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(54) **BLOOD PRESSURE MEASURING APPARATUS BASED ON MULTIPROCESSING AND METHOD OF OPERATING THE SAME**

(71) Applicant: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(72) Inventors: **Jae Min KANG**, Seoul (KR); **Yong Joo KWON**, Yongin-si (KR); **Sun Kwon KIM**, Suwon-si (KR)

(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

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(57) **ABSTRACT**

A blood pressure measuring apparatus based on multiprocessing and a method of operating the same are provided. The blood pressure measuring apparatus based on multiprocessing includes: at least two multichannel pulse wave measurers including a plurality of pulse wave measuring sensors configured to measure pulse waves; and at least two processors, each processor of the at least two processors being configured to receive corresponding pulse waves among the measured pulse waves from a corresponding multichannel pulse wave measurer of the at least two multichannel pulse wave measurers, and analyze the corresponding pulse waves and extract feature points from the analyzed pulse waves, wherein the at least two processors comprise a master processor configured to measure a blood pressure based on the feature points extracted by each of the at least two processors.

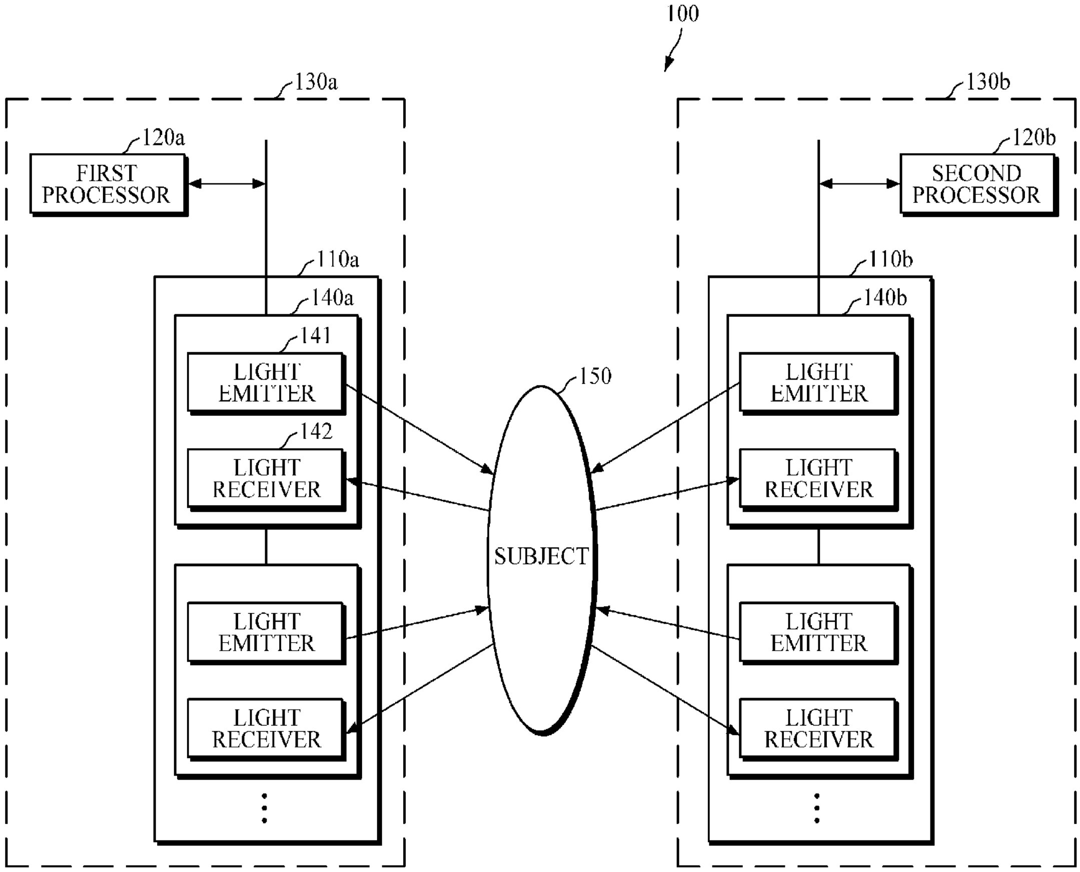


FIG. 1

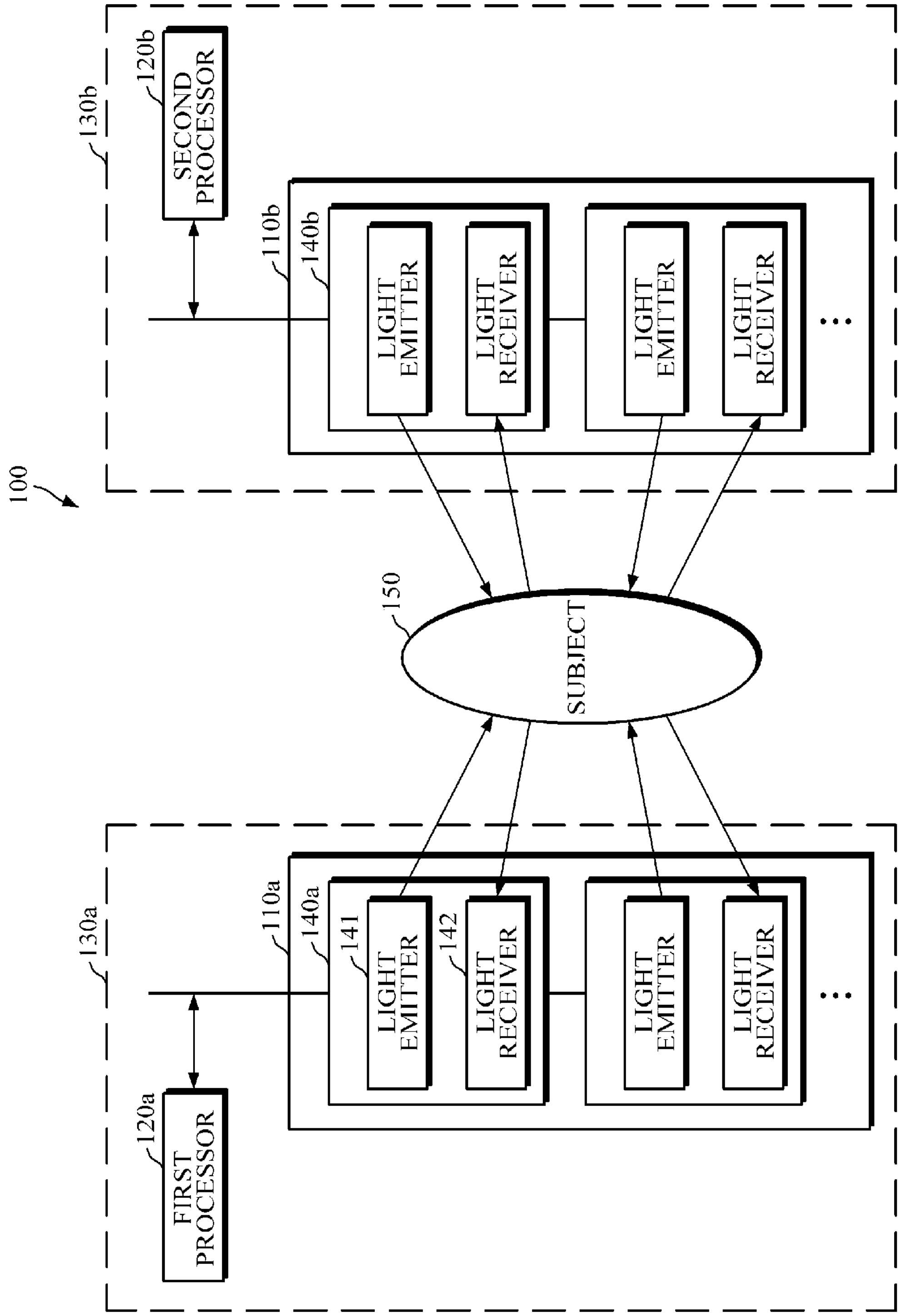

100
130b
120b
SECOND PROCESSOR
110b
140b
LIGHT EMITTER
LIGHT RECEIVER
LIGHT EMITTER
LIGHT RECEIVER
...
150
SUBJECT
130a
120a
FIRST PROCESSOR
110a
140a
141
LIGHT EMITTER
142
LIGHT RECEIVER
LIGHT EMITTER
LIGHT RECEIVER
...

