hub 106 via the Bluetooth protocol. The wearable device 102 may also send Received Signal Strength Indicator (RSSI) data with the sensed data.

20 **[0030]** Further, the transmitter 114 of the sensor hub 106 may send the received sensed data from the wearable device 102 and the one or more sensors 104 to the backend system 108 over a communication network 110. The communication network 110 may be, without any limitation, based on a wired communication protocol,
25 a wireless communication protocol or a combination thereof.

[0031] Further, the backend system 108 may include a data processing engine 118, a device data repository 120, a console 122, a visualization module 124 and a notification module 126.
30 The console 122, the visualization module 124 and the notification module 126 may be communicatively coupled to the device data repository 120. Further, the data processing engine 118 may be communicatively coupled to the sensor hub 106 and may be located in proximity of the user, in remote location, or
35 cloud environment. The data processing engine 118 may be

configured to calibrate, using one or more machine learning models, the readings associated with one or more physiological parameters of the user based on a determined bias in the sensed data from the wearable device 102. The device data repository
5 120 may store the sensed data from the wearable device 102, the sensed data from the one or more sensors 104 and the calibrated data. The console 122 may be understood as browser based device management application to allow one or more users to view and control various operations related to devices in the block 128
10 that is devices deployed in the ambient space, such as the one or more sensors 104 and the sensor hub 106. In exemplary embodiments of the present invention, the one or more users may include, without any limitation, the patient and caretakers. Further, the visualization module 124 may be a browser based
15 application that may facilitate visualization of sensed data received from the sensor hub 106. Furthermore, the notifications module 134 may constantly monitor the data acquired through the sensor hub 106 and raises notification events through various channels, such as SMS and emails, for the one or more users to
20 be able to respond to alarming situations.

[0032] In an embodiment of the present invention, the data processing engine 118 may be configured to correlate the sensed data from the wearable device 102 and the sensed data from the
25 one or more sensors 104 by employing one or more machine learning models to determine a bias in the sensed data from the wearable device 102. In an exemplary embodiment of the present invention, the machine learning model may be a reinforcement learning based model. The data processing engine 118 may also be configured to
30 calibrate the readings associated with one or more physiological parameters of the user based on the determined bias in the sensed data from the wearable device 102. Before calibrating the readings the data processing engine 118 may check with the

inferencing engine 116 of the sensor hub 106 if the user is wearing the wearable device 102.

[0033] The inferencing engine 116 of the sensor hub 106 may be configured to detect occupancy of a space ambient to the user. The inferencing engine 116 of the sensor hub 106 may detect occupancy based on the readings of one or more Passive-Infrared (PIR) sensors 108 and RSSI value. Further, the inferencing engine 116 of the sensor hub 106 may be configured to determine change in RSSI value of the sensed data received from the wearable device 102 for a predetermined period of time. Since the sensor hub 106 may be at a fixed position, the RSSI value may change whenever the user wearing the wearable device 102 may move inside the ambient space. The value of RSSI signal may be highest when the user may be close to the sensor hub 106. In an exemplary embodiment of the present invention, the predetermined period of time may be 10-15 minutes. The inferencing engine 116 of the sensor hub 106 may also be configured to compare the subsequently obtained RSSI value of the sensed data of the wearable device 102 over a period of time to determine if the user is wearing the wearable device 102. For instance, when the RSSI value may not change for the predetermined time and the one or more motion sensors may detect that the user may be moving in the ambient space, the inferencing engine 116 of the sensor hub 106 may determine that the wearable device 102 may be off the user's body.

