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METHOD OF MEASURING BLOOD PRESSURE AND ELECTRONIC DEVICE SUPPORTING SAME

Abstract

An electronic device according to an embodiment may include communication circuitry and at least one processor. The at least one processor may be configured to receive a first PPG signal obtained by a first wearable device from the first wearable device via the communication circuitry and receive a second PPG signal from a second wearable device. The first wearable device may be worn on a first position of a user and the second wearable device may be worn on a second position of the user. The at least one processor may be configured to obtain a pulse transit time (PTT) taken for a pulse wave to be transferred from the first position to the second position, based on the first PPG signal and the second PPG signal. The at least one processor may be configured to obtain a distance between the first wearable device and the second wearable device. The at least one processor may be configured to obtain a pulse wave velocity (PWV) at which the pulse wave is transferred, based on the distance and the PTT. The at least one processor may be configured to obtain a first blood pressure by using a pulse wave analysis (PWA) method, based on the first PPG signal and/or the second PPG signal. The at least one processor may be configured to obtain a vascular characteristic value related to a characteristic of a blood vessel, based on the PWV and the first blood pressure. The at least one processor may be configured to obtain a blood pressure correction value for correcting a second blood pressure to be obtained, based on the vascular characteristic value.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION(S) [0001] This application is a continuation application, claiming priority under § 365(c), of an International application No. PCT/KR2025/000709, filed on Jan. 13, 2025, which is based on and claims the benefit of a Korean patent application number 10-2024-0020256, filed on Feb. 13, 2024, in the Korean Intellectual Property Office, and of a Korean patent application number 10-2024-0046910, filed on Apr. 5, 2024, in the Korean Intellectual Property Office, the disclosure of each of which is incorporated by reference herein in its entirety.

BACKGROUND
1. Field
[0002] The disclosure relates to a method of measuring a blood pressure and an electronic device supporting same.
2. Description of Related Art
[0003] Electronic devices are evolving in various forms for user convenience and are being miniaturized so that they are conveniently portable for users.
[0004] Recently, with the growing interest in health, electronic devices have been measuring biometric signals related to the human body and providing biometric information, based on the measured biometric signals. For example, an electronic device (e.g., a wearable device) may obtain a photoplethysmogram (PPG) signal through an optical sensor (e.g., a photoplethysmogram (PPG) sensor) for obtaining a biometric signal, and measure a blood pressure, based on the obtained PPG signal.
[0005] The above information is presented as background information only to assist with an understanding of the disclosure. No determination has been made, and no assertion is made, as to whether any of the above might be applicable as prior art with regard to the disclosure.
DETAILED DESCRIPTION OF THE INVENTION
Technical Solution
[0006] An electronic device (e.g., a wearable device) may correct a blood pressure (e.g., blood pressure value) measured based on a PPG signal by using a blood pressure measured using a blood pressure monitor, thereby calculating a final blood pressure. For example, the electronic device may measure a blood pressure (hereinafter, this is referred to as a “blood pressure measured based on a PPG signal”) by using a pulse wave analysis (PWA) method, based on a PPG signal obtained through a PPG sensor. However, a user's blood vessel state may change over time. Accordingly, the

electronic device may periodically calculate a correction value (hereinafter, this is referred to as a "correction value") for correcting the blood pressure measured based on the PPG signal, by using a blood pressure (hereinafter, this is referred to as a "reference blood pressure") measured using a blood pressure monitor (e.g., a blood pressure monitor using a cuff). The electronic device may, after the correction value is calculated, correct the blood pressure measured based on the PPG signal by using the correction value (e.g., add the correction value to the blood pressure measured based on the PPG signal), thereby calculating a final blood pressure (e.g., a blood pressure to be provided to the user).

[0007] However, measuring a reference blood pressure by using a blood pressure monitor and periodically performing of an operation of calculating the correction value by using the measured reference blood pressure may be inconvenient for the user. In addition, measurement of a more precise blood pressure may be required.

[0008] Aspects of the disclosure are to address at least the above-mentioned problems and/or disadvantages and to provide at least the advantages described below. Accordingly, an aspect of the disclosure is to provide a method of measuring a blood pressure and an electronic device supporting same, wherein an operation of measuring a blood pressure is performed in cooperation with multiple wearable devices, so that provision of a more precise blood pressure is possible without periodically performing the operation of calculating the correction value.

[0009] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0010] An electronic device according to an embodiment may include communication circuitry and at least one processor. The at least one processor may be configured to receive a first PPG signal obtained by a first wearable device from the first wearable device via the communication circuitry and receive a second PPG signal from a second wearable device via the communication circuitry. The first wearable device may be worn on a first position of a user and the second wearable device may be worn on a second position of the user. The at least one processor may be configured to obtain a pulse transit time (PTT) during which a pulse wave is transferred from the first position to the second position, based on the first PPG signal and the second PPG signal. The at least one processor may be configured to obtain a distance between the first wearable device and the second wearable device. The at least one processor may be configured to obtain a pulse wave velocity (PWV) at which the pulse wave is transferred, based on the distance and the PTT. The at least one processor may be configured to obtain a first blood pressure by using a pulse wave analysis (PWA) method, based on the first PPG signal and/or the second PPG signal. The at least one processor may be configured to obtain a vascular characteristic value related to a characteristic of a blood vessel, based on the PWV and the first blood pressure. The at least one processor may be configured to obtain a blood pressure correction value for correcting a second blood pressure to be obtained, based on the vascular characteristic value.

[0011] A method of providing a blood pressure by an electronic device according to an embodiment may include receiving a first PPG signal obtained by a first wearable device from the first wearable device via communication circuitry of the electronic device, and receiving a second PPG signal from a second wearable device via the communication circuitry. The first wearable device may be worn on a first position of a user and the second wearable device may be worn on a second position of the user. The method may include obtaining a pulse transit time (PTT) during which a pulse wave is transferred from the first position to the second position, based on the first PPG signal and the second PPG signal. The method may include obtaining a distance between the first wearable device and the second wearable device. The method may include obtaining a pulse wave velocity (PWV) at which the pulse wave is transferred, based on the distance and the PTT. The method may include obtaining a first blood pressure by using a pulse wave analysis (PWA) method, based on the first PPG signal and/or the second PPG signal. The method may include obtaining a vascular characteristic value related to a characteristic of a blood vessel, based on the PWV and the first blood pressure. The method may include obtaining a blood pressure correction value for correcting a second blood pressure to be obtained, based on the vascular characteristic value.

[0012] In an embodiment, in a non-transitory computer-readable medium for recording computer-executable instructions, the computer-executable instructions may, when executed by at least one processor of an electronic device, cause the electronic device to receive a first PPG signal obtained by a first wearable device from the first wearable device via communication circuitry of the electronic device and receive a second PPG signal from a second wearable device via the communication circuitry. The first wearable device may be worn on a first position of a user and the second wearable device may be worn on a second position of the user. The computer-executable instructions may, when executed by the at least one processor of the electronic device, cause the electronic device to obtain a pulse transit time (PTT) during which a pulse wave is from the first position to the second position, based on the first PPG signal and the second PPG signal. The computer-executable instructions may, when executed by the at least one processor of the electronic device, cause the electronic device to obtain a distance between the first wearable device and the second wearable device. The computer-executable instructions may, when executed by the at least one processor of the electronic device, cause the electronic device to obtain a pulse wave velocity (PWV) at which the pulse wave is transferred, based on the distance and the PTT. The computer-executable instructions may, when executed by the at least one processor of the electronic device, cause the electronic device to obtain a first blood pressure by using a pulse wave analysis (PWA) method, based on the first PPG signal and/or the second PPG signal. The computer-executable instructions may, when executed by the at least one processor of the electronic device, cause the electronic device to obtain a vascular characteristic value related to a characteristic of a blood vessel, based on the PWV and the first blood pressure. The computer-executable instructions may, when executed by the at least one processor of the electronic device, cause the electronic device to obtain a blood pressure correction value for correcting a second blood pressure to be obtained, based on the vascular characteristic value.

[0013] Other aspects, advantages, and salient features of the disclosure will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses various embodiments of the disclosure.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0014] The above and other aspects, features, and advantages of certain embodiments of the disclosure will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

[0015] FIG. **1** is a block diagram of an electronic device in a network environment according to an embodiment of the disclosure;

[0016] FIG. **2**A is a perspective view of a front surface of a first wearable device according to an embodiment of the disclosure;

[0017] FIG. **2**B is a perspective view of a rear surface of a first wearable device according to an embodiment of the disclosure;

[0018] FIG. **3**A is a perspective view of a second wearable device according to an embodiment of the disclosure;

[0019] FIG. **3**B is a sectional view of a second wearable device according to an embodiment of the disclosure;

[0020] FIG. **4** is a block diagram of an electronic device according to an embodiment of the disclosure;

[0021] FIG. **5** is a block diagram of a first wearable device according to an embodiment of the

disclosure;
[0022] FIG. **6** is a block diagram of a second wearable device according to an embodiment of the disclosure;
[0023] FIG. **7** is a flowchart illustrating a method of measuring a blood pressure according to an embodiment of the disclosure;
[0024] FIG. **8** is a diagram illustrating a method of synchronizing a first wearable device and a second wearable device according to an embodiment of the disclosure;
[0025] FIG. **9** is a diagram illustrating a method of obtaining a PTT, based on a first PPG signal and a second PPG signal according to an embodiment of the disclosure;
[0026] FIG. **10** is a diagram illustrating a method of obtaining a distance between a first wearable device and a second wearable device according to an embodiment of the disclosure;
[0027] FIG. **11** is a diagram illustrating a method of obtaining a vascular characteristic value by using a PWV blood pressure model and a PWA blood pressure model according to an embodiment of the disclosure;
[0028] FIG. **12** is a diagram illustrating a method of obtaining a blood pressure correction value, based on a vascular characteristic value according to an embodiment of the disclosure; and
[0029] FIG. **13** is a flowchart illustrating a method of obtaining a correlation between a vascular characteristic value and a blood pressure correction value according to an embodiment of the disclosure.
[0030] The same reference numerals are used to represent the same elements throughout the drawings.

MODE FOR CARRYING OUT THE INVENTION

[0031] The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of various embodiments of the disclosure as defined by the claims and their equivalents. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the various embodiments described herein can be made without departing from the scope and spirit of the disclosure. In addition, descriptions of well-known functions and constructions may be omitted for clarity and conciseness.
[0032] The terms and words used in the following description and claims are not limited to the bibliographical meanings, but, are merely used by the inventor to enable a clear and consistent understanding of the disclosure. Accordingly, it should be apparent to those skilled in the art that the following description of various embodiments of the disclosure is provided for illustration purpose only and not for the purpose of limiting the disclosure as defined by the appended claims and their equivalents.
[0033] It is to be understood that the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to “a component surface” includes reference to one or more of such surfaces.
[0034] It should be appreciated that the blocks in each flowchart and combinations of the flowcharts may be performed by one or more computer programs which include computer-executable instructions. The entirety of the one or more computer programs may be stored in a single memory device or the one or more computer programs may be divided with different portions stored in different multiple memory devices.
[0035] Any of the functions or operations described herein can be processed by one processor or a combination of processors. The one processor or the combination of processors is circuitry performing processing and includes circuitry like an application processor (AP, e.g., a central processing unit (CPU)), a communication processor (CP, e.g., a modem), a graphical processing unit (GPU), a neural processing unit (NPU) (e.g., an artificial intelligence (AI) chip), a wireless-fidelity (Wi-Fi) chip, a Bluetooth.sup.TM chip, a global positioning system (GPS) chip, a near field communication (NFC) chip, connectivity chips, a sensor controller, a touch controller, a finger-

print sensor controller, a display drive integrated circuit (IC), an audio CODEC chip, a universal serial bus (USB) controller, a camera controller, an image processing IC, a microprocessor unit (MPU), a system on chip (SoC), an IC, or the like.

[0036] FIG. **1** is a block diagram illustrating an electronic device **101** in a network environment **100** according to an embodiment of the disclosure.

[0037] Referring to FIG. **1**, the electronic device **101** in the network environment **100** may communicate with an electronic device **102** via a first network **198** (e.g., a short-range wireless communication network), or at least one of an electronic device **104** or a server **108** via a second network **199** (e.g., a long-range wireless communication network). According to an embodiment, the electronic device **101** may communicate with the electronic device **104** via the server **108**. According to an embodiment, the electronic device **101** may include a processor **120**, memory **130**, an input module **150**, a sound output module **155**, a display module **160**, an audio module **170**, a sensor module **176**, an interface **177**, a connecting terminal **178**, a haptic module **179**, a camera module **180**, a power management module **188**, a battery **189**, a communication module **190**, a subscriber identification module (SIM) **196**, or an antenna module **197**. In some embodiments, at least one of the components (e.g., the connecting terminal **178**) may be omitted from the electronic device **101**, or one or more other components may be added in the electronic device **101**. In some embodiments, some of the components (e.g., the sensor module **176**, the camera module **180**, or the antenna module **197**) may be implemented as a single component (e.g., the display module **160**).

[0038] The processor **120** may execute, for example, software (e.g., a program **140**) to control at least one other component (e.g., a hardware or software component) of the electronic device **101** coupled with the processor **120**, and may perform various data processing or computation. According to one embodiment, as at least part of the data processing or computation, the processor **120** may store a command or data received from another component (e.g., the sensor module **176** or the communication module **190**) in volatile memory **132**, process the command or the data stored in the volatile memory **132**, and store resulting data in non-volatile memory **134**. According to an embodiment, the processor **120** may include a main processor **121** (e.g., a central processing unit (CPU) or an application processor (AP)), or an auxiliary processor **123** (e.g., a graphics processing unit (GPU), a neural processing unit (NPU), an image signal processor (ISP), a sensor hub processor, or a communication processor (CP)) that is operable independently from, or in conjunction with, the main processor **121**. For example, when the electronic device **101** includes the main processor **121** and the auxiliary processor **123**, the auxiliary processor **123** may be adapted to consume less power than the main processor **121**, or to be specific to a specified function. The auxiliary processor **123** may be implemented as separate from, or as part of the main processor **121**.

