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(54) **Method and apparatus for producing three-dimensional ultrasonic images in quasi real time**

Verfahren und Vorrichtung zur Herstellung drei-dimensionaler Ultraschallbilder in Quasi-Echtzeit

Procédé et dispositif pour produire des images ultrasonores tri-dimensionelles en quasi temps réel

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Description

[0001] The present invention relates generally to ultrasound imaging, and more particularly, to a three-dimensional (3D) ultrasound imaging method and apparatus for producing a 3D moving image of a moving target object.

[0002] Static 3D images are conventionally produced by obtaining raw 3D data, e.g., data on a coordinate system (x, y, z), through a 3D probe regardless of acquisition time, by stacking frames over one another at a uniform time interval to form consecutive frames, and by processing the consecutive frames using a 3D rendering technique. Where static 3D images are used for ultrasound diagnostic purposes, one may easily make accurate observation, diagnosis, or treatment of the internal state of a human body without performing complicated procedures associated with invasive operations. Thus, static 3D images are widely used. However, static 3D images are not useful in observing a moving target object in real time, such as an embryo in the uterus.

[0003] In order to overcome this shortcoming, a live 3D imaging method and apparatus for providing a 3D moving image, rather than static 3D images, has been developed. Herein, a live 3D image should be understood and interpreted as a quasi real-time 3D moving image, representing movement of a moving target object. The live 3D image consists of fewer frames than those of a real-time 3D moving image so that it does not completely represent movement of a moving target object. However, since the live 3D image consists of more frames than static 3D images, e.g., 2 to 4 frames per second, it can represent movement of a moving target object more smoothly than the static 3D images.

[0004] Referring to Fig. 1, which illustrates a schematic block diagram of a conventional ultrasound apparatus for producing alive 3D image, live 3D imaging apparatus 100 comprises probe 102 for transmitting and receiving ultrasound signals to/from a moving target object (not shown), i.e., scanning the moving target object; image processing unit 104 for producing a live 3D image by using the reflected ultrasound signals transmitted from probe 102; and display unit 106 for displaying the live 3D image produced by image processor 104.

[0005] Image processing unit 104 includes raw 3D data obtaining unit 108 and rendering unit 110. Raw 3D data obtaining unit 108 obtains raw data required for producing the live 3D image based on the reflected ultrasound signals transmitted from probe 102, which are transmitted to rendering unit 110. (Hereinafter, raw data refers to raw 3D data) Raw 3D data obtaining unit 108 may sequentially store raw 3D data corresponding to each frame on a predetermined storage unit (not shown), which are transmitted to rendering unit 110. Rendering unit 110 then performs a conventional rendering process on the raw 3D data transmitted from raw 3D data obtaining unit 108 and produces the live 3D image to be displayed on display unit 106.

[0006] Referring to Fig. 2, which shows a flow chart for conventionally producing a live 3D image, probe 102 scans a moving target object by transmitting ultrasound signals to the moving target object and receiving the ultrasound signals reflected therefrom (Step S202). Raw 3D data obtaining unit 108 of image processing unit 104 obtains raw 3D data and stores them on a predetermined storage unit (Step S204). Where the stored raw 3D data correspond to ***n*** number of frames, rendering unit 110 reads raw 3D data corresponding to the $(n-1)^{th}$ frame among ***n*** number of the frames, which is stored just before the n^{th} frame, and performs a high-speed rendering on the $(n-2)^{th}$ frame, which is stored just before the $(n-1)^{th}$ frame (Step S206). By performing such parallel rendering processes repetitively, rendering unit 110 performs live 3D imaging to produce the live 3D image of the moving target object. Display unit 106 displays the live 3D image thereon (Step S208). The frame rate of the live 3D image displayed on display unit 106 is typically 2 to 4 frames/second.

[0007] As described above, with conventional live 3D imaging apparatus 100, displaying images like a cinema is very difficult, since the live 3D image consists of 2 to 4 frames per second while the cinema typically consists of at least 30 frames per second. For example, if a frame rate of the live 3D image is 4 frames per second, the live 3D image may be discontinuously displayed for one second.

[0008] Patent US-5966178-A and publication "Interpolation of Cinematic Sequences" of Ribas-Corbera and al. XP010023164, disclose uses of interpolation for data compression and reproduction of sequence video frames.

[0009] Patent application US-2002/0045822-A1 discloses a medical apparatus for scanning and imaging part of heart wall.

[0010] It is also known, by patent application EP-094402-A, method for producing a three-dimensional moving image according to the preamble of claim 1.

[0011] Thus, need exists for an apparatus and method for providing a natural looking 3D moving image by raising the conventional frame rate of live 3D image without increasing the calculation load of a live 3D imaging apparatus.

[0012] Therefore, an objective of the present invention is to provide an ultrasound imaging apparatus and method for producing a live 3D image of a moving target object, which looks more natural than a conventional live 3D image, by raising the frame rate of conventional live 3D image by inserting a predetermined number of virtual image frames at a uniform time interval between the live 3D image frames obtained from raw 3D data of the moving target object. The invention relates to a method according to claim 1. The invention also relates to a system according to claim 2.

