



US 20170252576A1

(19) **United States**(12) **Patent Application Publication**
JUNG et al.(10) **Pub. No.: US 2017/0252576 A1**(43) **Pub. Date: Sep. 7, 2017**(54) **RESPIRATORY GATING SYSTEM FOR
PATIENT USING NATURAL BREATHING
METHOD DURING RADIATION THERAPY,
AND METHOD FOR EMITTING RADIATION
THEREBY**(52) **U.S. Cl.**
CPC *A61N 5/1037* (2013.01); *A61B 5/08*
(2013.01); *A61B 90/39* (2016.02); *A61B 6/032*
(2013.01); *A61B 5/0071* (2013.01); *A61B*
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SUK SUH**, Seoul (KR)(21) Appl. No.: **15/304,529**(22) PCT Filed: **Jul. 1, 2014**(86) PCT No.: **PCT/KR2014/005866**

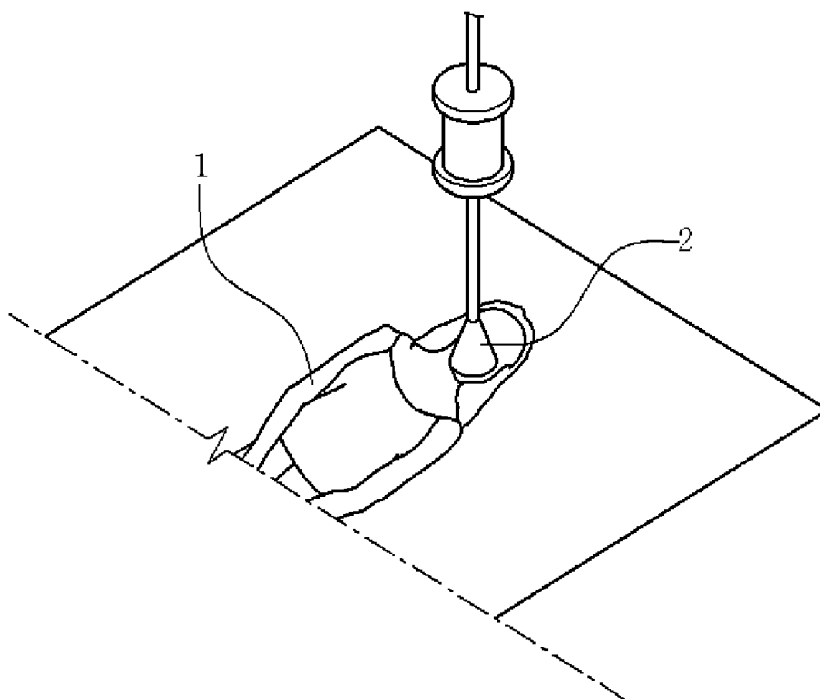
§ 371 (c)(1),

(2) Date: **Oct. 16, 2016**(30) **Foreign Application Priority Data**

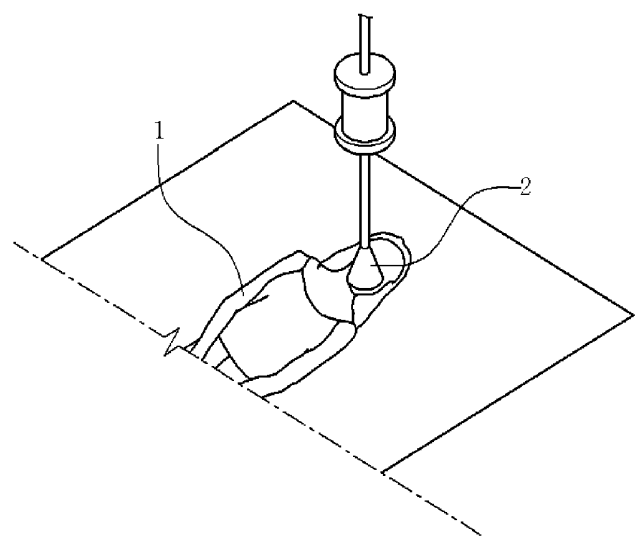
Apr. 16, 2014 (KR) 10-2014-0045432

Publication Classification(51) **Int. Cl.**
A61N 5/10 (2006.01)
A61B 5/055 (2006.01)
A61B 6/03 (2006.01)
A61B 5/00 (2006.01)
A61B 5/08 (2006.01)
A61B 90/00 (2006.01)(57) **ABSTRACT**