[0034] In an embodiment of the present invention, when the result of the comparison may indicate that the sensed data of the wearable device 102 and the sensed data of the one or more sensors 104 may be same for the predetermined period of time, despite the user not moving inside the ambient space, it may be inferred by the inferencing engine 116 of the sensor hub 106 that the wearable device 102 may be off the user's body and the

wearable device 102 is measuring the ambient parameters around the user. Further, when the result of the comparison may indicate that the sensed data of the wearable device 102 and the sensed data of the one or more sensors 104 have a predetermined
5 difference for the predetermined period of time, it may be inferred by the inferencing engine 116 of the sensor hub 106 that the wearable device 102 may be worn by the user and the wearable device 102 is measuring one or more physiological parameters of the user.

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[0035] In an embodiment of the present invention, the data processing engine 118 may also be configured to create an annotated event timeline based on the received sensed data from the wearable device 102, received sensed data from the one or
15 more sensors 104 and determined position of the wearable device 102 with respect to the user's body, regarding which the information is received from the inferencing engine 116 of the sensor hub 106, as illustrated in Figure 2. The annotated event timeline may represent various events and their corresponding
20 time of occurrence, as shown in Figure 2. For instance, when the wearable device 102 may employ the temperature sensor, the annotated event timeline may depict various events including temperature of the ambient space measured by the one or more temperature sensors positioned in the system 100 as represented
25 by the block 202 in Figure 2 and temperature of the user measured by the wearable device 102 as represented by the block 204 in Figure 2. Further, the annotated event timeline may also depict events indicating that the wearable device 102 may be off the user's body as represented by the block 206 in Figure 2 and
30 event indicating that the wearable device 102 may be on the user's body, as represented by the block 208 in Figure 2. Furthermore, the annotated event timeline from the OFF_BODY EVENT 206 TO ON_BODY EVENT 208 may be a calibration window 210,

as shown in Figure 2 during which the calibration may be performed by the data processing engine 118.

[0036] Further, the data processing engine 118 may also be configured to generate a transfer curve by employing one or more machine learning models on the received sensed data from the wearable device 102, received sensed data from the one or more sensors 104 and determined position of the wearable sensor 102. In an embodiment of the present invention, the data processing engine 118 may compare the sensed data from the wearable device 102 with the sensed data from the one or more sensors 104 in the calibration window 210 to generate the transfer curve by employing one or more machine learning model. It may be understood that in a scenario when the wearable device 102 senses a single physiological parameter via a single type of sensor, for example a temperature sensor, the transfer curve may correspond to the wearable device 102 and may vary for another wearable device. Further, the transfer curve may be different for each sensor of the wearable device 102, in case the wearable device 102 includes plurality of type of sensors for different physiological parameters. For example, the transfer curve generated for temperature sensor may be different from the transfer curve generated for the blood pressure sensor for the same wearable device 102. Furthermore, the data processing engine 118 may be configured to calibrate readings of the wearable device 102 based on the transfer curve. In an exemplary embodiment of the present invention, the data processing engine 118 may be configured to predict readings associated with calibrated wearable sensor 102. In an embodiment of the present invention, the data processing engine 118 may continuously update the transfer curve based on the received sensed data from the wearable device 102, received sensed data from the one or more sensors 104 and determined position of the wearable sensor

102 to maintain accuracy of the readings of the one or more physiological parameters of the user.

[0037] In an embodiment of the present invention, after the readings from the wearable device 102 may be calibrated, the data processing engine 118 may also calibrate readings from the one or more sensors 104 based on correlation of the sensed data from the calibrated wearable device 102 and the sensed data from the one or more sensors 104 by employing one or more machine learning models. For example, readings from the one or more humidity sensors 104b may be calibrated based on the effect of opened door detected by the one or more door contact sensors 104f and temperature detected by the one or more temperature sensors 104a.

[0038] In an embodiment of the present invention, the data processing engine 118 may also facilitate detection of failure of the wearable device 102 and one or more sensors 104 based on correlation of the sensed data from the calibrated wearable device 102 and the sensed data from the one or more sensors 104 by employing one or more machine learning models.