[0013] The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood with reference to the following description, taken in conjunction with the accompanying drawings.

Fig. 1 is a schematic block diagram of a conventional ultrasound imaging apparatus for producing a live three-dimensional (3D) image of a moving target object.

Fig. 2 illustrates a flow chart for conventionally producing a live 3D image of a moving target object.

Fig. 3 is a schematic block diagram of an ultrasound imaging apparatus for producing a live 3D image of a moving target object in accordance with the present invention.

Fig. 4A illustrates virtual image frames produced by using interpolation in accordance with the present invention.

Fig. 4B illustrates virtual image frames produced by using extrapolation in accordance with the present invention.

Fig. 4C shows an example of the virtual image frames produced by using interpolation in accordance with the present invention.

Fig. 5 illustrates a flow chart for producing a live 3D image of a moving target object in accordance with the present invention.

[0014] Referring to Fig. 3, which shows a schematic block diagram of an apparatus for producing a live 3D image in accordance with the present invention, live 3D imaging apparatus 300 comprises probe 302 for transmitting ultrasound signals to a moving target object (not shown) and receiving the ultrasound signals reflected therefrom, image processing unit 310 for producing a live 3D image of the moving target object based on the reflected ultrasound signals transmitted from probe 302, and display unit 308 for displaying the live 3D image produced by image processing unit 310.

[0015] Image processing unit 310 includes raw 3D data obtaining unit 304 and enhanced live 3D imaging unit 306. Raw 3D data obtaining unit 304 of image processing unit 310 obtains raw data required for producing the live 3D image based on the reflected ultrasound signals transmitted from probe 302, which are transmitted to enhanced live 3D imaging 306. Raw 3D data obtaining unit 304 sequentially transmits raw 3D data corresponding to each frame of the live 3D image to enhanced live 3D imaging unit 306. Enhanced live 3D imaging unit 306 produces data including the frames of the live 3D image (hereinafter, the original live 3D image frames) to be displayed on display unit 308 based on the raw 3D data transmitted from raw 3D data obtaining unit 304. Enhanced live 3D imaging unit 306 then produces data including virtual image frames to be inserted between the original live 3D image frames based on the original live 3D image frame data. Thereafter, enhanced live 3D imaging unit 306 performs 3D rendering on a live 3D image in which the original live 3D image frames and the virtual image frames are mixed together, using the original live 3D image frame data and the virtual image frame data. Enhanced live 3D imaging unit 306 employs interpolation or extrapolation, to produce the virtual image frame data.

[0016] Fig. 4A illustrates $(n-1)^{th}$ frame 402 and n^{th} frame 406 among $\boldsymbol{n}$ number of the original live 3D image frames, and $\boldsymbol{m}$ number of virtual image frames 404 which are produced by using interpolation and inserted between $(n-1)^{th}$ frame 402 and n^{th} frame 406 among the original live 3D image frames. Fig. 4B illustrates $\boldsymbol{m}$ number of virtual image frames 408 produced by using extrapolation. Virtual image frames 408 are added next to n^{th} frame 406 of the original live 3D image frames. Fig. 4C shows an example of virtual image frames produced by using interpolation as described with reference to Fig. 4A. As may be seen from Fig. 4C, movement of an embryo is represented naturally since the virtual image frames produced are inserted between the $(n-1)^{th}$ frame and n^{th} frame among the original live 3D image frames. Herein, the total number of the original live 3D image frames is $\boldsymbol{n}$ and the total number of virtual image frames produced through interpolation or extrapolation is $\boldsymbol{m}$, wherein $\boldsymbol{n}$ and $\boldsymbol{m}$ are integers.

[0017] As illustrated in Fig. 4A, where enhanced live 3D imaging unit 306 employs linear interpolation, display time t_{aj} of the j^{th} virtual image frame among m number of virtual image frames 404 and a color value y_{aj} corresponding to one of pixels in the j^{th} virtual image frame may be defined as follows:

$$t_{aj} = t_{n-1} + \frac{(m-j)}{m} \times (t_n - t_{n-1}) \qquad \text{(Eq. 1)}$$
$$y_{aj} = y_{n-1} \times \frac{(m-j)}{m} + y_n \times \frac{j}{m}$$

wherein y_{aj} is a color value corresponding to a pixel having a coordinate (t_{aj}, y_{aj}) among the pixels in the j^{th} virtual image frame; y_n is a color value corresponding to a predetermined pixel in one of the original live 3D image frames, which is displayed at time t_n; $\boldsymbol{m}$ is the total number of virtual image frames 404 inserted between $(n-1)^{th}$ frame 402 and n^{th} frame 406; and $\boldsymbol{a}$ is a pixel among the pixels in one of virtual image frames 404. Data including $\boldsymbol{m}$ number of virtual image frames 404 are obtained by applying Equation 1 to every pixel in each of virtual image frames 404. (Hereinafter, virtual image frame data refers to the data including $\boldsymbol{m}$ number of virtual image frames 404) Similarly, when receiving data including the (n+1)th frame (not shown) among the original live 3D image frames, enhance live 3D imaging unit 306 generates virtual image frame data including virtual image frames (not shown) to be inserted between nth frame 406 and (n+1)th frame by repeating the above.

