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G06T 17/20 (2006.01)

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INT CL **A61B, A61N, G06T**
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(54) Abstract Title**: Surface-imaging breathing monitor**

(57) A breathing monitor comprises a number of stereoscopic cameras 1, 2, 3 arranged to observe a patient 8 on a treatment couch 7. Images of the patient 8 are passed to a computer 5, which processes the obtained images to generate a surface model of the patient 8. This surface model is then used to monitor the patient's breathing. In this way irregular breathing can be identified and also the breathing monitor can be used to determine the timing of gating of a treatment apparatus 6. A series of images of the internal anatomy of the individual may also be obtained. A breathing coaching method is also disclosed which comprises varying a coaching signal to be displayed on the basis of the determination of the consistency of breathing by the individual. The breathing monitor may be used with radiotherapy devices or computed tomography (CT) scanners.

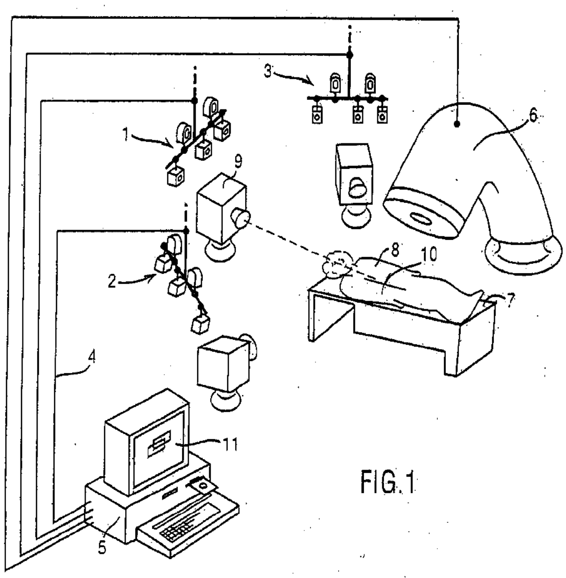


FIG.1

GB 2 441 550 A

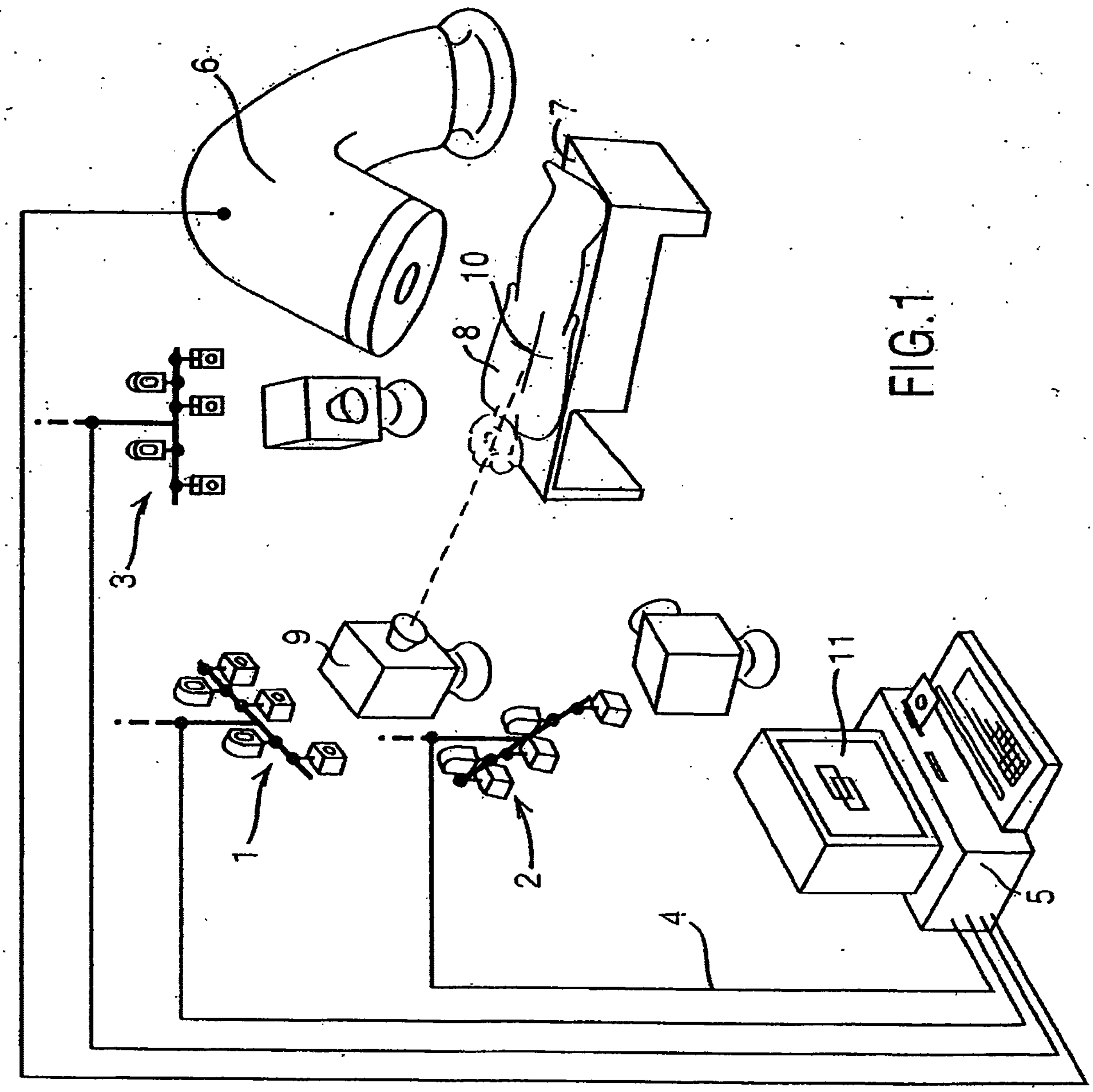
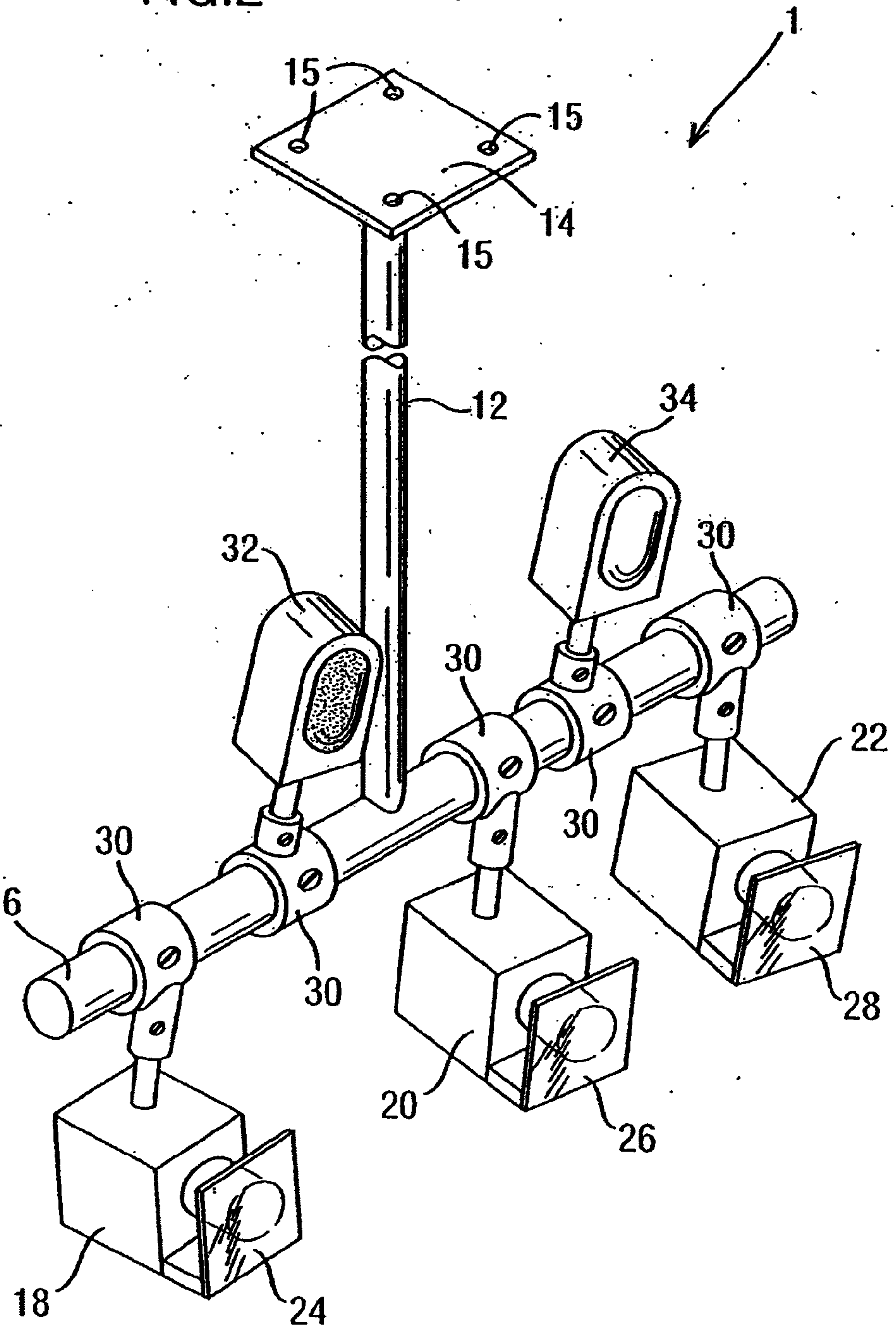


