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(54) Ultrasound system and method of forming elastic images capable of preventing distortion

Ultraschallsystem und Verfahren zur Bildung von elastischen Bildern mit Funktion zur Vermeidung von Verzerrungen

Système et procédé à ultrasons de formation d'images élastiques capables d'empêcher la distorsion

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- **PESAVENTO A ET AL: "Real time strain imaging and in-vivo applications in prostate cancer" 2001 IEEE ULTRASONICS SYMPOSIUM PROCEEDINGS. ATLANTA, GA, OCT. 7 - 10, 2001; [IEEE ULTRASONICS SYMPOSIUM PROCEEDINGS], NEW YORK, NY : IEEE, US, vol. 2, 7 October 2001 (2001-10-07), pages 1647-1652, XP010584829 ISBN: 978-0-7803-7177-4**

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Description

BACKGROUND OF THE INVENTION

[Technical Field]

[0001] The present invention generally relates to ultrasound systems, and more particularly to an ultrasound system and a method of forming elastic images capable of preventing distortion.

[Background Art]

[0002] An ultrasound system, which has been widely used in the field of medical diagnosis, transmits ultrasound signals to a target and receives echo signals reflected from the target to form an ultrasound image. A brightness-mode (B-mode) is a representative ultrasound image display mode, which is expressed with reflection coefficients of tissues depending on acoustic impedance differences between the tissues. However, it is difficult to observe a tissue having the reflection coefficient not lager than those of neighboring tissues such as a tumor.

[0003] Tissues such as tumor or cancer can be found with the elastography showing the mechanical characteristics of the tissues (i.e., elastography images of tissues), which cannot be diagnosed with the B-mode ultrasound image. Thus, the elastography is very helpful to diagnose resins.

[0004] In order to form an elastic image, reference signals are formed with reflective signals from the target prior to applying pressure to the target and receive signals are formed with other reflective signals from the target to which the pressure is applied. The displacement of the target due to the pressure is obtained with the difference between the reference signals and the receive signals, i.e., the delay time between the reference signals and the receive signals.

[0005] While forming the ultrasound image by applying the pressure to the target through a probe, the target moves in upward, downward, left or right directions due to the pressure, density distribution of a medium or density of the tissues around the target. Thus, the target is not located on a fixed position in the image frames. That is, in such a case of forming image frames F_1, F_2 and F_3 with applying pressure to target T (shown in FIG. 1), the position of target T is not fixed on one fixed position even though the density of a medium M is uniform. If the variation of the target's position is ignored in forming the elastic image of the target, then distortion is generated.

[0006] In order to prevent the generation of distortion, various methods such as an optical flow, a 2-dimensional correlation and a block matching have been adopted to correct the positions of the target in image frames. However, such conventional methods require a significant amount of calculation and take a long process time. Thus, the capability of a processor should be guaranteed above a certain level.

[0007] US-B1-6 508 768 describes an ultrasound imaging system, in which a displacement vector is estimated for a pattern of samples throughout an imaged region of interest (ROI) by comparing two successive B-mode frames. The displacement vector is preferably estimated using block matching. Once displacement vectors are estimated for samples throughout the ROI, corresponding strain values are estimated, which indicate the degree of elasticity of the respective tissue portions. An image is then displayed showing the strain distribution within the ROI as it is stressed.

[0008] This document discloses the subject-matter of the preambles of claims 1, 4 and 6.

[0009] Document XP010584829 "Real time strain imaging and in-vivo applications in prostate cancer" by Pesavento and Lorenz discloses an in-vivo real time strain image which shows that real times strain imaging is able to detect hard tissue regions which correspond to tumor location in the histological cross sections.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Arrangements and embodiments may be described in detail with reference to the following drawings in which like reference numerals refer to like elements and wherein:

FIG. 1 is a schematic diagram showing a variation of target's positions in a plurality of ultrasound images with pressure applied to the target;
FIG. 2 is a schematic diagram showing an example of an ultrasound imaging system in accordance with the present invention;
FIG. 3 is a schematic diagram showing a variation of target's position and boundary pixels in a plurality of ultrasound images;
FIG. 4 is a graph showing a variation of displacement in a horizontal direction in the ultrasound images;
FIG. 5 is a graph showing a variation of displacement in a vertical direction in the ultrasound images;
FIGS. 6 and 7 are schematic diagrams illustrating the addition or deduction of pixels between moved boundary pixels;
FIG. 8 is a flow chart showing a procedure of forming an elastic image in accordance with the present invention; and

FIGS. 9 and 10 are diagrams illustrating a persistence result of the present invention in comparison with the conventional method.

