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(54) METHOD AND APPARATUS FOR DISPLAYING AN ULTRASOUND IMAGE

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(57) **ABSTRACT**

A method for displaying an ultrasound image on a display device is provided. Image signals are generated with an ultrasound probe during examination of an item under examination with ultrasound and are transferred to a data processing device. The image signals are displayed by the data processing device as an ultrasound image on a display device. In order to make it easier for an operator to observe the ultrasound image, by means of an orientation detection device, a change in orientation of the display device in space is detected and an associated change in orientation signal is provided to the data processing device and the orientation of the ultrasound image on the display device is changed by the data processing device as a function of the change in orientation of the display device in space. An apparatus for carrying out the method is also provided.

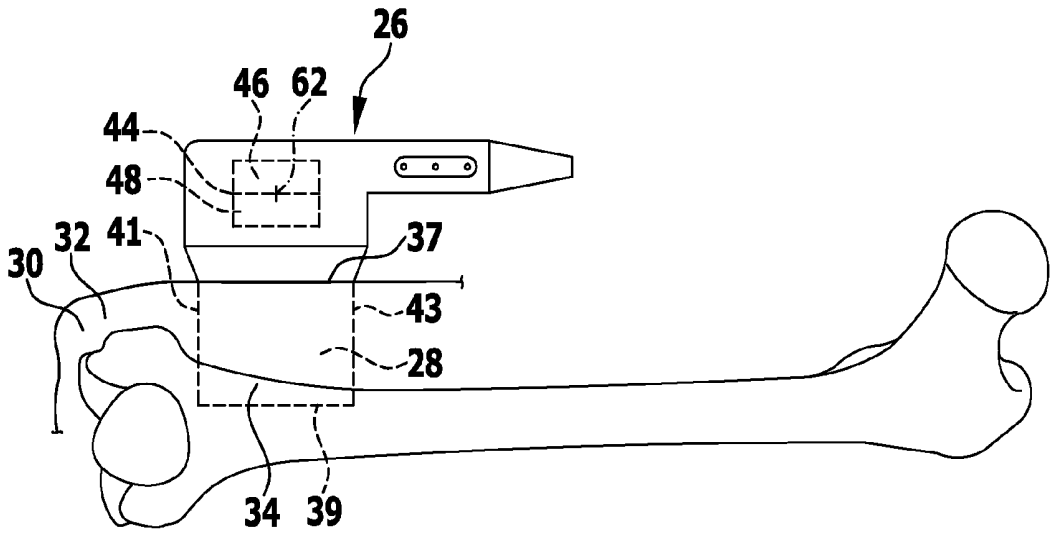
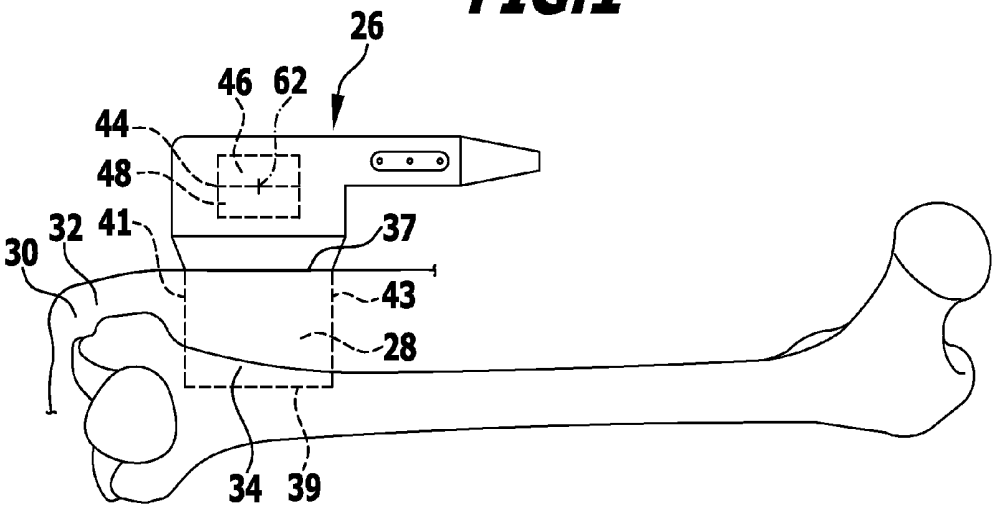


FIG.1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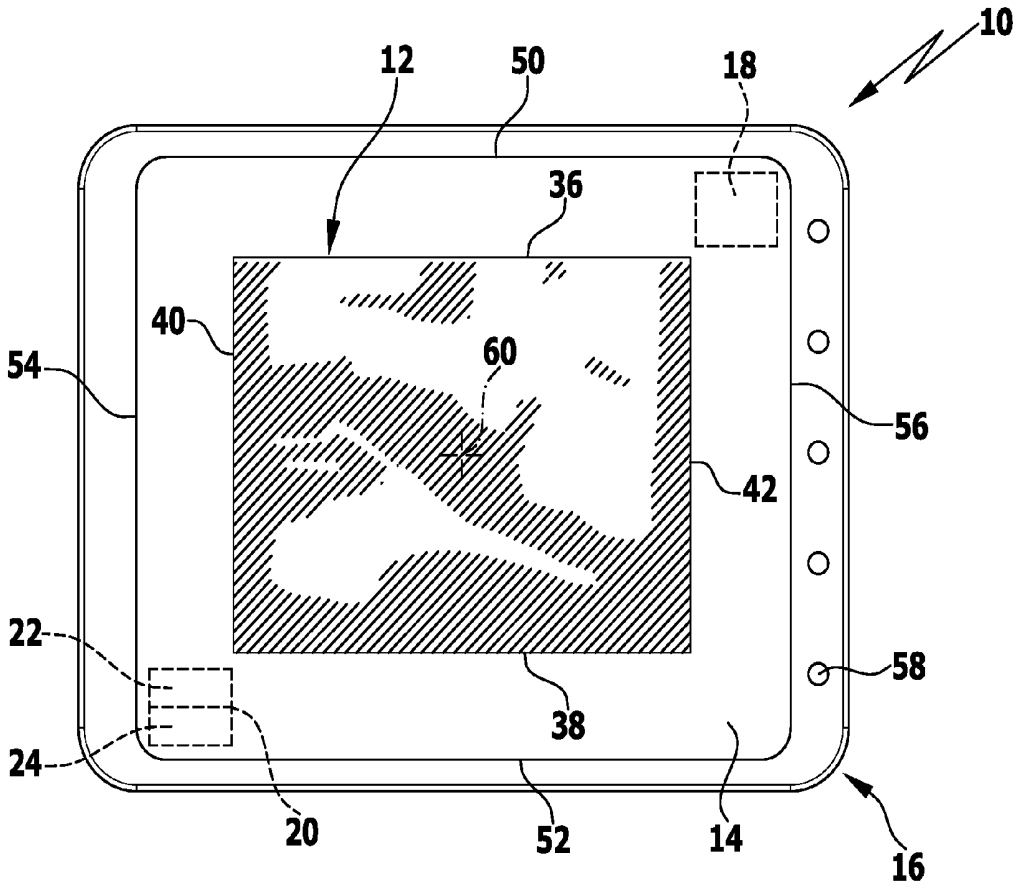
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FIG.2

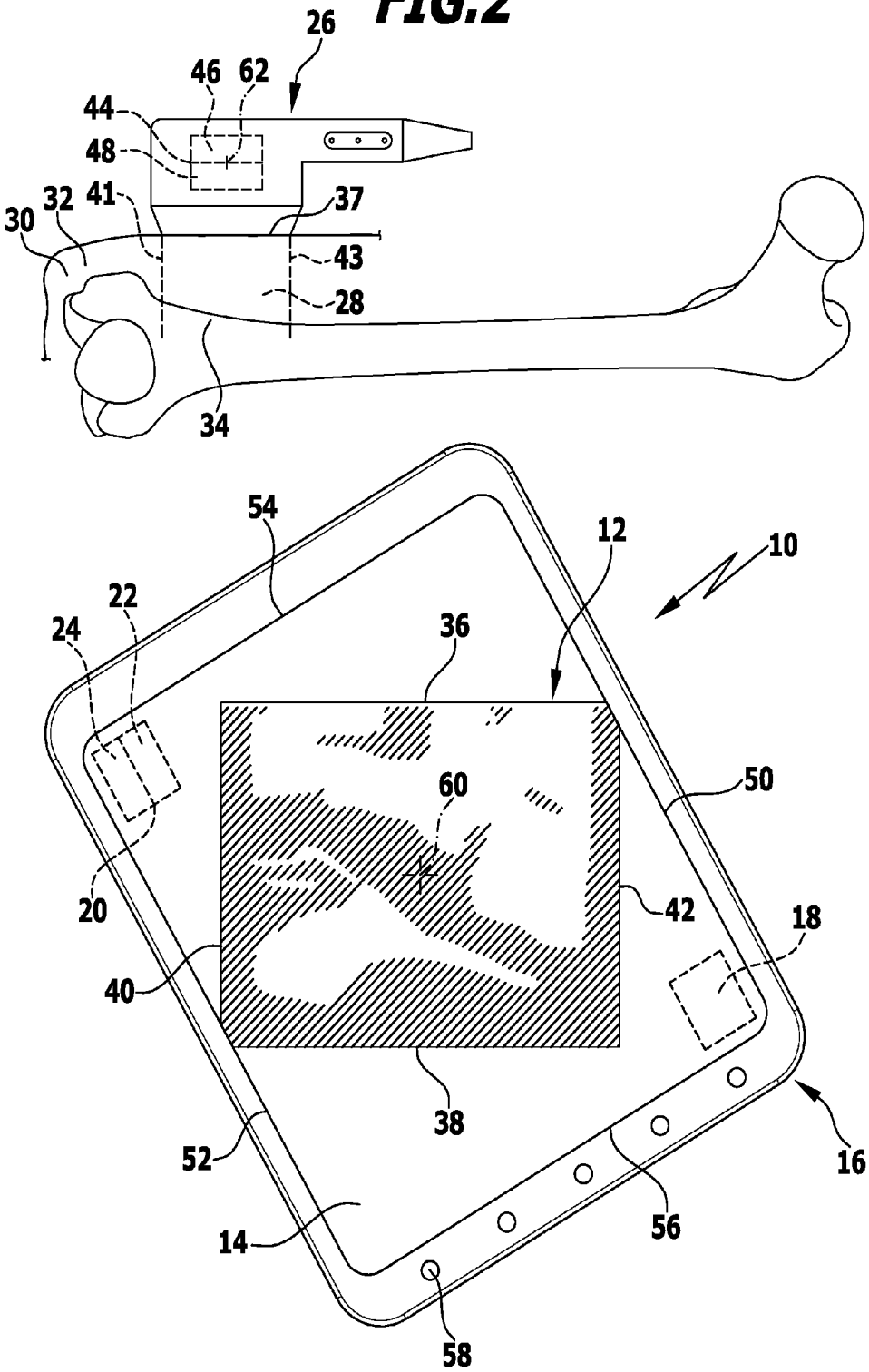
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FIG.3

