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(54) **METHOD OF CALCULATING BLOOD PRESSURE USING A MOBILE DEVICE**

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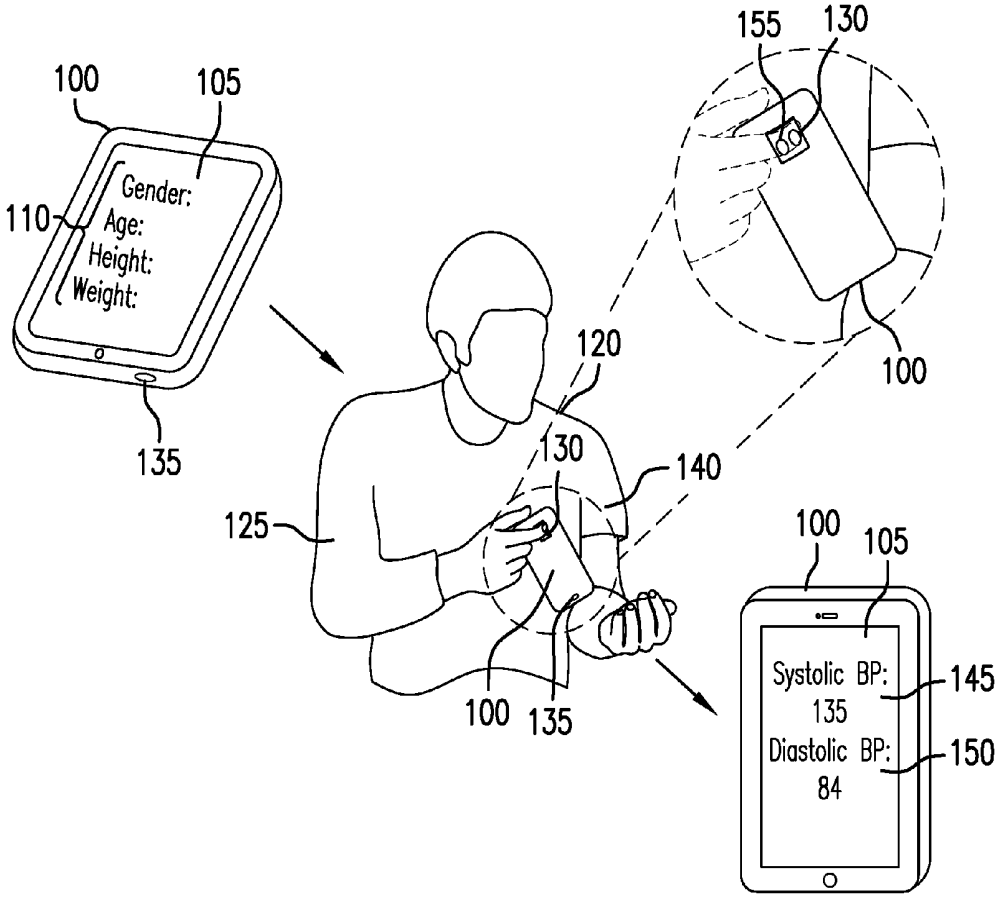
(57) **ABSTRACT**

Apparatus and associated methods relate to determining a user's blood pressure via information collected by a camera and a microphone of a portable communication device (PCD). In an illustrative example, the PCD simultaneously records a blood flow and a pulsation for the user. The blood flow may be recorded by positioning the camera such that camera aligns with a finger of a first arm of the user. The pulsation may be recorded by positioning the microphone such that the microphone proximate to an antecubital artery of the second arm of the user. In response, the PCD uses the recorded blood flow and pulsation information to determine a systolic blood pressure and diastolic blood pressure for the user in accordance with previously input body parameters (e.g., height, weight, age, gender) of the user.



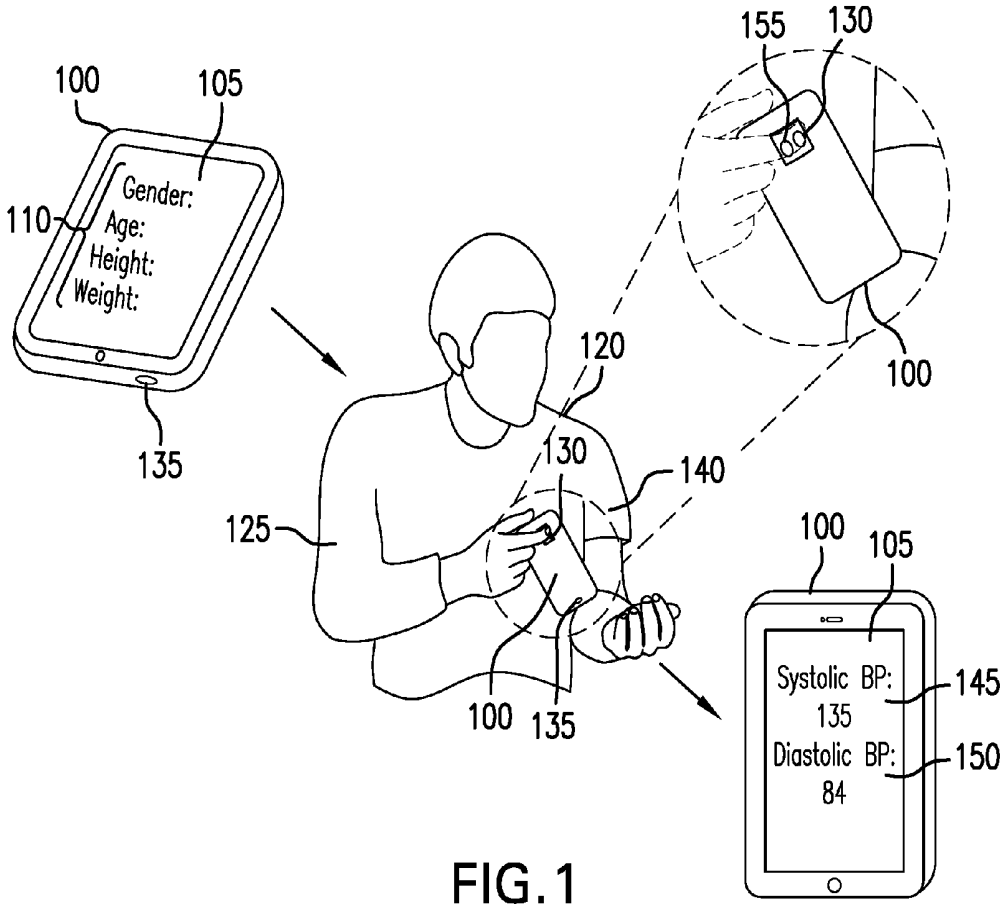

100
105
110
Gender:
Age:
Height:
Weight:
135
155
130
60
100
120
130
140
125
100
135
100
105
Systolic BP:
135
145
Diastolic BP:
84
150

FIG. 1

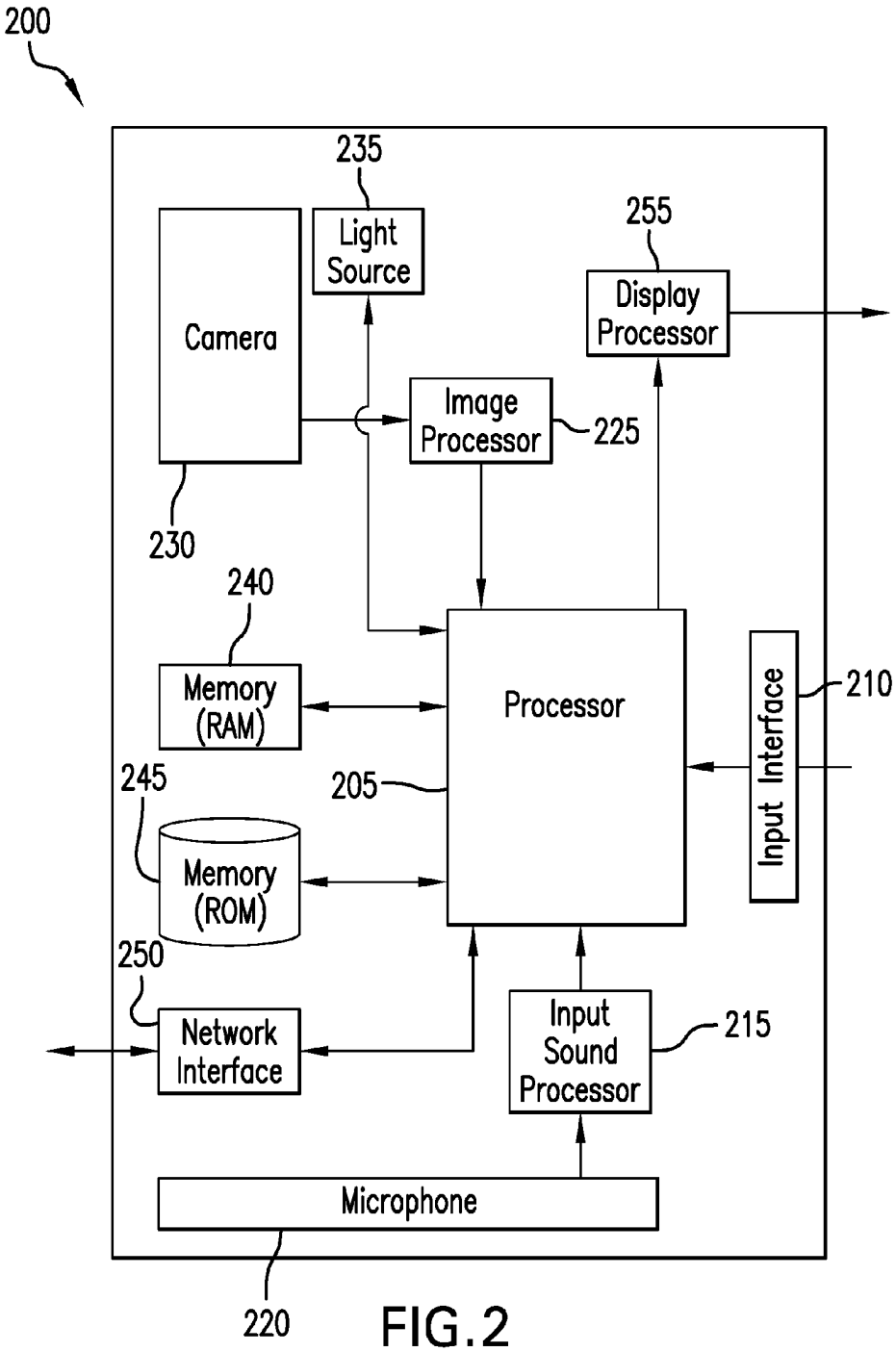

200
235
Light Source
255
Display Processor
Camera
Image Processor
225
230
240
Memory (RAM)
Processor
210
Input Interface
245
205
Memory (ROM)
250
Network Interface
Input Sound Processor
215
Microphone
220