FIG.1

FIG.2



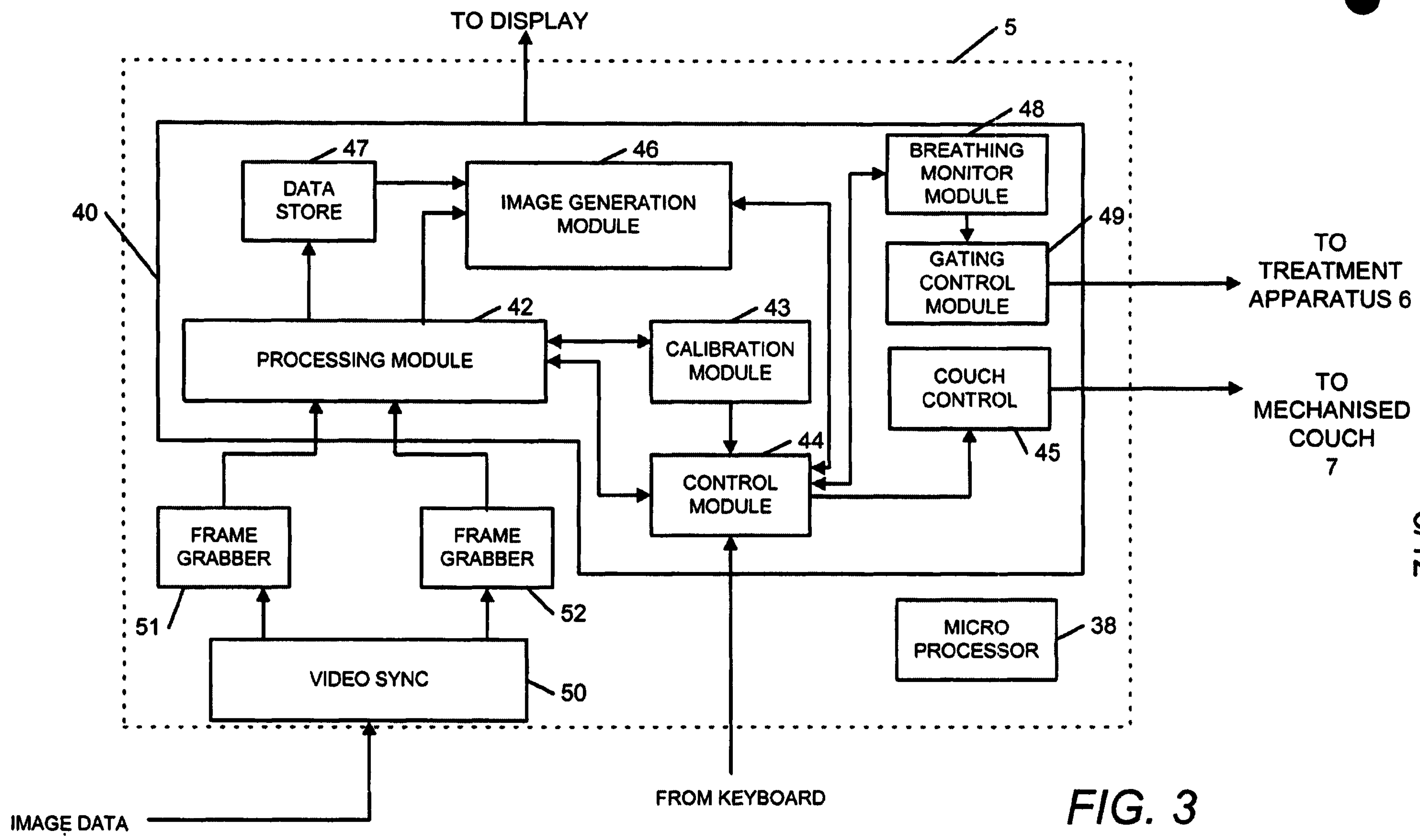

TO DISPLAY
5
40
47
DATA STORE
46
IMAGE GENERATION MODULE
48
BREATHING MONITOR MODULE
49
GATING CONTROL MODULE
TO TREATMENT APPARATUS 6
42
PROCESSING MODULE
43
CALIBRATION MODULE
COUCH CONTROL
45
TO MECHANISED COUCH 7
44
CONTROL MODULE
FRAME GRABBER
51
FRAME GRABBER
52
VIDEO SYNC
50
MICRO PROCESSOR
38
IMAGE DATA
FROM KEYBOARD

FIG. 3

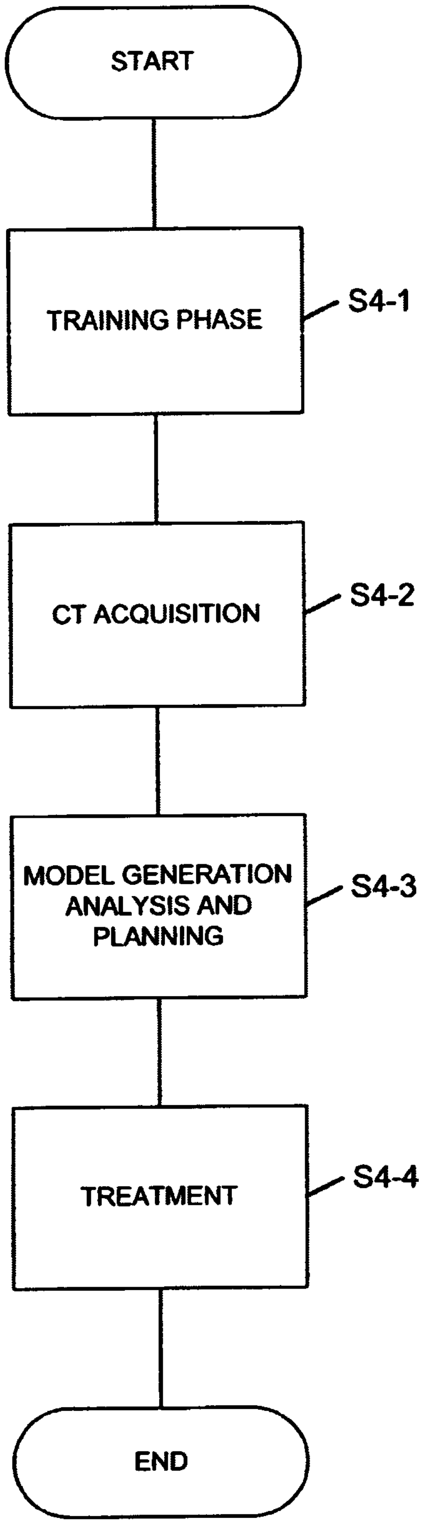

START
TRAINING PHASE
S4-1
CT ACQUISITION
S4-2
MODEL GENERATION ANALYSIS AND PLANNING
S4-3
TREATMENT
S4-4
END

FIG. 4

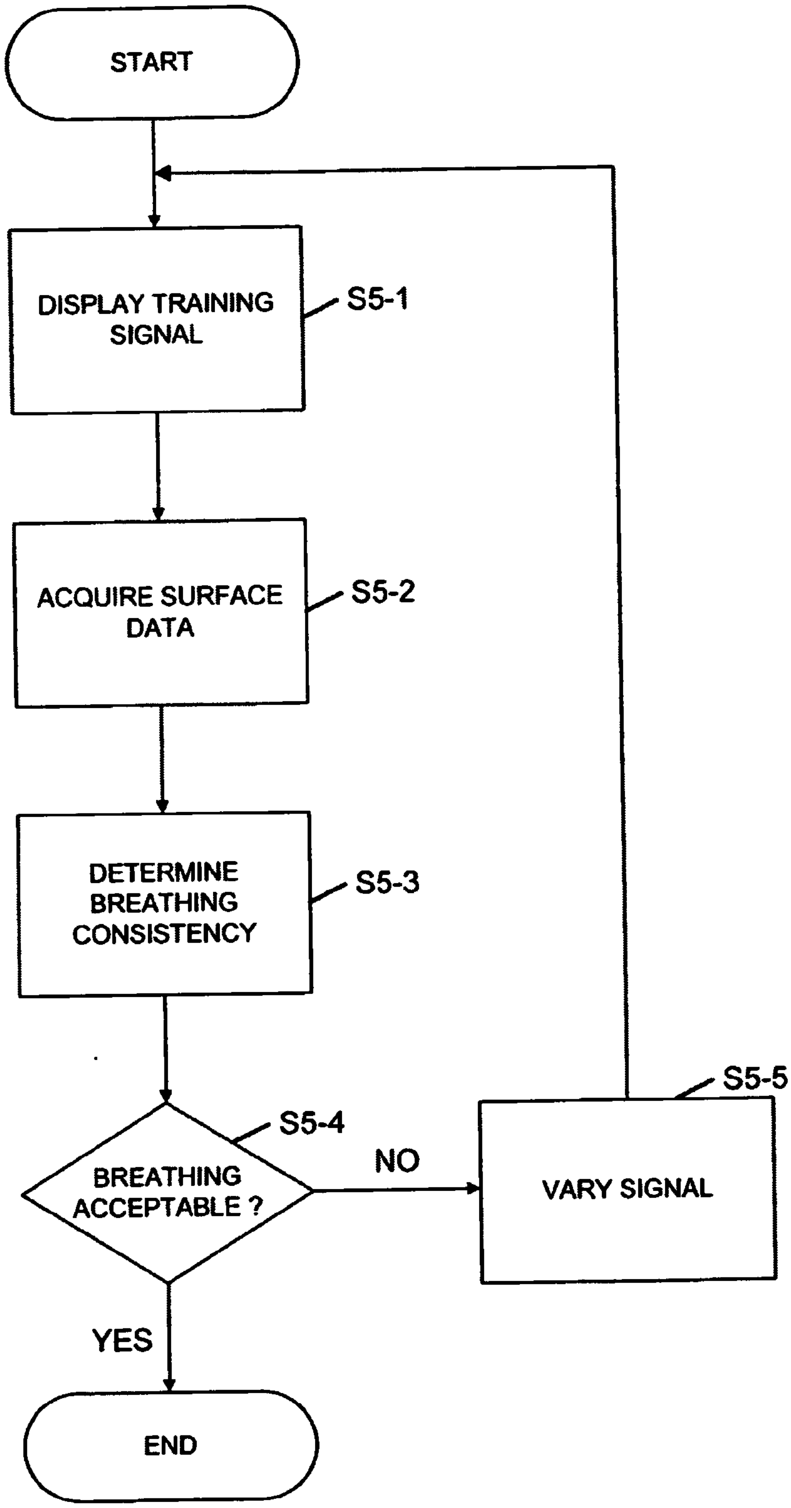

START
DISPLAY TRAINING SIGNAL
S5-1
ACQUIRE SURFACE DATA
S5-2
DETERMINE BREATHING CONSISTENCY
S5-3
S5-4
BREATHING ACCEPTABLE ?
NO
S5-5
VARY SIGNAL
YES
END

