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(54) **DETECTION OF FOOT EDEMA THROUGH IN-SHOE PRESSURE SENSORS**

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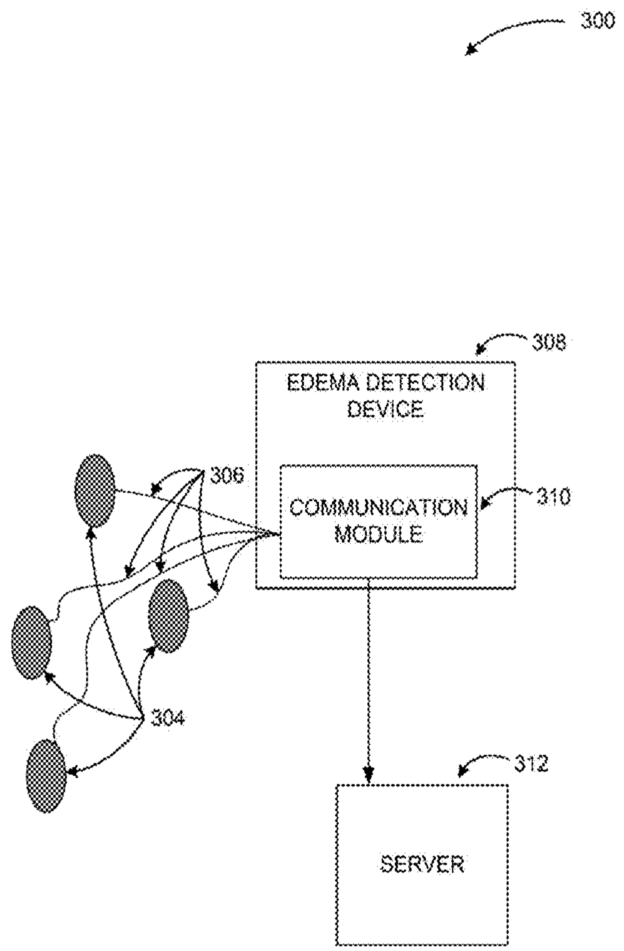
(57) **ABSTRACT**

Technologies are generally described for detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values. Multiple pressure sensors may be employed in contact with a foot. The pressure sensors may detect pressure generated on a surface of the foot by fluid accumulation within cells of the foot. A change in pressure may be monitored by analyzing pressure values received from the pressure sensors. In some embodiments, a pressure rebound curve may be determined while monitoring the change in the pressure. A comparison between a newly acquired pressure rebound curve and an established-normal pressure rebound curve corresponding to a healthy foot may be made. If the pressure rebound curve is determined to indicate a slower change (rebound) in detected pressure than a change in pressure indicated by the normal pressure rebound curve, the presence of foot edema may be inferred.



