**Title:** IMAGING SYSTEM AND IMAGING METHOD FOR IMAGING AN OBJECT

**Abstract:** The invention relates to an imaging system for imaging an object, wherein the imaging system is adapted for scanning the object in accordance with a scan parameter. The imaging system comprises a projection image generation unit (15) for generating a two-dimensional projection image of the object. A model provision unit (16) provides a three-dimensional model of the object, and a registration unit (17) registers the three-dimensional model with the two-dimensional projection image. A scan parameter determination unit (18) determines the scan parameter from the registered three-dimensional model.

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Imaging system and imaging method for imaging an object

FIELD OF THE INVENTION

The invention relates to an imaging system, an imaging method and a computer program for imaging an object. The invention relates further to a scan parameter determination device, a scan parameter determination method and a computer program for determining a scan parameter.

BACKGROUND OF THE INVENTION

A computed tomography system is an imaging system for imaging an object. A computed tomography system comprises an X-ray source and a detection unit, which move relative to an examination zone, in which an object is located. Detection values are acquired, which depend on the radiation after having passed the object, and an image of the object is reconstructed using the acquired detection values. The X-ray source illuminates generally only the part of the object, which has to be illuminated in order to have detection values, which are sufficient for reconstructing a desired region of interest. The region of interest is generally defined by hand. For defining the region of interest by hand a two-dimensional projection image is generated and displayed on a monitor, and a user defines a region of interest on the two-dimensional projection image by using a graphical user interface. The two-dimensional projection image is generated by moving an object table, on which the object is located, linearly and by illuminating the object by radiation of the X-ray source, which does not rotate during generation of the two-dimensional projection image.

This determination of the region of interest has the drawback that in the projection direction overlaying structures of the object can not be distinguished in the two-dimensional projection image resulting in a decreased quality of the determination of the region of interest.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an imaging system for imaging an object, wherein the determination of a scan parameter, like the region of interest, is improved.
In an aspect of the invention an imaging system for imaging an object is presented, wherein the imaging system is adapted for scanning the object in accordance with a scan parameter, the imaging system comprising:

- a projection image generation unit for generating a two-dimensional projection image of the object,
- a model provision unit for providing a three-dimensional model of the object,
- a registration unit for registering the three-dimensional model with the two-dimensional projection image,
- a scan parameter determination unit for determining the scan parameter from the registered model.

The invention is based on the idea that, since the model is a three-dimensional model, structures, which lie in the projection direction of the projection image one upon the other, can be distinguished in the three-dimensional model, wherein the determination of the scan parameter is improved.

The imaging system comprises preferentially further a display unit for displaying at least one of the registration between the two-dimensional projection image and the three-dimensional model and the determined scan parameter. This allows a user monitoring the registration between the two-dimensional projection image and the three-dimensional model and/or monitoring the determination of the scan parameter.

It is further preferred that the imaging system comprises a modification unit for allowing a user modifying at least one of the registration between the two-dimensional projection image and the three-dimensional model and the determined scan parameter. This allows a user correcting at least one of the registration between the two-dimensional projection image and the three-dimensional model and the determined scan parameter, wherein the determination of the scan parameter is further improved.

It is further preferred that the imaging system comprises a motion determination unit for determining a motion of the object, wherein the model provision unit is adapted for providing a moving three-dimensional model of the object, wherein the registration unit is adapted for registering the moving three-dimensional model with the two-dimensional projection image using the determined motion of the object, wherein the scan parameter determination unit is adapted for determining the scan parameter from the registered moving three-dimensional model.

Since the motion of the object is considered during the generation of the two-dimensional projection image, during the registration of the two-dimensional projection
image with the three-dimensional model and during the determination of the scan parameter from the registered three-dimensional model, the determination of the scan parameter is improved, even if the object, which has to be scanned, is a moving object.