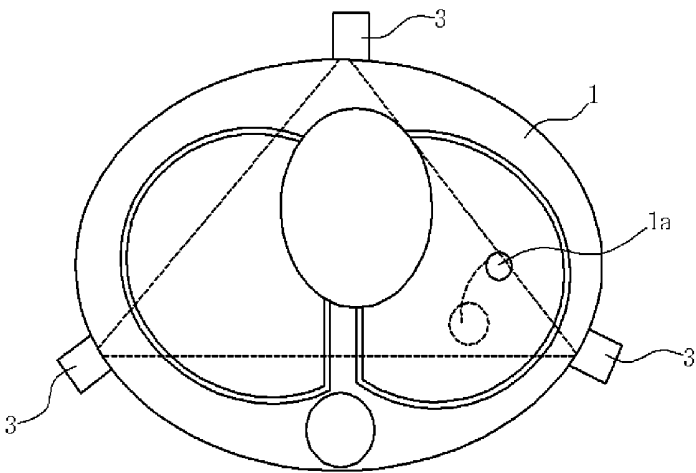
The present invention relates to a respiratory gating system for a patient using a natural breathing method during radiation therapy, and a method for emitting radiation thereby. A respiratory gating system allowing radiation to be emitted by orienting to the position, which varies according to a patient's breathing, of a subject on which treatment is to be carried out, comprises: a breathing respirator for allowing the patient's respiration amount to be measured; external markers to be respectively adhered to triangulation points outside the human body of the surrounding region of the subject, of the patient, on which treatment is to be carried out; an image diagnosis device for imaging the region of the subject of the patient on which treatment is to be carried out, by photographing the same; and a computer program programmed so as to calculate, as position coordinates, the change in position of the subject on which treatment is to be carried out, according to the respiration amount measured by the computed tomography equipment and the each external marker, through a triangulation method and dual polynomial equations, and to transmit the position coordinates, which changes in real time, to radiation therapy equipment, wherein radiation is emitted by the respiratory gating system, and there is an effect of further increasing the accuracy and stability of the entire radiation therapy result by tracking, in real time, the movement of an organ, which is the subject on which treatment is to be carried out according to breathing, through a respiratory gating system which uses natural breathing rather than a breathing method through the training of the patient.



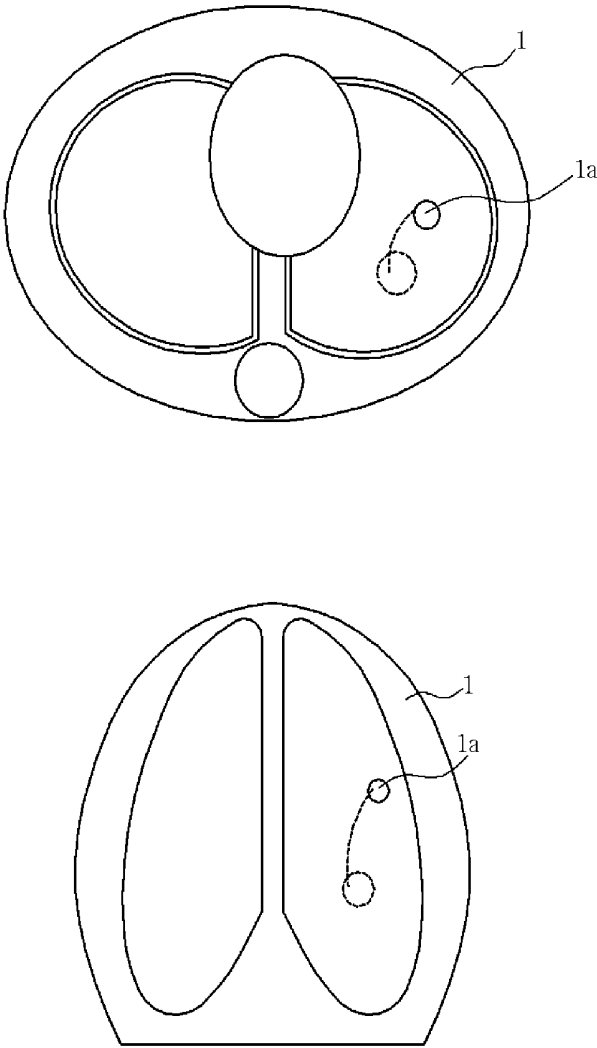
[Fig. 1]



