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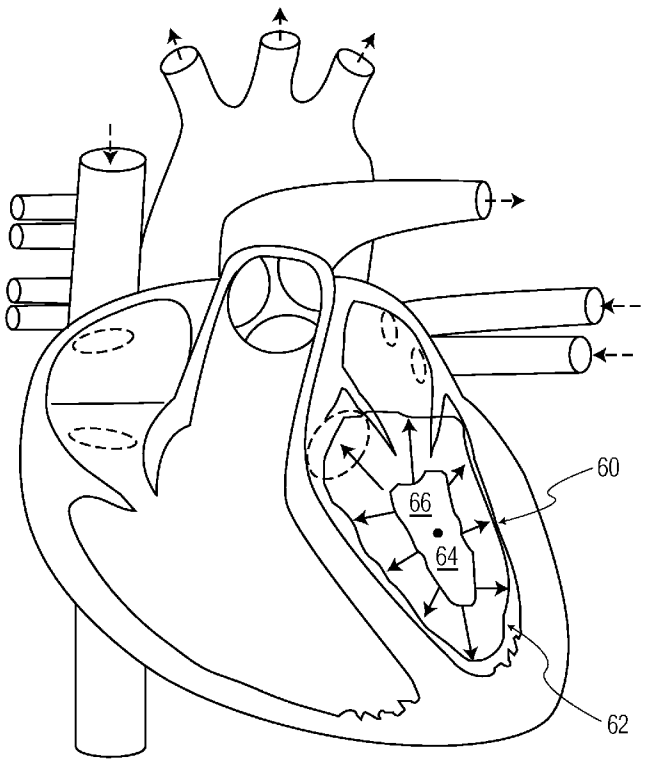
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(54) Title: 3D-2D ADAPTIVE SHAPE MODEL SUPPORTED MOTION COMPENSATED RECONSTRUCTION



(57) Abstract: A method for generating or reconstruction of three-dimensional (3D) images corresponding to a structure of interest (60) including: acquiring a plurality of image projections corresponding to a structure of interest (60); applying a shape model (66) at a selected 3D seed point (64); and adapting the shape model (66) to represent the structure of interest (60), yielding an adapted shape model. A system for generation and reconstruction of three-dimensional (3D) images. The system (10) includes: an imaging system (12) configured to provide projection data corresponding to a structure of interest (60); and a controller (50) in operable communication with the imaging system (50). The controller (50) is configured to: receive the projection data, (64); apply a shape model (66) at a selected 3D seed point (64); and adapt the shape model (66) to represent the structure of interest (60), thereby yielding an adapted shape model.

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3D-2D ADAPTIVE SHAPE MODEL SUPPORTED MOTION COMPENSATED RECONSTRUCTION

The present disclosure is directed to a methodology for compensating motion in 3D and 4D image reconstructions. Particularly motion compensation and augmentation of images generated with X-ray fluoroscopy and the like based on an adaptive shape model.

In X-ray guided cardiac interventions, as e.g. for electro physiology interventions, 3D and 4D reconstructions of a target ventricular structure are often utilized in order to plan and guide the intervention. Currently, these data can, if necessary, be acquired pre-intervention using a different imaging modality. However, with this approach, data may not be the most current. In addition, data acquired with a different imaging modality have to be registered with respect to the actual imaging information used for guidance adding cost, time and complexity.

Furthermore, patient motion during any kind of imaging leads to inconsistent data and hence to artifacts such as blurring and ghost images. Therefore, patient motion has to be avoided or compensated. Practically, avoiding motion, e.g., fixation of the patient is generally difficult or impossible. Thus compensation of/for patient motion is most practicable. The majority of motion compensation methods focus on how to obtain consistent projection data that all belong to the same motion state and then use this sub-set of projection data for reconstruction. Using multiples of such sub-sets, different motion states of the measured object can be reconstructed. For example, one method employed parallel re-binning cone-beam backprojection to compensate for object motion and time evolution of the X-ray attenuation. A motion field is estimated by block matching of sliding window reconstructions, and consistent data for a voxel under consideration is approximated for every projection angle by linear regression from temporally adjacent projection data from the same direction. The filtered projection data for the voxel is chosen according to the motion vector field. Other methods address motion effects in image reconstructions using a precomputed motion vector field to modify the projection operator and calculate a motion-compensated reconstruction.

Despite efforts to date, a need remains for an effective and cost effective methodology to generate a 3D/4D data set. Particularly beneficial would be generating a 3D/4D data set on the imaging system, which is also used for the intervention. Furthermore, it would be beneficial to conduct this imaging for intervention concurrent

therewith to avoid additional expenses and time associated with additional laboratory time and image registration.

In an exemplary embodiment disclosed herein is a method for generating or reconstruction of three-dimensional (3D) images based on image projection data corresponding to a structure of interest. The method includes: acquiring a plurality of image projections corresponding to a structure of interest with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from said image projections; selecting a 3D seed point; applying a shape model at the 3D seed point; and adapting the shape model to represent the structure of interest, thereby yielding an adapted shape model.

According to exemplary implementations, in another optional embodiment, the abovementioned methodology may further include: acquiring data indicative of motion of the structure of interest associated with the image projections; adapting the shape model to represent the structure of interest based on the data indicative of motion of the structure of interest, thereby yielding another adapted shape model; and generating the 3D images of the structure of interest based on the other adapted shape model.

Further, in another exemplary embodiment, there is disclosed herein a system for generation and reconstruction of three-dimensional (3D) images. The system includes: an imaging system configured to provide image projection data corresponding to a structure of interest with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from said image projections; and a controller in operable communication with the imaging system. The controller is configured to: receive the image projection data; select a 3D seed point; apply a shape model at the 3D seed point; and adapt the shape model to represent the structure of interest, thereby yielding an adapted shape model.

Also disclosed herein, in yet another exemplary embodiment, is a system for generation or reconstruction of three-dimensional (3D) images. The system includes: means for acquiring a plurality of image projections corresponding to a structure of interest with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from said image projections; means for selecting a 3D seed point; means for applying a shape model at the 3D seed point; and means for adapting the shape model to represent the structure of interest, thereby yielding an adapted shape model.