FIG. 2

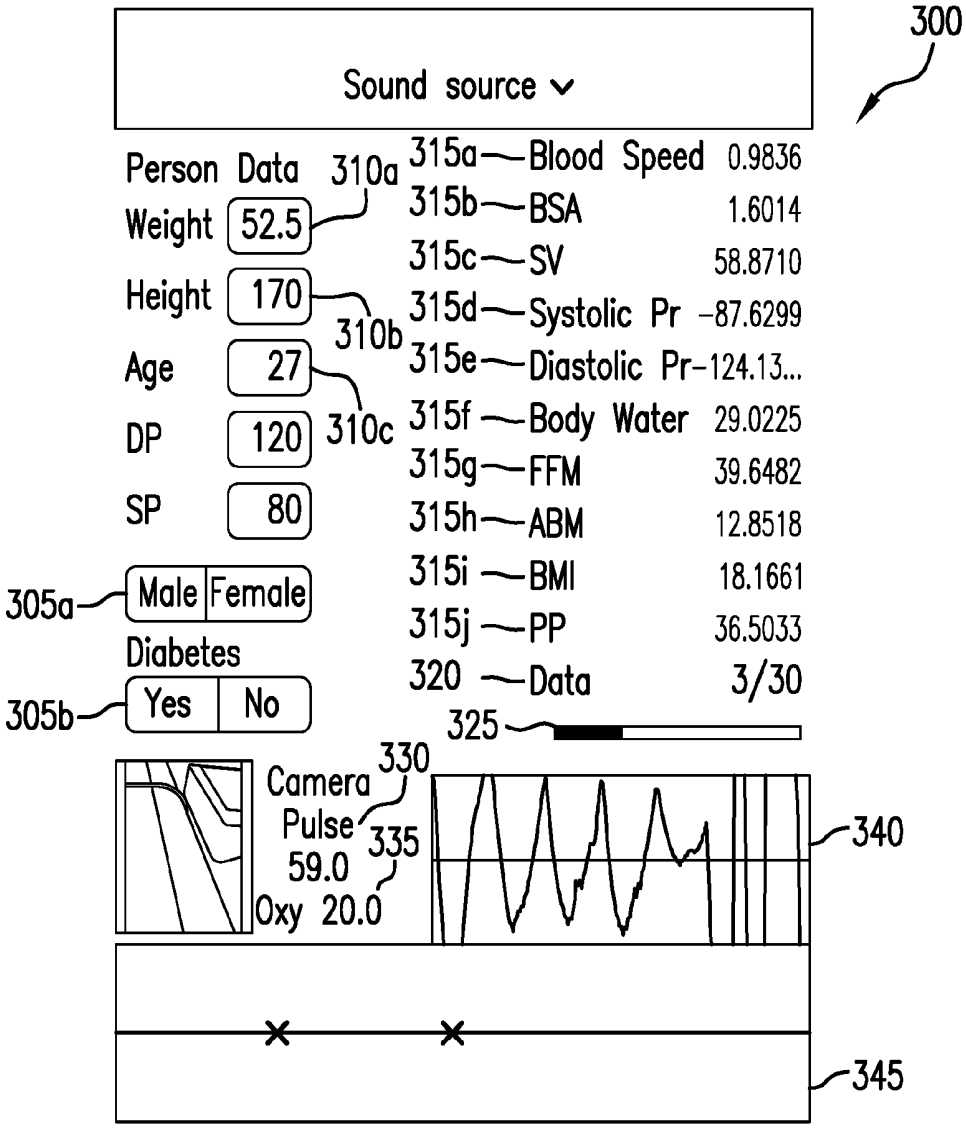

300
Sound source
Person Data
310a
Weight
52.5
Height
170
310b
Age
27
310c
DP
120
SP
80
305a
Male
Female
Diabetes
305b
Yes
No
315a Blood Speed 0.9836
315b BSA 1.6014
315c SV 58.8710
315d Systolic Pr -87.6299
315e Diastolic Pr-124.13...
315f Body Water 29.0225
315g FFM 39.6482
315h ABM 12.8518
315i BMI 18.1661
315j PP 36.5033
320 Data 3/30
325
330
Camera
Pulse
335
59.0
Oxy 20.0
340
345

FIG.3

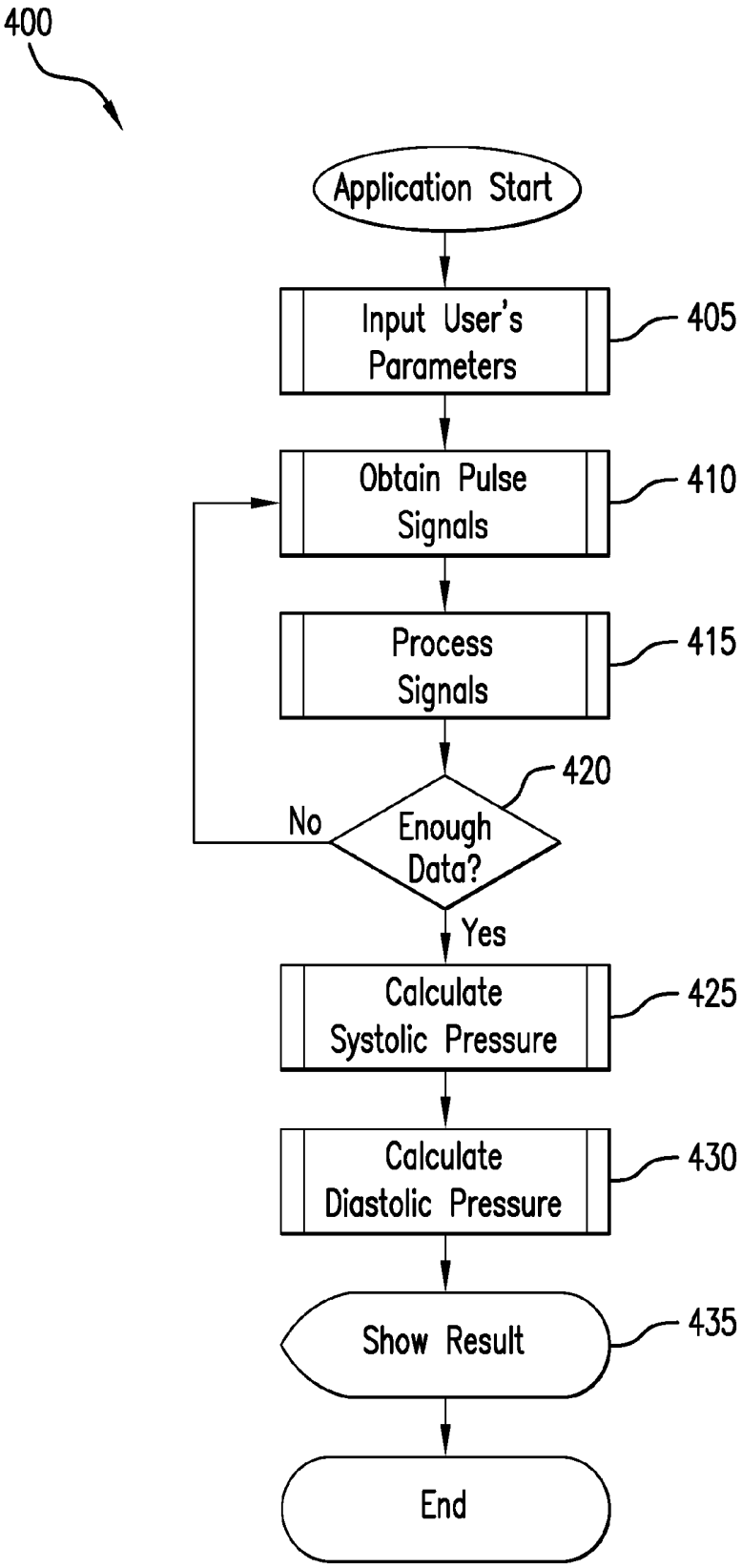

400
Application Start
Input User's Parameters
405
Obtain Pulse Signals
410
Process Signals
415
420
No
Enough Data?
Yes
Calculate Systolic Pressure
425
Calculate Diastolic Pressure
430
Show Result
435
End