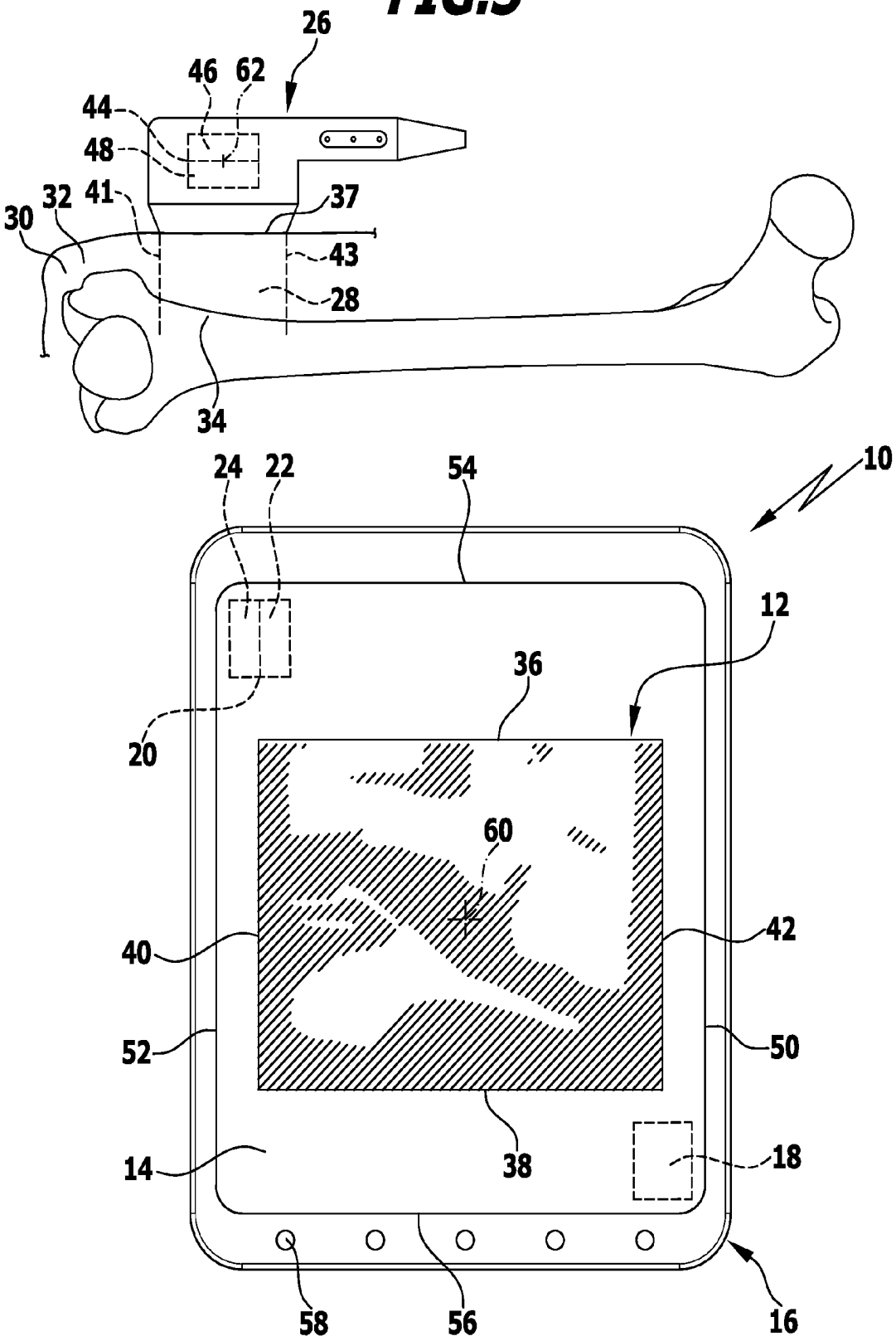
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FIG.4

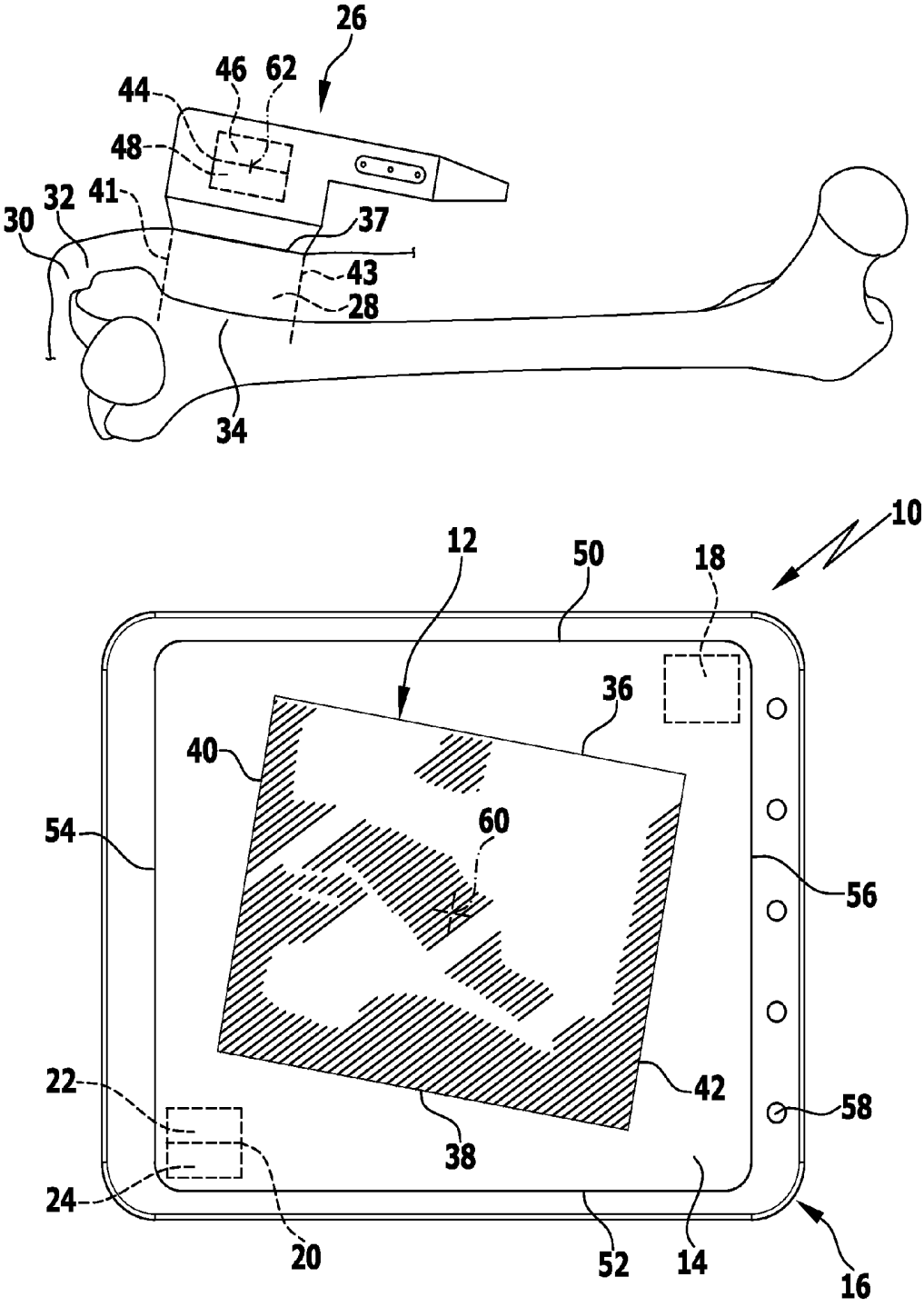
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FIG.5

