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(54) DEVICE AND METHOD FOR MONITORING BLADDER VOLUME OF A SUBJECT

VORRICHTUNG UND VERFAHREN ZUR ÜBERWACHUNG DES BLASENVOLUMENS EINER
PERSON

DISPOSITIF ET PROCÉDÉ DE CONTRÔLE DU VOLUME DE LA VESSIE D'UN SUJET

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(73) Proprietor: **Koninklijke Philips N.V.**

5656 AE Eindhoven (NL)

(72) Inventor: **XU, Jingping**

NL-5656 AE Eindhoven (NL)

(74) Representative: **Gravendeel, Cornelis**

Philips Intellectual Property & Standards

High Tech Campus 5

5656 AE Eindhoven (NL)

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Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to medical monitoring of a subject, e.g., a patient, especially monitoring of the bladder volume of the subject.

BACKGROUND OF THE INVENTION

[0002] The bladder is an organ that collects urine excreted by kidneys before disposal by urination. As urine accumulates in the bladder of a patient, increases the bladder volume of the patient and thus increases the internal pressure of the bladder. In response to the increased internal pressure of the bladder reaching a critical pressure level, the patient may feel the urge to urinate.

[0003] There are several conditions which may affect urination from the bladder of a patient. Bladder dysfunction, e.g., incontinence and urine retention, is one of them. Another condition is marrow nerve damage due to which a patient cannot respond to internal pressure of his/her bladder. Generally, such marrow nerve damage may be caused by trauma.

[0004] Several methods have been used for patients suffering from such conditions. One method is to implant a pressure sensor into the bladder of the patient and detect the moment at which the pressure of the bladder, indicated by the pressure sensor, reaches a critical pressure level. However, implantation of a pressure sensor is invasive and often very expensive. Another method is to measure the bladder volume of the patient non-invasively using ultrasound imaging. Several devices for automated portable bladder volume measurement have been developed based on ultrasound imaging techniques. However, the devices are designed for general checking in daily clinical practice and their battery can be used for several hours only, therefore, the devices are not suitable for long-time monitoring and warning.

[0005] US 6 372 951 B1 discloses a disposable article to be fitted to a wearer. The disposable article preferably comprises a sensor operatively connected to the article. The article may comprise a monitoring system including a piezoelectric transducer that measures the volume of a fluid-filled cavity in the body, such as a bladder or rectum. When stimulated, the piezoelectric transducer sends an ultrasound pulse into the abdomen. The pulse may be sent out at any pre-defined or random interval.

SUMMARY OF THE INVENTION

[0006] Therefore, it would be desirable to provide a device and a method for achieving long-time monitoring of the bladder of a subject, e.g., a patient, in an automated and non-invasive manner.

[0007] According to the present invention, a sensor is attached to a region on the exterior surface of the abdo-

men of the patient and used for obtaining sensor signals indicating the bladder volume of the patient continually, the region corresponding to the bladder of the patient. For example, the sensor can be attached to a region on the skin of the subject or patient above the bladder volume. Ultrasound imaging of the bladder of a patient is triggered when, based on a sensor signal of the continually obtained sensor signals, it is determined in real time that the change of the bladder volume of the patient exceeds a predetermined amount, so as to perform the ultrasound imaging in a discrete mode. Therefore, the total monitoring time using ultrasound imaging may be prolonged, wherein the bladder volume generally increases as urine accumulates in the bladder of the subject as a dynamic process.

[0008] In addition, the sensor signal from the sensor attached to the region on the exterior surface of the abdomen of the subject corresponding to the bladder of the patient may coarsely indicate bladder volume and internal pressure of the bladder of the patient, therefore, by using it to trigger more accurate bladder volume measurement by ultrasound imaging of the patient, comparable monitoring of the bladder of the patient through continuous monitoring of the bladder using ultrasound imaging can be achieved. In one embodiment of the invention, the sensor may be a pressure sensor which may obtain a pressure signal indicating internal pressure of the bladder of the patient and thereby indirectly indicating the bladder volume of the subject. In another embodiment of the invention, the sensor may be a linear displacement sensor which may obtain a perimeter signal indicating the perimeter of the abdomen of the subject and indirectly indicating the bladder volume of the subject.

[0009] In one aspect, the present invention provides a device for monitoring bladder volume of a subject. The device comprises a sensor to be attached to a region on the exterior surface of the abdomen of the subject, the region corresponding to the bladder of the subject, the sensor being configured to obtain a sensor signal indicating the bladder volume of the subject; a controlling unit configured to generate a control signal if it determines that the change of the bladder volume of the subject exceeds a predetermined amount based on the sensor signal; an ultrasound probe to be attached to the subject and configured to emit, in response to the control signal, an ultrasonic signal toward the bladder of the subject and receive echo signals from the bladder of the subject; a deriving unit configured to derive the bladder volume of the subject from the received echo signals. The predetermined amount may be a constant in some embodiments and time-varied in other embodiments.

[0010] In one embodiment, the controlling unit is further configured to determine whether the derived bladder volume of the subject reaches a predefined threshold, and the device of the invention further comprises an alarm configured to give an alarm if the controlling unit determines that the derived bladder volume of the subject reaches the predefined threshold. Therefore, the device

of the invention may be adapted for providing a warning when the bladder volume of the subject reaches a critical volume for urination.

[0011] In one embodiment, the device further comprises a low-pass filtering unit configured to apply low-pass filtering to the sensor signal, and the controlling unit determines whether the change of the bladder volume of the subject exceeds the predetermined amount based on the low-pass filtered sensor signal of the subject. According to the embodiment, artifacts such as those induced by respiration of the subject may be at least partially eliminated by means of said low-pass filtering, because respiration change is more frequent than bladder volume change.

[0012] As an alternative, the device further comprises one or more additional sensors to be attached to one or more additional regions on the exterior surface of the abdomen of the subject outside the region corresponding to the bladder of the subject and adapted to obtain one or more additional sensor signals, wherein the controlling unit determines whether the change of the bladder volume of the subject exceeds the predetermined amount based on the sensor signal and the one or more additional sensor signals. According to the embodiment, artifacts such as those induced by the subject's respiration may also be at least partially eliminated, because the one or more additional sensor signals obtained outside the bladder region are expected to represent mostly the artifacts rather than the change of the volume, whilst the sensor signal obtained within the bladder region is expected to represent a combination of the artifacts and the change of the bladder volume.

[0013] In one embodiment, the device further comprises a movement detecting unit configured to obtain movement data of the subject. The controlling unit is further configured to determine whether the variation rate of the movement data of the subject is less than a predetermined value and, if so, generate the control signal. In this way, artifacts due to movement of the subject may be at least partially eliminated.

[0014] Furthermore, the device may comprise a receiving unit for receiving a parameter value indicating the predefined threshold, wherein the controlling unit generates the predefined threshold based on the parameter value. Thus, the predefined threshold may be set to be different for different individual subjects by the device of the invention. In this way, the device can be adjusted to fit the various conditions or needs of different users. For example, the urge to void may be different for different users.