[0018] Where enhanced live 3D imaging unit 306 employs high-order interpolation instead of linear interpolation, the Nth polynomial expression of interpolation may be expressed as follows:

$$y = c_0 + c_1 t + c_2 t^2 + \cdots + c_n t^n \qquad \text{(Eq. 2)}$$

wherein c_0 to c_n are arbitrary coefficients; $\boldsymbol{t}$ is the display time of the live 3D image; $\boldsymbol{y}$ is virtual image frame data; and, $\boldsymbol{n}$ is the total number of the original live 3D image frames.

[0019] Where ***m*** number of virtual image frames to be inserted between (n-1)th frame 402 and nth frame 406 among the original live 3D image frames are generated, display time t_{aj} of the jth virtual image frame among ***m*** number of the virtual image frames generated may be expressed by Equation 1 as described above. At display time t_{aj}, a color value corresponding to a predetermined pixel in the jth virtual image frame may be expressed as follows:

$$y_{aj} = c_0 + c_1 t_{aj} + c_2 t^2{}_{aj} + \cdots + c_n t^n{}_{aj} \qquad \text{(Eq. 3).}$$

[0020] Data including the jth virtual image frame are obtained by calculating a color value corresponding to every pixel in the jth virtual image frame among ***m*** number of the virtual image frames through Equation 3. Where the number of the original live 3D image frames is ***F***, the total number of image frames to be displayed per second, which is obtained by using the linear interpolation and high-order interpolation described above, becomes ***F****(***m***+1).

[0021] As illustrated in Fig. 4B, where enhanced live 3D imaging unit 306 employs high-order extrapolation, display time t_{ej} of the jth virtual image frame among ***m*** number of virtual image frames 408 and a color value y_{ej} corresponding to one of pixels in the jth virtual image frame are defined as follows:

$$t_{ej} > t_n$$
$$y_{ej} = c_0 + c_1 t_{ej} + c_2 t^2{}_{ej} + \cdots + c_n t^n{}_{ej} \qquad \text{(Eq. 4)}$$

wherein y_{ej} is a color value corresponding to a pixel having a coordinate (t_{ej}, y_{ej}) among the pixels in the jth virtual image frame.

[0022] Data including the jth virtual image frame are obtained by calculating a color value corresponding to every pixel in the jth virtual image frame among ***m*** number of the virtual image frames through Equation 4. Where the number of the original live 3D image frames is ***F***, the total number of image frames to be displayed per second, which is obtained by using high-order extrapolation described above, becomes ***F****(***m***+1).

[0023] Although enhanced live 3D imaging unit 306 has been described to produce the virtual image frames to be inserted between the original live 3D image frames by using linear interpolation, high-order interpolation, and high-order extrapolation, enhanced live 3D imaging unit 306 may produce the virtual image frames by using any appropriate technique.

[0024] The frame rate of a live 3D image may vary with conditions such as the kind of probe, depth of ultrasound images, and acquisition rate of 3D images. By controlling the number of virtual image frames obtained through interpolation or extrapolation, the operation time for interpolation or extrapolation should be minimized and the virtual image frames should be inserted and displayed at a uniform time interval between the original live 3D image frames. For example, where the frame rate of original live 3D image frames is ***F*** frames/second, data including ***F*** frames per second are obtained. Accordingly, where ***m*** number of virtual image frames are to be inserted between the original live 3D image frames, the time for performing interpolation or extrapolation on ***m*** number of the virtual image frames must not exceed 1/(***F****(***m***+1)) seconds, since a live 3D image containing the original live 3D image frames and the inserted virtual image frames should be displayed at every 1/(***F****(***m***+1)) second. Therefore, determining the number of virtual image frames, which may be obtained within 1/(***F****(***m***+1)) seconds, is necessary.

[0025] Referring to Fig. 5, which illustrates a flow chart for producing a live 3D image in accordance with the present invention, probe 302 scans a moving target object by transmitting ultrasound signals to the moving target object and receiving the ultrasound signals reflected therefrom (Step S502). Raw 3D data obtaining unit 304 of image processing unit 310 obtains and stores raw 3D data based on the reflected ultrasound signals transmitted from probe 302 (Step S504). Enhanced live 3D imaging unit 306 generates data including original live 3D image frames based on the raw 3D data obtained by raw 3D data obtaining unit 304 and produces data including virtual image frames to be inserted between the original live 3D image frames (Step S506). Enhanced live 3D imaging 306 then renders a live 3D image of the moving target object using the original 3D image data and the virtual image data (Step S508). Display unit 308 displays thereon the live 3D image, i.e., a 3D moving image (Step S510).