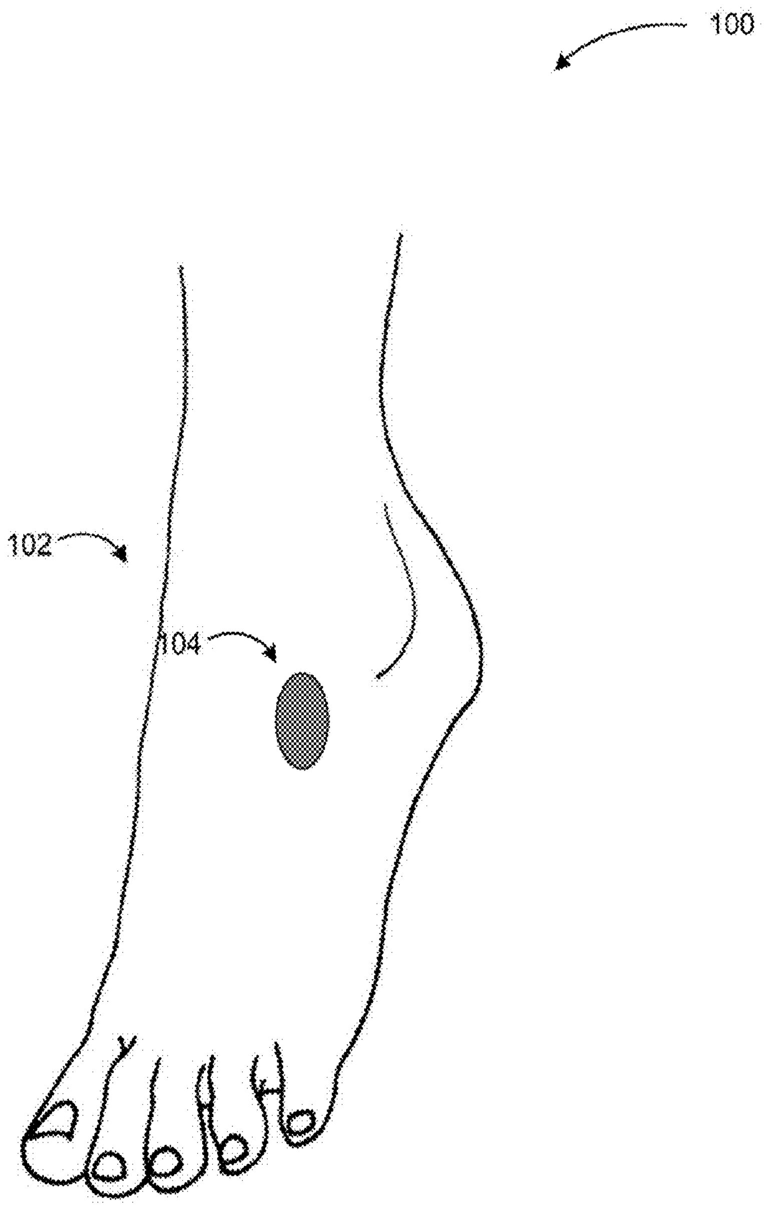


FIG. 1

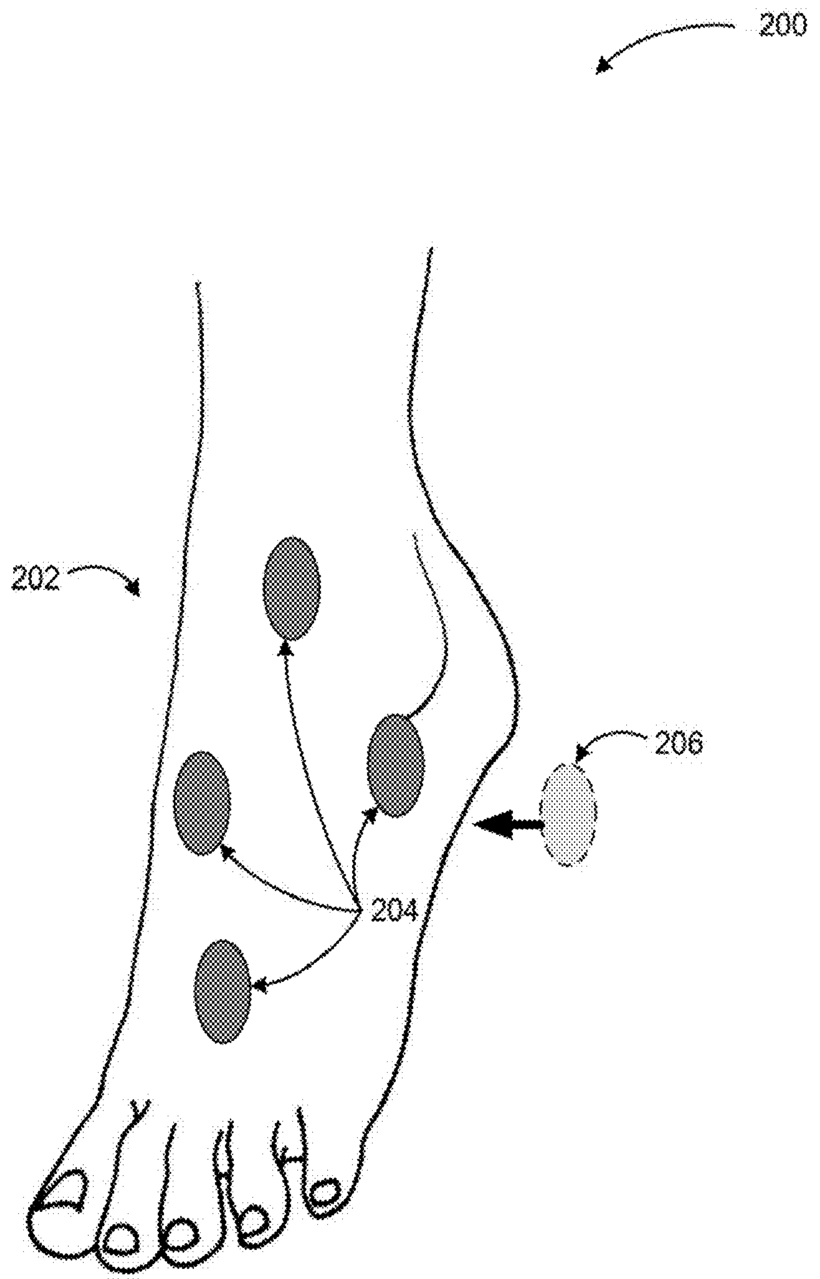


FIG. 2

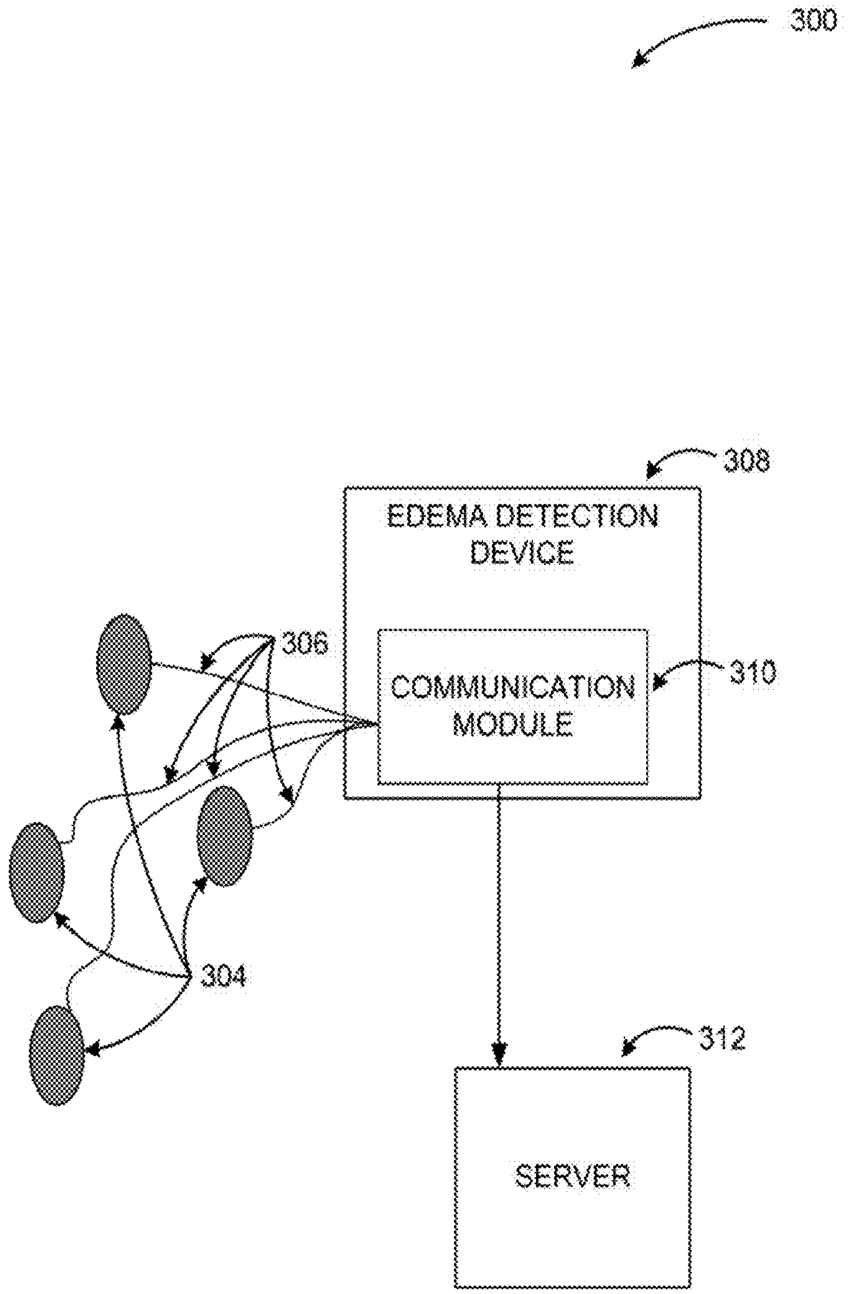

300
308
EDEMA DETECTION DEVICE
306
COMMUNICATION MODULE
310
304
312
SERVER

FIG. 3

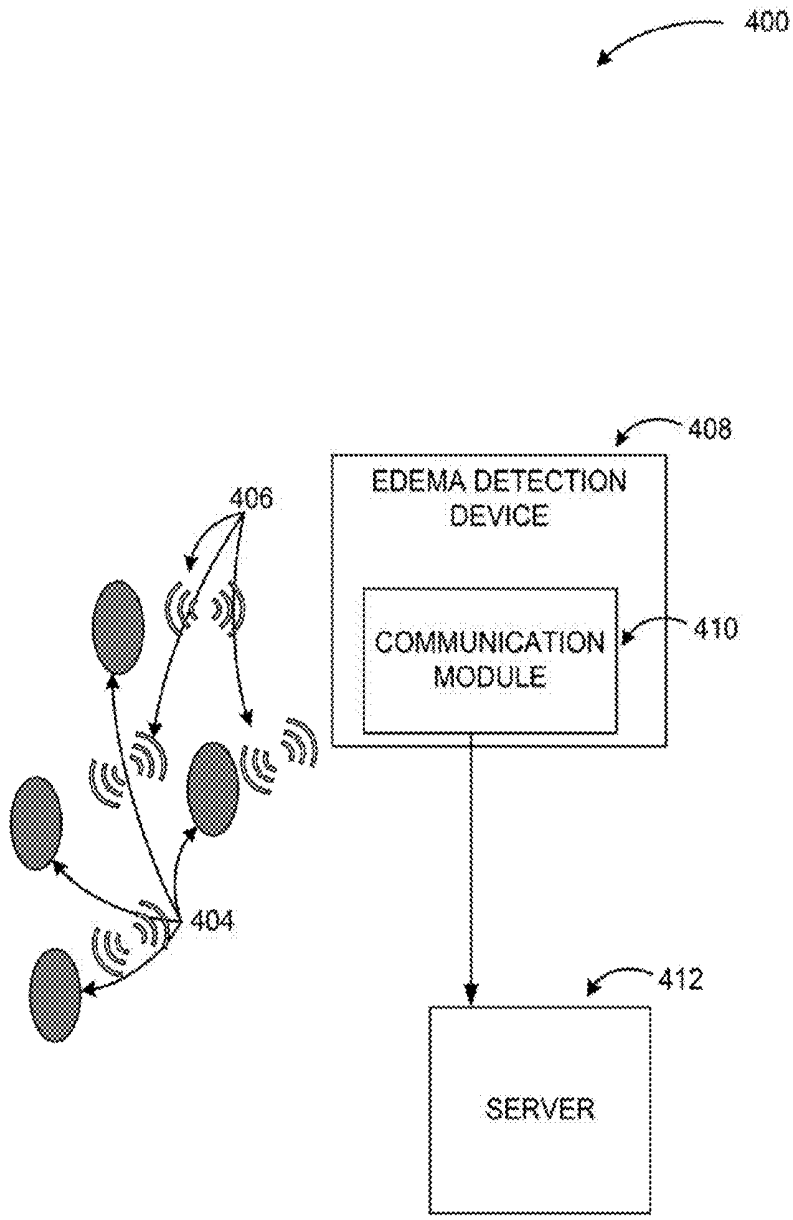

400
408
EDEMA DETECTION DEVICE
406
COMMUNICATION MODULE
410
404
412
SERVER

FIG. 4

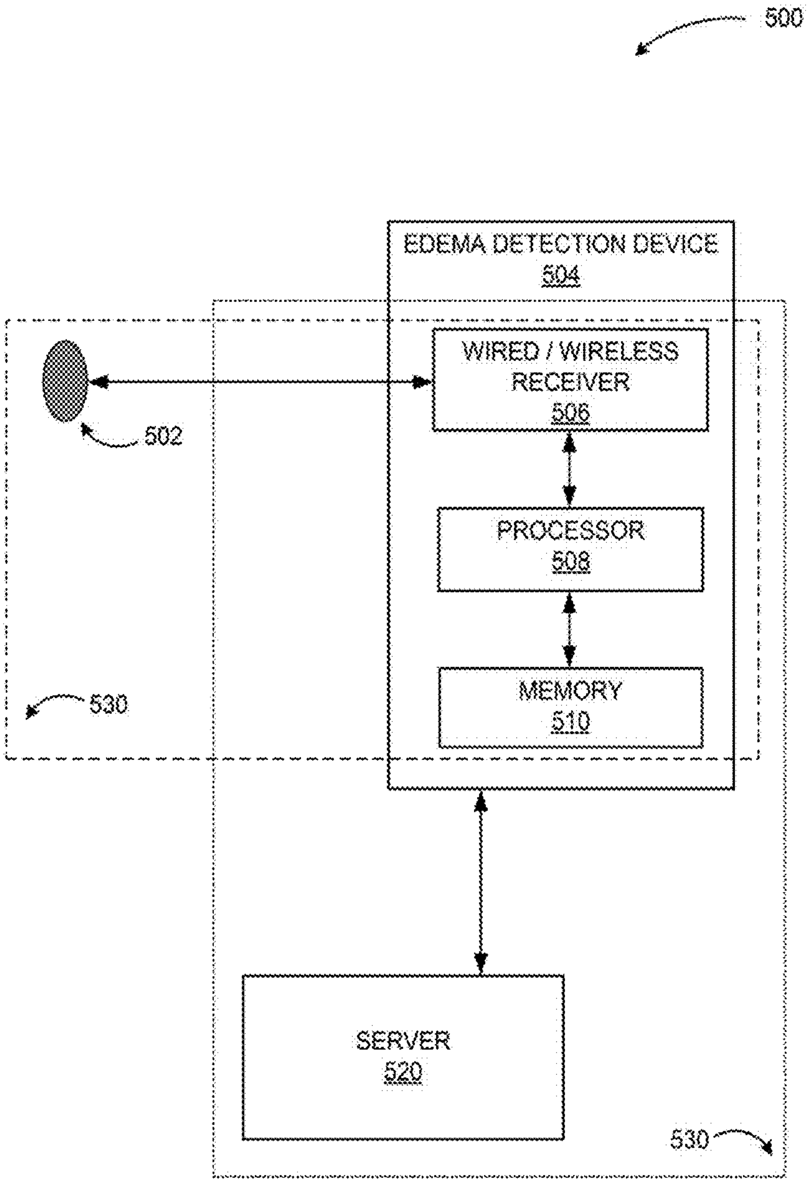

500
EDEMA DETECTION DEVICE
504
WIRED / WIRELESS
RECEIVER
506
502
PROCESSOR
508
MEMORY
510
530
SERVER
520
530

FIG. 5

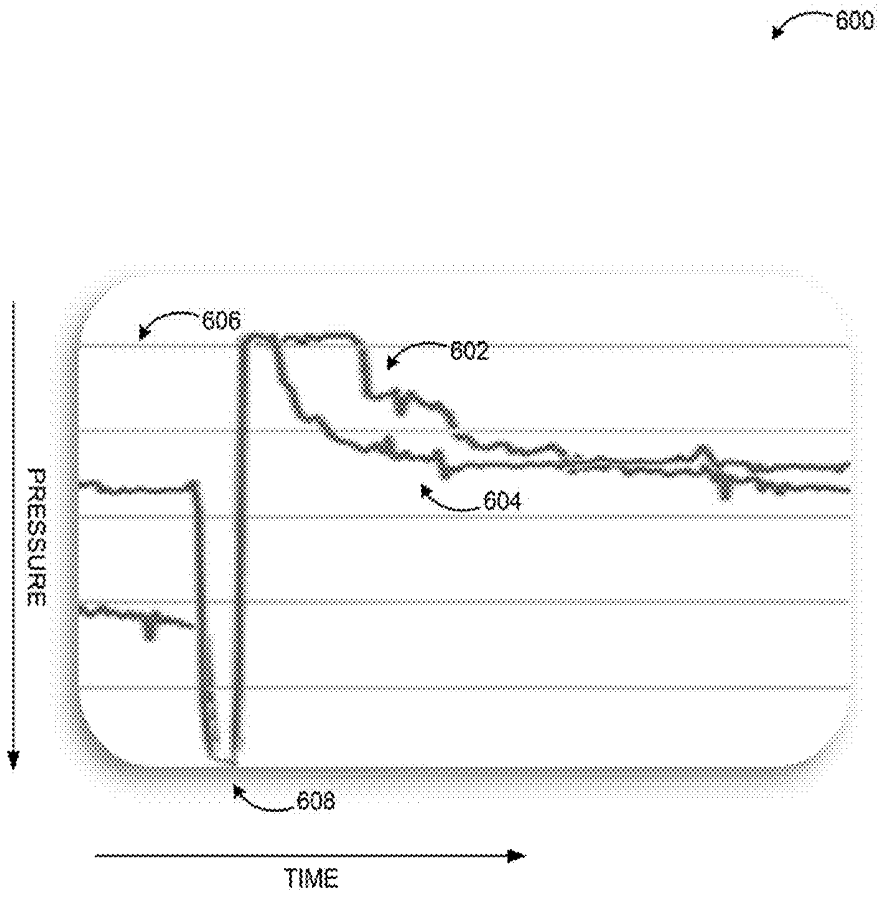


FIG. 6

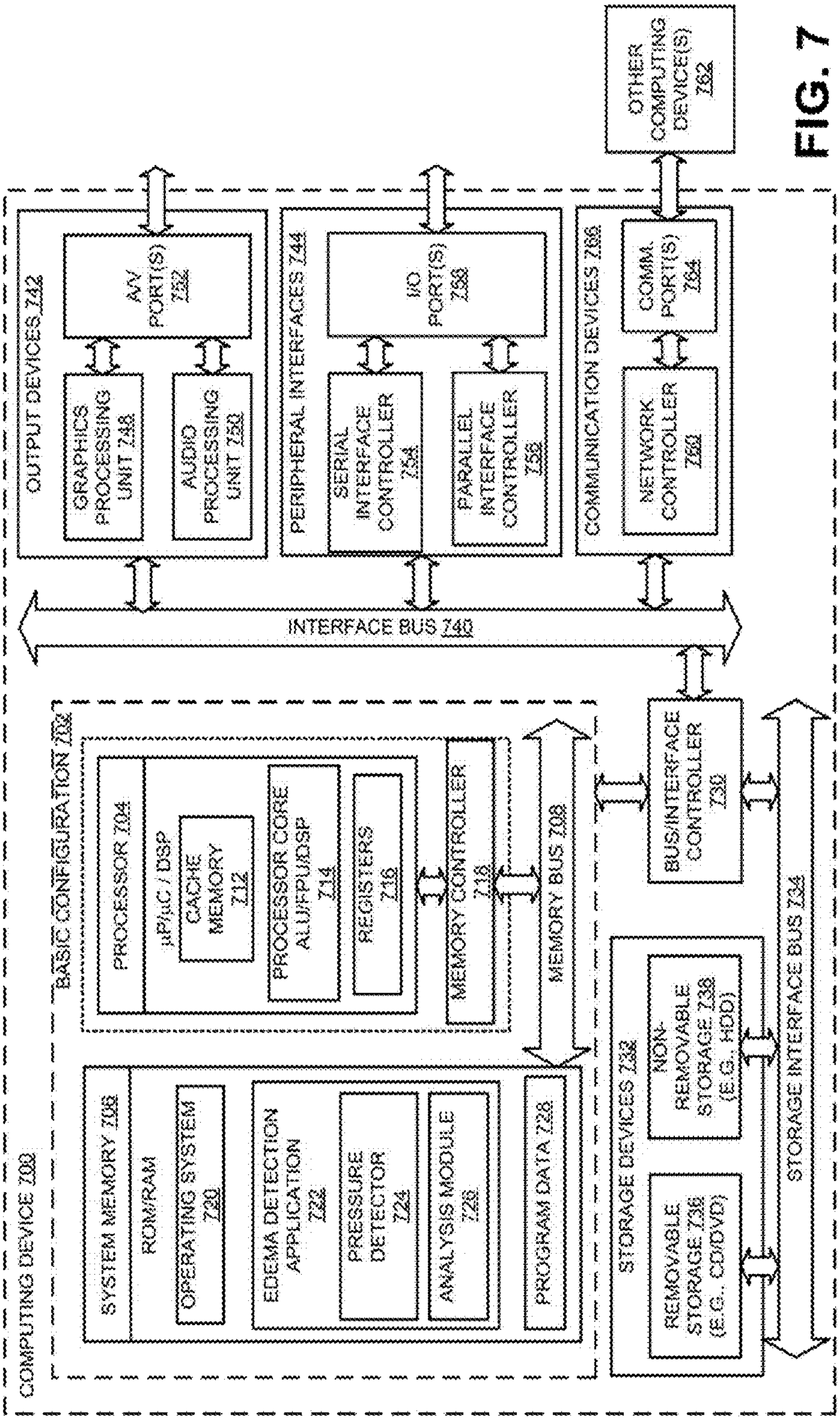

COMPUTING DEVICE 700
BASIC CONFIGURATION 702
SYSTEM MEMORY 706
ROM/RAM
OPERATING SYSTEM 720
EDEMA DETECTION APPLICATION 722
PRESSURE DETECTOR 724
ANALYSIS MODULE 726
PROGRAM DATA 728
PROCESSOR 704
µP/µC / DSP
CACHE MEMORY 712
PROCESSOR CORE ALU/FPU/DSP 714
REGISTERS 716
MEMORY CONTROLLER 718
MEMORY BUS 708
BUS/INTERFACE CONTROLLER 730
STORAGE DEVICES 732
REMOVABLE STORAGE 736 (E.G., CD/DVD)
NON-REMOVABLE STORAGE 738 (E.G., HDD)
STORAGE INTERFACE BUS 734
INTERFACE BUS 740
OUTPUT DEVICES 742
GRAPHICS PROCESSING UNIT 748
AUDIO PROCESSING UNIT 750
A/V PORT(S) 752
PERIPHERAL INTERFACES 744
SERIAL INTERFACE CONTROLLER 754
PARALLEL INTERFACE CONTROLLER 756
I/O PORT(S) 758
COMMUNICATION DEVICES 766
NETWORK CONTROLLER 760
COMM. PORT(S) 764
OTHER COMPUTING DEVICE(S) 762