FIG. 2A

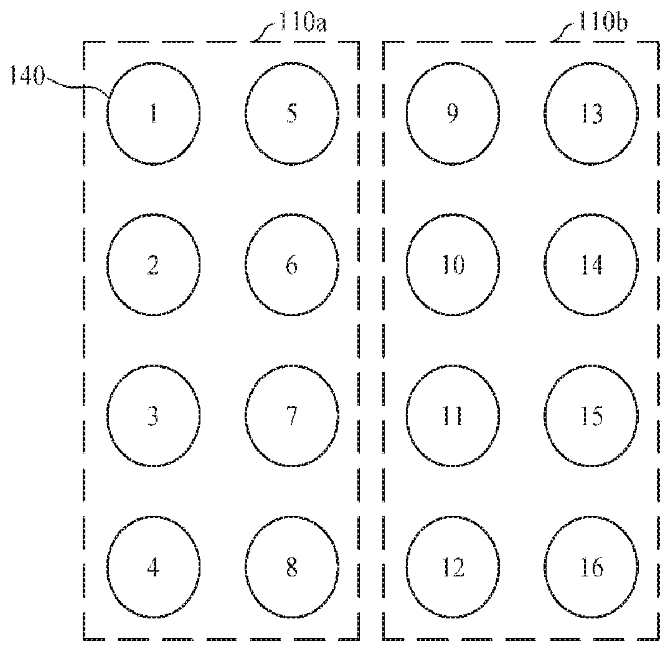


FIG. 2B

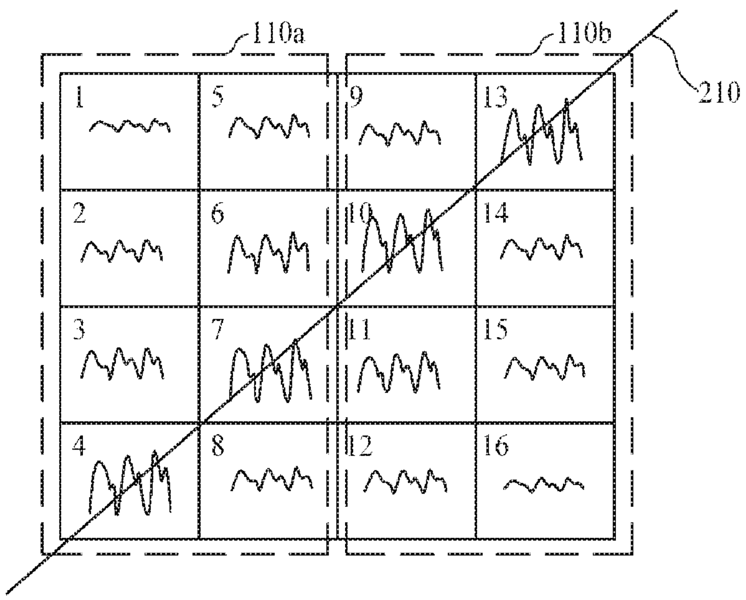


FIG. 3A

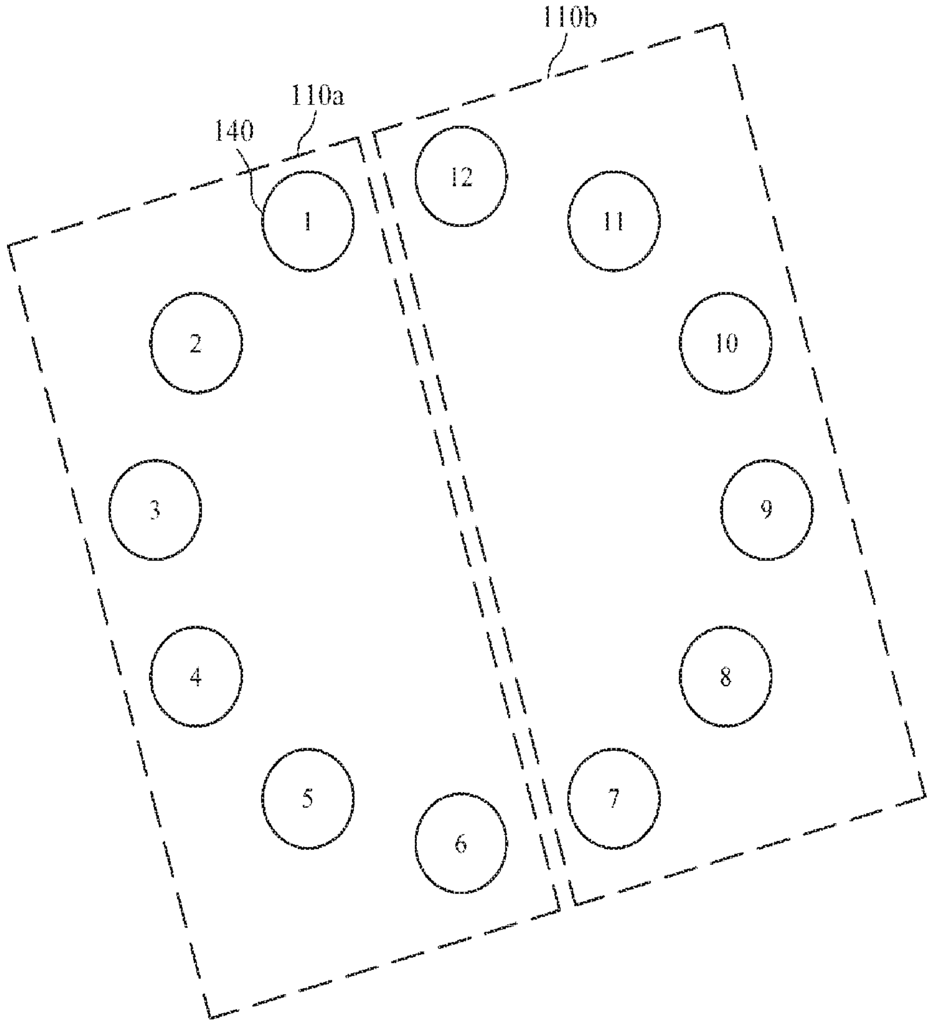


FIG. 3B

