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(54) Title: INTERVENTIONIST HAND RADIATION PROTECTION

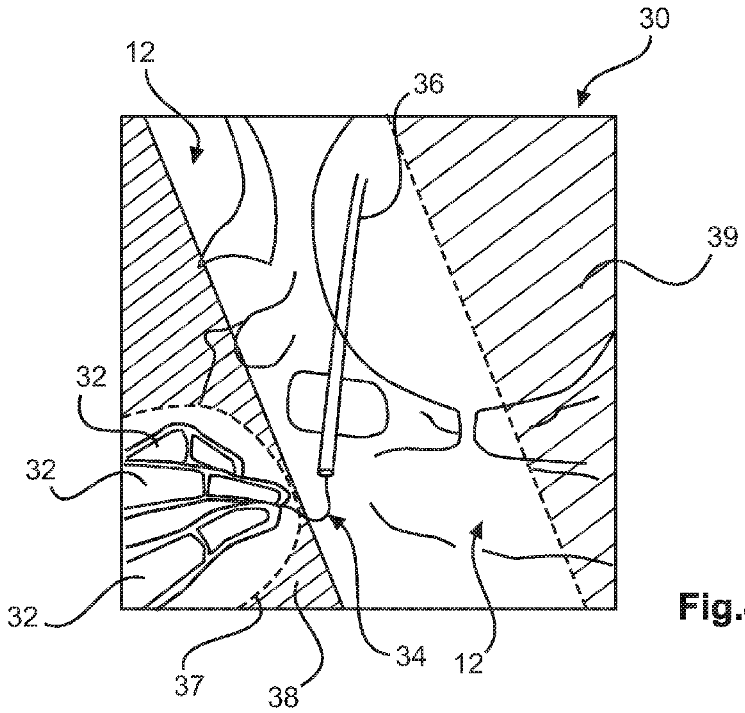

Fig.4B

(57) Abstract: An X-ray imaging system is proposed, comprising an image acquisition unit (13), a processing unit (22) and a shutter unit (18). The processing unit is adapted to detect a user's hand in an image (30) or in a stream of images (30) and determines a mask area (38). The mask area (38) is less irradiated by X-rays than other surrounding areas in order to protect the user's hand from radiation. A shutter control signal (26) is generated and provided to the shutter unit (18) to adapt an according shape of the X-ray beam based on the shutter control signal (26).

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Interventionist hand radiation protection

FIELD OF THE INVENTION

The present invention relates to medical image information acquisition of an object. In particular, the present invention relates to control of a shutter device of a medical X-ray imaging system for protection of an interventionist's hand and a method for controlling a shutter device of an X-ray imaging system.

BACKGROUND OF THE INVENTION

The exposure of medical staff to X-ray radiation during interventions is a topic of major concern in hospital radiation protection, in particular due to a rapidly increasing use of X-ray-based imaging technology, for instance fluoroscopy. Furthermore, the fast development of interventional radiology in recent years and the only limited increase in the number of specialists leads to higher workloads for the interventional radiologists, and therefore to an increased overall dose of radiation for the concerned medical staff. Although direct exposure is tried to be avoided, medical staff can often be affected by scattered radiation. In WO 2012123850 A1 an intervention device may be continuously tracked and a collimator device may restrict a field of view to a location of the intervention device and can thereby significantly reduce an applied X-ray dose to a patient. US 2012/0235065 A1 describes a radiation control system and method, in which radiation, delivered to a patient and/or the operator of the equipment, is minimized. However, the aspect of further protection of medical staff is not addressed herein. In recent years, development of medical imaging systems was mainly focused on a reduction of radiation doses for patients. For instance, shuttering or wedging of X-ray beams is used to reduce the dose of radiations for the patient during X-ray interventions. In order to reduce that patient's dose, the shutters have to be positioned as tight as possible around the treatment area. However, this shuttering is generally static and is usually performed manually.

SUMMARY OF THE INVENTION

Hence, there may be a need for a facilitated way of reducing the overall radiation dose for medical staff, in particular direct irradiation of interventionists, during interventions.

The object of the present invention is solved by the subject-matter of the independent claims, wherein further embodiments are incorporated in the dependent claims.

It should be noted that the following described aspects of the invention also apply for the method for shuttering in a medical X-ray imaging system.

According to the invention, a medical X-ray imaging system is provided, which comprises an image acquisition unit, a processing unit, and a shutter unit. The X-ray image acquisition unit comprises an X-ray source and an X-ray detector, and the X-ray image acquisition unit is adapted to provide at least one image of a region of interest. The processing unit is adapted to detect a user’s hand in the at least one image. The processing unit is, furthermore, adapted to determine a mask area of the image covering the detected hand. In addition, the processing unit is adapted to generate a shutter control signal for adjusting a shutter unit such that the mask area is less irradiated by X-rays compared to other parts of the region of interest. The shutter control signal is provided by the processing unit to the shutter unit. The shutter unit comprises a shutter control device and at least one shutter device. The shutter control unit is adapted to adjust the at least one shutter device of the shutter unit to adapt a cross-sectional shape of the X-ray beam based on the shutter control signal.

“At least one” shutter device relates, for instance, to one, two, three or five shutter devices.

The term “shutter unit” also refers to, more generically, a collimation unit, i.e. the term also comprises other units or devices that provide affecting the X-ray beam.

An advantage can be seen in less exposure of the user’s hand to X-rays and a flexible and automatic control of components of the imaging system without manual interaction. The proposed solution bases on the known principle of acquisition of medical images using X-rays. In many cases, an X-ray source emits X-rays in a direction towards a detector, wherein an object or region of interest is positioned in between the X-ray source and detector. In other words, X-ray source, region of interest, and detector are arranged such that the region of interest is irradiated and the radiation, which has passed the region of interest, is detected by the X-ray detector. The X-ray image acquisition unit can then process the received signals from the detector and generate a medical image of the region of interest. The region of interest can be, for instance, a part of a patient's body.

Instead of distinct single images, also a stream of X-ray images, also known as stream of X-ray frames or live fluoroscopy, can be provided. Such stream can consist of, for instance, 2 to 15 frames per second, which are acquired in a predetermined timely sequence.

A stream of X-ray frames are, for instance, applied during cardiac or similar minimal invasive interventions in order to allow live monitoring of performed actions and movements in the area of the region of interest. As an example, for a cardiac or other minimal invasive intervention, the interventionist places a wire into an opening and guides this wire along a predetermined path within the patient's body. In these cases, it may become necessary for the interventionist to place his hand into the X-ray beam in order to be able to perform the necessary steps of the intervention.

The "mask area" defines that part of the image, which needs to be shadowed and for which the radiation dose has to be lowered. In other words, the mask area can be seen as the minimum area which has to be shaded in relation to the region of interest by means of the shutter unit. Depending on the specific requirements for certain interventions and certain situations, such a mask area can be roughly the size of the detected hand, but can also be larger or smaller than the detected hand.

In one example, the mask area has the size of the detected hand, in order to avoid unnecessary shading of other areas outside the hand within the region of interest. Reason is that the interventionist should be provided a best possible visibility of the region of interest, while keeping a radiation exposure to the interventionist's hand as low as possible.

A shutter device can be seen as a device, which is arranged close to the X-ray source and which is able to form a shape of the X-ray beam and/or can influence the intensity of the X-ray across a cross-sectional plane of the beam. An example of a shutter device can be found in US 2012/0215095 A1. For instance, wedges can be positioned within the X-ray beam to shade or absorb radiation generated by the X-ray source. The position of the shutter device, for instance the wedges or other shuttering elements, can be controlled by a shutter control device.

In one example, the shutter control device receives a shutter control signal. This signal is translated to control signals for actuators of shutter elements to adapt a certain position and thus to effect a certain shape of the X-ray beam.

The shape of the X-ray beam relates to a geometrical shape in a plane or dimension transversely to a projection direction, which can be seen as a virtual connection line between X-ray source and X-ray detector. In other words, the shape relates to a cross-sectional shape of the X-ray beam.

The term “less irradiated” relates to a dose of X-ray within the same time frame, which is lower for the mask area than for other surrounding parts of the image of the region of interest and can also be, in an example, even zero. In another example, radiation intensity can be lowered by a predetermined percentage to still allow reduced visibility within the mask area.

According to one example, the X-ray image acquisition unit is adapted to provide at least two images. The processing unit is adapted to detect a movement of the user’s hand in relation to the region of interest based on a comparison of the detected hand in the at least two images. The term “detected hand” can also be understood as a specific image area, which, due to its position change between at least two images, could possibly be an interventionist’s hand.