In an embodiment, the registration unit is adapted for using registration features, which are detectable in the two-dimensional projection image and in the three-dimensional model, for registration, wherein the scan parameter determination unit uses scan parameter determining features of the three-dimensional model for determining the scan parameter from the registered three-dimensional model. This allows optimizing the registration features for the registration and optimizing the scan parameter determining features for the determination of the scan parameter independently from each other. This further improves the quality of the registration and the quality of the determination of the scan parameter.

Preferentially, the three-dimensional model of the object does not only comprise the object itself, but also further objects or entities, in particular registration features. For example, if the object, which has to be imaged, is a heart of a patient, the model of the object preferentially does not only comprise the heart, but several objects or entities located in a thorax region of a human patient, i.e., if the object, which has to be imaged, is a heart of a patient, the model of the heart is preferentially a thorax model including the heart of the patient and further entities or objects within the thorax region like the spinal column and the ribs, which can be used as registration features.

It is preferred that the model provision unit is adapted for adapting the three-dimensional model to the two-dimensional projection image. The three-dimensional model can be transformed, for example, translated and/or rotated and/or contracted and/or extended, in order to match as good as possible to the projection image. For example, a similarity measure can be used, like a sum of absolute differences or a correlation, and the three-dimensional model can be transformed such that the similarity measure applied to the two-dimensional projection image and to a simulated two-dimensional projection image, which has, for example, been simulated by forward projecting the transformed three-dimensional model in the projection geometry of the provided two-dimensional projection image, is minimized. Since the three-dimensional model is adapted to the two-dimensional projection image, which shows a projection of the object, which has to be scanned currently, the three-dimensional model is adapted to the respective object, and not to a standard object. Since the scan parameter is determined using this adapted three-dimensional model, which is a three-
dimensional model specific to the respective object, the determination of the scan parameter is further improved.

In a further aspect of the invention a scan parameter determination device for determining a scan parameter is provided, which is usable by an imaging system for scanning an object in accordance with the scan parameter, the scan parameter determination device being provided with a two-dimensional projection image of the object generated by a projection image generation unit, wherein the scan parameter determination device comprises:

- a model provision unit for providing a three-dimensional model of the object,
- a registration unit for registering the three-dimensional model with the two-dimensional projection image,
- a scan parameter determination unit for determining the scan parameter from the registered three-dimensional model.

In a further aspect of the present invention an imaging method for imaging an object is presented, when the imaging method is adapted for scanning the object in accordance with a scan parameter, the imaging method comprising following steps

- generating a two-dimensional projection image of the object by a projection image generation unit,
- providing a three-dimensional model of the object by a model provision unit,
- registering the three-dimensional model with the two-dimensional projection image by a registration unit,
- determining the scan parameter from the registered three-dimensional model by a scan parameter determination unit.

In a further aspect of the present invention a scan parameter determination method for determining a scan parameter is provided, which is usable by an imaging system for scanning an object in accordance with the scan parameter, the scan parameter determination method being provided with a two-dimensional projection image of the object generated by a projection image generation unit, wherein the scan parameter determination method comprises following steps:

- providing a three-dimensional model of the object by a model provision unit,
- registering the three-dimensional model with the two-dimensional projection image by a registration unit,
- determining the scan parameter from the registered three-dimensional model by a scan parameter determination unit.
In a further aspect of the invention a computer program for imaging an object is provided, wherein the computer program comprises program code means for causing a computer to carry out the steps of the imaging method as claimed in claim 6 when the computer program is carried out on a computer controlling an imaging system as claimed in claim 1.

In a further aspect of the present invention a computer program for determining a scan parameter is provided, wherein the computer program comprises program code means for causing a computer to carry out the steps of the scan parameter determination method as claimed in claim 7 when the computer program is carried out on a computer controlling a scan parameter determination device as claimed in claim 5.