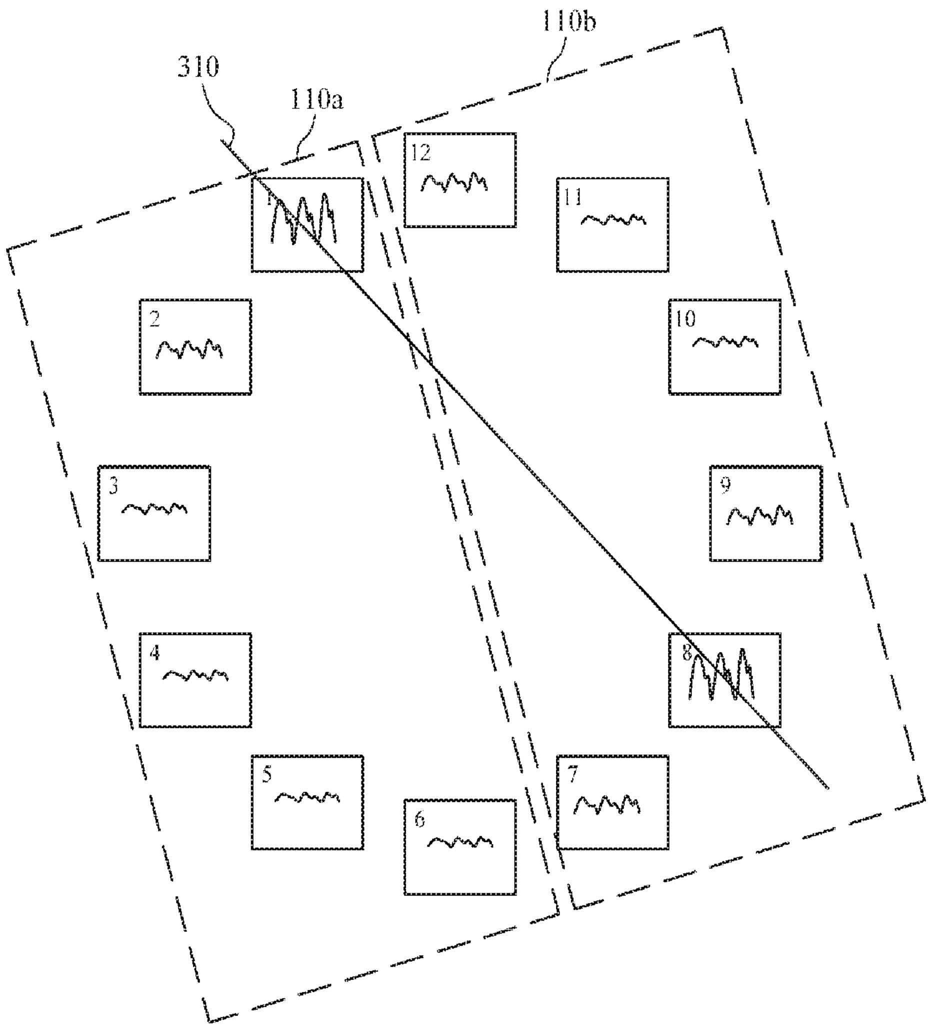


FIG. 4

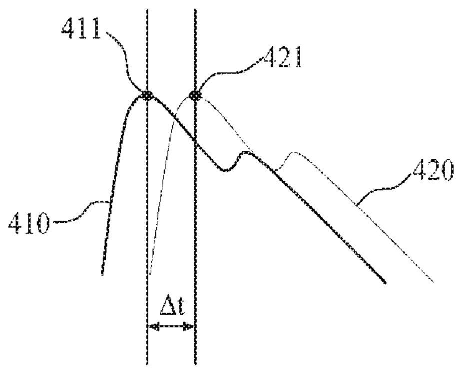


FIG. 5

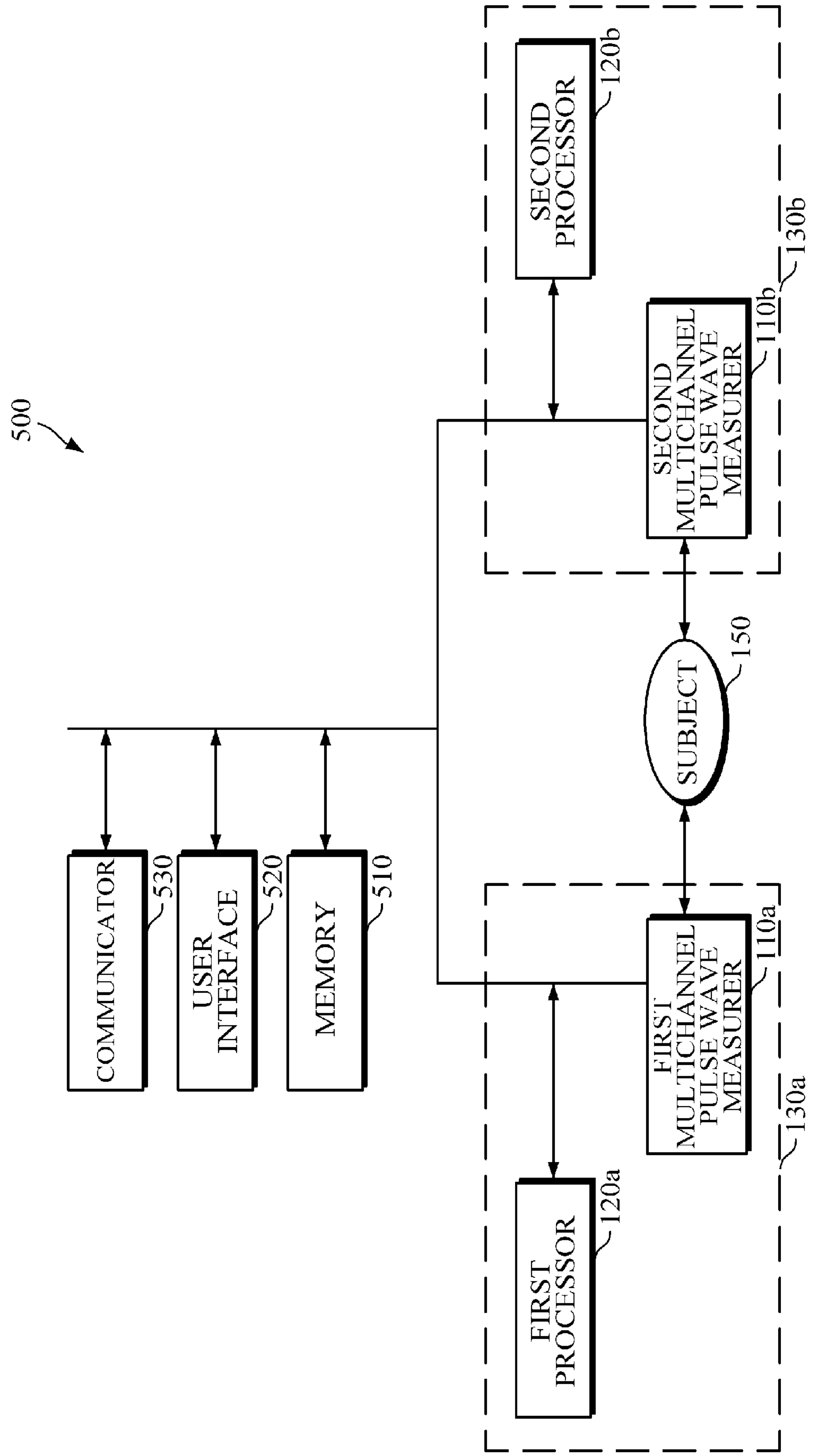
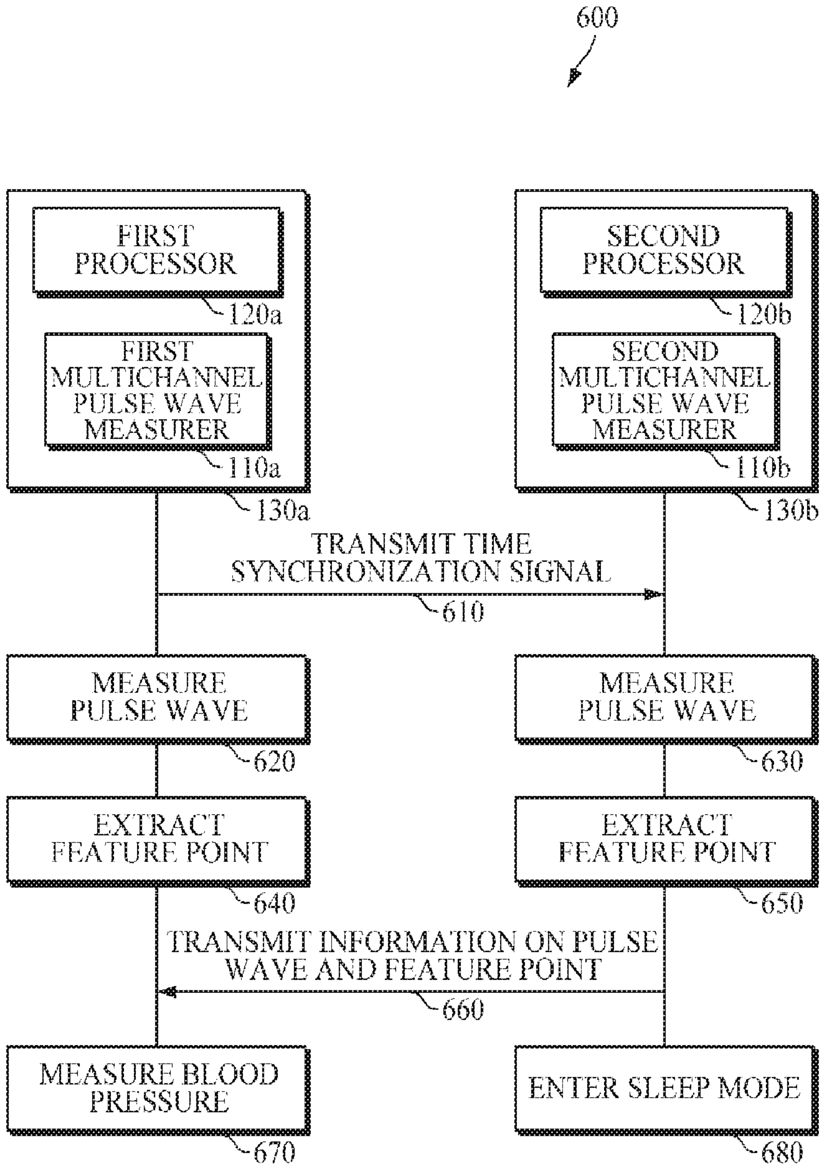