FIG. 5

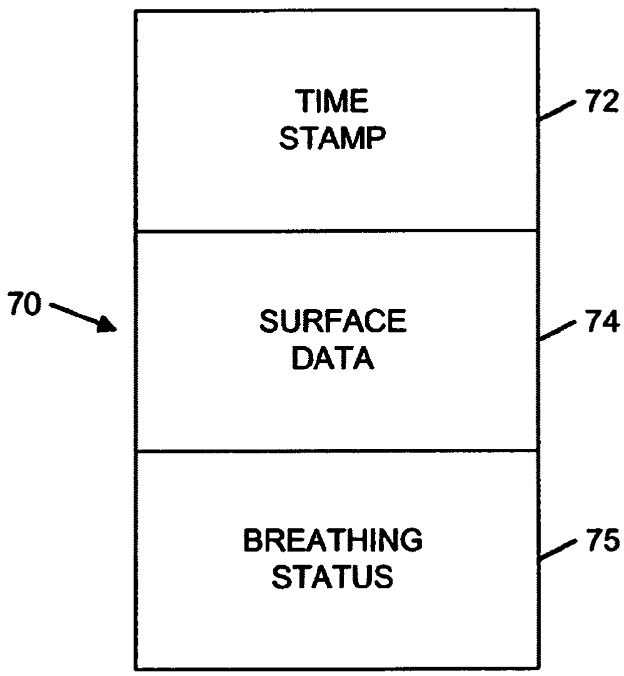


FIG. 6

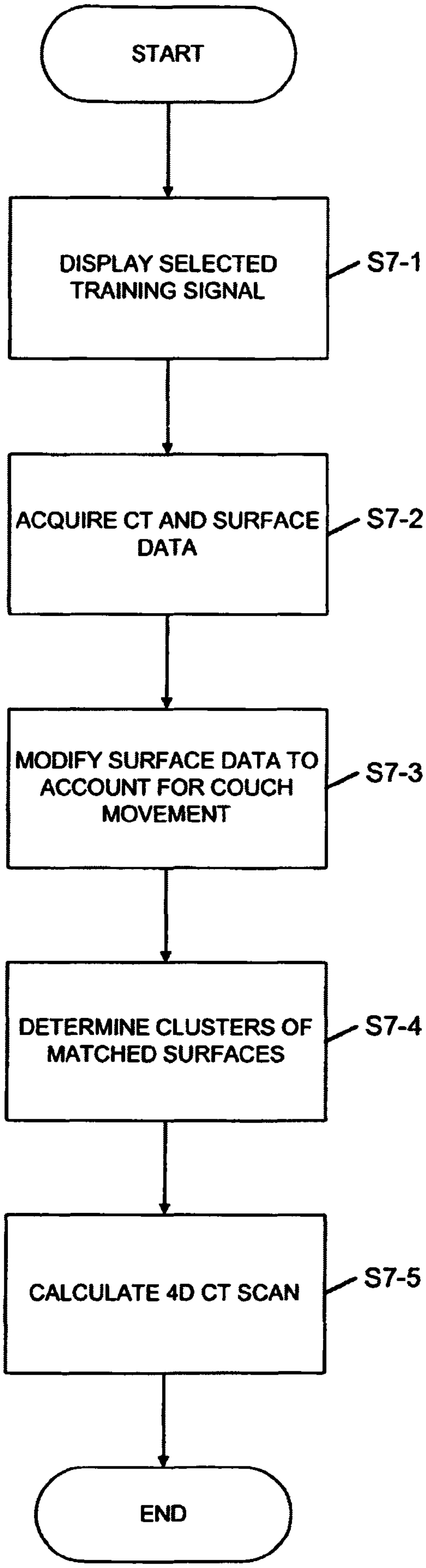

START
DISPLAY SELECTED TRAINING SIGNAL
S7-1
ACQUIRE CT AND SURFACE DATA
S7-2
MODIFY SURFACE DATA TO ACCOUNT FOR COUCH MOVEMENT
S7-3
DETERMINE CLUSTERS OF MATCHED SURFACES
S7-4
CALCULATE 4D CT SCAN
S7-5
END

FIG. 7

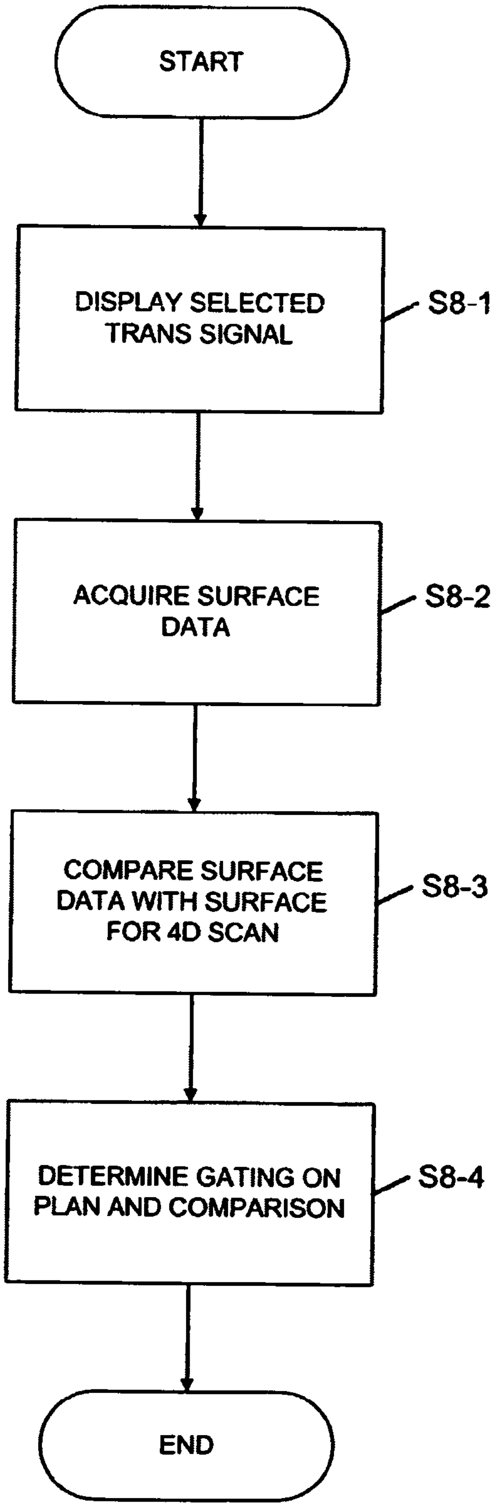

START
DISPLAY SELECTED TRANS SIGNAL
S8-1
ACQUIRE SURFACE DATA
S8-2
COMPARE SURFACE DATA WITH SURFACE FOR 4D SCAN
S8-3
DETERMINE GATING ON PLAN AND COMPARISON
S8-4
END

FIG. 8

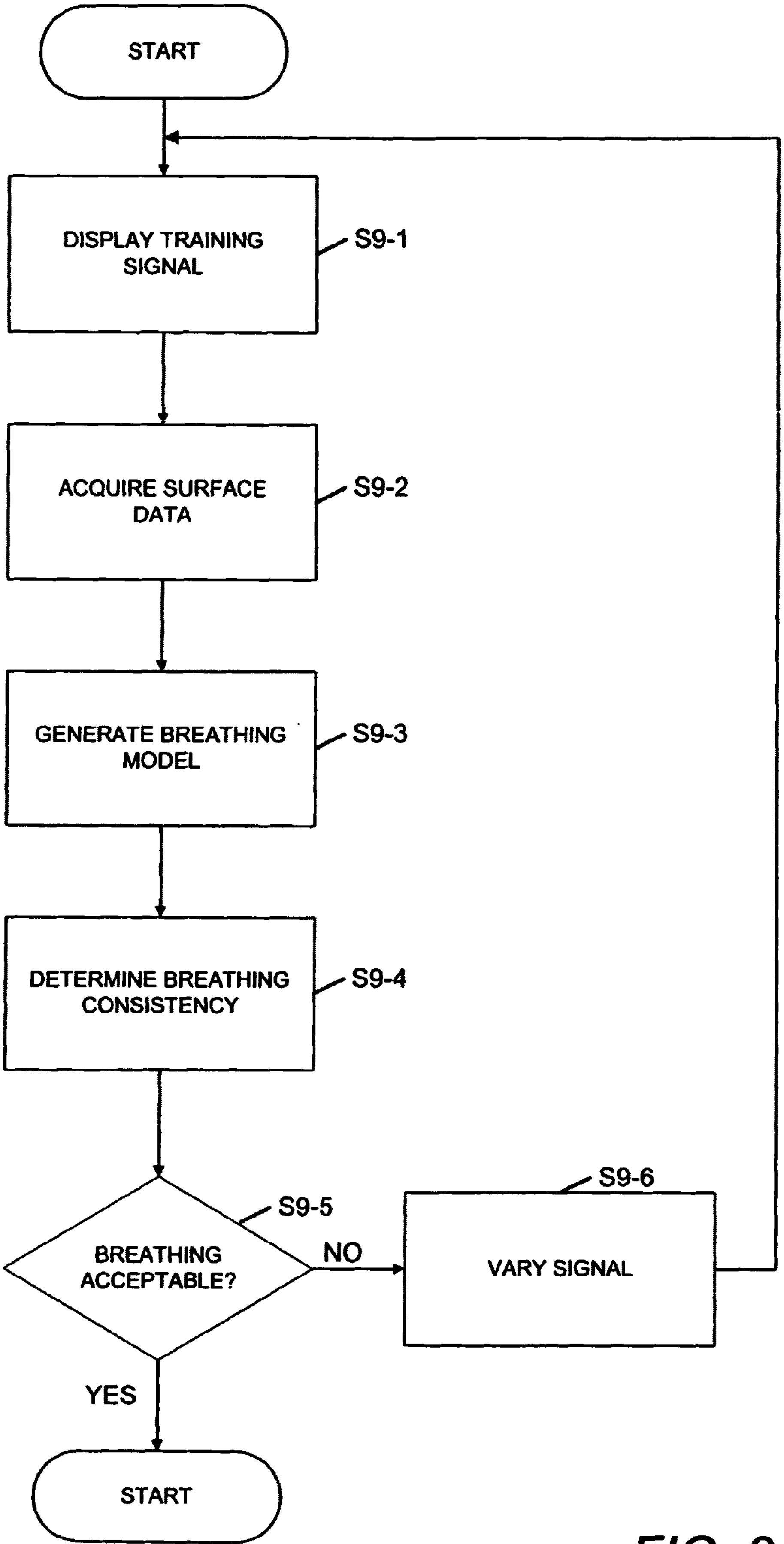

START
DISPLAY TRAINING SIGNAL
S9-1
ACQUIRE SURFACE DATA
S9-2
GENERATE BREATHING MODEL
S9-3
DETERMINE BREATHING CONSISTENCY
S9-4
BREATHING ACCEPTABLE?
S9-5
NO
VARY SIGNAL
S9-6
YES
START