[0039] The auxiliary processor **123** may control at least some of functions or states related to at least one component (e.g., the display module **160**, the sensor module **176**, or the communication module **190**) among the components of the electronic device **101**, instead of the main processor **121** while the main processor **121** is in an inactive (e.g., sleep) state, or together with the main processor **121** while the main processor **121** is in an active state (e.g., executing an application). According to an embodiment, the auxiliary processor **123** (e.g., an image signal processor or a communication processor) may be implemented as part of another component (e.g., the camera module **180** or the communication module **190**) functionally related to the auxiliary processor **123**. According to an embodiment, the auxiliary processor **123** (e.g., the neural processing unit) may include a hardware structure specified for artificial intelligence model processing. An artificial intelligence model may be generated by machine learning. Such learning may be performed, e.g., by the electronic device **101** where the artificial intelligence is performed or via a separate server (e.g., the server **108**). Learning algorithms may include, but are not limited to, e.g., supervised learning, unsupervised learning, semi-supervised learning, or reinforcement learning. The artificial intelligence model may include a plurality of artificial neural network layers. The artificial neural network may be a deep neural network (DNN), a convolutional neural network (CNN), a recurrent neural network (RNN), a restricted Boltzmann machine (RBM), a deep belief network (DBN), a bidirectional recurrent deep neural network (BRDNN), deep Q-network or a combination of two or more thereof but is not limited thereto. The artificial intelligence model may, additionally or alternatively, include a software structure other than the hardware structure.

[0040] The memory **130** may store various data used by at least one component (e.g., the processor **120** or the sensor module **176**) of the electronic device **101**. The various data may include, for example, software (e.g., the program **140**) and input data or output data for a command related thereto. The memory **130** may include the volatile memory **132** or the non-volatile memory **134**.

[0041] The program **140** may be stored in the memory **130** as software, and may include, for example, an operating system (OS) **142**, middleware **144**, or an application **146**.

[0042] The input module **150** may receive a command or data to be used by another component (e.g., the processor **120**) of the electronic device **101**, from the outside (e.g., a user) of the electronic device **101**. The input module **150** may include, for example, a microphone, a mouse, a keyboard, a key (e.g., a button), or a digital pen (e.g., a stylus pen).

[0043] The sound output module **155** may output sound signals to the outside of the electronic device **101**. The sound output module **155** may include, for example, a speaker or a receiver. The speaker may be used for general purposes, such as playing multimedia or playing record. The receiver may be used for receiving incoming calls. According to an embodiment, the receiver may be implemented as separate from, or as part of the speaker.

[0044] The display module **160** may visually provide information to the outside (e.g., a user) of the electronic device **101**. The display module **160** may include, for example, a display, a hologram device, or a projector and control circuitry to control a corresponding one of the display, hologram device, and projector. According to an embodiment, the display module **160** may include a touch sensor adapted to detect a touch, or a pressure sensor adapted to measure the intensity of force incurred by the touch.

[0045] The audio module **170** may convert a sound into an electrical signal and vice versa. According to an embodiment, the audio module **170** may obtain the sound via the input module **150**, or output the sound via the sound output module **155** or a headphone of an external electronic device (e.g., an electronic device **102**) directly (e.g., wiredly) or wirelessly coupled with the electronic device **101**.

[0046] The sensor module **176** may detect an operational state (e.g., power or temperature) of the electronic device **101** or an environmental state (e.g., a state of a user) external to the electronic device **101**, and then generate an electrical signal or data value corresponding to the detected state. According to an embodiment, the sensor module **176** may include, for example, a gesture sensor, a gyro sensor, an atmospheric pressure sensor, a magnetic sensor, an acceleration sensor, a grip sensor, a proximity sensor, a color sensor, an infrared (IR) sensor, a biometric sensor, a temperature sensor, a humidity sensor, or an illuminance sensor.

[0047] The interface **177** may support one or more specified protocols to be used for the electronic device **101** to be coupled with the external electronic device (e.g., the electronic device **102**) directly (e.g., wiredly) or wirelessly. According to an embodiment, the interface **177** may include, for example, a high definition multimedia interface (HDMI), a universal serial bus (USB) interface, a secure digital (SD) card interface, or an audio interface.

[0048] A connecting terminal **178** may include a connector via which the electronic device **101** may be physically connected with the external electronic device (e.g., the electronic device **102**). According to an embodiment, the connecting terminal **178** may include, for example, a HDMI connector, a USB connector, a SD card connector, or an audio connector (e.g., a headphone connector).

[0049] The haptic module **179** may convert an electrical signal into a mechanical stimulus (e.g., a vibration or a movement) or electrical stimulus which may be recognized by a user via his tactile

sensation or kinesthetic sensation. According to an embodiment, the haptic module **179** may include, for example, a motor, a piezoelectric element, or an electric stimulator.
[0050] The camera module **180** may capture a still image or moving images. According to an embodiment, the camera module **180** may include one or more lenses, image sensors, image signal processors, or flashes.
[0051] The power management module **188** may manage power supplied to the electronic device **101**. According to one embodiment, the power management module **188** may be implemented as at least part of, for example, a power management integrated circuit (PMIC).
[0052] The battery **189** may supply power to at least one component of the electronic device **101**. According to an embodiment, the battery **189** may include, for example, a primary cell which is not rechargeable, a secondary cell which is rechargeable, or a fuel cell.
[0053] The communication module **190** may support establishing a direct (e.g., wired) communication channel or a wireless communication channel between the electronic device **101** and the external electronic device (e.g., the electronic device **102**, the electronic device **104**, or the server **108**) and performing communication via the established communication channel. The communication module **190** may include one or more communication processors that are operable independently from the processor **120** (e.g., the application processor (AP)) and supports a direct (e.g., wired) communication or a wireless communication. According to an embodiment, the communication module **190** may include a wireless communication module **192** (e.g., a cellular communication module, a short-range wireless communication module, or a global navigation satellite system (GNSS) communication module) or a wired communication module **194** (e.g., a local area network (LAN) communication module or a power line communication (PLC) module). A corresponding one of these communication modules may communicate with the external electronic device via the first network **198** (e.g., a short-range communication network, such as Bluetooth™, wireless-fidelity (Wi-Fi) direct, or infrared data association (IrDA)) or the second network **199** (e.g., a long-range communication network, such as a legacy cellular network, a 5G network, a next-generation communication network, the Internet, or a computer network (e.g., LAN or wide area network (WAN)). These various types of communication modules may be implemented as a single component (e.g., a single chip), or may be implemented as multi components (e.g., multi chips) separate from each other. The wireless communication module **192** may identify and authenticate the electronic device **101** in a communication network, such as the first network **198** or the second network **199**, using subscriber information (e.g., international mobile subscriber identity (IMSI)) stored in the subscriber identification module **196**.
[0054] The wireless communication module **192** may support a 5G network, after a 4G network, and next-generation communication technology, e.g., new radio (NR) access technology. The NR access technology may support enhanced mobile broadband (eMBB), massive machine type communications (mMTC), or ultra-reliable and low-latency communications (URLLC). The wireless communication module **192** may support a high-frequency band (e.g., the mmWave band) to achieve, e.g., a high data transmission rate. The wireless communication module **192** may support various technologies for securing performance on a high-frequency band, such as, e.g., beamforming, massive multiple-input and multiple-output (massive MIMO), full dimensional MIMO (FD-MIMO), array antenna, analog beam-forming, or large scale antenna. The wireless communication module **192** may support various requirements specified in the electronic device **101**, an external electronic device (e.g., the electronic device **104**), or a network system (e.g., the second network **199**). According to an embodiment, the wireless communication module **192** may support a peak data rate (e.g., 20 Gbps or more) for implementing eMBB, loss coverage (e.g., 164 dB or less) for implementing mMTC, or U-plane latency (e.g., 0.5 ms or less for each of downlink (DL) and uplink (UL), or a round trip of 1 ms or less) for implementing URLLC.
[0055] The antenna module **197** may transmit or receive a signal or power to or from the outside (e.g., the external electronic device) of the electronic device **101**. According to an embodiment, the

antenna module **197** may include an antenna including a radiating element composed of a conductive material or a conductive pattern formed in or on a substrate (e.g., a printed circuit board (PCB)). According to an embodiment, the antenna module **197** may include a plurality of antennas (e.g., array antennas). In such a case, at least one antenna appropriate for a communication scheme used in the communication network, such as the first network **198** or the second network **199**, may be selected, for example, by the communication module **190** (e.g., the wireless communication module **192**) from the plurality of antennas. The signal or the power may then be transmitted or received between the communication module **190** and the external electronic device via the selected at least one antenna. According to an embodiment, another component (e.g., a radio frequency integrated circuit (RFIC)) other than the radiating element may be additionally formed as part of the antenna module **197**.

[0056] According to various embodiments, the antenna module **197** may form a mmWave antenna module. According to an embodiment, the mmWave antenna module may include a printed circuit board, a RFIC disposed on a first surface (e.g., the bottom surface) of the printed circuit board, or adjacent to the first surface and capable of supporting a designated high-frequency band (e.g., the mmWave band), and a plurality of antennas (e.g., array antennas) disposed on a second surface (e.g., the top or a side surface) of the printed circuit board, or adjacent to the second surface and capable of transmitting or receiving signals of the designated high-frequency band.

[0057] At least some of the above-described components may be coupled mutually and communicate signals (e.g., commands or data) therebetween via an inter-peripheral communication scheme (e.g., a bus, general purpose input and output (GPIO), serial peripheral interface (SPI), or mobile industry processor interface (MIPI)).

[0058] According to an embodiment, commands or data may be transmitted or received between the electronic device **101** and the external electronic device **104** via the server **108** coupled with the second network **199**. Each of the electronic devices **102** or **104** may be a device of a same type as, or a different type, from the electronic device **101**. According to an embodiment, all or some of operations to be executed at the electronic device **101** may be executed at one or more of the external electronic devices **102**, **104**, or **108**. For example, if the electronic device **101** should perform a function or a service automatically, or in response to a request from a user or another device, the electronic device **101**, instead of, or in addition to, executing the function or the service, may request the one or more external electronic devices to perform at least part of the function or the service. The one or more external electronic devices receiving the request may perform the at least part of the function or the service requested, or an additional function or an additional service related to the request, and transfer an outcome of the performing to the electronic device **101**. The electronic device **101** may provide the outcome, with or without further processing of the outcome, as at least part of a reply to the request. To that end, a cloud computing, distributed computing, mobile edge computing (MEC), or client-server computing technology may be used, for example. The electronic device **101** may provide ultra low-latency services using, e.g., distributed computing or mobile edge computing. In another embodiment, the external electronic device **104** may include an internet-of-things (IoT) device. The server **108** may be an intelligent server using machine learning and/or a neural network. According to an embodiment, the external electronic device **104** or the server **108** may be included in the second network **199**. The electronic device **101** may be applied to intelligent services (e.g., smart home, smart city, smart car, or healthcare) based on 5G communication technology or IoT-related technology.

[0059] The electronic device according to various embodiments may be one of various types of electronic devices. The electronic devices may include, for example, a portable communication device (e.g., a smartphone), a computer device, a portable multimedia device, a portable medical device, a camera, a wearable device, or a home appliance. According to an embodiment of the disclosure, the electronic devices are not limited to those described above.

[0060] It should be appreciated that an embodiment of the present disclosure and the terms used therein are not intended to limit the technological features set forth herein to particular embodiments and include various changes, equivalents, or replacements for a corresponding embodiment. With regard to the description of the drawings, similar reference numerals may be used to refer to similar or related elements. It is to be understood that a singular form of a noun corresponding to an item may include one or more of the things, unless the relevant context clearly indicates otherwise. As used herein, each of such phrases as “A or B,” “at least one of A and B,” “at least one of A or B,” “A, B, or C,” “at least one of A, B, and C,” and “at least one of A, B, or C,” may include any one of, or all possible combinations of the items enumerated together in a corresponding one of the phrases. As used herein, such terms as “1st” and “2nd,” or “first” and “second” may be used to simply distinguish a corresponding component from another, and does not limit the components in other aspect (e.g., importance or order). It is to be understood that if an element (e.g., a first element) is referred to, with or without the term “operatively” or “communicatively”, as “coupled with,” “coupled to,” “connected with,” or “connected to” another element (e.g., a second element), it means that the element may be coupled with the other element directly (e.g., wiredly), wirelessly, or via a third element.

[0061] As used in connection with an embodiment of the disclosure, the term “module” may include a unit implemented in hardware, software, or firmware, and may interchangeably be used with other terms, for example, “logic,” “logic block,” “part,” or “circuitry”. A module may be a single integral component, or a minimum unit or part thereof, adapted to perform one or more functions. For example, according to an embodiment, the module may be implemented in a form of an application-specific integrated circuit (ASIC).

[0062] An embodiment as set forth herein may be implemented as software (e.g., the program **140**) including one or more instructions that are stored in a storage medium (e.g., internal memory **136** or external memory **138**) that is readable by a machine (e.g., the electronic device **101**). For example, a processor (e.g., the processor **120**) of the machine (e.g., the electronic device **101**) may invoke at least one of the one or more instructions stored in the storage medium, and execute it, with or without using one or more other components under the control of the processor. This allows the machine to be operated to perform at least one function according to the at least one instruction invoked. The one or more instructions may include a code generated by a complier or a code executable by an interpreter. The machine-readable storage medium may be provided in the form of a non-transitory storage medium. Wherein, the term “non-transitory” simply means that the storage medium is a tangible device, and does not include a signal (e.g., an electromagnetic wave), but this term does not differentiate between where data is semi-permanently stored in the storage medium and where the data is temporarily stored in the storage medium.