[0026] As described above, inserting the virtual image frames between the original live 3D image frames raises the frame rate of the live 3D image being displayed. Thus, a more-natural-looking, live 3D image, i.e., a 3D moving image, compared to the conventional live 3D image, is obtained without increasing the calculation load of a live 3D imaging apparatus.

Claims

1. A method for producing a three-dimensional (3D) moving image of a moving target object, comprising the steps of:

a) transmitting ultrasound signals to the moving target object and receiving reflected ultrasound signals;
b) sequentially obtaining raw 3D data based on the reflected ultrasound signals;
c) generating image frame data including a plurality of image frames based on the obtained raw 3D data;
d) rendering a 3D moving image of the moving target object using the image frame,
characterized in that the method further comprises the steps of:
e) determining a total number ***m*** of virtual image frames, which are to be inserted between the neighboring image frames;
f) generating virtual image frame data including a multiplicity of the virtual image frames, which are to be inserted between the plurality of image frames, based on the image frame data;

wherein:

- virtual image frame data is also used to render a 3D moving image of the moving target object;
- the image frames are generated at a rate of F frames/second;
- determining the number ***m*** as a function of the variation of the frame rate of the original image frames; and
- each of the multiplicity of virtual image frames is obtained within $1/(\boldsymbol{F}^{*}(\boldsymbol{m}+1))$ seconds by using one of interpolation and extrapolation based on the image frame data.

2. An apparatus for producing a three-dimensional (3D) moving image of a moving target object, comprising:

a probe for transmitting ultrasound signals to the moving target object and receiving reflected ultrasound signals;
means for sequentially obtaining raw 3D data based on the reflected ultrasound signals; and
means for generating image frame data including a plurality of image frames based on the obtained raw 3D data, and rendering a 3D moving image of the moving target object using the image frame,

characterized in that said apparatus further comprises means for determining a total number ***m*** of virtual image frames, which are to be inserted between the neighboring image frames, and for generating virtual image frame data including a multiplicity of virtual image frames which are to be inserted between the plurality of image frames, based on the image frame data,
wherein:

- said means for rendering also use virtual image frame data to render a 3D moving image of the moving target object;
- the image frames are generated at a rate of ***F*** frames/second;
- said means for determining determine the number ***m*** as a function of the variation of the frame rate of the original image frames; and
- each of the multiplicity of virtual image frames is obtained within $1(\boldsymbol{F}_{*}(\boldsymbol{m}+1))$ seconds by using one of interpolation and extrapolation based on the image frame data.

Patentansprüche

1. Eine Methode zur Erzeugung von dreidimensionalen (3D) beweglichen Bildern eines sich bewegenden Zielobjekts, die folgende Schritte umfaßt:

    a) Übertragung von Ultraschallsignalen zum sich bewegenden Zielobjekt und Erhalt von reflektierten Ultraschallsignalen;
    b) Erhalt von nacheinander auf den reflektierten Ultraschallsignalen basierenden rohen 3D Daten;
    c) Erzeugung von Bildrahmendaten einschließlich einer Vielzahl von auf den erzielten rohen 3D Daten basierenden Bildrahmen;
    d) Wiedergabe eines 3D Bewegungsbildes des sich bewegenden Zielobjekts unter Benutzung des Bildrahmens;
    dadurch gekennzeichnet, daß die Methode ferner die folgenden Schritte UMFAßT:
    e) Bestimmung einer Gesamtzahl m von virtuellen Bildrahmen, die zwischen die benachbarten Bildrahmen eingefügt werden sollen;
    f) Erzeugung von Daten virtueller Bildrahmen einschließlich einer Vielzahl der virtuellen Bildrahmen, die zwischen der Vielzahl von Bildrahmen eingefügt werden sollen, die auf den Bildrahmendaten basieren;

    dadurch gekennzeichnet, daß:

    - Daten virtueller Bildrahmen auch dafür benutzt werden, um ein 3D bewegliches Bild des sich bewegenden Zielobjekts wiederzugeben;
    - Die Bildrahmen im allgemeinen mit einer Rate von F Rahmen/Sekunde erzeugt werden;
    - Die Zahl m als eine Funktion der Schwankung der Rahmenrate der originalen Bildrahmen bestimmt wird;
    - Jeder der vielfältigen virtuellen Bildrahmen innerhalb von 1/(F.(m+1)) Sekunden erzielt wird, indem eine Interpolation oder eine Extrapolation auf der Basis der Bildrahmenrate benutzt wird.