FIG. 9

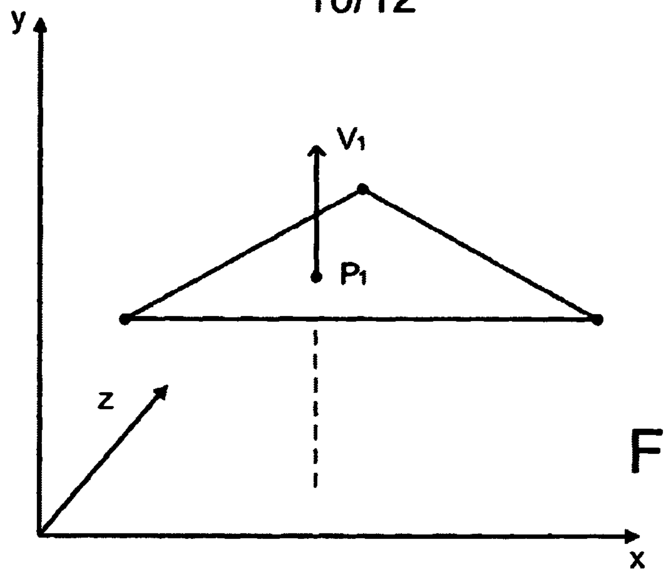


FIG 10A

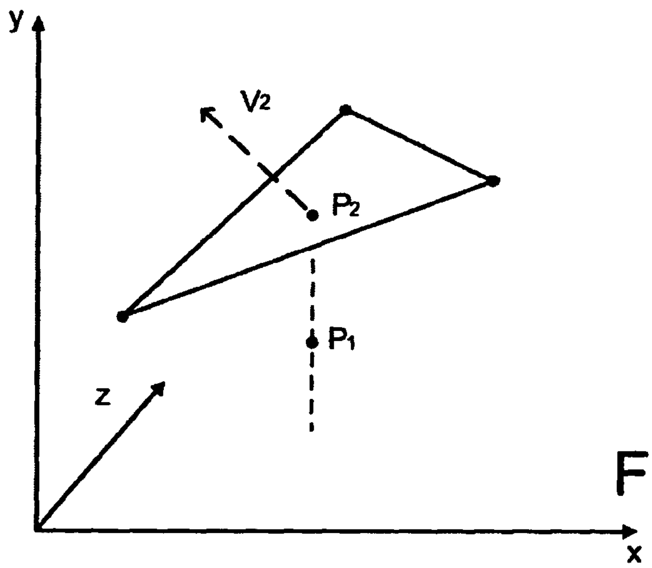


FIG 10B

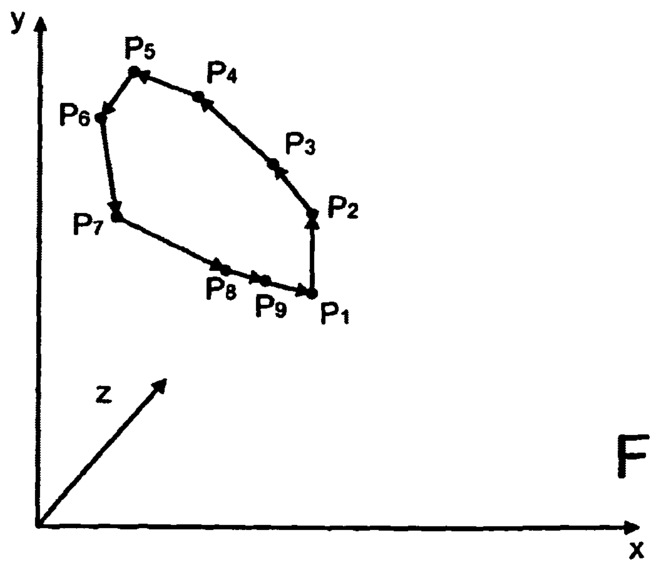


FIG 10C

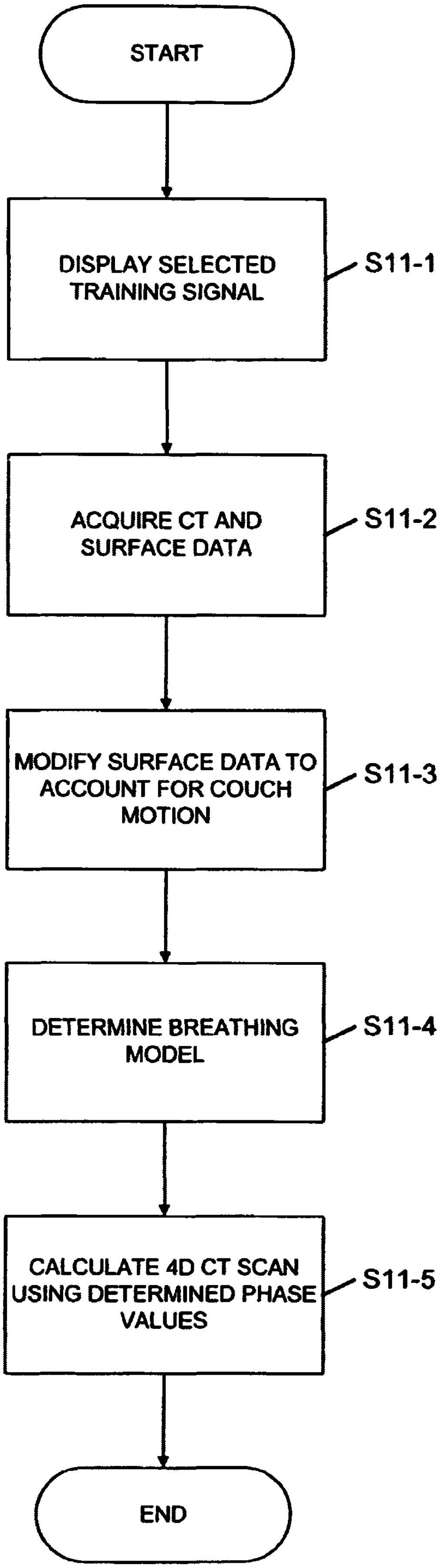

START
DISPLAY SELECTED TRAINING SIGNAL
S11-1
ACQUIRE CT AND SURFACE DATA
S11-2
MODIFY SURFACE DATA TO ACCOUNT FOR COUCH MOTION
S11-3
DETERMINE BREATHING MODEL
S11-4
CALCULATE 4D CT SCAN USING DETERMINED PHASE VALUES
S11-5
END

FIG. 11

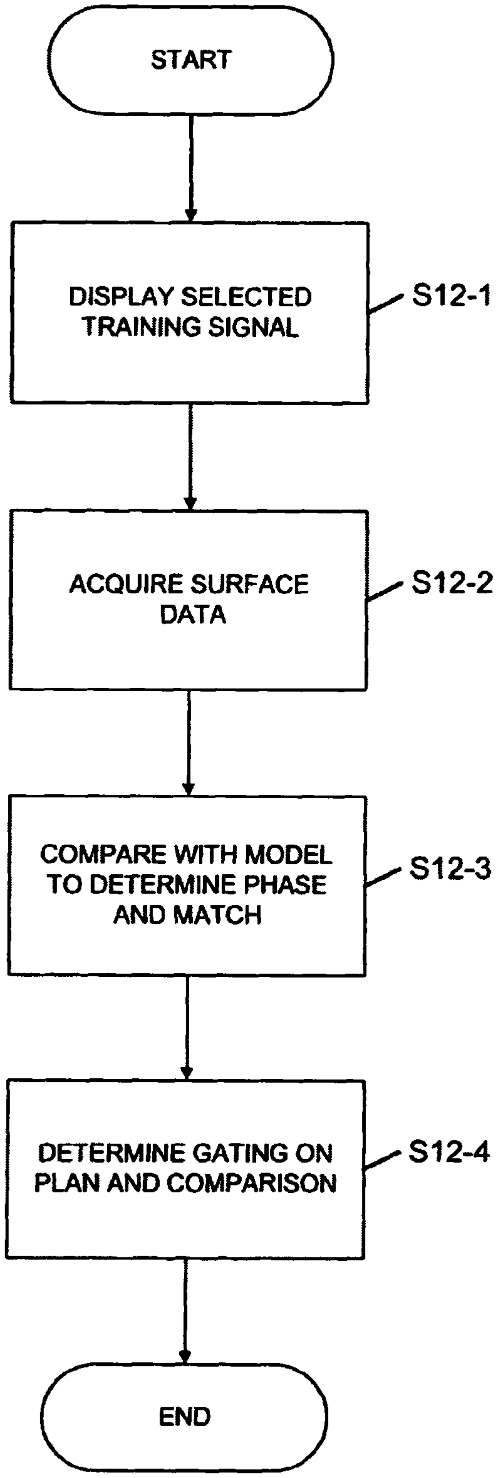

START
DISPLAY SELECTED TRAINING SIGNAL
S12-1
ACQUIRE SURFACE DATA
S12-2
COMPARE WITH MODEL TO DETERMINE PHASE AND MATCH
S12-3
DETERMINE GATING ON PLAN AND COMPARISON
S12-4
END

FIG. 12

BREATHING MONITOR

The present invention relates to breathing monitors. More particularly, embodiments of the present invention relate to breathing monitors for use with radio therapy devices and computed tomography (CT) scanners and the like.

Radiotherapy consists of projecting onto a predetermined region of a patient's body, a radiation beam so as to destroy or eliminate tumours existing therein. Such treatment is usually carried out periodically and repeatedly. At each medical intervention, the radiation source must be positioned with respect to the patient in order to irradiate the selected region with the highest possible accuracy to avoid radiating adjacent tissue on which radiation beams would be harmful.

When a tumour is located in the thoracic or abdominal chest cavities, the position of a tumour can vary considerably (e.g. by as much as a few centimetres) throughout the breathing cycle. In order to obtain reliable CT scanning data it is therefore important to obtain data consistently at the same point within a breathing cycle.

Certain modern CT scanners are able to process CT scanning data acquired at different times within a breathing cycle to generate a representation of the 3D movement of internal organs during breathing. Such "4D" representations of organ movement are invaluable in determining a course of treatment for irradiating a cancer. Again in order for quality planning data to be generated, the timing within the breathing cycle when individual CT scans are acquired must be known so that 4D representation accurately represents the movement of the internal organs.

Further, when applying radiation to a patient, the gating of treatment apparatus should be matched with the breathing cycle so that radiation is focused on the location of a tumour and collateral damage to other tissues is minimised.

A number of monitoring systems for monitoring a patient's breathing during radiotherapy have therefore been proposed. Thus for example, US 6621889 discloses a system in which the gating of a radiation apparatus is linked to a determination that the periodicity of a patients breathing has deviated from an earlier measurement.

An improved system for monitoring and measuring patient breathing is, however desirable.

In accordance with one aspect of the present invention there is provided apparatus for monitoring an individual's breathing comprising:

a stereoscopic camera operable to obtain frames of image data of an individual from a first and a second view point;

an image processor operable to process frames of image data obtained by said stereoscopic camera to determine model data representative of at least part of the surface of an individual appearing in said image data; and

a monitoring unit operable to determine a difference measurement from model data generated for different frames and utilise said determined difference measurement to associate image frames with timings within the breathing cycle of said individual.

In accordance with another aspect of the present invention there is provided a method of monitoring an individual's breathing comprising:

obtaining frames of image data of an individual from a first and a second view point using a stereoscopic camera;

processing frames of image data obtained by said stereoscopic camera to determine model data representative of at least part of the surface of an individual appearing in said image data; and

associating image frames with timings within the breathing cycle of an individual utilising a calculated difference measurement for generated model data for different image frames.

Further aspects and embodiments of the present invention will become apparent with reference to the following description and accompanying drawings in which:

Figure 1 is a schematic diagram of a breathing monitor in accordance with an embodiment of the present invention;

Figure 2 is a perspective view of a camera rig of the breathing monitor of Figure 1;

Figure 3 is a block diagram of the computer of the breathing monitor of Figure 1;

Figure 4 is a flow diagram of the steps involved in planning and undertaking radio therapy treatment;

Figure 5 is a flow diagram illustrating processing undertaken by a monitoring system in accordance with a first embodiment of the present invention during breathing coaching;

Figure 6 is a schematic diagram of model data generated for an image frame by the computer of the breathing monitor of Figure 1;

Figure 7 is a flow diagram illustrating processing undertaken by a monitoring system in accordance with a first embodiment of the present invention during CT acquisition;

Figure 8 is a flow diagram illustrating processing undertaken by a monitoring system in accordance with a first embodiment of the present invention during treatment;

Figure 9 is a flow diagram illustrating processing undertaken by a monitoring system in accordance with a second embodiment of the present invention during breathing coaching;

Figures 10 A-C are schematic diagrams for explaining the monitoring of movement on the surface of a patient by a monitoring system in accordance with a second embodiment of the present invention;

Figure 11 is a flow diagram illustrating processing undertaken by a monitoring system in accordance with a second embodiment of the present invention during CT acquisition; and

Figure 12 is a flow diagram illustrating processing undertaken by a monitoring system in accordance with a second embodiment of the present invention during treatment.