[0063] According to an embodiment, a method according to an embodiment of the disclosure may be included and provided in a computer program product. The computer program product may be traded as a product between a seller and a buyer. The computer program product may be distributed in the form of a machine-readable storage medium (e.g., compact disc read only memory (CD-ROM)), or be distributed (e.g., downloaded or uploaded) online via an application store (e.g., PlayStore™), or between two user devices (e.g., smart phones) directly. If distributed online, at least part of the computer program product may be temporarily generated or at least temporarily stored in the machine-readable storage medium, such as memory of the manufacturer's server, a server of the application store, or a relay server.

[0064] According to an embodiment, each component (e.g., a module or a program) of the above-described components may include a single entity or multiple entities, and some of the multiple entities may be separately disposed in different components. According to an embodiment, one or more of the above-described components may be omitted, or one or more other components may be added. Alternatively or additionally, a plurality of components (e.g., modules or programs) may be integrated into a single component. In such a case, according to various embodiments, the integrated component may still perform one or more functions of each of the plurality of components in the same or similar manner as they are performed by a corresponding one of the plurality of components before the integration. According to an embodiment, operations performed by the module, the program, or another component may be carried out sequentially, in parallel, repeatedly, or heuristically, or one or more of the operations may be executed in a different order or omitted, or one or more other operations may be added.

[0065] FIG. **2**A is a perspective view **200***a* of a front surface of a first wearable device **201** according to an embodiment of the disclosure.

[0066] FIG. **2**B is a perspective view **200***b* of a rear surface of the first wearable device **201** according to an embodiment of the disclosure.

[0067] Referring to FIGS. **2**A and **2**B, the first wearable device **201** according to an embodiment may include a housing **210** including a first surface (or front surface) **211**, a second surface (or rear surface) **211***b*, and a lateral surface **213** surrounding a space between the first surface **211** and the second surface **212**, and wearing members **250** and **260** connected to at least a part of the housing **210** and configured to detachably attach the first wearable device **201** to a part (e.g., wrist or ankle) of a user's body. In another embodiment of the disclosure, the housing **210** may indicate a structure configuring a part of the first surface **211**, the second surface **212**, and the lateral surface **213** illustrated in FIGS. **2**A and **2**B. According to an embodiment of the disclosure, the first surface **211** may be configured by a front plate **222** (e.g., a polymer plate or a glass plate including various coating layers), at least a part of which is substantially transparent. The second surface **212** may be configured by a rear plate **207** that is substantially opaque. In an embodiment of the disclosure, when a sensor module **265** (e.g., the sensor module **176** in FIG. **1**) disposed at the second surface **212** of the first wearable device **201** is included, the rear plate **207** may at least partially include a transparent area.

[0068] The rear plate **207** may be made of, for example, coated or colored glass, ceramic, polymer, metal (e.g., aluminum, stainless steel (STS), or magnesium), or a combination of two or more of the materials. The lateral surface **213** may be configured by a lateral bezel (or a “lateral member”) **206** that is coupled to the front plate **222** and the rear plate **207** and includes metal and/or polymer. In an embodiment of the disclosure, the rear plate **207** and the lateral bezel structure **206** may be integrally configured, and may include an identical material (e.g., a metal material, such as aluminum). The wearing members **250** and **260** may be made of various materials and forms. For example, the wearing members may be made of fabric, leather, rubber, urethane, metal, ceramic, or a combination of two or more of the above materials to be one piece or multiple unit links movable with respect to each other.

[0069] According to an embodiment of the disclosure, the first wearable device **201** may include at least one of a display **220** (e.g., the display module **160** in FIG. **1**), an audio module **205** and **208** (e.g., the audio module **170** in FIG. **1**), the sensor module **265** (e.g., the sensor module **176** in FIG. **1**), key input devices **202**, **203**, and **204** (e.g., the input module **150** in FIG. **1**), and a connector hole **209**. In an embodiment of the disclosure, the first wearable device **201** may omit at least one (e.g., the key input devices **202**, **203**, and **204**, the connector hole **209**, or the sensor module **265**) of the elements or additionally include another element.

[0070] According to an embodiment of the disclosure, the first wearable device **201** may include multiple electrodes for measurement of a biometric signal, and at least one electrode among the multiple electrodes may be disposed at least one position among a position of the key input device **202**, **203**, or **204**, a position of the lateral bezel **206**, and a position of the display **220** or the housing **210**. The wheel key **202** among the key input devices may include a rotary bezel.

[0071] The display **220** may be, for example, exposed through a considerable part of the front plate **222**. The display **220** may have a shape corresponding to a shape of the front plate **222**, and may have various shapes, such as a circle, an oval, or a polygon. The display **220** may be coupled to or disposed to be adjacent to a touch detection circuit, a pressure sensor capable of measuring the strength (pressure) of touch, and/or a fingerprint sensor.

[0072] According to an embodiment of the disclosure, the display **220** may include at least one transparent electrode for biometric signal measurement among the multiple electrodes for biometric signal measurement.
[0073] The audio module **205** and **208** may include the microphone hole **205** and the speaker hole **208**. A microphone for obtaining external sound may be disposed in the microphone hole **205**, and in an embodiment of the disclosure, multiple microphones may be arranged therein to detect a direction of sound. The speaker hole **208** may be used as an external speaker and a call receiver. In an embodiment of the disclosure, a speaker may be included without a speaker hole (e.g., a piezo speaker).
[0074] The sensor module **265** may generate an electrical signal or a data value corresponding to an internal operational state or an external environmental state of the first wearable device **201**. The sensor module **265**, for example, the biometric sensor module **265** (e.g., heart rate monitor (HRM) sensor) disposed at the second surface **212** of the housing **210** may include an electrocardiogram (ECG) sensor **265***a* including at least two electrodes a**1** and a**2** for electrocardiogram measurement and a PPG sensor **265***b* for heart rate measurement. The first wearable device **201** may further include a sensor module that is not illustrated, for example at least one of a gesture sensor, a gyro sensor, an atmospheric pressure sensor, a magnetic sensor, an acceleration sensor, a grip sensor, a color sensor, an infrared (IR) sensor, a biometric sensor, a temperature sensor, a humidity sensor, or an illuminance sensor.
[0075] The key input devices **202**, **203**, and **204** may include the wheel key **202** disposed on the first surface **211** of the housing **210** and rotatable in at least one direction and/or the side key buttons **203** and **204** arranged on the lateral surface **213** of the housing **210**. The wheel key **202** may have a shape corresponding to a shape of the front plate **222**. In another embodiment of the disclosure, some of the key input devices **202**, **203**, and **204** may be implemented in a different type, such as a soft key on the display **220**. The connector hole **209** may receive a connector (e.g., a USB connector) for transmission and reception of power and/or data with an external electronic device, and may include another connector hole (not illustrated) capable of receiving a connector for transmission and reception of an audio signal with an external electronic device. The first wearable device **201** may further include, for example, a connector cover (not illustrated) that covers at least a part of the connector hole **209** and blocks inflow of external foreign material through the connector hole.
[0076] The wearing members **250** and **260** may be detachably attached to at least a partial area of the housing **210** by using locking members **251** and **261**. The locking members **251** and **261** may include engagement components, such as pogo pins, and the components may be replaced with protrusions or recesses formed on the locking members **251** and **261** according to an embodiment. For example, the wearing members **250** and **260** may be coupled to the housing **210** by being engaged with recesses or protrusions formed on the housing **210**. The wearing members **250** and **260** may include one or more of a fixing member **252**, a fixing member fastening hole **253**, a band guide member **254**, a band fixing ring **255**.
[0077] The fixing member **252** may be configured to fix the housing **210** and the wearing members **250** and **260** to a part (e.g., wrist or ankle) of a user's body. The fixing member fastening hole **253** may correspond to the fixing member **252** and fix the housing **210** and the wearing members **250** and **260** to a part (e.g., wrist or ankle) of a user's body. The band guide member **254** may be configured to restrict a movement range of the fixing member **252** when the fixing member **252** is fastened to the fixing member fastening hole **253**, thereby enabling the wearing members **250** and **260** to come in close contact with and be attached to a part of a user's body. The band fixing ring **255** may restrict a movement range of the wearing members **250** and **260** in a state where the fixing member **252** and the fixing member fastening hole **253** have been fastened.
[0078] FIG. **3**A is a perspective view illustrating a second wearable device **301** according to an embodiment of the disclosure.

[0079] FIG. **3**B is a sectional view of the second wearable device **301** according to an embodiment of the disclosure.
[0080] Referring to FIGS. **3**A and **3**B, the second wearable device **301** may include a housing **310**. The housing **310** may configure the overall external appearance of the second wearable device **301**.
[0081] According to an embodiment of the disclosure, the housing **310** may have an annular shape. The housing **310** may include an opening configured to accommodate a user's finger. For example, the opening may be defined as a hole formed through the housing **310**.
[0082] According to an embodiment of the disclosure, the housing **310** may include an external housing part **311** or an internal housing part **313**. The internal housing part **313** may be coupled to the external housing part **311**. According to an embodiment of the disclosure, the external housing part **311** and the internal housing part **313** may be separately manufactured and combined or may be integrally configured.
[0083] According to an embodiment of the disclosure, the external housing part **311** may include a material capable of resisting external impact and/or scratches and implementing a design feature. For example, the external housing part **311** may include at least one of titanium, stainless steel, or ceramic. The external housing part **311** may be colored or coated for design implementation.
[0084] According to an embodiment of the disclosure, the internal housing part **313** may be a part coming into contact with a user's finger when the user puts on the second wearable device **301**. The internal housing part **313** may be manufactured of a material, such as, a molding material, transparent plastic, or glass for sensing. For example, the internal housing part **313** may be configured to be at least partially transparent. For example, the internal housing part **313** may include a material capable of transmitting light for measuring biometric information. At least a part of the internal housing part **313** may be manufactured of a material substantially identical or similar to that of the external housing part **311**. In addition, at least a part of the internal housing part **313** may include a metallic material for measuring biometric information.
[0085] According to an embodiment of the disclosure, the external housing part **311** and the internal housing part **313** may be coupled so that an inner space of the housing **310** is provided. In the inner space of the housing **310**, various electrical/electronic components of the second wearable device **301** may be arranged and/or mounted. For example, the housing **310** may accommodate various electrical/electronic components.
[0086] According to an embodiment of the disclosure, the second wearable device **301** may include a circuit board **340**, at least one light emitter **350**, at least one sensor **360**, at least one blocking member **370**, or a battery **389** (e.g., the battery **189** in FIG. **1**).
[0087] According to an embodiment of the disclosure, the circuit board **340** may be disposed in the inner space of the housing **310**. The circuit board **340** may include at least one of a printed circuit board (PCB), a flexible printed circuit board (FPCB), or a rigid-flexible PCB (RF-PCB).
[0088] According to an embodiment of the disclosure, various electrical/electronic components may be arranged and/or mounted on the circuit board **340**. For example, a processor (e.g., the processor **120** in FIG. **1**), memory (e.g., the memory **130** in FIG. **1**), a communication module (e.g., the communication module **190** in FIG. **1**), or a sensor module (e.g., the sensor module **176** in FIG. **1**, or the at least one light emitter **350** or the at least one sensor **360** in FIG. **3**B) may be mounted on the circuit board **340**.
[0089] According to an embodiment of the disclosure, the circuit board **340** may include multiple printed circuit boards. For example, the multiple printed circuit boards may be arranged according to a shape of the inner space of the housing **310** or may be electrically connected to each other. The circuit board **340** may include a flexible printed circuit board (FPCB). For example, the flexible printed circuit board may be at least partially bent according to the shape of the inner space of the housing **310**.
[0090] According to an embodiment of the disclosure, the battery **389** may include a non-rechargeable primary battery, a rechargeable secondary battery, or a fuel cell as a device for

supplying power to an element of the second wearable device **301**. The battery **389** may be integrally disposed in the second wearable device **301**, and may be detachably attached to the second wearable device **301**. According to an embodiment of the disclosure, the battery **389** may be configured to be one integrated battery or include multiple separable batteries. The battery **389** may include a battery pack that is bent according to the shape of the inner space of the housing **310**. The battery **389** may include multiple battery packs that are not bent by the housing **310**. The battery **389** may include a bendable battery pack and non-bendable multiple battery packs.

[0091] According to an embodiment of the disclosure, the second wearable device **301** may include a power management module (e.g., the power management module **188** in FIG. **1**) disposed on the circuit board **340**.

[0092] According to an embodiment of the disclosure, the second wearable device **301** may include a sensor for obtaining (or measuring) at least one piece of biometric information. For example, the at least one piece of biometric information may include at least one of information on a user's blood pressure, information on a user's oxygen saturation, or information on a user's heart rate. For example, the sensor may include a photoplethysmography (PPG) sensor for measuring a blood pressure, oxygen saturation, or heart rate.

[0093] According to an embodiment of the disclosure, the PPG sensor may include a light source (e.g., the at least one light emitter **350**) configured to emit light of two wavelength bands (e.g., RED wavelength band, or infrared wavelength band). The PPG sensor may include a light receiver (e.g., the at least one sensor **360**) configured to detect at least a part of light reflected by or transmitted through a part (e.g., a finger or the skin or a blood vessel of a finger) of a user's body.

[0094] According to an embodiment of the disclosure, the at least one light emitter **350** may emit, for measurement of a user's oxygen saturation, respective light rays of substantially identical or different wavelengths to radiate the light rays to a part (e.g., a finger or the skin and/or a blood vessel of a finger) of the user's body. The light emitter **350** may be configured to emit light of multiple wavelength bands including a red wavelength and an infrared wavelength. For example, the at least one light emitter **350** may emit light of various bands and may include at least one of a light emitting diode (LED), a laser diode, or a vertical cavity surface emitting laser (VCSEL). The at least one light emitter **350** may be disposed and/or mounted on the circuit board **340**. The at least one light emitter **350** may be configured to divide time to sequentially (or repeatedly) emit light of different wavelength bands. For example, the light emitter **350** may be configured to emit light through the internal housing part **313**.