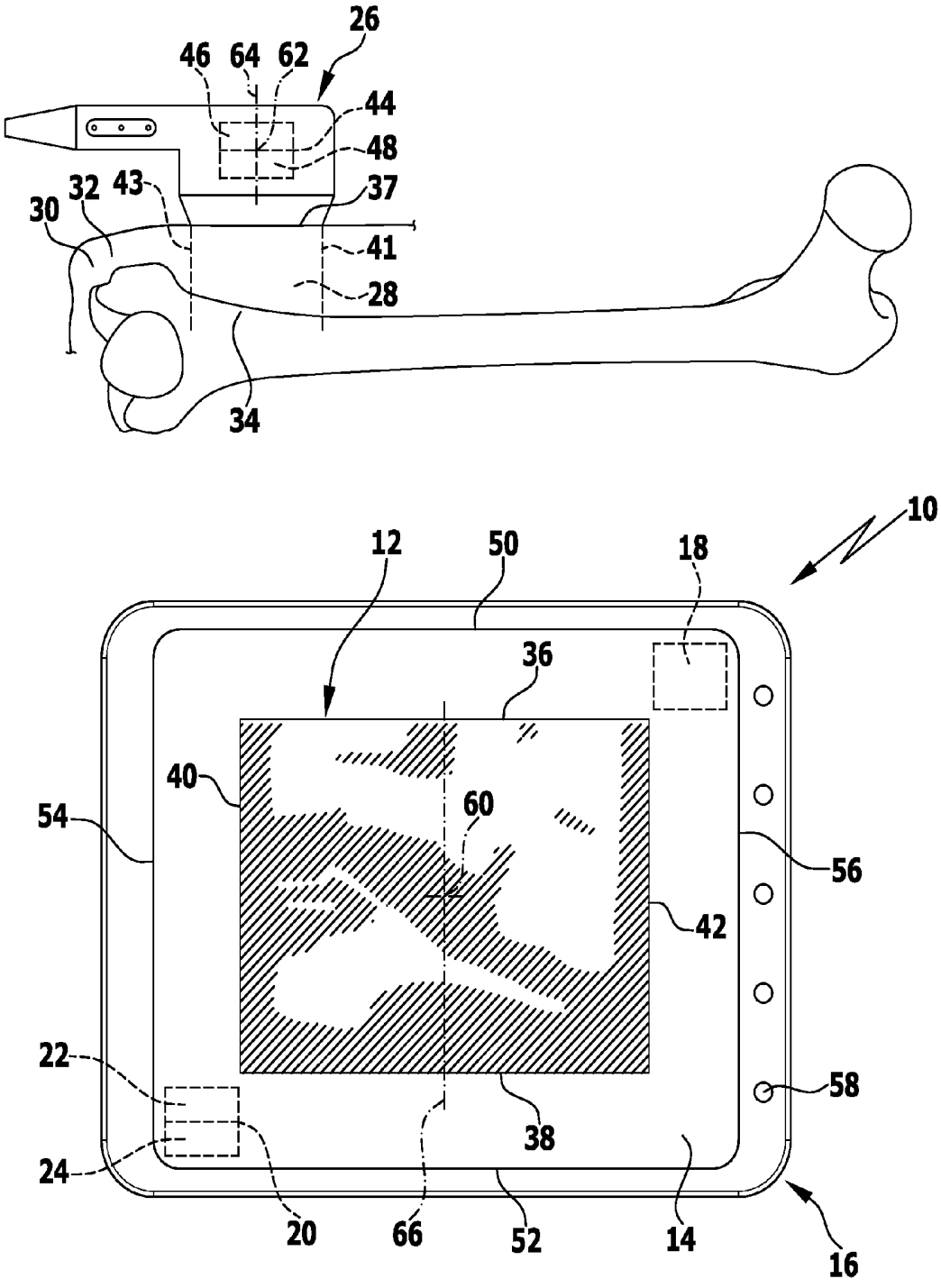
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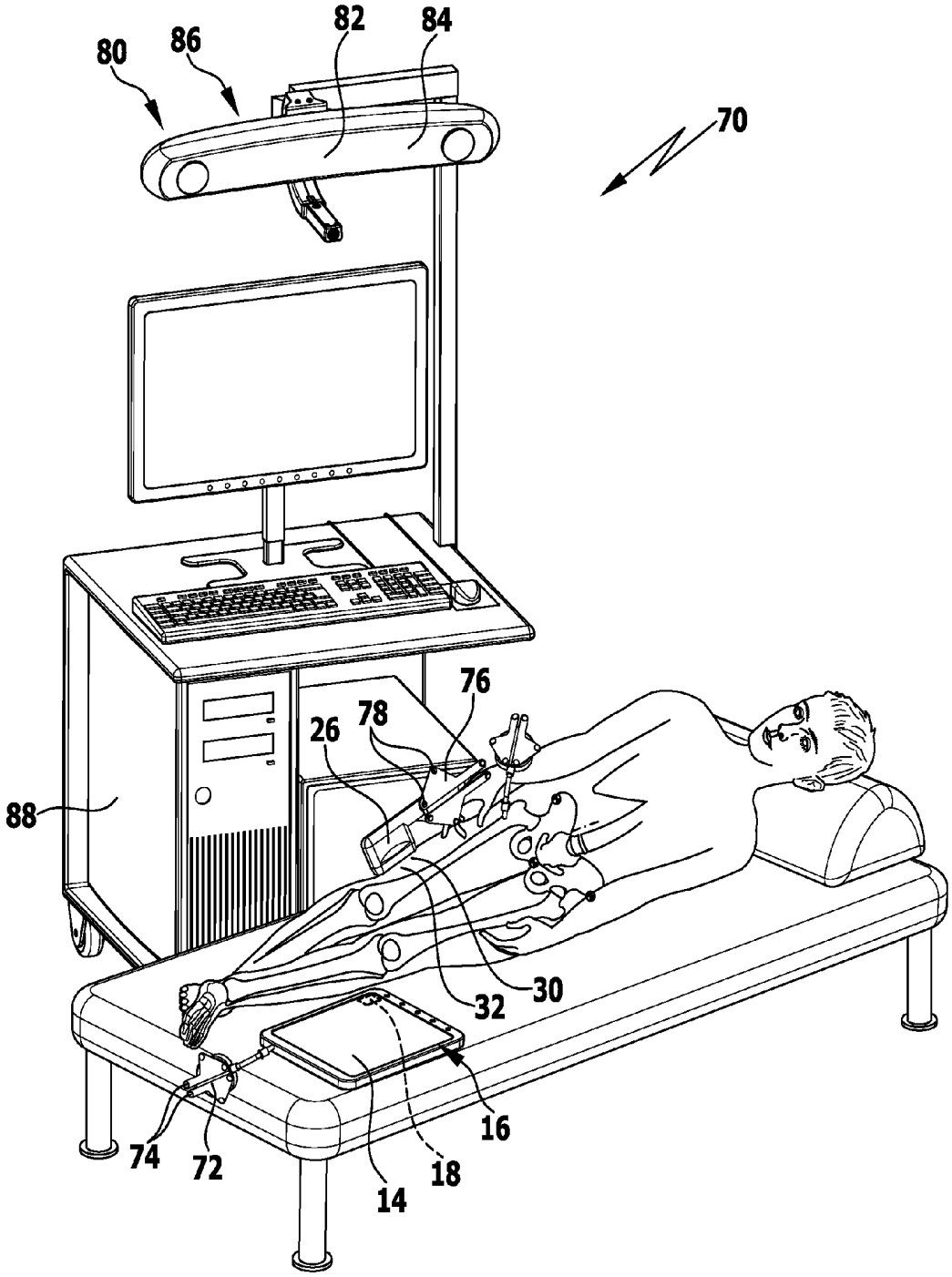
FIG.6



METHOD AND APPARATUS FOR DISPLAYING AN ULTRASOUND IMAGE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of German application number DE 10 2012 100 504.4, filed Jan. 23, 2012, which is incorporated herein by reference in its entirety and for all purposes.

FIELD OF THE INVENTION

[0002] The present invention relates to a method for displaying an ultrasound image on a display device, in which image signals are generated with an ultrasound probe during examination of an item under examination with ultrasound and are transferred to a data processing device and the image signals are displayed by the data processing device as an ultrasound image on a display device.

[0003] Moreover, the present invention relates to an apparatus for displaying an ultrasound image on a display device, in particular for carrying out the above-stated method, comprising an ultrasound probe for generating image signals during examination of an item under examination with ultrasound, a data processing device to which the image signals are transferable and on which the image signals are processable, and a display device which is suppliable by the data processing device with ultrasound image information for displaying an ultrasound image.