DETAILED DESCRIPTION OF THE INVENTION

[0011] A detailed description may be provided with reference to the accompanying drawings. One of ordinary skill in the art may realize that the following description is illustrative only and is not in any way limiting. Other embodiments of the present invention may readily suggest themselves to such skilled persons having the benefit of this disclosure.

[0012] Referring to FIG. 2, the ultrasound system 100 includes a frame data forming unit 110, a frame data storing unit 120, a displacement map forming unit 130, a displacement map storing unit 140, a strain calculating unit 150, a strain storing unit 160, a local information processing unit 170, a local information storing unit 180 and an image processing unit 190.

[0013] The frame data forming unit 110 is configured to form frame data with receive signals provided from an ultrasound diagnosis unit (not shown). The receive signals may be RF signals or IQ signals. The frame data include reference frame data formed with reflective signals from the target without applying pressure and interest frame data formed with other reflective signals from the target undergoing the pressure. A plurality of the interest frames may be formed periodically one after another by applying the pressure to the target. The reference frame data and the interest frame data may be stored in the frame data storing unit 120 and may be inputted to the displacement map forming unit 130.

[0014] The displacement map forming unit 130 forms a displacement map of the interest frame by comparing the interest frames with the reference frame. The displacement map may be formed with the conventional methods, i.e., phase differences between the reference frame and the interest frames are calculated with the conventional methods such as the cross correlation or the autocorrelation of complex baseband signals to form the displacement. The displacement map may be formed by comparing all or some pixels of the reference frame and the interest frames. In addition, the displacement map forming unit 130 applies a space filter to the displacement maps of the interest frames for reducing noise. A median filter or an average filter may be utilized as the space filter. The filtered displacement maps of the interest frames are stored in the displacement map storing unit 140.

[0015] The strain calculating unit 150 calculates strains of the interest frames with the use of the displacement maps. The strains may be calculated with the gradient method of obtaining the displacement per unit length. In such a case of forming the displacement maps by comparing all of the pixels in the reference frames and the interest frame, the strains of all the pixels in the interest frame may be calculated. In such a case of comparing some pixels of the reference frame and the interest frame to form the displacement map, the strains of some pixels may be calculated. The strains of the respective interest frame may be stored in the strain storing unit 160.

[0016] The local information processing unit 170 receives the displacement map and the strains of the interest frames F_A, F_B and F_C, which are obtained periodically, one after another when the intensity of the pressure P increases in one direction (shown in FIGS. 3 to 5). The local information processing unit 170 analyzes the strain at each pixel and determines boundary pixels with the pixels where the strain varies, i.e., the boundary pixels are on the boundary of the target T, the strain of which is different from those of the neighboring media. For example, boundary pixels a_1 to a_3 and b_1 to b_3 may be determined on horizontal line L-L', as shown in FIGS. 3 and 4, while boundary pixels c_1 to c_3 and d_1 to d_3 may be determined on vertical line H-H', as shown in FIGS. 3 and 5. Referring to FIGS. 4 and 5, the variation amount of the displacement according to the position change of the pixels may be the strain. FIGS. 3 to 5 show only some boundary pixels found on the two lines L-L' and H-H'. However, those boundary pixels are only examples, i.e., the local information processing unit 170 may set up the boundary pixels in all the regions in which the displacement or the strain is formed.

[0017] Once first boundary pixels are set up in the n^{th} interest frame, the local information processing unit 170 may move the first boundary pixels of the $n-1^{th}$ interest frame to positions corresponding to the first boundary pixels of n^{th} interest frame to set up second boundary pixels in the $n-1^{th}$ interest frame. Hereinafter, the second boundary pixel in the respective interest frame is also referred to as the moved pixel.

[0018] Since the moved pixels are obtained by changing the position of the first boundary pixels, it is assumed that the pixels may be increased or decreased between the moved pixels. Referring to FIG. 6, if first boundary pixels P11, P12, P13, P14 and P15 on a target boundary Tn-1 in the $n-1^{th}$ interest frame are moved to positions of the first boundary pixels on a target boundary Tn in the n^{th} interest frame to obtain the second boundary pixels P21, P22, P23, P24 and P25, then the numbers of pixels between two first boundary pixels are changed. For instance, the pixel number between the two pixels P11 and P12 is different from the pixel number between the two pixels P21 and P22.