[0015] Moreover, the ultrasound probe of the invention may be improved in order to be attached to the subject in a fixed location for long-time monitoring and in order to derive the volume of the bladder of the subject.

[0016] In one embodiment, the ultrasound probe comprises an ultrasound transducer comprising two sets of ultrasound transducer elements configured in a cross shape or T shape, each set comprising one or more ul-

trasound transducer elements. In particular, the two sets of ultrasound transducer elements respectively form the two bars of the cross-shape or T-shape and are configured to emit ultrasonic signals toward the bladder of the subject in a set-by-set sequential manner.

[0017] In another embodiment, the ultrasound probe comprises two separate ultrasound transducers which are configured in a cross shape or T shape, each of which comprises one or more ultrasound transducer elements. In particular, the two ultrasound transducers respectively form the two bars of the cross-shape or T-shape and are configured in a cross-shape or T-shape sequentially emit ultrasonic signals toward the bladder of the subject.

[0018] In a further embodiment, the ultrasound probe comprises a capacity micro-machined ultrasound transducer (CMUT).

[0019] In another aspect, the present invention provides a method of monitoring the bladder volume of a subject. The method comprises a) obtaining a sensor signal indicating the bladder volume of the subject by means of a sensor to be attached to a region on the exterior surface of the abdomen of the subject, the region corresponding to the bladder of the subject; b) generating a control signal if it is determined that the change of the bladder volume of the subject exceeds a predetermined amount based on the sensor signal; c) in response to the control signal, emitting an ultrasonic signal toward the bladder of the subject and receiving echo signals from the bladder of the subject by an ultrasound probe; d) deriving the bladder volume of the subject from the received echo signals; e) determining whether the derived bladder volume of the subject reaches a predefined threshold; f) repeating the steps a)-e) if it is determined that the derived bladder volume of the subject does not reach the predefined threshold in step e).

[0020] In a further aspect, the present invention provides a computer program product which comprises computer program instructions which, when executed on the device of the invention, enables the device to perform the method of the invention.

[0021] Various aspects and features of the disclosure are described in further detail below. And other objects and advantages of the present invention will become more apparent and will be easily understood with reference to the description made in combination with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

[0022] The present invention will be described and explained hereinafter in more detail in combination with embodiments and with reference to the drawings, wherein:

Fig. 1 is a schematic block diagram of a device 1 for monitoring the bladder volume of a subject according to one embodiment of the present invention;

Fig. 2 is a schematic block diagram of a device 1A for monitoring the bladder volume of a subject ac-

cording to another embodiment of the present invention;

Fig. 3 is a flowchart of a method for monitoring the bladder volume of a subject according to one embodiment of the present invention;

Fig. 4 is a flowchart of a method for monitoring the bladder volume of a subject according to another embodiment of the present invention.

[0023] The same reference signs in the figures indicate similar or corresponding features and/or functionalities.

DETAILED DESCRIPTION

[0024] The present invention will be described with respect to particular embodiments and with reference to certain drawings, but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn to scale for illustrative purposes.

[0025] Fig.1 shows a device 1 for monitoring the bladder volume of a subject, e.g., a patient, according to one embodiment of the present invention. The device 1 comprises a sensor 10 which may be attached to a region on the exterior surface of the abdomen of the subject corresponding to the bladder of the subject and which obtains a sensor signal indicating the bladder volume of the subject; a controlling unit 11 which generates a control signal when it is determined that the change of the bladder volume of the subject exceeds a predetermined amount based on the sensor signal; an ultrasound probe 12 which is to be attached to the subject and which is configured to emit, in response to the control signal, an ultrasonic signal toward the bladder of the subject and which receives echo signals from the bladder of the subject; and a deriving unit 13 which derives the bladder volume of the subject from the received echo signals.

[0026] The sensor 10 is used for obtaining a sensor signal which may indirectly indicate the bladder volume of a subject. In one preferred embodiment, the sensor 10 may be a pressure sensor, e.g., a piezoelectric sensor, and the sensor signal is a pressure signal indicating internal pressure of the bladder of the subject. Since the volume of the bladder of the subject increases proportionally with the internal pressure of the bladder of the subject, the pressure signal may indirectly indicate the bladder volume of the subject.

[0027] However, the sensor 10 is not limited to a pressure sensor; any kind of other sensor which can generate a sensor signal directly or indirectly indicating the bladder volume of the subject may be used. Accordingly, the sensor signal is not limited to the pressure signal only; any kind of sensor signal which can directly or indirectly indicate the bladder volume of the subject may be used.

[0028] An example of an alternative sensor is a linear displacement sensor which is to be attached to the region on the exterior surface of the subject corresponding to

the bladder of the subject. The linear displacement sensor can measure the perimeter of the abdomen of the subject. In this case, the sensor signal is a perimeter signal indicating the perimeter of the abdomen of the subject. Since the perimeter of the abdomen of the subject may increase as the bladder volume of the subject increases, the perimeter signal may reflect the bladder volume of the subject to some extent.

[0029] Certainly, the sensor signal may be a displacement signal obtained from the linear displacement sensor also. Such a displacement signal may indicate the change of the bladder volume of the subject.

[0030] The controlling unit 11 receives the sensor signal from the sensor 10 and determines whether the change of the bladder volume of the subject exceeds a predetermined amount based on the sensor signal. In one embodiment, the predetermined amount may be a value representing volume difference. In this case, a coarse value of the bladder volume can be derived from the sensor signal.

[0031] Preferably, the predetermined amount is an increment of the sensor signal, or a proportional increment, e.g., 5%, between the original sensor signal of the subject, e.g., the sensor signal obtained at the beginning of monitoring, and the current sensor signal of the subject. The controlling unit 11 determines whether the change of the sensor signal exceeds the predetermined amount directly. If the controlling unit 11 determines that the change of the sensor signal exceeds the predetermined amount, it generates the control signal.

[0032] The predetermined amount may be constant or the predetermined amount may be varied as the urine accumulates in the bladder of the subject. For example, the predetermined amount may be set to a large value after urination and reduces gradually until next urination. In this way, ultrasound imaging may be triggered more frequently when more urine accumulates in the bladder of the subject. Thus, the bladder volume may be derived more frequently as the next urination approaches and thus warning the patient about the next urination can be done in advance more accurately.

[0033] In addition, the predetermined amount may be varied for individual patients also.

[0034] It may be contemplated that the predetermined amount may be a pressure amount or a perimeter amount as long as it intimately correlates to the bladder volume change of the subject.

[0035] Certainly, it is possible that the sensor 10 obtains a sensor signal indicating the bladder volume change and the controlling unit 11 compares the sensor signal with the predetermined amount to determine whether the change of the bladder volume is sufficient to trigger the generation of the control signal.