FIG. 7

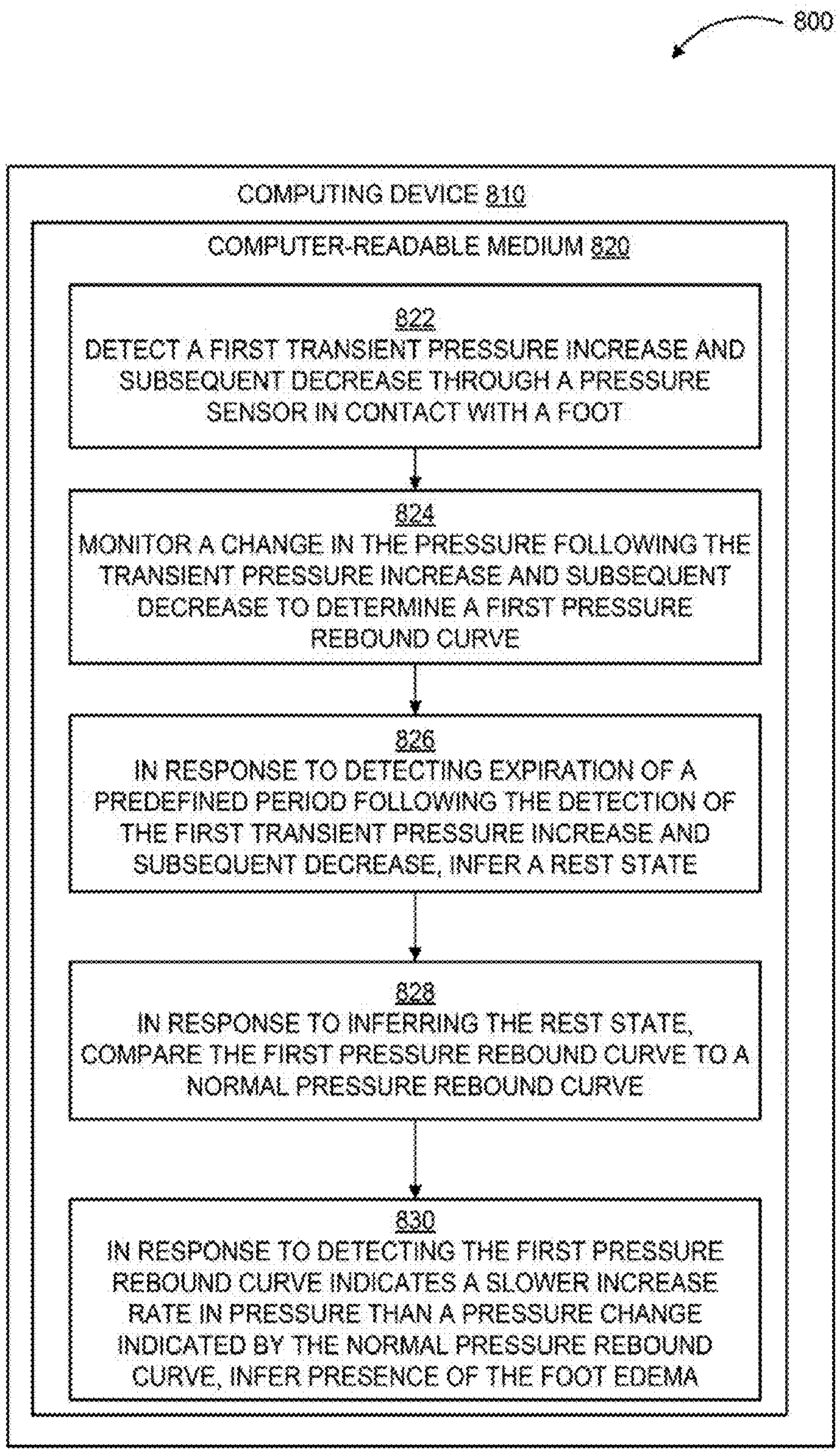

800
COMPUTING DEVICE 810
COMPUTER-READABLE MEDIUM 820
822
DETECT A FIRST TRANSIENT PRESSURE INCREASE AND SUBSEQUENT DECREASE THROUGH A PRESSURE SENSOR IN CONTACT WITH A FOOT
824
MONITOR A CHANGE IN THE PRESSURE FOLLOWING THE TRANSIENT PRESSURE INCREASE AND SUBSEQUENT DECREASE TO DETERMINE A FIRST PRESSURE REBOUND CURVE
826
IN RESPONSE TO DETECTING EXPIRATION OF A PREDEFINED PERIOD FOLLOWING THE DETECTION OF THE FIRST TRANSIENT PRESSURE INCREASE AND SUBSEQUENT DECREASE, INFER A REST STATE
828
IN RESPONSE TO INFERRING THE REST STATE, COMPARE THE FIRST PRESSURE REBOUND CURVE TO A NORMAL PRESSURE REBOUND CURVE
830
IN RESPONSE TO DETECTING THE FIRST PRESSURE REBOUND CURVE INDICATES A SLOWER INCREASE RATE IN PRESSURE THAN A PRESSURE CHANGE INDICATED BY THE NORMAL PRESSURE REBOUND CURVE, INFER PRESENCE OF THE FOOT EDEMA

FIG. 8

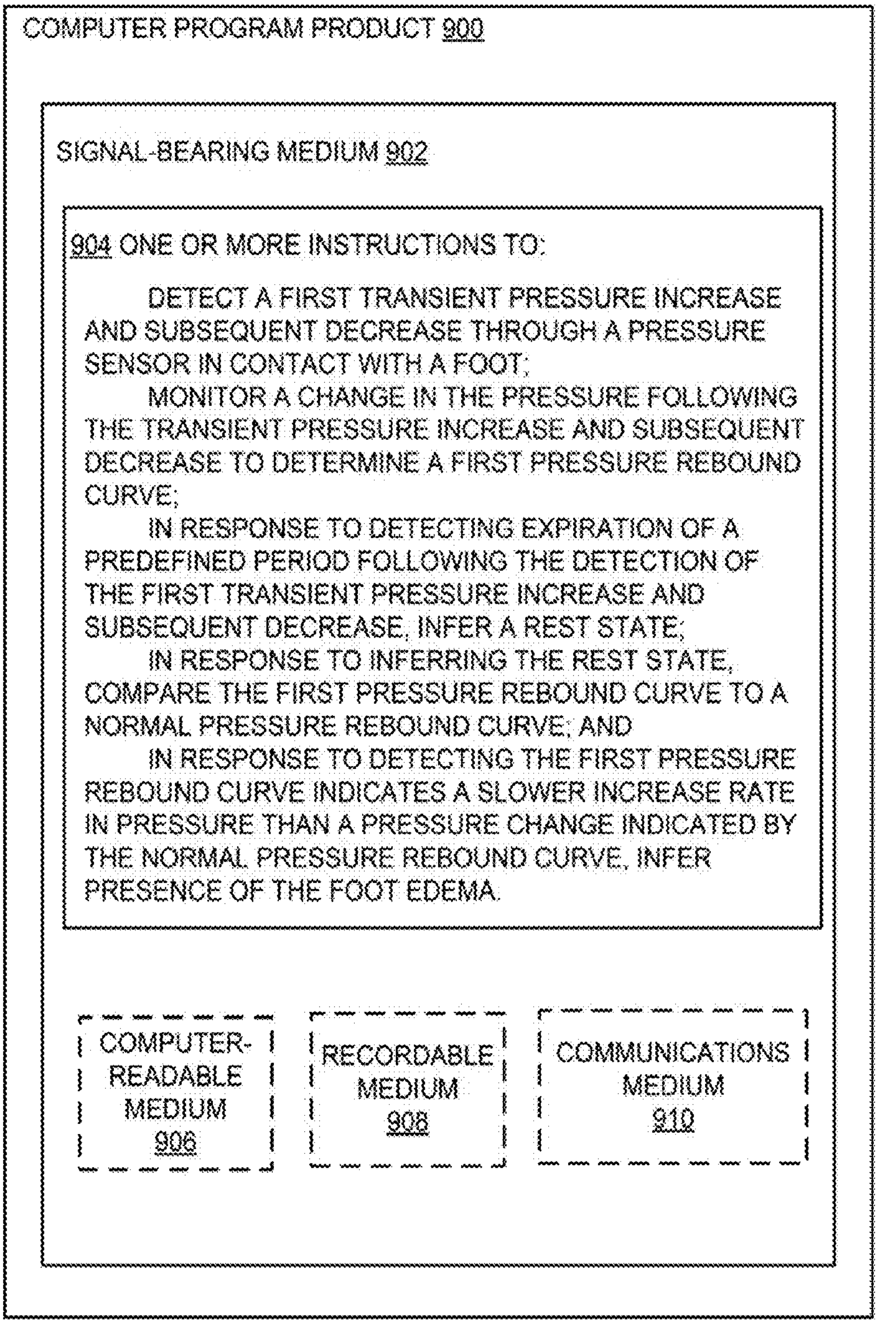

COMPUTER PROGRAM PRODUCT 900
SIGNAL-BEARING MEDIUM 902
904 ONE OR MORE INSTRUCTIONS TO:
DETECT A FIRST TRANSIENT PRESSURE INCREASE AND SUBSEQUENT DECREASE THROUGH A PRESSURE SENSOR IN CONTACT WITH A FOOT;
MONITOR A CHANGE IN THE PRESSURE FOLLOWING THE TRANSIENT PRESSURE INCREASE AND SUBSEQUENT DECREASE TO DETERMINE A FIRST PRESSURE REBOUND CURVE;
IN RESPONSE TO DETECTING EXPIRATION OF A PREDEFINED PERIOD FOLLOWING THE DETECTION OF THE FIRST TRANSIENT PRESSURE INCREASE AND SUBSEQUENT DECREASE, INFER A REST STATE;
IN RESPONSE TO INFERRING THE REST STATE, COMPARE THE FIRST PRESSURE REBOUND CURVE TO A NORMAL PRESSURE REBOUND CURVE; AND
IN RESPONSE TO DETECTING THE FIRST PRESSURE REBOUND CURVE INDICATES A SLOWER INCREASE RATE IN PRESSURE THAN A PRESSURE CHANGE INDICATED BY THE NORMAL PRESSURE REBOUND CURVE, INFER PRESENCE OF THE FOOT EDEMA.
COMPUTER-READABLE MEDIUM 906
RECORDABLE MEDIUM 908
COMMUNICATIONS MEDIUM 910

FIG. 9

DETECTION OF FOOT EDEMA THROUGH IN-SHOE PRESSURE SENSORS

BACKGROUND

[0001] Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to be prior art by inclusion in this section.

[0002] Foot Edema is a painless swelling which may affect legs, calves or thighs. Because of the effect of gravity, swelling may particularly be noticeable in the lower part of the body. Foot, leg and ankle swelling may be commonly caused by a blood clot in the leg, a leg infection, veins in the legs that cannot properly pump blood back to the heart, and an injury or surgery involving the leg, ankle, or foot. Swelling may also occur after pelvic surgery, including surgery for pelvic cancer. Long airplane flights or car rides as well as standing for long periods of time may also lead to some swelling in the feet and ankles.

[0003] Swelling may also occur in women who take estrogen or during parts of the menstrual cycle. Some women may experience some swelling during pregnancy. More severe swelling during pregnancy may be a sign of preeclampsia (also called toxemia), a serious condition that includes high blood pressure and swelling. Swollen legs may also be a sign of heart failure, kidney failure, or liver failure. In these conditions, there is too much fluid retained in the body. Further, certain medications may also lead to feet edema such as antidepressants, blood pressure medicines, hormones and steroids. Thus, these conditions need early detection, as the risks involved are high.

SUMMARY

[0004] The present disclosure generally describes techniques for detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values.

[0005] According to some examples, a system configured to detect foot edema through pressure sensing is described. The system may include a pressure sensor configured to contact a surface of a foot and detect a pressure generated on the surface of the foot by fluid accumulation within cells of the foot; and a processing device communicatively coupled to the pressure sensor. The processing device may include a communication module configured to receive the detected pressure from the pressure sensor; a memory configured to store instructions; and a processor coupled to the communication module and the memory, the processor configured to execute an edema detection application in conjunction with the instructions stored in the memory. The edema detection application may be configured to detect a first transient increase and a subsequent decrease in the detected pressure; monitor a change in the pressure following thee first transient increase and the subsequent decrease in the detected pressure to determine a first pressure rebound curve; compare the first pressure rebound curve to a normal pressure rebound curve, wherein the normal pressure rebound corresponds to a pressure change in a healthy person's foot; and in response to detecting that the first pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema.

[0006] According to other examples, a method to detect foot edema through pressure sensing is described. The method may include detecting a first transient increase and a subsequent decrease in a pressure detected through a pressure sensor in contact with a foot, where the pressure is generated on a surface of the foot by fluid accumulation within cells of the foot; monitoring a change in the pressure following the transient increase and the subsequent decrease in the detected pressure to determine a first pressure rebound curve; in response to detecting expiration of a predefined time period following the detection of the first transient increase and the subsequent decrease in the detected pressure, inferring a rest state; in response to inferring the rest state, comparing the first pressure rebound curve to a normal pressure rebound curve, where the normal pressure rebound curve corresponds to a change in detected pressure of a healthy person's foot; and in response to detecting that the first pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema.