Further disclosed herein, in yet another exemplary embodiment, is a storage medium encoded with a machine readable computer program code, the code including

instructions for causing a computer to implement the abovementioned method for generation or reconstruction of three-dimensional (3D) images.

Disclosed herein, in another exemplary embodiment, is a computer data signal; the computer data signal comprising instructions for causing a computer to implement the abovementioned method for generation or reconstruction of three-dimensional (3D) images.

Additional features, functions, and advantages associated with the disclosed methodology will be apparent from the detailed description which follows, particularly when reviewed in conjunction with the figures appended hereto.

To assist those of ordinary skill in the art in making and using the disclosed embodiments, reference is made to the appended figures, wherein like references are numbered alike.

FIGURE 1 depicts an X-ray imaging system in accordance with an exemplary embodiment of the invention;

FIGURE 2 is a block diagram depicting an example of the disclosed methodologies;

FIGURE 3 depicts an example of an exemplary embodiment as applied to an illustration of the heart;

FIGURE 4 depicts an illustration of a method for determining a seed point in accordance with an exemplary embodiment of the invention;

FIGURE 5A depicts an illustrative shape model and a forward projection onto the projection of interest;

FIGURE 5B depicts a boundary determination in accordance with an exemplary embodiment; and

FIGURE 5C depicts modification of the bounding points in accordance with an exemplary embodiment.

As set forth herein, the present disclosure advantageously permits and facilitates three-dimensional (3D) rotational X-ray imaging, particularly of ventricular structures, especially for electro physiology (EP) interventions. Furthermore, the present disclosure permits and facilitates shape model based reconstruction from a low number of projections and results in a low dose 4D (e.g., 3D with cardiac phase) X-ray reconstruction.

The present invention may be utilized for various types of applications of 3D/4D imaging. A preferred embodiment of the invention, by way of illustration, is described

herein as it may be applied to X-ray imaging as utilized for electro physiology interventions. While a preferred embodiment is shown and described by illustration and reference to X-ray imaging and interventions, it will be appreciated by those skilled in the art that the invention is not limited to the X-ray imaging or interventions alone, and may be applied to imaging systems and applications. Moreover, it will be appreciated that the applications disclosed herein are not limited to interventions alone but are in fact, applicable to any application, in general, where 3D/4D imaging is desired.

It will further be appreciated that, while particular sensors and nomenclature are enumerated to describe an exemplary embodiment, such sensors are described for illustration only and are not limiting. Numerous variations, substitutes, and equivalents will be apparent to those contemplating the disclosure herein.

In an exemplary embodiment, 3D rotational X-ray data of the ventricular structure of interest are acquired concurrent with the measurement of the electrocardiogram (ECG) of the patient. A seed point of the target structure is selected and an adaptive shape model is placed around this seed, with an orientation that is adapted to the patient position and a shape that is preferably one known to represent the target vascular structure well. According to the actual patient data represented in the projection data, the shape model is adapted to multiple cardiac phases. The resulting 4D ventricular model may be utilized directly in the intervention guidance and for the estimation of ventricular parameters. Alternatively, the modeled 3D motion of the shape surface can be used to generate a local motion vector field, which may be utilized to provide compensation for the rotational X-ray data to yield a local motion compensated reconstruction of a 4D data set.

Turning now to Figure 1, a system is depicted in accordance with an exemplary embodiment of the invention. The system 10 includes an X-ray device 12 with a C-arm 14 with an X-ray tube 16 arranged at a first end and an X-ray detector 18, for example an image intensifier, arranged at its other end. Such an X-ray device 12 is suitable for forming X-ray projection images of a patient 20 arranged on a table 22 from different X-ray positions; to this end, the position of the C-arm 14 can be changed in various directions; the C-arm 14 is also constructed so as to be rotatable about three axes in space, that is, X, Z as shown and Y (not shown). The C-arm 14 may be attached to the ceiling via a supporting device 24, a pivot 26, and a slide 28 which is displaceable in the horizontal direction in a rail system 30. The control of these motions for the acquisition of

projections from different X-ray positions and of the data acquisition is performed by means of a control unit 50.

A medical instrument 32 including but not limited to a probe, needle, catheter, guidewire, and the like, as well as combinations including at least one of the foregoing may be introduced into the patient 20 such as during an angiography procedure, a biopsy or an intervention treatment. The position of the medical instrument 32 relative to a three-dimensional image data set of the examination zone of the patient 20 may be acquired and measured with a position measurement system (not shown) and/or superimposed on the 3D/4D images reconstructed as described herein in accordance with an exemplary embodiment.

In addition, an electrocardiogram (ECG) measuring system 46 is provided with the X-ray device 12 as part of the system 10. In an exemplary embodiment the ECG measuring system 46 is interfaced with the control unit 50. Preferably, the ECG of the patient 20 is measured and recorded during the X-ray data acquisition to facilitate determination of cardiac phase. In an exemplary embodiment, cardiac phase information is employed to partition and distinguish the X-ray projection data. It will be appreciated that while an exemplary embodiment is described herein with reference to measurement of ECG to ascertain cardiac phase other approaches are possible. For example, cardiac phase and/or projection data partitioning may be accomplished based on the X-ray data alone, other parameters, or additional sensed data.

The control unit 50 controls the X-ray device 12 and facilitates image capture and provides functions and processing to facilitate image reconstruction. The control unit 50 receives the data acquired (including, but not limited to, X-ray images, position data, and the like) so as to be processed in an arithmetic unit 52. The arithmetic unit 52 is also controlled and interfaced with the control unit 50. Various images can be displayed on a monitor 54 in order to assist the physician during the intervention.

In order to perform the prescribed functions and desired processing, as well as the computations therefore (e.g., the X-ray control, image reconstruction, and the like), the control unit 50, arithmetic unit 52, monitor 54, and reconstruction unit 56, and the like may include, but not be limited to, a processor(s), computer(s), memory, storage, register(s), timing, interrupt(s), communication interface(s), and input/output signal interfaces, and the like, as well as combinations comprising at least one of the foregoing. For example, control unit 50, arithmetic unit 52, monitor 54, and reconstruction unit 56, and the like may

include signal interfaces to enable accurate sampling, conversion, acquisitions or generation of X-ray signals as needed to facilitate generation of X-ray projections and reconstruction of 3D/4D images therefrom. Additional features of the control unit 50, arithmetic unit 52, monitor 54, and reconstruction unit 56, and the like, are thoroughly discussed herein.