[0036] In response to the control signal from the controlling unit 11, the ultrasound probe 12 transmits an ultrasonic signal toward the bladder of the subject and receives echo signals from the bladder of the subject. The ultrasonic signal comprises a series of ultrasonic pulses

or ultrasonic waves. In order to attach the ultrasound probe to the subject in a fixed location for long-time monitoring and in order to change the transmission angle of the ultrasound probe to derive the volume of the bladder of the subject, the ultrasound probe may have the following configurations.

[0037] In one configuration, the ultrasound probe comprises an ultrasound transducer comprising two sets of ultrasound transducer elements configured in a cross shape or a T shape. The two sets of ultrasound transducer elements respective form the two bars of the cross shape or T shape. The two sets of ultrasound transducer elements are configured to emit ultrasonic signals toward the bladder of the subject in a set-by-set sequential manner. Each set of the ultrasound transducer elements may include one or more ultrasound transducer elements. In this way, the two sets of ultrasound transducer elements may be controlled by only one controller to sequentially emit the ultrasonic signals to the subject.

[0038] In another configuration, the ultrasound probe comprises two separate ultrasound transducers which are configured so as to respectively be the two bars of the cross-shape or T-shape. According to an embodiment of the present invention, the ultrasound transducers emit ultrasonic signals toward the bladder of the subject in a sequential manner. Each one of the ultrasound transducers may comprise one or more ultrasound transducer elements. This configuration may be simply achieved by two existing ultrasound transducers, and in this way the two ultrasound transducers can be controlled separately.

[0039] Such a configured ultrasound probe is lightweight and thin, and it is easy to change the transmission angle of the ultrasonic signal of the ultrasound probe so as to facilitate the deriving of the bladder volume of the subject.

[0040] In one preferred embodiment, the ultrasound probe comprises a capacity micro-machined ultrasound transducer (CMUT).

[0041] The deriving unit 13 receives the echo signals from the ultrasound probe 12, generates image data of the bladder of the subject and derives the bladder volume of the subject based on the image data of the bladder of the subject. The commonly used methods for deriving the bladder volume comprise the prolate ellipsoid method, double area method and double ellipsoid method. The derived bladder volume may be displayed on a display (not shown) for a user. In some embodiments, one or more 2D or 3D images can be further generated from the image data and displayed. In other embodiments, no ultrasound image is generated or displayed.

[0042] In one embodiment, the derived bladder volume may be transmitted to the controlling unit 11 which compares the derived bladder volume with a predefined threshold. If the derived bladder volume reaches or exceeds the predefined threshold, the controlling unit 11 triggers an alarm 14 to give an alarm to the user. The alarm may be a visual signal displayed on the display (not shown) or an audio signal.

[0043] The predefined threshold may be preset in the controlling unit 11.

Alternatively, the predefined threshold may be received from the user via a receiving unit 17, as shown in Fig.2. Preferably, the receiving unit 17 may receive a parameter value indicating the predefined threshold and the controlling unit 11 generates the predefined threshold based on the parameter value. In this case, the predefined threshold may be set based on individual subjects, more particularly, different urges to void of different individual patients. That is, the predefined threshold may be set to be different for different individual subjects.

[0044] In Fig.2, a device 1A is illustrated. In one preferred embodiment, the device 1A further comprises a low-pass filtering unit 15 which is used to at least partially eliminate artifacts, induced by respiration of the subject, e.g., the patient, from the sensor signal, e.g., the pressure signal or the displacement signal. Compared with the artifact caused by the respiration of the subject, the sensor signal is a low-frequency signal due to the increase of the bladder volume of the subject. This is because, compared with breathing cycles, the change of the bladder volume is very slow because the accumulation process of urine in the bladder is a very slow process. In addition, since the breathing signal is a near-sine signal, the low-pass filtering unit 15 may be designed to separate the low-frequency signal, i.e., the sensor signal, due to the increase of the bladder volume of the subject, from the near-sine signal through spectral analysis of the sensor signal.

[0045] The low-pass filtering unit 15 receives the sensor signal, e.g., the pressure signal or the perimeter signal, from the sensor 10 and performs low-pass filtering on the sensor signal to at least partially eliminate the artifacts caused by the respiration of the subject. In this case, the controlling unit 11 determines whether the bladder volume change of the subject exceeds the predetermined amount based on the low-pass filtered sensor signal of the subject.

[0046] Instead of using the low-pass filtering unit 15, one or more additional sensors (not shown) may be attached to one or more additional regions on the exterior surface of the abdomen of the subject outside the region corresponding to the bladder of the subject. Since the one or more additional sensors are not attached to the region corresponding to the bladder of the subject, i.e., the bladder region, one or more additional sensor signals obtained by the one or more additional sensors substantially do not include the sensor signal caused by the increase of the bladder volume of the subject, but include the artifacts such as those induced by the respiration of the subject. In this case, the controlling unit 11 receives the one or more additional sensor signals from the one or more additional sensors also and determines whether the bladder volume change of the subject exceeds the predetermined amount based on the sensor signal and the one or more additional sensor signals. In the case of one additional sensor, the controlling unit 11 determines

whether the bladder volume change of the subject exceeds the predetermined amount based on a difference between the sensor signal and the additional sensor signal. In the case of a plurality of additional sensors, a plurality of differences between the sensor signal and individual additional sensor signals of a plurality of additional sensor signals from the plurality of additional sensors may be averaged and the controlling unit 11 determines whether the bladder volume change of the subject exceeds the predetermined amount based on the averaged difference. In this case, it is preferred that the sensor 10 and the additional sensors are the same kind of sensor. In one embodiment, both of them are pressure sensors. In another embodiment, both of them are linear displacement sensors.

[0047] In another preferred embodiment, the device 1A may further comprise a movement detecting unit 16, e.g., an accelerator, which collects movement data of the subject. In this embodiment, the controlling unit 11 determines whether the variation rate of the movement data of the subject is less than a predetermined value, and generates the control signal if it determines that the variation rate of the movement data of the subject is less than the predetermined value. In particular, the controlling unit 11 receives the movement data of the subject from the movement detecting unit 16, determines the variation rate of the movement data of the subject, e.g., by determining a derivative of the movement data, compares the variation rate with the predetermined value, e.g., input by a user or a patient, and generates the control signal when the variation rate of the movement data of the subject is less than the predetermined value.

[0048] In this case, the control signal is generated by taking both the sensor signal and the variation rate of the movement data of the subject into consideration. Therefore, artifacts due to movement of the subject may be at least partially eliminated and thus a more accurate bladder volume may be derived.

[0049] Although the device 1 of the invention is described with respect to a sensor 10, a controlling unit 11, an ultrasound probe 12, a deriving unit 13 and an alarm 14, as shown in Fig.1, and the device 1A of the invention is described with respect to a sensor 10, a controlling unit 11, an ultrasound probe 12, a deriving unit 13, an alarm 14, a low-pass filtering unit 15, a movement detecting unit 16 and a receiving unit 17, as shown in Fig.2, it will be understood that the device of the invention is not limited to the configurations described above. One or more components of the device may be omitted or integrated into one component to perform the same function. Or, one or more components of the device may be omitted directly to omit their function without affecting the implementation of the invention. For example, for a patient who cannot move, the movement detecting unit 16 may be omitted.