It shall be understood that the imaging system of claim 1, the scan parameter determination device of claim 5, the imaging method of claim 6, the scan parameter determination method of claim 7, the computer program of claim 8 and the computer program of claim 9 have similar and/or identical preferred embodiments as defined in the dependent claims.

It shall be understood that preferred embodiments of the invention can also be combinations of, for example, two or more dependent claims with the respective independent claim.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described herein after. In the following drawings:

Fig. 1 shows schematically a representation of an imaging system in accordance with the invention,

Fig. 2 shows schematically a representation of a scan parameter determination device in accordance with the invention,

Fig. 3 shows schematically a flowchart illustrating an imaging method for imaging an object in accordance with the invention, and

Fig. 4 shows schematically a flowchart illustrating a scan parameter determination method for determining a scan parameter in accordance with the invention.
DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1 shows an imaging system for imaging an object, which is, in this embodiment, a computed tomography system (CT system). The CT system includes a gantry 1, which is capable of rotation about an axis of rotation R, which extends parallel to the z direction. A radiation source 2, which is, in this embodiment, an X-ray source 2, is mounted on the gantry 1. The X-ray source 2 is provided with a collimator 3, which forms in this embodiment a conical radiation beam 4 from the radiation produced by the X-ray source 2. The radiation traverses an object (not shown), such as a patient, in an examination zone 5, which is in this embodiment cylindrical. After having traversed the examination zone 5, the X-ray beam 4 is incident on a detection unit 6, which comprises in this embodiment a two-dimensional detection surface. The detection unit 6 is mounted on the gantry 1.

The imaging system comprises a driving device having two motors 7, 8. The gantry 1 can be rotated at a preferably constant but adjustable angular speed by the motor 7. The motor 8 is provided for displacing the object, for example, a patient, who is arranged on a patient table in the examination zone 5, parallel to the direction of the axis of rotation R or the z axis. These motors 7, 8 are controlled by a control unit 9, for instance, such that the radiation source 2 and the examination zone 5 move relative to each other along a helical trajectory. However, it is also possible that the examination zone 5 is not moved, but that only the radiation source 2 is rotated, i.e., that the radiation source 2 moves along a circular directory relative to the examination zone 5. Furthermore, it is also possible that the examination zone 5 including the object is moved parallel to the axis of rotation R or the z direction, and that the radiation source 2 is not rotated, i.e., that the radiation source 2 and the examination zone 5 move relative to each other along a linear trajectory.

In another embodiment, the collimator 3 can be adapted for forming a fan beam and the detection unit 6 can also be a one-dimensional detector.

The control unit 9 is adapted such that during an acquisition of detection values, which will be used for reconstructing an image of the object, the object is scanned in accordance with one or more scan parameters. For determining the scan parameters the radiation source 2 and the examination zone 5 move relative to each other along a linear trajectory, wherein detection values are acquired by the detection unit 6, which are transmitted to a projection image generation unit 15. During acquisition of these detection values preferentially the radiation source 2 is not rotated and the examination zone 5, and, therefore, the object 2 are moved parallel to the z direction or the axis of rotation R, for
example, by moving a patient table, on which the object is located, parallel to the parallel
direction or the axis of rotation R. The projection image generation unit 15 generates a two-
dimensional projection image of the object and transmits the generated two-dimensional
projection image to a scan parameter determination device 12.

The scan parameter determination device 12, which is schematically shown in
more detail in Fig. 2, comprises a model provision unit 16 for providing a three-dimensional
model of the object, a registration unit 17 for registering the three-dimensional model with
the two-dimensional projection image, a scan parameter determination unit 18 for
determining the scan parameter from the registered three-dimensional model and a
modification unit 19 for allowing a user modifying at least one of the registration between the
two-dimensional projection image and the three-dimensional model and the determined scan
parameter. The determined scan parameter and/or the three-dimensional registered model
and the two-dimensional projection image can be shown on a display 11. The scan parameters
determined by the scan parameter determination unit 18 are transmitted to the control unit 9,
which controls the scanning of the object for acquiring detection values, which will be used
for reconstructing an image of the object, in accordance with the determined scan parameters.