The two images may be in a temporal sequence. An advantage can be seen in a more secure detection of an image object as a hand of a user or interventionist. If two images are provided, a movement of an object within an image can be detected by a comparison of the two images. Changes in certain areas of the image can indicate a movement.

In another example, also a single image can be provided and a movement can be detected by a blurring effect of specific areas within the image. Such a blurring effect can occur when during a certain exposure time the irradiated object is moving and therefore causes diffuse edges or borders of certain image structures.

The term “at least two images” can also relate to a stream of images as typically generated, for instance, during cardiac interventions.

According to an example, the processing unit is adapted to detect a spatial association of the user’s hand with an edge of the at least one image. An advantage can be seen in a better identification of a hand within an image, because the hand and possibly associated parts of the arm of the interventionist is brought into the region of interest from the outside. Therefore, a hand can be detected, if the related structure in the image is connected with an outer area of the image due to the connection of the hand with the arm of the interventionist. In other words, a hand/arm is characterized by the fact that it reaches into the region of interest from the outside of the imaging system. This can be seen as another separation or detection criteria for detection of a hand. An “edge of the image” here describes the outer limit or border of the image.

According to one example, the processing unit is adapted to track the hand in the image. An advantage can be seen in a faster, simpler detection, because no initial detection sequence is necessary. Here, a rough segmentation can be used, to re-detect a hand, which was detected in one of the previous images. This can require less computing resources and can lead to a faster detection. Furthermore, only the area of the image can be searched, in which the hand was previously detected and not the entire image. Information regarding the shape and position can be stored and can, for instance, help to re-detect a previously recognized hand.

According to an example, the processing unit is adapted to segment the detected hand and to separate the segmented hand from a surrounding area of the image. An advantage can be seen in a possible processing and handling of the detected object as separate graphical instance. Furthermore, the extraction or separation of the hand structure furthermore allows a following definition or calculation of the mask area.

According to one example, a part of the region of interest is a determined treatment area. The processing unit is adapted to determine an overlap area between the mask area and the treatment area and to subtract the overlap area from the mask area to generate a modified mask area. The processing unit is further adapted to generate the shutter control signal for adjusting a shutter unit such that the modified mask area is less irradiated. An advantage can be seen in avoiding a restricted visibility of the critically important treatment area. The “treatment area” can be seen as a, for instance centrally arranged, area within the region of interest. In this treatment area, usually the interventional steps take place. Therefore, sufficient visibility of this region is very important. For this purpose, the treatment area should not be shadowed or shaded. In the event that the interventionist's hand gets into the treatment area, the area of the interventionist's hand, which reaches into the treatment area, should therefore not be protected. In other words, in this case visibility of the region of interest has higher priority over the protection of the user’s hand. In one example, the treatment area is defined by a surgical instrument or similar tool, for instance a needle head. In this case, the area around the needle head can be defined as treatment area.

Furthermore, a method for shuttering in a medical X-ray imaging system is proposed. The method comprises the following steps:

a) providing a least one image of a region of interest,

b) detecting a user's hand in at least one image,

c) determining a mask area of the image covering the detected hand,

d) generating a shutter control signal for adjusting a shutter unit such that the mask area is less irradiated by X-ray radiation compared to other parts of the region of interest,

e) providing the shutter control signal to the shutter unit,

f) adjusting one shutter device of the shutter unit to adapt a cross-sectional shape of an X-ray beam based on the shutter control signal.

In an example, step b) comprises the sub-step of segmenting the detected hand. In another example, step c) comprises the sub-step of separating the detected hand from a surrounding area of the image. In one example, the segmented hand is separated from the region of interest. Following step f), a step g) is provided of further radiating the region of interest for generating further images with adjusted shutter position. For example, step b) comprises detecting finger bones in the at least one image. In another example, step b) comprises detecting a reference shape in the image. One or more reference shapes may be provided by a collection of reference shapes stored in a database.

According to one example, in step a), at least two images are provided. Further, in step b), a movement of the user's hand in relation to the region of interest is detected based on a comparison of the detected hand in the at least two images. In one example, the movement of the hand is detected by registering the detected hand of at least two images determining a motion vector.

According to an example, a part of the region of interest is a determined treatment area. Following step c), an overlap area between the mask area and the treatment area is determined and the overlap area is subtracted from the mask area generating a modified mask area. In step d), the shutter control signal for adjusting a shutter unit is generated such that the modified mask area is less irradiated.

The term "treatment area" refers to an area, where a substantial and essential part of an intervention takes place, for example a surgical step. In one example, the treatment area is manually determined by a user. In another example, the treatment area is determined by a predetermined interventional tool, such as an inserted stent or the tip of a catheter. For example, the interventional tool is detected in the image and the treatment area is determined as a predetermined region around the detected interventional tool. In one example, the shutter control signal for adjusting a shutter unit is generated such that the overlap area is less irradiated by X-ray radiation compared to other parts of the region of interest, but is irradiated with more X-ray radiation compared to the modified mask area.

It can be seen as an idea of the invention to automatically adjust a shutter or collimator system of an X-ray source such that a moving hand, that is brought into or near a region of interest or into an X-ray beam from the outside, and which is detected in the image, is protected from radiation by shielding the hand from radiation.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention will be described in the following with reference to the following drawings:

Fig. 1 schematically illustrates an example of a medical X-ray imaging system from a side view;

Fig. 2 schematically illustrates functional units of a medical X-ray imaging system;

Fig. 3A and 3B schematically each show an example of an image of a region of interest with an interventionist's hand;

Fig. 3C and 3D show the respective correlating photographic images of Fig. 3A and 3B;

Fig. 4A and 4B schematically show an example of an image of a region of interest with an interventionist's hand and a mask area according to the invention;

Fig. 4C and 4D show the respective correlating photographic images of Fig. 4A and 4B;

Fig. 5 schematically shows an image of a region of interest with a modified mask area;

Fig. 6 schematically describes the steps of a method for shuttering in a medical X-ray imaging system.

DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1 shows a medical imaging system 10 based on X-rays for generation of imaging information of a region of interest 12. The medical imaging system 10 comprises an X-ray source 14, an X-ray detector 16, a shutter unit 17, and a support arrangement 20. The region of interest 12 can be positioned on a patient support 22. The X-ray source 14 and the X-ray detector 16 are mounted to the support means 20 in order to allow exact arrangement of X-ray source 14 and detector 16 to irradiate the region of interest 12. In the shown case the support arrangement 20 is a C-arc. The shutter unit 17 is disposed between the X-ray source 14 and the X-ray detector 16 close to the X-ray source 14 and can be disposed outside the vacuum tube. In many cases, the shutter unit 17 is directly mounted to the X-ray source and moves along with the X-ray source 14, if the image acquisition unit (X-ray source 14, X-ray detector 16) is moved or rotated. Also other types of X-ray based imaging systems are possible, for example computer tomography imaging systems.

In Fig. 2, a medical imaging system 10 is schematically shown, comprising an X-ray source 14, an X-ray detector 16, a region of interest 12 and a shutter unit 18. Furthermore, a processing unit 22 is shown. The detector 16 provides image information 24 to the processing unit 22. The shutter control device 19 receives a shutter control signal 26 from the processing unit 22. The shutter control unit 19 generates control signals for the shutter device 18 based on the received shutter control signal 26. The shutter device 18 then sets, for instance, wedges to a certain spatial position and thus influences or sets a certain cross-sectional shape of the X-ray beam.

An image acquisition unit 13, which is adapted to provide at least one image of the region of interest 12, comprises the detector 16 and the X-ray source 14. In the shown example the X-ray source 14 is arranged on the lower side, whereas the detector is arranged diametrically opposed on the upper side of the C-arc. It is also possible to arrange the X-ray source 14 and the X-ray detector 16 in any other way, as long as the X-ray detector 16 is diametrically opposed arranged towards the X-ray source 14 and the region of interest 12 is irradiated by the X-ray source 14.

The processing unit 22 is adapted to process the image information 24 and to detect a hand 32 of a user. Furthermore the processing unit is adapted to provide the shutter control signal 26 as a function of the image information 24 and information of the detected hand 32. Instead of a user's hand, also other distinctive parts of the human body can be detected. In certain cases it may also be possible, that other parts of a person get into the X-ray beam. If the term "hand" is used, besides the hand itself also parts of the arm of the interventionist can be included.

In one example, also other objects can be detected. Besides parts of the human body, for instance tools, surgical instruments or similar objects can be subject to a desired reduction of exposure to X-rays. The detection of such tools or instruments is known in the field of medical imaging.