[0039] In an embodiment of the present invention, before employing the one or more machine learning models, the one or more machine learning models may be trained. The one or more machine learning models may calculate errors while calibrating readings of the wearable device 102 based on the created annotated event timeline. In an embodiment of the present invention, the annotated event timeline may be annotated based on the readings of infra-red temperature sensors to allow error calculation for the generation of the one or more machine learning models.

[0040] In operation, when the wearable device 102 may include one or more temperature sensors for measurement of core body temperature of a user, the wearable device 102 may capture the body temperature of the user. Further, the one or more sensors 104 may capture ambient parameters of the user. The wearable device 102 may send the captured body temperature to the receiver 112 of the sensor hub 106 via the Bluetooth protocol. The one or more sensors 104 may also send the captured ambient parameters to the receiver 112 of the sensor hub 106 via Zigbee protocol. In an example, the received sensed data from the wearable device 102 and the one or more sensors 104 may be converted to, without any limitation, JavaScript Object Notation (JSON). The transmitter 114 of the sensor hub 106 may send the received sensed data from the wearable device 102 and the one or more sensors 104 to the backend system 108 over, without any limitation, Message Queuing Telemetry Transport- Transport Layer Security (MQTT-TLS). At the backend system 108, the data processing engine 118 may correlate the sensed data from the wearable device 102 and the sensed data from the one or more sensors 104 by employing one or more machine learning model to generate simple browser based charting and exporting based on which the readings of the wearable device 102 may be calibrated.

[0041] Before calibrating the readings of the wearable device 102, the data processing engine 118 may check with the inferencing engine 116 of the sensor hub 106 if the user is wearing the wearable device 102 for enhanced calibration of the readings of the wearable device 102. The inferencing engine 116 of the sensor hub 106 may compare the subsequently obtained RSSI value of the sensed data of the wearable device 102 over a period of time to determine whether the user is wearing the wearable device 102. In the current scenario, the temperature measured by the wearable device 102 and the temperature measured by the one or more sensors 104 positioned in proximity of the user may

be same. Therefore, the wearable device 102 is off the user's body. Further, the data processing engine 118 may compare the sensed temperature of the wearable device 102 with the sensed temperature of the ambient space in the calibration window 210 to generate the transfer curve by employing one or more machine learning model. Furthermore, the data processing engine 118 may calibrate the wearable device 102 based on the transfer curve.

[0042] Thus, the present invention provides the system 100 for calibrating readings associated with one or more physiological parameters of a user. Since the system 100 uses ambient parameters for calibration of the readings of the wearable device 102 this improves accuracy of the readings and reduces probability of error in the readings of the wearable devices. Further, the implementation of the machine learning models for continuous calibration ensure an automated and periodic detection and correction of errors in the readings of the wearable device 102. Furthermore, the inclusion of the position of the wearable device 102 with respect to user's body as one of the factor for calibration enhances the accuracy of the calibration of the readings. Accordingly, the present invention calibrates the readings of the wearable device 102 automatically in an automated manner based on ambient parameters of the user.

[0043] Figure 3 is a flowchart illustrating an automated method to calibrate readings associated with one or more physiological parameters of a user in accordance with an embodiment of the present invention. In an example, the automated method may operate, without any limitation, for medical care and treatment of patients. At step 302, data associated with one or more physiological parameters of a user may be sensed by a wearable device. The user may be understood as a patient. In an embodiment of the present invention, the

one or more physiological parameters of a user may include core body temperature, oxygen saturation, blood pressure, glucose level and pulse rate.

5 **[0044]** At step 304, data associated with one or more ambient parameters of the user may be sensed by one or more sensors positioned in proximity of the user. In an embodiment of the present invention, the one or more sensors may include one or more temperature sensors, one or more humidity sensors, one or
10 more light sensors, one or more pressure sensors, one or more Passive-Infrared (PIR) sensors as motion sensors, one or more Magnetic Switch sensors as door contact sensors or a combination thereof. Further, the one or more sensors may include a set of identical sensors, a set of non-identical sensors or a
15 combination thereof.