The acquired detection values, which have been acquired while the control
unit 9 has controlled the imaging system in accordance with the determined one or more scan
parameters, are provided to an image generation device 10 for generating an image of the
object. The image generation device 10 reconstructs an image of the object using the
acquired detection values.

The reconstructed image can finally be provided to the display 11 for
displaying the image. Also the image generation device 10 and/or the scan parameter
determination device 12 and/or the projection image generation unit 15 are preferably
controlled by the control unit 9.

The control unit 9 is connected to an input unit 20, which is, for example, a
keyboard or a mouse, in particular for allowing a user selecting or choosing a desired scan.
For example, a user can input that only a certain part of the object or, if several objects are
present, a certain object should be imaged.

The CT system further comprises, in this embodiment, a motion determination
unit 14 for determining a motion of the object. The motion determination unit 14 is, for
example, an electrocardiograph for acquiring an electrocardiogram, which is directly related
to the movement of a heart of the patient, if a heart or a part, i.e. a region of interest, of a
heart has to be imaged. In addition or alternatively, the motion determination unit 14 can
comprise a device for determining the motion of a patient caused by respiration. Furthermore, the motion determination unit 14 can be adapted such that it determines a motion of the object from the acquired detection values, which will be used for reconstructing an image of the object, wherein the images of the object can also image a part of an object or a region of interest of an object.

In the following, an embodiment of an imaging method for imaging an object in accordance with the invention will be described in more detail with reference to a flowchart shown in Fig. 3.

In step 101, a type of scan is provided, which has to be performed. For instance, a user can define the type of scan, for example, by inputting a corresponding input signal in the control unit 9 using the input unit 20. The user can, for example, define that a certain organ of a patient, like the heart, should be imaged, furthermore, a user can define that only a part of an object, like a part or a region of interest of an organ, should be imaged. Furthermore, for example, a user can define that a cardiac computed tomography angiography scan (cardiac CTA scan) should be performed. If a type of scan has not been provided, for example, by a selection performed by a user, a predefined default type of scan is used in the following steps.

In step 102, a two-dimensional projection image is generated. For this generation of a two-dimensional projection image, the X-ray source 2 does not rotate and the examination zone 5 including the object is moved parallel to the z direction or the axis of rotation R, i.e. the X-ray source 2 and the examination zone 5 move relative to each other along a linear trajectory. The X-ray source 2 emits X-ray radiation traversing the object in the examination zone 5. The X-ray radiation, which has passed the object, is detected by the detection unit 6, which generates detection values. These detection values are transmitted to the projection image generation unit 15, which generates a projection image of the object from the detection values. This projection image is an overview image, i.e. the projection image shows a region of the examination zone 5, which is surely large enough for including the object or the part of the object or the region of interest within the object, which has to be scanned for allowing performing the type of scan defined in step 101. For example, if in step 101 it has been defined that the whole heart of a patient should be imaged, i.e. if a cardiac scan type has been defined, the projection image is generated such, and the detection values are acquired such, that the projection image shows surely and at least the human heart. For example, in this case, the projection image can show the whole thorax. Such a projection image is, for example, a scanogram.
A three-dimensional model of the object is provided by the model provision unit 16 in step 103. The model provision unit 16 is, for example, a memory, in which a three-dimensional model of the object, which corresponds to the type of scan defined in step 101, is stored, if, for instance, in step 101 a cardiac scan type has been defined by a user, the model provision unit 16 provides a three-dimensional model, which comprises the heart.

Preferentially the three-dimensional model does not only comprise the heart itself, but also registration features, which are detectable in the two-dimensional projection image and in the three-dimensional model. These registration features are, for example, bones of the thorax.