FIG.4

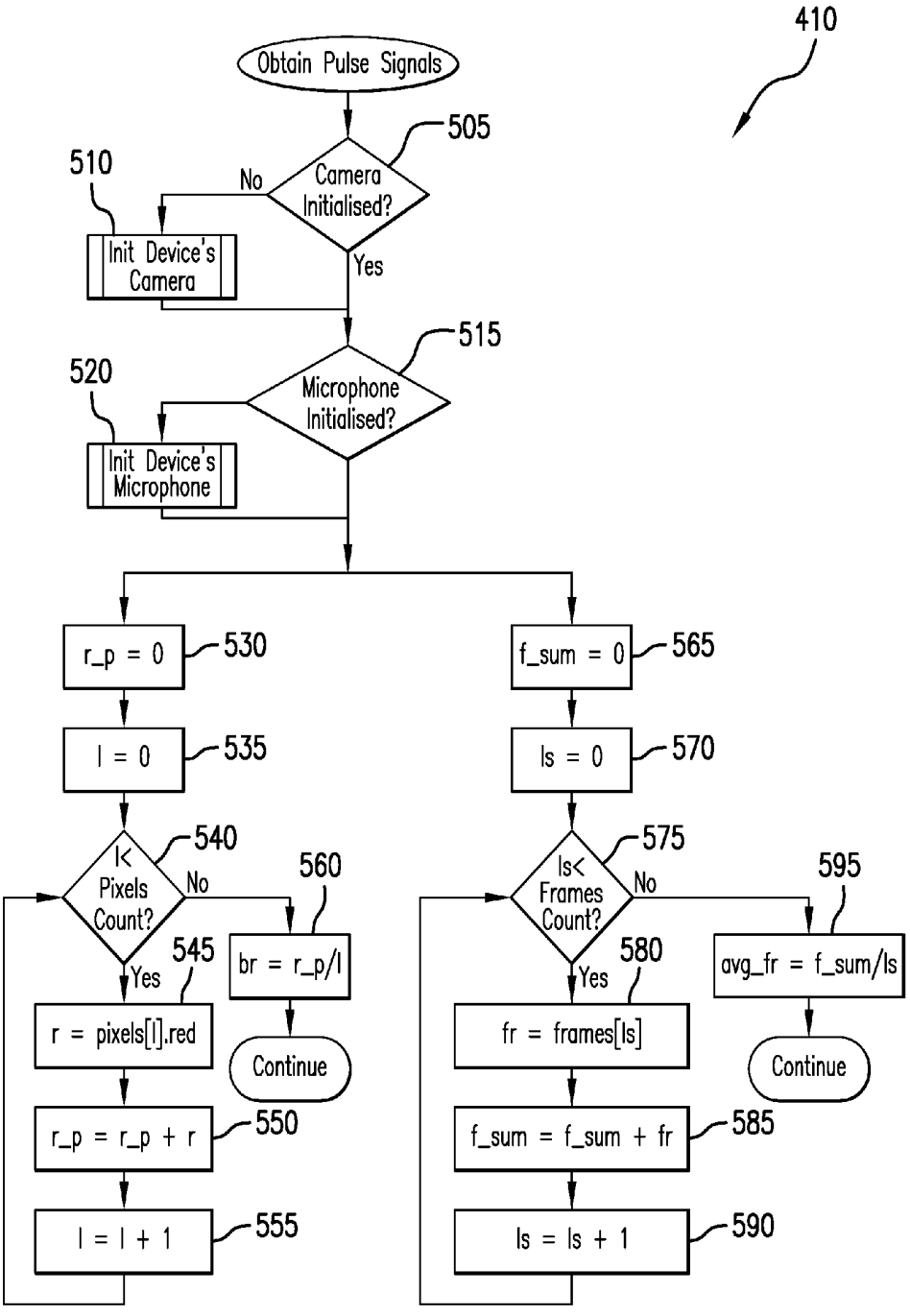

410
Obtain Pulse Signals
505
Camera Initialised?
No
Yes
510
Init Device's Camera
515
Microphone Initialised?
520
Init Device's Microphone
r_p = 0
530
l = 0
535
l< Pixels Count?
540
No
Yes
545
r = pixels[l].red
r_p = r_p + r
550
l = l + 1
555
560
br = r_p/l
Continue
f_sum = 0
565
ls = 0
570
ls< Frames Count?
575
No
Yes
580
fr = frames[ls]
f_sum = f_sum + fr
585
ls = ls + 1
590
595
avg_fr = f_sum/ls
Continue

FIG.5

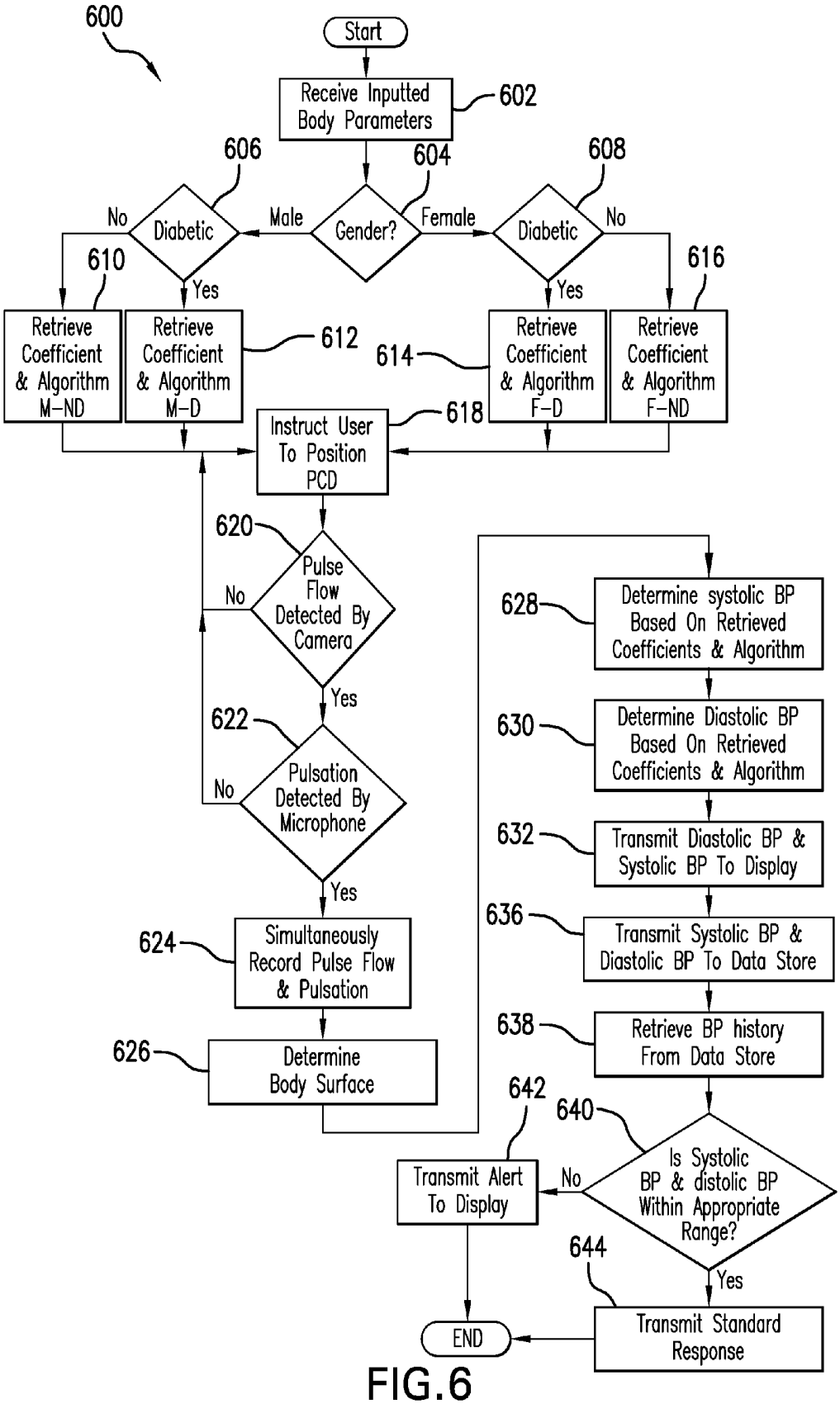

600
Start
Receive Inputted Body Parameters
602
604
Gender?
Male
Female
606
Diabetic
No
Yes
608
Diabetic
No
Yes
610
Retrieve Coefficient & Algorithm M-ND
612
Retrieve Coefficient & Algorithm M-D
614
Retrieve Coefficient & Algorithm F-D
616
Retrieve Coefficient & Algorithm F-ND
618
Instruct User To Position PCD
620
Pulse Flow Detected By Camera
No
Yes
622
Pulsation Detected By Microphone
No
Yes
624
Simultaneously Record Pulse Flow & Pulsation
626
Determine Body Surface
628
Determine systolic BP Based On Retrieved Coefficients & Algorithm
630
Determine Diastolic BP Based On Retrieved Coefficients & Algorithm
632
Transmit Diastolic BP & Systolic BP To Display
636
Transmit Systolic BP & Diastolic BP To Data Store
638
Retrieve BP history From Data Store
640
Is Systolic BP & distolic BP Within Appropriate Range?
No
Yes
642
Transmit Alert To Display
644
Transmit Standard Response
END