2. Ein Gerät für die Erzeugung von dreidimensionalen (3D) beweglichen Bildern eines sich bewegenden Zielobjekts, das folgende Teile umfaßt:

    Eine Sonde für die Übertragung von Ultraschallsignalen an das sich bewegende Zielobjekt und Erhalt von reflektierten Ultraschallsignalen;
    Mittel für den Erhalt von auf den reflektierten Ultraschallsignalen basierenden rohen 3D Daten;
    Mittel zum Erzeugen von Bildrahmendaten einschließlich einer Vielzahl von auf den erzielten rohen 3D Daten basierenden Bildrahmen und Wiedergabe eines 3D Bewegungsbildes des sich bewegenden Zielobjekts unter Benutzung des Bildrahmens;

    dadurch gekennzeichnet, daß das besagte Gerät ferner Mittel zum Bestimmen einer Gesamtzahl m von virtuellen Bildrahmen umfaßt, die zwischen die benachbarten Bildrahmen eingefügt werden sollen und zum Erzeugen von Daten virtueller Bildrahmen einschließlich einer Vielzahl von virtuellen Bildrahmen, die zwischen die Vielzahl von Bildrahmen eingefügt werden sollen, die auf den Bildrahmendaten basieren,
    dadurch gekennzeichnet, daß:

    - Die besagten Mittel zur Wiedergabe auch virtuelle Bildrahmendaten benutzen, um ein 3D bewegliches Bild des sich bewegenden Zielobjekts wiederzugeben;
    - Die Bildrahmen mit einer Rate von F Rahmen/Sekunde erzeugt werden;
    - Die besagten Mittel zur Bestimmung die Zahl m als eine Funktion der Schwankung der Rahmenrate der originalen Bildrahmen bestimmen;
    - Jeder der vielfältigen virtuellen Bildrahmen innerhalb von 1/(F.(m+1)) Sekunden erzielt wird, indem eine Interpolation oder eine Extrapolation auf der Basis der Bildrahmenrate benutzt wird.

Revendications

1. Procédé de production d’une image en mouvement en trois dimensions (3D) d’un objet cible en mouvement, comprenant les étapes de :

    a) transmission des signaux en ultrason vers l’objet cible en mouvement et réception des signaux en ultrason réfléchis ;

b) obtention séquentielle de données 3D brutes basées sur les signaux en ultrason réfléchis ;
c) génération de données de trame d'image incluant une pluralité de trames d'image basées sur les données 3D brutes obtenues ;
d) rendu d'une image en mouvement en 3D de l'objet cible en mouvement en utilisant la trame d'image,
caractérisé en ce que le procédé comprend en outre les étapes de :
e) détermination d'un nombre total m de trames d'image virtuelles, qui doivent être insérées entre les trames d'image adjacentes ;
f) génération de données de trame d'image virtuelle incluant une multiplicité de trames d'image virtuelles, qui doivent être insérées entre la pluralité de trames d'image, basées sur les données de trame d'image;

dans lequel :

- les données de trame d'image virtuelle sont également utilisées pour rendre une image en mouvement en 3D de l'objet cible en mouvement ;
- les trames d'image sont générées à une cadence de F trames/seconde
- la détermination du nombre m en fonction de la variation de la cadence de trame des trames d'image originales ; et
- chacune de la multiplicité des trames d'image virtuelles est obtenue dans la limite de 1/(F•(m + 1)) secondes en utilisant l'une de l'interpolation et de l'extrapolation, basées sur les données de trame d'image.

2. Appareil permettant de produire une image en mouvement en trois dimensions (3D) d'un objet cible en mouvement, comprenant:

une sonde permettant de transmettre des signaux en ultrason vers l'objet cible en mouvement et de recevoir les signaux en ultrason réfléchis ;
un moyen permettant d'obtenir séquentiellement des données en 3D brutes basées sur des signaux en ultrason réfléchis ; et
un moyen permettant de générer des données de trame d'image incluant une pluralité de trames d'image basées sur les données 3D brutes obtenues et de rendre une image en mouvement en 3D de l'objet cible en mouvement en utilisant la trame d'image,

caractérisé en ce que ledit appareil comprend en outre un moyen de détermination d'un nombre total m de trames d'image virtuelles qui doivent être insérées entre les trames d'image adjacentes et de générer des données de trame d'image virtuelle incluant une multiplicité de trames d'image virtuelles, qui doivent être insérées entre la pluralité de trames d'image, basées sur les données de trame d'image,
dans lequel :

- ledit moyen de rendu utilise également les données de trame d'image virtuelle pour rendre une image en mouvement en 3D de l'objet cible en mouvement ;
- les trames d'image sont générées à une cadence de F trames/seconde ;
- ledit moyen de détermination détermine le nombre m en fonction de la variation de la cadence des trames d'image originales ; et
- chacune de la multiplicité des trames d'image virtuelles est obtenue dans les limites de 1/(F•(m + 1)) secondes en utilisant l'une de l'interpolation et de l'extrapolation en se basant sur les données de trame d'image.