The three-dimensional model is, for example, an anatomical model of the respective anatomical region, which corresponds to the type of scan defined in step 101. The anatomical model is, for example, a model of the head/neck region, the thorax/abdomen region, the pelvis or the legs region. These anatomical models comprise the corresponding bone structures and the soft tissue, in particular the organs, located in the respective anatomical region. For example, the anatomical model of the thorax region preferentially contains the complete spinal column, rib cage, heart, aorta and main arterial branches, lungs, trachea and diaphragm. A model is, for example, disclosed in „Geometrical Rib-Cage Modelling, Detection, and Segmentation“, Tobias Klinder, Diploma thesis, Universitat Hannover, Institut für Informationsverarbeitung, 2006.

The order of steps 102 and 103 can be changed, i.e. step 103 can be performed before step 102.

The provided three-dimensional model and the two-dimensional projection image are transmitted to the registration unit 17, which registers the three-dimensional model with the two-dimensional projection image and which furthermore preferentially adapts the three-dimensional model to the two-dimensional projection image in step 104. For this registration and adaptation, in this embodiment, the registration features are used. The registration features are preferentially bone structures, which can be identified in the three-dimensional model and in the two-dimensional projection image. A bone structure within the projection image can be detected by using thresholding and/or a casting of search rays and/or a generalized Hough transform. The use of a casting of search rays is, for example, disclosed in "Fast automated object detection by recursive casting of search rays", C. Lorenz, J.v. Berg, CARS, 2005, and the use of the generalized Hough transform is, for example, disclosed in "Generalizing the Hough transform to detect arbitrary shapes", D. H. Ballard, Pattern Recognition, 13(2): 111-122, 1981.
Bone structures are preferentially characterized by a gray-value pattern across the structure given by the density change between cortical bone close to the surface and bone marrow inside the structure. This change which relates to the typical dimensions of the searched structure can be detected by search rays that are casted through the volume (casting of search rays).

The registration unit 17 uses the registration features, i.e. in this embodiment the detected bone structure, for positioning the three-dimensional model with respect to the two-dimensional projection image and for adapting the three-dimensional model to the two-dimensional projection image. The positioning and adaptation of the model with respect to the projection image is performed by using a 2D-3D registration method. Preferentially the model is positioned and transformed such that the registration features, in this embodiment the bone structure, of the model match as good as possible to the registration features of the projection image. The transformation preferentially includes a translation, a rotation and an extension or contraction of the three-dimensional model. The 2D-3D registration can, for example, use simulated projection images or radiographs generated from the model as, for example, described in "An approach to 2D/3D registration of a vertebra in 2D X-ray fluoroscopies with 3D CT images", J. Weese, T.M. Buzug, C. Lorenz, C. Fassnacht, VRMed 1997, pages 119-128, ISBS: 3-540-62794-0, or a matching of silhouette lines to edge features in the projection image as, for example, described in "Recovering the position and orientation of free form objects from image contours using 3D distance maps", S. Lavallee, R. Szeliski, IEEE PAMI, 17(4), 1995. For example, a similarity measure can be used, like a sum of absolute differences or a correlation, and the three-dimensional model can be transformed such that the similarity measure applied to the registration features of the two-dimensional projection image and the registration features of a simulated two-dimensional projection image, which has, for example, been simulated by forward projecting the transformed three-dimensional model, in particular by forward projecting the registration features of the transformed three-dimensional model, in the projection geometry of the provided two-dimensional projection image, is minimized. As already mentioned above, registration features are, for example, bones and, in particular, silhouette lines and edge features of bones.

If, for example, the three-dimensional model is a thorax model, in the projection image preferentially the spinal column and the ribs are detected within the two-dimensional projection image as the registration features, wherein preferentially the above mentioned casting of search rays technique or the generalized Hough transform is used. The 2D-3D registration is then preferentially performed by positioning and adapting the three-
dimensional thorax model such that the ribs and/or the spinal column of the three-dimensional model match as good as possible to the ribs and/or the spinal column identified in the two-dimensional projection image.