The X-ray device 12 shown is suitable for forming a series of X-ray projection images from different X-ray positions prior to and/or in the instance on an exemplary embodiment concurrent with an intervention. From the X-ray projection images a three-dimensional image data set, three-dimensional reconstruction images, and if desired X-ray slice images therefrom may be generated. The projections acquired are applied to an arithmetic unit 52 which, in conformity with the method, in accordance with an exemplary embodiment of the invention and then to a reconstruction unit 56 which forms a respective reconstruction image from the projections based on the motion compensation as disclosed at a later point herein. The resultant 3D image can be displayed on a monitor 54. Finally, three-dimensional image data set, three-dimensional reconstruction images, X-ray projection images and the like may be saved and stored in a storage unit 58.

Turning now to Figures 2 and 3 as well, Figure 2 depicts a block diagram 100 illustrating an exemplary embodiment of the disclosed methodologies. Figure 3 depicts an example of an exemplary embodiment as applied to a diagram of the heart. Initially, as depicted at block 102, 3D rotational X-ray data of a structure of interest 60 (e.g., a ventricular structure including, but not limited to the left ventricle), are acquired along a trajectory with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from the image projections. In one embodiment, a coverage angle of at least 180° plus the fan-angle is employed. To facilitate the acquisition of the 3D X-ray data, the contrast of the blood volume contained within the structure of interest 60 is enhanced by contrast agent shown generally as 62. The contrast agent 62 may be applied intravenously, but preferably is supplied directly to the structure of interest 60 via a catheter, so that the structure of interest 60 is filled along the complete rotational acquisition. In parallel to the rotational X-ray data acquisition, the ECG of the patient 20 is measured.

A 3D seed point (e.g., initiation point for a model) 64 in 3D space corresponding to the structure of interest 60 is selected as depicted at block 104. In an exemplary

embodiment, the center of the minimum intensity of the projections is employed. However, other seed points 64 and methods for their selection are possible.

Turning now to Figure 4 as well, to select the 3D seed point 64 in 3D space, on each measured projection, a two-dimensional set of line integrals along a cone beam geometry is measured. For example, when applied to a structure of interest 60 such as a contrast agent filled ventricle in 3D space, the corresponding line integrals through this structure show up with a high value on the detector, after proper calibration. It will be appreciated that originally the intensity is measured, but knowing the intensity of the primary beam, the line integral through the absorption coefficients may be calculated by inverting Lambert Beers Law.

The approximate center of the structure of interest 60, e.g., ventricle, in the projection denoted (m1) is determined for each projection by taking the maximum line integral for that projection, or by convolving the projection with a low pass filter and subsequently taking the maximum to avoid noise. Alternatively, a segmentation method can be applied that searches for certain shapes (which are similar to the projection of a ventricle) in the projection plane and calculate the center of mass of the line integrals within this shape or by means of a different method.

Having determined the approximate center (m1) of the structure of interest 60 in each projection plane, at least three, but preferably more projections belonging to the same cardiac phase are selected from the set of projections for example the projections belonging to the 10% RR interval. One projection of the set of gated projections denoted in this instance (θ_i), (θ_j), and (θ_k) is selected e.g., (θ_i), corresponding to a selected "angle" or angles associated with this projection, and a ray denoted S_i from the center of the projection of the structure of interest 60 denoted ($m1_i$) to the source is taken. From all other projections θ_j, θ_k , ... corresponding to the same phase corresponding rays S_j, S_k, ... are generated. The shortest distances to the ray S_i from the other rays e.g., S_j, S_k are calculated in 3D space. A set of points d(i,k), d(i,j) on this ray S_i for (θ_i) results, and the weighted sum M1(i) is calculated according to the following equations:

$$M1(i) = (\Sigma_n d(i,n)\, w(i,n)) / \Sigma_n w(i,n) \quad (1)$$

$$w(i,n) = \sin(\theta_n - \theta_i). \quad (2)$$

Thereafter, procedure is repeated for the second ray e.g., S_j from θ_j of the set of gated projections. A set of points d(j,k), d(j,i) on the ray S_j for (θ_j) results, and the

weighted sum M1(j) is calculated, and so on for all the selected projections. For each of the projections, and thus the corresponding rays belonging to the same cardiac phase a 3D point (M1(i), M1(j) and so on, on each of the rays results. Finally, the 3D seed point 60 results as the center of "mass" of these points again achieved by a weighted averaging or summing scheme. The same procedure can be applied for all projections with or without cardiac gating. However, due to cardiac motion, without gating, the result may be disturbed. Advantageously, the above-described methodology delivers a single unique seed point 60 per cardiac phase.

Continuing with Figure 2, and referring to block 106, after selecting a 3D seed point, an adaptive shape model 66 is applied around this seed point 64. Preferably, but not necessarily, the adaptive shape model 66 is placed with an orientation adapted to the patient position and a shape which is known to represent the target structure of interest 60 well. For example, in a vascular application for cardiac interventions, the shape model 66 is preferably positioned and shaped in a manner similar to the imaged vascular structure e.g., the left ventricle.

Turning to block 108, in an exemplary embodiment, accurate knowledge of the projection geometry associated with the structure of interest 60 is employed as part of an adaptation process to generate forward estimation projections of the shape of the structure of interest 60 onto the various projection data sets. For example, the shape model 66 is adapted for a single cardiac phase based on actual patient data represented in the projection data; namely, the boundary of the structure of interest 60, (e.g., the ventricle) and the values of the line integrals, representing the thickness and absorption of the structure in 3D.