[Fig. 2]



[Fig. 3]



**RESPIRATORY GATING SYSTEM FOR
PATIENT USING NATURAL BREATHING
METHOD DURING RADIATION THERAPY,
AND METHOD FOR EMITTING RADIATION
THEREBY**

TECHNICAL FIELD

[0001] The present invention relates to a respiratory gating system for a patient using a natural breathing method during radiation therapy and a method for emitting radiation thereby. More particularly, the present invention relates to a respiratory gating system for a patient using a natural breathing method during radiation therapy which measures and photographs a position, of a subject on which treatment is to be carried out, which varies according to a depth and an amount of respiration of a patient who wears a breathing respirator, using external markers which are located in triangulation points outside the patient and an image diagnosis device, calculates, as position coordinates, a trajectory of the measured change in position of the subject on which treatment is to be carried out through a triangulation method and dual polynomial equations, and then emits radiation therethrough and a method for emitting radiation thereby.

BACKGROUND ART

[0002] According to a recent trend of radiation therapy, in order to check an accurate position of a subject on which a treatment is to be carried out, such as a tumor, an image guided radiation therapy (IGRT) or respiratory gated radiation therapy (RGRT) technique is used. According to the IGRT, whenever the radiation therapy is performed, an image of a subject on which treatment is to be carried out, such as a tumor of the patient, is obtained using computed tomography (CT) equipment immediately before the radiation therapy. When a therapy plan is built, the obtained image is compared to re-adjust a position where the radiation is emitted, thereby securing accuracy of the therapy. Further, according to the RGRT, a real-time position management (RPM) system is used to track a position of a subject on which treatment is to be carried out, such as a tumor, in a chest or an abdomen, according to a respiration cycle of a patient and the radiation is emitted according to the movement of the tracked position.

[0003] The method for tracking a position of a subject on which treatment is to be carried out, such as a tumor, is mainly classified into two methods: The first method is a method of tracking a position by implanting a fiducial marker (or a gold marker) in a target. The first method has an advantage in that a movement displacement of the target is accurately checked, but also has a disadvantage in that the method is invasive and the target needs to be removed after performing the therapy. The second method is a method for tracking a position using an external marker. This method is non-invasive and may secure accuracy of target localization. However, in the related art, only one external marker is provided, which may lower accuracy of tracking a position.

[0004] According to Patent Document 1 (Korean Registered Patent No. 10-0943180), a biological signal is stabilized using training and relaxation response is provided to perform bio feedback. In the above-mentioned technologies, even though high tech equipment is used to correct the movement according to respiration of a patient, a cost therefor and training for every patient are uncertain. Further,

a stability of a patient which has difficulty in breathing is lowered, so that a treatment time is increased. Specifically, a recent radiation technique transmits high dose intensity at once at a short treatment time so that movement of the patient, that is, a respiration amount needs to be indispensably considered.

DISCLOSURE

Technical Problem

[0005] The present invention has been made in an effort to provide a respiratory gating system for a patient using a natural breathing method during radiation therapy which tracks the position of the subject on which treatment is to be carried out, such as a tumor, which is a target, by collecting and processing inhalation and exhalation amounts of the breathing, that is, the respiration amount in real time while maintaining natural breathing of the patient during radiation therapy, thereby removing uncertainty of a bio feedback of the related art. The respiratory gating system includes a breathing respirator which is worn by the patient, three external markers and an image diagnosis device which measures and photographs the change in position of the subject on which treatment is to be carried out according to the depth and the amount of the respiration which is transmitted through the breathing respirator, and a computer program which tracks a trajectory according to the measured change in position of the subject on which treatment is to be carried out to convert the trajectory as a vector and calculates, as position coordinates, the vector using a triangulation method and dual polynomial equations and transmits the position coordinates to radiation therapy equipment.