In this embodiment, the motion determination unit 14 has determined the motion of the object, for example, the motion of a heart present in the examination zone 5. The provided three-dimensional model is therefore preferentially a moving three-dimensional model of the object, wherein the registration unit 17 is adapted for registering the moving three-dimensional model with and preferentially adapting the moving three-dimensional model to the two-dimensional projection image using the determined motion of the object during the acquisition of the projection image. Therefore, for each or several projection images the corresponding motion phase of the object is determined, and during the registration and preferentially adaptation the moving three-dimensional model in the respective motion phase is registered with and preferentially adapted to a two-dimensional projection image having this respective motion phase.

In step 105, the registered three-dimensional model is transmitted to the scan parameter determination unit 18 for determining one or more scan parameters from the registered three-dimensional model. Since within the three-dimensional model the dimensions and the position of an object are known, one or more scan parameters can be determined such that an object, i.e., for instance, a whole object, a part of an object or a region of interest of an object, can be imaged by the imaging system. For example, if the object, which has to be imaged, is a heart and if the three-dimensional model is a thorax model, which has been registered with respect to the two-dimensional projection image, the region, which has to be scanned by the rays of the radiation unit 2, can be determined as a scan parameter such that the whole heart, a part or a region of interest of the heart can be reconstructed. Furthermore, for instance, the slice and the in-slice position for an aorta contrast peak measurement used for a bolus injection delay time can be determined from the registered three-dimensional thorax model including a three-dimensional model of a heart.

Preferentially, the three-dimensional model is an anatomical three-dimensional model, like a thorax model, which is composed of entities (for instance individual vertebrae, ribs, organs) carrying an entity specific local coordinate system. The relations between the individual coordinate systems are known, for example, by learning during the generation of the anatomical three-dimensional model. Since the positions, orientations and dimensions of the registration features, which are in this embodiment bone structures, are known after the registration step 104 and since the spatial relations between the individual coordinate systems

of the registration features, i.e. the registration entities, and of the other entities, like a soft tissue organ, are known, the positions, orientations and dimensions of objects within the anatomical three-dimensional model or a region of interest within the anatomical model, for example, the position, orientation and dimensions of the heart, can easily be determined.

Since the positions, orientations and dimensions of one or several objects or entities are known, this information can be used for determining at least one scan parameter depending on the type of scan defined in step 101. For example, if a cardiac scan, which requires imaging the whole heart, has been defined in step 101, the region of the patient, which has to be illuminated for reconstructing an image of the heart, can easily be determined, because the position, orientation and the dimensions of the heart of the specific patient are known. Furthermore, if a cardiac CTA scan type has been provided in step 101, the position, orientation and dimensions of the aorta can be determined from the registered anatomical model, and the scan parameters can be defined such that an image of the aorta can be reconstructed for a contrast peak measurement used for the bolus injection delay time. The bolus is a contrast agent bolus used for visualizing the heart vessels.

The determination of the one or more scan parameters is preferentially performed automatically.

In step 106, the display 11 displays at least one of the two-dimensional projection image, the registered three-dimensional model and the determined scan parameters. In step 107, the registration of the three-dimensional model with the two-dimensional projection image and/or the determined scan parameters can be modified by a user using the modification unit 19. The modification unit 19 comprises, for example, a graphical user interface allowing a user modifying the registration, for example, by modifying the position of the three-dimensional model with respect to the two-dimensional projection image, or the determined scan parameters, for example, by modifying a region of interest of the examination zone 5, which has preferentially been determined as a scan parameter in step 105. If a user modifies the registration of the three-dimensional model with the two-dimensional projection image, the scan parameters are preferentially determined again in step 105, wherein the modified registration of the three-dimensional model with the two-dimensional projection image is used. In another embodiment, after the registration has been modified by a user in step 107, the method can continue with the registration in step 104, wherein the modified position of the three-dimensional model with respect to the two-dimensional projection image is used as an initial position of the three-dimensional model with respect to the two-dimensional projection image for the registration or wherein only an
extension or contraction of the three-dimensional model is performed, in order to adapt the three-dimensional model having a fixed position and orientation modified by the modification unit 19 to the two-dimensional projection image.