[0050] Furthermore, it may be determined that the controlling unit 11, the deriving unit 13, and the low-pass filtering unit 15 of the device of the invention may be

achieved by any one of software, hardware, firmware or a combination thereof. In particular, they may be achieved not only by computer programs for performing corresponding functions but also by various entity devices, such as application-specific integrated circuits (ASIC), digital signal processors (DLP), programmable logic devices (PLD), field-programmable gate arrays (FPGA), and CPU. More particularly, they may be implemented as part of a handheld computer or laptop for home monitoring purpose or as part of a hospital central workstation for hospital monitoring purpose.

[0051] It may be anticipated that the device of the invention may be used not only for a single evaluation of the bladder volume of the subject for initial screening but also for long-time serial monitoring of the bladder volume of the subject. In the case of long-time monitoring of the bladder volume of the subject, the sensor 10 and the ultrasound probe 12 are to be attached to the subject at a fixed location, and other components of the device may be integrated into a handheld device or a wearable device, e.g., a handheld or wearable processor, for home monitoring purpose and into a bedside monitoring device or a workstation for hospital monitoring purpose. The sensor 10 obtains sensor signals continually. The controlling unit 11 receives the sensor signals and determines whether the bladder volume change of the subject exceeds a predetermined amount based on each of the sensor signals. The controlling unit 11 generates the controlling signal when it is determined that the bladder volume change of the subject exceeds a predetermined amount based on the sensor signals. Similarly, the low-pass filtering unit 15 and the movement detecting unit 16 may also be adapted for long-time monitoring.

[0052] It may also be anticipated that the signals or data may be transferred between the components of the device of the invention in wired or wireless manner.

[0053] It may be contemplated that the device of the invention may be achieved by means of a sensor to be attached to the subject, any kind of ultrasound imaging system, and one of a handheld computer or laptop and a hospital central workstation.

[0054] It may also be contemplated that the device of the invention may comprise a plurality of sensors 10, a plurality of ultrasound probes 12, and optionally a plurality of movement detecting units 16, which are to be used to monitor a plurality of subjects, e.g., patients. Each of the plurality of subjects is provided with a sensor 10, an ultrasound probe 12, and optionally a movement detecting unit 16. According to an embodiment of the present invention, the controlling unit 11, the deriving unit 13, the alarm 14 as well as the low-pass filtering 15 may be incorporated into a central unit such as a workstation. The central unit is configured to communicate with each sensor 10, each ultrasound probe 12 and each movement detecting unit 16 in wired or wireless manner. In an embodiment, each of the plurality of subjects may be further provided with a communicating unit, which is connected to the sensor 10, the ultrasound probe 12 and the move-

ment detecting unit 16 provided to that subject and is configured to relay the communication with the center unit.

[0055] It may be further contemplated that any one of a predetermined amount, a predefined threshold and a predetermined value may be preset, before delivery of the device to a patient, or received from a user via a receiving unit 17.

[0056] Fig.3 shows a flowchart of a method of monitoring the bladder volume of a subject according to one embodiment of the present invention. In step S_1 , a sensor signal indicating the bladder volume change of the subject is obtained by means of a sensor 10 attached to a region on the exterior surface of the abdomen of the subject, the region corresponding to the bladder of the subject. In one embodiment, the sensor signal may be a pressure signal indicating internal pressure of the bladder of the subject. In a preferred embodiment, one or more additional sensor signals may be obtained from one or more additional regions on the exterior surface of the abdomen of the subject outside the region corresponding to the bladder of the subject.

[0057] In step S_2 , it is determined whether the change of the bladder volume of the subject exceeds a predetermined amount based on the sensor signal and an additional sensor signal, if any, of the subject.

[0058] In particular, if no additional sensor signal is obtained, by determining that the change of the sensor signal has reached a predefined criterion it may be determined that the change of the bladder volume of the subject exceeds the predetermined amount. In the case where one additional sensor signal is obtained, it may be determined whether the change of the bladder volume of the subject exceeds the predetermined amount based on the sensor signal and the additional sensor signal, more particularly, based on the difference between the sensor signal and the additional sensor signal. In the case where a plurality of additional sensor signals are obtained, as described above, the averaged difference between the sensor signal and an individual additional sensor signal of a plurality of additional sensor signals may be used.

[0059] If it is determined that the change of the bladder volume of the subject exceeds the predetermined amount, a control signal is generated in step S_3 . Otherwise, no control signal is generated and the process returns to step S_1 .

[0060] In step S_4 , in response to the control signal, an ultrasound probe emits an ultrasonic signal toward the bladder of the subject and receives echo signals from the bladder of the subject.

[0061] In step S_5 , the bladder volume of the subject is derived from the received echo signals. In particular, a 2D/3D image is generated from the received echo signals and the bladder volume of the subject is derived from the image using algorithms known in the art, as described above.

[0062] In step S_6 , the derived bladder volume of the

subject is compared with a predefined threshold. If it is determined that the derived bladder volume of the subject reaches the predefined threshold, an alarm is given in step S_7 . Otherwise, no alarm is given and the process returns to step S_1 .

[0063] Fig.4 shows a flowchart of a method of monitoring the bladder volume of a subject according to another embodiment of the present invention. Most of the steps shown in Fig.4 are the same as those in Fig.3. The method shown in Fig.4 is different from that shown in Fig.3 in that the method shown in Fig.4 comprises steps S_0 , S_1' , S_a and S_b . The step S_0 indicates the start of the method of the invention. After the start of the method of the invention in step S_0 , steps S_1 and S_a are performed.

[0064] In step S_1' , the sensor signal obtained in step S_1 is low-pass filtered to at least partially eliminate artifacts caused by respiration of a subject. In this case, in step S_2 , whether the change of the bladder volume of the subject exceeds a predetermined amount is determined based on the low-pass filtered sensor signal, and if it is determined that the change of the bladder volume of the subject fails to exceed a predetermined amount, the process returns to step S_0 to restart the method of the invention.

[0065] In step S_a , movement data of the subject is obtained. In step S_b , it is determined whether the variation rate of the movement data of the subject is less than a predetermined value. If it is determined that the variation rate of the movement data of the subject is less than the predetermined value, the process proceeds to step S_3 . Otherwise, it returns to step S_0 to restart the method of the invention.

[0066] According to the method of the embodiment, in step S_3 , a control signal is generated when the following two requirements are met: (1) it is determined that the change of the bladder volume of the subject exceeds the predetermined amount based on the sensor signal and (2) the variation rate of the movement data of the subject is less than the predetermined value.

[0067] Although the methods of the invention are described with respect to the steps shown in Figs. 3 and 4, it may be understood that some of the steps may be omitted to omit their function without affecting the implementation of the invention. For example, for a patient who cannot move, steps S_a and S_b may be omitted. It may also be understood that some of the steps may be combined into one step to fulfill the same function.