[0006] The present invention has been made in an effort to further provide a method for emitting radiation by a respiratory gating system for a patient using a natural breathing method during radiation therapy.

Technical Solution

[0007] According to an aspect of the present invention, there is provided a respiratory gating system for a patient using a natural breathing method during radiation therapy allows radiation to be emitted by orienting to a position which varies according to a patient's breathing, of a subject on which treatment is to be carried. The respiration gating system includes: a breathing respirator for allowing the patient's respiration amount to be measured; external markers to be respectively adhered to triangulation points outside a human body of the surrounding region of the subject of the patient on which treatment is to be carried out; an image diagnosis device for imaging the region of the subject of the patient on which treatment is to be carried out by photographing the same; and a computer program programmed so as to calculate, as position coordinates, the change in position of the subject on which treatment is to be carried out, according to the respiration amount measured by the computed tomography equipment and the each external marker, through a triangulation method and dual polynomial equations, and to transmit the position coordinates, which changes in real time, to radiation therapy equipment.

[0008] Further, the image diagnosis device may be a computed tomography (CT) device, fluoroscopy or magnetic resonance (MR) imaging device.

[0009] Further, according to another aspect of the present invention, there is provided a method for emitting radiation by a respiratory gating system allowing radiation to be emitted by orienting to a position, which varies according to a patient's breathing, of a subject on which treatment is to be carried out. The method includes putting a breathing respirator which transmits a respiration amount on a nasal cavity and a mouth of a patient; adhering external markers to triangulation points outside a human body of the surrounding region of the subject of the patient on which treatment is to be carried out; imaging a position of the subject on which treatment is to be carried out according to a signal of a depth and an amount of respiration by a respiration amount of the patient which is transmitted from the breathing respirator by computed tomography (CT) equipment in real time; measuring the change in position, which is imaged by the external markers, of the subject on which treatment is to be carried out; calculating, as a position coordinate, the change in position of the subject on which treatment is to be carried out using a triangulation method and dual polynomial equations; and transmitting the position coordinates to radiation therapy equipment to emit radiation to the subject on which treatment is to be carried out, whose position varies.

[0010] The triangulation equation may estimate the position, which varies, of the subject on which treatment is to be carried out, on an XY coordinate with respect to triangulation positions of external markers and the dual polynomial equations may track a trajectory according to the change in position of the subject on which treatment is to be carried out which is estimated by the triangulation equation and then create an equation using a vector value of the trajectory to calculate the position coordinate.

[0011] Collecting of a signal of a depth and an amount of the respiration may include: measuring a physical phenomenon such as a pressure using data acquisition (DAQ); patterning an input signal value using a field programmable gate array (FPGA) on the signal collected in the measuring of a physical phenomenon in an image diagnosis device; and adjusting an on/off time of radiation based on information obtained by patterning the signal value according to movement in the patterning of a signal value.

Advantageous Effects

[0012] According to the respiratory gating system for a patient using a natural breathing method during radiation therapy and the method for emitting radiation thereby of the present invention, the accuracy and stability of the entire radiation therapy result may be further increased by tracking, in real time, the movement of an organ, which is the subject on which treatment is to be carried out according to breathing, through a respiratory gating system which uses natural breathing rather than a breathing method through the training of the patient.

[0013] Moreover, the radiation may be emitted on a more accurate position, which varies in real time according to a patient's breathing, of the subject on which treatment is to be carried out by measuring a position of the subject on which treatment is to be carried out, through three external markers which are located outside the patient and calculating the change in position of the subject on which treatment is to be carried out, through a triangulation method and dual polynomial equations.

DESCRIPTION OF DRAWINGS

[0014] FIG. 1 is a conceptual view illustrating a wearing status of a breathing respirator which configures a respiratory gating system for a patient using a natural breathing method during radiation therapy according to the present invention.

[0015] FIG. 2 is a conceptual view illustrating an arrangement of external markers which configure a respiratory gating system for a patient using a natural breathing method during radiation therapy according to the present invention.