[0095] According to an embodiment of the disclosure, the at least one sensor **360** may accumulate photocharges corresponding to the amount of light incident after being reflected by or transmitted through a part of a user's body, and convert, into a digital signal, a biometric signal of an analog current type according to the accumulated photocharges. For example, light (or optical signal) obtained (or detected) through the at least one sensor **360** may be converted through an analog-to-digital converter (ADC) and then be stored in memory or a sensor buffer. The at least one sensor **360** may include at least one of a photodiode (PD), a photo transistor, a charge-coupled device (CCD), or a complementary metal oxide semiconductor (CMOS). The at least one sensor **360** is not limited thereto, and may include various devices capable of converting an incident optical signal to an electrical signal.

[0096] According to an embodiment of the disclosure, the at least one sensor **360** may include a first sensor **361** or a second sensor **363**. The first sensor **361** and/or the second sensor **363** may be disposed and/or mounted on the circuit board **340**.

[0097] According to an embodiment of the disclosure, the first sensor **361** may be disposed to be farther away from the at least one light emitter **350** than the second sensor **363**. For example, the first sensor **361** may be positioned to be farther away from the at least one light emitter **350** than the second sensor **363** with respect to a circumferential direction of the housing **310**. For example, the distance between the first sensor **361** and the light emitter **350** may be greater than that between the second sensor **363** and the light emitter **350**.

[0098] According to an embodiment of the disclosure, the angle formed by the at least one light emitter **350** and the second sensor **363** with respect to a center O of the second wearable device **301** of the annular shape may be smaller than that formed by the at least one light emitter **350** and the first sensor **361** with respect to the center O of the second wearable device **301**.

[0099] According to an embodiment of the disclosure, the first sensor **361** may be configured to receive light transmitted through a part of a user's body. The first sensor **361** may be referred as a transmissive sensor. The first sensor **361** may receive at least some of light transmitted through a part of a user's body, convert the transmitted light into an electrical signal, and transfer the electrical signal to a processor (e.g., the processor **120** in FIG. **1**). According to an embodiment of the disclosure, the second sensor **363** may be configured to receive light reflected by a part of a user's body. The second sensor **363** may be referred as a reflective sensor. The second sensor **363** may receive at least some of light reflected by a part of a user's body, convert the reflected light into an electrical signal, and transfer the electrical signal to a processor (e.g., the processor **120** in FIG. **1**).

[0100] According to an embodiment of the disclosure, light emitted from the at least one light emitter **350** may reach the first sensor **361** along a first optical path **11** or reach the second sensor **363** along a second optical path **13**. For example, the first optical path **11** may be a path in which light is transmitted through a part (e.g., a finger, the skin of a finger, or a blood vessel of a finger) of a user's body, and the second optical path **13** may be a path in which light is reflected by a part of a user's body.

[0101] According to an embodiment of the disclosure, the second wearable device **301** may include the at least one blocking member **370**. The at least one blocking member **370** may include a material that absorbs or blocks light. The at least one blocking member **370** may be configured to block light emitted from the at least one light emitter **350**, from being propagated in the inner space of the housing **310**.

[0102] According to an embodiment of the disclosure, the at least blocking member **370** may include a first wall **371** or a second wall **373**. The first wall **371** may be positioned between the first sensor **361** and the second sensor **363** in the inner space of the housing **310**. The second wall **373** may be positioned between the second sensor **363** and the at least one light emitter **350** in the inner space of the housing **310**.

[0103] FIG. **4** is a block diagram of an electronic device **401** according to an embodiment of the disclosure.

[0104] Referring to FIG. **4**, in an embodiment of the disclosure, an electronic device **401** may be the electronic device **101** of FIG. **1**.

[0105] In an embodiment of the disclosure, the electronic device **401** may include communication circuitry **410**, a display **420**, a camera **430**, memory **440**, and/or a processor **450**.

[0106] In an embodiment of the disclosure, the communication circuitry **410** may be the communication module **190** in FIG. **1**. The communication circuitry **410** may support communication performed between the electronic device **401** and an external electronic device (e.g., the electronic device **102**, or the electronic device **104**). For example, the communication circuitry **410** (e.g., short-range communication circuit) may enable the electronic device **401** to be wirelessly connected to a first wearable device **501** and a second wearable device **601**.

[0107] In an embodiment of the disclosure, the display **420** may be the display module **160** in FIG. **1**.

[0108] In an embodiment of the disclosure, the display **420** may display various information. For example, the display **420** may display information required for performing an operation of measuring a blood pressure. For example, the display **420** may, based on a blood pressure being obtained, display the obtained blood pressure (e.g., a blood pressure value). However, information displayed by the display **420** is not limited to the above examples.

[0109] In an embodiment of the disclosure, the camera **430** may be the camera module **180** in FIG. **1**.
[0110] In an embodiment of the disclosure, the camera **430** may obtain (e.g., capture) an image for the first wearable device **501** and the second wearable device **601** worn on a user while the first wearable device **501** is displaying an object having a designated length (e.g., a bar-shaped image having an edge of about 1 cm as a real length). Based on the captured image, the distance between the first wearable device **501** and the second wearable device **601** may be obtained. An operation of, based on the captured image, obtaining the distance between the first wearable device **501** and the second wearable device **601** will be described later in detail with reference to FIG. **10**.
[0111] In an embodiment of the disclosure, the memory **440** may be the memory **130** in FIG. **1**.
[0112] In an embodiment of the disclosure, the memory **440** may store information required for performing an operation of measuring a blood pressure.
[0113] In an embodiment of the disclosure, the processor **450** may be the processor **120** in FIG. **1**.
[0114] In an embodiment of the disclosure, the processor **450** may control the overall operation of measuring a blood pressure (e.g., a blood pressure value). The processor **450** may include one or more processors for performing an operation of measuring a blood pressure. An operation performed by the processor **450** to measure a blood pressure will be described in detail later.
[0115] FIG. **4** illustrates that the electronic device **401** includes the communication circuitry **410**, the display **420**, the camera **430**, the memory **440**, and/or the processor **450**, but the disclosure is not limited thereto. For example, the electronic device **401** may further include at least one component included in the electronic device **101** in FIG. **1**.
[0116] FIG. **5** is a block diagram of a first wearable device **501** according to an embodiment of the disclosure.
[0117] Referring to FIG. **5**, in an embodiment of the disclosure, a first wearable device **501** may be the electronic device **101** of FIG. **1** or the first wearable device **201** in FIGS. **2**A and **2**B. For example, the first wearable device **501** may include a smart watch that performs an operation while being worn on a user's wrist.
[0118] In an embodiment of the disclosure, the first wearable device **501** may include communication circuitry **510**, a display **520**, a biometric sensor **530**, memory **540**, and/or a processor **550**.
[0119] In an embodiment of the disclosure, the communication circuitry **510** may be the communication module **190** in FIG. **1**. The communication circuitry **510** may support communication performed between the first wearable device **501** and an external electronic device (e.g., the electronic device **401** and/or a second wearable device **601**).
[0120] In an embodiment of the disclosure, the display **520** may be the display module **160** in FIG. **1** or the display **220** in FIGS. **2**A and **2**B.
[0121] In an embodiment of the disclosure, the biometric sensor **530** may include at least one of sensors included in the sensor module **176** in FIG. **1** or sensors included in the sensor module **265** in FIGS. **2**A and **2**B.
[0122] In an embodiment of the disclosure, the biometric sensor **530** may include a PPG sensor **531**. The PPG sensor (e.g., the PPG sensor **265***b* in FIGS. **2**A and **2**B) may obtain (e.g., measure) a PPG signal. However, a sensor included in the biometric sensor **530** is not limited to the PPG sensor **531**. For example, the biometric sensor **530** may further include the ECG sensor **265***a* including the at least two electrodes a**1** and a**2** for electrocardiogram measurement, illustrated in FIG. **2**B.
[0123] In an embodiment of the disclosure, the memory **540** may be the memory **130** in FIG. **1**.
[0124] In an embodiment of the disclosure, the memory **540** may store information required for performing an operation of measuring a blood pressure.
[0125] In an embodiment of the disclosure, the processor **550** may be the processor **120** in FIG. **1**.
[0126] In an embodiment of the disclosure, the processor **550** may perform a part of an operation

for measuring a blood pressure. The processor **550** may include one or more processors for performing the part of the operation for measuring a blood pressure. The part of the operation performed by the processor **550** to measure a blood pressure will be described in detail later.

[0127] FIG. **5** illustrates that the first wearable device **501** includes the communication circuitry **510**, the display **520**, the biometric sensor **530**, the memory **540**, and/or the processor **550**, but the disclosure is not limited thereto. For example, the first wearable device **501** may further include at least one component included in the electronic device **101** in FIG. **1** or the first wearable device **201** in FIGS. **2**A and **2**B.

[0128] FIG. **6** is a block diagram of a second wearable device **601** according to an embodiment of the disclosure.

[0129] Referring to FIG. **6**, in an embodiment of the disclosure, a second wearable device **601** may be the electronic device **101** of FIG. **1** or the second wearable device **301** in FIGS. **3**A and **3**B. For example, the second wearable device **601** may include a smart ring that performs an operation while being worn on a user's finger.

[0130] In an embodiment of the disclosure, the second wearable device **601** may include communication circuitry **610**, a biometric sensor **620**, memory **630**, and/or a processor **640**.

[0131] In an embodiment of the disclosure, the communication circuitry **610** may be the communication module **190** in FIG. **1**. The communication circuitry **610** may support communication performed between the second wearable device **601** and an external electronic device (e.g., the electronic device **401** and/or the first wearable device **501**).

[0132] In an embodiment of the disclosure, the biometric sensor **620** may include at least one of sensors included in the sensor module **176** in FIG. **1**.

[0133] In an embodiment of the disclosure, the biometric sensor **620** may include a PPG sensor **621**.

[0134] In an embodiment of the disclosure, the PPG sensor **621** may obtain (e.g., measure) a PPG signal. The PPG sensor **621** may include the at least one light emitter **350** and the at least one sensor **360** in FIG. **3**B to obtain a PPG signal.

[0135] However, a sensor included in the biometric sensor **620** is not limited to the PPG sensor **621**.

[0136] In an embodiment of the disclosure, the memory **630** may be the memory **130** in FIG. **1**.

[0137] In an embodiment of the disclosure, the memory **630** may store information required for performing an operation of providing a blood pressure.

[0138] In an embodiment of the disclosure, the processor **640** may be the processor **120** in FIG. **1**.

[0139] In an embodiment of the disclosure, the processor **640** may perform a part of an operation for measuring a blood pressure. The processor **640** may include one or more processors for performing the part of the operation for measuring a blood pressure. The part of the operation performed by the processor **550** to measure a blood pressure will be described in detail later.

[0140] FIG. **6** illustrates that the second wearable device **601** includes the communication circuitry **610**, the biometric sensor **612**, the memory **630**, and/or the processor **640**, but the disclosure is not limited thereto. For example, the second wearable device **601** may further include at least one component included in the electronic device **101** in FIG. **1** or the second wearable device **301** in FIGS. **3**A and **3**B.

[0141] FIG. **7** is a flowchart **700** illustrating a method of measuring a blood pressure (e.g., a blood pressure value) according to an embodiment of the disclosure.

[0142] Referring to FIG. **7**, in operation **701**, in an embodiment of the disclosure, the processor **450** may receive, through the communication circuitry **410**, a first PPG signal (hereinafter, a PPG signal received from the first wearable device **501** is referred as a “first PPG signal”) from the first wearable device **501** and receive a second PPG signal (hereinafter, a PPG signal received from the second wearable device **601** is referred as a “second PPG signal”) from the second wearable device **601**.

[0143] In an embodiment of the disclosure, the processor **450** may receive, from the first wearable device **501** through the communication circuitry **410**, a first PPG signal obtained (e.g., measured) by the first wearable device **501** and time information (hereinafter, this is referred to as “first time information”) on a time at which the first PPG signal is obtained. For example, the processor **450** may receive, from the first wearable device **501** through the communication circuitry **410**, values of a first PPG signal measured by the first wearable device **501** by using a PPG sensor and respective time points at which the values of the first PPG signal are measured.

[0144] In an embodiment of the disclosure, the processor **450** may receive, from the second wearable device **601** through the communication circuitry **410**, a second PPG signal obtained by the second wearable device **601** and time information (hereinafter, this is referred to as “second time information”) on a time at which the second PPG signal is obtained. For example, the processor **450** may receive, from the second wearable device **601** through the communication circuitry **410**, values of a second PPG signal measured by the second wearable device **601** by using a PPG sensor and respective time points at which the values of the second PPG signal are measured.

[0145] In an embodiment of the disclosure, first time information on a time at which a first PPG signal is obtained and second time information on a time at which a second PPG signal is obtained may be synchronized time information. For example, first time information and second time information may be time information on times at which PPG signals are obtained by the first wearable device **501** and the second wearable device **601** for which times serving as a reference (hereinafter, these are referred as “reference times”) are configured to be identical. Hereinafter, an operation in which the first wearable device **501** and the second wearable device **601** configure reference times to be identical may be referred as an operation of synchronizing the first wearable device **501** and the second wearable device **601**. The operation of synchronizing the first wearable device **501** and the second wearable device **601** will be described with reference to FIG. **8**.

[0146] FIG. **8** is a diagram illustrating a method of synchronizing a first wearable device **501** and a second wearable device **601** according to an embodiment of the disclosure.

[0147] Referring to FIG. **8**, in an embodiment of the disclosure, as indicated by reference numeral **801**, the processor **450** may transmit (e.g., broadcast) an advertising signal **811** (e.g., BLE beacon signal) including time information (e.g., time stamp of the electronic device **401**) by using the communication circuitry **410** (e.g., Bluetooth™ communication circuit). For example, as indicated by reference numeral **802**, the processor **450** may periodically transmit an advertising packet including time information of the electronic device **401** (e.g., local operating system (OS) time information of the electronic device **401**) at a first time point t**1** by using a Bluetooth™ (e.g., Bluetooth™ low energy (BLE) or Bluetooth™ classic) communication circuit.