[0068] Please note that the device according to the present invention should not be limited to the device mentioned above. It will be apparent to those skilled in the art that the various aspects of the invention claimed may be practiced in other examples that depart from these specific details. The invention being defined by claims 1-15.

[0069] Furthermore, the mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

[0070] It should be noted that the above-mentioned embodiments illustrate rather than limit the invention and that those skilled in the art would be able to design alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps not listed in a claim or in the description. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. In the product claims enumerating several units, several of these units can be embodied by one and the same item of software and/or hardware. The usage of the words first, second and third, et cetera, does not indicate any ordering. These words are to be interpreted as names. The invention is defined by the attached claims 1-15.

Claims

1. A device (1, 1A) for monitoring the bladder volume of a subject, comprising:

a sensor (10) to be attached to a region on the exterior surface of the abdomen of the subject, the region corresponding to the bladder of the subject, the sensor being configured to obtain a sensor signal indicating the bladder volume of the subject;

a controlling unit (11) configured to generate a control signal if it determines that the change of the bladder volume of the subject exceeds a predetermined amount based on the sensor signal;
characterized by further comprising:

an ultrasound probe (12) to be attached to the subject and configured to emit, in response to the control signal, an ultrasonic signal toward the bladder of the subject and receive echo signals from the bladder of the subject;
a deriving unit (13) configured to derive the bladder volume of the subject from the received echo signals.

2. The device of claim 1, wherein the controlling unit (11) is further configured to determine whether the derived bladder volume of the subject reaches a predefined threshold,
the device (1,1A) further comprises an alarm (14) configured to give an alarm if the controlling unit (11) determines that the derived bladder volume of the subject reaches the predefined threshold.
3. The device of claim 1, wherein the device (1, 1A) further comprises a
low-pass filtering unit (15) configured to apply low-

pass filtering to the sensor signal,
wherein the controlling unit (11) determines whether the change of the bladder volume of the subject exceeds the predetermined amount based on the low-pass filtered sensor signal of the subject.

4. The device of claim 1, further comprises one or more additional sensors to be attached to one or more additional regions on the exterior surface of the abdomen of the subject outside the region corresponding to the bladder of the subject and adapted to obtain one or more additional sensor signals, wherein the controlling unit (11) determines whether the change of the bladder volume of the subject exceeds the predetermined amount based on the sensor signal and the one or more additional sensor signals.

5. The device of any one of claims 1 to 4, further comprising:

a movement detecting unit (16) configured to obtain movement data of the subject;
wherein the controlling unit (11) is further configured to determine whether the variation rate of the movement data of the subject is less than a predetermined value, and generate the control signal if it determines that the variation rate of the movement data of the subject is less than a predetermined value.

6. The device of claim 2, further comprising:

a receiving unit (17) for receiving a parameter value indicating the predefined threshold,
wherein the controlling unit (11) generates the predefined threshold based on the parameter value.

7. The device of claim 1, wherein the ultrasound probe (12) comprises an ultrasound transducer comprising two sets of ultrasound transducer elements configured in a cross shape or T shape, each set comprising one or more ultrasound transducer elements.

8. The device of claim 1, wherein the ultrasound probe (12) comprises two separate ultrasound transducers which are configured in a cross shape or T shape, each of which comprises one or more ultrasound transducer elements

9. The device of claim 1, wherein the sensor signal is a pressure signal indicating internal pressure from the bladder of the subject and the sensor (10) is a piezoelectric sensor.

10. The device of claim 1, wherein the sensor signal is a perimeter signal indicating the perimeter of the abdomen of the subject and the sensor (10) is a linear

displacement sensor.

11. A method of monitoring the bladder volume of a subject, comprising the step of

a) obtaining a sensor signal indicating the bladder volume of the subject by means of a sensor when the sensor is attached to a region on the exterior surface of the abdomen of the subject, the region corresponding to the bladder of the subject (S_1);
 b) generating a control signal (S_3) if it is determined that the change of the bladder volume of the subject exceeds a predetermined amount based on the sensor signal (S_2);
 c) in response to the control signal, emitting an ultrasonic signal toward the bladder of the subject and receiving echo signals from the bladder of the subject by means of an ultrasound probe (S_4);
 d) deriving the bladder volume of the subject from the received echo signals (S_5);
 e) determining whether the derived bladder volume of the subject reaches a predefined threshold (S_6);
 f) repeating the steps a)-e) if it is determined that the derived bladder volume of the subject does not reach the predefined threshold in the step e) (S_6).

12. The method of claim 11, further comprising a step of giving an alarm if it is determined that the derived bladder volume of the subject reaches the predefined threshold in the step e) (S_7).

13. The method of claim 12, further comprising a step of applying low-pass filtering to the sensor signal (S_1'), and wherein the step b) further comprises determining that the change of the bladder volume of the subject exceeds the predetermined amount based on the low-pass filtered sensor signal of the subject (S_2).

14. The method of any one of claims 11 to 13, further comprising steps of:

obtaining movement data of the subject (S_a);
 and
 determining whether the variation rate of the movement data of the subject is less than a predetermined value (S_b),
 wherein the step b) further comprises generating the control signal (S_3) if it is determined that the variation rate of the movement data of the subject is less than a predetermined value (S_b).

15. A computer program product comprising computer program instructions,

which, when on a device according to any one of claims 1 to 10, enable the device to perform the method of any one of claims 11 to 14.

Patentansprüche

1. Vorrichtung (1, 1A) zur Überwachung des Blasen volumens einer Person, Folgendes umfassend:

einen Sensor (10), der in einem Bereich an der Außenfläche des Abdomens der Person anzu bringen ist, wobei der Bereich der Blase der Per son entspricht, wobei der Sensor konfiguriert ist, um ein Sensorsignal zu erhalten, welches das Blasen volumen der Person angibt;
 eine Steuerungseinheit (11), die konfiguriert ist, um ein Steuersignal zu erzeugen, wenn sie fest stellt, dass die Änderung des Blasen volumens der Person einen vorbestimmten Umfang basie rend auf dem Sensorsignal übersteigt;
dadurch gekennzeichnet, dass sie darüber hi naus Folgendes umfasst:

eine Ultraschallsonde (12), die an der Per son anzubringen ist, und die konfiguriert ist, um als Reaktion auf das Steuersignal ein Ultraschallsignal in Richtung der Blase der Person zu senden, und Echosignale von der Blase der Person zu empfangen;
 eine Ableiteinheit (13), die konfiguriert ist, das Blasen volumen der Person aus den empfangenen Echosignalen abzuleiten.

2. Vorrichtung nach Anspruch 1, wobei die Steue rungseinheit (11) darüber hinaus konfiguriert ist, um zu bestimmen, ob das abgeleitete Blasen volumen der Person einen vordefinierten Schwellenwert er reicht,

wobei die Vorrichtung (1, 1A) darüber hinaus einen Alarm (14) umfasst, der konfiguriert ist, um einen Alarm auszugeben, falls die Steuerungseinheit (11) bestimmt, dass das abgeleitete Blasen volumen der Person den vordefinierten Schwellenwert erreicht.