[0019] As shown in FIG. 6, when the number of pixels between the second boundary pixels P21 and P23 is larger than that between the first boundary pixels P11 and P13 on the same row, it is assumed that pixels are added between the two second boundary pixels, i.e.,

[0020] between the two moved pixels. The moved pixels may have the original strain. However, the strain of the added pixels is zero. Referring to FIG. 7, when the number of the pixels between the two moved pixels P21 and P23 is smaller than that between the first boundary pixels P11 and P13, it is assumed that image pixels are omitted between the two moved image pixels. The local information storing unit 180 stores the positions and strains of the first and second boundary pixels.

[0021] The image processing unit 190 reforms frame data of the n-1th interest frame with the second boundary pixels. For instance, the image processing unit 190 searches the pixels having a zero strain (i.e., the added pixels) and forms inferred strains of the added pixels in consideration of the strains of moved pixels adjacent to the added pixels in the same row or column. The inferred strain of the added pixel may be identical to that of the most adjacent moved pixel. Also, the inferred strain of the added pixel may be obtained by applying weight values to the strains of two adjacent pixels in consideration of the distances between the added pixel and the two adjacent pixels. Further, the image processing unit 190 forms an elastic image by performing persistence with the reformed the n-1th interest frame and the nth interest frame. The persistence may be performed in accordance with the following Equation 1.

$$S_n(i,j) = P \times S_{n-1}(i,j) + (1-P) \times X_n(i,j) \qquad \text{Eq. (1)}$$

[0022] Equation 1 denotes that pixel value $S_n(i, j)$ of a pixel located at (i, j) in the nth interest frame is obtained with strain $X_n(i,j)$ of the pixel located at (i, j) in the nth interest frame and the pixel value $S_{n-1}(i, j)$ of the other pixel located at (i, j) in the n-1th interest frame.

[0023] In Equation 1, P denotes a persistence ratio.

[0024] The frame data forming unit 110, the displacement map forming unit 130, the strain calculating unit 150, the local information processing unit 170 and the image processing unit 190 may be configured with one processor or respective processors. The frame data storing unit 120, the displacement map storing unit 140, the displacement strain storing unit 160 and the local information storing unit may be configured with one memory or respective memories.

[0025] FIG. 8 shows the method of forming elastic images in accordance with another embodiment of the present invention.

[0026] A reference frame data is formed with reflective signals from a target prior to applying pressure to the target. Further, an interest frame data is formed with other reflective signals from the target, which is undergoing the pressure (step S801).

[0027] Displacement maps of the interest frames are formed by comparing the interest frames with the reference frame (S802). The displacement map may be formed by comparing all or some pixels of the reference frame and the interest frame. The strains of the interest frames are calculated by using the displacement maps (S803).

[0028] The strain of each pixel is analyzed. First boundary pixels are set up with the pixels where the strains vary, in the nth interest frame, and the position of the first boundary pixels of the nth interest frame are stored (S804). Herein, "n" is a natural number denoting the order of the interest frame and the initial value of the "n" is one.

[0029] It is determined whether the nth interest frame is the first interest frame or not (S805). In such a case of the first interest frame, the number "n" is increased by one and processes mentioned above are preformed again. In such a case where the nth interest frame

[0030] is not the first interest frame, the first boundary pixels of the n-1th interest frame interest are moved to the positions corresponding to the first boundary pixels of nth interest frame to set up second boundary pixels in the n-1th interest frame and the second boundary pixels are stored (S807).

[0031] The n-1th interest frame is reformed with the use of the second boundary pixels (S808). In reforming the n-1th interest frame, the inferred strains of added pixels between the second boundary pixels may be calculated in accordance with the foregoing embodiment.

[0032] An elastic image is formed by performing persistence with the reformed n-1th interest frame and the nth interest frame (S809). The persistence may be performed in accordance with the foregoing embodiment.

[0033] Further, in accordance with another embodiment of the present invention, a computer readable medium may store a program for performing the method mentioned above.

[0034] In the present invention, the persistence of the previous frame and the present frame is performed after moving the boundary pixels set up in the previous interest frame to the boundary pixels in the present interest frame. This is so that the distortion of the elastic image may be reduced and the signal to noise ratio (SNR) may be increased. In other words, in case of performing the persistence with the boundary pixels of the two frames without meeting the positions of the boundary pixels as the conventional method, the targets T1 and T2 in each interest frame do not meet and the distortion is generated and a distorted elastic image is obtained. However, in the present invention, the boundary pixels of the n-1th and the nth interest frames are met with each other prior to performing the persistence. Thus, the positions of the targets T1 and T2 in each interest frame are identical and more apparent elastic image may be obtained. Accordingly, the present invention is capable of preventing the distortion due to the pressure applied to the target in the process of forming the elastic image.