500
COMMUNICATOR
530
USER INTERFACE
520
MEMORY
510
SECOND PROCESSOR
120b
SECOND MULTICHANNEL PULSE WAVE MEASURER
110b
130b
SUBJECT
150
FIRST MULTICHANNEL PULSE WAVE MEASURER
110a
130a
FIRST PROCESSOR
120a

FIG. 6


600
FIRST PROCESSOR
120a
FIRST MULTICHANNEL PULSE WAVE MEASURER
110a
130a
SECOND PROCESSOR
120b
SECOND MULTICHANNEL PULSE WAVE MEASURER
110b
130b
TRANSMIT TIME SYNCHRONIZATION SIGNAL
610
MEASURE PULSE WAVE
620
MEASURE PULSE WAVE
630
EXTRACT FEATURE POINT
640
EXTRACT FEATURE POINT
650
TRANSMIT INFORMATION ON PULSE WAVE AND FEATURE POINT
660
MEASURE BLOOD PRESSURE
670
ENTER SLEEP MODE
680

BLOOD PRESSURE MEASURING APPARATUS BASED ON MULTIPROCESSING AND METHOD OF OPERATING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from Korean Patent Application No. 10-2015-0083616, filed on Jun. 12, 2015 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] 1. Field

[0003] Apparatuses and methods consistent with exemplary embodiments relate to a blood pressure measuring technology based on multiprocessing.

[0004] 2. Description of the Related Art

[0005] With a growing interest in personal health, various types of biometric information detection devices are being developed, and devices specifically designed for healthcare are being developed with the widespread use of various wearable devices that may be directly worn by subjects.

[0006] A cuff-less blood pressure sensor is a blood pressure sensor of an indirect measurement method, in which blood pressure is measured by a Pulse Transit Time (PTT) method using an optical signal and an electrocardiogram (ECG) signal, or by a Pulse Wave Analysis (PWA) method that analyzes pulse waves based on an optical signal.

[0007] However, the PTT method is cumbersome in that touches of both hands are required, and an ECG signal is further needed in addition to a pulse wave signal. The PWA method analyzes only a waveform of pulse waves, and thus blood pressure may not be measured accurately by the method.

SUMMARY

[0008] Exemplary embodiments address at least the above problems and/or disadvantages and other disadvantages not described above. Also, the exemplary embodiments are not required to overcome the disadvantages described above, and may not overcome any of the problems described above.

[0009] According to an aspect of an exemplary embodiment, there is provided a blood pressure measuring apparatus based on multiprocessing, the apparatus including: at least two multichannel pulse wave measurers including a plurality of pulse wave measuring sensors configured to measure pulse waves; and at least two processors, each processor of the at least two processors being configured to receive corresponding pulse waves among the measured pulse waves from a corresponding multichannel pulse wave measurer of the at least two multichannel pulse wave measurers, and analyze the corresponding pulse waves and extract feature points from the analyzed pulse waves, wherein the at least two processors comprise a master processor configured to measure a blood pressure based on the feature points extracted by each of the at least two processors.

[0010] The plurality of pulse wave measuring sensors may be arranged in a matrix or in a circle.

[0011] The plurality of pulse wave measuring sensors may measure the pulse waves by emitting light to a subject and by sensing light from the subject. The plurality of pulse wave measuring sensors may be further configured to emit light to a subject that reflects the light, and sense the light reflected from the subject and measure the pulse waves from the reflected light.

[0012] The master processor may determine a radial artery line, corresponding to a position of a radial artery of the subject, based on the pulse waves measured by the at least two multichannel pulse wave measurers, and measure the blood pressure based on a first feature point of a first pulse wave measured at a first point on the determined radial artery line and a second feature point of a second pulse wave measured a second point on the determined radial artery line.

[0013] The master processor may determine a pulse wave velocity between the first feature point and the second feature point, and measure the blood pressure based on the determined pulse wave velocity and a blood pressure estimation equation.

[0014] The master processor may determine a time difference between the first feature point and the second feature point, and determine the pulse wave velocity by dividing a distance between the first point and the second point by the determined time difference.

[0015] The at least two processors may further include a slave processor configured to transmit information on the corresponding pulse waves measured by the corresponding multichannel pulse wave measurer and information on the feature points extracted from the corresponding pulse waves to the master processor, and enter a sleep mode.

[0016] The master processor may generate a time synchronization signal to synchronize pulse wave measurement by each of the multichannel pulse wave measurers and pulse wave analysis by each of the processors, which are performed in parallel.

[0017] The blood pressure measuring apparatus based on multiprocessing may further include a user interface to output the measured blood pressure.

[0018] The blood pressure measuring apparatus based on multiprocessing may further include a communicator to transmit the measured blood pressure to an external device.

[0019] The blood pressure measuring apparatus based on multiprocessing may be configured to be wearable by the subject.

[0020] According to an aspect of another exemplary embodiment, there is provided a method of operating a multiprocessing-based blood pressure measuring apparatus including at least two multichannel pulse wave measurers that include a plurality of pulse wave measuring sensors, and at least two processors. The method includes: measuring first pulse waves by a first pulse wave measurer of the at least two multichannel pulse wave measurers; measuring second pulse waves by a second pulse wave measurer of the at least two multichannel pulse wave measures; analyzing the first pulse waves and extracting feature points from the first pulse waves by a first processor of the at least two processors; analyzing the second pulse waves and extracting feature points from the second pulse waves by a second processor of the at least two processors; and measuring, by the first processor, a blood pressure based on the feature points extracted by the first processor and the second processor, the first processor being operated as a master processor.

[0021] The plurality of pulse wave measuring sensors may be arranged in a matrix or in a circle.