3. Vorrichtung nach Anspruch 1, wobei die Vorrichtung (1, 1A) darüber hinaus eine Niederpassfiltereinheit (15) umfasst, die konfiguriert ist, um eine Nieder passfilterung auf das Sensorsignal anzuwenden, wobei die Steuerungseinheit (11) bestimmt, ob die Änderung des Blasen volumens der Person den vor bestimten Umfang basierend auf dem niederpass gefilterten Sensorsignal der Person übersteigt.

4. Vorrichtung nach Anspruch 1, die darüber hinaus einen oder mehrere zusätzliche Sensoren umfasst, die in einem oder mehreren zusätzlichen Bereichen der Außenfläche des Abdomens der Person außer-

- halb des Bereichs anzubringen sind, die der Blase der Person entspricht, und ausgeführt sind, um eines oder mehrere zusätzliche Sensorsignale zu erhalten, wobei die Steuerungseinheit (11) bestimmt, ob die Änderung des Blasen Volumens der Person den vorbestimmten Umfang basierend auf dem Sensorsignal und dem einen oder mehreren zusätzlichen Sensorsignalen übersteigt.
- 5
5. Vorrichtung nach irgendeinem der Ansprüche 1 bis 4, darüber hinaus Folgendes umfassend: 10
- eine Bewegungserfassungseinheit (16), die konfiguriert ist, um Bewegungsdaten der Person zu erhalten; 15
- wobei die Steuerungseinheit (11) darüber hinaus konfiguriert ist, um zu bestimmen, ob die Abweichungsrate der Bewegungsdaten der Person kleiner ist, als ein vorbestimmter Wert, und das Steuersignal zu erzeugen, wenn sie feststellt, dass die Abweichungsrate der Bewegungsdaten der Person kleiner ist, als ein vorbestimmter Wert. 20
6. Vorrichtung nach Anspruch 2, darüber hinaus Folgendes umfassend: 25
- eine Empfangseinheit (17) zum Empfangen eines Parameterwerts zur Angabe des vordefinierten Schwellenwerts, 30
- wobei die Steuerungseinheit (11) den vordefinierten Schwellenwert basierend auf dem Parameterwert erzeugt.
7. Vorrichtung nach Anspruch 1, wobei die Ultraschallsonde (12) einen Ultraschallumformer umfasst, der zwei Sätze an Ultraschallumformer-Elementen umfasst, die in einer überkreuzten Form oder T-Form konfiguriert sind, wobei jeder Satz einen oder mehrere Ultraschallumformer-Elemente umfasst. 35 40
8. Vorrichtung nach Anspruch 1, wobei die Ultraschallsonde (12) zwei getrennte Ultraschallumformer umfasst, die in einer überkreuzten Form oder T-Form konfiguriert sind, von denen jeder eines oder mehrere Ultraschallumformer-Elemente umfasst. 45
9. Vorrichtung nach Anspruch 1, wobei das Sensorsignal ein Drucksignal ist, das einen Innendruck von der Blase der Person angibt und der Sensor (10) ein piezoelektrischer Sensor ist. 50
10. Vorrichtung nach Anspruch 1, wobei das Sensorsignal ein Umfangssignal ist, das den Umfang des Abdomens der Person angibt und der Sensor (10) ein linearer Weggeber ist. 55
11. Verfahren zur Überwachung des Blasen Volumens einer Person, die folgenden Schritte umfassend
- a) Erhalten eines Sensorsignals, welches das Blasen Volumen der Person durch einen Sensor angibt, wenn der Sensor in einem Bereich an der Außenfläche des Abdomens der Person angebracht ist, wobei der Bereich der Blase der Person (S_1) entspricht;
- b) Erzeugen eines Steuersignals (S_3), wenn festgestellt wird, dass die Änderung des Blasen Volumens der Person einen vorbestimmten Umfang basierend auf dem Sensorsignal (S_2) übersteigt;
- c) als Reaktion auf das Steuersignal, das Senden eines Ultraschallsignals in Richtung der Blase der Person und Empfangen von Echosignalen von der Blase der Person durch eine Ultraschallsonde (S_4);
- d) Ableiten des Blasen Volumens der Person von den empfangenen Echosignalen (S_5);
- e) Bestimmen, ob das abgeleitete Blasen Volumen der Person einen vordefinierten Schwellenwert (S_6) erreicht;
- f) Wiederholen der Schritte a)-e) wenn festgestellt wird, dass das abgeleitete Blasen Volumen der Person den vordefinierten Schwellenwert im Schritt e) (S_6) nicht erreicht.
12. Verfahren nach Anspruch 11, darüber hinaus einen Schritt der Ausgabe eines Alarms umfassend, wenn festgestellt wird, dass das abgeleitete Blasen Volumen der Person den vordefinierten Schwellenwert im Schritt e) (S_7) erreicht.
13. Verfahren nach Anspruch 12, darüber hinaus einen Schritt des Anwendens einer Niederpassfilterung auf das Sensorsignal (S_1') umfassend, und wobei der Schritt b) darüber hinaus die Bestimmung umfasst, dass die Änderung des Blasen Volumens der Person den vorbestimmten Umfang basierend auf dem niederpassgefilterten Sensorsignal der Person (S_2) übersteigt.
14. Verfahren nach irgendeinem der Ansprüche 11 bis 13, darüber hinaus die folgenden Schritte umfassend:
- Erhalten von Bewegungsdaten der Person (S_a); und
- Bestimmen, ob die Abweichungsrate der Bewegungsdaten der Person kleiner ist, als ein vorbestimmter Wert (S_b), wobei der Schritt b) darüber hinaus das Erzeugen eines Steuersignals (S_3) umfasst, wenn festgestellt wird, dass die Abweichungsrate der Bewegungsdaten der Person kleiner ist, als ein vorbestimmter Wert (S_b).

15. Computerprogrammprodukt, Computerprogramm-befehle umfassend, die, wenn sie sich in einer Vorrichtung nach einem der Ansprüche 1 bis 10 befinden, die Vorrichtung dazu befähigen, das Verfahren nach irgendeinem der Ansprüche 11 bis 14 durchzuführen.

Revendications

1. Dispositif (1, 1A) de surveillance du volume de la vessie d'un sujet, comprenant :

un détecteur (10) à fixer à une région de la surface externe de l'abdomen du sujet, la région correspondant à la vessie du sujet, le détecteur étant configuré pour obtenir un signal du détecteur indiquant le volume de la vessie du sujet ; une unité de contrôle (11) configurée pour générer un signal de contrôle si elle détermine que le changement de volume de la vessie du sujet excède une quantité prédéterminée sur la base du signal du détecteur ;

caractérisé en ce qu'il comprend en outre :

une sonde à ultrasons (12) à fixer au sujet et configurée pour émettre, en réponse au signal de contrôle, un signal ultrasonique vers la vessie du sujet et recevoir des signaux d'écho de la vessie du sujet ; une unité de dérivation (13) configurée pour dériver le volume de la vessie du sujet à partir des signaux d'écho reçus.