Turning now to Figures 5A-5C as well, in an exemplary embodiment, the adaptation of the 3D shape model 66 is achieved by an adaptation of the model 66 to a selected number of the plurality of projections separately. Optionally, to address a subset of image projections data exhibiting similar motion characteristics, a simultaneous adaptation to all projections which belong to the same cardiac phase may be employed. Provided that the 3D adaptive shape model 66 includes of a number of points distributed on the surface of the shape with a number of connection lines, the adaptation may be formulated as depicted in Figures 5A – 5C.

Initially, the surface points of the 3D adaptive shape model 66 are forward projected into the projection plane under consideration. Figure 5A depicts an illustrative shape model and a forward projection onto the projection of interest. Those 3D surface

points which are bounding the point cloud in its projection on the detection plane are identified as shown in Figure 5B. A connection between neighboring bounding points in the detection plane describes the border. For each of the bounding points in the direction perpendicular to the 3D border or to the projected 3D border it is searched for an edge which may represent the border of the structure in the projection data. The bounding points are modified accordingly as depicted in Figure 5C. It is noteworthy to appreciate that in the instance where multiple gated projections are available, this adaptation is preferably carried out in each of the projections belonging to the same cardiac phase. After having determined the new 3D positions of the bounding points, the other points of the adaptive 3D shape model are modified according to a given inner energy term of the 3D shape.

As additional information to adapt the shape model 66, the line integral through the shape model 66 in 3D space in the direction of the projection under consideration may be taken into account. For example, the line integrals through the adapted 3D shape model 66 may be calculated and the corresponding two-dimensional distribution of line integrals in the particular projection can be correlated with the measured values to determine the optimal 3D shape adaptation based on the 2D boundary modification.

The shape adaptation can be performed in a single adaptation step based on both measures (edge detection and line integral distribution) or it can be carried out in an iterative manner.

It will be appreciated that advantage is taken of the various known or inferable information to further constrain and facilitate the adaptation of the shape model 66. For example, in one exemplary embodiment, to facilitate the adaptation, the known orientation of the patient permits certain logical assumptions or "educated guesses" corresponding to the "likely" orientation of the structure of interest 60. Similarly, known information regarding the structure of interest for individual patients may be employed to further facilitate the adaptation of the shape model 66. Furthermore, it should be appreciated that concurrent or subsequent adaptation for other cardiac phases may optionally involve knowledge about the shape model or the shape of the structure of interest 60 in neighboring phases and thereby, restrict shape changes to result in a continuous movement of the shape model surface. It should also be appreciated that increasingly more accurate placement and initial shape for the shape model 66 improves adaptation by minimizing the differences

between the actual shape of the structure of interest 60 and that modeled and reducing the iterations required for the adaptation to achieve a satisfactory result.

Finally, the resulting 4D ventricular model may be used directly to facilitate intervention guidance and for the estimation of ventricular parameters by providing 4D images as generated from the shape model 60 as adapted based on the initial X-ray projections. This approach is depicted as block 110 in Figure 2. Alternatively, the 3D motion of the shape model surface can be employed to generate a local motion vector field, which can be applied during the reconstruction process resulting in a motion compensated reconstruction of the rotational X-ray data. Thereby, all available projections are motion compensated during the reconstruction process with respect to a certain reference state. This approach is depicted at block 112 in Figure 2.

It should be noted that the non-dynamic part of the disclosed methodology may be used to generate 3D models of static structures. Furthermore, it will be appreciated that the techniques disclosed herein are readily applicable to any application where a shape is changed or moved by a periodic movement during a rotational data acquisition.

In yet a further embodiment of the disclosed invention is to generate the required chamber information by means of modeling. Here, the outline of the chambers is being defined in multiple projections obtained in the same cardiac phase from different projection directions. The outlined chamber structure is used for the calculation of the 3D shape of the chambers. This technique can also be extended to 4D modeling, providing the functional information.

In sum, the disclosed invention advantageously permits and facilitates three-dimensional (3D) rotational X-ray imaging, particularly of ventricular structures, especially for electro physiology (EP) interventions. Furthermore, the present disclosure permits and facilitates shape model based reconstruction from a low number of projections and results in a low dose 4D (e.g., 3D with cardiac phase) X-ray reconstruction. The disclosed system and methodologies provide significant benefits to operators, particularly physicians, relying on 3D/4D reconstructions for guidance and navigation during electro physiology interventions. Indeed, the disclosed system and methodology provides modeling and/or reconstruction of 3D/4D image data particularly addressing compensation for motion induced in the cardiac cycle. An additional advantage of the disclosed system and methodologies is that the modeling and reconstructions can be performed based on a reduced set of X-ray projections resulting in lowered patient dosage.

It will be evident that there exist numerous numerical methodologies in the art for implementation of mathematical functions, in particular as referenced here, line integrals, filters, taking maximums, and summations. While many possible implementations exist, a particular method of implementation as employed to illustrate the exemplary embodiments should not be considered limiting.

The system and methodology described in the numerous embodiments hereinbefore provides a system and methods for modeling and/or reconstruction of 3D/4D image data particularly addressing compensation for motion induced in the cardiac cycle. In addition, the disclosed invention may be embodied in the form of computer-implemented processes and apparatuses for practicing those processes. The present invention can also be embodied in the form of computer program code containing instructions embodied in tangible media 58, such as floppy diskettes, CD-ROMs, hard drives, or any other computer-readable storage medium, wherein, when the computer program code is loaded into and executed by a computer, the computer becomes an apparatus for practicing the invention. The present invention can also be embodied in the form of computer program code, for example, whether stored in a storage medium, loaded into and/or executed by a computer, or as data signal transmitted whether a modulated carrier wave or not, over some transmission medium, such as over electrical wiring or cabling, through fiber optics, or via electromagnetic radiation, wherein, when the computer program code is loaded into and executed by a computer, the computer becomes an apparatus for practicing the invention. When implemented on a general-purpose microprocessor, the computer program code segments configure the microprocessor to create specific logic circuits.

It will be appreciated that the use of "first" and "second" or other similar nomenclature for denoting similar items is not intended to specify or imply any particular order unless otherwise specifically stated. Likewise the use of "a" or "an" or other similar nomenclature is intended to mean "one or more" unless otherwise specifically stated.