FIG.6

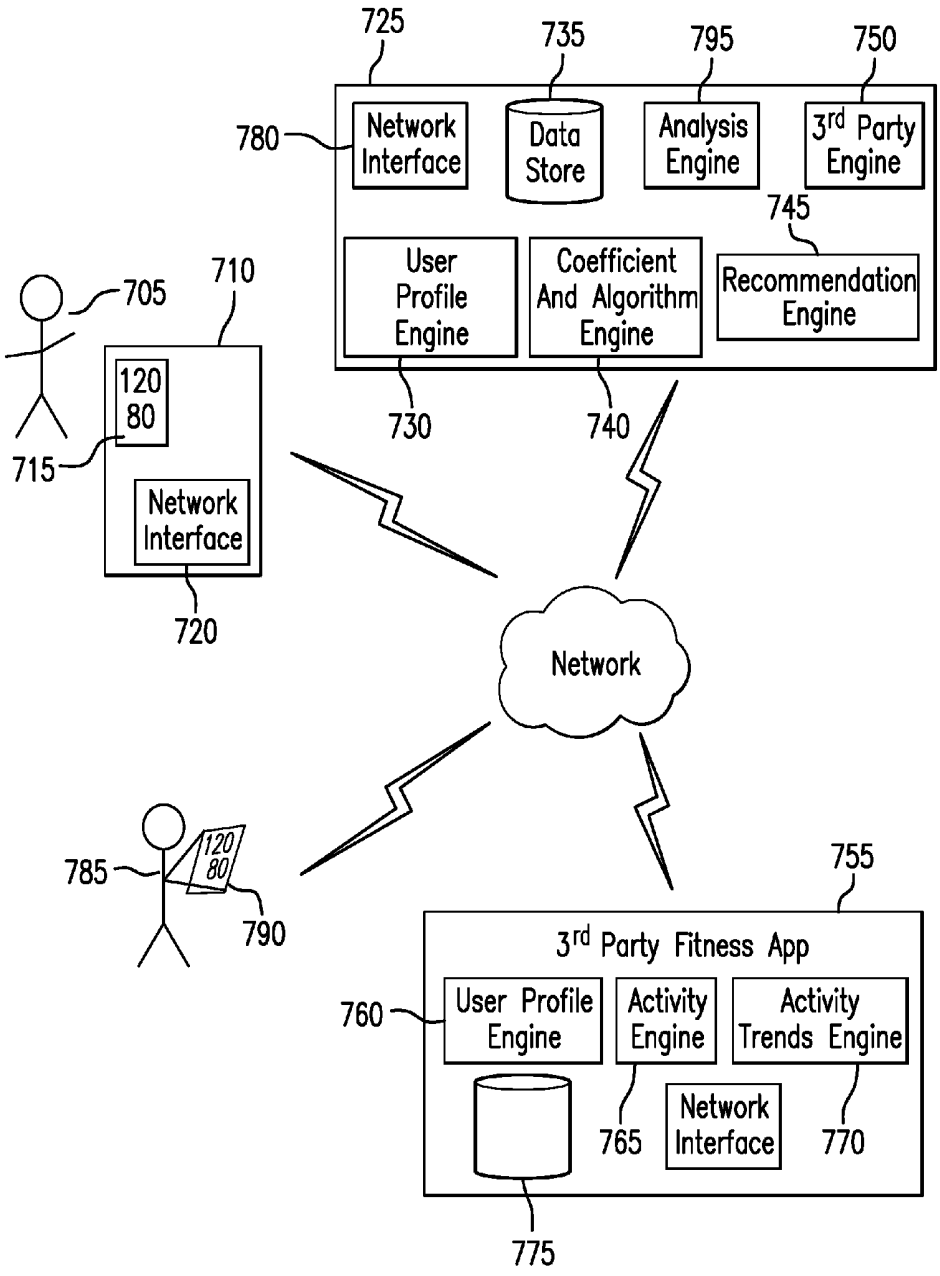

725
735
795
750
780
Network Interface
Data Store
Analysis Engine
3rd Party Engine
745
User Profile Engine
Coefficient And Algorithm Engine
Recommendation Engine
730
740
705
710
120 80
715
Network Interface
720
Network
785
120 80
790
755
3rd Party Fitness App
760
User Profile Engine
Activity Engine
Activity Trends Engine
765
Network Interface
770
775

FIG.7

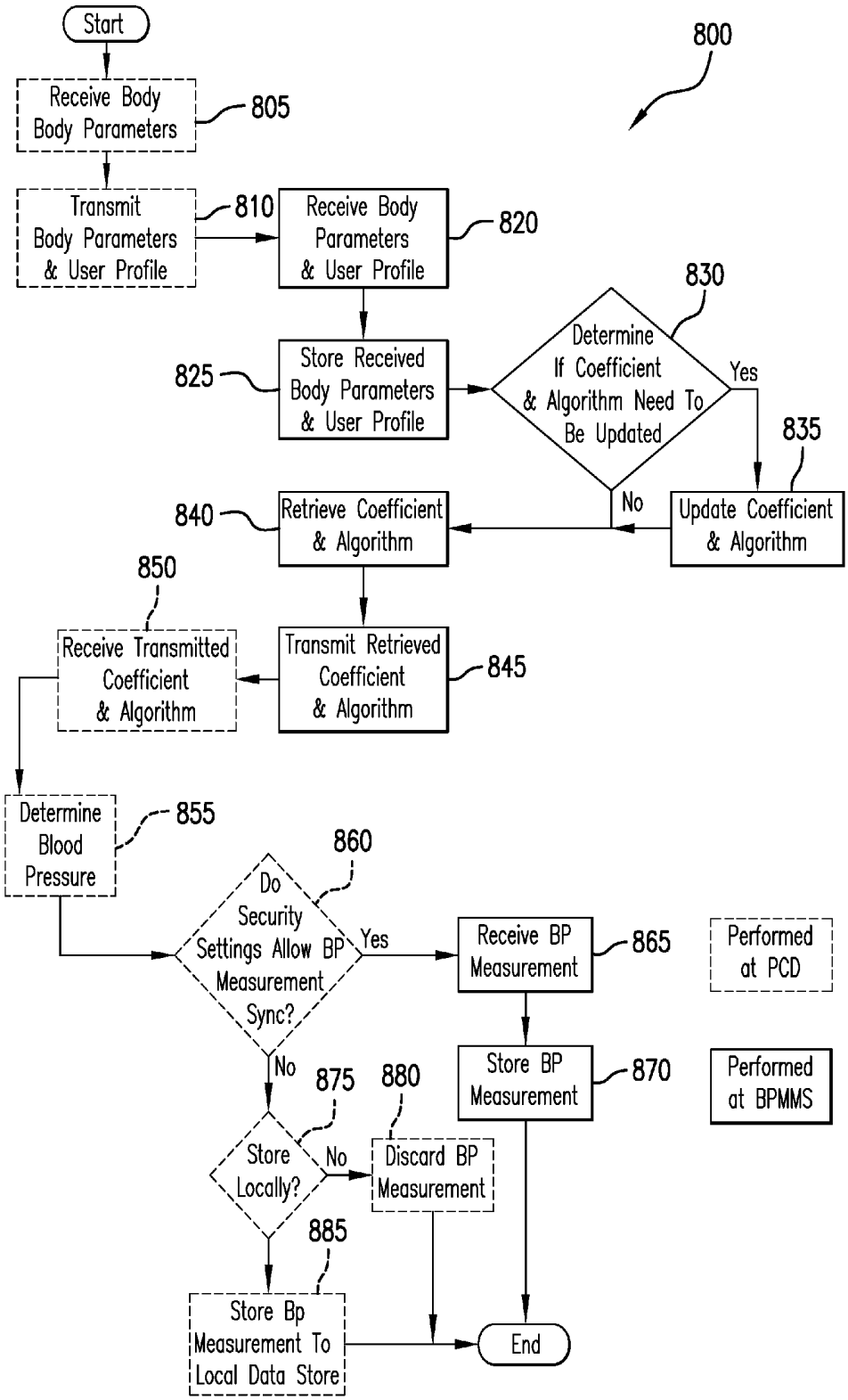

Start
800
Receive Body Body Parameters
805
Transmit Body Parameters & User Profile
810
Receive Body Parameters & User Profile
820
Store Received Body Parameters & User Profile
825
Determine If Coefficient & Algorithm Need To Be Updated
830
Yes
No
Update Coefficient & Algorithm
835
Retrieve Coefficient & Algorithm
840
Transmit Retrieved Coefficient & Algorithm
845
Receive Transmitted Coefficient & Algorithm
850
Determine Blood Pressure
855
Do Security Settings Allow BP Measurement Sync?
860
Yes
No
Receive BP Measurement
865
Performed at PCD
Store BP Measurement
870
Performed at BPMMS
Store Locally?
875
No
Discard BP Measurement
880
Store Bp Measurement To Local Data Store
885
End

FIG.8

METHOD OF CALCULATING BLOOD PRESSURE USING A MOBILE DEVICE

TECHNICAL FIELD

[0001] Various embodiments relate generally to blood pressure measurement devices.

BACKGROUND

[0002] In the medical field, it is common practice to monitor the vital signs of a patient. Vital signs typically include a body temperature, a blood pressure, a pulse, and a breathing rate of a patient. Doctors commonly use vital signs when administering a diagnosis of a patient or determining a treatment plan for the patient.

[0003] Various medical equipment may be used to measure a patient's vital signs. For example, a digital thermometer may be used to measure a patient's body temperature. A stethoscope and blood pressure cuff may be used to measure the blood pressure of a patient. While some types of medical equipment may be found in a patient's home such as a thermometer, for example, the medical equipment necessary to monitor vitals requires a visit to a doctor's office, a medical facility, or a medical transportation vehicle (e.g., ambulance).

SUMMARY

[0004] Apparatus and associated methods relate to determining a user's blood pressure via information collected by a camera and a microphone of a portable communication device (PCD). In an illustrative example, the PCD simultaneously records a blood flow and a pulsation for the user. The blood flow may be recorded by positioning the camera such that camera aligns with a finger of a first arm of the user. The pulsation may be recorded by positioning the microphone such that the microphone proximate to an antecubital artery of the second arm of the user. In response, the PCD uses the recorded blood flow and pulsation information to determine a systolic blood pressure and diastolic blood pressure for the user in accordance with previously input body parameters (e.g., height, weight, age, gender) of the user.

[0005] Various embodiments may achieve one or more advantages. For example, some embodiments may permit the user to transfer the user's inputted body parameters and determined blood pressure to a medical facility, or a doctor' office, for medical diagnosis. The user's inputted body parameters and determined blood pressure may be stored in a data memory to create a metrics history for the user. The stored information may be associated with a unique user profile for the user. The unique user profile, in accordance with the stored information, may provide individual trends and patterns for the user. The individual trends and patterns may assist in a medical diagnosis administered by a healthcare practitioner or self-care by the patient.

[0006] In some embodiments, the unique user profile may increase accuracy for determining blood pressure by tailoring an algorithm for specific use with the unique user profile. The algorithm may be updated in real-time to reflect the most recent stored information for the user associated with the unique user profile.

[0007] The details of various embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** depicts an exemplary use of a PCD for measuring a blood pressure of a user.

[0009] FIG. **2** depicts a schematic view of an exemplary PCD for measuring a blood pressure of a user.

[0010] FIG. **3** depicts a home screen for an exemplary blood pressure measuring application running on a PCD.

[0011] FIG. **4** depicts a flowchart for an exemplary method of measuring a user's blood pressure with a PCD.

[0012] FIG. **5** depicts a flowchart of an exemplary method of using a PCD to capture image frames and sound samples.

[0013] FIG. **6** a flowchart of an exemplary method of using a PCD to measure a blood pressure for a user.

[0014] FIG. **7** depicts an illustration of an exemplary blood pressure monitoring management system (BPMMS) integrated for use multi-use applications.