[0148] In an embodiment of the disclosure, the first wearable device **501** and the second wearable device **601** may receive the signal **811** including time information of the electronic device **401** transmitted from the electronic device **401**, at a substantially identical time. For example, as indicated by reference numeral **802**, the first wearable device **501** and the second wearable device **601** may substantially simultaneously receive, at a second time point t**2**, the signal **811** having been transmitted from the electronic device **401** at the first time point t**1**.

[0149] In an embodiment of the disclosure, the first wearable device **501** and the second wearable device **601** may be synchronized by configuring, as reference times, the second time point t**2** at which the first wearable device **501** and the second wearable device **601** have received the signal **811** substantially simultaneously.

[0150] However, the method of synchronizing the first wearable device **501** and the second wearable device **601** is not limited to the above example. For example, in a case where the electronic device **401**, the first wearable device **501**, and the second wearable device **601** support short-range communication (e.g., Wi-Fi) other than Bluetooth™, the electronic device **401**, the first wearable device **501**, and the second wearable device **601** may perform an operation of synchronizing the first wearable device **501** and the second wearable device **601**, by using the different short-range communication. For example, the electronic device **401**, the first wearable device **501**, and the second wearable device **601** may perform an operation of synchronizing the first wearable device **501** and the second wearable device **601**, by using an audio signal using an inaudible frequency.

[0151] Referring to FIG. **7** again, in an embodiment of the disclosure, after the first wearable device **501** and the second wearable device **601** are synchronized, the first wearable device **501** and the second wearable device **601** may obtain PPG signals through the PPG sensors **531** and **621**. For example, each of the first wearable device **501** and the second wearable device **601** may perform an operation of obtaining PPG signals, according to a pre-configured period. For example, each of the first wearable device **501** and the second wearable device **601** may perform an operation of obtaining PPG signals, at the time of a user input. For example, each of the first wearable device **501** and the second wearable device **601** may perform an operation of obtaining PPG signals, when a signal including a command to obtain a PPG signal is received from the electronic device **401**.

[0152] In an embodiment of the disclosure, after the first wearable device **501** and the second wearable device **601** are synchronized, each of the first wearable device **501** and the second wearable device **601** may perform an operation of obtaining a PPG signal, when a designated condition is satisfied. For example, the first wearable device **501** (and the second wearable device **601**) may perform an operation of obtaining a PPG signal, based on the size of movement of the first wearable device **501** being equal to or smaller than a threshold size. For example, the first wearable device **501** (and the second wearable device **601**) may perform an operation of obtaining a PPG signal through the PPG sensor **531**, based on the size of movement of the first wearable device **501** being equal to or smaller than a threshold size and a heart rate obtained through the first wearable device **501** being equal to or smaller than a threshold (and/or based on a heart rate variability).

[0153] In an embodiment of the disclosure, each of the first wearable device **501** and the second wearable device **601** may perform an operation of obtaining a first PPG signal and a second PPG signal for a pre-configured time (e.g., about 1 minute).

[0154] In an embodiment of the disclosure, the first wearable device **501** may include a smart watch that performs an operation of obtaining a first PPG signal, while being worn on a user's first position (e.g., the user's wrist). The second wearable device **601** may include a smart ring that performs an operation of obtaining a second PPG signal, while being worn on a user's second position (e.g., the user's finger).

[0155] In an embodiment of the disclosure, the first wearable device **501** and the second wearable device **601** may obtain a first PPG signal and a second PPG signal and then transmit the obtained first PPG signal and second PPG signal to the electronic device **401**. The processor **450** may receive a first PPG signal and a second PPG signal from the first wearable device **501** and the second wearable device **601** through the communication circuitry **410** to obtain the first PPG signal and the second PPG signal.

[0156] In operation **703**, in an embodiment of the disclosure, the processor **450** may obtain, based on the first PPG signal and the second PPG signal, a pulse transit time (PTT) during which a pulse wave is transferred from the user's first position (hereinafter, this is also referred to as a “first position”) on which the first wearable device **501** is worn, to the user's second position (hereinafter, this is also referred to as a “second position”) on which the second wearable device **601** is worn. Hereinafter, an operation of obtaining a PTT, based on a first PPG signal and a second PPG signal is described with reference to FIG. **9**.

[0157] FIG. **9** is a diagram illustrating a method of obtaining a PTT, based on a first PPG signal and a second PPG signal according to an embodiment of the disclosure.

[0158] Referring to FIG. **9**, in an embodiment of the disclosure, reference numeral **901** may indicate the first wearable device **501** and the second wearable device **601** worn on a user **910**. For example, the first wearable device **501** may be worn on a wrist of the user **910** and the second wearable device **601** may be worn on a finger of the user **910**. Reference numeral **901** to reference numeral **911** may show a blood vessel (e.g., artery) of the user **910**.

[0159] In an embodiment of the disclosure, reference numeral **902** may indicate a graph including a first PPG signal **921** (e.g., the wave form of the first PPG signal), and reference numeral **903** may indicate a graph including a second PPG signal **931** (e.g., the wave form of the second PPG signal). In each of the graphs of reference numeral **902** and reference numeral **903**, the x axis represents time and the y axis represents the size (e.g., amplitude) of the PPG signal.

[0160] In an embodiment of the disclosure, in each of the graphs of reference numeral **902** and reference numeral **903**, the time represented by the x axis may be time having a reference time (e.g., the second time point t**2**) as a reference. In each of the graphs of reference numeral **902** and reference numeral **903**, the y axis may represent the size of a PPG signal measured by a wearable device (e.g., each of the first wearable device **501** and the second wearable device **601**) by using a reference time (e.g., the second time point t**2**) as a reference.

[0161] In an embodiment of the disclosure, the processor **450** may obtain (e.g., extract), from each of the first PPG signal **921** and the second PPG signal **931**, one or more feature points including a point having a maximum size, a point having a minimum size, an inflection point, and/or a point having a maximum slope. However, the one or more feature points are not limited to the above examples.

[0162] In an embodiment of the disclosure, the processor **450** may obtain a PTT by comparing the times of mutually corresponding feature points in the first PPG signal **921** and the second PPG signal **931** (e.g., based on the difference between the times of mutually corresponding feature points). For example, the processor **450** may identify times t**1** and t**2** of points **922** and **932** corresponding to each other and having minimum sizes in the first PPG signal **921** and the second PPG signal **931**. The processor **450** may subtract the time t**1** corresponding to the point **922** from the time t**2** corresponding to the point **932** to obtain (e.g., calculate) a PTT. In the above example, obtaining a PTT, based on the times t**1** and t**2** corresponding to the points **922** and **932** having minimum sizes is described, but the disclosure is not limited thereto. For example, the processor **450** may obtain a PTT by subtracting a time corresponding to a point **923** having a maximum size in the first PPG signal **921** from a time corresponding to a point **933** having a maximum size in the second PPG signal **931**.

[0163] Referring to FIG. **7** again, in operation **705**, in an embodiment of the disclosure, the processor **450** may obtain the distance between the first wearable device **501** and the second wearable device **601**.

[0164] In an embodiment of the disclosure, the distance between the first wearable device **501** and the second wearable device **601** may be substantially identical to the distance between the user's first position (e.g., a position on which the first PPG signal is measured) on which the first wearable device **501** is worn and the user's second position (e.g., a position on which the second PPG signal is measured) on which the second wearable device **601** is worn. Hereinafter, an operation of obtaining the distance between the first wearable device **501** and the second wearable device **601** is described with reference to FIG. **10**.

[0165] FIG. **10** is a diagram illustrating a method of obtaining a distance between a first wearable device **501** and a second wearable device **601** according to an embodiment of the disclosure.

[0166] Referring to FIG. **10**, in an embodiment of the disclosure, the processor **450** may obtain (e.g., calculate) the distance between the first wearable device **501** and the second wearable device **601**, based on an image for the first wearable device **501** and the second wearable device **601** worn on a user.

[0167] In an embodiment of the disclosure, the processor **450** may transmit, to the first wearable device **501** through the communication circuitry **410**, a signal that causes the first wearable device **501** to display, through the display **520**, an object having a designated length (e.g., a bar-shaped image having an edge of about 1 cm as a real length). For example, the processor **450** may, based on the electronic device **401** operating in a mode for obtaining the distance between the first wearable device **501** and the second wearable device **601**, control the first wearable device **501** such that the display **520** of the first wearable device **501** displays an object having a designated length.

[0168] In an embodiment of the disclosure, while the first wearable device **501** is displaying the object, the processor **450** may obtain an image for the first wearable device **501** and the second wearable device **601** worn on the user by using the camera **430**. For example, as indicated by reference numeral **1001**, in a state where the user is holding the electronic device **401** by using the user's right hand **1042**, the processor **450** may obtain an image for the first wearable device **501** and the second wearable device **601** worn on the left hand by using the camera **430**.

[0169] In an embodiment of the disclosure, as indicated by reference numeral **1001**, the processor **450** may display, through the display **420**, an image **1010** which is obtained through the camera **430** and includes a part **1020** representing the first wearable device **501**, a part **1030** representing the second wearable device **601**, and a part **1041** representing the left hand.

[0170] In an embodiment of the disclosure, the processor **450** may obtain (e.g., identify), in the image **1010**, the length (hereinafter, this is referred to as a “first length”) of a part **1050** representing an object that has a designated length and is displayed through the first wearable device **501** (e.g., a bar-shaped image having an edge of about 1 cm as a real length).

[0171] In an embodiment of the disclosure, the processor **450** may obtain (e.g., identify), from the image **1010**, the distance (hereinafter, this is referred as a “first distance”) between the part **1020** representing the first wearable device **501** and the part **1030** representing the second wearable device **601**. For example, the processor **450** may identify, in the image **1010**, the distance between the center of the part **1020** representing the first wearable device **501** and the center of the part **1030** representing the second wearable device **601**.

[0172] In an embodiment of the disclosure, the processor **450** may obtain the distance between the first wearable device **501** and the second wearable device **601** (e.g., the real distance between the first wearable device **501** and the second wearable device **601**), based on the designated length of the object, the first length, and the first distance. For example, the processor **450** may calculate the distance between the first wearable device **501** and the second wearable device **601** by using Equation 1 below.

[00001] $D = (\text{firstdistance}) / (\text{firstlength}) * (\text{designatedlengthofobject}) \quad \text{Equation1}$

[0173] In an embodiment of the disclosure, in Equation 1, D may denote the real distance between the first wearable device **501** and the second wearable device **601**. In Equation 1, the designated length of the object may indicate the real length (e.g., about 1 cm) of the object displayed through the display **520** of the first wearable device **501**.

[0174] Although not illustrated in FIG. **10**, in an embodiment of the disclosure, the processor **450** may obtain the distance between the first wearable device **501** and the second wearable device **601**, based on an image for the first wearable device **501** and the second wearable device **601** worn on the user, and a real length of the display **520** of the first wearable device **501** (e.g., a real diameter of the display **520** of the first wearable device **501**) replaceable with the designated length of the object described above.

[0175] In an embodiment of the disclosure, the processor **450** may receive identification information of the first wearable device **501** (e.g., a model name of the first wearable device **501**) from the first wearable device **501** through the communication circuitry **410**, or may obtain identification information of the first wearable device **501** stored in the memory **440** from the memory **440**. The processor **450** may transmit identification information of the first wearable device **501** to a server through the communication circuitry **410** to receive the real length (hereinafter, this is referred to as a “second length”) of the display **520** of the first wearable device

501 from the server. However, the disclosure is not limited thereto. For example, in a case where a second length is stored in the memory **440** as the real length of the display **520** of the first wearable device **501**, the processor **450** may obtain the second length from the memory **440**.

[0176] In an embodiment of the disclosure, the processor **450** may obtain a length (hereinafter, this is referred to as a “third length”) of a part representing the display **520** of the first wearable device **501** in and based on an image, obtained through the camera **430**, for the first wearable device **501** and the second wearable device **601** worn on the user. For example, when the part representing the display **520** of the first wearable device **501** in the image is displayed using a circular shape, the third length may be the length of the diameter of the circle. When the part representing the display **520** of the first wearable device **501** in the image is displayed using an oval shape, the third length may be the length between points at which the apsidal line of the oval and the oval cross over each other.

[0177] In an embodiment of the disclosure, the processor **450** may obtain (e.g., identify), from the image, a first distance between a part representing the first wearable device **501** and a part representing the second wearable device **601**.

[0178] In an embodiment of the disclosure, the processor **450** may obtain the distance between the first wearable device **501** and the second wearable device **601**, based on the first distance, the second length, and the third length. For example, the processor **450** may calculate the distance between the first wearable device **501** and the second wearable device **601** by using Equation 2 below.

[00002] $D = (\text{firstdistance}) / (\text{thirdlength}) * (\text{secondlength})$ Equation2

[0179] In an embodiment of the disclosure, in Equation 2, D may denote the real distance between the first wearable device **501** and the second wearable device **601**.

[0180] In the above examples, the display **520** of the first wearable device **501** displays an object having a designated length or the real length of the display **520** of the first wearable device **501** is used, but the disclosure is not limited thereto. For example, in a case where the second wearable device **601** includes a display, the above operations may be performed using an object having a designated length displayed through the display of the second wearable device **601** or the real length of the display of the second wearable device **601**.

[0181] In an embodiment of the disclosure, the processor **450** may obtain the distance between the first wearable device **501** and the second wearable device **601**, based on a transmission/reception time of an audio signal (e.g., inaudible sound wave) between the first wearable device **501** and the second wearable device **601** and a velocity of the audio signal. For example, as indicated by reference numeral **1002**, in a state where the first wearable device **501** and the second wearable device **601** are worn on a user **1043**, the first wearable device **501** may transmit an audio signal to the second wearable device **601** in a direction indicated by an arrow **1061**. The second wearable device **601** may transmit an audio signal to the first wearable device **501** in a direction indicated by an arrow **1062** in response to receiving the audio signal. The processor **450** may control an operation of transmitting and receiving an audio signal between the first wearable device **501** and the second wearable device **601**. The processor **450** may receive, from the first wearable device **501** through the communication circuitry **410**, a time from a time point at which the first wearable device **501** has transmitted the audio signal to the second wearable device **601** to a time point at which the first wearable device has received the audio signal from the second wearable device **601**.