[0007] According to further examples, an edema detection device configured to detect foot edema through pressure sensing is described. The edema detection device may include a communication module communicatively coupled through a wired or wireless communication medium to one or more pressure sensors each sensor configured to contact a foot and detect a pressure generated on a surface of the foot by fluid accumulation within cells of the foot; a memory configured to store instructions; and a processor coupled to the memory and the communication module. The processor may be configured to detect one or more transient increases and subsequent decreases in the detected pressure through the one or more pressure sensors; determine a pressure rebound curve with each of the one or more pressure sensors based on changes in the pressure following the one or more transient increases and subsequent decreases in the detected pressure; determine a combined pressure rebound curve based on a weighted average of the pressure rebound curves, where the pressure rebound curves are weighted based on locations of corresponding pressure sensors; compare the combined pressure rebound curve to a normal pressure rebound curve, where the normal pressure rebound curve corresponds to a change in pressure of a healthy person's foot; in response to detecting that the combined pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema; and transmit one or more of an audio alert, a visual alert, a tactile alert, and a textual alert to a computing device.

[0008] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The foregoing and other features of this disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are, therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings, in which:

[0010] FIG. **1** illustrates an example pressure sensor placed on a foot as part of a system to detect foot edema through in-shoe pressure sensors and analysis of detected pressure values;

[0011] FIG. **2** illustrates example pressure sensors placed on different locations of a foot as part of a system to detect foot edema through in-shoe pressure sensors and analysis of detected pressure values;

[0012] FIG. **3** illustrates an example system diagram for detection of foot edema through in-shoe wired pressure sensors and analysis of detected pressure values;

[0013] FIG. **4** illustrates an example system diagram for detection of foot edema through in-shoe wireless pressure sensors and analysis of detected pressure values;

[0014] FIG. **5** illustrates a block diagram of an edema detection device for detection of foot edema through in-shoe wireless pressure sensors and analysis of detected pressure values;

[0015] FIG. **6** illustrates an example graphical representation of an example normal pressure rebound curve and an edema-indicating pressure rebound curve following a transient pressure increase and release;

[0016] FIG. **7** illustrates a general purpose computing device, which may be associated with detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values;

[0017] FIG. **8** is a flow diagram illustrating an example process for detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values, that may be performed by a computing device, such as the computing device in FIG. **7**; and

[0018] FIG. **9** illustrates a block diagram of an example computer program product, all arranged in accordance with at least some embodiments described herein.

DETAILED DESCRIPTION

[0019] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be used, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. The aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0020] This disclosure is generally drawn, among other things, to methods, apparatus, systems, devices, and/or computer program products related to detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values.

[0021] Briefly stated, technologies are generally described for detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values. Multiple pressure sensors may be employed in contact with a foot. The pressure sensors may detect pressure generated on a surface of the foot by fluid accumulation within cells of the foot. A change in pressure may be monitored by analyzing pressure values received from the pressure sensors. In some embodiments, a pressure rebound curve may be determined while monitoring the change in the pressure. A comparison between a newly acquired pressure rebound curve and an established-normal pressure rebound curve corresponding to a healthy foot may be made. If the pressure rebound curve is determined to indicate a slower change (increase rate) in detected pressure than a change in pressure indicated by the normal pressure rebound curve, the presence of foot edema may be inferred.

[0022] Because feet edema is related to many health conditions, monitoring of early signs of developing edema may be helpful to take prophylactic or therapeutic actions as early as possible. Such actions may include raising legs above heart level while lying down, exercising, wearing support stockings, or taking appropriate medications.

[0023] If edema develops subsequently, it may be useful to a physician to know when the process started, and how quickly it developed. It may also be useful to know if edema affected just one or both feet.

[0024] FIG. **1** illustrates an example pressure sensor placed on a foot as part of a system to detect foot edema through in-shoe pressure sensors and analysis of detected pressure values, arranged in accordance with at least some embodiments described herein.

[0025] As shown in a diagram **100**, a pressure sensor **104** may be placed in contact with a foot **102** to detect foot edema. In some examples, the pressure sensor **104** may be integrated with a shoe. The pressure sensor **104** may be configured to detect a pressure generated on the surface of the foot by fluid accumulation within cells of the foot **102**. A baseline pressure level may be assumed, which is due to the sensor pressing against a normal skin tissue.

[0026] The skin of the edematous foot contains higher amounts of fluids than normal amounts of fluids, and therefore its volume is larger. Since the fluids may be located between the cells and outside of the blood vessels, these fluids may flow slowly from place to place. When pressure is applied on a specific area of the edematous skin, a dimple forms because these fluids are pushed away from the specific area of the skin. This dimple may fill up again slowly and disappear when pressure is removed, because it takes a relatively longer time for the fluids to flow back to the tissue below the specific area of the skin. This is why this type of edema is also known as "pitting edema". In contrast, normal skin may dimple less, and the dimple may fill up much more quickly.

[0027] FIG. **2** illustrates example pressure sensors placed on different locations of a foot as part of a system to detect foot edema through in-shoe pressure sensors and analysis of detected pressure values, arranged in accordance with at least some embodiments described herein.

[0028] As shown in a diagram **200**, multiple pressure sensors **204** may be placed in contact with one or more surfaces of a foot **202** to detect foot edema. The pressure sensors **204** may be placed at selected or random locations on the foot **202**. In some examples, the pressure sensors **204** may be integrated with a shoe at different locations. For example, a pressure sensor **206** may be placed under the surface of the foot **202** (e.g., on the sole). The pressure sensors **204** and **206** may sense different pressure values at each location. The sensed pressure values may depend on the mechanical relationship between shoe size and shape to the foot size and shape, but they may also depend on how much tissue is available between the bones and the skin at a particular location (thus, how much fluid can accumulate in the tissue and result in corresponding increase in pressure). The pressure values may be combined, averaged, and/or weighted depending on the locations.

[0029] In one example, locations where a larger amount of tissue is available under a corresponding pressure sensor may be assigned a higher pressure variability compared to locations where a smaller amount of tissue is available under a corresponding pressure sensor (e.g., locations over the navicular bone of the foot compared to sole of the foot).

[0030] Furthermore, a shape and size of a shoe worn by the person may also impact pressure detection. For example, a tight fitting shoe may result in higher baseline pressure readings compared to a relaxed fitting shoe. Thus, a calibration process may be performed in some embodiments to determine an effect of the shoe on the pressure detection. As described in more detail below, the pressure sensors **204** and **206** may be communicatively coupled to a system to receive and analyze the detected pressure in order to determine a presence of foot edema. For example, the pressure sensors may be wired to a communication or processing module attached to the shoe, wirelessly coupled to the same module or another system not attached to the shoe. A show as used herein refers to any implement wearable on the feet including, but not limited to, boots, sandals, slippers, flip-flops and other foot/leg-protective wear.

[0031] FIG. **3** illustrates an example system diagram for detection of foot edema through in-shoe wired pressure sensors and analysis of detected pressure values, arranged in accordance with at least some embodiments described herein.

[0032] As shown in a diagram **300**, an edema detection device **308** may be configured to detect foot edema. The edema detection device **308** may include a communication module **310**. The communication module **310** may be communicatively connected to multiple pressure sensors **304** through a wired communication medium **306** in some examples. The pressure sensors **304** may be placed at different locations of a foot to detect foot edema. In some examples, the pressure sensors **304** may be integrated with a shoe at different locations. The communication module **310** may receive detected pressure values from the pressure sensors **304** embedded in the shoe. In other examples, at least one of the pressure sensors may include an accelerometer.

[0033] During an operation, the pressure sensors **304** may be configured to detect the pressure generated on a surface of the foot due to fluid accumulation within the cells of the foot. The pressure sensors **304** may send the detected pressure values to the communication module **310**. The edema detection device **308** may be further configured to analyze the detected pressure values and to monitor multiple transient increases in the detected pressure from the pressure sensors. The edema detection device **308** may be further configured to determine multiple pressure rebound curves based on changes in the pressure from the different pressure sensors. A combined pressure rebound curve may be determined based on a combination (e.g., an average) of the multiple pressure rebound curves. A comparison between a determined pressure rebound curve and a normal pressure rebound curve may be performed. If the determined pressure rebound curve indicates a slower change (increase rate) in the detected pressure than a rebound indicated by the normal pressure rebound curve, the presence of foot edema may be inferred. If the determined pressure rebound curve indicates a faster change (increase rate) in the detected pressure than the rebound indicated by the nonnal pressure rebound curve, a (re-)calibration of the normal pressure rebound curve may be performed based on the faster pressure rebound curve.

[0034] In other examples, the edema detection device **308** may be further configured to adjust a pressure rebound curve based on one or more parameters associated with a person on whose foot is being monitored. The parameters may include, for example, a weight of the person, a size of the foot of the person, an average blood pressure level of the person, and a health indicator of the person, among others.

[0035] The communication module **310** may be further configured to transmit data associated with the detected pressure or determined pressure rebound curve to a server **312**. The transmitted data may include raw detected pressure data, determined pressure rebound curve, comparison results, and/or other data such as analysis results of the pressure rebound curve. The edema detection device **308** may not necessarily be in contact with the foot. For example, the edema detection device **308** may be a portable device attached to the shoe. The portable device could be on straps of the shoe, or in walls of the shoe. Furthermore, the pressure sensors **304** may also be in direct or indirect (e.g., through a pressure sensitive material) contact with the surface of the foot.

[0036] FIG. **4** illustrates an example system diagram for detection of foot edema through in-shoe wireless pressure sensors and analysis of detected pressure values, arranged in accordance with at least some embodiments described herein.

[0037] As shown in a diagram **400**, an edema detection device **408** may be configured to detect foot edema. The edema detection device **408** may include a communication module **410**. The communication module **410** may be communicatively connected to multiple pressure sensors **404** through a wireless communication medium **406**. The communication module **410** receive the detected pressure values from the pressure sensors **404** embedded in the shoe at different locations. The wireless communication medium may be a radio frequency (RF) communication such as Bluetooth or a Wi-Fi technology, an infrared communication medium, a visible light communication medium, or one based on magnetic or electric fields, as well as acoustic communication. Furthermore, the wireless communication may be direct, that is, directly between the pressure sensors and the edema detection device **408** or indirect, that is via intermediary communication devices or media (e.g., Internet communication or via a local router).

[0038] In some embodiments, the communication module **410** may be further configured to transmit an alert to a server **412** or a communication device associated with the person (e.g, a smart phone) in response to inferring the presence of the foot edema. The alert may be an audio alert, a visual alert, a tactile alert, or a textual alert. In ether embodiments, the edema detection device **408** may be a portable or wearable device worn or carried by the person, a special purpose computer or a general purpose computer within the person's home or office, or a remotely placed device, for example, at a health care provider's, facility.