[0015] FIG. **8** depicts a flowchart of an exemplary PCD-BPMMS operations executed between a PCD and a BPMMS.

[0016] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0017] To aid understanding, this document is organized as follows. First, an exemplary use of a PCD to measure a blood pressure of a user is briefly introduced with reference to FIG. **1**. Second, with reference to FIGS. **2-3**, the discussion turns to exemplary embodiments that illustrate the hardware architecture and a home screen for measuring a blood pressure of a user. With reference to FIGS. **4-6**, software flowcharts illustrate various operations for measuring a blood pressure with a PCD. With reference to FIG. **7**, a blood pressure monitoring management system illustrates various applications associated with measuring a blood pressure with a PCD. Finally, with reference to FIG. **8**, a flowchart of operations executed between a PCD and a BPMMS for updating and retrieving coefficients and algorithms tailored for an individual user.

[0018] FIG. **1** depicts an exemplary use of a PCD for measuring a blood pressure of a user. A portable communication device (PCD) **100** includes a display screen **105**. The PCD **100** may be a smartphone, such as an iPhone®, commercially available from Apple of Washington, or a smartphone for Android™, commercially available from Google of California. As depicted, the display screen **105** illustrates body parameters **110** associated with a user **120**. The user **120** holds the PCD **100** with a hand of a first arm **125** positioning a finger of the first arm **125** such that the finger aligns with a camera **130** of the PCD **100**. The person, with the finger aligned with the camera **130**, positions a microphone **135** of the PCD **100** proximate to an antecubital artery of the second arm **140** of the user **120**. The PCD **100** simultaneously records a pulse flow, via the camera **130**, and a pulsation, via the microphone **130**. In response to the recorded pulse flow and the recorded pulsation, the PCD **100**, in accordance with the inputted body parameters, determines a systolic blood pressure **140** and a diastolic

blood pressure **150**. The display screen **105** displays the systolic blood pressure **140** and the diastolic blood pressure **150**.

[0019] In some embodiments, the body parameters **110** may include medical conditions for the user **120** administering the blood pressure measurement. For example, the body parameters **110** may include whether the user **120** suffers from diabetes. The body parameters **110** may modify an algorithm for specific use with the user **120**. For example, a second person having a same gender, height and weight as the user **120**, but having a different age, may require modification to the algorithm used for determining the blood pressure of the second person.

[0020] In various embodiments, the PCD **100** may store inputted and recorded information to a data store. The data store may be in the PCD **100**, or in a remote database accessible from the PCD **100** via a communication network. The stored information may be used to analyze trends of the blood pressure for the user **120**. In some embodiments, the stored information may be used to create trends for various body parameters, such as, for example, weight loss and weight gain. The data store may be used to create statistics to improve the accuracy of an algorithm associated with the user **120**.

[0021] FIG. **2** depicts a schematic view of an exemplary PCD for measuring a blood pressure of a user. A PCD **200** includes a processor **205** operably connected to an input interface **210**. The input interface **210** may be used by a user **120** to input the user's body parameters **110**. The processor **205** operably connects to an input sound processor **215** to receive input sound signals from a microphone **220**. The processor **205** operably connects to an image processor **225** to receive image information from a camera **230**. A light source **235** in proximity to the camera **235** operably connects to the processor **205**. The processor **205** operably connects to a random-access-memory module (RAM) **240** and a storage device **245**. The storage device module **245** may be a data store. A network interface **250** transmits communication information between the processor **205** and an external source (not shown). A display processor **255** operably connects to the processor **205** to receive image information for display on the display screen **105**.

[0022] In an illustrative embodiment, the processor **205** may transmit positioning instructions to the display processor **255** via the image processor **225** to be displayed on the display screen **105**. The positioning instructions may include instructions to the user **120** for positioning the PCD **200** such that the camera **230** aligns with a finger of the first arm **125** of the user **120** and the microphone **220** of the PCD **200** may be proximate to an antecubital artery of the second arm **140** of the user **120**. In some embodiments, the PCD **200** may transmit an output sound signal to a speaker (not show) to indicate proper positioning of the PCD **200**. In various embodiments, the PCD **200** may transmit an output sound signal to indicate the PCD **200** is not properly positioned to begin recording a pulse flow and a pulsation of the user.

[0023] In some embodiments, the storage device **245** may include instructions for execution by the processor **205**. For example, the storage device **245** may include instructions for execution by the processor **205** to initiate, via the input sound processor **215**, the microphone **220** to begin recording sound samples from the antecubital artery of the user **120**. In various embodiments, the storage device **245** may include instructions for execution by the processor to initiate the camera **230**, via the image processor **225**, and the light source **235** to begin recording image frames from the finger of the user **120** to determine pulse flow. In various embodiments, the storage device **245** may include instructions for the processor **205** to simultaneously record the sound samples and the image frames.

[0024] In some embodiments, the processor **205** may transmit to the display processor **255** status updates for display on the display screen **105**. The status updates may indicate to the user **120** progress information concerning a recording of the sound samples and image frames. For example, an empty status bar may be displayed to indicate the recording of sound samples and image frames has not commenced. When the recordings begin, the status bar may fill incrementally to indicate progress. The progress indicated may be time transpired or time remaining. In various embodiments, a fixed number of sound samples and image frames may need to be recorded, for example, a sample size of thirty may be required for a more accurate blood pressure measurement. The status bar may indicate how many sound samples and image frames have been recorded or remain to be recorded. In some embodiments, multiple status bars may indicate statuses for different processes.

[0025] FIG. **3** depicts a home screen for an exemplary blood pressure measuring application running on a PCD. In the illustrated embodiment, the home screen **300** includes a pair of soft switches **305***a*, **305***b*. As depicted, the soft switches **305***a*, **305***b* may be toggled to select a specific parameter associated with the user **105**. For example, the soft switch **305***a* may be a toggle between a "Male" position and a "Female" position to indicate the sex of the user **105**. Soft switch **305***b* may be toggled between a "Yes" position and a "No" position to indicate whether the user **105** has diabetes. In some embodiments, more soft switches may be included on the home screen **300**. Each soft switch may indicate a distinct parameter for the user **105**. For example, a soft switch may be used to indicate whether a blood pressure measurement should be transmitted to an external source, such as, for example, the user's **120** doctor.

[0026] The home screen **300** includes input fields **310***a-c* to receive, via the input interface **210**, inputted body parameters about the user **105**. As depicted, the input field **310***a* is configured to receive the weight of the user **105**. The input field **310***b* is configured to receive the height of the user **105** and the input field **310***c* is configured to receive the age of the user **105**. In response to the received body parameters from the input fields **310***a-c*, the processor **205** may retrieve a blood pressure measurement algorithm tailored according to the received body parameters of the user **105**. In some embodiments, more input fields may be included on the home screen **300** and configured to receive different information. For example, the user **105** may input the amount of sleep averaged in a 24-hour span.

[0027] The home screen **300** includes display fields **315***a-j* to display values determined via a blood measuring algorithm. As depicted, the display field **315***a* displays a determined blood speed of the user **105**. The display fields **315***b*, **315***c* display a determined body surface area and a determined stroke volume, respectively, for the user **105**. The display fields **315***d*, **315***e* display a determined systolic blood pressure and a determined diastolic blood pressure, respectively, for the user **105**. As depicted, display fields **315***f*-**315***j* display, respectively, a determined body water, a determined fat-free mass, a determined normal body mass

index, a determined body mass index, and a determined pulse pressure. In some embodiments, the display fields may display other types of information. For example, a normal body mass index (NBMI) can be displayed as a reference point.

[0028] The home screen **300** includes a status display field **320**. As depicted the status display field **320** is configured to display real-time data progression information. In the illustrated embodiment, thirty recordings of the pulse flow and pulsation are required to measure the blood pressure of the user **120**. The status display field **320** displays the amount of recordings taken over the total amount of recordings needed. In some embodiments, the status display field **320** may display the number of recordings remaining. The home screen **300** includes a status bar **325** to indicate a progress of a specific operation. For example, the status bar **325** may be an illustrative depiction of the information displayed via status display field **320**. In various embodiments, the status bar **325** may indicate progress information not associated with the information displayed via the status display field. **320**.

[0029] The home screen **300** includes display fields **330**, **335** to display pulse information and pulse oxygenation levels (SpO2), respectively. As depicted, a pulse graph **340** illustrates a heart rate for the user **120**. The pulse graph **340** may be used to indicate whether the camera **230** is receiving blood flow information. The home screen **300** includes a sound graph **345**. The sound graph **345** may indicate whether the microphone **220** is receiving pulsation information about the user **120**. The home screen **300** includes a camera window **350**. The camera window **350** may show whether a finger of the user **120** properly aligns with the camera **130** to indicate proper usage of the camera for determining a blood pressure of the user **120**. In some embodiments, the camera window **350** may indicate whether a finger of the user **120** entirely or partially covers the camera **130**.

[0030] In some embodiments, the home screen **300** may arrange the input fields, the soft switches, the display fields, and the graphs in a different manner. In various embodiments, different screens may be included to display distinct information, such as, for example, a screen may include the input fields **310***a-c* without the display fields or the graphs. Multiple screens may be included to guide a user **120**. For example, a first screen may be included such that the user **120** needs to fill in the input fields before the user **120** may continue to a next step. A next step may be a screen displaying instruction for positions the PCD **200** for proper operations of a retrieved blood measuring algorithm.

[0031] FIG. **4** depicts a flowchart for an exemplary set of steps to measure a user's blood pressure with a PCD. The user **120** begins, at **405**, by inputting, into the PCD **200**, the user's **120** body parameters **110**. At **410**, after the PCD **200** receives the body parameters **110**, the PCD **200** records pulse signals from the user **120**. The PCD **200**, at **415**, processes the recorded signals. If the recorded signals do not exceed a predetermined threshold, the PCD **200** continues to record pulse signals, at **410**. If the recorded signals do exceed a predetermined threshold, the PCD **200** determines, at **425**, a systolic blood pressure for the user **120**. At **430**, the PCD **200** determines the diastolic blood pressure for the user **120**. At **435**, the PCD **200** displays, via the display screen **105**, the determined systolic blood pressure, from **425**, and the determined diastolic blood pressure, from **430**.