[0022] The measuring the blood pressure may include: determining a radial artery line, corresponding to a position of a radial artery of a subject, based on the first pulse waves and the second pulse waves; and measuring the blood pressure based on a first feature point of pulse waves measured at a first point on the determined radial artery line and a second feature point of pulse waves measured a second point on the determined radial artery line.

[0023] The measuring the blood pressure may include: determining a pulse wave velocity between the first feature point and the second feature point; and measuring the blood pressure based on the determined pulse wave velocity and a blood pressure estimation equation.

[0024] The calculating the pulse wave velocity may include: determining a time difference between the first feature point and the second feature point; and determining the pulse wave velocity by dividing a distance between the first point and the second point by the determined time difference. The method may further include: transmitting information on the second pulse waves and information on the feature points extracted from the second pulse waves from the second processor to the first processor, the second processor being operated as a slave processor; and enabling the second processor to enter a sleep mode.

[0025] The method may further include: generating a time synchronization signal to synchronize pulse wave measurement by each of the multichannel pulse wave measurers and pulse wave analysis by each of the processors, which are performed in parallel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The above and/or other aspects will be more apparent by describing certain exemplary embodiments, with reference to the accompanying drawings, in which:

[0027] FIG. **1** is a block diagram illustrating an example of a blood pressure measuring apparatus based on multiprocessing;

[0028] FIG. **2**A is a diagram illustrating an example of an arrangement of pulse wave measuring sensors, and FIG. **2**B is a diagram illustrating an example of pulse waves measured by using the pulse wave measuring sensors illustrated in FIG. **2**A;

[0029] FIG. **3**A is a diagram illustrating another example of an arrangement of pulse wave measuring sensors, and FIG. **3**B is a diagram illustrating an example of pulse waves measured by using each of the pulse wave measuring sensors illustrated in FIG. **3**A;

[0030] FIG. **4** is a diagram explaining a principle of calculating a pulse wave velocity by using feature points;

[0031] FIG. **5** is a block diagram illustrating another example of a blood pressure measuring apparatus based on multiprocessing; and

[0032] FIG. **6** is a flowchart illustrating a method of operating a blood pressure measuring apparatus **100** based on multiprocessing.

DETAILED DESCRIPTION

[0033] Exemplary embodiments are described in greater detail below with reference to the accompanying drawings.

[0034] In the following description, like drawing reference numerals are used for like elements, even in different drawings. The matters defined in the description, such as detailed construction and elements, are provided to assist in a comprehensive understanding of the exemplary embodiments. However, it is apparent that the exemplary embodiments can be practiced without those specifically defined matters. Also, well-known functions or constructions are not described in detail since they would obscure the description with unnecessary detail.

[0035] FIG. **1** is a block diagram illustrating an example of a blood pressure measuring apparatus based on multiprocessing.

[0036] The blood pressure measuring apparatus **100** may measure blood pressure of a subject in a non-invasive manner. For example, the blood pressure measuring apparatus **100** is a cuff-less type blood pressure measuring apparatus, which measures blood pressure by emitting light to a subject (e.g., a body part of a user wearing the blood pressure measuring apparatus **100**), measuring pulse waves by sensing reflected or scattered light, and analyzing the measured pulse waves.

[0037] The blood pressure measuring apparatus **100** may be a wearable device to be worn on a subject. For example, the blood pressure measuring apparatus **100** may be a wristwatch type, a bracelet type, or a wristband type. However, the blood pressure measuring apparatus **100** is not limited thereto, and may be a ring type, a glasses type, a hairband type, and the like.

[0038] Referring to FIG. **1**, the blood pressure measuring apparatus **100** includes a first multichannel pulse wave measurer **110***a*, a second multichannel pulse wave measurer **110***b*, a first processor **120***a*, and a second processor **120***b*.

[0039] The first processor **120***a* may be configured as a master processor. Further, the first multichannel pulse wave measurer **110***a* and the first processor **120***a* may be interconnected with each other to form a first processing group **130***a*, and the second multichannel pulse wave measurer **110***b* and the second processor **120***b* may be interconnected with each other to form a second processing group **130***b*. When the first processor **120***a* operates as a master processor, the second processor **120***b* may operate as a slave processor.

[0040] Although the blood pressure measuring apparatus **100** is illustrated as including the two processing groups **130***a* and **130***b* in FIG. **1**, the blood pressure measuring apparatus **100** may include three or more processing groups according to use and performance of a system. That is, each of the multichannel pulse wave measurer **110** and the processor **120** may be increased to three or more in number.

[0041] The multichannel pulse wave measurers **110***a* and **110***b* may measure pulse waves at various points. To this end, the first multichannel pulse wave measurer **110***a* may include a plurality of pulse wave measuring sensors **140***a*, and the second multichannel pulse wave measurer **110***b* may include a plurality of pulse wave measuring sensors **140***b*.

[0042] Each of the pulse wave measuring sensors **140***a* and **140***b* may include a light emitter **141** and a light receiver **142**. The light emitter **141** may emit light on the subject **150**, and the light receiver **142** may detect light scattered or reflected from the subject **150**. The pulse wave measuring sensors **140***a* and **140***b* may acquire pulse waves from a detected optical signal.

[0043] That is, the first multichannel pulse wave measurer **110***a* may measure pulse waves at various points by using the plurality of pulse wave measuring sensors **140***a*, and the second multichannel pulse wave measurer **110***b* may measure pulse waves at various points by using the plurality of pulse wave measuring sensors **140***b*.

[0044] In one exemplary embodiment, a light emitting diode (LED) or a laser diode may be used as the light emitter **141**. A photo diode, a photo transistor (PTr), or a charge-couple device (CCD) may be used as the light receiver **142**.

[0045] The processors **120***a* and **120***b* may generate a driving signal to measure pulse waves by using the respective connected multichannel pulse wave measurers **110***a* and **110***b*. That is, the first processor **120***a* generates a driving signal to drive the first multichannel pulse wave measurer **110***a*, and the second processor **120***b* generates a driving signal to drive the second multichannel pulse wave measurer **110***b*.

[0046] However, the processors **120***a* and **120***b* are not limited thereto, and the first processor **120***a*, which is configured as a master processor, may generate both the driving signal to drive the first multichannel pulse wave measurer **110***a* and the driving signal to drive the second multichannel pulse wave measurer **110***b*.

[0047] The first multichannel pulse wave measurer **110***a* may measure pulse waves at various points by sequentially driving the pulse wave measuring sensors **140***a* according to the driving signal generated by the first processor **120***a*, and the second multichannel pulse wave measurer **110***b* may measure pulse waves by sequentially driving the pulse wave measuring sensors **140***b* according to the driving signal generated by the second processor **120***b*.

[0048] The processors **120***a* and **120***b* may analyze pulse waves measured by the respective connected multichannel pulse wave measurers **110***a* and **110***b*. That is, the first processor **120***a* analyzes pulse waves measured by the first multichannel pulse wave measurer **110***a*, and the second processor **120***b* analyzes pulse waves measured by the second multichannel pulse wave measurer **110***b*.

[0049] In one exemplary embodiment, the first processor **120***a* may extract feature points from each pulse wave measured by the pulse wave measuring sensors **140***a* of the first multichannel pulse wave measurer **110***a*. The second processor **120***b* may extract feature points from each pulse wave measured by the pulse wave measuring sensors **140***b* of the second multichannel pulse wave measurer **110***b*. The feature points may include a start point, a maximum point, a minimum point, and the like.

[0050] The first processor **120***a*, which is configured as a master processor, may receive pulse wave information and feature point information from the second processor **120***b*, and may measure blood pressure based on pulse waves measured by the first multichannel pulse wave measurer **110***a*, feature points extracted from the pulse waves, and pulse wave information and feature point information received from the second processor **120***b*.