While the invention has been described with reference to an exemplary embodiment thereof, it will be understood by those skilled in the art that the present disclosure is not limited to such exemplary embodiments and that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, a variety of modifications, enhancements, and/or variations may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential spirit or scope thereof. Therefore, it is

intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS:

1. A method for generating or reconstruction of three-dimensional (3D) images based on image projection data corresponding to a structure of interest (60), the method comprising:

acquiring a plurality of image projections corresponding to a structure of interest (60) with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from said image projections;

selecting a 3D seed point (64);

applying a shape model (66) at said 3D seed point (64); and

adapting said shape model (66) to represent said structure of interest (60),thereby yielding an adapted shape model.

2. The method of claim 1 further including:

generating the 3D images of said structure of interest (60) based on said adapted shape model.

3. The method of claim 2 wherein said generating is based on a selected phase of motion for said structure of interest (60).

4. The method of claim 3 wherein said phase of motion corresponds to a cardiac phase.

5. The method of claim 4 wherein said data indicative of a phase of motion is an electrocardiogram.

6. The method of claim 1 further including:

acquiring data indicative of motion of said structure of interest (60) associated with said image projections;

adapting said shape model (66) to represent said structure of interest (60) based on said data indicative of motion of said structure of interest (60), thereby yielding another adapted shape model; and

generating the 3D images of said structure of interest (60) based on said another adapted shape model.

7. The method of claim 1 further including:

generating a motion vector field based on said adapted shape model and said motion of said structure of interest (60); and

compensating said plurality of image projections based on said motion vector field to facilitate the reconstruction.

8. The method of claim 7 wherein said generating a motion vector field is based on a selected phase of motion for said structure of interest (60).

9. The method of claim 1 wherein said acquiring data indicative of motion is conducted substantially concurrent with said acquiring said plurality of image projections.

10. The method of claim 1 wherein said structure of interest is a coronary vessel or cardiac chamber.

11. The method of claim 1 wherein said 3D seed point (64) corresponds to a center of mass of about the minimum intensity of a selected set of said plurality of said image projections.

12. The method of claim 1 wherein said adapting is based on a subset of said plurality of image projections.

13. The method of claim 1 wherein said angular coverage corresponds to at least about a 180 degrees plus fan angle.

14. A system (10) for generation and reconstruction of three-dimensional (3D) images comprising:

an imaging system (12) configured to provide image projection data corresponding to a structure of interest (60) with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from said image projections; and

a controller (50) in operable communication with said imaging system (12), said controller (50) configured to:

receive said image projection data,

select a 3D seed point (64);

apply a shape model (66) at said 3D seed point (64); and

adapt said shape model (66) to represent said structure of interest (60), thereby yielding an adapted shape model.

15. The system (10) of claim 14 wherein said controller (50) is further configured to generate the 3D images of said structure of interest (60) based on said adapted shape model.

16. The system (10) of claim 15 wherein the 3D images are further based on a selected phase of motion for said structure of interest (60).

17. The system (10) of claim 16 wherein said phase of motion corresponds to a cardiac phase.

18. The system (10) of claim 17 wherein said data indicative of a phase of motion is an electrocardiogram.

19. The system (10) of claim 14 wherein said controller is further configured to:

generate a motion vector field based on at least one of said adapted shape model and a motion of said structure of interest (60); and

compensate said plurality of image projections based on said motion vector field to facilitate the reconstruction.

20. The system (10) of claim 19 wherein said motion vector field is based on a selected phase of motion for said structure of interest (60).

21. The system (10) of claim 14 further including:

a measurement system (46) operatively connected with said controller (50) or said imaging system (12), said measurement system (46) configured to provide data indicative of motion of said structure of interest (60) associated with said image projection data;

wherein said controller (50) is further configured to adapt said shape model (66) to represent said structure of interest (60) based on said data indicative of motion of said structure of interest (60), thereby yielding another adapted shape model; and

generating the 3D images of said structure of interest (60) based on said another adapted shape model.

22. The system (10) of claim 21 wherein said data indicative of motion is acquired substantially concurrent with said plurality of image projections.

23. The system (10) of claim 14 wherein said structure of interest is a coronary vessel or cardiac chamber.

24. The system (10) of claim 14 wherein said 3D seed point (64) corresponds to a center of mass of about the minimum intensity of a selected set of said plurality of said image projections.

25. The system (10) of claim 14 wherein said imaging system (12) is an X-ray imaging system.

26. The method of claim 1 wherein said angular coverage corresponds to at least about a 180 degrees plus fan angle.

27. A system (10) for generation or reconstruction of three dimensional (3D) images, the system (10) comprising:

means for acquiring a plurality of image projections corresponding to a structure of interest (60) with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from said image projections;

means for selecting a 3D seed point (64);

means for applying a shape model (66) at said 3D seed point (64); and

means for adapting said shape model (66) to represent said structure of interest (60), thereby yielding an adapted shape model.

28. A storage medium (58) encoded with a machine readable computer program code, the code including instructions for causing a computer to implement a method for generation or reconstruction of three dimensional (3D) images, the method comprising:

acquiring a plurality of image projections corresponding to a structure of interest (60) with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from said image projections;

selecting a 3D seed point (60);

applying a shape model (66) at said 3D seed point (60); and

adapting said shape model (66) to represent said structure of interest (60), thereby yielding an adapted shape model.

29. A computer data signal, said computer data signal comprising instructions for causing a computer to implement a method for generation or reconstruction of three-dimensional (3D) images, the method comprising:

acquiring a plurality of image projections corresponding to a structure of interest (60) with angular coverage sufficient to facilitate the generating or reconstruction of the 3D images from said image projections;

selecting a 3D seed point (64);

applying a shape model (64) at said 3D seed point (66); and

adapting said shape model (66) to represent said structure of interest (60), thereby yielding an adapted shape model.