According to an example, the processing unit 22 is adapted to detect a reference shape in the image for the detection of the user's hand. It can be seen as an advantage, that better detection can be achieved by reduction of complexity by searching for known shapes.

A reference shape can be any typical shape or form of components of a hand, for instance, certain thin bones of a hand bone structure. Also, when detecting any other objects, various types of reference shapes are possible. These can be tools, external devices, or other parts of the human body. Before comparing shapes, the related image structures can be segmented or separated in advance. In another example, reference shapes are stored in a library. In one example, the reference shape is a standardized contour shape of a bone of a human hand. In another example, the processing unit is adapted to detect a tool in the image. It can be seen as an advantage that also tools, which should be protected from X-ray radiation, can be detected and shaded from radiation.

Furthermore, additional criteria can be considered when generating the shutter control signal 26. The processing unit 22 is furthermore adapted to determine a mask area 38, which defines the area which at least needs to be shaded from radiation or at least radiated with reduced radiation intensity. The shutter control device 19 is adapted to receive the shutter control signal 26 and to translate this signal into control signals for the adjustment of, for instance mechanical, elements of the shutter device 18. The shutter device 18 is adapted to set a cross sectional shape of the X-ray-beam, for instance through partial shading of the X-ray beam by wedges, which are positioned into the X-ray beam.

According to one example, the X-ray imaging system further comprises a display unit 33, wherein the display unit is configured to display the at least one image. It is noted that the display 33 is shown with a dotted line in Fig. 1 indicating that the display is an optional feature that may be provided in combination with the other features shown in Fig 1. The other features of Fig. 1 can thus also be provided without the display 33. In one example, the display is configured to display further acquired images 30 with adjusted shutter position. An advantage can be seen in a possibility of a live monitoring of the intervention, for instance on a screen, mounted close to the interventionist in the operation theatre. In an example, an interventionist can graphically follow his hand movement or the movement of a tool or instrument he is uses.

Fig. 3A shows an example of an image 30 of a region of interest 12 with a hand 32. The image 30 was acquired by the X-ray image acquisition system 13. In the shown image, parts of the fingers of the hand 32 reach into the region of interest 12. In the shown example, the hand 32 arises from the outside and guides a surgical instrument, here a surgical wire 34, which is guided into a catheter device 36.

In Fig. 3B, a timely later image is shown, where the hand 32 has moved further into a centre of the image or closer to the catheter device 36. Comparing Fig. 3A and Fig. 3B, it can be seen, that moving the hand relative to a region of interest 12 accordingly results in a moving of the respective projection of the hand 32 in the medical image 30. While the hand 32 is moving, the other image elements remain in the same position within the image 30. The shown catheter device 36 and the wire 32 are only examples of typical instruments used in clinical environments, for instance cardiac interventions, in conjunction with application of imaging systems. Both are only shown for a better understanding and are not part of the invention. The hand 32 is, as shown in Fig. 3A and Fig. 3B, exposed to X-ray radiation like all areas of the region of interest 12.

In Fig. 3C and Fig. 3D, photographic representations of the example of the image 30 of Figs. 3A and 3B are shown.

Fig. 4A again shows an image 30 of the same region of interest 12 with a catheter device 36, a wire 34 and a hand 32. In difference to the previous images, Fig. 4A now shows a shuttered area 38. The shuttered area 38 is positioned such that it at least covers a mask area 37. In other words, the mask area 37, which was determined by the processing unit 22 in a previous step, defines the area, which at least needs to be shaded. Depending on the shading mechanism, which is used in the shutter device 18, the shuttered area can be larger than the mask area 37. For instance, as shown in Fig. 4A and 4B, the border between shuttered and non-shuttered areas can be a straight line, which in this case defines triangular shaped shuttered area 38 in the image 30. If the hand 32 moves from the edge of the image towards the centre of the region of interest 12, the shuttered area 38 is dynamically adjusted and moves along with the movement of the hand 32. This way, the hand 32 with the corresponding mask area 37 is exposed to less radiation.

Fig. 4B shows the same region of interest 12 with the wire 34 and the catheter device 36, wherein the hand 32 moves towards the catheter device 36. It can be seen, that the shuttered area 38 has shifted accordingly to shield the hand 32 with the associated mask area 37 from X-ray radiation. The hand 32, once initially detected, can be re-detected or traced by the processing unit 22 during a movement of the hand 32. This way, the shutter can be dynamically adapted to the current position of the hand 32 until the hand 32 leaves the X-ray beam. An adjustment of the shutter device 18 can preferably performed such that the shuttered area 38 masks or shades other areas outside the mask area as little as possible

A second shuttered area 39 is only shown as another example for a better understanding as it does not relate to any movement of the hand 32. However, it can be possible to also control this second shuttered area 39, for instance, if a hand of a second person reaches into the region of interest from an opposite side of the patient table.

In Fig. 4C and Fig. 4D, photographic representations of the image of Fig. 4A and Fig. 4B is are provided.

In Fig. 5, an example is shown, where fingers of the hand 32 move into a predetermined treatment area 40. The image 30 shows the same region of interest 12 like in Figs. 3A-3D and Figs. 4A-4D. It can be seen, that the mask area 37, which was shown in Fig. 4B, and the treatment area 40 define an overlap area 44. In the shown example, the treatment area 40 defines an area of the region of interest, which can be critically important, for instance for a surgical procedure. In the shown figure it is of roughly circular shape and reaches into the mask area 37. This resulting overlap area 44 is subtracted or cut out of the mask area 37 and results in the shown modified mask area 42. Background is that the treatment area is not allowed to be shaded or shielded, in order to provide best visibility of this critical area to the interventionist. In other words, even in the event that fingers or the hand 32 of the interventionist reach into the treatment area 40, any shielding or shuttering that area is prevented.

In Fig. 6, an example of a method 100 for shuttering in a medical X-ray imaging system is shown. In a first step 110, at least one image 30 of a region of interest 12 is provided. In a second step 120, a user's hand 32 is detected within at least one image 30. Then, in a third step 130, a mask area 38 of the image 30 covering the detected hand 32 is determined. In a fourth step 140, a shutter control signal 26 for adjusting a shutter unit 17 is generated. This is done such that the mask area 38 is less irradiated by X-ray radiation compared to other parts of the region of interest 12. In a following fifth step 150, a shutter control signal 26 is provided to the shutter unit 17. Lastly, in sixth step 160, at least one shutter device 18 of the shutter unit 17 is adjusted to adapt a cross-sectional shape of an X-ray beam based on the shutter control signal 26. Step 110 is referred to as step a), step 120 is referred to as step b), step 130 is referred to as c), step 140 is referred to as step d), step 150 is referred to as step e), and step 160 is referred to as step f).

In an example (not shown), step b) comprises detecting a spatial association of the user's hand with an edge of the at least one image. In other words, as a human hand is always connected with a body of the interventionist outside the imaging system, therefore, a hand in an image can in many cases identified, because it is connected to the border or edge of the image. The term "edge" can also be referred to as "border" of the image. It can also relate to an image position, where image properties in respect to contrast of density substantially change due to differing image parameters, but not due to changes in the objects parameters.

Fig. 7 illustrates another example of the method 100, in which, in addition, the treatment area 40 is considered in the process of setting a shutter device 18 accordingly. Steps a), b) and c) are identical with the steps a), b) and c) described in Figure 6. Now, following step c), in a step 135 an overlap area between the mask area and the treatment area 40 is defined. The information of the predetermined treatment area is provided (shown as step 115) and is considered and processed in step 135, when the overlap area is determined. Such an overlap of mask area and treatment area can occur, when, as illustrated in Fig. 5, for example fingers of a hand 32 reach into the treatment area. In order to avoid a shading of that overlap area 44, it is in step 135 subtracted from the initial mask area and a modified mask area 42 is generated. In the following step 140' now a shutter control signal 26 is generated, wherein this modified mask area 42 is less irradiated. In the step 150' this shutter control signal 26 is provided to the shutter unit 17. In a last step 160' the shutter device 18 of the shutter unit 17 is adapted to adapt a cross-sectional shape of the X-ray beam based on the previously generated shutter control signal 26.

The steps described in Fig. 6 and 7 can be elements of a computer program (not shown), which are adapted to perform the described method steps, when the program elements are executed by a computer processing unit.

The computer program elements can be stored on a computer readable medium (not shown).

In another exemplary embodiment of the present invention, a computer program or a computer program element is provided that is characterized by being adapted to execute the method steps of the method according to one of the preceding embodiments, on an appropriate system.