Breathing monitor

Figure 1 is a schematic diagram of a breathing monitor in accordance with an embodiment of the present invention. In accordance with this embodiment, there is provided a set of three camera rigs 1, 2, 3 that are connected by wiring 4 to a computer 5. The computer 5 is also connected to treatment apparatus 6 such as a linear accelerator for applying radiotherapy or an x-ray simulator for planning radiotherapy. A mechanical couch 7 is provided as part of the treatment apparatus 6 upon which a patient 8 lies during treatment. The treatment apparatus 6 and the mechanical couch 7 are arranged such that under the control of the computer 5 the relative positions of the mechanical couch 7 and the treatment apparatus 6 may be varied, laterally, vertically, longitudinally and rotationally. Also provided as part of the system is a laser projection apparatus 9 which is arranged to project three laser beams 10 onto the body of a patient 8 lying on the mechanical couch 7 where the three laser beams 10 are such to project planes of light which collectively identify the focussing point of the radiation generated by the treatment apparatus 6.

In use, the cameras of the camera rigs 1, 2, 3 obtain video images of a patient 8 lying on the mechanical couch 7. These video images are passed via the wiring 4 to the computer 5. The computer 5 then processes the images to generate a three-dimensional model of the surface of the patient, which is displayed on the screen 11 of the computer 5. This processing is described in detail in the applicant's pending US patent application US 10/516400 published as WO 2004/004828 which is hereby incorporated by reference.

The three-dimensional model of the patient 8 is continually updated utilising the stream of video images obtained from the cameras of the camera rigs 1, 2, 3. This enables the breathing of a patient 8 to be monitored during treatment. The generated three-dimensional models of the surface of a patient 8 can then be utilised by the computer 5 to control the treatment apparatus 6.

Figure 2 is a schematic illustration of one of the set of camera rigs 1, 2, 3 of this embodiment of the present invention. All of the camera rigs 1, 2, 3 in this embodiment are identical to the others with the three camera rigs 1, 2, 3 being arranged with one either side of the mechanical couch 7 and one at the head of the mechanical couch 7. The arrangement of cameras of the rigs 1, 2, 3 are such that all the cameras of the camera rigs view substantially the same portion of the patient 8 immediately beneath the treatment apparatus 6 so that a complete model of that portion of the patient 8 can be generated.

The camera rigs 1, 2, 3 each comprise a T-bar 12 which is suspended from the roof of the room within which the treatment apparatus 6 is provided. To this end a base plate is provided at the top of the T-bar 12 with the main body of the T-bar 12 extending down from the centre of this base plate. Provided in each of the corners of the base plate 14 are fixing holes 15 through which bolts pass to fix the T-bar 12 in position in the room containing the treatment apparatus 6.

Provided at the opposite end of the T-bar 12 to the base plate 14 attached to the horizontal cross bar 16 forming the T-section of the T-bar are three cameras 18,22,24. These cameras 18,22,24 are arranged along the cross bar 16, and in order from left to right along the cross bar 16 are a first geometry camera 18, a texture camera 20 and a second geometry camera 22. The cameras 18, 20, 22 each comprise monochrome analogue video cameras such as the Pulnix PE100.

Provided in front of the lenses of each of the cameras are filters 24, 26, 28. The filters on the two geometry cameras 18, 22 are arranged to prevent the geometry cameras 18, 24 from receiving light having a wavelength below 570 nm. The filter 26 in front of the lens of the texture camera 20 comprises a filter preventing the texture camera 20 from receiving light with a wavelength greater than 540 nm.

Each of the cameras 18, 20, 22 is attached to the horizontal bar 16 of the T-bar 12 by a clamp 30 which attaches the cameras 18, 20, 22 to the horizontal cross bar 16 of the T-bar 12, whilst permitting the orientation of the cameras 18, 20, 22 relative to the horizontal bar 16 of the T-bar 12 to be adjusted.

Also attached to the horizontal bar 16 of the T-bar 12 by further clamps 30 are a first 32 and second 34 light source. In this embodiment the first light 32 source comprises a light source arranged to irradiate light having a wavelength greater than 570 nm and being arranged to project onto the surface of a patient 8 lying on the mechanical couch 7 of the treatment apparatus 6 a random speckle pattern. An example of a suitable light source would be a slide and slide projector, where the slide bears a non-repeating speckle pattern and the slide projector comprises a filtered light source filtered to prevent light with a wavelength less than 570 nm from being projected onto the slide.

The second light source 34 comprises a conventional light bulb with a filter to allow light with a wavelength of less than 540 nm to pass. The second light source 34 is also arranged to illuminate the portion of a patient 8 which is visible from the cameras 18, 20, 22. The filtration of the light from the second light source 34 prevents the light from the second light source 34, interfering and saturating the speckle pattern generated by the first light source 32.

In use, images of the speckle pattern are obtained by the geometry cameras 18, 22 as these cameras are arranged to detect light having a frequency of greater than

570 nm. These images from the geometry cameras 18, 22 are then subsequently processed so that the position and orientation of the surface of the body of the patient 8 visible from the geometry cameras 18, 22 can be determined and a three dimensional model of the surface of the individual generated as is described in WO 2004/004828.

In order to avoid saturation occurring at the boundaries of the speckle patterns, in this embodiment the first light source 32 of each camera rig 1, 2, 3 comprises a flash light source such as an arrangement of LED's. When images are desired the flash light sources 32 of different camera rigs 1, 2, 3 are then activated at slightly different times. In this way interference between patterns at the boundary of images obtained from different camera rigs 1, 2, 3 is avoided.

When a textured rendered model of a patient 8 is desired, the images of the patient 8 are obtained from the texture camera 20. These images are then utilised to texture render the model created from the geometry camera 18, 22 images. As the texture camera 20 is arranged only to detect light having a wave length of less than 540 nm, this image does not contain the speckle pattern projected by the first light source 32 but rather corresponds to the visible images perceived by an operator within the treatment room.

Figure 3 is a schematic block diagram of the computer 5 of Figure 1. The computer 5 comprises a microprocessor 38 and memory 40. The memory 40 is configured into a number of notional functional modules.

In this embodiment, these functional modules comprise a processing module 42 for controlling the microprocessor 38 to co-ordinate receiving and processing images; a control module 44 arranged to control the microprocessor 38 to receive signals from the keyboard of the computer 5 and co-ordinate the processing by the processing of the other modules; a calibration module 43 enabling microprocessor 38 to calibrate the positioning system so that relative to the point of focus of the treatment apparatus 6, the processing module 42 is able to identify the location of the surface of a patient 8; a mechanical couch control module 45 arranged to enable the microprocessor 38 to utilise generated surface models of an individual to generate positioning instructions which are then passed to the mechanical couch 7 of the treatment apparatus 6 so that a patient 8 may be automatically correctly positioned for treatment; an image generation module 46 to enable the microprocessor 38 to generate an image of the portion of the patient 8 being treated and display it on the screen 11 of the computer 5; and a data store 47.

Also provided in the memory 40 of the computer 5 are a breathing monitor module 48 and a gating control module 49. As will be described in detail later, after a patient 8 has been correctly positioned for treatment, the breathing monitor module 48, monitors the manner in which the surface of an individual varies during breathing.

During treatment, the information obtained by the breathing monitor module 48 can be utilised to help train a patient 8 to increase the proportion of treatment time when radiation can be administered. When performing computed tomography (CT) scanning, information obtained by the breathing monitor module 48 enables appropriate labelling of CT scanning data so that complete 4-D scanning data of a site under investigation can be obtained. Finally the gating control module 49, utilises information obtained by the breathing monitor module 48 to control the gating of a treatment apparatus 6 so as to apply radiation to a patient 8 at specific times during the breathing cycle and to cease irradiating a patient 8 if a patient's breathing becomes irregular, for example when a patient coughs.

A video sync unit 50 and a first and a second frame grabber 51, 52 are also provided as part of the computer 5. The first and second frame grabbers 51, 52 are arranged to receive image data from the three cameras attached to each of the camera rigs 1, 2, 3, specifically the first and second frame grabbers 51, 52 are arranged to receive video signals from the geometry cameras 18, 22 of the camera rigs 1, 2, 3 via the video sync 50. Video images for the six geometry cameras (two cameras on each of the three camera rigs) are received by the video sync 50 and passed to the two frame grabbers 51, 52, three to the first frame grabber 51 and three to the second frame grabber 52. The video sync 50 passes timing signals from the first frame grabber 51 to the second frame grabber 52 to ensure that image data from the geometry cameras 18, 22 is acquired simultaneously. By providing two frame grabbers 51, 52, in this way the computer 5 is arranged to receive image data from the geometry cameras 18, 22 of all three rigs 1, 2, 3 simultaneously so that an instantaneous three dimensional model of the surface of a patient 8 can be generated.

Use of Breathing Monitor

The use of a breathing monitor in a course of treatment will now be described in outline with reference to Figure 4 which is a flow diagram illustrating typical steps in a course of treatment.

Initially (S4-1) in a training phase, a breathing monitor may be used to help assist a patient 8 regularise their breathing. Ordinarily, when an individual breathes, there is variation, which in certain cases can be significant, between different breathing cycles as to the manner in which the chest expands and contracts both in the timing of breathing, the periodicity of breathing and also the extent of expansion and contraction in the chest itself. By monitoring a patient's actual breathing and providing bio feedback a sustainable and more consistent manner of breathing can be achieved.

After an initial training phase, a CT scan of a patient 8 can then be acquired (S4-2). This CT scan enables a visualisation of a patient's internal organs to be determined. When a CT scan is acquired, a number of CT images "slicing" through an individual are acquired successively. These different images are then rearranged into a 4D representation of how the internal organs of a patient 8 move during a breathing cycle by identifying different "slices" acquired at different points in time. In order for the reconstruction of a "4D" representation of the internal movement of organs during a breathing cycle, it is necessary to maximise the consistency of a patient's breathing and also to identify at which points during a breathing cycle images have been acquired.

When CT data has been acquired using the information about the manner in which internal organs move, an appropriate course of treatment can be planned (S4-3). In this embodiment, in addition to generating a model representation of the movement of internal organs during a breathing cycle, as surface data of a patient's exterior during breathing is also acquired, this data can be used to provide a model against which the activation of a radiotherapy apparatus can be plotted so as to irradiate a selected portion of the patient.