[0032] FIG. **5** depicts a flowchart of an exemplary method of using a PCD to capture image frames and sound samples. In an illustrative embodiment, the processor **205** begins execution of the method **410** by determining whether the camera **230** is initialized, at **505**. If the camera **230** is not initialized, the processor **205** initializes, at **510**, the camera **230**. If the camera **230** is initialized, the processor **205** determines, at **515**, whether the microphone **220** is initialized. If the microphone **220** is not initialized, the processor **205** initializes, at **520**, the microphone **220**. If the microphone **220** is initialized, the processor **205** simultaneously captures image frames from the camera **230** and captures sound samples from the microphone **220**.

[0033] At **530**, the processor **205** assigns a variable r_p (red plane) a value of zero. The variable r_p represents the sum of all red values of a captured frame. For example, each pixel has a red value of 0-255 and the variable r_p represents the sum of all red values in the each red pixel of a frame. At **535**, the processor **205** assigns a counter variable (i) a value of zero. At **540**, the processor determines whether the value of the counter variable (i) exceeds a predetermined pixel count threshold. If the value of the counter variable (i) does not exceed the predetermined pixel count threshold, a variable (r) receives, at **545**, an assigned value equal to the number of red pixels for a frame at the counter variable (i). The variable (r_p) increases, at **550**, by the value of the variable (r), from **545**. The counter variable (i) increases by one, at **555**. The processor **205** repeats, at **540**, determining whether the most recent value of the counter variable (i) is less than the predetermined pixel count threshold.

[0034] If, at **540**, the counter variable (i) exceeds the predetermined pixel count threshold, the processor **205** determines, at **560**, a quotient blood rate such that the quotient blood rate equals the most recent value of r_p divided by the value of the most recent counter variable (i).

[0035] At **565**, the processor **205** assigns a variable (f_sum) a value of zero. The variable f_sum represents sum of all values of all captured audio samples. For example, each audio sample has an audio value that is a sound level. The variable f_sum represents the sum all audio values in all audio samples. At **570**, the processor **205** assigns a sample counter variable (Is) a value of zero. At **575**, the processor determines whether the value of the sample counter variable (Is) exceeds a predetermined audio sample threshold. If the value of the sample counter variable (Is) does not exceed the predetermined audio sample threshold, a variable (fr) receives, at **580**, an assigned value equal to the number of audio detections for an audio sample at the sample counter variable (Is). The variable (f_sum) increases, at **585**, by the value of the variable (fr), from **580**. The sample counter variable (Is) increases by one, at **590**. The processor **205** repeats, at **575**, determining whether the most recent value of the sample counter variable (Is) is less than the predetermined audio sample threshold.

[0036] If, at **575**, the sample counter variable (Is) exceeds the predetermined audio sample threshold, the processor **205** determines, at **560**, a quotient average audio sample (avg_fr) such that the quotient average audio sample equals the most recent value of f_sum divided by the value of the most recent sample audio counter variable (Is).

[0037] In some embodiments, the predetermined pixel count threshold may be equal to 50. The predetermined pixel count threshold and the predetermined audio sample threshold may be equal, such as, for example, both the predeter-

mined pixel count threshold and the predetermined audio sample threshold may both equal thirty. In various embodiments, the predetermined pixel count threshold and the predetermined audio sample threshold may be different values. For example, the predetermined pixel count threshold may equal forty and the predetermined audio sample threshold may equal sixty.

[0038] FIG. **6** a flowchart of an exemplary method of using a PCD to measure a blood pressure for a user. In some examples, some of the steps in a method **600** may be included in a program of instructions stored in the data storage device **245**. The method **600** illustrates an exemplary process for determining a user's **120** blood pressure, the blood pressure being a function of the inputted body parameters **110**, pulse propagation time, body surface area, body water, fat-free mass, body mass index, stroke volume, and pulse pressure. In some embodiments, a normal body mass index may be included as a parameter from which the blood pressure is a function thereof. The method **600** receives, at **602**, inputted body parameters **110** via the input interface **220**. The processor **205**, based on the inputted body parameters **110**, determines, at **604**, the gender of the user **120**. At **606** and **608**, the processor **205** determines, based on the inputted body parameters **110**, whether the user is diabetic.

[0039] At **606**, if a male user is not diabetic, the processor **205** retrieves from the data store **245**, at **610**, a set of coefficients and a blood measuring algorithm (M-ND) based on the inputted body parameters **110**. If a male user is diabetic, the processor **205** retrieves from the data store **245**, at **612**, a set of coefficients and a blood measuring algorithm (M-D) based on the inputted body parameters **110**. At **608**, if a female user is diabetic, the processor **205** retrieves from the data store **245**, at **614**, a set of coefficients and a blood measuring algorithm (F-D) based on the inputted body parameters **110**. If a female user is not diabetic, the processor **205** retrieves from the data store **245**, at **616**, a set of coefficients and a blood measuring algorithm (F-ND) based on the inputted body parameters **110**. In various embodiments, the data store may be at a remote location. The processor **205** may transmit and retrieve information from the remote data store via the network interface **250**.

[0040] At **618**, the processor transmits, via the display processor **255**, to the display **105** instructions for positioning the PCD **200** such that a finger of a first arm **125** aligns with the camera **230** and positions a microphone **220** proximate to an antecubital artery of the second arm **140** of the user **120**. At **620**, the processor determines whether a pulse flow is detected by the camera **230**. If a pulse flow is not detected, the processor re-transmits, at **618**, positioning instructions to the display **105**. If a pulse flow is detected, the processor **205** determines whether a pulsation is detected by the microphone **220**, at **622**. If a pulsation is not detected, the processor re-transmits, at **622**, positioning instructions to the display **105**.

[0041] If a pulsation is detected, at **622**, the processor **205** simultaneously records, at **624**, received information from the camera **230** and the microphone **220**. The received information may be captured via the method **410**. The processor determines, at **626**, a body surface for the user **105** based on the retrieved coefficients and body measuring algorithm in accordance with the inputted body parameters **110**. For example, if the inputted body parameters indicate the user is a female with diabetes, the processor may user the coefficients and body measuring algorithm (F-D), from **614**, to determine the body surface of the user.

[0042] At **628**, the processor **205**, in response to the record information from the camera **230** and the microphone **220**, determines an average time difference between the pulse flow and the pulsation to determine a pulse propagation time. The processor **205** determines a body mass index and a normal body mass index. The processor **205** determines a body mass index correlation using the determined body mass index and the determined normal body mass index. Using a predetermined coefficient (k) retrieved from the data store **245** and the determined body mass index correlation, the processor **205** determines a systolic blood pressure. In some embodiments, the predetermined coefficient (k) is determined through statistical research based on recorded pulse propagation and blood pressure measurements recorded using a vital signs monitor, such as, for example, a Spot Vital Signs® Device as distributed by WelchAllyn®, Inc. of New York. At **630**, the processor **205** determines a body surface area, a body water, a fat-free mass, a stroke volume, and a pulse pressure. The processor **205** determines a diastolic blood pressure. In some embodiments, the diastolic pressure may be the difference between the predetermined systolic pressure and the pulse pressure. At **632**, the processor **205** transmits the determined systolic blood pressure and the determined diastolic blood pressure to the display **105** via the display processor **255**.

[0043] The processor **205**, at **636**, transmits the determined systolic blood pressure and the determined diastolic blood pressure to the data store **245** to store. At **638**, the processor **205** retrieves, from the data store **245**, a blood pressure history for the user **120**. In some embodiments, the processor **205** may transmit the inputted body parameters, the determined systolic blood pressure and the determined diastolic blood pressure to a remote data store via the network interface **250**. The processor **205** may receive, from the remote data store via the network interface, a blood pressure history for the user **120**. In various embodiments, the processor **205** may retrieve from the remote data store the coefficients and body measuring algorithm for the user **105** based on the inputted parameters.

[0044] At **640**, it is determined whether the determined systolic blood pressure and the determined diastolic blood pressure are within a predetermined blood pressure range. The predetermined blood pressure range may be based on the inputted body parameters **110** of the user **120**. If the determined systolic blood pressure and the determined diastolic blood pressure are not within the predetermined blood pressure range, the processor **205** transmits, at **642**, an alert to the display **105** via the display processor **255**. The alert may advise the user **120** to measure the user's **120** blood pressure again. If the determined systolic blood pressure and the determined diastolic blood pressure are within the predetermined blood pressure range, the processor **205** may transmit, at **644**, a message indicating a successful measurement of blood pressure to the display **105**.

[0045] In some embodiments, the predetermined blood pressure range may be based on a combination of user's **105** blood pressure history and the inputted body parameters. In various embodiments, the processor **205** may transmit, via the network interface **250**, the determined systolic blood pressure and the determined diastolic blood pressure to a remote medical facility. For example, the determined information may be transmitted to a doctor's office for analysis

or to assist in a diagnosis of the user **120**. In various embodiments, if the determined systolic blood pressure and the determined diastolic blood pressure are not within the predetermined blood pressure range based on the inputted body parameters, the processor **205** may execute a self-diagnosis routine to ensure proper functioning of the PCD **200**.

[0046] FIG. **7** depicts an illustration of an exemplary blood pressure monitoring management system (BPMMS) integrated for use multi-use applications. A user **605** measures the user's **705** blood pressure **715** using a PCD **710**. The PCD **710** transmits, via a network interface **720**, the measured blood pressure **715** to a blood pressure monitoring management system (BPMMS) **725**. The BPMMS **725** includes a user profile engine **730**. The user profile engine **730** may associate a unique user identification (UID) with information received about the user's **705** measured blood pressure **715**. A data store, also included in the BPMMS **725**, may store the received information such that the information may be retrieved using the user's UID. In some embodiments, other information, such as, for example, the user's **705** body parameters, may be transmitted from the PCD **710** and received by the user profile engine **730** to configure for storing.