The computer program element might therefore be stored on a computer unit, which might also be part of an embodiment of the present invention. This computing unit may be adapted to perform or induce a performing of the steps of the method described above. Moreover, it may be adapted to operate the components of the above described apparatus. The computing unit can be adapted to operate automatically and/or to execute the orders of a user. A computer program may be loaded into a working memory of a data processor. The data processor may thus be equipped to carry out the method of the invention.

This exemplary embodiment of the invention covers both, a computer program that right from the beginning uses the invention and a computer program that by means of an up-date turns an existing program into a program that uses the invention.

Further on, the computer program element might be able to provide all necessary steps to fulfil the procedure of an exemplary embodiment of the method as described above.

According to a further exemplary embodiment of the present invention, a computer readable medium, such as a CD-ROM, is presented wherein the computer readable medium has a computer program element stored on it which computer program element is described by the preceding section.

A computer program may be stored and/or distributed on a suitable medium, such as an optical storage medium or a solid state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the internet or other wired or wireless telecommunication systems.

However, the computer program may also be presented over a network like the World Wide Web and can be downloaded into the working memory of a data processor from such a network. According to a further exemplary embodiment of the present invention, a medium for making a computer program element available for downloading is provided, which computer program element is arranged to perform a method according to one of the previously described embodiments of the invention.

It has to be noted that embodiments of the invention are described with reference to different embodiments. However, a person skilled in the art will gather from the above and the following description that, unless otherwise notified, any combination between features relating to different embodiments is considered to be disclosed within this application. However, all features can be combined providing synergetic effects that are more than the simple summation of the features.

While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practising a claimed invention, from a study of the drawings, the disclosure, and the dependent claims.

In the claims, the word “comprising” does not exclude other elements or steps, and the indefinite article “a” or “an” does not exclude a plurality. A single processor or other unit may fulfil the functions of several items recited in the claims. 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. Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS

1. A medical X-ray imaging system (10), comprising:
- an image acquisition unit (13);
- a processing unit (22); and
- a shutter unit (17);

wherein the X-ray image acquisition unit (13) comprises an X-ray source (14) and an X-ray detector (16); and wherein the X-ray image acquisition unit (13) is adapted to provide at least one image (30) of a region of interest (12);

wherein the processing unit (22) is adapted to detect a user’s hand (32) in the at least one image (30), and to determine a mask area (37) of the image (30) covering the detected hand (32), and to generate a shutter control signal (26) for adjusting the shutter unit (17) such that the mask area (37) is less irradiated by X-ray radiation compared to other parts of the region of interest (12); and to provide the shutter control signal (26) to the shutter unit (17); and

wherein the shutter unit (17) comprises a shutter control device (19) and at least one shutter device (18); wherein the shutter control device (19) is adapted to adjust the at least one shutter device (18) of the shutter unit (17) to adapt a cross-sectional shape of an X-ray beam based on the shutter control signal (26).

2. The medical X-ray imaging system (10) according to claim 1, wherein the X-ray image acquisition unit (13) is adapted to provide at least two images (30); and

wherein the processing unit (22) is adapted to detect a movement of the user’s hand (32) in relation to the region of interest (12) based on a comparison of the detected hand (32) in the at least two images (30).

3. The medical X-ray imaging system according to claim 1 or 2, wherein the processing unit (22) is adapted to detect a spatial association of the user’s hand (32) with an edge of the at least one image (30).

4. The medical X-ray imaging system (10) according to any of the previous claims, wherein the processing unit (22) is adapted to detect a reference shape in the image (30) for the detection of the user's hand (32).

5. The medical X-ray imaging system (10) according to any of the previous claims, wherein the processing unit (22) is adapted to track the hand (32) in the image (30).

6. The medical X-ray imaging system (10) according to any of the previous claims, wherein the processing unit (22) is adapted to segment the detected hand (32) and to separate the segmented hand (32) from a surrounding area of the image (30).

7. The medical X-ray imaging system (10) according to any of the previous claims, wherein a part of the region of interest (12) is a determined treatment area (40); and

wherein the processing unit (22) is adapted to determine an overlap area (44) between the mask area (37) and the treatment area (40) and to subtract the overlap area (44) from the mask area (37) to generate a modified mask area (42); and

wherein the processing unit (22) is further adapted to generate the shutter control signal (26) for adjusting a shutter unit (17) such that the modified mask area (42) is less irradiated.

8. The medical X-ray imaging system (10) according to any of the previous claims, further comprising:

- a display unit (33); and

wherein the display unit (33) is configured to display the at least one image (30).

9. A method (100) for shuttering in a medical X-ray imaging system, the method comprising the following steps:

a) providing (110) at least one image of a region of interest;

b) detecting (120) a user's hand in the at least one image;

c) determining (130) a mask area of the image covering the detected hand;

d) generating (140) a shutter control signal for adjusting a shutter unit such that the mask area is less irradiated by X-ray radiation compared to other parts of the region of interest;

e) providing (150) the shutter control signal to the shutter unit; and

f) adjusting (160) at least one shutter device of the shutter unit to adapt a cross-sectional shape of an X-ray beam based on the shutter control signal.

10. Method according to claim 9, wherein in step a), at least two images are provided; and

wherein in step b), a movement of the user's hand in relation to the region of interest is detected based on a comparison of the detected hand in the at least two images.

11. Method according to claim 9 or 10, wherein step b) comprises detecting a spatial association of the user's hand with an edge of the at least one image.

12. Method according to claim 9, 10 or 11, wherein a part of the region of interest is a determined treatment area;

wherein following step c), an overlap area between the mask area and the treatment area is determined (135) and the overlap area is subtracted from the mask area generating a modified mask area; and

wherein in step d), the shutter control signal for adjusting a shutter unit is generated (140) such that the modified mask area is less irradiated.

13. A computer program element for controlling an apparatus according to one of the claims 1 to 8, which, when being executed by a processing unit, is adapted to perform the method step of claims 9 to 12.