BACKGROUND OF THE INVENTION

[0004] It is known to produce two-dimensional images of items under examination with ultrasound probes and to display said images as an ultrasound image on a display device. The ultrasound probe conventionally comprises a plurality of ultrasound transmitters arranged in a linear array which in each case emit ultrasound radiation and consequently generate an ultrasound image which conventionally defines a plane. The emitted ultrasound radiation penetrates into the item under examination, is reflected on specific structures thereof and received back by the ultrasound probe, the distance of the reflective structure from the ultrasound probe being determined by the echo time of the ultrasound radiation between emission thereof and reception by the ultrasound probe. The ultrasound image is generally a two-dimensional representation of the reflective structure. Starting from upper edge of the ultrasound image, which corresponds to an examination zone adjacent the linear array of ultrasound transmitters, the propagation time of the ultrasound beam and thus the distance of the reflective structures from the ultrasound transmitters is displayed downwardly. The transverse direction of the ultrasound image corresponds to the spatial arrangement of the reflective structures lengthwise or parallel to the linear arrangement of ultrasound transmitters.

[0005] The ultrasound image is typically displayed in the plane of the ultrasound probe in which the ultrasound radiation is emitted. For example, the left-hand side of the display device is associated with the left-hand side of the ultrasound probe and the right-hand side of the display device to the right-hand side of the ultrasound probe.

[0006] However, if the orientation of the ultrasound probe changes relative to the item under examination, for instance in the event of rotation, tilting or panning of the probe, this association remains unchanged. This may on occasion make it more difficult for an operator to establish how the ultrasound probe is oriented relative to the item under examination. In order to make this easier for an operator, DE 10 2006 024 629 B4 proposes determining the location of the ultrasound probe in space by means of a navigation system and supplying a corresponding signal to the data processing device which displays the ultrasound image on the display device. The data processing device keeps the orientation of the image constant if the change in orientation of the ultrasound probe in space is within a defined angular range but changes the orientation of the image on the display device if the ultrasound probe is moved out of this angular range into an adjacent angular range.

[0007] The method described in DE 10 2006 024 629 B4 does not take account of the fact that the operator may move relative to the display device and that the operator's viewing angle onto the display device may change. Despite the advantage which may be achieved by the method mentioned in the above-stated document, associating structures recognisable in the ultrasound image with structures of the item under examination may be made more difficult.

[0008] An object underlying of the present invention is to provide a method of the generic type and an apparatus of the generic type which make it easier for an operator to observe the ultrasound image.

SUMMARY OF THE INVENTION

[0009] In an aspect of the invention, a method is provided for displaying an ultrasound image on a display device, in which image signals are generated with an ultrasound probe during examination of an item under examination with ultrasound and are transferred to a data processing device and the image signals are displayed by the data processing device as an ultrasound image on a display device. By means of an orientation detection device, a change in the orientation of the display device in space is detected and an associated change in orientation signal is provided to the data processing device and the orientation of the ultrasound image on the display device is changed by the data processing device as a function of the change in orientation of the display device in space.

[0010] In another aspect of the invention, an apparatus for displaying an ultrasound image on a display device, in particular for carrying out the above-stated method, comprises an ultrasound probe for generating image signals during examination of an item under examination with ultrasound, a data processing device to which the image signals are transferable and on which the image signals are processable, and a display device which is suppliable by the data processing device with ultrasound image information for displaying an ultrasound image. The apparatus comprises a first orientation detection device for detecting a change in orientation of the display device in space and transferring an associated change in orientation signal to the data processing device. The data processing device is configured and programmed such that it changes the orientation of the ultrasound image on the display device as a function of the change in orientation of the display device in space.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0011] The foregoing summary and the following description may be better understood in conjunction with the drawing figures, of which:

[0012] FIG. **1**: is a schematic diagram of a preferred embodiment of an apparatus according to an aspect of the invention comprising an ultrasound probe, with which an item under examination in the form of a femur is examined, and of an integrated display and data processing device on which an ultrasound image is displayed;

[0013] FIG. **2**: shows the apparatus from FIG. **1**, the display device being illustrated rotated by a first angle of rotation;

[0014] FIG. **3**: shows the apparatus from FIG. **1**, the display device being illustrated rotated by a second angle of rotation;

[0015] FIG. **4**: shows the apparatus from FIG. **1**, the ultrasound probe and the ultrasound image in each case being illustrated rotated by an angle of rotation;

[0016] FIG. **5**: shows the apparatus from FIG. **1**, the ultrasound probe examining the same examination zone of the femur but being illustrated rotated by 180° and

[0017] FIG. **6**: shows a further preferred embodiment of the apparatus according to an aspect of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0018] Although the invention is illustrated and described herein with reference to specific embodiments, the invention is not intended to be limited to the details shown. Rather, various modifications may be made in the details within the scope and range of equivalents of the claims and without departing from the invention.

[0019] The present invention relates to a method for displaying an ultrasound image on a display device, in which image signals are generated with an ultrasound probe during examination of an item under examination with ultrasound and are transferred to a data processing device and the image signals are displayed by the data processing device as an ultrasound image on a display device. By means of an orientation detection device, a change in the orientation of the display device in space is detected and an associated change in orientation signal is provided to the data processing device and the orientation of the ultrasound image on the display device is changed by the data processing device as a function of the change in orientation of the display device in space.

[0020] The method according to an aspect of the invention provides detecting when the orientation of the display device in space changes. A corresponding change in orientation signal may be supplied to the data processing device. The data processing device is capable of changing the ultrasound image on the display device as a function of the change in orientation. This for example makes it possible to use a display device which is designed to be movable in such a manner that it may be positioned as required by the operator such that the ultrasound image is readily visible. For example, the display device may be positioned such that the ultrasound image is displayed for the operator in the plane of the ultrasound probe. A change in orientation of the ultrasound image on the display device by the data processing device may in particular proceed in such a manner that, in the event of a change in orientation of the display device, the ultrasound image is maintained for the operator. For example, in this way a user-oriented display of the ultrasound image may be achieved which, in the event of a change in orientation of the display device in space, is stationary relative to the operator. This makes it considerably easier for an operator to recognise the ultrasound image and to associate structures contained therein with structures of the item under examination. A display device which is freely movable in space, for example included in a tablet computer or the like, is preferably used in the method according to an aspect of the invention. This enables the operator to position the display device flexibly in space in such a manner that he/she has the best possible view of the ultrasound image.

[0021] The ultrasound image may, for example, be rotated as a function of rotation of the display device in space.

[0022] It is favourable for the ultrasound image to be rotated in the opposite direction to the rotation of the display device, preferably by the same angular amount, about an axis of rotation oriented perpendicularly to ultrasound image plane. This makes it possible to display the ultrasound image on the display device stationarily relative to the operator.

[0023] Advantageously, the ultrasound image is not rotated if the angle of rotation of the display device is below a predeterminable threshold angle of rotation and is only rotated once the angle of rotation exceeds the threshold angle of rotation. In the event of an only slight rotation of the display device by an angle of rotation below the threshold angle of rotation, the image is kept constant on the display device. This is in particular advantageous in the event of an intrinsically unintentional rotation of the display device, for example due to its being knocked.

[0024] The orientation of the ultrasound image is preferably not changed if the display device is rotated about an axis of rotation which extends in the ultrasound image plane, i.e. if the display device is inclined or tilted relative to the original ultrasound image plane. In this way, a user-oriented display of the ultrasound image on the display device may for example be kept constant.

[0025] In the event of a movement of the display device in space such that it is moved parallel relative to the original ultrasound image plane, but no rotation occurs, it is advantageous for there to be no change in orientation of the ultrasound image.

[0026] If the display device is panned about an axis which is oriented obliquely relative to the ultrasound image plane, this may be attributed to a superimposed movement, namely rotation of the display device about an axis oriented perpendicularly to the ultrasound image plane, about at least one axis extending in the ultrasound image plane, optionally together with a parallel movement of the display device in space. A possible change in orientation of the ultrasound image on the display device may then be identified by considering the change in orientation of the ultrasound image as a function of the rotation about the axes perpendicular to or in the ultrasound image plane and as a function of the parallel movement of the display device.

[0027] It is favourable for the change in orientation of the ultrasound image to proceed as a function of a change in orientation of the display device subject to an actuating element being actuated by an operator, without which actuation the orientation of the ultrasound image is kept constant even in the event of a change in orientation of the display device in space. This enables the operator to set a display mode of the display device in such a manner that the ultrasound image is changed selectively. As a consequence, the method exhibits greater versatility. It may for example be provided for the operator initially to position the display device in a manner advantageous to the operator and then to actuate the actuating element, whereupon the orientation of the ultrasound image is changed as a function of the change in orientation of the display device.

[0028] An orientation detection device included in or arranged on the display device is preferably used to detect a change in orientation of the display device in space, the display device and the data processing device favourably being integrated in one another. "Integrated in one another" may in the present case in particular mean "located in a common device". This proves advantageous for example when using a tablet computer or the like which includes the display device. The orientation detection device for example comprises an inclination sensor and/or a compass sensor for detecting a change in orientation of the display device.

[0029] It may alternatively or additionally be provided that an orientation detection device spatially separate from the display device be used in order to detect the change in orientation of the display device in space. It is here in particular possible for a marker device to be fixed to the display device or for the latter to comprise such a marker device, the change in orientation of which in space is detected by the orientation detection device. It may for example be provided for this purpose that the marker device emit and/or reflect electromagnetic radiation which is detected by the orientation detection device which may for this purpose comprise a camera.