[0045] Next, at step 306, the sensed data from the wearable device and the sensed data from the one or more sensors may be received at the sensor hub. Further, at step 308, the sensed
20 data from the wearable device and the sensed data from the one or more sensors may be correlated by employing one or more machine learning models to determine a bias in the sensed data from the wearable device.

25 **[0046]** Further, at step 310, the readings associated with one or more physiological parameters of the user may be calibrated based on the determined bias in the sensed data from the wearable device.

30 **[0047]** In an embodiment of the present invention, the automated method further includes detecting occupancy of the space ambient to the user. Further, determining change in Received Signal Strength Indicator (RSSI) value of the sensed data received from the wearable device for a predetermined

period of time upon detection of the presence of the user in the ambient space and comparing the subsequently obtained RSSI value of the sensed data of the wearable device over a period of time to determine if the user is wearing the wearable device.

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[0048] In an embodiment of the present invention, when the result of the comparison indicates that the sensed data of the wearable device and the sensed data of the one or more sensors has been same for the predetermined period of time outputting that the wearable device is off the user's body and measuring the ambient parameters of the user. Further, when the result of the comparison indicates that the sensed data of the wearable device and the sensed data of the one or more sensors have a predetermined difference for the predetermined period of time outputting that the wearable device is worn by the user and measuring one or more physiological parameters of the user.

[0049] In an embodiment of the present invention, the automated method also includes creating an annotated event timeline based on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable device with respect to the user's body. Further, generating a transfer curve by employing one or more machine learning model on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable sensor. Furthermore, calibrating the readings associated with one or more physiological parameters of the user based on the transfer curve.

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[0050] Thus, the present invention provides the automated method for calibrating readings associated with one or more physiological parameters of a user. Since the automated method uses ambient parameters for calibration of the readings of the

wearable device this improves accuracy of the readings and reduces probability of error in the readings of the wearable devices. Further, the implementation of the machine learning models for continuous calibration ensure an automated and periodic detection and correction of errors in the readings of the wearable device. Furthermore, the inclusion of the position of the wearable device with respect to user's body as one of the factor for calibration enhances the accuracy of the calibration of the readings. Accordingly, the present invention calibrates the readings of the wearable device automatically in an automated manner based on ambient parameters of the user.

[0051] In an embodiment of the present invention, the automated method may be practiced using a non-transitory computer program product comprising at least one computer-readable storage medium having computer-executable program code stored therein. The computer executable program code comprising instructions that when executed by a processor, cause the processor to: sense, by a wearable device, data associated with one or more physiological parameters of a user and sense, by a one or more sensors positioned in proximity of the user, data associated with one or more ambient parameters of the user. Further, receive the sensed data from the wearable device and receive the sensed data from the one or more sensors. Furthermore, correlate the sensed data from the wearable device and the sensed data from the one or more sensors by employing one or more machine learning models to determine a bias in the sensed data from the wearable device and calibrate the readings associated with one or more physiological parameters of the user based on the determined bias in the sensed data from the wearable device.

[0052] In an embodiment of the present invention, the computer program product comprises instructions to detect

occupancy of a space ambient to the user, determine change in Received Signal Strength Indicator (RSSI) value of the sensed data received from the wearable device for a predetermined period of time upon detection of the presence of the user in the ambient space, and compare the successively obtained RSSI value of the sensed data of the wearable device over a period of time to determine if the user is wearing the wearable device.

[0053] In an embodiment of the present invention, the computer program product comprises instructions to infer that the wearable device is off the user's body and measuring the ambient parameters of the user, when the result of the comparison indicates that the sensed data of the wearable device and the sensed data of the one or more sensors are same for the predetermined period of time. Further, infer that the wearable device is worn by the user and measuring one or more physiological parameters of the user, when the result of the comparison indicates that the sensed data of the wearable device and the sensed data of the one or more sensors have a predetermined difference for the predetermined period of time.