Fig. 1

100

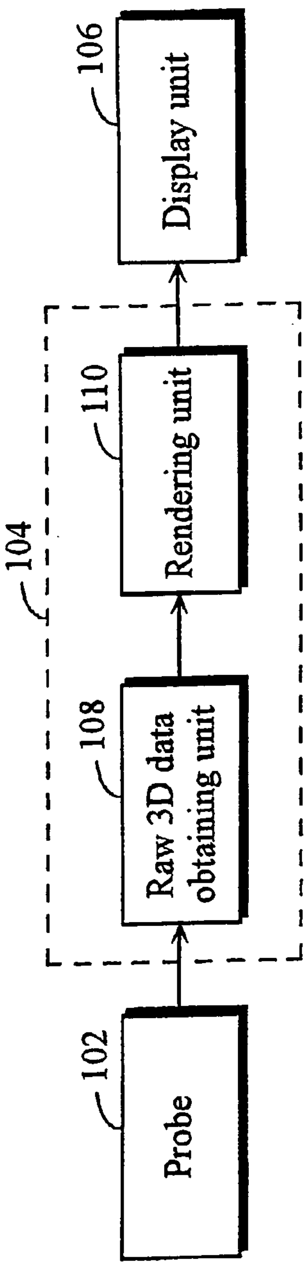

106
Display unit
104
110
Rendering unit
108
Raw 3D data obtaining unit
102
Probe

Fig. 2

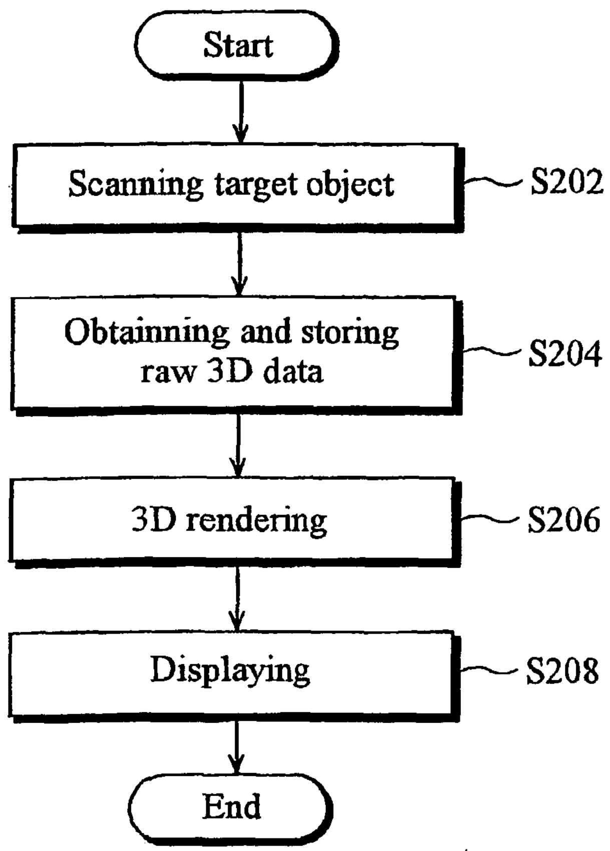

Start
Scanning target object
S202
Obtainning and storing raw 3D data
S204
3D rendering
S206
Displaying
S208
End