[0030] The orientation of the ultrasound image on the display device is preferably selected such that the ultrasound image is oriented on the display device parallel to the ultrasound field emitted by the ultrasound probe, relative to a projection of the ultrasound image on a plane defined by the ultrasound field. This makes it possible to display the ultrasound image in the plane of the ultrasound field in such a manner that for example the left-hand and the right-hand side of the ultrasound image are respectively associated with the left-hand and right-hand side of the ultrasound field, and the top side and the bottom side of the ultrasound image are respectively associated with the beginning and end of the ultrasound field (smallest and greatest distances from the ultrasound transmitters and ultrasound receivers). It may thus be ensured that the ultrasound image is displayed in a fixed geometric relationship to the ultrasound field. This enables the operator more straightforwardly to associate structures of the ultrasound image with structures of the item under examination.

[0031] It is advantageous if, by means of an orientation detection device, a change in orientation of the ultrasound probe in space is detected and an associated change in orientation signal is transferred to the data processing device and if the orientation of the ultrasound image on the display device is changed as a function of the change in orientation of the ultrasound probe in space. This additionally makes it simpler for an operator to associate structures in the ultrasound image with structures of the item under examination. In this manner, it is in particular possible not only to enable a user-oriented display of the ultrasound image, but it is furthermore at the same time also possible to provide a device-oriented display of the ultrasound image, which display changes in the event of a change in orientation of the ultrasound probe in space.

[0032] For example, the ultrasound image is rotated on the display device as a function of rotation of the ultrasound probe in space.

[0033] In particular, it may advantageously be provided that, in the event of rotation of the ultrasound probe about an axis of rotation perpendicular to a plane defined by the ultrasound field, the ultrasound image on the display device be rotated about an axis of rotation oriented perpendicularly to the ultrasound image plane, in the same direction of rotation and preferably by the same angular amount. For example, if the ultrasound probe is rotated rightwards relative to an operator, the ultrasound image on the display device is likewise rotated rightwards and vice versa, the geometric relationship of the ultrasound image to the geometry of the ultrasound field preferably being maintained.

[0034] It may furthermore be provided that the image not be rotated if the angle of rotation of the ultrasound probe is below a predeterminable threshold angle of rotation and only be rotated once the angle of rotation exceeds the threshold angle of rotation, such that, in the event of slight rotational movements of the ultrasound probe which fall below the threshold angle of rotation, there is no change to the ultrasound image. This makes it easier for an operator to recognise the ultrasound image.

[0035] In the event of rotation of the ultrasound probe by 180° or substantially 180° about an axis of rotation which extends centrally in the plane of the ultrasound field, it is advantageous for the ultrasound image on the display device to be mirrored about a mirror plane perpendicular to the ultrasound image plane, which is oriented parallel to or contains the axis of rotation and extends through the centre of the ultrasound image. This makes it possible to provide two left/right orientation options and/or two top/bottom orientation options for the ultrasound image. If, for example, the ultrasound probe is rotated by 180° about an axis of rotation oriented centrally in the ultrasound field along the direction of propagation of the ultrasound radiation and thus the left-hand side of the ultrasound probe is, as it were, swapped with the right-hand side, the ultrasound image observable by the operator remains unchanged. This saves the operator the task of mirroring the ultrasound image in his/her head, this instead being carried out by mirroring of the ultrasound image on the display device. A corresponding situation applies when the ultrasound probe is rotated by 180° about an axis of rotation which is oriented perpendicularly to direction of propagation the ultrasound radiation and extends in the plane of the ultrasound field.

[0036] An orientation detection device included in or arranged on the ultrasound probe is preferably used in order to detect the change in orientation of the ultrasound probe in space. The orientation detection device comprises for example an inclination sensor and/or a compass sensor for detecting the change in orientation. A corresponding change in orientation signal may be supplied to the data processing device, together with the image signals for the ultrasound image.

[0037] It may alternatively or additionally be provided that an orientation detection device spatially separate from the ultrasound probe be used in order to detect the change in orientation of the ultrasound probe in space. For example, a marker device arranged on or included in the ultrasound probe is used which is capable of emitting and/or reflecting electromagnetic radiation, the electromagnetic radiation being detectable by the orientation detection device and an associated change in orientation signal being transferrable to the data processing device.

[0038] Moreover, the present invention relates to an apparatus for displaying an ultrasound image on a display device comprising an ultrasound probe for generating image signals during examination of an item under examination with ultrasound, a data processing device to which the image signals are transferable and on which the image signals are processable, and a display device which is suppliable by the data process-

ing device with ultrasound image information for displaying an ultrasound image. The apparatus comprises a first orientation detection device for detecting a change in orientation of the display device in space and transferring an associated change in orientation signal to the data processing device. The data processing device is configured and programmed such that it changes the orientation of the ultrasound image on the display device as a function of the change in orientation of the display device in space.

[0039] The method according to the aspect of the invention mentioned above may be carried out by means of the apparatus, and the advantages achievable by using the method according to the aspect of the invention mentioned above, to which reference is made in order to avoid repetition, may likewise be achieved by means of the apparatus.

[0040] The data processing device is for example configured and programmed such that it rotates the ultrasound image as a function of rotation of the display device in space.

[0041] It is favourable for the data processing device to be configured and programmed such that it rotates the ultrasound image on the display device in the opposite direction to the rotation of the display device, preferably by the same angular amount, about an axis of rotation oriented perpendicularly to the ultrasound image plane.

[0042] It may here in particular be provided that the data processing device be configured and programmed such that it does not rotate the ultrasound image if the angle of rotation of the display device is below a threshold angle of rotation and only rotates it once the angle of rotation exceeds the threshold angle of rotation.

[0043] The data processing device is advantageously configured and programmed such that it does not change the orientation of the ultrasound image on the display device if the display device is rotated about an axis of rotation which extends in the ultrasound image plane.

[0044] It is also favourable for the data processing device to be configured and programmed such that the orientation of the ultrasound image is not changed if the display device is moved parallel in space relative to the original ultrasound image plane, but no rotation occurs.

[0045] It is favourable for the apparatus to comprise an actuating element and for the data processing device to be configured and programmed such that it changes the orientation of the ultrasound image as a function of actuation of the actuating element, without which actuation the data processing device keeps the orientation of the ultrasound image constant even in the event of a change in orientation of the display device in space. The actuating element is arranged for example on the display device or on the data processing device.

[0046] The display device preferably comprises the first orientation detection device, the data processing device and the display device preferably being integrated in one another. This enables a spatially compact and simple design of the apparatus.

[0047] It may be provided that the first orientation detection device comprise at least one inclination sensor and/or at least one compass sensor for detecting the change in orientation of the display device in space.

[0048] It may alternatively or additionally be provided that the first orientation detection device be constructed spatially separately from the display device, that the display device comprise a marker device or such a marker device be arranged on the display device and that the orientation detection device preferably be configured for detecting radiation emitted and/or reflected from the marker device. This makes it possible for example to use a navigation system in which, by means of the orientation detection device, not only is a change in orientation of the display device in space detected, but also a change in orientation of further components of the apparatus in space, in particular of the ultrasound probe.

[0049] It is favourable for the data processing device to be configured and programmed such that it selects the orientation of the ultrasound image on the display device such that the ultrasound image is oriented parallel to the ultrasound field emitted by the ultrasound probe, relative to a projection of the ultrasound image on a plane defined by the ultrasound field. In this manner, as already mentioned, a fixed geometric relationship may be ensured between the ultrasound image and the ultrasound field, with for example the left-hand side of the ultrasound image being associated with the left-hand side of the ultrasound field and the right-hand side of the ultrasound image with the right-hand side of the ultrasound field.

[0050] It is advantageous for the apparatus to comprise a second orientation detection device for detecting a change in orientation of the ultrasound probe in space and transferring an associated change in orientation signal to the data processing device and for the data processing device to be configured and programmed such that it changes the orientation of the ultrasound image on the display device as a function of the change in orientation of the ultrasound probe in space. As already mentioned, in this way the ultrasound image may be displayed not only in user-oriented manner but additionally in device-oriented manner. This makes it easier for an operator to associate structures in the ultrasound image with structures of the item under examination.

[0051] It may be provided that the first and the second orientation detection device be integrated in one another. In particular, the first orientation detection device may entirely or in part include and/or form the second orientation detection device.

[0052] The data processing device is, for example, configured and programmed such that it rotates the ultrasound image on the display device as a function of rotation of the ultrasound probe in space.

[0053] Advantageously, the data processing device is configured and programmed such that, in the event of rotation of the ultrasound probe about an axis of rotation perpendicular to a plane defined by the ultrasound field, it rotates the ultrasound image on the display device about an axis of rotation oriented perpendicularly to the ultrasound image plane, in the same sense of rotation and preferably by the same angular amount.

[0054] It is favourable for the data processing device to be configured and programmed such that it does not rotate the image if the angle of rotation of the ultrasound probe is below a threshold angle of rotation and only rotates it once the angle of rotation exceeds the threshold angle of rotation, in order to keep the ultrasound image constant in the event of the ultrasound probe being turned by only a small angular amount and to make it easier for an operator to comprehend it.