14. A computer readable medium having stored the program element of claim 13.

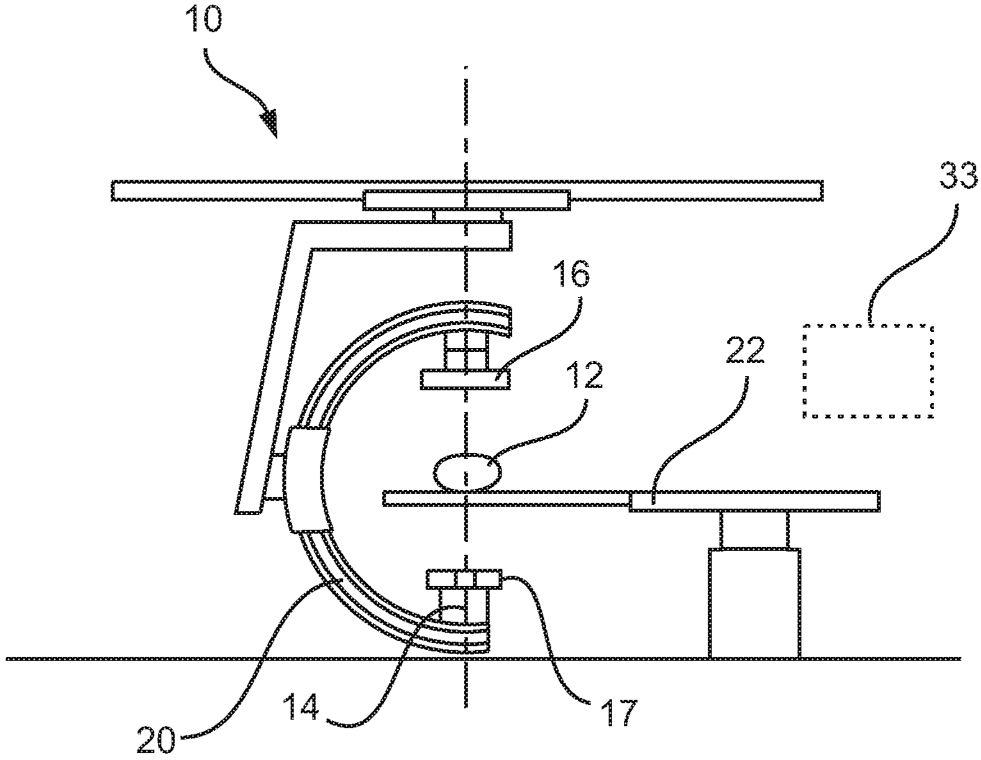

Fig.1

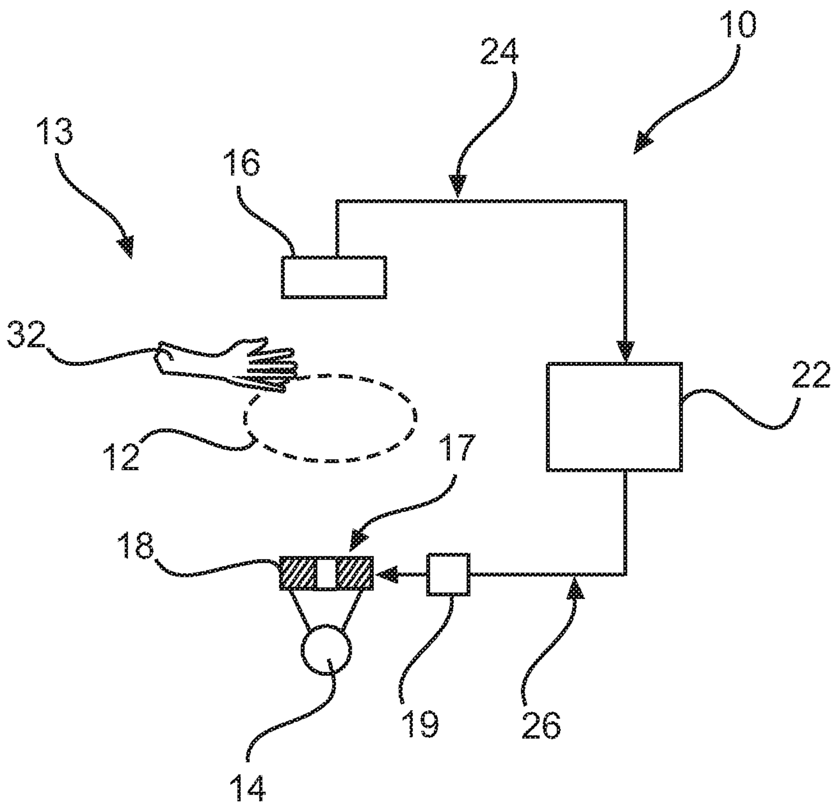

Fig.2

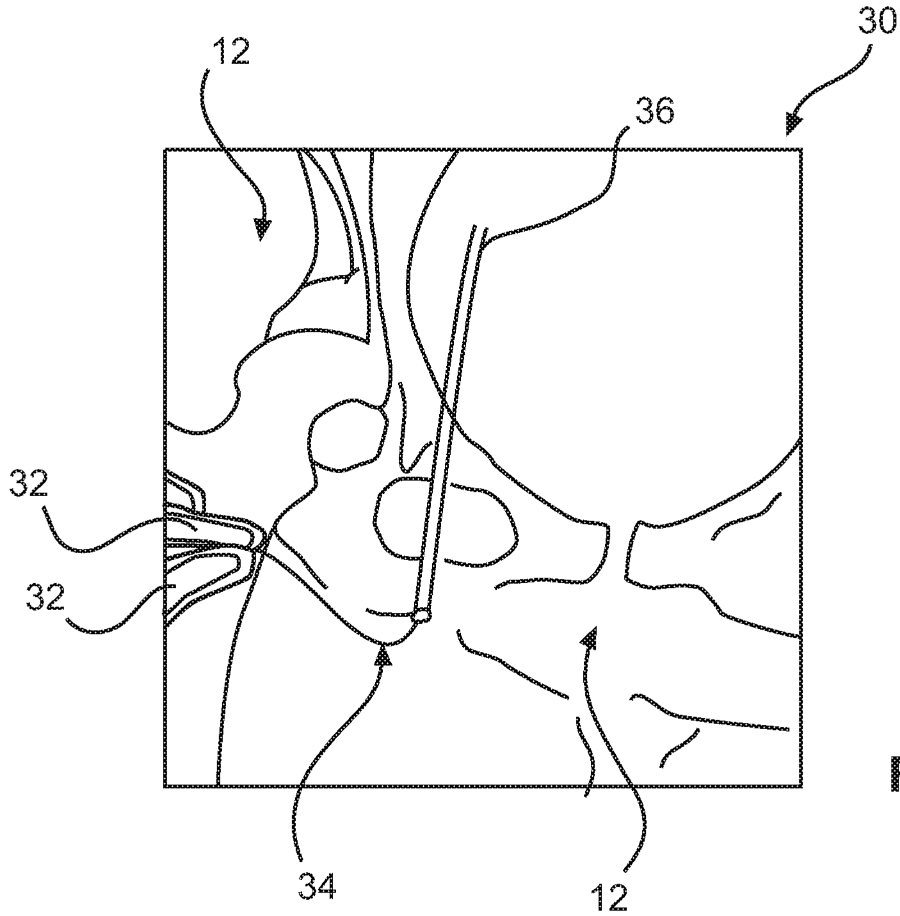

Fig. 3A

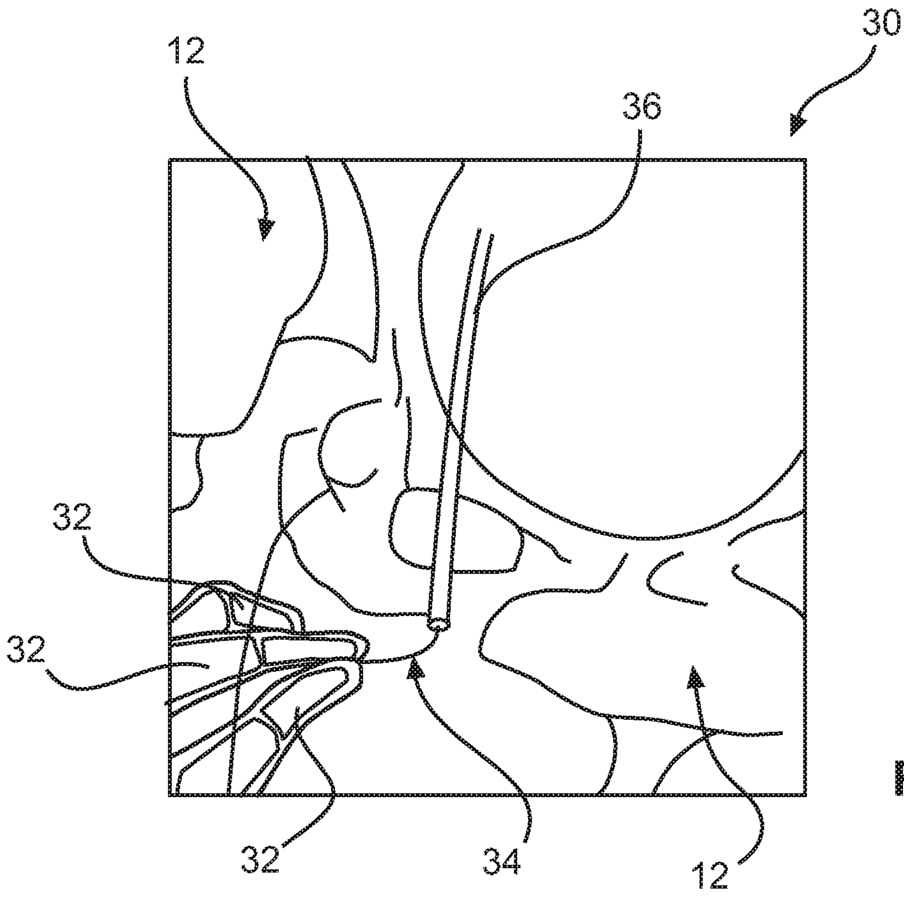

Fig. 3B

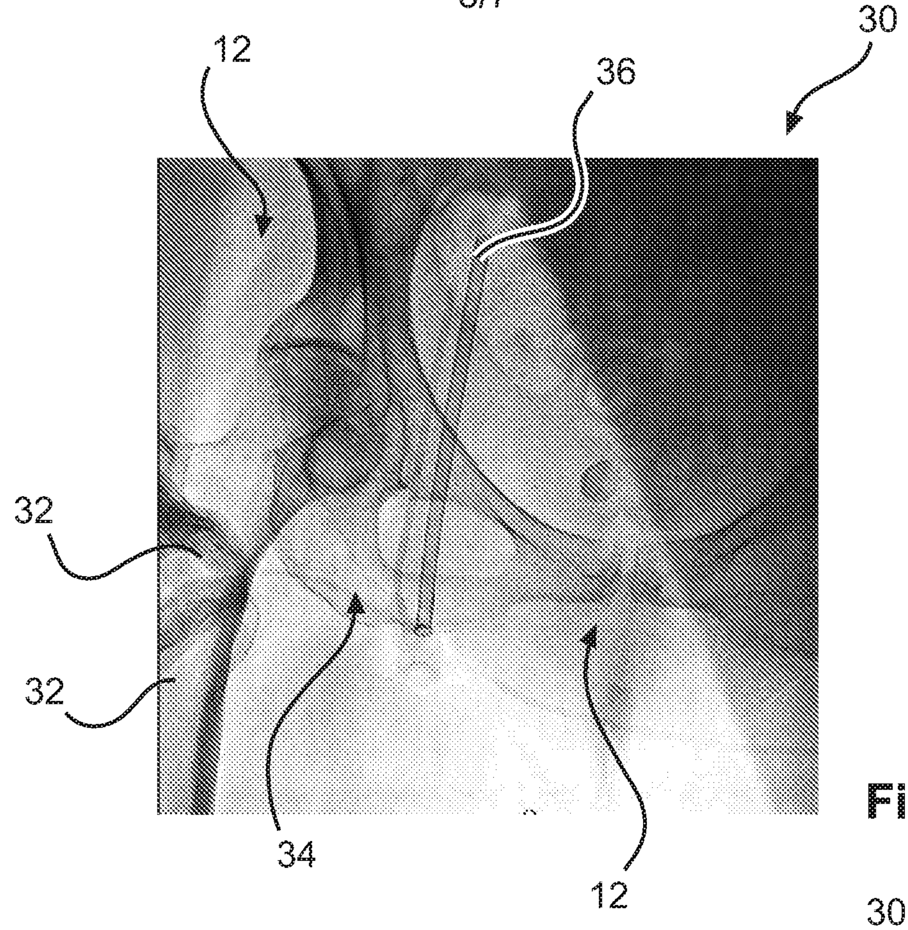

Fig. 3C

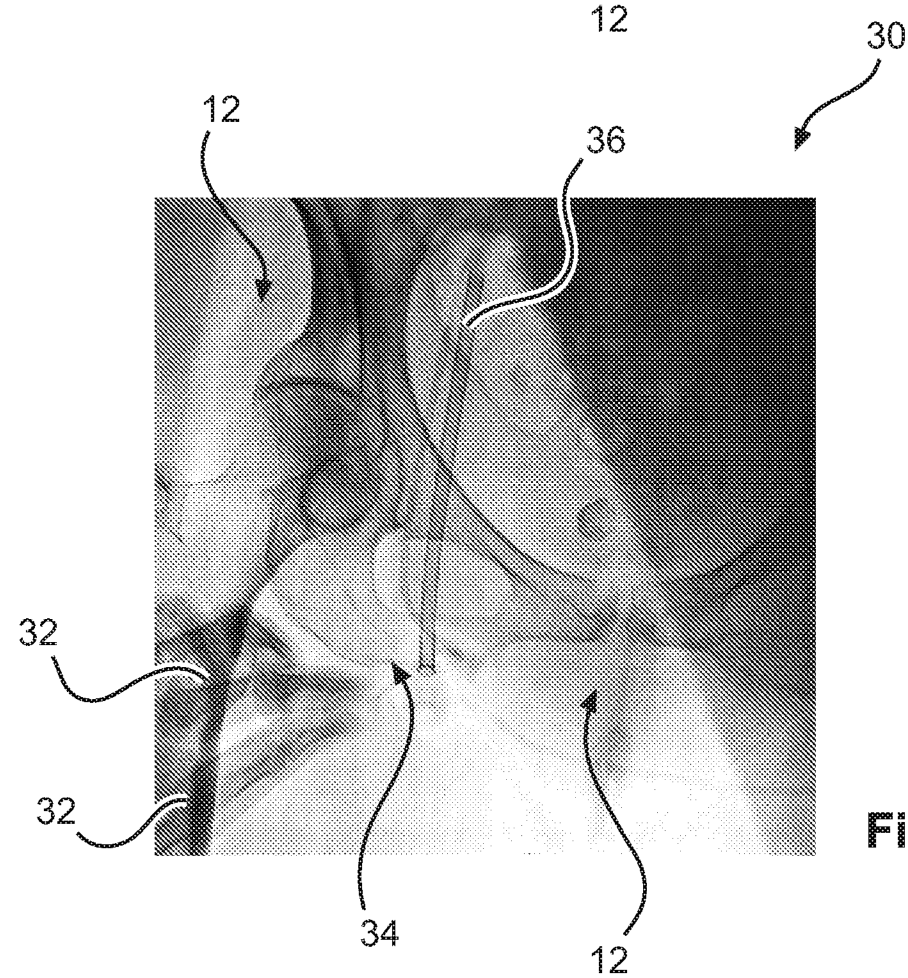

Fig. 3D

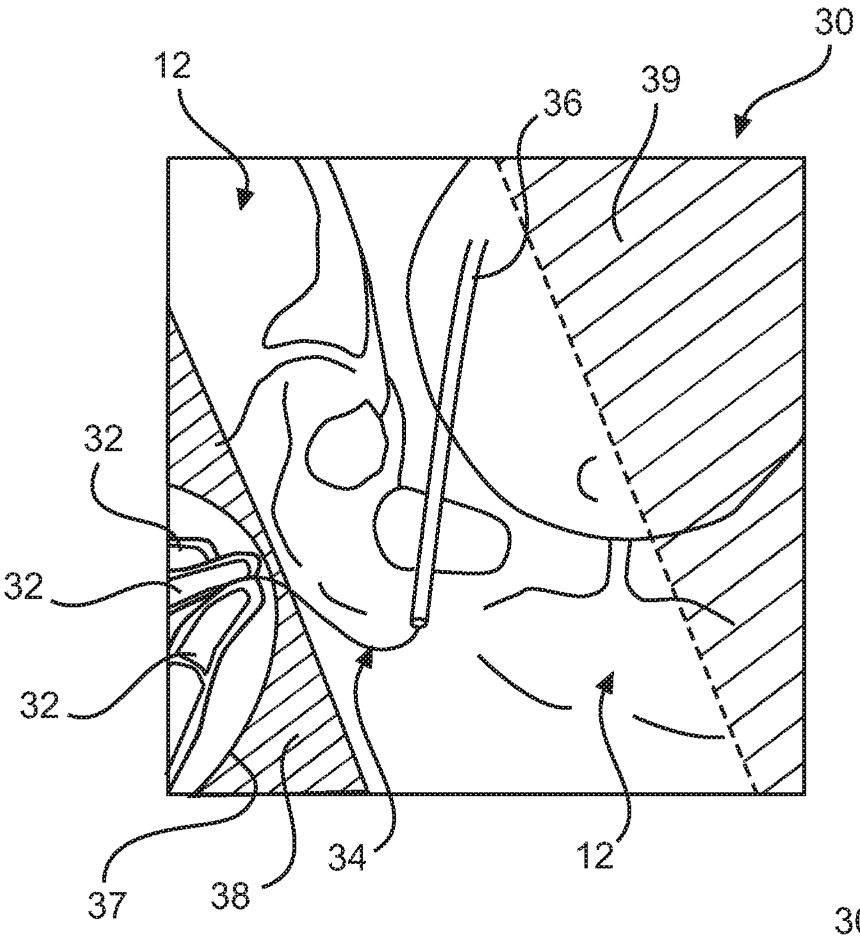

Fig.4A

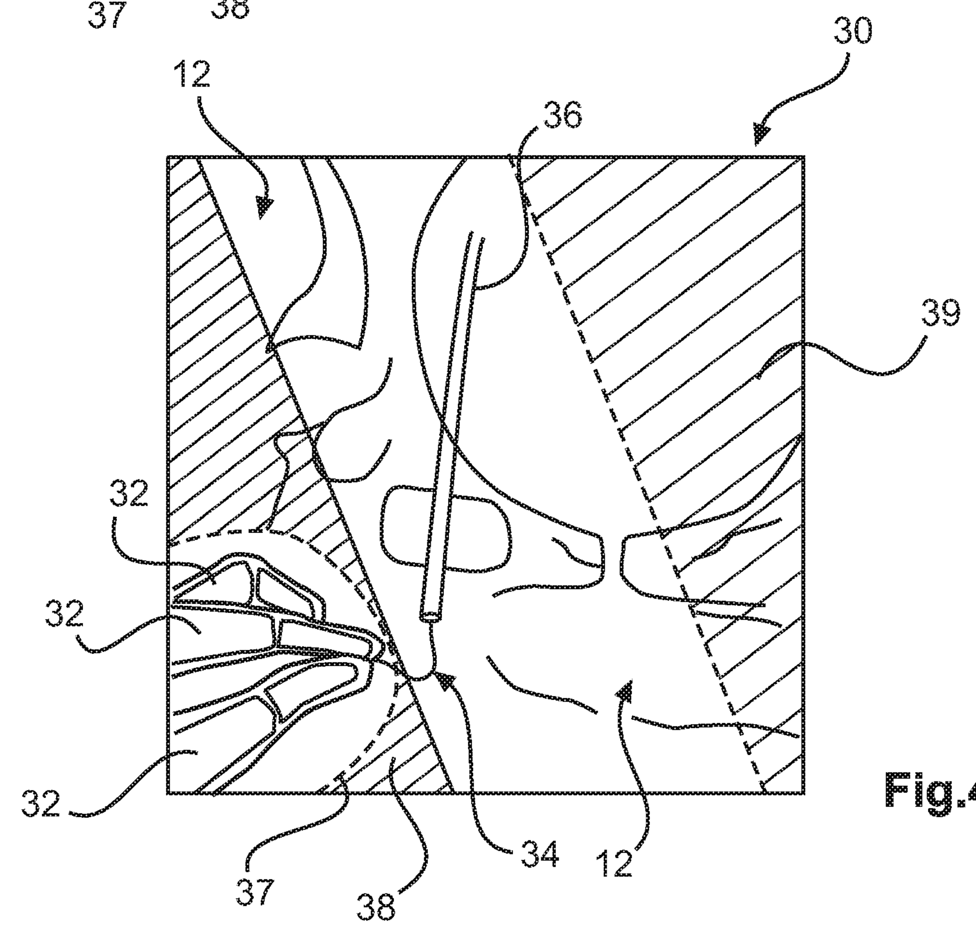

Fig.4B

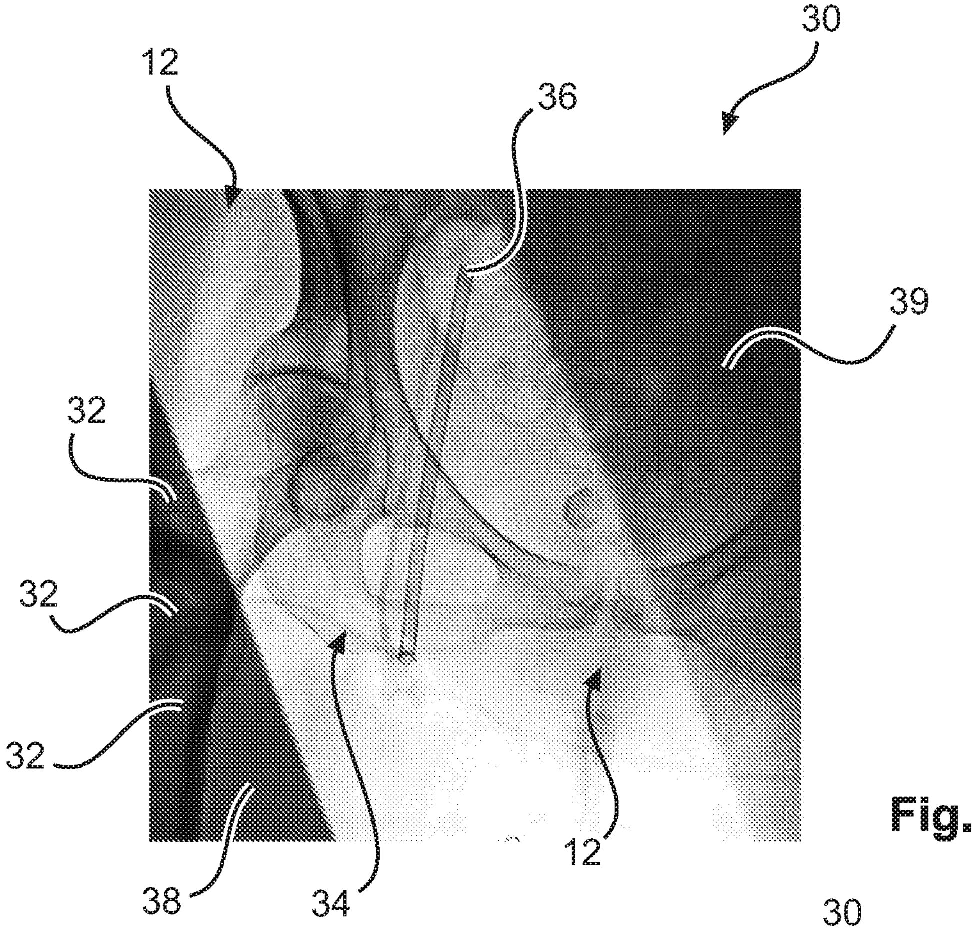

Fig.4C

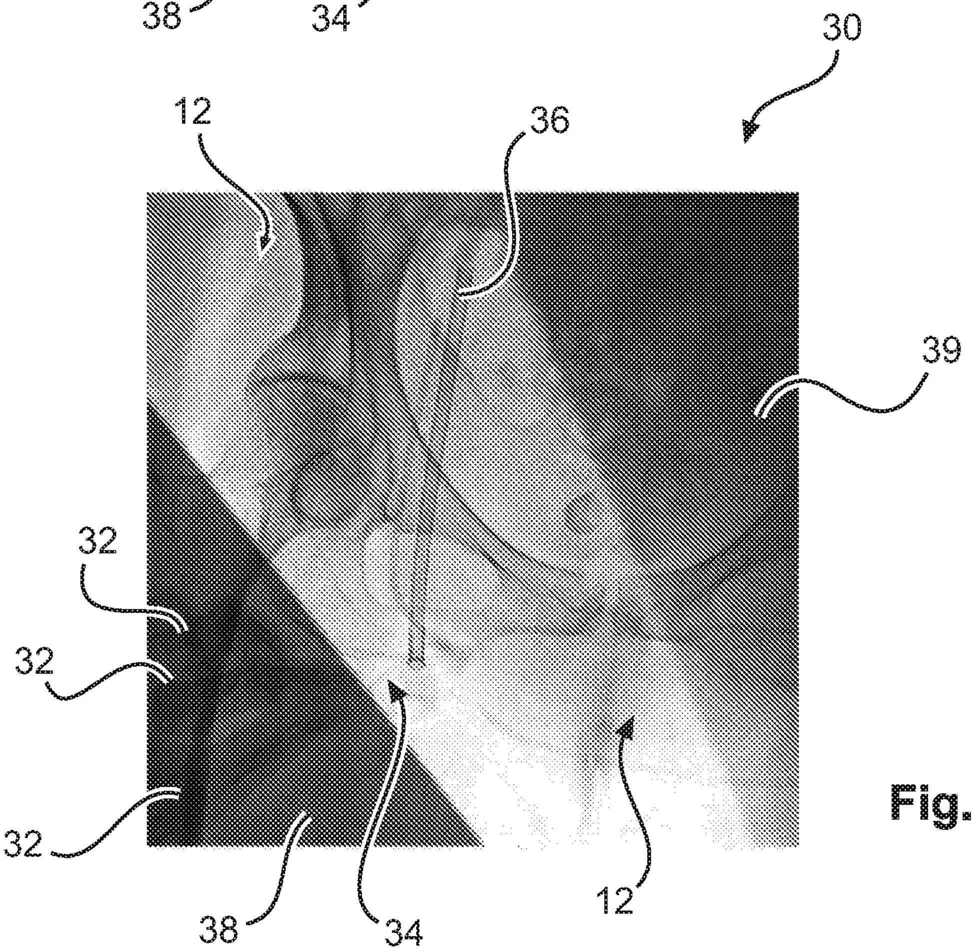