[0047] A coefficient and algorithm engine (CAE) **740**, also included in the BPMMS **725**, may determine a set of coefficients and a blood pressure algorithm based on the stored information, in the data store **735** associated with the UID of the user **705**. The CAE **740** may transmit the determined set of coefficients and blood pressure algorithm to the PCD **710** for use in measuring a blood pressure of the user **705**. In some embodiments, as information continues to be stored in the data store **735**, the CAE **740** may continuously modify the set of coefficients and the blood pressure algorithm associated with the UID of the user **705** such the accuracy of the blood pressure measurements for the user **705** increases as more information about the user **705** is stored in the data store **735**.

[0048] The BPMMS **725** includes a recommendation engine **745**. The recommendation engine **745** may transmit, in response to a user's **705** blood pressure measurement **715**, recommendations from the BPMMS **725** to the PCD **710**. For example, if the blood pressure measurement **715** indicates that the user is experiencing high blood pressure, the recommendation engine **715** may transmit a recommendation to the user **705** that an appointment be scheduled with a doctor. In some embodiments, the recommendation engine may propose appointment times based a user's **705** doctor's office calendar, and in response to the user **705** selecting an appointment time, schedule the appointment with the user's **705** office.

[0049] The BPMMS **725** further includes a third party engine **750**. The third party engine **705** may be configured to communicate with a third party fitness application **755**. The third party fitness application includes a user profile engine **760**, an activity engine **765**, an analytics engine **770**, and data store **775**. The third party engine **750** may receive, via a network interface **780**, from the user profile engine **760** identifying information about the user **705** such that the user profile engine **730** associates the received identifying information with the UID of the user **705**. In response to associating the received identifying information with the UID, the third party engine **750** may receive from the activity engine **765** and the analytics engine **770** activity data (e.g., types of activities such as running) and activity trends data (e.g., amount of daily activity time). The received activity data and the activity trends data may be stored in the data store **735**. An analytic engine **785** of the BPMMS **725**, may perform analytics on the stored data in the data store **735**. For example, the analytic engine may determine trends about the user's **705** blood pressure **715** as it relates to the user's activity data. The results of the analytics performed by the analytic engine **735** may be transmitted to the PCD **710** for display or to a doctor to assist in a diagnosis of the user **705**.

[0050] A doctor **785** may retrieve the user's **705** blood pressure measurement **715** in real-time. For example, a doctor may conduct a consultation with the user **705** over a telephone. During the consultation, the doctor **785** may request the user **705** perform a blood pressure measurement **715** to assist the doctor **785** with a diagnosis. In response to the user **705** using the PCD **710** to take a blood pressure measurement **715**, the blood pressure measurement may be transmitted, via the network interface **720**, to a PCD **790** of the doctor **785**. The PCD **790** may be a computer, an iPad©, or a tablet for use Android™. In some embodiments, the doctor **785** may retrieve from the BPMMS **725** information pertaining to the UID of the user **705**. As depicted, the retrieved information may include blood pressure history, body parameters, analytics, and activity levels for the user **705**. In various embodiments, the doctor **785**, via the BPMMS **725**, may create a schedule to define times when the user **705** needs to take a blood pressure measurement.

[0051] The BPMMS **725** includes an analytics engine **795**. The analytics engine **795** may generate trends based on the information stored in the data store **735**. For example, the analytics engine may generate a graph charting the relationship between the user's **120** weight and the user's **120** blood pressure. In various embodiments, the analytics engine **795** may factor in information received from a third party app. For example, the analytics engine may generate a graph illustrating the user's **120** blood pressure as it relates to the user's **120** activity levels. The generated trends may be transmitted to the PCD **710** to be displayed for the user **120** to review. In some embodiments, the generated trends may be transmitted to the PCD **790** for the doctor **785** to review.

[0052] FIG. **8** depicts a flowchart of an exemplary PCD-BPMMS operations executed between a PCD and a BPMMS. In some examples, some of the steps in a method **800** may be included in a program of instructions. The program of instructions may be stored in either the data storage device **245** or the BPMMS **725**. In some embodiments, the PCD **200** may store a subset of the program of instructions in the data store device **245**, and the BPMMS **725** may store a remaining subset of the program of instructions in the data store **735**.

[0053] At **805**, the PCD **200** receives, via the input interface **210**, inputted body parameters. The PCD **200** associates the inputted body parameters with a previously create user profile. The user profile may include identifying information, such as, for example, a name and a birthday, to identify the user **120**. In some embodiments, the PCD **200** may include a multitude of user profiles such that each profile is associated with an individual user. An individual user may select a user profile that corresponds to the individual user before inputting the body parameters.

[0054] At **810**, the PCD **200** transmits, via the network interface **250**, the inputted body parameters with the asso-

ciated user profile to the BPMMS **725**. At **820**, the BPMMS **725** receives, via the network interface **780**, the transmitted inputted body parameters and the associated user profile. At **825**, the BPMMS **725** stores the received inputted body parameters such that the received user profile may be used to retrieved the saved inputted body parameters.

[0055] At **830**, the BPMMS **725** determines whether a set of coefficients and an algorithm associated with the received user profile needs to be modified in response to the received inputted body parameters. For example, if a weight of the user **120** increases since a previous measurement, the set of coefficients and an algorithm associated with the user **120** may need to be modified to account for the increase in weight. In some embodiments, the determination of whether the set of coefficients and the algorithm associated with the received user profile needs to be modified may include factors received from a third party. For example, the BPMMS **725** may receive, from the fitness app **755**, data about the activity levels of the user **120**. In the event the user's **120** activity levels have decreased, the CAE **740** may need to modify the set of coefficients and the algorithm to reflect the decrease in activity levels.

[0056] If the BPMMS **725** determines that the set of coefficients and the algorithm associated with the received user profile needs to be modified, the BPMMS **725**, via the CAE **740**, modifies, at **835**, the set of coefficients and the algorithm associated with the received user profile to reflect the received inputted body parameters. In various embodiments, the accuracy of the of the blood pressure measurement may increase as the set of coefficients and the algorithm are modified over time. If the BPMMS **725** determines that the set of coefficients and the algorithm associated with the received user profile does not need to be modified, the set of coefficients and the algorithm associated with the received user profile remain unchanged. In some embodiments, a user profile may not have an associated set of coefficients nor an associated algorithm. As such, the BPMMS **725** may provide a default set of coefficients and a default algorithm based only on the user inputted body parameters.

[0057] At **840**, the BPMMS **725** retrieves the set of coefficients and the algorithm associated with the received user profile as determined from **830**. The BPMMS **725** transmits, at **845**, the retrieved set of coefficients and the retrieved algorithm to the PCD **200**. The PCD **200** receives, at **850**, the transmitted set of coefficients and the transmitted algorithm. At **855**, the PCD **200** uses the set of coefficients and the algorithm received, from **850**, along with blood flow and pulsation information received from the camera **230** and the microphone **220** to determine a blood pressure measurement for the user **120**.

[0058] At **860**, the PCD **200** determines whether a security setting for the associated user profile permits the syncing the determined blood pressure measurement with the BPMMS **725**. If the security setting does permit syncing, the PCD **200** transmits the determined blood pressure measurement to the BPMMS **725**. At **865**, the BPMMS **725** receives the transmitted blood pressure measurement. The BPMMS **725** stores, at **870**, the received blood pressure measurement. In some embodiments, the BPMMS **725** may store the blood pressure measurements such that a third party (e.g., doctor's office) may retrieve the blood pressure measurements associated with an individual user profile based on security setting of the BPMMS **725**.

[0059] If the security setting does not permit syncing, the PCD **200** determines, at **875**, whether to store the blood pressure measurement locally. If the blood pressure measurement is not to be stored locally, the PCD **200** discards, at **880**, the blood pressure measurement. If the blood pressure measurement is to be stored locally, the PCD **200** stores, at **885**, the blood pressure measurement to the data store device **245**. In various embodiments, a user may manually sync blood pressure measurements at a later time. For example, the user may decide to store a number of blood pressure measurements locally and sync the stored blood pressure measurements at a same time. In some embodiments, the BPMMS **725**, via the analytics engine **795**, may generate trends to be used with inputted body parameters in determining a set of coefficients and an algorithm.

[0060] Although various embodiments have been described with reference to the Figures, other embodiments are possible. For example, the blood pressure measurement may be directed towards a mobile software application (App) that resides on a mobile device, such as a smartphone. The App may measure a user's blood pressure without the need for any external devices, such as, for example, an arm cuff. When the App is activated to measure blood pressure, the App, through the camera and the microphone of a mobile device, may gather pulse data from a user's index finger and elbow artery. In response to the gathered pulse data, the App may use the user's input body parameters (e.g., gender, age, weight, height) to calculate systolic and diastolic pressure and may display the results on a graphical display of the mobile device.

[0061] In some embodiments the BPMMS **725** may include a HIPPA management engine to manage hippa compliance of the information being received, stored, and transmitted. In various embodiments, the blood pressure measurement system may include a reminder engine to notify a user of a next scheduled blood pressure measurement. In some embodiments, the reminder engine may alert a user after a predetermined time period has been exceed since the most recent blood pressure measurement. In various embodiments, the reminder engine may be included in the BPMMS **725**.

[0062] Some aspects of embodiments may be implemented as a computer system. For example, various implementations may include digital and/or analog circuitry, computer hardware, firmware, software, or combinations thereof. Apparatus elements can be implemented in a computer program product tangibly embodied in an information carrier, e.g., in a machine-readable storage device, for execution by a programmable processor; and methods can be performed by a programmable processor executing a program of instructions to perform functions of various embodiments by operating on input data and generating an output. Some embodiments can be implemented advantageously in one or more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and instructions from, and to transmit data and instructions to, a data storage system, at least one input device, and/or at least one output device. A computer program is a set of instructions that can be used, directly or indirectly, in a computer to perform a certain activity or bring about a certain result. A computer program can be written in any form of programming language, including compiled or interpreted languages, and it can be deployed in any form, including as a

stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment.