[0055] It is advantageous for the data processing device to be configured and programmed such that, in the event of rotation of the ultrasound probe by 180° or substantially 180° about an axis of rotation which extends centrally in the plane of the ultrasound field and centrally therethrough, the ultrasound image on the display device is mirrored about a mirror

plane perpendicular to the ultrasound image plane, which is oriented parallel to or contains the axis of rotation and extends through the centre of the ultrasound image. As already explained, it is consequently possible for there to be two left/right orientation options and/or two top/bottom orientation options for the ultrasound image relative to the geometry of the ultrasound probe. An operator is thereby saved the task of mirroring the ultrasound image mentally in order to associate structures of the ultrasound image with structures of the item under examination.

[0056] In order to achieve a compact and simple design of the apparatus, it may be provided that the ultrasound probe include the second orientation detection device.

[0057] For example, it is favourable for the second orientation detection device to comprise at least one inclination sensor and/or at least one compass sensor with which a change in orientation of the ultrasound probe may be detected.

[0058] Alternatively or additionally, it may advantageously be provided that the second orientation detection device be constructed spatially separately from the ultrasound probe, that the ultrasound probe comprise a marker device or such a marker device be arranged on the ultrasound probe and that preferably the second orientation detection device be configured for detecting radiation emitted and/or reflected by the marker device. It may in particular be provided in this embodiment that the first and the second orientation detection device be identical and be capable of detecting radiation emitted and/or reflected in each case by marker devices which are associated with the display device or to ultrasound probe.

[0059] It is favourable for the apparatus to comprise a tablet computer which comprises the display device. This makes it possible for the operator to position the display device in such a manner that he/she has a good view of the ultrasound image and is consequently able straightforwardly to associate structures of the ultrasound image with structures of the item under examination. By means of a change in orientation of the tablet computer in space, in particular rotation about an axis perpendicular to the ultrasound image plane, the ultrasound image on the display device is changed and in particular rotated in the opposite direction, so enabling a user-oriented display of the ultrasound image. In addition, as explained above, the ultrasound image may be displayed in device-oriented manner, a fixed spatial relationship preferably being provided between the ultrasound image and the ultrasound field. In particular, a change in orientation of the ultrasound probe in space may be detected, specifically rotation about an axis perpendicular to the ultrasound image plane and in this manner the image on the display may be changed and in particular rotated about an axis of rotation perpendicular to the ultrasound image plane.

[0060] The present invention is described below taking an ultrasound investigation of an item under examination in the form of a femur by way of example. It goes without saying, however, that the present invention may also be used for investigating any desired items and other bodies, for example for examining machine parts, vehicle parts etc. All that is essential is that the item under examination is capable of reflecting ultrasound radiation, such that, by point-by-point scanning of structures of the item under examination by means of ultrasound radiation, it is possible to determine the distance of the respective structure from an ultrasound probe and an ultrasound image may consequently be displayed.

[0061] FIG. **1** shows a schematic view of a preferred embodiment of an apparatus according to an aspect of the invention, designated overall **10**, for displaying an ultrasound image **12** (hereafter image **12**) on a display device **14**. The display device **14** is included in the case of the apparatus **10** by a tablet computer **16**, which comprises a portable integrated electronic device which, in addition to the display device **14**, also comprises an integrated data processing device **18**. The data processing device **18** is only shown schematically in the drawings and comprises for example integrated electronic circuits or is constructed as an assembly of such integrated electronic circuits, for instance in the form of a microprocessor.

[0062] The data processing device **18** is configured and programmed so as to display the image **12** on the display device **14** by means of image signals which are supplied to the tablet computer **16** via for example wireless or wired data transfer interfaces which are not shown in the drawing. The data processing device **18** is furthermore configured and programmed so as to change, in particular to rotate and mirror, the display of the image **12** on the display device **14**, this being explained in greater detail below. Where any mention is made below of a change to the image **12** on the tablet computer **16**, in particular the display device **14** thereof, said change is initiated by the data processing device **18**. Display of the image **12** on the tablet computer **16** means display of the image **12** on the integrated display device **14** thereof.

[0063] The tablet computer **16** furthermore comprises an orientation detection device **20**, likewise shown only schematically, with which a change in orientation of the tablet computer **16** in space may be detected. The orientation detection device **20** comprises for this purpose a compass sensor **22** and an inclination sensor **24**, such that a change in orientation of the tablet computer **16** in the event of rotation and/or panning about three spatial axes, in particular located perpendicularly to one another in pairs, may be detected. An associated change in orientation signal may be supplied to the data processing device **18** and evaluated by the latter.

[0064] It may furthermore be provided that the orientation detection device **20** also be configured to detect a change in location of the tablet computer **16** in space, for example in the event of movement thereof such that the tablet computer **16** is only moved in parallel to its original location in space, but not rotated.

[0065] If the orientation and location of the tablet computer **16** in space is changed in a manner which results from a possible parallel movement and rotation about more than just one spatial axis, the data processing device **18** may attribute this to superimposed movement. In particular, it is possible to identify rotation about an axis of rotation which is oriented perpendicularly to a plane defined by the image **12** (image plane), and rotational movements about axes of rotation extending in the image plane.

[0066] The apparatus **10** furthermore comprises an ultrasound probe **26** (hereafter probe **26**), with which ultrasound radiation may be emitted in per se known manner and an ultrasound field **28** may be generated. The probe **26** comprises ultrasound transmitters arranged as a linear array, which are combined with corresponding ultrasound receivers, each of the ultrasound transmitters emitting ultrasound radiation and the ultrasound transmitters consequently together being capable of providing the ultrasound field **28**.

[0067] The probe **26** may be used to examine an item under examination **30**, in the present example a femur **32**, the ultra-

sound field **28** penetrating in a manner known per se into the femur **32**. The ultrasound transmitters and ultrasound receivers are combined with one another such that the radiation is in each case received at the location from which it has been emitted. The femur **32** is therefore examined point-by-point in the plane of the ultrasound field **28**, the distance of a specific structure **34** from the probe **26** being obtained by the measured propagation time between emission and reception of the ultrasound radiation. In the transverse direction of the ultrasound field **28**, the spatial arrangement of the individual regions of the structure **34** is obtained in that ultrasound radiation reflected from the respective regions of the structure **34** is received in different ultrasound receivers and it is consequently possible to resolve the structure **34** in the second spatial direction defined by the ultrasound field **28**.

[0068] The composite image signal assembled from the contributions of the individual ultrasound receivers may be supplied to the tablet computer **16** and thus to the data processing device **18**, for example by wired or wireless means, as shown in the drawings. The data processing device **18** processes the image signals and displays the image **12** on the display device **14**, there being a fixed relationship between the image **12** and the geometry of the probe **26**, apart from an exception which will be explained in greater detail below. For example, a top side **36** of the image **12** is associated with a top side **37** of the probe **26**, the top side **37** being the region of the ultrasound field **28** located closest to the ultrasound transmitters and ultrasound receivers. A bottom side **38** of the image **12** is associated with a bottom side **39** of the probe **26** or the ultrasound field **28** thereof, which corresponds to that distance from the top side **37** which is still measured with the ultrasound field **28**, i.e. by which radiation reflected by the structure **34** is still taken into account. A left-hand side **40** of the image **12** is associated with a left-hand side **41** of the probe **26**, and a right-hand side **42** of the image **12** with a right-hand side **43** of the probe **26**. The lengthwise direction of the sides **40** and **42** thus indicates the respective distance of a structure **34** from the probe **26**, and the ultrasound radiation contributions received in each case by the ultrasound receivers are arranged side by side along the sides **36** and **38** transversely thereof.

[0069] The probe **26** likewise comprises an orientation detection device which is designated with the reference numeral **44**. The orientation detection device **44** serves to detect a change in orientation of the probe **26** in space, in particular rotation about three spatial axes, in particular located perpendicularly to one another in pairs, and comprises for this purpose a compass sensor **46** and an inclination sensor **48**. As has already been described above by way of example in relation to the orientation detection device **20**, it may furthermore be provided that the orientation detection device **44** be capable of detecting a change in the location of the probe **26** in space, if said probe is moved in space with the ultrasound field **28** being moved in parallel in space.

[0070] A change in orientation and location of the probe **26** may be attributed to rotation thereof about an axis of rotation perpendicular to a plane defined by the ultrasound field **28** and to rotational movements of the probe **26** about axes of rotation which extend in the plane of the ultrasound field **28**.

[0071] A change in orientation signal supplied by the orientation detection device **44** may be transferred to the data processing device **18** and taken into account thereby for displaying the image **12** on the display device **14**.

[0072] When using the apparatus **10**, the operator may arrange the ultrasound probe **26** on the item under examination **30** such that the desired structure **34** is detected by the ultrasound field **28**. Image signals are transferred to the tablet computer **16** and displayed by the data processing device **18** as an image **12** on the display device **14**. In the same manner as with a conventional display of an ultrasound image, the image **12** is initially displayed such that the top side **36** is oriented parallel to an upper edge **50**, the bottom side **38** parallel to a lower edge **52**, the left-hand side **40** parallel to a left-hand edge **54** and the right-hand side **42** parallel to a right-hand edge **56** of the display device **14**. The terms "top", "bottom", "left" and "right" for the edges **50** to **56** are here selected on the basis of the orientation of the tablet computer **16** shown in FIG. **1**. In a different orientation of the tablet computer **16**, for example the orientation shown in FIG. **3**, the upper edge **50** is arranged on the right, the right-hand edge **56** at the bottom, the lower edge **52** on the left and the left-hand edge **54** at the top.