[0054] In an embodiment of the present invention, the computer program product comprises instructions to create an annotated event timeline based on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable device with respect to the user's body. Further, generate a transfer curve by employing one or more machine learning model on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable sensor. Furthermore, calibrate the readings associated with one or more physiological parameters of the user based on the transfer curve.

[0055] Figure 4 illustrates an exemplary computer system 400 in which various embodiments of the present invention may be implemented. Particularly, computing machines such as but not limited to internal/external server clusters, quantum computers, desktops, laptops, smartphones, tablets and wearables which may be used to execute the system 100 or may have the structure of the computer system 400. The computer system 400 may include additional components not shown and that some of the components described may be removed and/or modified. In another example, a computer system 400 with multiple GPUs can sit on external-cloud platforms or internal corporate cloud computing clusters, or organizational computing resources, etc.

[0056] The computer system 400 may represent a computational platform that includes components that may be in a server or another computer system. The computer system 400 may execute, by a processor (e.g., a single or multiple processors) or other hardware processing circuit, the methods, functions and other processes described herein. These methods, functions and other processes may be embodied as machine-readable instructions stored on a computer-readable medium, which may be non-transitory, such as hardware storage devices (e.g., RAM (random access memory), ROM (read-only memory), EPROM (erasable, programmable ROM), EEPROM (electrically erasable, programmable ROM), hard drives, and flash memory). The computer system 400 may include a processor 402 that executes software instructions or code stored on a non-transitory computer-readable storage medium 404 to perform methods of the present disclosure. The software code includes, for example, instructions to gather data and analyze data. In an example, data processing engine 118 may be the software codes.

[0057] The instructions on the computer-readable storage medium 404 are read and stored the instructions in storage 406

or in random access memory (RAM) 408. The storage 406 provides a large space for keeping static data where at least some instructions could be stored for later execution. The stored instructions may be further compiled to generate other representations of the instructions and dynamically stored in the RAM 408. The processor 402 reads instructions from the RAM 408 and performs actions as instructed.

[0058] The computer system 400 further includes an output device 410 to provide at least some of the results of the execution as output including, but not limited to, visual information to users, such as position of the wearable device 102 with respect to the user's body. The output device 410 can include a display on computing devices and virtual reality glasses. For example, the display can be a mobile phone screen or a laptop screen. GUIs and/or text are presented as an output on the display screen. The computer system 400 further includes input device 412 to provide a user or another device with mechanisms for entering data and/or otherwise interact with the computer system 400. The input device 412 may include, for example, sensors, a keyboard, a keypad, a mouse, or a touchscreen. Each of these output devices 410 and input devices 412 could be joined by one or more additional peripherals. In an example, the output device 410 may be used to display the alert regarding position of the wearable device 102 with respect to the user's body.

[0059] A network communicator 414 may be provided to connect the computer system 400 to a network and in turn to other devices connected to the network including other clients, servers, data stores, and interfaces, for instance. A network communicator 414 may include, for example, a network adapter such as a LAN adapter or a wireless adapter. The computer system 400 includes a data source interface 416 to access data source 418. A data source

is an information resource. As an example, wearable device 102 and the one or more sensors 104 may be a data source. Moreover, knowledge repositories and curated data may be other examples of data sources.

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[0060] While the exemplary embodiments of the present invention are described and illustrated herein, it will be appreciated that they are merely illustrative. It will be understood by those skilled in the art that various
10 modifications in form and detail may be made therein without departing from or offending the scope of the invention as defined by the appended claims.