[0051] The first processor **120***a* may determine a radial artery line, which corresponds to the position of a radial artery of the subject **150**, based on pulse waves measured by the first multichannel pulse wave measurer **110***a* and pulse wave information received from the second processor **120***b*. More specifically, when the multichannel pulse wave measurers **110***a* and **110***b* measure pulse waves, a signal-to-noise ratio of pulse waves measured by the pulse wave measuring sensors **140***a* and **140***b* may vary depending on a relative distance between locations of the pulse wave measuring sensors **140***a* and **140***b* and the radial artery of the subject **150**. For example, pulse waves measured by one pulse wave measuring sensor, which is located relatively closer to the radial artery among the plurality of pulse wave measuring sensors **140***a* and **140***b*, have a higher signal-to-noise ratio, and pulse waves measured by one pulse wave measuring sensor, which is located relatively farther from the radial artery among the plurality of pulse wave measuring sensors **140***a* and **140***b*, have many noise components, and thus have a lower signal-to-noise ratio. As described above, by analyzing a signal-to-noise ratio of measured pulse waves, at least two pulse wave measuring sensors which have a relatively higher signal-to-noise ratio may be selected from among the plurality of pulse wave measuring sensors **140***a* and **140***b*, so that a radial artery line may be determined by connecting location points of the two pulse wave measuring sensors.

[0052] The first processor **120***a*, configured as a master processor, may measure blood pressure by using feature points of pulse waves measured at two points on the determined radial artery line. For example, assuming that the first pulse wave is measured at a first point on the radial artery line, and the second pulse wave is measured at a second point on the radial artery line, the first processor **120***a* may calculate a pulse wave velocity by calculating a time difference Δt between a feature point of the first pulse wave and a feature point of the second pulse wave, and by dividing a distance between the first point and the second point, i.e., a distance between a pulse wave measuring sensor measuring the first pulse wave and a pulse wave measuring sensor measuring the second pulse wave, by the calculated time difference Δt.

[0053] The first processor **120***a* may calculate blood pressure by using the pulse wave velocity and a blood pressure estimation equation that defines a relationship between blood pressure and the pulse wave velocity, and the blood pressure estimation equation may be stored in a database or in an external memory.

[0054] The first processor **120***a*, configured as a master processor, may generate a time synchronization signal for time synchronization of pulse wave measurement and/or pulse wave analysis with the second processor **120***b*, and may transmit the generated time synchronization signal to the second processor **120***b*. Upon receiving the time synchronization signal, the second processor **120***b* is time-synchronized with the first processor **120***a*, so that the second processor **120***b* may measure and/or analyze pulse waves in parallel with the first processor **120***a*. Unlike the example illustrated in FIG. **2**, in the case where the blood pressure measuring apparatus **100** includes three processing groups **130**, i.e., in the case where each of the multichannel pulse wave measurer **110** and the processor **120** is increased to three or more in number, the master processor may transmit the time synchronization signal to processors other than the master processor.

[0055] After finishing measurement of pulse waves and extraction of feature points, the second processor **120***b*, which is not a master processor, may transmit information on the measured pulse waves and extracted feature points to the first processor **120***a* which is a master processor. Further, upon completing transmission of information to the first processor **120***a*, the second processor **120***b* may enter a sleep mode. The sleep mode is a power saving mode, in which a minimum power is supplied or the power supply is blocked such that processors stop operating. Unlike the example illustrated in FIG. **2**, in the case where the blood pressure measuring apparatus **100** includes three processing groups **130**, i.e., each of the multichannel pulse wave measurer **110** and the processor **120** is increased to three or more in number, processors other than the master processor may enter a sleep mode after completing transmission of information to the master processor.

[0056] The subject **150** is a subject of which blood pressure is to be measured, and may be a body part that may contact or may be adjacent to the pulse wave measuring sensors **140***a* and **140***b* of the blood pressure measuring apparatus **100**, or a body part of which pulse waves may be easily measured by using photoplethysmography (PPG). For example, the subject **150** may be an area on a wrist that is adjacent to the radial artery. In the case of measuring pulse waves on a position of the wrist over the radial artery, there may be relatively less external factors, such as the thickness of the skin tissue of the wrist, which may cause measurement errors. The radial artery is known to be a position where blood pressure may be measured more accurately than other arteries. However, the subject **150** is not limited thereto, and may be distal body portions, such as fingers and toes, which have a high density of blood vessels.

[0057] FIG. **2**A is a diagram illustrating an example of an arrangement of pulse wave measuring sensors, and FIG. **2**B is a diagram illustrating an example of pulse waves measured by using the pulse wave measuring sensors illustrated in FIG. **2**A.

[0058] Referring to FIGS. **1** and **2**A, 16 pulse wave measuring sensors **140** may be arranged in a 4×4 matrix, in which first to eighth pulse wave measuring sensors may be included in the first multichannel pulse wave measurer **110***a*, and a ninth to sixteenth pulse wave measuring sensors may be included in the second multichannel pulse wave measurer **110***b*. As described above, each of the pulse wave measuring sensors **140** includes a light emitter and a light receiver.

[0059] Each of the pulse wave measuring sensors **140** measures pulse waves by using its own light emitter and a light receiver. FIG. **2**B illustrates an exemplary embodiment of pulse waves measured by using each of the pulse wave measuring sensors illustrated in FIG. **2**A.

[0060] The first processor **120***a* analyzes first to eighth pulse waves measured by the first to eighth pulse wave measuring sensors, and extracts feature points thereof. The second processor **120***b* analyzes ninth to sixteenth pulse waves measured by the ninth to sixteenth pulse wave measuring sensors, and extracts feature points thereof.

[0061] The second processor **120***b* transmits information on the ninth to sixteenth pulse waves, and information on feature points extracted from the ninth to sixteenth pulse waves to the first processor **120***a* which is a master processor.

[0062] The first processor **120***a* may determine a radial artery line by analyzing a signal-to-noise ratio of each pulse wave based on the information on the first to sixteenth pulse waves. In the exemplary embodiment, a radial artery line is set as a line **210** determined by connecting location points of the fourth, seventh, tenth, and thirteenth pulse wave measuring sensors that measure pulse waves (fourth, seventh, tenth, and thirteenth pulse waves), which have a relatively higher signal-to-noise ratio.

[0063] The first processor **120***a* calculates blood pressure by using feature points of any two pulse waves (e.g., the fourth and thirteenth pulse waves) among the fourth, seventh, and thirteenth pulse waves.

[0064] In the case where the blood pressure measuring apparatus **100** includes four processing groups **130**, i.e., in the case where each of the multichannel pulse wave measurer **110** and the processor **120** is four in number, the first, second, fifth, and sixth pulse wave measuring sensors may be included in the first multichannel pulse wave measurer; the third, fourth, seventh, and eighth pulse wave measuring sensors may be included in the second multichannel pulse wave measurer; the ninth, tenth, thirteenth, and fourteenth pulse wave measuring sensors may be included in the third multichannel pulse wave measurers; and the eleventh, twelfth, fifteenth, and sixteenth pulse wave measuring sensors may be included in the fourth multichannel pulse wave measurer. In this case, pulse waves measured by the first multichannel pulse wave measurer may be analyzed by the first processor; pulse waves measured by the second multichannel pulse wave measurer may be analyzed by the second processor; pulse waves measured by the third multichannel pulse wave measurer may be analyzed by the third processor; and pulse waves measured by the fourth multichannel pulse wave measurer may be analyzed by the fourth processor.

[0065] FIG. **3**A is a diagram illustrating another example of an arrangement of pulse wave measuring sensors, and FIG. **3**B is a diagram illustrating an example of pulse waves measured by using each of the pulse wave measuring sensors illustrated in FIG. **3**A.