[0039] FIG. **5** illustrates a block diagram of an edema detection device for detection of foot edema through in-shoe wireless pressure sensors and analysis of detected pressure values, arranged in accordance with at least some embodiments described herein.

[0040] As shown in a diagram **500**, an edema detection device **504** may be configured to detect foot edema as described above. The edema detection device **504** may include a wired/wireless receiver **506**, a memory **510** configured to store instructions, and a processor **508** coupled to the memory and the wired/wireless receiver **506**. The wired/wireless receiver **506** may be communicatively coupled to a pressure sensor **502**. The pressure sensor **502** may be configured to contact a foot and detect a pressure generated on a surface of the foot by fluid accumulation within cells of the foot.

[0041] During an operation, the pressure sensor **502** may send detected pressure values to the wired/wireless receiver **506**. The processor **508** may determine a state of activity by monitoring a transient increase in the detected pressure. It may infer a rest state if a predefined time period expires following the detection of a first transient increase in the detected pressure. Otherwise, the processor **508** may infer an activity state and disregard detected pressure values. In some embodiments, a pressure rebound curve may be determined while monitoring the change in the pressure. A comparison between the determined pressure rebound curve and a normal pressure rebound curve corresponding to a healthy foot in rest state may be made. If the determined pressure rebound curve in the rest state indicates a slower increase rate or rebound in the detected pressure than an increase rate or rebound indicated by the normal pressure rebound curve, the presence of foot edema may be inferred.

[0042] The edema detection device **504** may transmit the inference of presence of foot edema to a server **520**. The server **520** may further transmit one or more of an audio alert, a visual alert, a tactile alert, and a textual alert to a computing device.

[0043] In some embodiments, the processor **508**, the memory **510**, the wired/wireless receiver **506**, and/or the pressure sensor **502** may be a separate portable device (as indicated by the dashed lines **530**) attached to the shoe or carried on the body of the user. The portable device may be attached to straps of the shoe, or to a wall of the shoe, for example.

[0044] In other embodiments, the pressure sensor **502** may be physically separate from the edema detection device **504**. In further embodiments, the processor **508**, the memory **510**, and/or the wired/wireless receiver **506** may be integrated components of a server **520** (as indicated by the dotted lines **540**) and receive data associated with detected pressure directly from the pressure sensor **502** or via the edema detection device **504**. Thus, components and functionality of a system according to embodiments may be distributed in various ways among portable/wearable devices and remote computing devices.

[0045] FIG. **6** illustrates an example graphical representation of an example normal pressure rebound curve and an edema indicating pressure rebound curve following a transient pressure increase and decrease, arranged in accordance with at least some embodiments described herein.

[0046] A graph **600** depicts pressure characteristics along pressure and time axes. In one scenario, following a transient increase **608**, a relatively short relay and a return to normal, a pressure rebound curve **602** may indicate a slower increase rate of detected pressure values from a minimum value **606** compared to a pressure rebound curve **604**, where the detected pressure values rebound relatively faster. Thus, if the pressure rebound curve **604** is the normal pressure rebound curve (corresponding to healthy person in rest state), the pressure rebound curve **602** may indicate presence of foot edema.

[0047] Because detected pressure on the foot surface(s) may change frequently and randomly in an activity state (e.g., when the person is walking, running, dancing, or performing other physical activities), detected pressure values may not be useful in such a state. However, the activity state may be inferred from the changes, that is, the transient increase being repeated within a predefined time period. The time period (threshold for rest state) may be determined from calibration measurements in some examples and may range from 30 seconds to several minutes, for example.

[0048] FIG. **7** illustrates a general purpose computing device, which may be associated with detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values, arranged in accordance with at least some embodiments described herein.

[0049] For example, the computing device **700** may be a management or security server at a datacenter associated with detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values as described herein. In an example basic configuration **702**, the computing device **700** may include one or more processors **704** and a system memory **706**. A memory bus **708** may be used to communicate between the processor **704** and the system memory **706**. The basic configuration **702** is illustrated in FIG. **7** by those components within the inner dashed line.

[0050] Depending on the desired configuration, the processor **704** may be of any type, including but not limited to a microprocessor (μP), a microcontroller (μC), a digital signal processor (DSP), or any combination thereof. The processor **704** may include one more levels of caching, such as a cache memory **712**, a processor core **714**, and registers **716**. The example processor core **714** may include an arithmetic logic unit (ALU), a floating point unit (FPU), a digital signal processing core (DSP Core), or any combination thereof. An example memory controller **718** may also be used with the processor **704**, or in some implementations, the memory controller **718** may be an internal part of the processor **704**.

[0051] Depending on the desired configuration, the system memory **706** may be of any type including but not limited to volatile memory (such as RAM), non-volatile memory (such as ROM, flash memory, etc.) or any combination thereof. The system memory **706** may include an operating system **720**, edema detection application **722**, and program data **728**. The edema detection application **722** may include a pressure detector **724** and an analysis module **726** for detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values as described herein.

[0052] The computing device **700** may have additional features or functionality, and additional interfaces to facilitate communications between the basic configuration **702** and any desired devices and interfaces. For example, a bus/interface controller **730** may be used to facilitate communications between the basic configuration **702** and one or more data storage devices **732** via a storage interface bus **734**. The data storage devices **732** may be one or more removable storage devices **736**, one or more non-removable storage devices **738**, or a combination thereof. Examples of the removable storage and the non-removable storage devices include magnetic disk devices such as flexible disk drives and hard-disk drives (HDDs), optical disk drives such as compact disc (CD) drives or digital versatile disk (DVD) drives, solid state drives (SSDs), and tape drives to name a few. Example computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules, or other data.

[0053] The system memory **706**, the removable storage devices **736** and the non-removable storage devices **738** are examples of computer storage media. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVDs), solid state drives, or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which may be used to store the desired information and which may be accessed by the computing device **700**. Any such computer storage media may be part of the computing device **700**.

[0054] The computing device **700** may also include an interface bus **740** for facilitating communication from various interface devices (for example, one or more output devices **742**, one or more peripheral interfaces **744**, and one or more communication devices **766**) to the basic configuration **702** via the bus/interface controller **730**. Some of the example output devices **742** include a graphics processing unit **748** and an audio processing unit **750**, which may be configured to communicate to various external devices such as a display or speakers via one or more A/V ports **752**. One or more example peripheral interfaces **744** may include a serial interface controller **754** or a parallel interface controller **756**, which may be configured to communicate with external devices such as input devices (for example, keyboard, mouse, pen, voice input device, touch input device, etc.) or other peripheral devices (for example, printer, scanner, etc.) via one or more I/O ports **758**. An example communication device **766** includes a network controller **760**, which may be arranged to facilitate communications with one or more other computing devices **762** over a network communication link via one or more communication ports **764**.

[0055] The network communication link may be one example of a communication media. Communication media may be embodied by computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as a carrier wave or other transport mechanism, and may include any information delivery media. A "modulated data signal" may be a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media may include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, radio frequency (RF), microwave, infrared (IR) and other wireless media. The term computer readable media as used herein may include both storage media and communication media

[0056] The computing device **700** may be implemented as a part of a general purpose or specialized server, mainframe, or similar computer that includes any of the above functions. The computing device **700** may also be implemented as a personal computer including both laptop computer and non-laptop computer configurations

[0057] FIG. **8** is a flow diagram illustrating an example process for detection of foot edema through in-shoe pressure sensors and analysis of detected pressure values, that may be performed by a computing device, such as the computing device, in FIG. **7**, arranged in accordance with at least some embodiments described herein.

[0058] Example methods may include one or more operations, functions or actions as illustrated by one or more of blocks **822**, **824**, **826**, **828** and/or **830**, and may in some embodiments be performed by a computing device such as the computing device **700** in FIG. **7**. The operations described in the blocks **822-830** may also be stored as computer-executable instructions in a computer-readable medium such as a computer-readable medium **820** of a computing device **810**.

[0059] An example process to detect foot edema through pressure sensing may begin with block **822**, "DETECT A FIRST TRANSIENT INCREASE AND SUBSEQUENT DECREASE IN A PRESSURE DETECTED THROUGH A PRESSURE SENSOR IN CONTACT WITH A FOOT", where an edema detection application implemented on a server may detect a first transient increase and subsequent decrease in a pressure through a pressure sensor in contact with a foot. In some embodiments, the pressure may be generated on a surface of the foot by fluid accumulation within cells of the foot.

[0060] Block **822** may be followed by block **824**, "MONITOR A CHANGE IN THE PRESSURE FOLLOWING THE TRANSIENT INCREASE AND SUBSEQUENT DECREASE IN THE DETECTED PRESSURE TO DETERMINE A FIRST PRESSURE REBOUND CURVE", where edema detection application implemented on a server may monitor a change in the pressure because of transient increase and subsequent decrease in the detected pressure. In some embodiments, a pressure rebound curve may be determined while monitoring the change in the pressure. The pressure rebound curve may correspond to a change in pressure indicating a return of the skin to its normal shape over time after the transient pressure event.

[0061] Block **824** may be followed by block **826**, "IN RESPONSE TO DETECTING EXPIRATION OF A PREDEFINED TIME PERIOD FOLLOWING THE DETECTION OF THE FIRST TRANSIENT INCREASE AND SUBSEQUENT DECREASE IN THE DETECTED PRESSURE, INFER A REST STATE", where edema detection application may detect expiration of a predefined period after detecting an increase in transient pressure and subsequent decrease. In some embodiments, the edema detection application may infer a rest state after detecting the expiration of the predefined period.

[0062] Block **826** may be followed by block **828**, "IN RESPONSE TO INFERRING THE REST STATE, COMPARE THE FIRST PRESSURE REBOUND CURVE TO A NORMAL PRESSURE REBOUND CURVE", where edema detection application may compare the first pressure rebound curve to a normal pressure rebound curve after getting inference of the rest state.