[0063] Suitable processors for the execution of a program of instructions include, by way of example and not limitation, both general and special purpose microprocessors, which may include a single processor or one of multiple processors of any kind of computer. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. The essential elements of a computer are a processor for executing instructions and one or more memories for storing instructions and data. Storage devices suitable for tangibly embodying computer program instructions and data include all forms of non-volatile memory, including, by way of example, semiconductor memory devices, such as EPROM, EEPROM, and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and, CD-ROM and DVD-ROM disks. The processor and the memory can be supplemented by, or incorporated in, ASICs (application-specific integrated circuits). In some embodiments, the processor and the member can be supplemented by, or incorporated in hardware programmable devices, such as FPGAs, for example.

[0064] In some implementations, each system may be programmed with the same or similar information and/or initialized with substantially identical information stored in volatile and/or non-volatile memory. For example, one data interface may be configured to perform auto configuration, auto download, and/or auto update functions when coupled to an appropriate host device, such as a desktop computer or a server.

[0065] In some implementations, one or more user-interface features may be custom configured to perform specific functions. An exemplary embodiment may be implemented in a computer system that includes a graphical user interface and/or an Internet browser. To provide for interaction with a user, some implementations may be implemented on a computer having a display device, such as an LCD (liquid crystal display) monitor for displaying information to the user, a keyboard, and a pointing device, such as a mouse or a trackball by which the user can provide input to the computer.

[0066] In various implementations, the system may communicate using suitable communication methods, equipment, and techniques. For example, the system may communicate with compatible devices (e.g., devices capable of transferring data to and/or from the system) using point-to-point communication in which a message is transported directly from the source to the first receiver over a dedicated physical link (e.g., fiber optic link, point-to-point wiring, daisy-chain). The components of the system may exchange information by any form or medium of analog or digital data communication, including packet-based messages on a communication network. Examples of communication networks include, e.g., a LAN (local area network), a WAN (wide area network), MAN (metropolitan area network), wireless and/or optical networks, and the computers and networks forming the Internet. Other implementations may transport messages by broadcasting to all or substantially all devices that are coupled together by a communication network, for example, by using Omni-directional radio frequency (RF) signals. Still other implementations may transport messages characterized by high directivity, such as RF signals transmitted using directional (i.e., narrow beam) antennas or infrared signals that may optionally be used with focusing optics. Still other implementations are possible using appropriate interfaces and protocols such as, by way of example and not intended to be limiting, USB 2.0, Fire wire, ATA/IDE, RS-232, RS-422, RS-485, 802.11a/b/g, Wi-Fi, Ethernet, IrDA, FDDI (fiber distributed data interface), token-ring networks, or multiplexing techniques based on frequency, time, or code division. Some implementations may optionally incorporate features such as error checking and correction (ECC) for data integrity, or security measures, such as encryption (e.g., WEP) and password protection.

[0067] A number of implementations have been described. Nevertheless, it will be understood that various modification may be made. For example, advantageous results may be achieved if the steps of the disclosed techniques were performed in a different sequence, or if components of the disclosed systems were combined in a different manner, or if the components were supplemented with other components. Accordingly, other implementations are contemplated.

What is claimed is:

1. A method of measuring a human's blood pressure, the method comprising:

receiving, in a portable communication device (PCD), user input information about body parameters of an operator;

simultaneously recording:

a blood flow information by positioning a camera of the PCD such that the camera aligns with a finger of a first arm;

a pulsation information by positioning a microphone of the PCD such that the microphone proximate to an antecubital artery of a second arm;

determining, in response to the recorded blood flow information and the recorded pulsation information, a pulse velocity;

determining, in response to the determined pulse velocity, a systolic blood pressure measurement;

determining, in response to the inputted body parameters and the recorded pulsation information, a pulse pressure;

determining, in response to the determined pulse pressure, a diastolic blood pressure measurement; and,

transmitting, the determined systolic blood pressure and the determined diastolic blood pressure for display on a display panel of the PCD.

2. The method of claim **1**, further comprising associating a unique user profile to the received inputted body parameters and the determined systolic blood pressure and the determined diastolic blood pressure.

3. The method of claim **2**, further comprising storing the received inputted body parameters, the determined systolic blood pressure, and the determined diastolic blood pressure in a data store such that the stored inputted body parameters, the stored systolic blood pressure, and the stored diastolic blood pressure is configured to be retrieved via the unique user profile.

4. The method of claim **3**, wherein the data store is configured to share the stored information with a remote PCD.

5. The method of claim **2**, further comprising retrieving, from the data store, a set of coefficients and a blood measuring algorithm, wherein the retrieved set of coefficients and the retrieved blood measuring algorithm are

determined based on the stored inputted body parameter, the stored systolic blood pressure measurements and the stored diastolic blood pressure measurements.

6. The method of claim **5**, wherein the data store comprises a remote location.

7. The method of claim **6**, further comprising transmitting, via a network interface, the unique user profile, the stored inputted body parameter, the stored systolic blood pressure measurements and the stored diastolic blood pressure measurements to be stored in the data store.

8. The method of claim **2**, further comprising analyzing the stored inputted body parameter, the stored systolic blood pressure measurements and the stored diastolic blood pressure measurements to create a trends analysis for the unique user profile.

9. The method of claim **1**, further comprising transmitting to a graphical display of the PCD positioning instructions to position the camera such that the camera aligns with a finger of the first arm, and the microphone such that the microphone proximate to an antecubital artery of the second arm.

10. The method of claim **2**, further comprising receiving, from a third party, information about fitness activities associated the unique user profile.

11. A computer program product (CPP) tangibly embodied in a data store, the CPP including instructions that, when executed, operate a portable communication device (PCD) to measure the blood pressure of a user, the operations comprising:

receive, in a portable communication device (PCD), user input information about body parameters of an operator;

simultaneously record:

a blood flow information by positioning a camera of the PCD such that the camera aligns with a finger of a first arm;

a pulsation information by positioning a microphone of the PCD such that the microphone proximate to an antecubital artery of a second arm;

determine, in response to the recorded blood flow information and the recorded pulsation information, a pulse velocity;

determine, in response to the determined pulse velocity, a systolic blood pressure measurement;

determine, in response to the inputted body parameters and the recorded pulsation information, a pulse pressure;

determine, in response to the determined pulse pressure, a diastolic blood pressure measurement; and,

transmit, the determined systolic blood pressure and the determined diastolic blood pressure for display on a display panel of the PCD.

12. The CPP of claim **11**, further comprising associate a unique user profile to the received inputted body parameters and the determined systolic blood pressure and the determined diastolic blood pressure.

13. The CPP of claim **12**, further comprising store the received inputted body parameters, the determined systolic blood pressure, and the determined diastolic blood pressure in a data store such that the stored inputted body parameters, the stored systolic blood pressure, and the stored diastolic blood pressure is configured to be retrieved via the unique user profile.

14. The CPP of claim **12**, further comprising retrieve, from the data store, a set of coefficients and a blood measuring algorithm, wherein the retrieved set of coefficients and the retrieved blood measuring algorithm are determined based on the stored inputted body parameter, the stored systolic blood pressure measurements and the stored diastolic blood pressure measurements.

15. The CPP of claim **14**, wherein the data store is disposed at a remote location.

16. The CPP of claim **15**, wherein the data store is configured to share the stored information with a remote PCD.

17. The CPP of claim **16**, further comprising transmit, in response to a received third party request, the received inputted body parameters, the determined systolic blood pressure, and the determined diastolic blood pressure to a remote PCD.

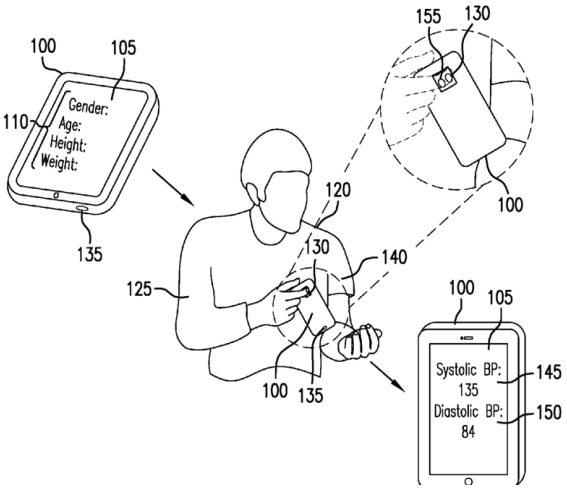
18. The CPP of claim **12**, further comprising analyze the stored inputted body parameter, the stored systolic blood pressure measurements and the stored diastolic blood pressure measurements to create a trends analysis for the unique user profile.

19. The CPP of claim **11**, further comprising transmit to a graphical display of the PCD positioning instructions to position the camera such that the camera aligns with a finger of the first arm, and the microphone such that the microphone proximate to an antecubital artery of the second arm.

20. The CPP of claim **11**, further comprising maintain different unique user profiles such that each unique user profile is associated with a distinct combination of the inputted body parameters.

* * * * *

专利名称(译)	使用移动设备计算血压的方法		
公开(公告)号	US20170319079A1	公开(公告)日	2017-11-09
申请号	US15/149863	申请日	2016-05-09
[标]发明人	MEZENOK DENIS KALMYKOV ARTEM BONDARCHYK ALEXEY		
发明人	MEZENOK, DENIS KALMYKOV, ARTEM BONDARCHYK, ALEXEY		
IPC分类号	A61B5/021 A61B5/00 A61B5/026 A61B5/024 A61B7/04		
CPC分类号	A61B5/021 A61B5/02438 A61B5/026 A61B5/6898 A61B7/04 A61B5/0022 A61B5/6826 A61B5/6824 A61B5/7278 A61B5/02108 A61B5/0261 G16H40/67		
外部链接	Espacenet USPTO		

摘要(译)

装置和相关方法涉及通过便携式通信设备（PCD）的相机和麦克风收集的信息来确定用户的血压。在说明性示例中，PCD同时为用户记录血流和脉动。可以通过定位相机使得相机与用户的第一臂的手指对准来记录血流。可以通过定位麦克风使得麦克风靠近用户的第二臂的肘前动脉来记录脉动。作为响应，PCD使用记录的血流和脉动信息，根据用户先前输入的身体参数（例如，身高，体重，年龄，性别）确定用户的收缩压和舒张压。