Finally, (S4-4) after appropriate analysis and planning, a patient 8 can be treated using the determined plan of treatment. This treatment step involves irradiating a selected portion of the patient 8 at various timings based upon the treatment plan where, in this embodiment, radiation is activated based upon a comparison of the surface of a patient 8 acquired during treatment with similar surface data acquired during CT acquisition (S4-2). By basing the treatment on data acquired during the

CT acquisition phase, a means is provided to ensure maximum correlation between the estimated movement of internal organs as represented by acquired CT scanning data and the surface of a patient 8 which can be scanned using the breathing monitor system.

First Embodiment

The use of a breathing monitor in accordance with a first embodiment of the present invention during the training, CT acquisition and generation and treatment phases of the present embodiment will now be described in detail with reference to Figures 5-8

Use during Training

During training, a training signal is displayed (S5-1) to a patient. Conventionally such a training signal may be in the form of a bar graph which rises and falls in a manner representative of an idealised breathing signal. A typical idealised signal is of the form of a sine or cosine function raised to the nth power where n is typically 1, 2, 4 or 6.

The visual display to a patient 8 could be of the form of display on a small liquid crystal monitor mounted on the treatment couch 7. Alternatively it could in the form of a display mounted within a set of goggles worn by the patient 8 or a series of light emitting diodes (LEDs) which were progressively illuminated so as to correspond to the selected training signal.

Any visual display of a breathing signal to be matched by a patient 8 may also be supplemented with an audio training signal, for example a sound varying pitch corresponding to thc raise and fall of the bar graph shown on the display or illustrated by the illuminated LEDs.

After a patient 8 has been instructed to try to regulate their breathing based upon the training signal, the cameras 18, 22, 24 on each of the camera rigs 1, 2, 3 proceed to acquire (S5-2) image data whilst the patient 8 breathes. The stream of acquired video images is passed by the video sync 50 to the frame grabbers 51, 52. The processing module 42 then proceeds to process the acquired image data to generate a wire mesh surface model representative of the surface of a patient 8 for individual image frames. This surface model data is then stored within the data store 47.

Figure 6 is a schematic block diagram of surface model data stored within the data store 47 of the computer 5. In this embodiment for each image frame model data 70 is stored comprising a time stamp 72 indicating the frame the model data represents, surface data 74 being a wire mesh model generated from acquired image data, and a breathing status flag 76 which in this embodiment is a flag indicating either inhale or exhale so as to distinguish surface data acquired during inhalation and surface data acquired during exhalation.

Returning to Figure 5 after surface data 74 has been acquired for a series of image frames representing a number of breathing cycles for example after 1-2 minutes, the breathing monitor module 48 then proceeds to utilise the stored model data 70 to determine (S5-3) how consistently a patient 8 is breathing.

The determination of breathing consistency in this embodiment is based upon a comparison of the surface data 74 associated with different frames. By calculating a difference measurement for the surface data 74 acquired at different times, a measure of difference between the manner in which the patient 8 breathes during different breathing cycles can be made.

Thus for example by identifying the time stamps 72 of model data 70 with the same breathing status 76 where the associated surface data 74 is similar, the difference in the time stamps 72 provides a measure of the periodicity of patient's breathing.

Additionally comparing the surface data 74 for different image frames, the length of time a patient 8 maintains their chest in substantially the same position within a breathing cycle can be determined. This can be achieved by for example determining clusters of frame model data 70 where the surface data 74 does not vary significantly. Thus in this way the breathing monitor module 48 is able to determine the regularity of breathing by a patient 8 and determine lengths of periods of time when radiation could be applied so as to impinge upon approximately the same location within the patient 8.

In addition to determining the regularity and repeatability of breathing the breathing monitor modules 42 could also process the surface data 74 for individual frames to determine if irregular breathing or movement of a patient 8 occurred. Typically such irregular breathing might arise due to the patient coughing or moving on the treatment couch 7.

When identifying whether surface data 74 associated with different time stamps 72 are similar, an overall difference measurement for the average difference between the two surfaces could be determined and two surfaces could be identified as being similar when such a difference measurement was less than some threshold value. Such a difference measurement could be determined from a direct comparison between individual sets of surface model data.

Alternative comparisons could however be utilised. Thus for example, a volume calculation for the volume beneath a surface could be calculated with that volume being taken to identify a position within a breathing cycle. Another alternative measure could be based upon the orientations of triangles within a calculated wire mesh model surface as represented by the surface data 74.

Based upon the comparison made by the breathing monitor module, the breathing monitor module 48 determines (S 5-4) whether the breathing undertaken by a patient 8 is satisfactory. That is to say the breathing monitor module 48 determines whether the patient's breathing is regular and provides sufficiently long periods of time for irradiation to be applied.

If a patient's breathing is not acceptable, for example the breathing has been irregular, the breathing monitor module 48 can then (S5-5) vary the training signal to be displayed to a patient 8 so as to correspond to a signal to which a patient 8 is better able to match and one which may enable the patient 8 to breathe in a way which is repeatable and consistent.

When the breathing monitor module 48 determines that the acquired model data 70 is acceptable, the selected training signal can then be utilised during CT acquisition as will now be described.

Use of Breathing Monitor during CT Acquisition

Referring to Figure 7, after a suitable coaching signal has been determined for a patient, when CT data is to be acquired this selected training signal is displayed to the patient 8 (S7-1) and the patient 8 is asked to try and match their breathing as much as possible with the displayed signal.

The CT apparatus is then utilised to start acquiring CT data (S7-2). At the same time as in during the training phase, image data is acquired by the cameras 18,22,24 on the camera rigs 1, 2, 3 and thc acquired image data is processed so as to generate surface data 74 associated with each image frame. When acquiring CT data it is important that the time stamps 72 associated with frames of surface data is synchronised with time stamp data indicative of the timing of the acquisition of individual items of CT scan data.

Once an entire CT scan has been completed initially the surface data 74 associated with individual image frames is modified (S 7-3) to account for any movement of the mechanical couch during the acquisition of CT data.

Typically during a CT scan a patient 8 is moved through the CT scanner using a mechanical couch 7. This causes the patient 8 to be translated in a predictable manner during CT acquisition. By applying a transformation inverse to the positioning of the couch at times represented by the individual time stamps 72, the stored surface data 74 can be modified so as to remove variations in surface data 74 which arise due to the translation of the patient 8 by the couch 7. Thus the surface data 74 acquired during CT acquisition is thereby made representative of surface data for breathing as though no movement of a couch 7 had taken place.

The modified surface data 74 is then (S7-4) utilised to identify time stamps 72 associated with similar surface data 74 and a similar breathing status 76. As the time stamps 72 associated with surface data 74 correspond to time stamps associated with frames of captured CT scan data, in this way the breathing monitor module 48 is able to identify frames of CT image data corresponding to times when a patient 8 had their chest in a particular position as represented by the modified surface data 74. If the surface data 74 associated with a particular frame is dissimilar to other frames, this will indicate that some irregularity occurred at that time, for example due to patient 8 movement or coughing. The CT data acquired at that time can thereby be discarded so as to avoid obtaining unrepresentative results.

Having determined the frames associated with similar surface data 74 and breathing status 76, the breathing monitor module then proceeds to generate (S7-5) a 4D representation of the movement of internal organs of the patient 8 using the acquired CT scan data and the surface model data 74 stored in the data store 47. Where CT data has been acquired at times corresponding to different frames having similar surface data and breathing status 74, 76 this CT data can be utilised to generate a frame of 4D CT scan representation. By reordering the acquired CT scan data so as to group scan acquired at the same time within the breathing cycle, CT data for different "slices" through the patient 8 can be incorporated in a single frame of CT scan data and hence the motion of the internal organs during breathing can be modelled by displaying the various group clusters of CT data in the order corresponding to an ordinary breathing cycle.

This 4D scan can then be utilised to select positions of the chest as represented by surface data when radiation is to be applied to a patient. The application of radiation to a patient 8 based on acquired surface data will now be described with reference to Figure 8.

Use of Breathing Monitor during Treatment

As in the CT acquisition phase, during treatment a selected training signal (S8-1) is displayed to a patient 8 who is instructed to try to match their breathing with the displayed signal.

The various cameras on the camera rigs 1, 2, 3 then proceed to acquire image data which is processed by the computer 5 to generate a representation of the surface 74 of the individual being imaged (S8-2).

When a surface has been determined, the surface data is then (S8-3) compared with surface data 74 acquired during the CT scanning phase and to identify which surface the patient's current position best matches and how closely the match between the patient's current surface and previously acquired surface data is.

If the breathing monitor module 48 determines that the acquired surface data closely matches representative surfaces used during the acquisition of CT scanning information and the surface corresponds to a portion of the breathing cycle where radiation is planned to be irradiated onto a patient 8, the breathing monitor module 48 then sends a signal to the gating control module 49 to cause the treatment apparatus 6 to proceed to irradiate the patient. If the comparison indicates that the patient's current surface differs significantly from that acquired when obtaining the CT scan data or alternatively the surface corresponds to a surface where no radiation is intended to be irradiated onto a patient 8 the breathing monitor module 48 sends a signal to the gating control module 49 to prevent the treatment apparatus 6 from irradiating a patient.

From the above it will be appreciated that by acquiring image data and processing the image data to generate a surface model of a patient 8 the breathing of a patient 8 can be monitored. This breathing information can be used to identify when a patient's breathing is consistent and regular. Further, by acquiring surface data when a CT scan is being performed, appropriate reordering of CT data can be achieved so as to generate a 4D model for the movement of a patient's organs throughout a breathing cycle. Finally by monitoring the surface of an individual during treatment the matching of a surface to surfaces using treatment planning corresponding to trigger points for irradiating a patient, can be used to control the gating of a treatment apparatus so as to irradiate a patient 8 appropriately.

Second Embodiment

Although in the first embodiment determination of the regularity of a breathing cycle, the reordering of CT scan data and the activation of a treatment apparatus is described based upon a comparison of surface data 74 acquired by the breathing monitor system, more complex control systems could be utilised. A second embodiment of the present invention will now be described with reference to Figures 9-12 in which a more complex model of a patient's breathing is generated and utilised to monitor the regularity of breathing, the generation of 4D CT scan and the timing of the irradiation of a patient 8 using a treatment apparatus 6.

Referring to Figure 9 and comparing the figure with Figure 5 of the previous embodiment, the steps in this embodiment are identical to the previous embodiment except after surface data has been obtained (S9-2) the breathing monitor module 47 then (S9-3) proceeds to generate a breathing model of the breathing of the patient 8 and then utilises the generated breathing model to determine the consistency with which the patient 8 is breathing (S9-4).

The generation of the monitoring of a movement of a point in accordance with this embodiment will now be explained further with reference to Figures 10A-C.

CLAIMS:

1. A breathing monitoring apparatus comprising:

a stereoscopic camera operable to acquire a series of images of an individual from a plurality of different view points;

an image processing module operable to process images of an individual from different view points to generate surface model data representative of the surface of said individual; and

a breathing monitor module operable to compare surfaces of an individual generated from different images in a series of images acquired by said stereoscopic camera to determine the consistency which an imaged individual is breathing.