Fig. 3

300

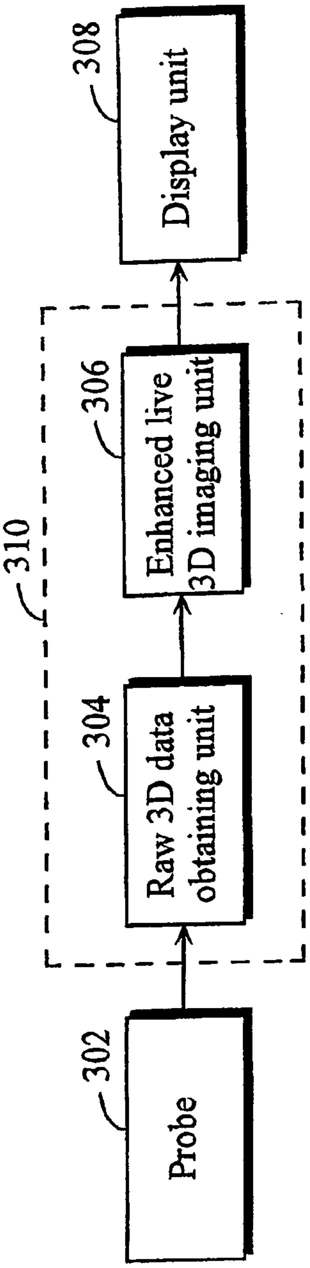

302
Probe
304
Raw 3D data obtaining unit
306
Enhanced live 3D imaging unit
310
308
Display unit

Fig. 4A

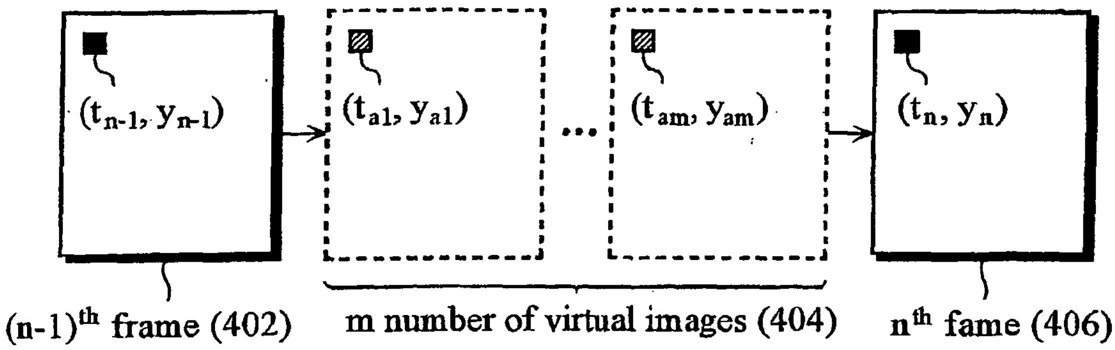

(t_{n-1}, y_{n-1})
(t_{a1}, y_{a1})
...
(t_{am}, y_{am})
(t_n, y_n)
(n-1)th frame (402)
m number of virtual images (404)
nth fame (406)

Fig. 4B

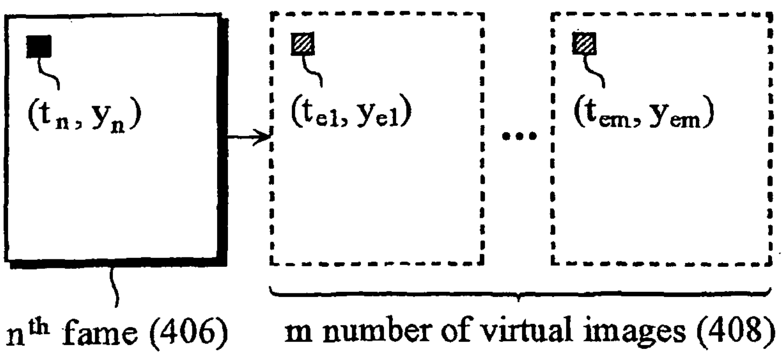

(t_n, y_n)
(t_{e1}, y_{e1})
...
(t_{em}, y_{em})
nth fame (406)
m number of virtual images (408)