CLAIMS

[Claim 1]

A system 100 for calibrating readings associated with one or
5 more physiological parameters of a user, the system 100
comprising:

a wearable device 102 to sense data associated with one or
more physiological parameters of a user;

one or more sensors 104 positioned in proximity of the user
10 to sense data associated with one or more ambient parameters of
the user;

a sensor hub 106 configured to:

receive sensed data from the wearable device 102;

receive sensed data from the one or more sensors 104;

15 and

a data processing engine 118 configured to:

correlate the sensed data from the wearable device 102
and the sensed data from the one or more sensors 104 by
employing one or more machine learning models to determine

20 a bias in the sensed data from the wearable device 102; and

calibrate the readings associated with one or more
physiological parameters of the user based on the
determined bias in the sensed data from the wearable device
102.

25

[Claim 2]

The system 100 as claimed in claim 1, wherein the one or more
physiological parameters of a user include core body
temperature, oxygen saturation, blood pressure, glucose level,
30 heart rate, activity and motion, and pulse rate.

[Claim 3]

The system 100 as claimed in claim 1, wherein the one or more
sensors 104 are at least one of: a set of identical sensors and

a set of non-identical sensors, further wherein the one or more sensors 104 include at least one of: one or more temperature sensors, one or more humidity sensors, one or more Passive Infrared based motion sensors, one or more light sensors, one
5 or more pressure sensors, and one or more Magnetic Switch sensors.

[Claim 4]

The system 100 as claimed in claim 1, wherein the data processing
10 engine 118 is communicatively coupled to the sensor hub 106 and is located in one of: proximity of the user, a remote location and cloud environment.

[Claim 5]

The system 100 as claimed in claim 1, wherein the wearable device
15 102 communicates with the sensor hub 106 via a first communication protocol and the one or more sensors 104 communicate with the sensor hub 106 via a second communication protocol.

[Claim 6]

The system 100 as claimed in claim 1, wherein the sensor hub 106
20 is further configured to:

detect occupancy of a space ambient to the user;

25 determine change in Received Signal Strength Indicator (RSSI) value of the sensed data received from the wearable device 102 for a predetermined period of time upon detection of the presence of the user in the ambient space; and

compare the successively obtained RSSI value of the sensed
30 data of the wearable device 102 over a period of time to determine if the user is wearing the wearable device 102.

[Claim 7]

The system 100 as claimed in claim 6, wherein when the result of the comparison indicates that the sensed data of the wearable device 102 and the sensed data of the one or more sensors 104 is same for the predetermined period of time, it is inferred that the wearable device 102 is off the user's body and is measuring the ambient parameters of the user.

[Claim 8]

The system 100 as claimed in claim 6, wherein when the result of the comparison indicates that the sensed data of the wearable device 102 and the sensed data of the one or more sensors 104 have a predetermined difference for the predetermined period of time it is outputted that the wearable device 102 is worn by the user and is measuring one or more physiological parameters of the user.

[Claim 9]

The system 100 as claimed in claim 1, wherein the data processing engine 118 is configured to:

create an annotated event timeline based on the received sensed data from the wearable device 102, received sensed data from the one or more sensors 104 and determined position of the wearable device 102 with respect to user's body;

generate a transfer curve by employing one or more machine learning models on the received sensed data from the wearable device 102, received sensed data from the one or more sensors 104 and determined position of the wearable sensor 102; and

calibrate the readings associated with one or more physiological parameters of the user based on the transfer curve.

[Claim 10]

An automated method to calibrate readings associated with one or more physiological parameters of a user, the automated method comprising:

5 sensing, by a wearable device, data associated with one or more physiological parameters of a user;

 sensing, by a one or more sensors positioned in proximity of the user, data associated with one or more ambient parameters of the user;

10 receiving the sensed data from the wearable device and the sensed data from the one or more sensors;

 correlating the sensed data from the wearable device and the sensed data from the one or more sensors by employing one or more machine learning models to determine a bias in the sensed
15 data from the wearable device; and

 calibrating the readings associated with one or more physiological parameters of the user based on the determined bias in the sensed data from the wearable device.

20 [Claim 11]

The automated method as claimed in claim 10, wherein the one or more physiological parameters of a user include core body temperature, oxygen saturation, blood pressure, glucose level, heart rate, activity and motion, and pulse rate.