2. A breathing monitoring apparatus in accordance with claim 1 wherein said breathing monitor module is operable to determine the consistency which an imaged individual is breathing by:

determining for surface model data generated from different image frames, image frames associated with substantially similar surface model data; and

determining the time differences between image frames associated with substantially similar surface model data.

Thus for example an average path for breathing in a particular manner can be identified. Subsequently by comparing the calculated positions for points being monitored variation between breathing cycles can be identified. More specifically if the measured position for a particular point on the surface of a patient 8 varies significantly from the expected path abnormal breathing can be determined.

Further by generating a model of the manner in which breathing occurs in this way a phase measurement being a measurement of position within a breathing cycle can be assigned to surface measurements within a series of surface measurements. Thus for example where the determined positions for a number of points predominately indicate that a patient 8 is at the end of exhale a value of zero might be given to a particular surface model. Conversely the maximum point of inhale could be labelled with a phase measurement of π with the subsequent end of exhale being 2π with intermediate measurements being assigned intermediate values. Such a phase measurement would enable both surface data to be labelled with a phase value indicating a relative position within a breathing cycle. Also by calculating a phase for a particular surface irregularities in breathing could be determined as when the phase associated with an individual surface disagree with an expected value based on the calculated model.

The use of such a breathing model during CT imaging is illustrated in Figure 11.

Figure 11 is identical to the content of Figure 7 except instead of matching CT scan "slices" using a clustering approach when a breathing model is generated (S11-4) such a breathing model can be utilised to assign to an individual item of surface data a phase value indicating a relative timing within the breathing cycle and hence assign individual image slices from the CT scan data with a phase value. When items of scanned data have been assigned a phase value, a 4D CT scan may be generated using the scan data and this determined phase information (S11-5).

Finally turning to Figure 12 a similar approach can also be utilised when determining activation times for a treatment apparatus 6.

In Figure 12, all steps in Figure 12 are identical to the steps shown in Figure 8 except after surface data is acquired (S12-2) the generated model of breathing is used to determine a phase for the breathing signal and based upon the comparison (S12-4) of the phase with a treatment plan and also the surface measurement with an expected surface for the identified phase gating is activated or deactivated. The advantage of this approach is that as a check can be made both on the phase value for the detected surface and the comparison between the detected surface and an expected surface, where an irregularity in breathing arises, irradiation can be avoided.

Further Modifications and Amendments

In the above embodiments, systems have been described in which an idealised breathing signal in the form of a sine or cosine function raised to a power is displayed to a patient where the signal is selected to match a patient's breathing. In alternative embodiments, rather than displaying an idealised signal, a patient's free breathing could be monitored and a signal corresponding to the detected free-breathing could be displayed to the patient. An advantage of such a system would be that as the displayed signal was based upon a patient's actual breathing, the signal would necessarily be one which it was possible for the patient to match. In such a system, a suitable training signal could be selected on the basis of a representative sample for free breathing. Alternatively, a number of breathing cycles could be monitored and the training signal could be based upon a calculated average cycle.

Although in the above embodiments systems have been described where image data is acquired from cameras, 18, 20,22 on three camera rigs 1,2,3, it will be appreciated that the generation of suitable surface data for monitoring a patient's breathing could be achieved using image data from fewer cameras. More specifically in other embodiments two or a single camera rig could be provided. In such systems, the field of view of the camera rigs would however be reduced compared to systems including a greater number of cameras. Additionally, in monitoring systems where textured model images are not required, no texture camera 20 would be needed. The reduction in the number of cameras would, in addition to reducing the overall cost of the system, also reduce the amount of data that a system had to process in order to generate surface model data and hence would increase the speed of the system. Further when only a single camera rig 1,2,3 were to be utilised, only a single frame grabber 51, 52 would be required further reducing the complexity of the system.

In the first embodiment a system is described which identifies similar items of surface data 74. It will be appreciated that various techniques could be utilised to help reduce the amount of processing required to identify similar surfaces.

Thus for example when determining which of a number of surfaces corresponds to a selected surface, rather than processing all available surfaces, an initial comparison could be made between one surface and a second whose time stamp 72 corresponds to the expected time stamp 72 for a corresponding portion of a breathing cycle given a patient's current measured rate of breathing. The result of this comparison could then be utilised to determine whether a patient is currently breathing faster or slower than expected and hence identify whether an earlier or later frame is most likely to be a suitable match. Alternatively, in such a system rather than relying upon an initial match between two surfaces, a number of surfaces in an expected time window as represented by the associated time stamp data could be compared and this comparison could be utilised to select candidates for detailed processing.

Although in the first embodiment a single difference measure is described as being used to identify similar and dissimilar surface data, it will be appreciated that multiple measures could be utilised to compare two surfaces as represented by surface data 74. Utilising different measures the variation in breathing between breathings cycles could be identified. Thus for example the extent to which breathing was thoracic or abdominal might be identified and utilised to classify a patient's breathing and any breathing irregularities. Other suitable methods for modelling breathing and detecting irregular breathing could be based on tracking the position of a point or points on the chest, measuring an estimated chest volume, comparing the similarity of a detected and measured chest surface or comparing the similarities between surface normals or any combination of such measures.

Although in the above embodiments the use of the system in processing CT scan data has been described, it will be appreciated that the present invention is equally applicable to any other type of internal imaging. Thus for example the system could be utilised with Positron Emission Tomography (PET Scans). Also rather than being restricted to processing 3D imaging data, it will also be appreciated that the described system is suitable for processing 2D image data such as X-ray fluoroscopy image data acquired during a breathing cycle.

Further although in the above embodiments the gating of a radio therapy apparatus has been described, it will be appreciated that monitoring the breathing of an individual using surface information could also be utilised to help direct or shapc a bcam of radiation in addition to switching a beam on and off.

CLAIMS:

1. A breathing monitoring apparatus comprising:

a stereoscopic camera operable to acquire a series of images of an individual from a plurality of different view points;

an image processing module operable to process images of an individual from different view points to generate surface model data representative of the surface of said individual; and

a breathing monitor module operable to compare surfaces of an individual generated from different images in a series of images acquired by said stereoscopic camera to determine the consistency which an imaged individual is breathing.

2. A breathing monitoring apparatus in accordance with claim 1 wherein said breathing monitor module is operable to determine the consistency which an imaged individual is breathing by:

determining for surface model data generated from different image frames, image frames associated with substantially similar surface model data; and

determining the time differences between image frames associated with substantially similar surface model data.

3. A breathing monitoring apparatus in accordance with claim 1 wherein said breathing monitor module is operable to determine the consistency which an imaged individual is breathing by:

determining for surface model data generated from different image frames, image frames associated with substantially similar surface model data; and

determining periods of successive image frames associated with substantially similar surface model data.

4. A breathing monitoring apparatus in accordance with claim 2 or 3 further comprising:

a breathing model generation module operable to generate breathing model data indicative of the motion of a one or more points on the surface of an image individual during a breathing cycle from different images in a series of images acquired by said stereoscopic camera wherein said breathing monitor module is operable to detect irregularities in breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from further obtained image data.

5. A breathing coaching apparatus comprising:

a display operable to display a coaching signal;

a breathing monitor in accordance with any preceding claim; and a signal selector operable to vary the coaching signal to be displayed on the display on the basis of the determination of the consistency of breathing by an individual by said breathing monitor.

6. A breathing coaching apparatus in accordance with claim 5, further comprising:

a speaker operable to generate an audio signal corresponding to a coaching signal to be displayed on said display.

7. A medical imaging device comprising:

a stereoscopic camera operable to acquire a series of images of an individual from a plurality of different view points;

an image processing module operable to process images of an individual from different view points to generate surface model data representative of the surface of said individual at a number of different times;

an imaging apparatus operable to obtain a series of images of the internal anatomy of an individual; and

a processing unit operable to generate a composite image of the internal anatomy of individual utilising images obtained by said imaging apparatus at times associated with similar surface model data.

8. A medical imaging apparatus in accordance with claim 7 comprising:

a mechanical couch;

wherein said image processing unit is operable to process generated surface model data to remove apparent movements of an imaged individual arsing due to movements of said mechanical couch, and said processing unit is operable to generate a composite image of the internal anatomy of individual utilising images obtained by said imaging apparatus at times associated with similar surface model data as modified by said processing unit.

9. A medical imaging device in accordance with claim 7 or 8 herein said image processing module is operable to associate surface model data representative of the surface of an individual at a number of different times with breathing data indicative of whether an imaged individual is inhaling or exhaling, wherein said processing unit operable to generate a composite image of the internal anatomy of individual utilising images obtained by said imaging apparatus at times associated with similar surface model data which are also associated with the same type of breathing data.

10. A breathing monitoring apparatus in accordance with any of claims 6-9 further comprising:

a breathing model generation module operable to generate breathing model data indicative of the motion of a one or more points on the surface of an image individual during a breathing cycle from different images in a series of images acquired by said stereoscopic camera wherein said breathing monitor module is operable to detect irregularities in breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from further obtained image data

wherein said processing unit operable to generate a composite image of the internal anatomy of individual utilising images obtained by said imaging apparatus at times associated with similar surface model data which are identified as being associated with regular breathing.

11. A medical imaging device in accordance with any of claims 7- 10 wherein said imaging apparatus comprises a CT scanner.

12. A radio therapy apparatus comprising:

a stereoscopic camera operable to acquire images of an individual from a plurality of different view points;

an image processing module operable to process images of an individual from different view points to generate surface model data representative of the surface of said individual;

an irradiating apparatus operable to irradiate an individual with radiation in accordance with a gating signal and

a gating control unit operable to generate a gating signal based upon a comparison of generated surface model data with data indicative of a model surface.

13. A radio therapy apparatus in accordance with claim 12 wherein said gating control unit is arranged to prevent the irradiation of an individual by said irradiating apparatus if generated surface model data differs from data indicative of a model surface by more than a predetermined amount.

14. A radio therapy apparatus in accordance with claim 12 or 13 further comprising:

a mechanical couch;

wherein said image processing unit is operable to process generated surface model data to remove apparent movements of an imaged individual arsing due to movements of said mechanical couch, and said gating unit is operable to a gating signal based upon a comparison of generated surface model data as modified by said processing unit with data indicative of a model surface

15. A radio therapy apparatus in accordance with any of claims 12 - 14 wherein said image processing module is operable to associate surface model data representative of the surface of an individual at a number of different times with breathing data indicative of whether an imaged individual is inhaling or exhaling, wherein said gating unit is operable to generate a gating signal based upon a comparison of generated surface model data with data indicative of a model surface associated with the same type of breathing data.

16. A radio therapy apparatus in accordance with any of claims 12 -15 further comprising:

a breathing model module operable to generate breathing model data indicative of the motion of a one or more points on the surface of an image individual during a breathing cycle, wherein said breathing monitor module is operable to detect irregularities in breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from obtained image data

wherein said gating control unit is arranged to prevent the irradiation of an individual when said breathing monitor module determines that the breathing of an individual is irregular.