[0063] Block **828** may be followed by block **830**, "IN RESPONSE TO DETECTING THE FIRST PRESSURE REBOUND CURVE INDICATES A SLOWER INCREASE RATE IN PRESSURE THAN A PRESSURE CHANGE INDICATED BY THE NORMAL PRESSURE REBOUND

CURVE, INFER PRESENCE OF THE FOOT EDEMA", where edema detection application may infer presence of the foot edema in response to detecting that first pressure rebound curve indicates a slower increase rate in the detected pressure than an increase rate indicated by the normal pressure rebound curve. The inference of foot edema may be followed by transmission of an audio alert, a visual alert, a tactile alert, and/or a textual alert to a computing device.

[0064] FIG. **9** illustrates a block diagram of an example computer program product, arranged in accordance with at least some embodiments described herein.

[0065] In some examples, as shown in FIG. **9**, a computer program product **900** may include a signal-bearing medium **902** that may also include one or more machine readable instructions **904** that, when executed by, for example, a processor may provide the functionality described herein. Thus, for example, referring to the processor **704** in FIG. **7**, the edema detection application **722** may undertake one or more of the tasks shown in FIG. **9** in response to the instructions **904** conveyed to the processor **704** by the signal-bearing medium **902** to perform actions associated with detecting of foot edema through in-shoe pressure sensors as described herein. Some of those instructions may include, for example, instructions to detect a first transient increase and subsequent decrease in a pressure detected through a pressure sensor in contact with a foot, where the pressure is generated on a surface of the foot by fluid accumulation within cells of the foot, monitor a change in the pressure following the transient increase and subsequent decrease in the detected pressure to determine a first pressure rebound curve, infer a rest state in response to detecting expiration of a predefined time period following the detection of the first transient and subsequent decrease increase in the detected pressure, compare the first pressure rebound curve to a normal pressure rebound curve in response to inferring the rest state, and/or infer presence of the foot edema in response to detecting that the first pressure rebound curve indicates a slower increase rate in the detected pressure than a change indicated by the normal pressure rebound curve, according to some embodiments described herein.

[0066] In some implementations, the signal-bearing medium **902** depicted in FIG. **9** may encompass computer-readable medium **906**, such as, but not limited to, a hard disk drive, a solid state drive, a Compact Disc (CD), a Digital Versatile Disk (DVD), a digital tape memory, etc. In some implementations, the signal-bearing medium **902** may encompass recordable medium **908**, such as, but not limited to, memory, read/write (R/W) CDs, R/W DVDs, etc. In some implementations, the signal-bearing medium **902** may encompass communications medium **910**, such as, but not limited to, a digital and/or an analog communication medium (for example, a fiber optic cable, a waveguide, a wired communications link, a wireless communication link, etc.). Thus, for example, the computer program product **900** may be conveyed to one or more modules of the processor **704** by an RF signal bearing medium, where the signal-bearing medium **902** is conveyed by a communications medium **910** (for example, a wireless communications medium conforming with the IEEE 802.11 standard).

[0067] According to some examples, a system configured to detect foot edema through pressure sensing is described. The system may include a pressure sensor configured to contact a surface of a foot and detect a pressure generated on the surface of the foot by fluid accumulation within cells of the foot; and a processing device communicatively coupled to the pressure sensor. The processing device may include a communication module configured to receive the detected pressure from the pressure sensor; a memory configured to store instructions; and a processor coupled to the communication module and the memory, the processor configured to execute an edema detection application in conjunction with the instructions stored in the memory. The edema detection application may be configured to detect a first transient increase and subsequent decrease in the detected pressure; monitor a change in the pressure following the first transient increase and the subsequent decrease in the detected pressure to determine a first pressure rebound curve; compare the first pressure rebound curve to a normal pressure rebound curve, wherein the normal pressure rebound curve corresponds to a pressure change in a healthy person's foot; and in response to detecting that the first pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema.

[0068] According to other examples, the edema detection application may be further configured to detect a second transient increase and subsequent decrease in the detected pressure within a predefined time period following the first transient increase and the subsequent decrease in the detected pressure; in response to detecting the second transient increase and the subsequent decrease in the detected pressure, infer an activity state; ignore the first pressure rebound curve; and compare the second pressure rebound curve to the normal pressure rebound curve. The edema detection application may also be configured to infer the activity state based on input from at least one other sensor. The at least one other sensor may include an accelerometer. The edema detection application may be further configured to in response to detecting expiration of a predefined time period following the detection of the first transient increase and the subsequent decrease in the detected pressure, infer a rest state; and compare the first pressure rebound curve to the normal pressure rebound currve in response to inferring the rest state.

[0069] According to further examples, the edema detection application may be further configured to in response to inferring the presence of the foot edema, transmit an alert to a computing device. The alert may be one or more of an audio alert, a visual alert, a tactile alert, and a textual alert. The system may further include a plurality of pressure sensors each sensor configured to contact one or more surfaces of the foot, and the edema detection application may be further configured to detect a plurality of transient increases and subsequent decreases in the detected pressure from the plurality of pressure sensors; determine a plurality of pressure rebound curves based on changes in the pressure following the plurality of transient increases and the subsequent decreases in the detected pressure; determine a combined pressure rebound curve based on an average of the plurality of pressure rebound curves; compare the combined pressure rebound curve to the normal pressure rebound curve; and in response to detecting that the combined pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema.

[0070] According to yet other examples, the edema detection application may be further configured to weight one or more of the plurality of pressure rebound curves to determine the combined pressure rebound curve and weight the one or more of the plurality of pressure rebound curves based on locations of one or more corresponding pressure sensors. The system may also include a plurality of pressure sensors each sensor configured to contact one or more surfaces of the foot, and the edema detection application may be further configured to detect a plurality of transient increases and subsequent decreases in the detected pressure from the plurality of pressure sensors; determine a plurality of pressure rebound curves based on changes in the detected pressure following the plurality of transient pressure increases and the subsequent decreases; and select a pressure rebound curve of the plurality of pre sure rebound curves that indicates a fastest rebound in the detected pressure as the first pressure rebound curve.

[0071] According to other examples, a method to detect foot edema through pressure sensing is described. The method may include detecting a first transient increase and a subsequent decrease in a pressure detected through a pressure sensor in contact with a foot, where the pressure is generated on a surface of the foot by fluid accumulation within cells of the foot; monitoring a change in the pressure following the transient increase and the subsequent decrease in the detected pressure to determine a first pressure rebound curve; in response to detecting expiration of a predefined time period following the detection of the first transient increase and the subsequent decrease in the detected pressure, inferring a rest state; in response to inferring the rest state, comparing the first pressure rebound curve to a normal pressure rebound curve, where the normal pressure rebound curve corresponds to a change in detected pressure of a healthy person's foot; and in response to detecting that the first pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema.

[0072] According to further examples, the method may also include in response to inferring the presence of the foot edema, transmitting one or more of an audio alert, a visual alert, a tactile alert, and a textual alert to a computing device. The method may further include determining that one or more pressure rebound curves indicate a faster increase rate in the detected pressure than the pressure increase rate indicated by the normal pressure rebound curve in the rest state; and calibrating the normal pressure rebound curve based on the one or more pressure rebound curves. The method may also include adjusting the first pressure rebound curve based on one or more parameters associated with a person on whose foot the first transient increase and the subsequent decrease is detected.

[0073] According to some examples, the one or more parameters may include one or more of: a weight of the person, a size of the foot of the person, an average blood pressure level of the person, and a health indicator of the person. The method may also include detecting a plurality of transient increases and subsequent decreases in the detected pressure through a plurality of pressure sensors in contact with the foot; determining a plurality of pressure rebound curves based on changes in the pressure following the plurality of transient increases and the subsequent decreases in the detected pressure; determining a combined pressure rebound curve based on a weighted average of the plurality of pressure rebound curves, where the one or more of the plurality of pressure rebound curves are weighted based on locations of corresponding pressure sensors; comparing the combined pressure rebound curve to the normal pressure rebound curve; and in response to detecting that the combined pressure rebound curve indicates a slower increase rate in the detected pressure than the pressure increase rate indicated by the normal pressure rebound curve, inferring presence of the foot edema.

[0074] According to further examples, an edema detection device configured to detect foot edema through pressure sensing is described. The edema detection device may include a communication module communicatively coupled through a wired or wireless communication medium to one or more pressure sensors each sensor configured to contact a foot and detect a pressure generated on a surface of the foot by fluid accumulation within cells of the foot; a memory configured to store instructions; and a processor coupled to the memory and the communication module. The processor may be configured to detect one or more transient increases and subsequent decreases in the detected pressure through the one or more pressure sensors; determine a pressure rebound curve with each of the one or more pressure sensors based on changes in the pressure following the one or more transient increases and subsequent decreases in the detected pressure; determine a combined pressure rebound curve based on a weighted average of the pressure rebound curves, where the pressure rebound curves are weighted based on locations of corresponding pressure sensors; compare the combined pressure rebound curve to a normal pressure rebound curve, where the normal pressure rebound curve corresponds to a change in pressure of a healthy person's foot; in response to detecting that the combined pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema; and transmit one or more of an audio alert, a visual alert, a tactile alert, and a textual alert to a computing device.

[0075] According to yet other examples, the edema detection device may be portable device attachable to a shoe. The edema detection device may also be integrated with a shoe.

[0076] Various embodiments may be implemented in hardware, software, or combination of both hardware and software (or other computer-readable instructions stored on a non-transitory computer-readable storage medium and executable by one or more processors); the use of hardware or software is generally (but not always, in that in certain contexts the choice between hardware and software may become significant) a design choice representing cost vs. efficiency tradeoffs. There are various vehicles by which processes and/or systems and/or other technologies described herein may be effected (for example, hardware, software, and/or firmware), and the preferred vehicle will vary with the context in which the processes and/or systems and/or other technologies are deployed. For example, if an implementer determines that speed and accuracy are paramount, the implementer may opt for a mainly hardware and/or firmware vehicle; if flexibility is paramount, the implementer may opt for a mainly software implementation;

or, yet again alternatively, the implementer may opt for some combination of hardware, software, and/or firmware.

[0077] The foregoing detailed description has set forth various embodiments of the devices and/or processes via the use of block diagrams, flowcharts, and/or examples. Insofar as such block diagrams, flowcharts, and/or examples contain one or more functions and/or operations, each function and/or operation within such block diagrams, flowcharts, or, examples may be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combnation thereof. In one embodiment, several portions of the subject matter described herein may be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), or other integrated formats. However, some aspects of the embodiments disclosed herein, in whole or in part, may be equivalently implemented in integrated circuits, as one or more computer programs executing on one or more computers (for example, as one or more programs executing on one or more computer systems), as one or more programs executing on one or more processors for example, as one or more programs executing on one or more microprocessors), as firmware, or as virtually any combination thereof, and designing the circuitry and/or writing the code for the software and/or firmware are possible in light of this disclosure.