[0182] In an embodiment of the disclosure, the processor **450** may obtain the distance between the first wearable device **501** and the second wearable device **601**, based on the received time and a velocity of the audio signal (e.g., the velocity of sound). For example, the processor **450** may obtain the real distance between the first wearable device **501** and the second wearable device **601**, by multiplying the received time by the velocity of the audio signal and dividing the resultant value by 2.

[0183] In the above example, the real distance between the first wearable device **501** and the second wearable device **601** is obtained based on the time from a time point at which the first wearable device **501** has transmitted the audio signal to the second wearable device **601** to a time point at which the first wearable device has received the audio signal from the second wearable device **601**. However, the disclosure is not limited thereto. For example, the processor **450** may obtain the distance between the first wearable device **501** and the second wearable device **601** by multiplying, by the velocity of an audio signal, a time from a time point at which the first wearable device **501** has transmitted the audio signal to a time point at which the second wearable device **601** has received the audio signal. For example, the processor **450** may obtain the distance between the first wearable device **501** and the second wearable device **601** by multiplying, by the velocity of an audio signal, a time from a time point at which the second wearable device **601** has transmitted the audio signal to a time point at which the first wearable device **501** has received the audio signal.
[0184] Referring to FIG. **7** again, in operation **707**, in an embodiment of the disclosure, the processor **450** may obtain a pulse wave velocity (PWV) at which a pulse wave is transferred, based on the PTT obtained through operation **703** and the distance between the first wearable device **501** and the second wearable device **601** obtained through operation **705**. For example, the processor **450** may obtain (e.g., calculate) a PWV by dividing, by the PTT, the distance between the first wearable device **501** and the second wearable device **601**.
[0185] In operation **709**, in an embodiment of the disclosure, the processor **450** may obtain a blood pressure by using a pulse wave analysis (PWA) method, based on the first PPG signal and/or the second PPG signal.
[0186] In an embodiment of the disclosure, the processor **450** may, as a pulse wave analysis (PWA) method, analyze the wave form of the first PPG signal and/or the wave form of the second PPG signal received through operation **701** to obtain (e.g., estimate) a blood pressure (e.g., hereinafter, a blood pressure obtained using the PWA method is referred as a “first blood pressure” or “P.sub.PWA”). For example, the processor **450** may obtain a first blood pressure in the wave form of the first PPG signal (and/or the wave form of the second PPG signal), based on the size (e.g., amplitude) of one or more feature points (e.g., a point having a maximum size, a point having a minimum size, an inflection point, and/or a point having a maximum slope in the wave form of the first PPG signal), the time interval between one or more feature points, and/or the slope of one or more feature points in time. For example, the processor **450** may differentiate twice the first PPG signal (and/or second PPG signal) to obtain the wave form of an accelerated pulse wave (plethysmograph), and analyze a peak characteristic in the wave form of the accelerated pulse wave (e.g., each peak value and the time difference between peaks in the wave form of the accelerated pulse wave). Based on the peak characteristic, the processor **450** may obtain the first blood pressure by using a correlation, stored in the memory **440**, between the first blood pressure (e.g., the value of the first blood pressure) and the peak characteristic of the wave form of the accelerated pulse wave. However, a method of obtaining a first blood pressure by using a PWA method is not limited to the above examples.
[0187] In an embodiment of the disclosure, the processor **450** may map the PWV obtained through operation **707** and the first blood pressure obtained through operation **709**, and store the mapped PWV and first blood pressure in the memory **440**.
[0188] In an embodiment of the disclosure, the processor **450** may perform operation **701** to operation **709** during a designated period (e.g., one day or one week). For example, the processor **450** may perform operation **701** to operation **709** during a designated period, to collect (e.g., store in the memory **440**) multiple PWVs and multiple first blood pressures corresponding to (e.g., mapped to) the multiple PWVs, respectively.
[0189] In operation **711**, in an embodiment of the disclosure, the processor **450** may obtain a value (or coefficient) related to a characteristic of a blood vessel (hereinafter, the value is referred as a “vascular characteristic value”), based on the PWV and the first blood pressure.

[0190] In an embodiment of the disclosure, the processor **450** may obtain a vascular characteristic value by using a PWV blood pressure model and a PWA blood pressure model. Hereinafter, an operation of obtaining a vascular characteristic value by using a PWV blood pressure model and a PWA blood pressure model is described with reference to FIG. **11**.

[0191] FIG. **11** is a diagram illustrating a method of obtaining a vascular characteristic value by using a PWV blood pressure model and a PWA blood pressure model according to an embodiment of the disclosure.

[0192] Referring to FIG. **11**, in an embodiment of the disclosure, Equation 3 below may show a Fung's hyperelastic model as a PWV blood pressure model (e.g., a blood pressure model using PWV).

[00003] $$\ln\left(\frac{P}{C}\right) + \ln\left(\sqrt{1 + \frac{8}{a_1}\frac{PWV^2}{P}} - 1\right) = \frac{a_1}{16}\left(\sqrt{1 + \frac{8}{a_1}\frac{\mathrm{PWV}^2}{P}} - 1\right)^2 \quad \text{Equation3}$$

[0193] In an embodiment of the disclosure, in Equation 3, P may denote a blood pressure. In Equation 3, p indicates vascular density, and C and a.sub.1 may be parameters related to vascular elasticity.

[0194] In an embodiment of the disclosure, Equation 3 may be expressed as Equation 4 below. For example, Equation 3 may be approximated by Equation 4 below.

[00004] $$P = \quad * (\mathrm{PWV}^2) + \quad \text{Equation4}$$

[0195] In an embodiment of the disclosure, in Equation 4, P may denote a blood pressure. In Equation 4, α and β may be coefficients related to a vascular characteristic. For example, α and β may be coefficients related to, as a vascular characteristic, vascular elasticity, vascular radius, vascular thickness, and/or vascular density. In an embodiment of the disclosure, at least one of α, β, and γ described later may be included in a vascular characteristic value.

[0196] In the above example, a Fung's hyperelastic model is used as an example of a PWV blood pressure model, but the disclosure is not limited thereto, and a different PWV blood pressure model (e.g., MK & Hughes model) may be used.

[0197] In an embodiment of the disclosure, Equation 5 below may indicate a pulse wave analysis (PWA) blood pressure model (e.g., a blood pressure model using PWA).

[00005] $$P = P_{\mathrm{PWA}} + P_{\mathrm{cal}} \quad \text{Equation5}$$

[0198] In an embodiment of the disclosure, in Equation 5, P may denote a blood pressure. In Equation 5, P.sub.PWA denotes a blood pressure measured using a PWA method, and P.sub.cal may denote a value for blood pressure correction (hereinafter, the value is referred as a “blood pressure correction value”) for calculating a blood pressure (P) by correcting P.sub.PWA.

[0199] In an embodiment of the disclosure, Equation 6 and Equation 7 below may be derived based on Equation 4 and Equation 5.

[00006] $$P_{PWA} = \quad * (\mathrm{PWV}^2) + \quad \text{Equation6} \qquad = \quad - P_{\mathrm{cal}} \quad \text{Equation7}$$

[0200] In an embodiment of the disclosure, the processor **450** may obtain (e.g., calculate) α and γ as vascular characteristic values by using regression analysis, based on multiple PWVs and multiple first blood pressures (P.sub.PWA values) (multiple first blood pressures corresponding to the multiple PWVs, respectively) (hereinafter, a PWV and a P.sub.PWA value corresponding to the PWV are referred as a “PWV-and-P.sub.PWA pair”) obtained (e.g., collected) for a designated period (e.g., one day or one week). Hereinafter, α is referred as a “first vascular characteristic value”, and γ may be referred as a “second vascular characteristic value”. In addition, β may be referred as a “third vascular characteristic value”.

[0201] In an embodiment of the disclosure, in Equation 4, Equation 5, Equation 6, and Equation 7, α (first vascular characteristic value), γ (second vascular characteristic value), β (third vascular characteristic value), and P.sub.cal (blood pressure correction value) may be variable values. Hereinafter, an operation of obtaining (e.g., calculating) α, γ, β, and/or P.sub.cal may include an operation of obtaining constant values of α, γ, β, and/or P.sub.cal.

[0202] In an embodiment of the disclosure, the processor **450** may perform a regression analysis, based on identifying that the number of PWV-and-P.sub.PWA pairs obtained for a designated period is equal to or greater than a designated number. The processor **450** may perform the regression analysis, thereby calculating an equation (hereinafter, this is also referred as a “relation formula”) representing a correlation between PWV.sup.2 and P.sub.PWA. The processor **450** may obtain α and γ (e.g., α and γ as constant values) from the calculated equation.
[0203] In an embodiment of the disclosure, in FIG. **11**, the X axis denotes PWV.sup.2 and the Y axis may denote P.sub.PWA. In FIG. **11**, points **1111** may correspond to PWV-and-P.sub.PWA pairs obtained during a designated period, respectively. For example, each of the points **1111** may be a point expressing a PWV-and-P.sub.PWA pair by using a relation between PWV.sup.2 and P.sub.PWA.
[0204] In an embodiment of the disclosure, the processor **450** may perform a regression analysis (e.g., linear regression analysis) for the points **1111**, thereby obtaining (e.g., calculate) a linear line **1110**. For example, the processor **450** may perform a linear regression analysis for the points **1111**, thereby calculating the linear line **1110** representing a relation formula between PWV.sup.2 and P.sub.PWA. The processor **450** may obtain (e.g., calculate) α and γ in Equation 6 as vascular characteristic values, based on the linear line **1110** representing the relation formula between PWV.sup.2 and P.sub.PWA.
[0205] Referring to FIG. **7** again, in operation **713**, in an embodiment of the disclosure, the processor **450** may obtain, based on the vascular characteristic value, a blood pressure correction value for correcting a second blood pressure to be obtained (e.g., P.sub.PWA obtained at the time of next blood pressure measurement) (hereinafter, this is referred as a “blood pressure correction value”) (e.g., P.sub.cal in Equation 5 and Equation 7. Hereinafter, an operation of obtaining a blood pressure correction value, based on a vascular characteristic value is described with reference to FIG. **12**.
[0206] FIG. **12** is a diagram illustrating a method of obtaining a blood pressure correction value, based on a vascular characteristic value according to an embodiment of the disclosure.
[0207] Referring to FIG. **12**, in an embodiment of the disclosure, the processor **450** may obtain a blood pressure correction value, based on a vascular characteristic value and a correlation between the vascular characteristic value and the blood pressure correction value. For example, the processor **450** may obtain a blood pressure correction value by using a correlation between a vascular characteristic value and the blood pressure correction value, based on the vascular characteristic value.
[0208] In an embodiment of the disclosure, the correlation between a vascular characteristic value and a blood pressure correction value may be a relation between β and P.sub.cal in Equation 7 (e.g., a function representing the relation between β and P.sub.cal). In an embodiment of the disclosure, the correlation between a vascular characteristic value and a blood pressure correction value may be obtained in advance (e.g., before operation **701** is performed), based on data related to a blood vessel collected from multiple users (e.g., multiple electronic devices corresponding to the multiple users, respectively). An operation of obtaining the correlation between a vascular characteristic value and a blood pressure correction value will be described later with reference to FIG. **13**.
[0209] In an embodiment of the disclosure, in FIG. **12**, the X axis denotes p and the Y axis may denote P.sub.cal. In FIG. **12**, respective points **1231** may be points expressing, by using β and P.sub.cal, respective data related to a blood vessel collected from multiple users (e.g., multiple electronic devices corresponding to the multiple users, respectively). In FIG. **12**, a line **1220** may represent a function representing the relation between β and P.sub.cal as a correlation between a vascular characteristic value and a blood pressure correction value.
[0210] In an embodiment of the disclosure, in FIG. **12**, a line **1210** may be a linear line (e.g., primary line) representing the relation between β and P.sub.cal and obtained by inputting γ obtained through operation **711** into Equation 7. For example, the y-intercept of a linear equation represented

by the line **1210** is −γ, and the slope thereof may be 1.

[0211] In an embodiment of the disclosure, the processor **450** may identify an intersection **1241** between the line **1210** and the line **1220**. The processor **450** may obtain a Y-axis value (Y1) of the intersection **1241** as a blood pressure correction value (P.sub.cal) (e.g., a blood pressure correction value (P.sub.cal) as a constant value). However, the disclosure is not limited thereto. For example, the processor **450** may determine an X-axis value (X1) of the intersection **1241** as β in Equation 7, and input the determined β and γ obtained through operation **711** into Equation 7 to obtain a blood pressure correction value (P.sub.cal).

[0212] In an embodiment of the disclosure, the processor **450** may perform an operation of obtaining a blood pressure correction value (P.sub.cal) according to a designated period (e.g., one week, one month, or three months) to update the blood pressure correction value (P.sub.cal).

[0213] Referring to FIG. **7** again, in an embodiment of the disclosure, after a blood pressure correction value (P.sub.cal) is obtained through operation **713**, the processor **450** may obtain a blood pressure (e.g., a third blood pressure to be provided to the user) by using the blood pressure correction value (P.sub.cal). For example, after a blood pressure correction value (P.sub.cal) is obtained, the processor **450** may perform an operation substantially identical to an operation described through operation **701** to receive, through the communication circuitry, a first PPG signal and/or a second PPG signal from the first wearable device **501** and/or the second wearable device **601**. The processor **450** may perform an operation substantially identical to an operation described through operation **709** to obtain a first blood pressure (P.sub.PWA) by using a PWA method, based on the first PPG signal and/or the second PPG signal. The processor **450** may obtain a second blood pressure to be provided to the user, based on the first blood pressure (P.sub.PWA) and the blood pressure correction value (P.sub.cal) (e.g., by adding the first blood pressure (P.sub.PWA) and the blood pressure correction value (P.sub.cal)).