17. A breathing monitoring apparatus comprising:

a stereoscopic camera operable to acquire a series of images of an individual from a plurality of different view points;

an image processing module operable to process images of an individual from different view points to generate surface model data representative of the surface of said individual, during one or more breathing cycles; and

a breathing monitor module operable to generate breathing model data indicative of the motion of a one or more points on the surface of an image individual during a breathing cycle from different images in a series of images acquired by said stereoscopic camera and to determine the consistency which an imaged individual is breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from further obtained image data.

18. A breathing coaching apparatus comprising:

a display operable to display a coaching signal;

a breathing monitor in accordance with claim 17; and

a signal selector operable to vary the coaching signal to be displayed on the display on the basis of the determination of the consistency of breathing by an individual by said breathing monitor.

19. A breathing coaching apparatus in accordance with claim 18, further comprising:

a speaker operable to generate an audio signal corresponding to a coaching signal to be displayed on said display.

20. A medical imaging device comprising:

a stereoscopic camera operable to acquire a series of images of an individual from a plurality of different view points;

an image processing module operable to process images of an individual from different view points to generate surface model data representative of the surface of said individual at a number of different times;

an imaging apparatus operable to obtain a series of images of the internal anatomy of an individual;

a breathing monitor module operable to generate breathing model data indicative of the motion of a one or more points on the surface of an image individual during a different phases in a breathing cycle from different images in a series of images acquired by said stereoscopic camera and to determine a phase and consistency which an imaged individual is breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from further obtained image data.; and

a processing unit operable to generate a composite image of the internal anatomy of individual utilising images obtained by said imaging apparatus at times associated with the same phase which are associated with periods of consistent breathing.

21. A medical imaging apparatus in accordance with claim 20 comprising:

a mechanical couch;

wherein said image processing unit is operable to process generated surface model data to remove movements of an imaged individual arsing due to movements of said mechanical couch.

22. A medical imaging device in accordance with claim 20 or 21wherein said image processing module is operable to associate surface model data representative of the surface of an individual at a number of different times with breathing data indicative of whether an imaged individual is inhaling or exhaling, wherein said processing unit operable to generate a composite image of the

internal anatomy of individual utilising images obtained by said imaging apparatus at times associated with the same phase and which are also associated with the same type of breathing data.

23. A medical imaging device in accordance with any of claims 20 – 22 wherein said imaging apparatus comprises a CT scanner.

24. A radio therapy apparatus comprising:

a stereoscopic camera operable to acquire images of an individual from a plurality of different view points;

an image processing module operable to process images of an individual from different view points to generate surface model data representative of the surface of said individual;

a breathing model store storing a breathing model indicative of the motion of a one or more points on the surface of an image individual during different phases in a breathing cycle;

a breathing monitor module operable to determine a phase and consistency which an imaged individual is breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from obtained image data;

an irradiating apparatus operable to irradiate an individual with radiation in accordance with a gating signal;

and

a gating control unit operable to generate a gating signal based upon a phase associated with generated surface data and a determination of whether breathing is regular by said breathing monitor module.

25. A radio therapy apparatus in accordance with claim 24 wherein said gating control unit is arranged to prevent the irradiation of an individual by said irradiating apparatus when breathing is determined to be irregular.

26. A method of breathing coaching comprising:

displaying a coaching signal;

acquiring a series of images of an individual from a plurality of different view points;

processing the acquired images of an individual from different view points to generate surface model data representative of the surface of said individual;

determining the consistency which an imaged individual is breathing by comparing surfaces of an individual generated from different images in a series of images; and

varying the coaching signal to be displayed on the display on the basis of the determination of the consistency of breathing by an individual by said breathing monitor.

27. A method of coaching breathing in accordance with claim 26, wherein determining the consistency which an imaged individual is breathing comprises:

determining for surface model data generated from different image frames, image frames associated with substantially similar surface model data; and

determining the time differences between image frames associated with substantially similar surface model data.

28. A method of coaching breathing in accordance with claim 26, wherein determining the consistency which an imaged individual is breathing comprises:

determining for surface model data generated from different image frames, image frames associated with substantially similar surface model data; and

determining periods of successive image frames associated with substantially similar surface model data.

29. A method of coaching breathing in accordance with any of claims 26 -28 further comprising:

generating breathing model data indicative of the motion of a one or more points on a calculated surface of an image individual during a breathing cycle from different images in a series of images; and

detecting irregularities in breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from further obtained image data.

30. A method of coaching breathing in accordance with any of claims 26 -29 further comprising:

generating an audio signal corresponding to a displayed coaching signal.

31. A method of generating an image of the internal anatomy of an individual comprising:

acquiring a series of images of an individual from a plurality of different view points whilst obtaining a series of images of the internal anatomy of an individual;

processing the obtained images of an individual from different view points to generate surface model data representative of the surface of said individual at a number of different times; and

generating a composite image of the internal anatomy of individual utilising images obtained at times associated with similar surface model data.

32. A method in accordance with claim 31 further comprising:

moving said individual on mechanical couch whilst obtaining a series of images of the internal anatomy of an individual;

processing generated surface model data to remove apparent movements of an imaged individual arsing due to movements of said mechanical couch; and

generating a composite image of the internal anatomy of individual utilising obtained images associated with similar surface model data as modified by said processing unit.

33. A method in accordance with claim 31 or 32 further comprising:

associating surface model data representative of the surface of an individual with breathing data indicative of whether an imaged individual is inhaling or exhaling;

generating a composite image of the internal anatomy of individual utilising images associated with similar surface model data which are also associated with the same type of breathing data.

34. A method in accordance with any of claims 31-33 further comprising:

generating a breathing model data indicative of the motion of a one or more points on the surface of an image individual during a breathing cycle from different images in a series of images;

detecting irregularities in breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from further obtained image data ; and

generating a composite image of the internal anatomy of individual utilising images associated with similar surface model data which are identified as being associated with regular breathing.

35. A method in accordance with any of claims 31-33 further wherein obtaining a series of images of the internal anatomy of an individual comprises

obtaining a series of images of the internal anatomy of an individual using a CT scanner.

36. A method of controlling a radio therapy apparatus comprising:

acquiring images of an individual from a plurality of different view points;

processing the acquired images of an individual from different view points to generate surface model data representative of the surface of said individual; and

generating a gating signal to control the irradiation of a radio therapy apparatus based upon a comparison of generated surface model data with data indicative of a model surface.

37. A method in accordance with claim 36 wherein generating a gating control signal comprises generating a signal to prevent if generated surface model data differs from data indicative of a model surface by more than a predetermined amount.

38. A method in accordance with claim 36 or 37 further comprising:

a moving an individual to be imaged on a mechanical couch;

processing generated surface model data to remove apparent movements of an imaged individual arsing due to movements of said mechanical couch,;

generating said gating signal based upon a comparison of generated surface model data as modified to remove apparent movements of an imaged individual arsing due to movements of said mechanical couch with data indicative of a model surface

39. A method according to any of claims 36-38 further comprising:

associating surface model data representative of the surface of an individual with breathing data indicative of whether an imaged individual is inhaling or exhaling;

wherein generating a gating signal comprises generating a gating signal based upon a comparison of generated surface model data associated with breathing data with data indicative of a model surface associated with the same type of breathing data.

40. A method according to any of claims 36 - 39 further comprising:

generating a breathing model indicative of the motion of a one or more points on the surface of an image individual during a breathing cycle; and

detecting irregularities in breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from obtained image data

wherein generating said gating signal comprises generating a signal to prevent the irradiation of an individual when the breathing of an individual is determined to be irregular.

41. A method of breathing coaching comprising:

displaying a coaching signal;

acquiring a series of images of an individual from a plurality of different view points;

processing the acquired images of an individual from different view points to generate surface model data representative of the surface of said individual;

generating a breathing model indicative of the motion of a one or more points on the surface of an image individual during a breathing cycle from different images in an acquired series of images;

determining the consistency with which an imaged individual is breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from further obtained image data.; and

varying the coaching signal to be displayed on the display on the basis of the determination of the consistency of breathing by an individual by said breathing monitor.

42. A method of generating an image of the internal anatomy of an individual comprising:

acquiring a series of images of an individual from a plurality of different view points whilst obtaining a series of images of the internal anatomy of an individual;

processing the obtained images of an individual from different view points to generate surface model data representative of the surface of said individual at a number of different times;

generating breathing model data indicative of the motion of a one or more points on the surface of an image individual during a different phases in a breathing cycle from different said generated surface model data;

determining the a phase and consistency which an imaged individual is breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from further obtained image data.

generating a composite image of the internal anatomy of individual utilising images obtained at times associated with the same phase which are associated with periods of consistent breathing.

43. A method of controlling a radio therapy apparatus comprising:

storing a breathing model indicative of the motion of a one or more points on the surface of an image individual during different phases in a breathing cycle;

acquiring images of an individual from a plurality of different view points;

processing the acquired images of an individual from different view points to generate surface model data representative of the surface of said individual; and

determining a phase and consistency which an imaged individual is breathing by comparing expected positions of corresponding points on the generated surface models of the surface an individual generated from obtained image data; and

generating a gating signal to control the irradiation of a radio therapy apparatus based upon a phase associated with generated surface data and a determination of whether breathing is regular by said breathing monitor module.

44. A breathing coaching apparatus comprising:

a display operable to display a coaching signal;

a stereoscopic camera operable to acquire a series of images of an individual from a plurality of different view points;

an image processing module operable to process images of an individual from different view points to generate surface model data representative of the surface of said individual; and

a signal generator operable to select a coaching signal to be displayed on the display on the basis of the surface model data generated by said image processing module.

45. A breathing coaching apparatus in accordance with claim 44 wherein said signal generator is operable to select a coaching signal on the basis of a determination of the manner in which an individual moves during one or more breathing cycles as determined from surface model data generated by said image processing module.

46. A breathing coaching apparatus in accordance with claim 45 wherein said signal generator is operable to select a coaching signal on the basis of a determination of an averaged manner in which an individual moves during a plurality of breathing cycles as determined from surface model data generated by said image processing module.

51

Application No: GB0617472.6 **Examiner:** Dr Susan Dewar

Claims searched: 1-6, 17-30, 41-43 **Date of search:** 14 December 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 at least	EP 1640922 A2 (VISION RT LTD) See paragraphs 0097-0101 & 0104-0106
X	1 at least	WO 2004/004828 A2 (VISION RT LTD) See in particular pages 38-41
X	1 at least	GB 2371964 A (TCT INTERNATIONAL PLC) Whole document relevant
X,E	1 at least	WO 2006/113323 A2 (UNIV. OF MARYLAND) See paragraphs 0063-0076

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

G1A

Worldwide search of patent documents classified in the following areas of the IPC

A61B; A61N; G06T

The following online and other databases have been used in the preparation of this search report

ONLINE: EPODOC, WPI, TXTE