[0078] The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations can be made without departing from its spirit and scope. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, are possible from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. Also, the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

[0079] In addition, the mechanisms of the subject matter described herein are capable of being distributed as a program product in a variety of forms, and that an illustrative embodiment of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to, the following: a recordable type medium such as a floppy disk, a hard disk drive, a Compact Disc (CD), a Digital Versatile Disk (DVD), a digital tape, a computer memory, a solid state drive, etc.; and a transmission type medium such as a digital and/or an analog communication medium (for example, a fiber optic cable, a waveguide, a wired communications link, a wireless communication link, etc.),

[0080] Those skilled in the art will recognize that it is common within the art to describe devices and/or processes in the fashion set forth herein, and thereafter use engineering practices to integrate such described devices and/or processes into data processing systems. That is, at least a portion of the devices and/or processes described herein may be integrated into a data processing system via a reasonable amount of experimentation. A data processing system may include one or more of a system unit housing, a video display device, a memory such as volatile and non-volatile memory, processors such as microprocessors and digital signal processors, computational entities such as operating systems, drivers, graphical user interfaces, and applications programs, one or more interaction devices, such as a touch pad or screen, and/or control systems including feedback loops and control motors (for example, feedback for sensing position and/or velocity of gantry systems; control motors to move and/or adjust components and/or quantities).

[0081] A data processing system may be implemented utilizing any suitable commercially available components, such as those found in data computing/communication and/or network computing/communication systems. The herein described subject matter sometimes illustrates different components contained within, or connected with, different other components. Such depicted architectures are merely exemplary, and in fact many other architectures may be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality may be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermediate components. Likewise, any two components so associated may also be viewed as being "operably connected", or "operably coupled", to each other to achieve the desired functionality, and any two components capable of being so associated may also be viewed as being "operably couplable", to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically connectable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

[0082] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0083] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (for example, bodies of the appended claims) are generally intended as "open" terms (for example, the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (for example, "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (for example, the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations).

[0084] Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (for example, "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0085] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," "greater than," "less than," and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or ,5 cells, and, so forth.

[0086] While various aspects and embodiments have been disclosed herein, other aspects and embodiments are possible. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. A system configured to detect foot edema through pressure sensing, the system comprising:

a pressure sensor configured to contact a surface of a foot, the pressure sensor further configured to detect a pressure generated on the surface of the foot by fluid accumulation within cells of the foot; and

a processing device communicatively coupled to the pressure sensor, the processing device comprising:

a communication module configured to receive the detected pressure from the pressure sensor;

a memory configured to store instructions; and

a processor coupled to the communication module and the memory, the processor configured to execute an edema detection application in conjunction with the instructions stored in the memory, wherein the edema detection application is configured to:

detect a first transient increase and a subsequent decrease in the detected pressure;

monitor a change in the pressure following the first transient increase and the subsequent decrease in the detected pressure to determine a first pressure rebound curve;

compare the first pressure rebound curve to a normal pressure rebound curve, wherein the normal pressure rebound curve corresponds to a pressure change in a healthy person's foot; and

in response to detecting that the first pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema.

2. The system of claim **1**, wherein the edema detection application is further configured to:

detect a second transient increase and subsequent decrease in the detected pressure within a predefined time period following the first transient increase and the subsequent decrease in the detected pressure;

in response to detecting the second transient increase and the subsequent decrease in the detected pressure, infer an activity state;

ignore the first pressure rebound curve; and

compare the second pressure rebound curve to the normal pressure rebound curve.

3. The system of claim **2**, wherein the edema detection application is further configured to:

infer the activity state based on input from at least one other sensor.

4. The system of claim **3**, wherein the at least one other sensor includes an accelerometer.

5. The system of claim **1**, wherein the edema detection application is further configured to:

in response to detecting expiration of a predefined time period following the detection of the first transient increase and the subsequent decrease in the detected pressure, infer a rest state; and

compare the first pressure rebound curve to the normal pressure rebound curve in response to inferring the rest state.

6. The system of claim **1**, wherein the edema detection application is further configured to:

in response to inferring the presence of the foot edema, transmit an alert to a computing device.

7. The system of claim **6**, wherein the alert is one or more of an audio alert, a visual alert, a tactile alert, and a textual alert.

8. The system of claim **1**, further comprising a plurality of pressure sensors each sensor configured to contact one or more surfaces of the foot, wherein the edema detection application is further configured to:

detect a plurality of transient increases and subsequent decreases in the detected pressure from the plurality of pressure sensors;

determine a plurality of pressure rebound curves based on changes in the pressure following the plurality of transient increases and the subsequent decreases in the detected pressure;

determine a combined pressure rebound curve based on an average of the plurality of pressure rebound curves;
compare the combined pressure rebound curve to the normal pressure rebound curve; and
in response to detecting that the combined pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema.

9. The system of claim **8**, wherein the edema detection application is further configured to:
weight one or more of the plurality of pressure rebound curves to determine the combined pressure rebound curve.

10. The system of claim **9**, wherein the edema detection application is further configured to:
weight the one or more of the plurality of pressure rebound curves based on locations of one or more corresponding pressure sensors.

11. The system of claim **1**, further comprising a plurality of pressure sensors each sensor configured to contact one or more surfaces of the foot, wherein the edema detection application is further configured to:
detect a plurality of transient increases and subsequent decreases in the detected pressure from the plurality of pressure sensors;
determine a plurality of pressure rebound curves based on changes in the detected pressure following the plurality of transient pressure increases and the subsequent decreases; and
select a pressure rebound curve of the plurality of pressure rebound curves that indicates a fastest rebound in the detected pressure as the first pressure rebound curve.

12. A method to detect foot edema through pressure sensing, the method comprising:
detecting a first transient increase and a subsequent decrease in a pressure detected through a pressure sensor in contact with a foot, wherein the pressure is generated on a surface of the foot by fluid accumulation within cells of the foot;
monitoring a change in the pressure following the transient increase and the subsequent decrease in the detected pressure to determine a first pressure rebound curve;
in response to detecting expiration of a predefined time period following the detection of the first transient increase and the subsequent decrease in the detected pressure, inferring a rest state;
in response to inferring the rest state, comparing the first pressure rebound curve to a normal pressure rebound curve, wherein the normal pressure rebound curve corresponds to a change in detected pressure of a healthy person's foot; and
in response to detecting that the first pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema.

13. The method of claim **12**, further comprising:
in response to inferring the presence of the foot edema, transmitting one or more of an audio alert, a visual alert, a tactile alert, and a textual alert to a computing device.

14. The method of claim **12**, further comprising:
determining that one or more pressure rebound curves indicate a faster increase rate in the detected pressure than the pressure increase rate indicated by the normal pressure rebound curve in the rest state; and
calibrating the normal pressure rebound curve based on the one or more pressure rebound curves.

15. The method of claim **12**, further comprising:
adjusting the fast pressure rebound curve based on one or more parameters associated with a person on whose foot the first transient increase and the subsequent decrease is detected.

16. The method of claim **15**, wherein the one or more parameters include one or more of: a weight of the person, a size of the foot of the person, an average blood pressure level of the person, and a health indicator of the person.

17. The method of claim **12**, further comprising:
detecting a plurality of transient increases and subsequent decreases in the detected pressure through a plurality of pressure sensors in contact with the foot;
determining a plurality of pressure rebound curves based on changes in the pressure following the plurality of transient increases and the subsequent decreases in the detected pressure;
determining a combined pressure rebound curve based on a weighted average of the plurality of pressure rebound curves, wherein the one or more of the plurality of pressure rebound curves are weighted based on locations of corresponding pressure sensors;
comparing the combined pressure rebound curve to the normal pressure rebound curve; and
in response to detecting that the combined pressure rebound curve indicates a slower increase rate in the detected pressure than the pressure increase rate indicated by the normal pressure rebound curve, inferring presence of the foot edema.

18. An edema detection device configured to detect foot edema through pressure sensing, the edema detection device comprising:
a communication module communicatively coupled through a wired or wireless communication medium to one or more pressure sensors each sensor configured to contact a foot and detect a pressure generated on a surface of the foot by fluid accumulation within cells of the foot;
a memory configured to store instructions; and
a processor coupled to the memory and the communication module, the processor configured to:
detect one or more transient increases and subsequent decreases in the detected pressure through the one or more pressure sensors;
determine a pressure rebound curve with each of the one or more pressure sensors based on changes in the pressure following the one or more transient increases and subsequent decreases in the detected pressure;
determine a combined pressure rebound curve based on a weighted average of the pressure rebound curves, wherein the pressure rebound curves are weighted based on locations of corresponding pressure sensors;
compare the combined pressure rebound curve to a normal pressure rebound curve, wherein the normal pressure rebound curve corresponds to a change in pressure of a healthy person's foot;

in response to detecting that the combined pressure rebound curve indicates a slower increase rate in the detected pressure than a pressure increase rate indicated by the normal pressure rebound curve, infer presence of the foot edema; and

transmit one or more of an audio alert, a visual alert a tactile alert, and a textual alert to a computing device.

19. The computing device of claim **18**, wherein the edema detection device is portable device attachable to a shoe.

20. The computing device of claim **18**, wherein the edema detection device is integrated with a shoe.

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专利名称(译)	通过鞋内压力传感器检测足部水肿		
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摘要(译)

通常描述技术用于通过内置式压力传感器检测脚水肿并分析检测到的压力值。多个压力传感器可以用于与脚接触。压力传感器可以通过脚的细胞内的流体积聚来检测在脚的表面上产生的压力。通过分析从压力传感器接收的压力值可以监测压力的变化。在一些实施例中，可以在监测压力变化的同时确定压力回弹曲线。可以对新获得的压力反弹曲线和对应于健康的脚的建立 - 正常压力反弹曲线进行比较。如果压力回弹曲线被确定为表明检测压力的变化（回弹）比常压回弹曲线所示的压力变化缓慢，则可以推断出现足部水肿。