[0016] FIG. 3 is a conceptual view illustrating change in position of a subject on which treatment is to be carried out according to a respiration amount using a respiratory gating system for a patient using a natural breathing method during radiation therapy according to the present invention.

BEST MODE

[0017] Hereinafter, exemplary embodiments of a respiratory gating system for a patient using a natural breathing method during radiation therapy and a method for emitting radiation thereby will be described in detail with reference to drawings. The present invention is not limited to embodiments to be disclosed below, but various forms different from each other may be implemented. However, the embodiments are provided to be completely known to those skilled in the art.

[0018] FIG. 1 is a conceptual view illustrating a wearing status of a breathing respirator which configures a respiratory gating system for a patient using a natural breathing method during radiation therapy according to the present invention and FIG. 2 is a conceptual view illustrating an arrangement of external markers which configure a respiratory gating system for a patient using a natural breathing method during radiation therapy according to the present invention.

[0019] As illustrated in FIGS. 1 and 2, a respiratory gating system for a patient using a natural breathing method during radiation therapy according to the present invention includes a breathing respirator 1, an image diagnosis device, three external markers 2, and a computer program which calculates position coordinates of a position which varies, of a subject on which treatment is to be carried out, through the above-mentioned components.

[0020] The breathing respirator 1 is put on a nasal cavity and a mouth of a subject, of a patient 3, on which treatment is to be carried out and radiation is to be emitted to guide and transmit inhalation and exhalation amounts of the patient 3 during radiation therapy, that is, a respiration amount.

[0021] Even though not illustrated, the image diagnosis device including computer images signals of a depth and an amount of respiration which is transmitted through the breathing respirator 1 in real time by photographing the same. Specific examples of the image diagnosis device include a computed tomography (CT) device, fluoroscopy or magnetic resonance (MR) imaging device.

[0022] The three external markers 2 are adhered to triangulation points of three places outside the human body of the surrounding region of the subject 1a of the patient on which treatment is to be carried out, that is, substantially three places of the abdomen and both sides to measure the change in position of the subject on which treatment is to be carried out according to the respiration amount, on an XY coordinate.

[0023] The computer program is installed in a computer of an image diagnosis device. The image diagnosis device images the subject **1a** of the patient **1** on which treatment is to be carried out by photographing the subject **1a**. The computer program drives a program of a triangulation method and dual polynomial equations which measure the position which varies, of the subject **1a** on which treatment is to be carried out, by three external markers **2**, using the image of the photographed subject on which treatment is to be carried out and calculate the position as position coordinates. Examples of the dual polynomial equations may include linear and quadratic equations, log, and exponent.

Embodiments

[0024] Next, a method for emitting radiation by the respiratory gating system for a patient using a natural breathing method during radiation therapy configured as described above will be described.

[0025] FIG. 3 is a conceptual view illustrating change in position of a subject on which treatment is to be carried out according to a respiration amount using a respiratory gating system for a patient using a natural breathing method during radiation therapy according to the present invention.

[0026] Referring to FIGS. 2 and 3, first, a breathing respirator **2** is worn on a nasal cavity and a mouth of a patient and whenever the patient naturally breathes, a signal of a depth and an amount of respiration is imaged in real time using the image diagnosis device.

[0027] Next, in an imaging step, a position, which varies, of the subject **1a** on which treatment is to be carried out and radiation is to be emitted is measured with respect to three external markers **3**, using the image of the photographed region of the subject **1a** of the patient **1** on which treatment is to be carried out.

[0028] Next, a trajectory of coordinates on which the subject **1a**, which varies, on which treatment is to be carried out is located is tracked by a computer program through the triangulation method and a real-time trajectory equation is created using a vector value of the trajectory through the dual polynomial equations. For example, the position, which varies on the XY coordinate, of the subject on which treatment is to be carried out is measured by three external markers **3** and the positions are connected to be represented by a trajectory. The trajectory is used to obtain an equation which is one of $y=ax$, $y=ax+bx$, $y=ax+bx+c$, $y=ax^2$, $y=ax^2+bx$, $y=ax^2+bx+c$ by the dual polynomial equations. Therefore, the change in position of the subject on which treatment is to be carried out according to variables of the respiration amount is mathematized through the equation to be calculated as a position coordinates. In this case, collecting of a signal of the respiration amount includes (a) measuring a physical phenomenon such as a pressure using data acquisition (DAQ), (b) patterning an input signal value using a field programmable gate array (FPGA) on the signal collected in step (a), and (c) adjusting an on/off time of radiation based on information obtained by patterning the signal value according to movement in step (b). As an example of the dual polynomial equations, log or exponent which is described above may be used in addition to the linear and quadratic equations.