Claims

1. An ultrasound system, comprising:

   a frame data forming unit (110) for forming reference frame data with reflective signals from a target prior to applying pressure to the target and interest frame data of a plurality of interest frames with other reflective signals from the target undergoing the pressure;
   a displacement map forming unit (130) for forming displacement maps of the interest frames by comparing the interest frames with the reference frame;
   a strain calculating unit (150) for calculating the strains of interest frames with the use of the displacement maps;
   characterized by
   a local information processing unit (170) adapted to analyze the strain at each pixel to determine boundary pixels, wherein the local processing unit is adapted to analyze the strains of a n^{th} interest frame and set up first boundary pixels in the n^{th} interest frame, and obtain second boundary pixels by moving the positions of the first boundary pixels of a $n\text{-}1^{th}$ interest frame to corresponding positions of the first boundary pixels of the n^{th} interest frame; and
   an image processing unit (190) adapted to reconstruct the $n\text{-}1^{th}$ interest frame with the second boundary pixels strains of the reconstructed $n\text{-}1^{th}$ interest frame and the strains of the n^{th} interest frame.

2. The ultrasound system of Claim 1, wherein the image processing unit (190) is configured to search additional pixels having a zero strain between the second boundary pixel in the $n\text{-}1^{th}$ interest frame and form inferred strain of the additional pixel from the stains of the second boundary pixels adjacent thereto in the same row or column, the image processing unit being further configured to set up the inferred strain as the strain of the additional pixel.

3. The ultrasound system of Claim 1, further comprising storing units (140, 160, 180) adapted to store the displacement maps, the strains, the positions and the strains of the first and second boundary pixels.

4. A method of forming an elastic image, comprising:

   forming a reference frame data with reflective signals from a target prior to applying pressure to the target;
   forming interest frame data of a plurality of interest frames with other reflective signals from the target undergoing the pressure;
   and to form an elastic image by performing persistence with the
   forming displacement maps of the interest frames by comparing the interest frames with the reference frame;
   calculating strains of the interest frames by using the displacement maps;
   characterized by
   analyzing the strains of the interest frame and setting up boundary pixels in the interest frame, wherein the strains of a n^{th} interest frame is analyzed and first boundary pixels are set up in the n^{th} interest frame;
   obtaining second boundary pixels by moving the positions of first boundary pixels of a $n\text{-}1^{th}$ interest frame to corresponding positions of the first boundary pixels of the n^{th} interest frame;
   reconstructing the $n\text{-}1^{th}$ interest frame with second boundary pixels; and
   forming an elastic image by performing persistence with the strains of the reconstructed $n\text{-}1^{th}$ interest frame and the strains of the n^{th} interest frame.

5. The method of Claim 4, wherein the step of reforming the $n\text{-}1^{th}$ interest frame includes:

   searching additional pixels having a zero strain between the second boundary pixels in the $n\text{-}1^{th}$ interest frame;
   forming inferred strains of the additional pixels from the stains of the second boundary pixels adjacent thereto in the same row or column; and
   setting up the inferred strain as the strain of the additional pixel.

6. A computer readable medium storing a program adapted to perform a method of forming an elastic image, the method comprising:

   forming a reference frame data with reflective signals from a target prior to applying pressure to the target;
   forming interest frame data of a plurality of interest frames with other reflective signals from the target undergoing the pressure;
   forming displacement maps of the interest frames by comparing the interest frames with the reference frame;

calculating strains of the interest frames by using the displacement maps;
characterized by
analyzing the strains of the interest frame and setting up boundary pixels in the interest frame, wherein the strains of a n^{th} interest frame is analyzed and first boundary pixels are set up in the n^{th} interest frame;
obtaining second boundary pixels by moving the positions of first boundary pixels of a n-1^{th} interest frame to corresponding positions of the first boundary pixels of the n^{th} interest frame;
reconstructing the n-1^{th} interest frame with second boundary pixels; and
forming an elastic image by performing persistence with the strains of the reconstructed n-1^{th} interest frame and the strains of the n^{th} interest frame.