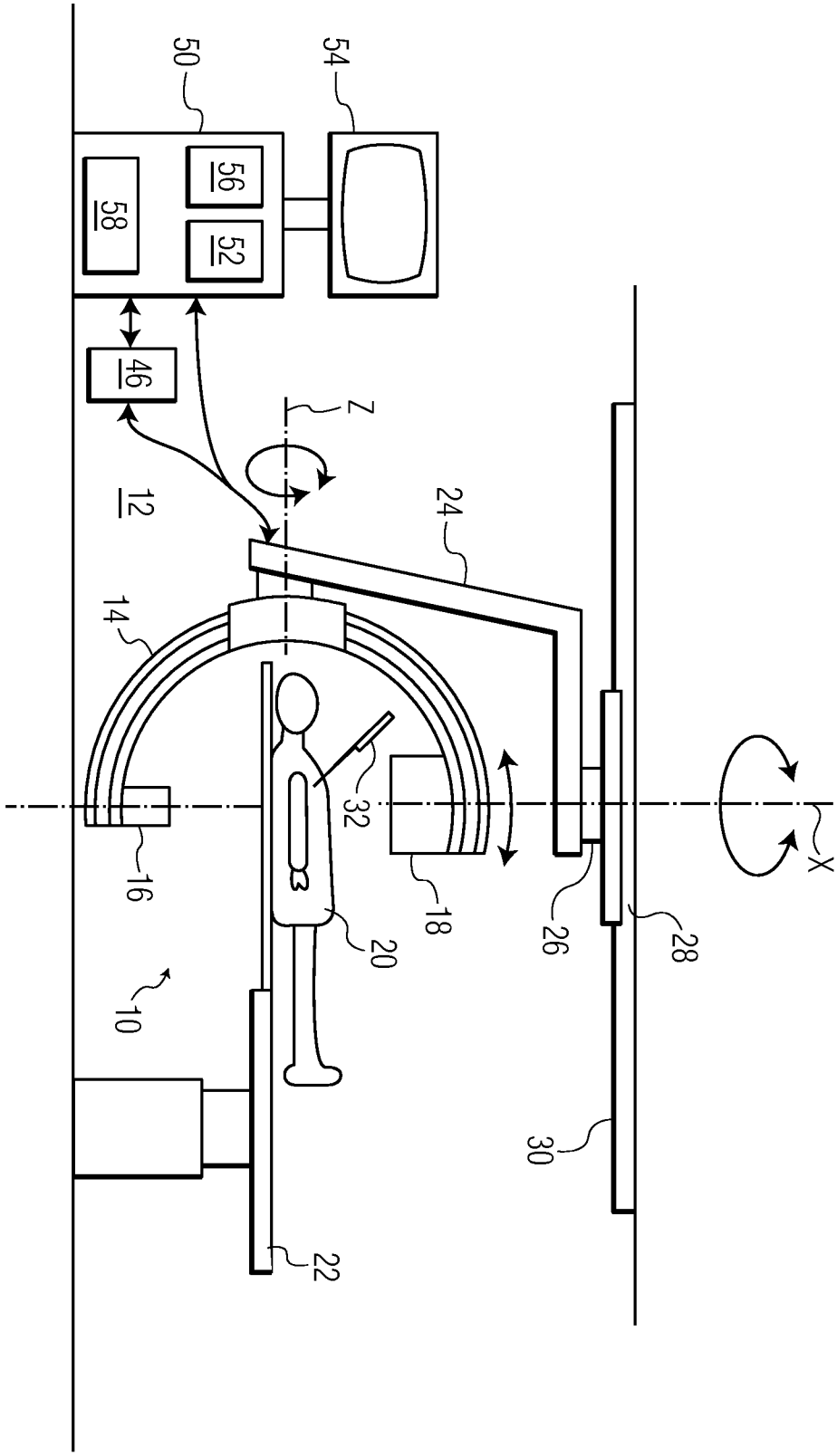


FIG. 1

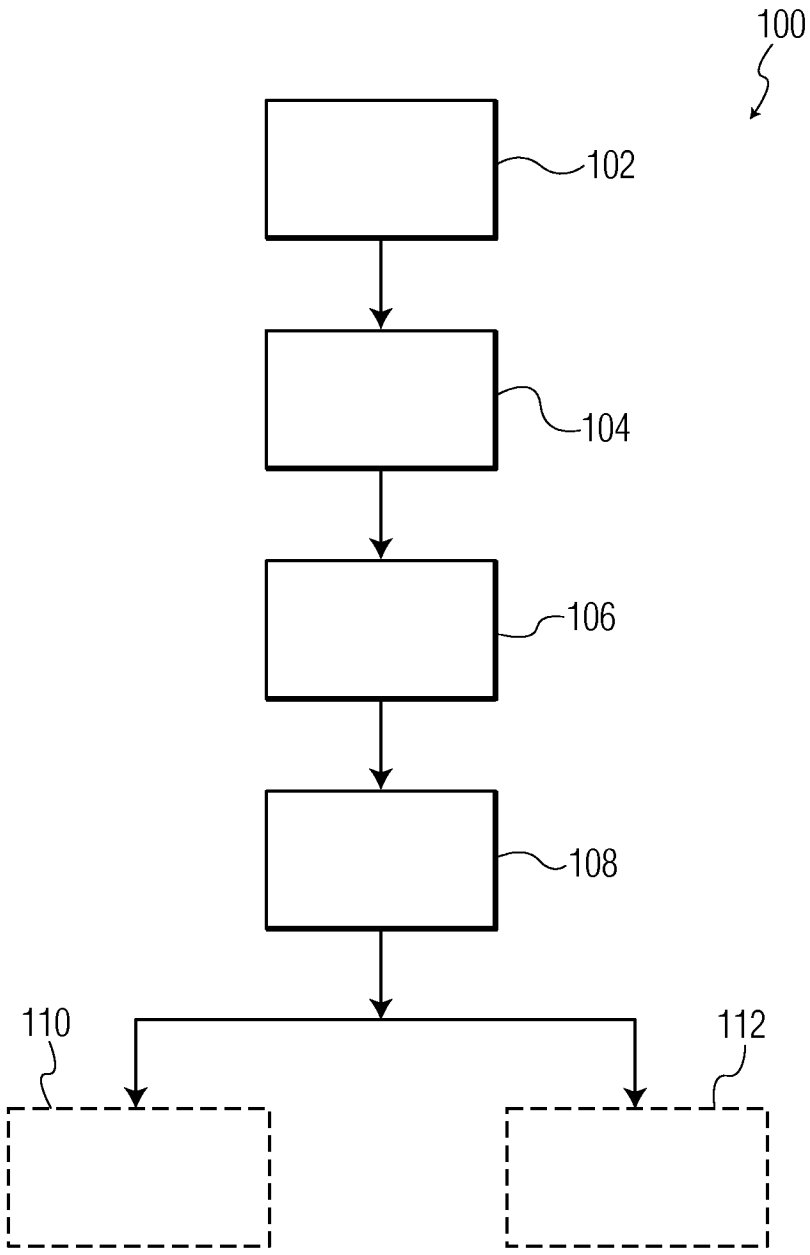


FIG. 2

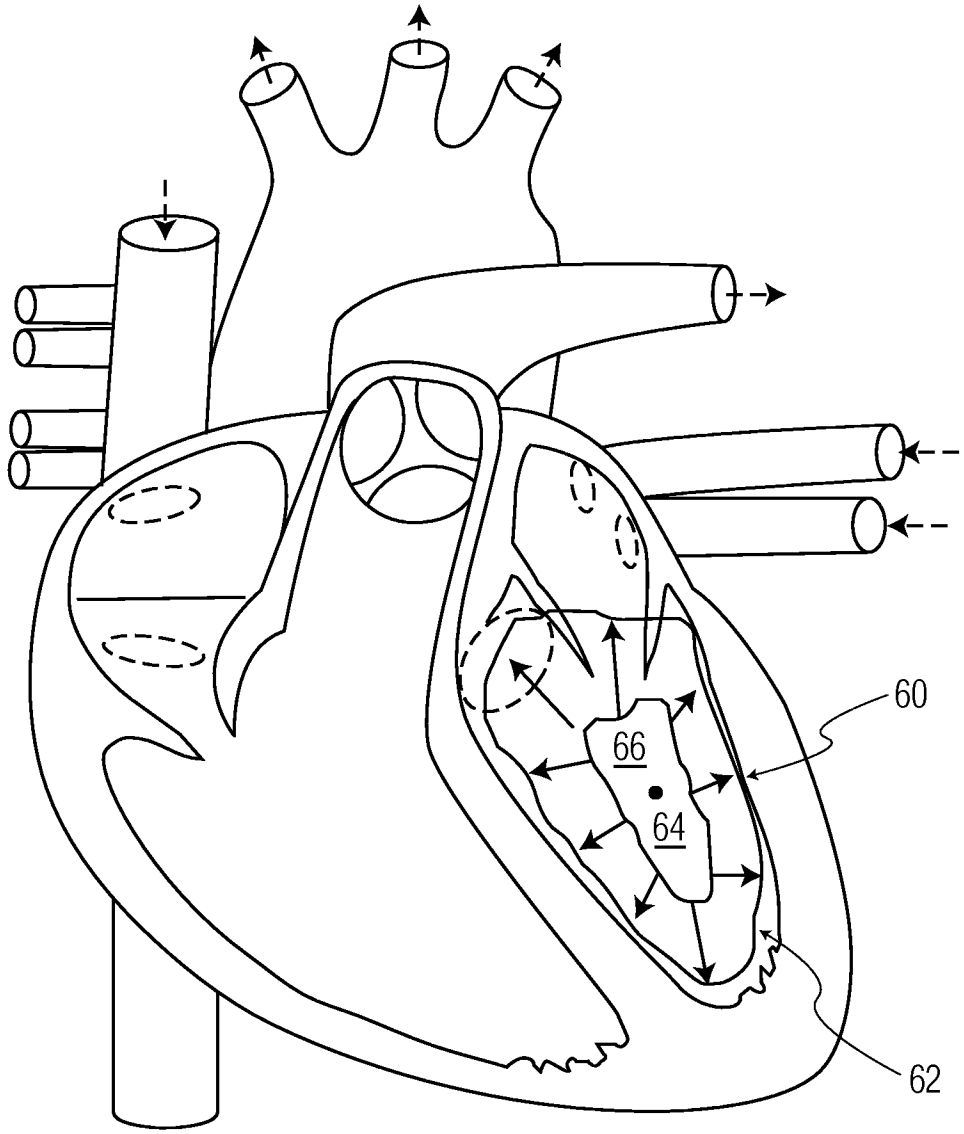


FIG. 3

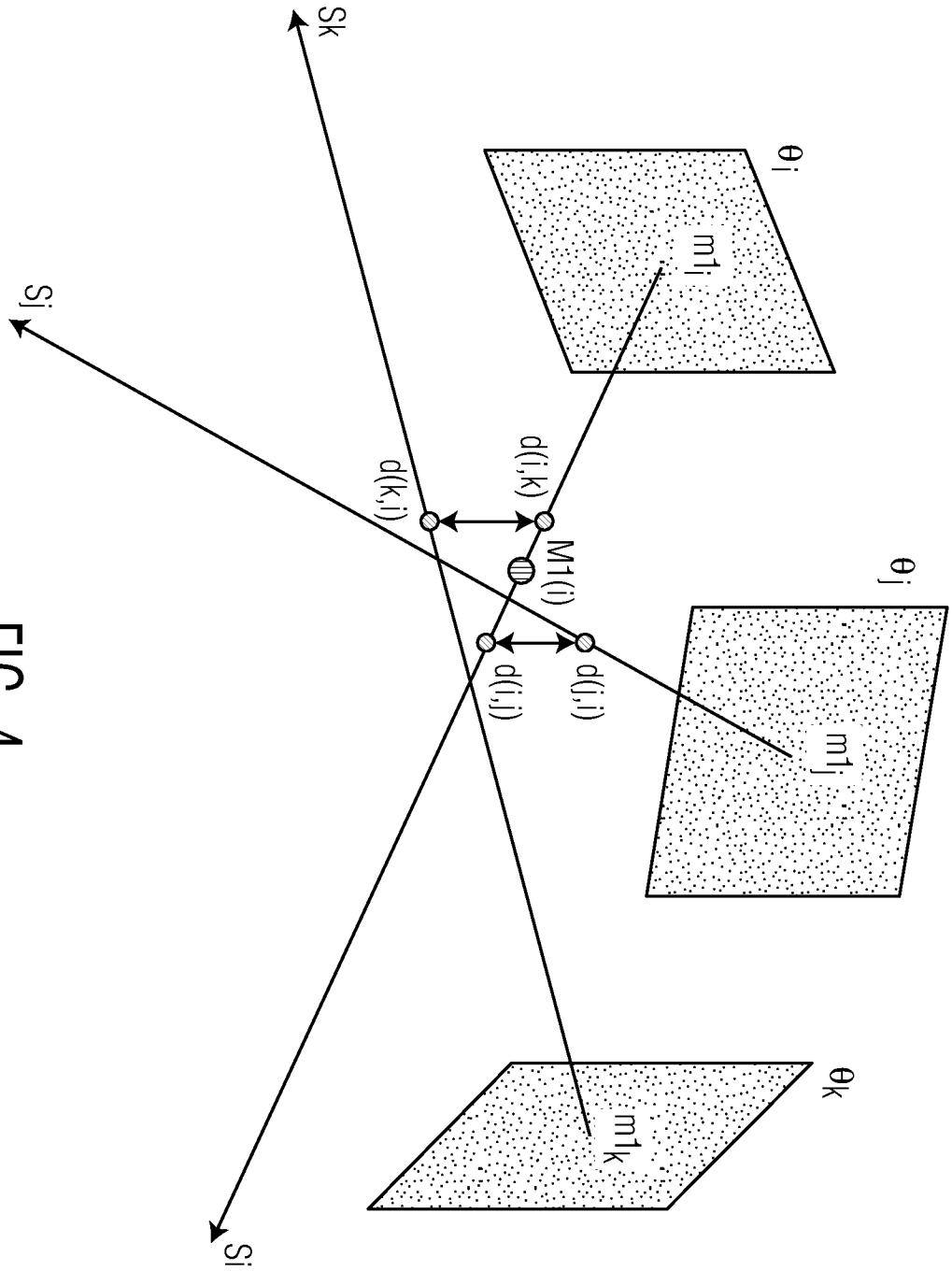


FIG. 4

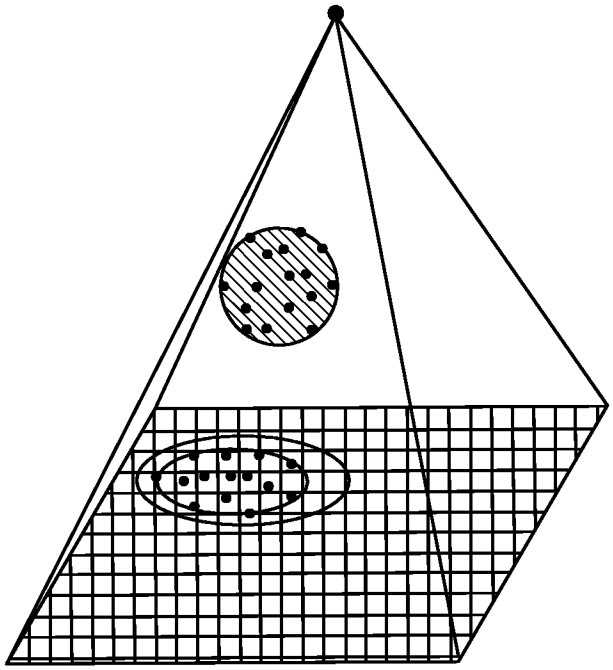


FIG. 5A

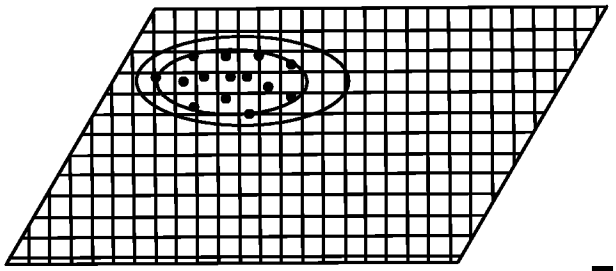


FIG. 5B

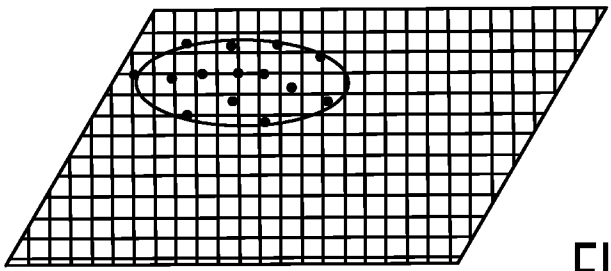


FIG. 5C

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/052375

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T11/00

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)
G06T

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 practical, search terms used)
EPO-Internal, INSPEC, COMPENDEX, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2004/111936 A (PHILIPS INTELLECTUAL PROPERTY [DE]; KONINKL PHILIPS ELECTRONICS NV [NL) 23 December 2004 (2004-12-23) figures 3a,3b	1,2,10, 13-15, 23,25-29 12
Y A	VIDYA ELANGOVAN AND ROSS T. WHITAKER: "From Sinograms to Surfaces: A Direct Approach to the Segmentation of Tomographic Data" LECTURE NOTES IN COMPUTER SCIENCE, vol. 2208, 14 October 2001 (2001-10-14), pages 213-223, XP007901427 Springer Berlin / Heidelberg page 214, paragraph 3; figure 1b page 213 - page 219	12 1-11, 13-29

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

[X] See patent family annex.

* Special categories of cited documents :

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

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"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

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"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
12 December 2006	20/12/2006

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Werling, Alexander

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/052375

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	MCINERNEY T ET AL: "Deformable Models in Medical Analysis: A Survey" MEDICAL IMAGE ANALYSIS, OXFORDUNIVERSITY PRESS, OXFORD, GB, vol. 1, no. 2, June 1996 (1996-06), pages 91-108, XP002230283 ISSN: 1361-8423 the whole document	1-29

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2006/052375

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2004111936 A	23-12-2004	US 2006147114 A1	06-07-2006