Fig. 4C

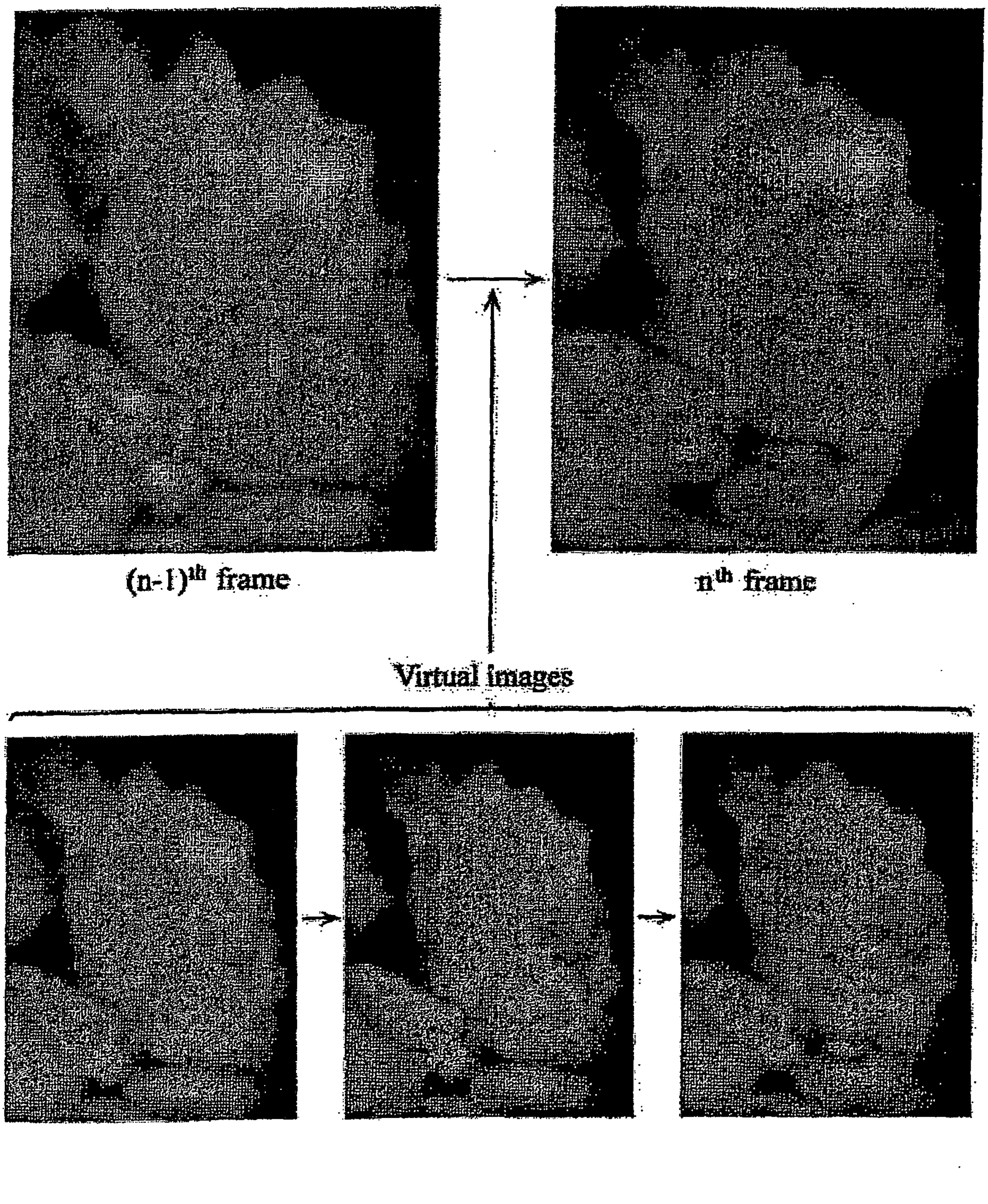
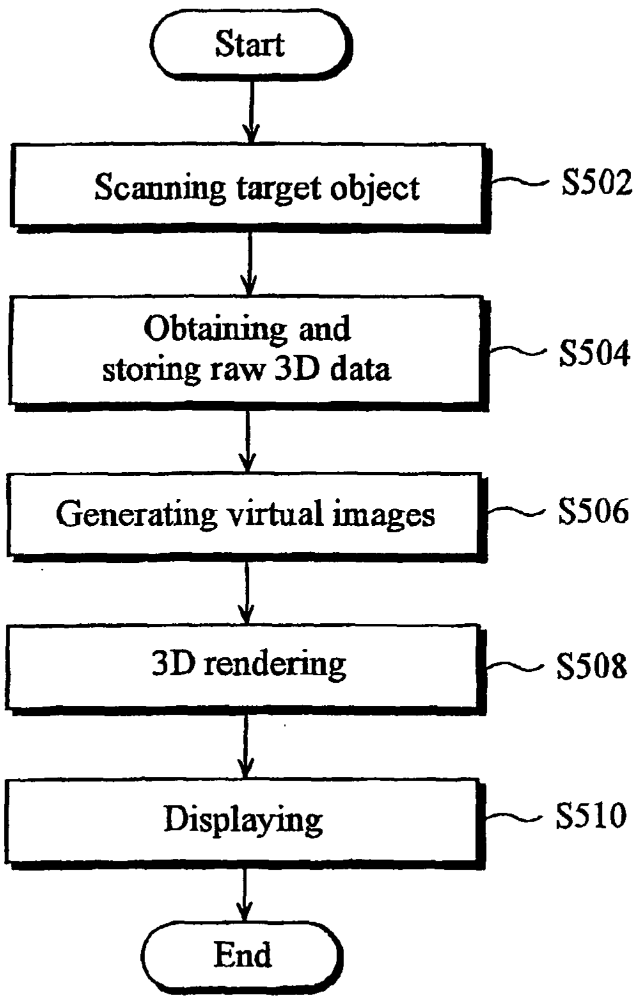


Fig. 5


Start
Scanning target object
S502
Obtaining and storing raw 3D data
S504
Generating virtual images
S506
3D rendering
S508
Displaying
S510
End

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 5966178 A **[0008]**
- US 20020045822 A1 **[0009]**
- EP 094402 A **[0010]**

专利名称(译)	用于准实时地产生三维超声图像的方法和设备		
公开(公告)号	EP1372001B1	公开(公告)日	2008-01-23
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申请(专利权)人(译)	MEDISON CO. , LTD.		
当前申请(专利权)人(译)	MEDISON CO. , LTD.		
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CPC分类号	G01S15/8993 G01S7/52068		
优先权	1020020032756 2002-06-12 KR		
其他公开文献	EP1372001A2 EP1372001A3		
外部链接	Espacenet		

摘要(译)

公开了一种用于产生移动目标对象的三维（3D）运动图像的装置和方法。该方法包括以下步骤：向/从移动目标对象发送和接收超声信号（S202），获得原始数据（S204）;基于所获得的原始数据生成图像帧数据;基于所生成的图像帧数据生成虚拟图像帧数据;以及使用图像和虚拟图像帧数据渲染（S206）移动目标对象的3D运动图像。该装置包括探头，原始3D数据获得单元和增强活3D成像单元，用于产生移动目标对象的3D图像。

$$t_{aj} = t_{n-1} + \frac{(m-j)}{m} \times (t_n - t_{n-1})$$

$$y_{aj} = y_{n-1} \times \frac{(m-j)}{m} + y_n \times \frac{j}{m} \qquad \text{(Eq. 1)}$$