[0214] However, a method of obtaining a second blood pressure is not limited to the above example. In an embodiment of the disclosure, the processor **450** may perform the above operations to obtain α and β as vascular characteristic values related to a blood vessel. After α and β are obtained, the processor **450** may perform operation **701** to operation **707** to obtain a PWV. The processor **450** may input α, β, and the PWV into Equation 4 to obtain a second blood pressure to be provided to the user.

[0215] FIG. **13** is a flowchart **1300** illustrating a method of obtaining a correlation between a vascular characteristic value and a blood pressure correction value according to an embodiment of the disclosure.

[0216] Referring to FIG. **13**, in an embodiment of the disclosure, operations of FIG. **13** may be performed in a server (e.g., the server **108**). However, the disclosure is not limited thereto, and at least some of the operations of FIG. **13** may also be performed in the electronic device **401**.

[0217] In operation **1301**, in an embodiment of the disclosure, a server may obtain (e.g., receive) a PWV-and-P.sub.PWA pair and a reference blood pressure from each of multiple electronic devices (e.g., multiple electronic devices corresponding to multiple users, respectively) (hereinafter, they are referred to as “multiple electronic devices”).

[0218] In an embodiment of the disclosure, each of multiple electronic devices (hereinafter, these are referred to as “electronic devices”) may obtain a PWV-and-P.sub.PWA pair and a reference blood pressure (e.g., a blood pressure measured using a blood pressure monitor (e.g., a blood pressure monitor using a cuff)) (hereinafter, this is referred to as a “reference blood pressure”) by using a first wearable device (e.g., a smart watch) and a second wearable device (e.g., a smart ring) wirelessly connected to the electronic device. For example, the multiple electronic devices may include a first electronic device and a second electronic device. The first electronic device may perform operation **701** to operation **709** of FIG. **7** described above to obtain a first PWV-and-P.sub.PWA pair (e.g., multiple first PWV-and-P.sub.PWA pairs) and obtain a first reference blood pressure measured using a blood pressure monitor (e.g., a blood pressure measured using a blood pressure monitor within a designated time before/after a time point at which the first PWV-and-P.sub.PWA pair is obtained). The second electronic device may perform operation **701** to operation **709** of FIG. **7** described above to obtain a second PWV-and-P.sub.PWA pair (e.g., multiple second PWV-and-P.sub.PWA pairs) and obtain a second reference blood pressure measured using a blood pressure monitor (e.g., a blood pressure measured using a blood pressure monitor within a designated time before/after a time point at which the second PWV-and-P.sub.PWA pair is obtained).

[0219] In an embodiment of the disclosure, the server may receive a PWV-and-P.sub.PWA pair (e.g., the first PWV-and-P.sub.PWA pair and the second PWV-and-P.sub.PWA pair) and a reference blood pressure (e.g., the first reference blood pressure and the second reference blood pressure) from each of the multiple electronic devices through communication circuitry (e.g., communication circuitry of the server).

[0220] In operation **1303**, in an embodiment of the disclosure, the server may obtain a vascular characteristic value, based on the PWV-and-P.sub.PWA pairs and the reference blood pressures obtained from the multiple electronic devices.

[0221] In an embodiment of the disclosure, the server may perform, for each of the multiple electronic devices (or the multiple users), a regression analysis using PWV-and-P.sub.PWA pairs obtained from the electronic device, to calculate a correlation between PWV.sup.2 and P.sub.PWA (e.g., an equation representing a correlation between PWV.sup.2 and P.sub.PWA). The server may calculate, for each of the multiple electronic devices (or the multiple users), a vascular characteristic vascular (e.g., α and/or γ in Equation 6 and Equation 7) from the calculated correlation between PWV.sup.2 and P.sub.PWA.

[0222] For example, the server may perform, for the first electronic device (or a first user of the first electronic device), a regression analysis using multiple PWV-and-P.sub.PWA pairs obtained from the first electronic device, to calculate a first correlation between PWV.sup.2 and P.sub.PWA (e.g., an equation representing a correlation between PWV.sup.2 and P.sub.PWA). The server may calculate, for the first electronic device (or the first user), a vascular characteristic vascular (e.g., α and/or γ in Equation 6 and Equation 7), based on the first correlation. The server may perform, for the second electronic device (or a second user of the second electronic device), a regression analysis using multiple PWV-and-P.sub.PWA pairs obtained from the second electronic device, to calculate a second correlation between PWV.sup.2 and P.sub.PWA (e.g., an equation representing a correlation between PWV.sup.2 and P.sub.PWA). The server may calculate, for the second electronic device (or the second user), a vascular characteristic vascular (e.g., α and/or γ in Equation 6 and Equation 7), based on the second correlation.

[0223] In an embodiment of the disclosure, the server may calculate, for each of the multiple electronic devices (or the multiple users), a blood pressure correction value (e.g., P.sub.cal in Equation 7), based on P.sub.PWA and the reference blood pressure. For example, the server may subtract the first reference blood pressure from P.sub.PWA (e.g., P.sub.PWA received from the first electronic device) for the first electronic device to calculate a first blood pressure correction value. The server may subtract the second reference blood pressure from P.sub.PWA (e.g., P.sub.PWA received from the second electronic device) for the second electronic device to calculate a second blood pressure correction value.

[0224] In an embodiment of the disclosure, the server may calculate, for each of the multiple electronic devices (or the multiple users), a vascular characteristic value (e.g., β in Equation 7), based on a vascular characteristic value (e.g., γ in Equation 6 and Equation 7) and a blood pressure correction value (e.g., P.sub.cal in Equation 7). For example, the server may input a vascular characteristic value (e.g., γ in Equation 6 and Equation 7) and the first blood pressure correction value (P.sub.cal) into Equation 6 for the first electronic device, to calculate a vascular characteristic value (e.g., β in Equation 7). For example, the server may input a vascular characteristic value (e.g., γ in Equation 6 and Equation 7) and the second blood pressure correction value (P.sub.cal)

into Equation 6 for the second electronic device, to calculate a vascular characteristic value (e.g., p in Equation 7).
[0225] In operation **1305**, in an embodiment of the disclosure, the server may obtain a correlation between the vascular characteristic value and the blood pressure correction value, based on the vascular characteristic value and the blood pressure correction value.
[0226] In an embodiment of the disclosure, the server may perform operation **1303** to obtain multiple vascular characteristic values (e.g., multiple β values) and multiple blood pressure correction values (e.g., P.sub.cal values) corresponding to the multiple electronic devices, respectively. For example, the server may perform operation **1303** to obtain the first blood pressure correction value (P.sub.cal) and a vascular characteristic value (e.g., β in Equation 7) for the first electronic device. The server may perform operation **1303** to obtain the second blood pressure correction value (P.sub.cal) and a vascular characteristic value (e.g., β in Equation 7) for the second electronic device.
[0227] In an embodiment of the disclosure, the server may perform a regression analysis for multiple vascular characteristic values (e.g., multiple β values) and multiple blood pressure correction values (e.g., P.sub.cal values) to calculate a correlation (e.g., an equation or function representing the correlation) (e.g., P.sub.cal=f(β)) between a vascular characteristic value (p) and a blood pressure correction value (P.sub.cal).
[0228] In an embodiment of the disclosure, after the correlation between a vascular characteristic value (p) and a blood pressure correction value (P.sub.cal) is calculated, the server may transmit the calculated correlation between a vascular characteristic value (p) and a blood pressure correction value (P.sub.cal) to an electronic device (e.g., the electronic device **401**). The electronic device (e.g., the electronic device **401**) may receive the correlation between a vascular characteristic value (β) and a blood pressure correction value (P.sub.cal) through communication circuitry to obtain the correlation between a vascular characteristic value (β) and a blood pressure correction value (P.sub.cal). The electronic device may perform operations in FIG. **7** after the correlation between a vascular characteristic value (β) and a blood pressure correction value (P.sub.cal) is obtained.
[0229] FIG. **13** illustrates an example in which the server performs operation **1301** to operation **1305**, but the disclosure is not limited thereto. For example, the electronic device **401** may perform at least some of operation **1301** to operation **1305**.
[0230] An electronic device **401** according to an embodiment may include communication circuitry **410** and at least one processor **450**. The at least one processor **450** may be configured to receive a first PPG signal obtained by a first wearable device **501** from the first wearable device **501** via the communication circuitry **410** and receive a second PPG signal from a second wearable device **601** via the communication circuitry **410**. The first wearable device **501** may be worn on a first position of a user and the second wearable device **601** may be worn on a second position of the user. The at least one processor **450** may be configured to obtain a pulse transit time (PTT) during which a pulse wave is transferred from the first position to the second position, based on the first PPG signal and the second PPG signal. The at least one processor **450** may be configured to obtain a distance between the first wearable device **501** and the second wearable device **601**. The at least one processor **450** may be configured to obtain a pulse wave velocity (PWV) at which the pulse wave is transferred, based on the distance and the PTT. The at least one processor **450** may be configured to obtain a first blood pressure by using a pulse wave analysis (PWA) method, based on the first PPG signal and/or the second PPG signal. The at least one processor **450** may be configured to obtain a vascular characteristic value related to a characteristic of a blood vessel, based on the PWV and the first blood pressure. The at least one processor **450** may be configured to obtain a blood pressure correction value for correcting a second blood pressure to be obtained, based on the vascular characteristic value.
[0231] In an embodiment of the disclosure, the at least one processor **450** may be configured to transmit time information via the communication circuitry **410** so that the first wearable device **501**

and the second wearable device **601** are synchronized.

[0232] In an embodiment of the disclosure, the at least one processor **450** may be configured to obtain the PTT during which the pulse wave is transferred from the first position to the second position, based on times of mutually corresponding feature points in the first PPG signal and the second PPG signal.

[0233] In an embodiment of the disclosure, the electronic device **401** may further include a camera **430**. The at least one processor **450** may be configured to transmit, to the first wearable device **501** via the communication circuitry **410**, a signal causing the first wearable device **501** to display an object having a designated length. The at least one processor **450** may be configured to, while the first wearable device **501** displays the object, obtain an image for the first wearable device **501** and the second wearable device **601** via the camera **430**. The at least one processor **450** may be configured to obtain a first length of a part representing the object in the image, and a first distance between a part representing the first wearable device **501** and a part representing the second wearable device **601** in the image. The at least one processor **450** may be configured to obtain the distance between the first wearable device (**501**) and the second wearable device (**601**), based on the designated length of the object, the first length, and the first distance.

[0234] In an embodiment of the disclosure, the at least one processor **450** may be configured to obtain the distance between the first wearable device **501** and the second wearable device **601**, based on a transmission/reception time of an inaudible sound wave between the first wearable device **501** and the second wearable device **601** and a velocity of the inaudible sound wave.

[0235] In an embodiment of the disclosure, the at least one processor **450** may be configured to obtain, by using a PWV blood pressure model and a PWA blood pressure model, a first equation including PWV.sup.2, the first blood pressure, and a first vascular characteristic value and a second vascular characteristic value representing a correlation between PWV.sup.2 and the first blood pressure, and obtain a second equation representing a relation between the second vascular characteristic value, a third vascular characteristic value, and the blood pressure correction value.

[0236] In an embodiment of the disclosure, the at least one processor **450** may be configured to obtain multiple PWVs and multiple first blood pressures corresponding to the multiple PWVs during a designated period. The at least one processor **450** may be configured to obtain the first vascular characteristic value and the second vascular characteristic value, by using regression analysis, based on the multiple PWVs and the multiple first blood pressures.

[0237] In an embodiment of the disclosure, the at least one processor **450** may be configured to obtain the blood pressure correction value by using the second equation and a correlation between the third vascular characteristic value and the blood pressure correction value.

[0238] In an embodiment of the disclosure, the at least one processor **450** may be configured to, after obtaining the blood pressure correction value, obtain the second blood pressure by using a PWA method, based on a PPG signal obtained from the first wearable device **501** or the second wearable device **601**. The at least one processor **450** may be configured to obtain a third blood pressure by adding the blood pressure correction value to the obtained second blood pressure.

[0239] In an embodiment of the disclosure, the electronic device **401** may include a smartphone, the first wearable device **501** may include a smart watch, and the second wearable device **601** may include a smart ring.

[0240] A method of measuring a blood pressure by an electronic device **401** according to an embodiment may include receiving a first PPG signal obtained by a first wearable device **501** from the first wearable device **501** via communication circuitry **410** of the electronic device **401**, and receiving a second PPG signal from a second wearable device **601** via the communication circuitry **410**. The first wearable device **501** may be worn on a first position of a user and the second wearable device **601** may be worn on a second position of the user. The method may include obtaining a pulse transit time (PTT) during which a pulse wave is transferred from the first position to the second position, based on the first PPG signal and the second PPG signal. The method may include obtaining a distance between the first wearable device **501** and the second wearable device **601**. The method may include obtaining a pulse wave velocity (PWV) at which the pulse wave is transferred, based on the distance and the PTT. The method may include obtaining a first blood pressure by using a pulse wave analysis (PWA) method, based on the first PPG signal and/or the second PPG signal. The method may include obtaining a vascular characteristic value related to a characteristic of a blood vessel, based on the PWV and the first blood pressure. The method may include obtaining a blood pressure correction value for correcting a second blood pressure to be obtained, based on the vascular characteristic value.

[0241] In an embodiment of the disclosure, the method may further include transmitting time information via the communication circuitry **410** so that the first wearable device **501** and the second wearable device **601** are synchronized.

[0242] In an embodiment of the disclosure, the obtaining of the PTT may include obtaining the PTT during which the pulse wave is transferred from the first position to the second position, based on times of mutually corresponding feature points in the first PPG signal and the second PPG signal.