[0066] Referring to FIGS. **1** and **3**A, 12 pulse wave measuring sensors **140** may be arranged in a circle, in which first to sixth pulse wave measuring sensors may be included in the first multichannel pulse wave measurer **110***a*, and seventh to twelfth pulse wave measuring sensors may be included in the second multichannel pulse wave measurer **110***b*. As described above, each of the pulse wave measuring sensors **140** includes a light emitter and a light receiver.

[0067] Each of the pulse wave measuring sensors **140** measures pulse waves by using its own light emitter and light receiver. FIG. **3**B illustrates an exemplary embodiment of pulse waves measured by using each of the pulse wave measuring sensors illustrated in FIG. **3**A.

[0068] The first processor **120***a* analyzes first to sixth pulse waves measuring by the first to sixth pulse wave measuring sensors, and extracts feature points thereof. The second processor **120***b* analyzes seventh to twelfth pulse waves measured by the seventh to twelfth pulse wave measuring sensors, and extracts feature points thereof.

[0069] The second processor **120***b* transmits information on the seventh to twelfth pulse waves, and information on feature points extracted from the seventh to twelfth pulse waves to the first processor **120***a* which is a master processor.

[0070] The first processor **120***a* may form a radial artery line by analyzing a signal-to-noise ratio of each pulse wave based on the information on the first to twelfth pulse waves. In the exemplary embodiment, a radial artery line is set as a line **310** determined by connecting location points of the first and eighth pulse wave measuring sensors that measure pulse waves (first and eighth pulse waves), which have a relatively higher signal-to-noise ratio.

[0071] The first processor **120***a* calculates blood pressure by using feature points of the first and eighth pulse waves.

[0072] FIG. **4** is a diagram explaining a principle of calculating a pulse wave velocity by using feature points.

[0073] Pulse wave velocity refers to the velocity of pulse waves flowing through blood vessels, and may be calculated by extracting feature points **411** and **421** from pulse waves **410** and **420** measured at two points, by calculating a time difference Δt between the extracted feature points **411** and **421**, and then by dividing a distance between measured points of the pulse waves **410** and **420**, i.e., a distance between pulse wave measuring sensors that measure the pulse waves **410** and **420**, by the calculated time difference Δt.

[0074] Since pulse wave velocity is increased when blood vessel elasticity is reduced, the pulse wave velocity may be a measure of change in blood vessel elasticity and blood pressure, and may be used to find a correlation between the pulse wave velocity and blood pressure values.

[0075] FIG. **5** is a block diagram illustrating another example of a blood pressure measuring apparatus based on multiprocessing.

[0076] Referring to FIG. **5**, when compared to the blood pressure measuring apparatus **100**, the blood pressure measuring apparatus **500** may further include a memory **510**, a user interface **520**, and a communicator **530** selectively.

[0077] The memory **510** may store programs to process and control the processors **120***a* and **120***b*, and may store input/output data. For example, the memory **510** may store programs for pulse wave analysis and blood pressure calculation performed by the processors **120***a* and **120***b*, and/or information on a blood pressure estimation equation. Further, the memory **510** may store pulse wave measurement results of the multichannel pulse wave measurer **110***a* and **110***b*. The processors **120***a* and **120***b* may read the pulse wave measurement results from the memory **510** and process the results.

[0078] The memory **510** may include at least one storage medium among flash memory type, hard disk type, multimedia card micro type, card type memory (e.g., SD or XD memory, etc.), random access memory (RAM), static random access memory (SRAM), read-only memory (ROM), electrically erasable programmable read only memory (EEPROM), programmable read only memory (PROM), magnetic memory, magnetic disks, optical discs, and the like.

[0079] The user interface **520** is an interface between the blood pressure measuring apparatus **500** and a user, and/or an interface between the blood pressure measuring apparatus **500** and other external device, and may include an input and an output. The user may be a subject of which blood pressure is to be measured, i.e., the subject **150**, but may be a concept wider than the subject **150**.

[0080] Information for operating the blood pressure measuring apparatus **500** is input through the user interface **520**, and measurement results of blood pressure may be output through the user interface **520**. The user interface **520** may include, for example, a button, a connector, a keypad, a display, and the like, and may further include a sound output component or a vibration motor.

[0081] The communicator **530** may communicate with external devices. For example, the communicator **530** may transmit measurement results of blood pressure to an external device, or may receive various types of information useful for measuring blood pressure from an external device.

[0082] The external device may be medical equipment using information on the measured blood pressure, a printer to print out results, or a display to display information on the measured blood pressure. In addition, the external device may be a smartphone, a mobile phone, a personal digital assistant (PDA) device, a laptop computer, a personal computer (PC), and other mobile or non-mobile computing devices.

[0083] The communicator **530** may communicate with external devices by using Bluetooth communication, Bluetooth Low Energy (BLE) communication, Near Field Communication (NFC), WLAN communication, Zigbee communication, Infrared Data Association (IrDA) communication, Wi-Fi Direct (WFD) communication, Ultra Wideband (UWB) communication, Ant+communication, Wi-Fi communication, Radio Frequency Identification (RFID) communication, and the like. However, the communicator **530** is merely illustrative, and is not limited thereto.

[0084] Further, depending on the use and performance of a system, each of the processing groups **130***a* and **130***b* may include a local memory and a local communicator.

[0085] FIG. **6** is a flowchart illustrating a method of operating a blood pressure measuring apparatus **100** based on multiprocessing. The first processing group **130***a* includes the first multichannel pulse wave measurer **110***a* and the first processor **120***a*, and the second processing group **130***a* includes the second processor **120***b*. Further, it is assumed that the first processor **120***a* is configured as a master processor.

[0086] Referring to FIGS. **1** and **6**, the first processor **120***a* generates a time synchronization signal for time synchronization of pulse wave measurement and/or pulse wave analysis with the second processor **120***b*, and transmits the generated time synchronization signal to the second processor **120***b* in operation **610**.

[0087] According to a driving signal from the first processor **120***a*, the first multichannel pulse wave measurer **110***a* measures pulse waves at various points by sequentially driving a plurality of pulse wave measuring sensors **140***a* in operation **620**. Further, according to a driving signal from the second processor **120***b*, the second multichannel pulse wave measurer **110***b* measures pulse waves at various points by sequentially driving a plurality of pulse wave measuring sensors **140***b* in operation **630**. In this case, the pulse waves measured by the first multichannel pulse wave measurer **110***a* in operation **620** and the pulse waves measured by the second multichannel pulse wave measurer **110***b* in operation **630** may be time-synchronized according to the time synchronization signal, and thus may be performed in parallel.

[0088] The pulse wave measuring sensors included in the first multichannel pulse wave measurer **110***a* and the second multichannel pulse wave measurer **120***a* may be arranged in a matrix or in a circle.

[0089] The first processor **120***a* analyzes the pulse waves measured by the first multichannel pulse wave measurer **110***a*, which is connected with the first processor **120***a*, and extracts feature points from each of the pulse waves in operation **640**. Further, the second processor **120***b* analyzes the pulse waves measured by the second multichannel pulse wave measurer **110***b*, which is connected with the second processor **120***b*, and extracts feature points from each of the pulse waves in operation **650**. In this case, the pulse waves analyzed by the first processor **120***a* in operation **640** and the pulse waves analyzed by the second processor **120***b* in operation **650** may be time-synchronized according to the time synchronization signal, and thus may be performed in parallel.

[0090] The second processor **120***b* transmits information on pulse waves measured by the second multichannel pulse wave measurer **110***b* and information on feature points extracted from each pulse wave to the first processor **120***a* in operation **660**.

[0091] The first processor **120***a* calculates blood pressure based on pulse waves measured by the first multichannel pulse wave measurer **110***a*, feature points extracted from the pulse waves, and pulse wave information and feature point information received from the second processor **120***b* in operation **670**.