[0029] Next, the position coordinates which are obtained by tracking the position, of the subject **1a** on which treatment is to be carried out, which varies in real time according to a natural breathing amount during the radiation therapy of

the subject **1a** of the patient on which treatment is to be carried out are transmitted to radiation therapy equipment so that the radiation therapy equipment irradiates radiation onto the subject **1a** on which treatment is to be carried out on an accurate position according to the position coordinates which vary.

[0030] As compared with a method of controlling a radiation beam to be on/off in a region of the subject, which is a moving target, on which treatment is to be carried out, by receiving breathing phase data of the related art, according to the respiratory gating system of the present invention may more accurately secure the movement of the subject on which treatment is to be carried out which is a target using not only a respiration amount but also a distortion through the triangulation method and the dual polynomial equations. Further, according to the respiratory gating system of the present invention, data of the position coordinate obtained from the patient is created as a respiratory pattern portfolio to be applied in an actual clinical treatment and a position coordinate of the subject (tumor) on which treatment is to be carried out is called in form of a library using inhalation and exhalation amounts, regardless of regular/irregular breathing pattern of the patient to input the position coordinate to the radiation therapy equipment in real time. The radiation therapy equipment which receives the position coordinate starts the image guided radiation therapy (IGRT) and the respiratory gated radiation therapy (RGRT) according to a determined coordinate. In this case, the image guided radiation therapy (IGRT) or the respiratory gated radiation therapy (RGRT) is determined in accordance with a breathing pattern classification of the patient. Therefore, in the case of a simple breathing pattern, a therapy system which is close to the IGRT may be selected.

[0031] As described above, the respiratory gating system for a patient using a natural breathing method during radiation therapy according to the present invention and the method for emitting radiation thereby have been described. However, the present invention is not limited to the exemplary embodiments and the drawings disclosed herein. Further, it should be understood that those skilled in the art may modify the present invention in various forms within the scope of the technical spirit of the present invention.

INDUSTRIAL APPLICABILITY

[0032] The present invention may be utilized as a respiratory gating system for a patient using a natural breathing method during radiation therapy and a method for emitting radiation thereby which may increase the accuracy and stability of the entire radiation therapy result by tracking, in real time, the movement of an organ, which is the subject on which treatment is to be carried out according to breathing, through a respiratory gating system which uses natural breathing rather than a breathing method through the training of the patient.

[0033] Moreover, the present invention may be further utilized as a respiratory gating system for a patient using a natural breathing method during radiation therapy and a method for emitting radiation thereby which may emit the radiation on a more accurate position, which varies according to a patient's breathing, of the subject on which treatment is to be carried out by measuring a position of the subject on which treatment is to be carried out, through three external markers which are located outside the patient and calculating the change in position of the subject on which

treatment is to be carried out, through a triangulation method and dual polynomial equations.

1. A respiratory gating system for a patient using a natural breathing method during radiation therapy allowing radiation to be emitted by orienting to a position which varies according to a patient's breathing, of a subject on which treatment is to be carried out, the system comprising:

a breathing respirator for allowing the patient's respiration amount to be measured;

external markers to be respectively adhered to triangulation points outside a human body of the surrounding region of the subject of the patient on which treatment is to be carried out;

an image diagnosis device for imaging the region of the subject of the patient on which the treatment is to be carried out by photographing the same; and

a computer program programmed so as to calculate, as position coordinates, the change in position of the subject on which treatment is to be carried out, according to the respiration amount measured by the computed tomography equipment and the each external marker, through a triangulation method and dual polynomial equations, and to transmit the position coordinates, which changes in real time, to radiation therapy equipment.