In step 108, the examination zone 5 and, therefore, the object is scanned in accordance with the scan parameters determined in step 105. For example, if in step 105 a scan parameter has been determined, which is a region of the examination zone 5, which has to be imaged, i.e., which is, for example, a region of interest, the radiation source 2 and the examination zone 5 move relative to each other such that detection values are acquired, which are sufficient to reconstruct an image of the region of the examination zone defined in step 105. In step 109, an image of the object is reconstructed using the detection values acquired in step 108. The reconstruction is performed by a reconstruction unit, which preferentially uses a filtered back projection technique for reconstructing the object. Also other reconstruction techniques can be used, like a radon inversion. During a reconstruction preferentially the motion of the object determined by the motion determination unit 14 is considered.

Steps 106 and/or 107 can be omitted. If step 106 is omitted, the imaging method for imaging an object does not visualize at least one of the registration of the three-dimensional model with the two-dimensional projection image and the determined scan parameters. If step 107 is omitted, the imaging method for imaging an object does not provide the possibility to modify at least one of the registration of the three-dimensional model with the two-dimensional projection image and of the determined scan parameters.

In the following, an embodiment of a scan parameter determination method for determining a scan parameter, which is usable by an imaging system for scanning an object in accordance with the scan parameter, will be described with reference to a flowchart shown in Fig. 4.

In step 201, a three-dimensional model of an object, which has to be imaged, is provided by the model provision unit 16. This provision of a three-dimensional model corresponds to step 103 in Fig. 3.

In step 202, the provided three-dimensional model and a two-dimensional projection image of the object provided by the projection image generation unit 15 are registered by the registration unit 17. Furthermore, preferentially the registration unit 17 adapts the three-dimensional model to the two-dimensional projection image. This step 202 corresponds to step 104.
The registered three-dimensional model is transmitted to the scan parameter determination unit 18 for determining one or more scan parameters from the registered three-dimensional model in step 203. This determination of one or more scan parameters from the registered three-dimensional model corresponds to step 105 in Fig. 3.

In step 204, the display 11 displays at least one of the two-dimensional projection image, the registered three-dimensional model and the determined one or more scan parameters. In step 205, the registration of the three-dimensional model with the two-dimensional projection image and/or the determined one or more scan parameters can be modified by a user using the modification unit 19. This provision of a modification by a modification unit 19 corresponds to step 107 in Fig. 3.

The scan parameter determination method for determining a scan parameter ends in step 206.

For a more detailed description of the steps 201 to 205, it is referred to the above described corresponding steps 103 to 107.

Steps 204 and/or 205 can be omitted, wherein, if step 204 is omitted, at least one of the registration of the three-dimensional model and the two-dimensional projection image and the scan parameters are not visualized, and wherein, if step 205 is omitted, the scan parameter determination method does not provide a possibility for a user to modify at least one of the registration of the three-dimensional model with the two-dimensional projection image and the determined scan parameters.

Although the imaging system, which has been described above, comprises a motion determination unit 14, the invention is not limited to an imaging system comprising a motion determination unit. For example, the imaging system can also be an imaging system, which does not comprise a motion determination unit.

The expression "imaging of an object" and similar expressions include the imaging of a whole object, a part of an object and/or a region of interest of an object. Furthermore, the imaging system can image several objects.

The invention is not limited to an imaging system being a computed tomography system. For example, the imaging system can also be an X-ray system mounted on a C-arm.