2. Dispositif selon la revendication 1, dans lequel l'unité de contrôle (11) est configurée en outre pour déterminer si le volume dérivé de la vessie du sujet atteint un seuil prédéfini, le dispositif (1, 1A) comprend en outre une alarme (14) configurée pour fournir une alarme si l'unité de contrôle (11) détermine que le volume dérivé de la vessie du sujet atteint le seuil prédéfini.
3. Dispositif selon la revendication 1, dans lequel le dispositif (1, 1A) comprend en outre une unité de filtration passe-bas (15) configurée pour appliquer une filtration passe-bas au signal de détecteur, où l'unité de contrôle (11) détermine si le changement de volume de la vessie du sujet excède la quantité prédéterminée sur la base du signal de détecteur filtré passe-bas du sujet.
4. Dispositif selon la revendication 1, comprenant en outre un ou plusieurs détecteurs additionnels à fixer à une ou plusieurs régions additionnelles sur la surface externe de l'abdomen du sujet en dehors de la région correspondant à la vessie du sujet et adaptés pour obtenir un ou plusieurs signaux de détecteur

additionnels, où l'unité de contrôle (11) détermine si le changement de volume de la vessie du sujet excède la quantité prédéterminée sur la base du signal du détecteur et du un ou plusieurs signaux de détecteur additionnels.

5. Dispositif selon l'une quelconque des revendications 1 à 4, comprenant en outre :

une unité de détection de mouvement (16) configurée pour obtenir des données de mouvement du sujet ; où l'unité de contrôle (11) est configurée en outre pour déterminer si le niveau de variation des données de mouvement du sujet est inférieur à une valeur prédéterminée, et génère le signal de contrôle si elle détermine que le niveau de variation des données de mouvement du sujet est inférieur à une valeur prédéterminée.

6. Dispositif selon la revendication 2, comprenant en outre :

une unité de réception (17) pour recevoir une valeur de paramètre indiquant le seuil prédéfini, où l'unité de contrôle (11) génère le seuil prédéfini sur la base de la valeur du paramètre.

7. Dispositif selon la revendication 1, la sonde à ultrasons (12) comprenant un transducteur pour ultrasons comprenant deux ensembles d'éléments de transducteur pour ultrasons configurés en forme de croix ou en forme de T, chaque ensemble comprenant un ou plusieurs éléments de transducteur pour ultrasons.

8. Dispositif selon la revendication 1, la sonde à ultrasons (12) comprenant deux transducteurs séparés pour ultrasons qui sont configurés en forme de croix ou en forme de T, chacun comprenant un ou plusieurs éléments de transducteur pour ultrasons.

9. Dispositif selon la revendication 1, le signal de détecteur étant un signal de pression indiquant la pression interne provenant de la vessie du sujet et le détecteur (10) étant un détecteur piézoélectrique.

10. Dispositif selon la revendication 1, le signal de détecteur étant un signal de périmètre indiquant le périmètre de l'abdomen du sujet et le détecteur (10) étant un détecteur de déplacement linéaire.

11. Procédé de suivi du volume de la vessie d'un sujet, comprenant l'étape de

a) obtention d'un signal de détecteur indiquant le volume de la vessie du sujet à l'aide d'un détecteur lorsque le détecteur est fixé à une région

- sur la surface externe de l'abdomen du sujet, la région correspondant à la vessie du sujet (S_1) ;
 b) production d'un signal de contrôle (S_3) s'il est déterminé que le changement de volume de la vessie du sujet excède une quantité prédéterminée sur la base du signal du détecteur (S_2) ;
 c) en réponse au signal de contrôle, l'émission d'un signal ultrasonique vers la vessie du sujet et la réception des signaux d'écho de la vessie du sujet à l'aide d'une sonde à ultrasons (S_4) ;
 d) dérivation du volume de la vessie du sujet à partir des signaux d'écho reçus (S_5) ;
 e) détermination du fait que le volume dérivé de la vessie du sujet atteint un seuil prédéfini (S_6) ;
 f) répétition des étapes a) à e) s'il est déterminé que le volume dérivé de la vessie du sujet n'atteint pas le seuil prédéfini dans l'étape e) (S_6).
12. Procédé selon la revendication 11, comprenant en outre une étape de fourniture d'une alarme s'il est déterminé que le volume dérivé de la vessie du sujet atteint le seuil prédéfini dans l'étape e) (S_7).
13. Procédé selon la revendication 12, comprenant en outre une étape d'application d'un filtre passe-bas au signal du détecteur (S_1'), et l'étape b) comprenant en outre la détermination que le changement de volume de la vessie du sujet excède la quantité prédéterminée sur la base du signal de détecteur filtré passe-bas du sujet (S_2).
14. Procédé selon l'une quelconque des revendications 11 à 13, comprenant en outre les étapes de :
- obtention de données de mouvement du sujet (S_a) ; et
 détermination du fait que le niveau de variation des données de mouvement du sujet est inférieur à une valeur prédéterminée (S_b),
 l'étape b) comprenant en outre la production du signal de contrôle (S_3) s'il est déterminé que le niveau de variation des données de mouvement du sujet est inférieur à une valeur prédéterminée (S_b).
15. Logiciel comprenant des instructions de programme informatique, qui, lorsqu'il se trouve sur un dispositif selon l'une quelconque des revendications 1 à 10, permet au dispositif d'exécuter le procédé selon l'une quelconque des revendications 11 à 14.