Fig.4D

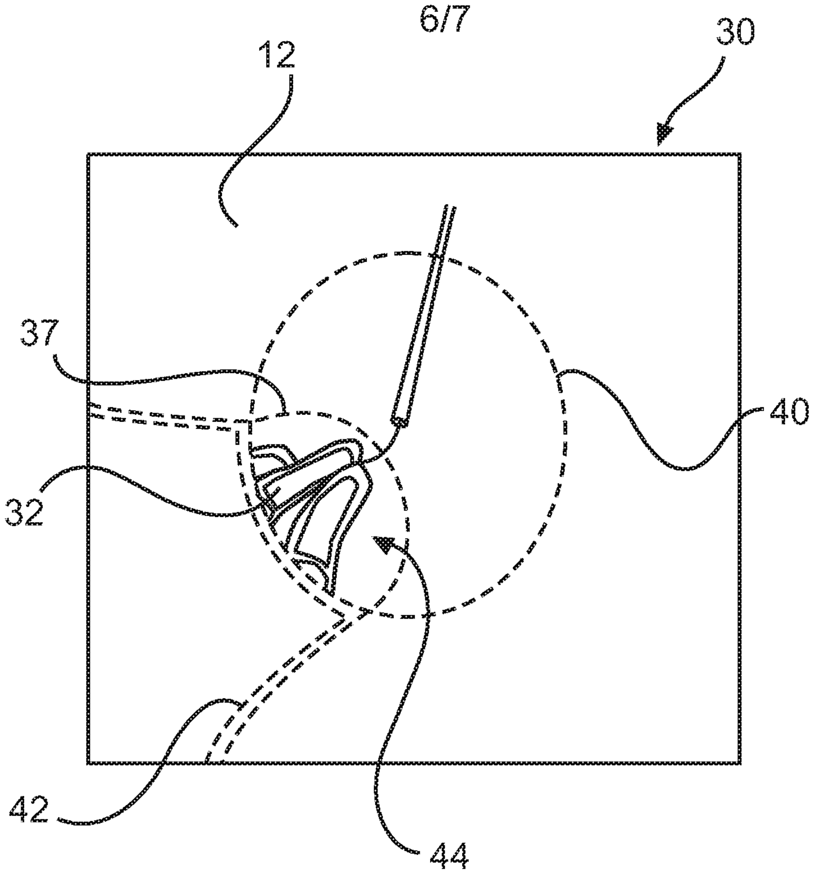

Fig.5

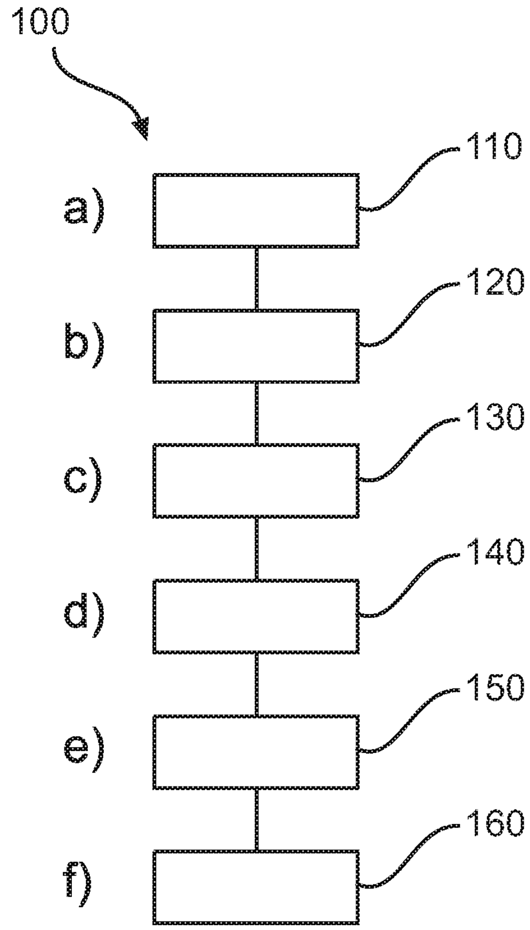

Fig.6

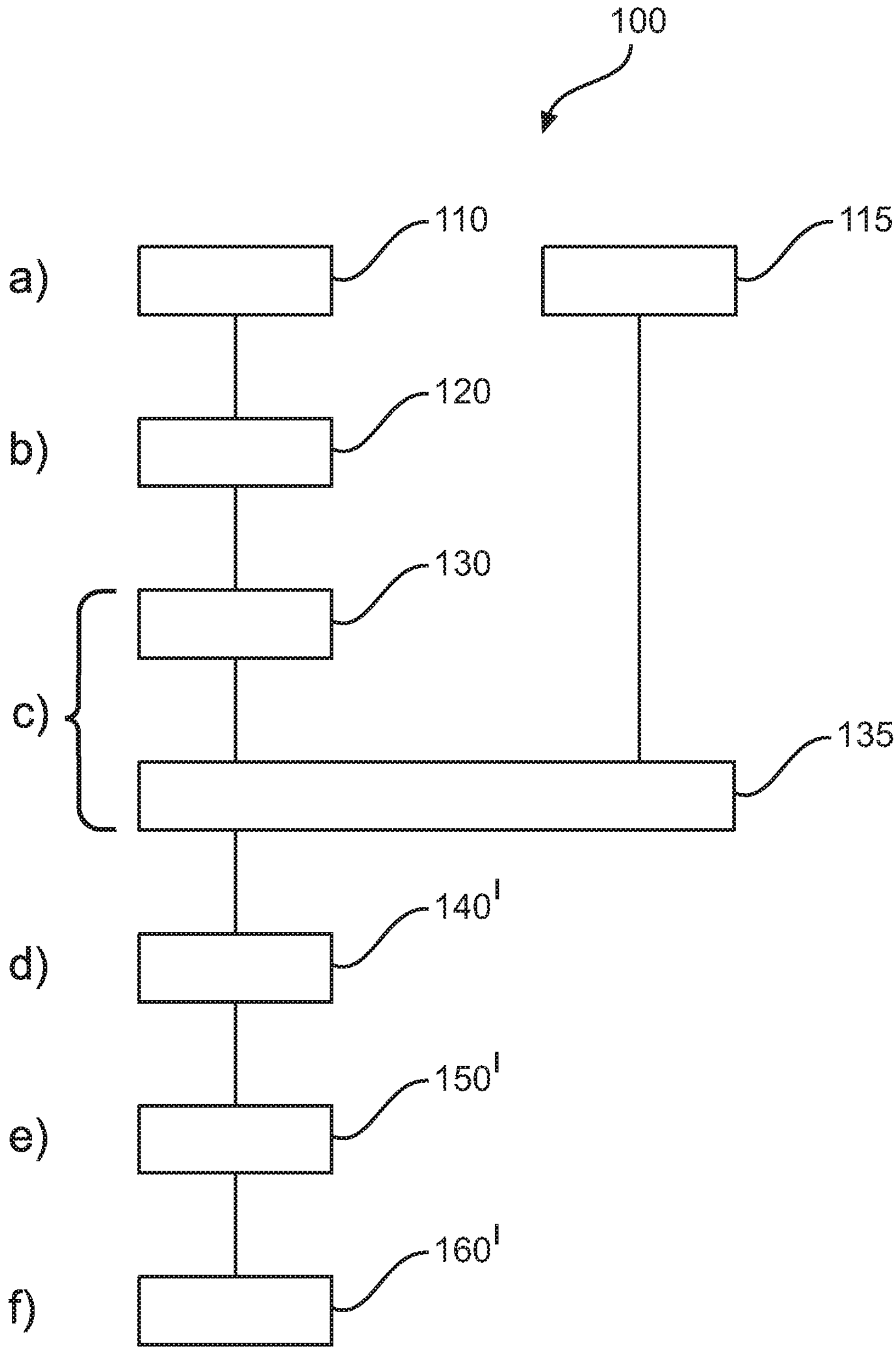

Fig.7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/060115

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B6/06 A61B6/10 A61B6/00 G06T7/00 G06K9/00
A61B5/107 A61B5/11 A61B19/00
ADD. A61B6/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B G06T G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 6 501 820 B2 (GUENDEL LUTZ [DE]) 31 December 2002 (2002-12-31) abstract column 4, line 1 - line 55 column 5, line 58 - column 8, line 60 claims 2,5,7; figures 1-3,5,6 -----	1,3,8,9, 11,13,14 2,4-6,10 7,12
Y	US 2008/187205 A1 (SHIOZAWA HIDETO [JP] ET AL) 7 August 2008 (2008-08-07) abstract paragraph [0077] - paragraph [0092] figures 1,7 -----	2,4-6,10
A	EP 1 384 441 A1 (GE MED SYS GLOBAL TECH CO LLC [US]) 28 January 2004 (2004-01-28) the whole document ----- -/--	1-14

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 May 2014	30/05/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Artikis, T

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2006 320468 A (GE MED SYS GLOBAL TECH CO LLC) 30 November 2006 (2006-11-30) abstract column 1, line 1 - column 2, line 5 column 4, line 21 - column 7, line 18 figures 1-4 -----	1,9,13, 14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2014/060115

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			JP	2008188276	A	21-08-2008
			US	2008187205	A1	07-08-2008
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			IL	156905	A	07-08-2008
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			JP	2006320468	A	30-11-2006