[0073] The operator may position the tablet computer **16** such that he/she has the best possible view of the image **12** and can associate the structures thereof with the structures **34** of the item under examination **30**. In practice, however, it is sometimes desirable to position the tablet computer **16** in a different manner. At the same time, it is desirable for the operator still to have the best possible view of the image **12**. This advantage may be achieved with the development described below of the tablet computer **16** and the apparatus **10**.

[0074] The tablet computer **16** comprises an actuating element **58** the form of a push button or switch, actuation of which switches the tablet computer **16** over to a display mode in which the image **12** of the data processing device **18** is changed on the display device **14** as a function of a signal from the orientation detection device **20**. This makes it possible to achieve a user-oriented display of the image **12** on the tablet computer **16**, even if the orientation of the tablet computer **16** in space changes. In this manner, the operator still has a good view of the image **12** and is still able straightforwardly to associate the structures thereof with the structures **34** of the item under examination **30**.

[0075] Once the actuating element **58** has been actuated, the data processing device **18** rotates the image **12** on the display device **14** if the latter is rotated in space about an axis of rotation **60** oriented perpendicularly to the image plane (FIGS. **1** to **3**). As mentioned, rotation of the tablet computer **16** may be detected by means of the orientation detection device **20** and an associated change in orientation signal is transferred to the data processing device **18**.

[0076] The data processing device **18** rotates the image **12** in the opposite direction to the rotation of the tablet computer **16** about the axis of rotation **60**, and specifically by the same angular amount. This makes it possible to display the image **12** stationarily relative to the operator, in order to make it easier for him/her to associate structures of the image **12** with structures **34** of the item under examination **30**.

[0077] In comparison with the orientation of the tablet computer **16** shown in FIG. **1**, the tablet computer is rotated in the orientation shown in FIG. **2** by roughly 30° about the axis of rotation **60**, and, in the orientation shown in FIG. **3**, by roughly 90° about the axis of rotation **60**. Correspondingly, the data processing device **18** rotates the image **12** in FIG. **2** by roughly 30° in the opposite direction about the axis of

rotation **60** and in FIG. **3** by roughly 90° in the opposite direction about the axis of rotation **60**.

[0078] It may be provided that the data processing device **18** only rotates the image **12** if the angle of rotation of the tablet computer **16** exceeds a predeterminable threshold angle of rotation, but keeps the image **12** constant in the event of rotation of less than said angle of rotation. Slight movements of the tablet computer **16**, for example due to its being knocked by the operator, are therefore disregarded in terms of rotation of the image **12**. Flickering of the image **12** may be avoided in that, in this manner, it may be more recognised more readily by the operator.

[0079] In contrast, if the tablet computer **16** is rotated about an axis of rotation which extends in the image plane, for example parallel to the sides **36** and **38** or parallel to the sides **40** and **42**, the data processing device **18** does not change the image **12** on the display device **14**. If the tablet computer **16** is rotated or panned accordingly in the orientation shown in FIGS. **1** to **3** out of the plane of the drawing, the image **12** is not changed. In this manner, the image **12** is still readily recognisable for the operator.

[0080] Correspondingly, the image **12** is not changed if the tablet computer **16** is moved parallel in space.

[0081] The display mode of the tablet computer **16**, in which the data processing device **18** changes the image **12** as a function of its change in orientation in space, may be switched off by actuating the actuating element **58** once again.

[0082] By making use of the orientation detection device **44** of the probe **26**, it is furthermore possible to display the image **12** on the display device **14** in a manner in which the image **12** is oriented parallel to and thus in a fixed geometric relationship with the ultrasound field **28**, relative to a projection of the image **12** in the plane defined by the ultrasound field **28**. The image **12** may be displayed such that the top sides **36** and **37**, the bottom sides **38** and **39**, the left-hand sides **40** and **41** and the right-hand sides **42** and **43** are oriented parallel to one another. The data processing device **18** is capable of orienting the image **12** as a function of the signal supplied to it from the orientation detection device **44** of the probe **26**. The geometry of the probe **26** is known to the data processing device **18**. Using the signal from the orientation detection device **44**, the data processing device **18** can therefore calculate how the ultrasound field **28** is oriented and display the image **12** accordingly on the display device **14**. This additionally makes it easier for an operator to associate structures of the image **12** with structures **34** of the item under examination **30**. Structures of the image **12** may, as it were, be shifted parallel into the item under examination **30** and located there.

[0083] The above configuration of the apparatus **10** furthermore makes it possible to change the image **12** on the display device **14** as a function of a change in orientation of the probe **26** in space (FIGS. **1** and **4**). If the probe **26** is rotated in space about an axis of rotation **62** which is oriented perpendicularly to the plane of the ultrasound field **28**, the data processing device **18** rotates the image **12** on the display device **14** about an axis of rotation perpendicular to the image plane. In the present case, this axis of rotation coincides with the axis of rotation **60**. The orientation detection device **44** may for this purpose supply a corresponding change in orientation signal to the data processing device **18**, which evaluates said signal for rotating the image **12**.

[0084] The image **12** is rotated in the same direction of rotation as the rotation of the probe **26** and by the same angular amount. It is furthermore also provided in this case that the image **12** is not rotated if the probe **26** is only rotated to such an extent that the angle of rotation is below a predeterminable threshold angle of rotation. In the event of only slight rotation of the probe **26**, for example slight shaking by the operator, the image **12** is kept constant and is consequently more readily recognisable by the operator.

[0085] If, in contrast, the probe **26** is rotated about an axis of rotation which extends in the plane of the ultrasound field **28**, the image **12** is not normally changed by the data processing device **18**. There is, however, an exception to this (FIGS. **1** and **5**). If the probe **26** is rotated about an axis of rotation **64** which extends parallel to the sides **41** and **43** through the centre of the ultrasound field **28**, and by an angle of 180° or substantially 180°, the data processing device **18** mirrors the image **12**. Mirroring occurs at a mirror plane **66** which is oriented perpendicular to the image plane and extends through the centre thereof parallel to the sides **40** and **42**. This proves advantageous in order to make it easier for operator to recognise the image **12** and to associate the structures thereof with structures **34** of the item under examination **30**.

[0086] When the image **12** is mirrored by the data processing device **18**, unlike in the configuration shown in FIG. **1**, the left-hand side **40** of the image **12** is associated with the right-hand side **43** of the ultrasound field **28**. The right-hand side **42** is correspondingly associated with the left-hand side **41**. In contrast, the top sides **36** and **37** and likewise the bottom sides **38** and **39** remain associated with one another. As a result, the image perceived by the operator on the display device **14** remains unchanged even once the probe **26** has been rotated about the axis of rotation **64**. The operator is consequently saved the task of mirroring the image **12** in his/her head in order to establish the spatial relationship thereof relative to the ultrasound probe **26**, thus to the ultrasound field **28**, and to the examined structures **34**.

[0087] Correspondingly, as has been explained above, in addition to two left/right orientation options, there are also two top/bottom orientation options in the apparatus **10**. This functions in a corresponding manner to that explained above and is not shown separately in the drawings. If the probe **26** is rotated about an axis of rotation which extends in the plane of the ultrasound field **28** parallel to the sides **37** and **39** centrally through the ultrasound field **28**, this results in mirroring of the image **12** by the data processing device **18** on the display device **14**. Mirroring proceeds centrally through the image **12** about a mirror plane perpendicular to the mirror plane **66** and to the image plane. There are therefore also two top/bottom orientation options in the relative arrangement of probe **26** and the display device **14**. This likewise makes it easier for an operator to recognise the image **12**, since he/she does not have to turn the image **12** upside down mentally in order to associate the structures contained therein with the structures **34** of the item under examination **30**.

[0088] A further preferred embodiment of an apparatus according to an aspect of the invention is shown in FIG. **6**, where it is designated overall with the reference numeral **70**. The apparatus **70** comprises the tablet computer **16** and the probe **26**, which are constructed as explained above, but do not necessarily comprise the orientation detection devices **20** and **44**. A marker device **72** is fixed to the tablet computer **16**, which marker device comprises marker elements **74** which are configured for reflecting electromagnetic radiation and in particular infrared radiation.

[0089] Similarly, a marker device **76** is fixed to the probe **26**, which marker device comprises marker elements **78** which are capable of emitting electromagnetic radiation and in particular infrared radiation. Accordingly, the marker device **72** is a passive marker device and the marker device **76** an active marker device.

[0090] The apparatus **70** furthermore comprises a navigation system **80** with a detection apparatus **82** which for example takes the form of a stereo camera **84**. The stereo camera **84** is capable of emitting electromagnetic radiation and in particular infrared radiation which is reflected by the marker elements **74**. This radiation and the radiation emitted by the marker elements **78** may be detected by the stereo camera **84**.