2. The system of claim 1, wherein the image diagnosis device is a computed tomography (CT) device, fluoroscopy or magnetic resonance (MR) imaging device.

3. A method for emitting radiation by a respiratory gating system allowing radiation to be emitted by orienting to a position, which varies according to a patient's breathing, of a subject on which treatment is to be carried out, the method comprising:

putting a breathing respirator which transmits a respiration amount on a nasal cavity and a mouth of a patient; adhering external markers to triangulation points outside a human body of the surrounding region of the subject of the patient on which treatment is to be carried out;

imaging a position of the subject on which treatment is to be carried out according to a signal of a depth and an amount of respiration by a respiration amount of the patient which is transmitted from the breathing respirator by computed tomography (CT) equipment in real time;

measuring the change in position, which is imaged by the external markers, of the subject on which treatment is to be carried out;

calculating, as position coordinates, the change in position of the subject on which treatment is to be carried out using a triangulation method and dual polynomial equations; and

transmitting the position coordinates to radiation therapy equipment to emit radiation to the subject on which treatment is to be carried out, whose position varies.

4. The method of claim 3, wherein the triangulation equation estimates the position, which varies, of the subject on which treatment is to be carried out, on an XY coordinate with respect to triangulation positions of external markers and the dual polynomial equations tracks a trajectory according to the change in position of the subject on which treatment is to be carried out which is estimated by the triangulation equation and then creates an equation using a vector value of the trajectory to calculate the position coordinate.

5. The method of claim 3 or 4, wherein collecting of a signal of a depth and an amount of the respiration includes: measuring a physical phenomenon such as a pressure using data acquisition (DAQ);

patterning an input signal value using a field programmable gate array (FPGA) on the signal collected in the measuring of a physical phenomenon in an image diagnosis device; and

adjusting an on/off time of radiation based on information obtained by patterning the signal value according to movement in the patterning of a signal value.

* * * * *

专利名称(译)	用于在放射治疗期间使用自然呼吸方法的患者的呼吸门控系统，以及由此发射辐射的方法		
公开(公告)号	US20170252576A1	公开(公告)日	2017-09-07
申请号	US15/304529	申请日	2014-07-01
[标]申请(专利权)人(译)	韩国IND学术合作天主教UNIV FOUND		
申请(专利权)人(译)	天主教大学学术产业合作基础		
当前申请(专利权)人(译)	天主教大学学术产业合作基础		
[标]发明人	JUNG JOO YOUNG YOON DO KUN SUH TAE SUK		
发明人	JUNG, JOO YOUNG YOON, DO KUN SUH, TAE SUK		
IPC分类号	A61N5/10 A61B5/055 A61B6/03 A61B5/00 A61B5/08 A61B90/00		
CPC分类号	A61N5/1037 A61B5/08 A61B90/39 A61N5/1039 A61B5/0071 A61B5/055 A61B6/032		
优先权	1020140045432 2014-04-16 KR		
其他公开文献	US10384081		
外部链接	Espacenet USPTO		

摘要(译)

本发明涉及一种用于在放射治疗期间使用自然呼吸方法的患者的呼吸门控系统，以及由此发射辐射的方法。一种呼吸门控系统，其允许通过定向到要对其进行治疗的受试者的根据患者的呼吸而变化的位置来发射辐射，包括：用于允许测量患者的呼吸量的呼吸呼吸器；外部标记分别粘附在患者周围区域的人体外部的三角测量点上，对其进行治疗；图像诊断装置，用于通过拍摄来对要对其进行治疗的患者的对象区域进行成像；计算机程序，其被编程为根据由计算机断层摄影设备和每个外部标记测量的呼吸量，通过三角测量计算要进行治疗的对象的位置变化作为位置坐标。方法和双重多项式方程，并将实时变化的位置坐标发送到辐射治疗设备，其中辐射由呼吸选通系统发射，并且具有进一步提高整个辐射的准确性和稳定性的效果治疗结果通过呼吸门控系统实时跟踪器官的运动，器官是根据呼吸进行治疗的对象，呼吸门控系统使用自然呼吸而不是呼吸方法通过训练患者。