25

[Claim 12]

The automated method as claimed in claim 10, wherein the one or more sensors are at least one of: set of identical sensors and set of non-identical sensor, further wherein the one or more
30 sensors include at least one of: one or more temperature sensors, one or more humidity sensors, one or more Passive-Infrared based motion sensors, one or more light sensors, one or more pressure sensors and one or more door Magnetic Switch sensors.

[Claim 13]

The automated method as claimed in claim 10, further comprising:

detecting occupancy of the space ambient to the user;

determining change in Received Signal Strength Indicator

5 (RSSI) value of the sensed data received from the wearable device
for a predetermined period of time upon detection of the presence
of the user in the ambient space ; and

comparing the successively obtained RSSI value of the
sensed data of the wearable device over a period of time to
10 determine if the user is wearing the wearable device.

[Claim 14]

The automated method as claimed in claim 13, wherein when the
result of the comparison indicates that the sensed data of the
15 wearable device and the sensed data of the one or more sensors
are same for the predetermined period of time, inferring that
the wearable device is off the user's body and measuring the
ambient parameters of the user.

20 [Claim 15]

The automated method as claimed in claim 13, wherein when the
result of the comparison indicates that the sensed data of the
wearable device and the sensed data of the one or more sensors
have a predetermined difference for the predetermined period of
25 time inferring that the wearable device is worn by the user and
measuring one or more physiological parameters of the user.

[Claim 16]

The automated method as claimed in claim 10, further comprising:

30 creating an annotated event timeline based on the received
sensed data from the wearable device, received sensed data from
the one or more sensors and determined position of the wearable
device with respect to the user's body;

generating a transfer curve by employing one or more machine learning model on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable sensor; and

5 calibrating the readings associated with one or more physiological parameters of the user based on the transfer curve.

[Claim 17]

10 A computer program product comprising at least one computer-readable storage medium having computer-executable program code stored therein, the computer executable program code comprising instructions that when executed by a processor, cause the processor to:

15 sense, by a wearable device, data associated with one or more physiological parameters of a user;

 sense, by a one or more sensors positioned in proximity of the user, data associated with one or more ambient parameters of the user;

20 receive the sensed data from the wearable device and the sensed data from the one or more sensors;

 correlate the sensed data from the wearable device and the sensed data from the one or more sensors by employing one or more machine learning models to determine a bias in the sensed data from the wearable device; and

25 calibrate the readings associated with one or more physiological parameters of the user based on the determined bias in the sensed data from the wearable device.

30 [Claim 18]

The computer program product as claimed in claim 17, further comprising instructions to:

 detect occupancy of the space ambient to the user;

determine change in Received Signal Strength Indicator (RSSI) value of the sensed data received from the wearable device for a predetermined period of time upon detection of the presence of the user in the ambient space ; and

5 compare the successively obtained RSSI value of the sensed data of the wearable device over a period of time to determine if the user is wearing the wearable device.

[Claim 19]

10 The computer program product as claimed in claim 18, further comprising instructions to:

infer that the wearable device is off the user's body and measuring the ambient parameters of the user, when the result of the comparison indicates that the sensed data of the wearable
15 device and the sensed data of the one or more sensors are same for the predetermined period of time; and

infer that the wearable device is worn by the user and measuring one or more physiological parameters of the user, wherein when the result of the comparison indicates that the
20 sensed data of the wearable device and the sensed data of the one or more sensors have a predetermined difference for the predetermined period of time.

[Claim 20]

25 The computer program product as claimed in claim 17, further comprising instructions to:

create an annotated event timeline based on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable
30 device with respect to the user's body;

generate a transfer curve by employing one or more machine learning model on the received sensed data from the wearable device, received sensed data from the one or more sensors and determined position of the wearable sensor; and

calibrate the readings associated with one or more physiological parameters of the user based on the transfer curve.