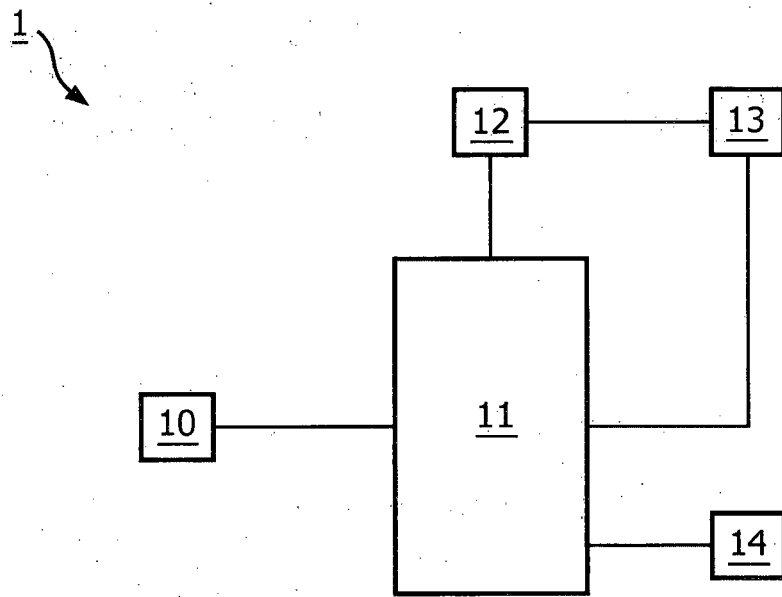


FIG. 1

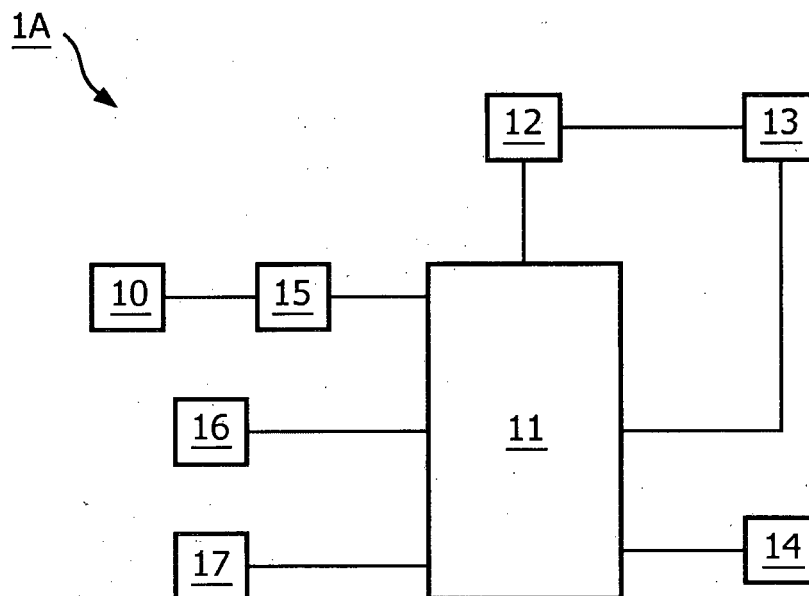


FIG. 2

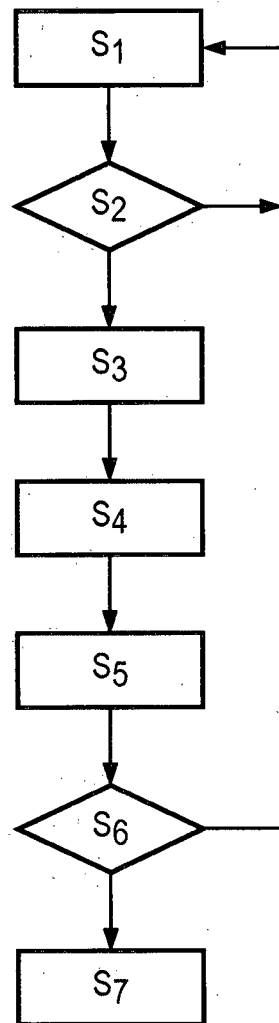


FIG. 3

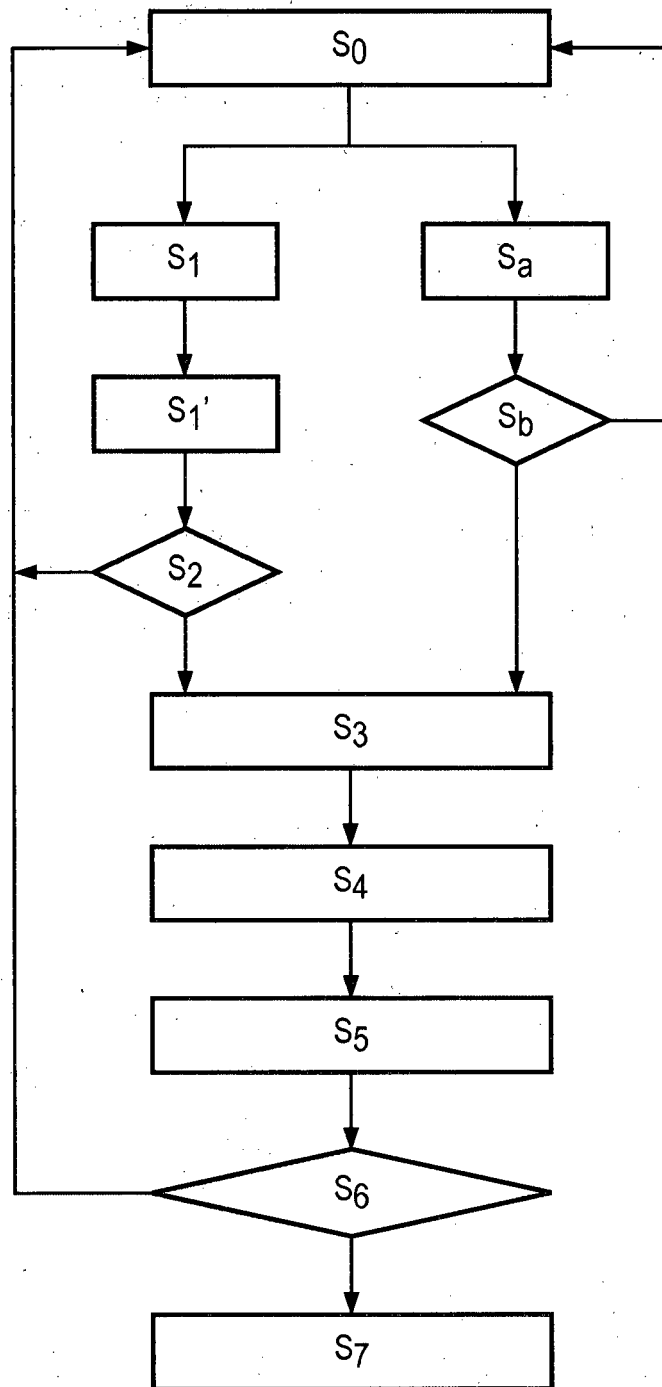


FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	用于监测受试者的膀胱体积的装置和方法		
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申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	XU JINGPING		
发明人	XU, JINGPING		
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摘要(译)

本发明提供了一种用于监测受试者的膀胱体积的装置和方法。一种用于监测对象的膀胱体积的装置包括传感器，该传感器附接到对象腹部的外表面上的区域，该区域对应于对象的膀胱，该传感器被配置为获得指示传感器信号的传感器信号。受试者的膀胱容积;控制单元，被配置为如果基于传感器信号确定对象的膀胱体积的变化超过预定量，则生成控制动作信号;超声探头，其连接到受试者并且被配置为响应于控制信号发射朝向受试者膀胱的超声信号并从受试者的膀胱接收回声信号;导出单元，被配置为从接收的回波信号中导出对象的膀胱体积。根据该装置，可以实现对受试者的膀胱体积的长时间监测。

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(54)DEVICE AND METHOD FOR MONITORING BLADDER VOLUME OF A SUBJECT
VORRICHTUNG UND VERFAHREN ZUR ÜBERWACHUNG DES BLASENVOLUMENS EINER PERSON
DISPOSITIF ET PROCÉDÉ DE CONTRÔLE DU VOLUME DE LA VESSIE D'UN SUJET

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(72)Inventor: XU, Jingping
NL 5656 AE Eindhoven (NL)

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(73)Applicant: Koninklijke Philips N.V.
5656 AE Eindhoven (NL)

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