[0243] In an embodiment of the disclosure, the obtaining of the distance between the first wearable device **501** and the second wearable device **601** may include transmitting, to the first wearable device **501** via the communication circuitry **410**, a signal causing the first wearable device **501** to display an object having a designated length. In an embodiment of the disclosure, the obtaining of the distance between the first wearable device **501** and the second wearable device **601** may include, while the first wearable device **501** is displaying the object, obtaining an image for the first wearable device **501** and the second wearable device **601** via a camera **430** of the electronic device **401**. The obtaining of the distance between the first wearable device **501** and the second wearable device **601** may include obtaining a first length of a part representing the object in the image, and a first distance between a part representing the first wearable device **501** and a part representing the second wearable device **601** in the image. The obtaining of the distance between the first wearable device **501** and the second wearable device **601** may include obtaining the distance between the first wearable device **501** and the second wearable device **601**, based on the designated length of the object, the first length, and the first distance.

[0244] In an embodiment of the disclosure, the obtaining of the distance between the first wearable device **501** and the second wearable device **601** may include obtaining the distance between the first wearable device **501** and the second wearable device **601**, based on a transmission/reception time of an inaudible sound wave between the first wearable device **501** and the second wearable device **601** and a velocity of the inaudible sound wave.

[0245] In an embodiment of the disclosure, the obtaining of the vascular characteristic value related to the characteristic of the blood vessel, based on the PWV and the first blood pressure may include obtaining, by using a PWV blood pressure model and a PWA blood pressure model, a first equation including PWV.sup.2, the first blood pressure, and a first vascular characteristic value and a second vascular characteristic value representing a correlation between PWV.sup.2 and the first blood pressure, and obtaining a second equation representing a relation between the second vascular characteristic value, a third vascular characteristic value, and the blood pressure correction value.

[0246] In an embodiment of the disclosure, the obtaining of the vascular characteristic value related to the characteristic of the blood vessel, based on the PWV and the first blood pressure may include obtaining multiple PWVs and multiple first blood pressures corresponding to the multiple PWVs during a designated period. The obtaining of the vascular characteristic value related to the characteristic of the blood vessel, based on the PWV and the first blood pressure may include obtaining the first vascular characteristic value and the second vascular characteristic value, by using regression analysis, based on the multiple PWVs and the multiple first blood pressures.

[0247] In an embodiment of the disclosure, the obtaining of the blood pressure correction value may include obtaining the blood pressure correction value by using the second equation and a

correlation between the third vascular characteristic value and the blood pressure correction value.
[0248] In an embodiment of the disclosure, the method may further include, after obtaining the blood pressure correction value, obtaining the second blood pressure by using a PWA method, based on a PPG signal obtained from the first wearable device **501** or the second wearable device **601**. The method may further include obtaining a third blood pressure by adding the blood pressure correction value to the obtained second blood pressure.
[0249] In an embodiment of the disclosure, in a non-transitory computer-readable medium for recording computer-executable instructions, the computer-executable instructions may, when executed by at least one processor **450** of an electronic device **401**, cause the electronic device **401** to receive a first PPG signal obtained by a first wearable device **501** from the first wearable device **501** via communication circuitry **410** of the electronic device **401** and receive a second PPG signal from a second wearable device **601** via the communication circuitry **410**. The first wearable device **501** may be worn on a first position of a user and the second wearable device **601** may be worn on a second position of the user. The computer-executable instructions may, when executed by the at least one processor **450** of the electronic device **401**, cause the electronic device **401** to obtain a pulse transit time (PTT) during which a pulse wave is transferred from the first position to the second position, based on the first PPG signal and the second PPG signal. The computer-executable instructions may, when executed by the at least one processor **450** of the electronic device **401**, cause the electronic device **401** to obtain a distance between the first wearable device **501** and the second wearable device **601**. The computer-executable instructions may, when executed by the at least one processor **450** of the electronic device **401**, cause the electronic device **401** to obtain a pulse wave velocity (PWV) at which the pulse wave is transferred, based on the distance and the PTT. The computer-executable instructions may, when executed by the at least one processor **450** of the electronic device **401**, cause the electronic device **401** to obtain a first blood pressure by using a pulse wave analysis (PWA) method, based on the first PPG signal and/or the second PPG signal. The computer-executable instructions may, when executed by the at least one processor **450** of the electronic device **401**, cause the electronic device **401** to obtain a vascular characteristic value related to a characteristic of a blood vessel, based on the PWV and the first blood pressure. The computer-executable instructions may, when executed by the at least one processor **450** of the electronic device **401**, cause the electronic device **401** to obtain a blood pressure correction value for correcting a second blood pressure to be obtained, based on the vascular characteristic value.
[0250] In addition, a data structure used in an embodiment disclosed herein may be recorded on a computer-readable recording medium through various means. The computer-readable recording medium may include a storage medium, such as a magnetic storage medium (e.g., ROM, floppy disc, or hard disc) or optical reading medium (e.g., CD-ROM or DVD).
[0251] It will be appreciated that various embodiments of the disclosure according to the claims and description in the specification can be realized in the form of hardware, software or a combination of hardware and software.
[0252] Any such software may be stored in non-transitory computer readable storage media. The non-transitory computer readable storage media store one or more computer programs (software modules), the one or more computer programs include computer-executable instructions that, when executed by one or more processors of an electronic device, cause the electronic device to perform a method of the disclosure.
[0253] Any such software may be stored in the form of volatile or non-volatile storage, such as, for example, a storage device like read only memory (ROM), whether erasable or rewritable or not, or in the form of memory, such as, for example, random access memory (RAM), memory chips, device or integrated circuits or on an optically or magnetically readable medium, such as, for example, a compact disk (CD), digital versatile disc (DVD), magnetic disk or magnetic tape or the like. It will be appreciated that the storage devices and storage media are various embodiments of non-transitory machine-readable storage that are suitable for storing a computer program or

computer programs comprising instructions that, when executed, implement various embodiments of the disclosure. Accordingly, various embodiments provide a program comprising code for implementing apparatus or a method as claimed in any one of the claims of this specification and a non-transitory machine-readable storage storing such a program.
[0254] While the disclosure has been shown and described with reference to various embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the disclosure as defined by the appended claims and their equivalents.

Claims

1. An electronic device comprising: communication circuitry; and at least one processor, wherein the at least one processor is configured to: receive a first photoplethysmography (PPG) signal obtained by a first wearable device from the first wearable device via the communication circuitry, and receive a second PPG signal from a second wearable device via the communication circuitry, the first wearable device being worn on a first position of a user and the second wearable device being worn on a second position of the user, based on the first PPG signal and the second PPG signal, obtain a pulse transit time (PTT) during which a pulse wave is transferred from the first position to the second position, obtain a distance between the first wearable device and the second wearable device, based on the distance and the PTT, obtain a pulse wave velocity (PWV) at which the pulse wave is transferred, based on the first PPG signal and/or the second PPG signal, obtain a first blood pressure by using a pulse wave analysis (PWA) method, based on the PWV and the first blood pressure, obtain a vascular characteristic value related to a characteristic of a blood vessel, and based on the vascular characteristic value, obtain a blood pressure correction value for correcting a second blood pressure to be obtained.
2. The electronic device of claim 1, wherein the at least one processor is configured to transmit time information via the communication circuitry so that the first wearable device and the second wearable device are synchronized.
3. The electronic device of claim 1, wherein the at least one processor is configured to obtain the PTT during which the pulse wave is transferred from the first position to the second position, based on times of mutually corresponding feature points in the first PPG signal and the second PPG signal.
4. The electronic device of claim 1, further comprising: a camera, wherein the at least one processor is configured to: transmit, to the first wearable device via the communication circuitry, a signal causing the first wearable device to display an object having a designated length, while the first wearable device displays the object, obtain an image for the first wearable device and the second wearable device via the camera, obtain a first length of a part representing the object in the image, and a first distance between a part representing the first wearable device and a part representing the second wearable device in the image, and based on the designated length of the object, the first length, and the first distance, obtain the distance between the first wearable device and the second wearable device.
5. The electronic device of claim 1, wherein the at least one processor is configured to obtain the distance between the first wearable device and the second wearable device, based on a transmission/reception time of an inaudible sound wave between the first wearable device and the second wearable device and a velocity of the inaudible sound wave.
6. The electronic device of claim 1, wherein the at least one processor is configured to: obtain, by using a PWV blood pressure model and a PWA blood pressure model, a first equation including PWV.sup.2, the first blood pressure, and a first vascular characteristic value and a second vascular characteristic value representing a correlation between PWV.sup.2 and the first blood pressure, and obtain a second equation representing a relation between the second vascular characteristic value, a

third vascular characteristic value, and the blood pressure correction value.

7. The electronic device of claim 6, wherein the at least one processor is configured to: obtain, during a designated period, multiple PWVs and multiple first blood pressures corresponding to the multiple PWVs, and obtain the first vascular characteristic value and the second vascular characteristic value, by using regression analysis, based on the multiple PWVs and the multiple first blood pressures.

8. The electronic device of claim 7, wherein the at least one processor is configured to obtain the blood pressure correction value by using the second equation and a correlation between the third vascular characteristic value and the blood pressure correction value.

9. The electronic device of claim 8, wherein the at least one processor is configured to: after obtaining the blood pressure correction value, based on a PPG signal obtained from the first wearable device or the second wearable device, obtain the second blood pressure by using a PWA method, and obtain a third blood pressure by adding the blood pressure correction value to the obtained blood pressure.

10. The electronic device of claim 1, wherein the electronic device comprises a smartphone, wherein the first wearable device comprises a smart watch, and wherein the second wearable device comprises a smart ring.

11. A method of measuring a blood pressure by an electronic device, the method comprising: receiving a first photoplethysmography (PPG) signal obtained by a first wearable device from the first wearable device via communication circuitry of the electronic device, and receiving a second PPG signal from a second wearable device via the communication circuitry, the first wearable device being worn on a first position of a user and the second wearable device being worn on a second position of the user; based on the first PPG signal and the second PPG signal, obtaining a pulse transit time (PTT) during which a pulse wave is transferred from the first position to the second position; obtaining a distance between the first wearable device and the second wearable device; based on the distance and the PTT, obtaining a pulse wave velocity (PWV) at which the pulse wave is transferred; based on the first PPG signal and/or the second PPG signal, obtaining a first blood pressure by using a pulse wave analysis (PWA) method; based on the PWV and the first blood pressure, obtaining a vascular characteristic value related to a characteristic of a blood vessel; and based on the vascular characteristic value, obtaining a blood pressure correction value for correcting a second blood pressure to be obtained.

12. The method of claim 11, further comprising transmitting time information via the communication circuitry so that the first wearable device and the second wearable device are synchronized.

13. The method of claim 11, wherein the obtaining of the PTT comprises obtaining the PTT during which the pulse wave is transferred from the first position to the second position, based on times of mutually corresponding feature points in the first PPG signal and the second PPG signal.

14. The method of claim 11, wherein the obtaining of the distance between the first wearable device and the second wearable device comprises: transmitting, to the first wearable device via the communication circuitry, a signal causing the first wearable device to display an object having a designated length; while the first wearable device displays the object, obtaining an image for the first wearable device and the second wearable device via a camera of the electronic device; obtaining a first length of a part representing the object in the image, and a first distance between a part representing the first wearable device and a part representing the second wearable device in the image; and based on the designated length of the object, the first length, and the first distance, obtaining the distance between the first wearable device and the second wearable device.

15. The method of claim 11, wherein the obtaining of the distance between the first wearable device and the second wearable device comprises obtaining the distance between the first wearable device and the second wearable device, based on a transmission/reception time of an inaudible sound wave between the first wearable device and the second wearable device and a velocity of the inaudible sound wave.

16. The method of claim 11, wherein the obtaining of the vascular characteristic value related to the characteristic of the blood vessel, based on the PWV and the first blood pressure comprises: obtaining, by using a PWV blood pressure model and a PWA blood pressure model, a first equation including PWV.sup.2, the first blood pressure, and a first vascular characteristic value and a second vascular characteristic value representing a correlation between PWV.sup.2 and the first blood pressure; and obtaining a second equation representing a relation between the second vascular characteristic value, a third vascular characteristic value, and the blood pressure correction value.

17. The method of claim 16, wherein the obtaining of the vascular characteristic value related to the characteristic of the blood vessel, based on the PWV and the first blood pressure comprises: obtaining, during a designated period, multiple PWVs and multiple first blood pressures corresponding to the multiple PWVs; and obtaining the first vascular characteristic value and the second vascular characteristic value, by using regression analysis, based on the multiple PWVs and the multiple first blood pressures.

18. The method of claim 17, wherein the obtaining of the blood pressure correction value comprises obtaining the blood pressure correction value by using the second equation and a correlation between the third vascular characteristic value and the blood pressure correction value.

19. The method of claim 18, further comprising: after obtaining the blood pressure correction value, based on a PPG signal obtained from the first wearable device or the second wearable device, obtaining the second blood pressure by using a PWA method; and obtaining a third blood pressure by adding the blood pressure correction value to the obtained blood pressure.

20. A non-transitory computer-readable storage media storing computer-executable instructions that, when executed by one or more processors of an electronic device individually or collectively, cause the electronic device to perform operations, the operations comprising: receiving a first photoplethysmography (PPG) signal obtained by a first wearable device from the first wearable device via communication circuitry of the electronic device, and receive a second PPG signal from a second wearable device via the communication circuitry, the first wearable device being worn on a first position of a user and the second wearable device being worn on a second position of the user; based on the first PPG signal and the second PPG signal, obtaining a pulse transit time (PTT) during which a pulse wave is transferred from the first position to the second position; obtaining a distance between the first wearable device and the second wearable device; based on the distance and the PTT, obtaining a pulse wave velocity (PWV) at which the pulse wave is transferred; based on the first PPG signal and/or the second PPG signal, obtaining a first blood pressure by using a pulse wave analysis (PWA) method; based on the PWV and the first blood pressure, obtaining a vascular characteristic value related to a characteristic of a blood vessel; and based on the vascular characteristic value, obtaining a blood pressure correction value for correcting a second blood pressure to be obtained.