[0092] In one exemplary embodiment, the first processor **120***a* determines a radial artery line, corresponding to the location of the radial artery of the subject **150**, based on pulse waves measured by the first multichannel pulse wave measurer **110***a* and pulse wave information received from the second processor **120***b*, and may calculate blood pressure by using feature points of pulse waves measured at two points on the determined radial artery line. For example, the first processor **120***a* may calculate a pulse wave velocity based on feature points of pulse waves measured at two points on the radial artery line, and may calculate blood pressure by using the calculated pulse wave velocity and a blood pressure estimation equation. The blood pressure estimation equation may be stored in a database or in an external memory.

[0093] The first processor **120***a* may calculate a pulse wave velocity by calculating a time difference Δt between feature points of pulse waves measured at two points, and by dividing a distance between the two points by the calculated time difference Δt.

[0094] Upon completing transmission of pulse wave information and feature point information in operation **660**, the second processor **120***b*, which is not a master processor, enters a sleep mode in operation **680**.

[0095] While not restricted thereto, an exemplary embodiment can be realized as a computer-readable code that is stored on a computer-readable recording medium and executed by a computer, a processor, integrated circuit, etc. Codes and code segments needed for realizing the present disclosure can be easily deduced by computer programmers of ordinary skill in the art. The computer-readable recording medium may be any type of recording device in which data is stored in a computer-readable manner. Examples of the computer-readable recording medium include a read-only memory (ROM), a random-access memory (RAM), a CD-ROM, a magnetic tape, a floppy disc, an optical disk, and the like. Further, the computer-readable recording medium can be distributed over a plurality of computer systems connected to a network so that a computer-readable recording medium is written thereto and executed therefrom in a decentralized manner. Also, an exemplary embodiment may be written as a computer program transmitted over a computer-readable transmission medium, such as a carrier wave, and received and implemented in general-use or special-purpose digital computers that execute the programs. Moreover, it is understood that in exemplary embodiments, one or more units of the above-described apparatuses and devices can include circuitry, a processor, a microprocessor, etc., and may execute a computer program stored in a computer-readable medium.

[0096] The foregoing exemplary embodiments are merely exemplary and are not to be construed as limiting. The present teaching can be readily applied to other types of apparatuses. Also, the description of the exemplary embodiments is intended to be illustrative, and not to limit the scope of the claims, and many alternatives, modifications, and variations will be apparent to those skilled in the art.

What is claimed is:

1. A blood pressure measuring apparatus based on multiprocessing, the apparatus comprising:

at least two multichannel pulse wave measurers including a plurality of pulse wave measuring sensors configured to measure pulse waves; and

at least two processors, each processor of the at least two processors being configured to receive corresponding pulse waves among the measured pulse waves from a corresponding multichannel pulse wave measurer of the at least two multichannel pulse wave measurers, and analyze the corresponding pulse waves and extract feature points from the analyzed pulse waves,

wherein the at least two processors comprise a master processor configured to measure a blood pressure based on the feature points extracted by each of the at least two processors.

2. The apparatus of claim **1**, wherein the plurality of pulse wave measuring sensors are arranged in a matrix or in a circle.

3. The apparatus of claim **1**, wherein the plurality of pulse wave measuring sensors are further configured to emit light to a subject that reflects the light, sense the light reflected from the subject and measure the pulse waves from the reflected light.

4. The apparatus of claim **1**, wherein the master processor is further configured to determine a radial artery line, corresponding to a position of a radial artery of the subject, based on the pulse waves measured by the at least two multichannel pulse wave measurers, and measure the blood pressure based on a first feature point of a first pulse wave measured at a first point on the determined radial artery line and a second feature point of a second pulse wave measured a second point on the determined radial artery line.

5. The apparatus of claim **4**, wherein the master processor is further configured to determine a pulse wave velocity between the first feature point and the second feature point, and measure the blood pressure based on the determined pulse wave velocity and a blood pressure estimation equation.

6. The apparatus of claim **5**, wherein the master processor is further configured to determine a time difference between the first feature point and the second feature point, and determine the pulse wave velocity by dividing a distance between the first point and the second point by the determined time difference.

7. The apparatus of claim **1**, wherein the at least two processors further comprise a slave processor configured to transmit information on the corresponding pulse waves measured by the corresponding multichannel pulse wave measurer and information on the feature points extracted from the corresponding pulse waves to the master processor, and enter a sleep mode.

8. The apparatus of claim **1**, wherein the master processor is further configured to generate a time synchronization signal to synchronize pulse wave measurement by each of the multichannel pulse wave measurers and pulse wave analysis by each of the processors, which are performed in parallel.

9. The apparatus of claim **1**, further comprising a user interface to output the measured blood pressure.

10. The apparatus of claim **1**, further comprising a communicator to transmit the measured blood pressure to an external device.

11. The apparatus of claim **1**, wherein the blood pressure measuring apparatus based on multiprocessing is configured to be wearable by the subject.

12. A method of operating a multiprocessing-based blood pressure measuring apparatus comprising at least two multichannel pulse wave measurers that include a plurality of pulse wave measuring sensors, and at least two processors, the method comprising:

measuring first pulse waves by a first pulse wave measurer of the at least two multichannel pulse wave measurers;

measuring second pulse waves by a second pulse wave measurer of the at least two multichannel pulse wave measures;

analyzing the first pulse waves and extracting feature points from the first pulse waves by a first processor of the at least two processors;

analyzing the second pulse waves and extracting feature points from the second pulse waves by a second processor of the at least two processors; and

measuring, by the first processor, a blood pressure based on the feature points extracted by the first processor and the second processor, the first processor being operated as a master processor.

13. The method of claim **12**, wherein the plurality of pulse wave measuring sensors are arranged in a matrix or in a circle.

14. The method of claim **12**, wherein the measuring the blood pressure comprises:

determining a radial artery line, corresponding to a position of a radial artery of a subject, based on the first pulse waves and the second pulse waves; and

measuring the blood pressure based on a first feature point of pulse waves measured at a first point on the determined radial artery line and a second feature point of pulse waves measured a second point on the determined radial artery line.

15. The method of claim **14**, wherein the measuring the blood pressure comprises:

determining a pulse wave velocity between the first feature point and the second feature point; and

measuring the blood pressure based on the determined pulse wave velocity and a blood pressure estimation equation.

16. The method of claim **15**, wherein the determining the pulse wave velocity comprises:

determining a time difference between the first feature point and the second feature point; and

determining the pulse wave velocity by dividing a distance between the first point and the second point by the determined time difference.

17. The method of claim **12**, further comprising:

transmitting information on the second pulse waves and information on the feature points extracted from the second pulse waves from the second processor to the first processor, the second processor being operated as a slave processor; and

enabling the second processor to enter a sleep mode.

18. The method of claim **12**, wherein further comprising generating a time synchronization signal to synchronize pulse wave measurement by each of the multichannel pulse wave measurers and pulse wave analysis by each of the processors, which are performed in parallel.

* * * * *

专利名称(译)	基于多处理的血压测量装置及其操作方法		
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[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD.		
[标]发明人	KANG JAE MIN KWON YONG JOO KIM SUN KWON		
发明人	KANG, JAE MIN KWON, YONG JOO KIM, SUN KWON		
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摘要(译)

提供了一种基于多处理的血压测量装置及其操作方法。基于多处理的血压测量装置包括：至少两个多通道脉搏波测量器，包括多个脉冲波测量传感器，用于测量脉搏波;至少两个处理器，所述至少两个处理器中的每个处理器被配置为接收来自所述至少两个多通道脉搏波测量器的相应多通道脉冲波测量器的测量脉冲波中的相应脉冲波，并分析相应的脉冲波和从所分析的脉冲波中提取特征点，其中所述至少两个处理器包括主处理器，所述主处理器被配置为基于由所述至少两个处理器中的每一个提取的特征点来测量血压。