[0091] If the tablet computer **16** and/or the probe **26** are moved in space, the movement may be recognised by the stereo camera **84** in that there is a change in the direction from which it receives the radiation from the marker elements **74** and **78**. This makes it possible to detect the location and orientation of the tablet computer **16** and the probe **26** in space and any changes thereto. In addition, the geometry of the marker devices **72** and **76** and their respective positional relationship to the tablet computer **16** and the probe **26** is likewise known.

[0092] The navigation system **80** is thus an orientation detection device **86** of the apparatus **70**. A change in orientation signal of the navigation system **80** may be supplied to a data processing device **88** of the apparatus **70**.

[0093] The above-described methods for changing the image **12** on the display device **14** may for example be carried out as follows with the apparatus **70**:

[0094] On the one hand, image signals from the probe **26** may be transferred directly to the tablet computer **16**. The data processing device **88** transfers the change in orientation signal to the data processing device **18** of the tablet computer **16**, whereupon the data processing device **18** changes the image **12** on the display device as a function of a change in orientation of the tablet computer **16** and the probe **26** in space.

[0095] On the other hand, provision may be made for image signals from the probe **26** firstly to be transferred to the data processing device **88** and for the data processing device **88**, taking account of the change in orientation signal of the navigation system **80**, to process and rotate the image to be displayed by the display device **14** such that the image **12** appears in rotated manner on the display device **14**. The change in orientation therefore takes place not in the data processing device **18**, but instead in the data processing device **88**.

[0096] Furthermore, the image **12** on the display device **14** may be changed with the apparatus **70** in a corresponding manner as has been explained above by way of example with apparatus **10** and with reference to FIGS. **1** to **5**.

1. A method for displaying an ultrasound image on a display device, in which image signals are generated with an ultrasound probe during examination of an item under examination with ultrasound and transferred to a data processing device and the image signals are displayed by the data processing device as an ultrasound image on a display device, wherein, by means of an orientation detection device, a change in orientation of the display device in space is detected and an associated change in orientation signal is provided to the data processing device and the orientation of the ultrasound image on the display device is changed by the data processing device as a function of the change in orientation of the display device in space.

2. A method according to claim **1**, wherein the ultrasound image is rotated on the display device in the opposite direction to the rotation of the display device, by the same angular amount, about an axis of rotation oriented perpendicularly to the ultrasound image plane.

3. A method according to claim **2**, wherein the ultrasound image is not rotated if the angle of rotation of the display device is below a predeterminable threshold angle of rotation and is only rotated once the angle of rotation exceeds the threshold angle of rotation.

4. A method according to claim **1**, wherein the orientation of the ultrasound image is not changed if the display device is rotated about an axis of rotation which extends in the ultrasound image plane.

5. A method according to claim **1**, wherein the change in orientation of the ultrasound image proceeds as a function of a change in orientation of the display device subject to an actuating element being actuated by an operator, without which actuation the orientation of the ultrasound image is kept constant even in the event of a change in orientation of the display device in space.

6. A method according to claim **1**, wherein an orientation detection device included in or arranged on the display device is used in order to detect the change in orientation of the display device in space, the display device and the data processing device being integrated in one another.

7. A method according to claim **1**, wherein an orientation detection device spatially separate from the display device is used in order to detect the change in orientation of the display device in space.

8. A method according to claim **1**, wherein the orientation of the ultrasound image on the display device is selected such that the ultrasound image is oriented parallel to the ultrasound field emitted by the ultrasound probe, relative to a projection of the ultrasound image on a plane defined by the ultrasound field.

9. A method according to claim **1**, wherein, by means of an orientation detection device, a change in orientation of the ultrasound probe in space is detected and an associated change in orientation signal is provided to the data processing device and wherein the orientation of the ultrasound image on the display device is changed as a function of the change in orientation of the ultrasound probe in space.

10. A method according to claim **9**, wherein, in the event of rotation of the ultrasound probe about an axis of rotation perpendicular to a plane defined by the ultrasound field, the ultrasound image on the display device is rotated about an axis of rotation oriented perpendicularly to the ultrasound image plane, in the same sense of rotation and by the same angular amount.

11. A method according to claim **9**, wherein, in the event of rotation of the ultrasound probe by 180° or substantially 180° about an axis of rotation which extends in the plane of the ultrasound field and centrally therethrough, the ultrasound image on the display device is mirrored about a mirror plane perpendicular to the ultrasound image plane, which is oriented parallel to or contains the axis of rotation and extends through the centre of the ultrasound image.

12. A method according to claim 9, wherein an orientation detection device included in or arranged on the ultrasound probe is used in order to detect the change in orientation of the ultrasound probe in space.

13. A method according to claim 9, wherein an orientation detection device spatially separate from the ultrasound probe is used in order to detect the change in orientation of the ultrasound probe in space.

14. An apparatus for displaying an ultrasound image on a display device, the apparatus comprising an ultrasound probe for generating image signals during examination of an item under examination with ultrasound, a data processing device, to which the image signals are transferable and by which the image signals are processable, and a display device which is suppliable by the data processing device with ultrasound image information for displaying an ultrasound image, wherein the apparatus comprises a first orientation detection device for detecting a change in orientation of the display device in space and transferring an associated change in orientation signal to the data processing device and wherein the data processing device is configured and programmed such that it changes the orientation of the ultrasound image on the display device as a function of the change in orientation of the display device in space.

15. An apparatus according to claim 14, wherein the data processing device is configured and programmed such that it rotates the ultrasound image on the display device in the opposite direction to the rotation of the display device about an axis of rotation oriented perpendicularly to the ultrasound image plane, by the same angular amount.

16. An apparatus according to claim 15, wherein the data processing device is configured and programmed such that it does not rotate the ultrasound image if the angle of rotation of the display device is below a predeterminable threshold angle of rotation and only rotates it once the angle of rotation exceeds the threshold angle of rotation.

17. An apparatus according to claim 14, wherein the data processing device is configured and programmed such that it does not change the orientation of the ultrasound image on the display device if the display device is rotated about an axis of rotation which extends in the ultrasound image plane.

18. An apparatus according to claim 14, wherein the apparatus comprises an actuating element and the data processing device is configured and programmed such that it changes the orientation of the ultrasound image as a function of an actuation of the actuating element, without which actuation the data processing device keeps the orientation of the ultrasound image constant even in the event of a change in orientation of the display device in space.

19. An apparatus according to claim 14, wherein the display device comprises the first orientation detection device, the data processing device and the display device being integrated in one another.

20. An apparatus according to claim 19, wherein the first orientation detection device comprises at least of at least one of an inclination sensor and at least one compass sensor.

21. An apparatus according to claim 14, wherein the first orientation detection device is formed spatially separately from the display device, wherein the display device comprises a marker device or such a marker device is arranged on the display device and wherein the orientation detection device is configured for detecting radiation emitted and/or reflected by the marker device.

22. An apparatus according to claim 14, wherein the data processing device is configured and programmed such that it selects the orientation of the ultrasound image on the display device such that the ultrasound image is oriented parallel to the ultrasound field emitted by the ultrasound probe, relative to a projection of the ultrasound image on a plane defined by the ultrasound field.

23. An apparatus according to claim 14, wherein the apparatus comprises a second orientation detection device for detecting a change in orientation of the ultrasound probe in space and for transferring an associated change in orientation signal to the data processing device and wherein the data processing device is configured and programmed such that it changes the orientation of the ultrasound image on the display device as a function of the change in orientation of the ultrasound probe in space.

24. An apparatus according to claim 23, wherein the data processing device is configured and programmed such that, in the event of rotation of the ultrasound probe about an axis of rotation perpendicular to a plane defined by the ultrasound field, it rotates the ultrasound image on the display device about an axis of rotation oriented perpendicularly to the ultrasound image plane, in the same sense of rotation and by the same angular amount.

25. An apparatus according to claim 23, wherein the data processing device is configured and programmed such that, in the event of rotation of the ultrasound probe by 180° or substantially 180° about an axis of rotation which extends in the plane of the ultrasound field and centrally therethrough, it mirrors the ultrasound image on the display device about a mirror plane perpendicular to the ultrasound image plane, which is oriented parallel to or contains the axis of rotation and extends through the centre of the ultrasound image.

26. An apparatus according to claim 23, wherein the ultrasound probe comprises the second orientation detection device.

27. An apparatus according to claim 26, wherein the second orientation detection device comprises at least one of at least one inclination sensor and at least one compass sensor.

28. An apparatus according to claim 23, wherein the second orientation detection device is formed spatially separately from the ultrasound probe, wherein the ultrasound probe comprises a marker device or such a marker device is arranged on the ultrasound probe and wherein the second orientation detection device is configured for detecting radiation emitted and/or reflected by the marker device.

29. An apparatus according to claim 14, wherein the apparatus comprises a tablet computer including the display device.

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专利名称(译)	用于显示超声图像的方法和设备		
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摘要(译)

提供了一种用于在显示设备上显示超声图像的方法。在用超声检查检查项目期间利用超声探头生成图像信号，并将其传送到数据处理设备。图像信号由数据处理设备显示为显示设备上的超声图像。为了使操作者更容易观察超声图像，借助于取向检测装置，检测显示装置在空间中的取向的变化，并且将取向信号的相关变化提供给数据处理装置，并且数据处理设备根据显示设备在空间中的取向变化来改变显示设备上的超声图像的取向。还提供了一种用于执行该方法的装置。