The invention is not limited to an imaging system for imaging organs or other objects of a patient. For example, also technical objects can be imaged. For example, in a fabrication quality control technical objects have to be imaged for monitoring purposes, but the technical objects could be different and could not be located within the imaging system in
the same way. The imaging system and the scan parameter determination device in accordance with the invention allow reproducibly, exactly and reliably monitoring of the technical objects in a fabrication quality control, independently of the form, position and orientation of the respective technical object.

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art and practicing the 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 indifferent article "a" or "an" does not exclude a plurality. In particular, the term "a scan parameter" in claim 1 does not limit the invention to the determination of only one scan parameter. Also several scan parameters can be determined in accordance with the invention.

A single unit may fulfill 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.

A computer program may be stored/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.

Any reference signs in the claims should not be construed as limiting the scope of the invention.
CLAIMS

1. An imaging system for imaging an object, wherein the imaging system is adapted for scanning the object in accordance with a scan parameter, the imaging system comprising
   - a projection image generation unit (15) for generating a two-dimensional projection image of the object,
   - a model provision unit (16) for providing a three-dimensional model of the object,
   - a registration unit (17) for registering the three-dimensional model with the two-dimensional projection image,
   - a scan parameter determination unit (18) for determining the scan parameter from the registered three-dimensional model.

2. The imaging system as claimed in claim 1, further comprising a modification unit (19) for allowing a user modifying at least one of the registration between the two-dimensional projection image and the three-dimensional model and the determined scan parameter.

3. The imaging system as claimed in claim 1, wherein the imaging system comprises a motion determination unit (14) for determining a motion of the three-dimensional object, wherein the model provision unit (16) is adapted for providing a moving three-dimensional model of the object, wherein the registration unit (17) is adapted for registering the moving three-dimensional model with the two-dimensional projection image using the determined motion of the object, wherein the scan parameter determination unit (18) is adapted for determining the scan parameter from the registered moving three-dimensional model.

4. The imaging system as claimed in claim 1, wherein the registration unit (17) is adapted for adapting the three-dimensional model to the two-dimensional projection image.
5. A scan parameter determination device for determining a scan parameter, which is usable by an imaging system for scanning an object in accordance with the scan parameter, the scan parameter determination device being provided with a two-dimensional projection image of the object generated by an projection image generation unit (15), wherein the scan parameter determination device comprises:
- a model provision unit (16) for providing a three-dimensional model of the object,
- a registration unit (17) for registering the three-dimensional model with the two-dimensional projection image,
- a scan parameter determination unit (18) for determining the scan parameter from the registered three-dimensional model.

6. An imaging method for imaging an object, wherein the imaging method is adapted for scanning the object in accordance with a scan parameter, the imaging method comprising following steps:
- generating a two-dimensional projection image of the object by a projection image generation unit (15),
- providing a three-dimensional model of the object by a model provision unit (16),
- registering the three-dimensional model with the two-dimensional projection image by a registration unit (17),
- determining the scan parameter from the registered three-dimensional model by a scan parameter determination unit (18).

7. A scan parameter determination method for determining a scan parameter, which is usable by an imaging system for scanning an object in accordance with the scan parameter, the scan parameter determination method being provided with a two-dimensional projection image of the object generated by an projection image generation unit (15), wherein the scan parameter determination method comprises following steps:
- providing a three-dimensional model of the object by a model provision unit (16),
- registering the three-dimensional model with the two-dimensional projection image by a registration unit (17),
- determining the scan parameter from the registered three-dimensional model
  by a scan parameter determination unit (18).

8. A computer program for imaging an object, comprising program code means

for causing a computer to carry out the steps of the imaging method as claimed in claim 6
when the computer program is carried out on a computer controlling an imaging system as
claimed in claim 1.

9. A computer program for determining a scan parameter, comprising program

code means for causing a computer to carry out the steps of the scan parameter determination
method as claimed in claim 7 when the computer program is carried out on a computer
controlling a scan parameter determination device as claimed in claim 5.
FIG. 2
FIG. 3