7. The computer readable medium of Claim 6, wherein the step of reconstructing the n-1^{th} interest frame includes:

searching additional pixels having zero strain between the second boundary pixels in the n-1^{th} interest frame;
forming inferred strains of the additional pixels from the strains of the second boundary pixels adjacent thereto in the same row or column; and
setting up the inferred strain as the strain of the additional pixel.

Patentansprüche

1. Ultraschallsystem, welches Folgendes aufweist:

eine Rahmendatenerzeugungseinheit (110) zum Erzeugen von Referenzrahmendaten mit reflektierten Signalen von einem Ziel vor dem Aufbringen von Druck auf das Ziel und Interessensrahmendaten aus einer Vielzahl von Interessensrahmen mit anderen reflektierten Signalen von dem dem Druck ausgesetzten Ziel;
eine Verschiebungskartenerzeugungseinheit (130) zum Erzeugen von Verschiebungskarten der Interessensrahmen durch Vergleichen der Interessensrahmen mit dem Referenzrahmen;
eine Spannungsberechnungseinheit (150) zum Berechnen der Spannungen der Interessensrahmen unter Verwendung der Verschiebungskarten;
gekennzeichnet durch
eine lokale Informationsverarbeitungseinheit (170), die dafür vorgesehen ist, die Spannung an jedem Pixel zu analysieren, um Grenzpixel zu ermitteln, wobei die lokale Verarbeitungseinheit dafür vorgesehen ist, die Spannungen eines n^{ten} Interessensrahmens zu analysieren und erste Grenzpixel in dem n^{ten} Interessensrahmen festzulegen und zweite Grenzpixel **durch** Bewegen der Positionen der ersten Grenzpixel eines n-1^{ten} Interessensrahmen zu Positionen zu erlangen, welche Positionen der ersten Grenzpixel des n^{ten} Interessensrahmens entsprechen; und
eine Bildverarbeietungseinheit (190), die dafür vorgesehen ist, den n-1^{ten} Interessensrahmen mit den zweiten Grenzpixeln zu rekonstruieren und ein elastisches Bild **durch** Durchführen einer Persistenz mit den Spannungen des rekonstruierten n-1^{ten} Interessensrahmens und den Spannungen des n^{ten} Interessensrahmens zu erzeugen.

2. Ultraschallsystem nach Anspruch 1, wobei die Bildverarbeitungseinheit (190) dafür vorgesehen ist, zusätzliche Pixel mit einer Spannung von Null zwischen dem zweiten Grenzpixel in dem n-1^{ten} Interessensrahmen zu suchen und eine abgeleitete Spannung aus dem zusätzlichen Pixel von den Spannungen der zweiten Grenzpixel benachbart dazu in derselben Reihe oder Spalte zu erzeugen, wobei die Bildverarbeitungseinheit des Weiteren dafür vorgesehen ist, die abgeleitete Spannung als die Spannung des zusätzlichen Pixels festzulegen.

3. Ultraschallsystem nach Anspruch 1, welches des Weiteren Speichereinheiten (140, 160, 180) aufweist, die dafür vorgesehen sind, die Verschiebungspläne, die Spannungen, die Positionen und die Spannungen der ersten und zweiten Grenzpixel zu speichern.

4. Verfahren zum Erzeugen eines elastischen Bilds, welches Folgendes aufweist:

Erzeugen von Referenzrahmendaten mit reflektierten Signalen von einem Ziel vor dem Aufbringen von Druck auf das Ziel;
Erzeugen von Interessensrahmendaten von einer Vielzahl von Interessensrahmen mit anderen Reflexionssignalen von dem dem Druck ausgesetzten Ziel;
Erzeugen von Verschiebungskarten aus den Interessensrahmen durch Vergleichen der Interessensrahmen mit den Referenzrahmen;

Berechnen von Spannungen der Interessensrahmen unter Verwendung der Verschiebungskarten;
gekennzeichnet durch
Analysieren der Spannungen des Interessensrahmens und Festlegen von Grenzpixeln in dem Interessensrahmen, wobei die Spannungen eines n^{ten} Interessensrahmens analysiert und erste Grenzpixel in dem n^{ten} Interessensrahmen festgelegt werden;
Erlangen zweiter Grenzpixel **durch** Bewegen der Positionen von ersten Grenzpixeln eines $n\text{-}1^{ten}$ Interessensrahmens zu entsprechenden Positionen der ersten Grenzpixel des n^{ten} Interessensrahmens;
Rekonstruieren des $n\text{-}1^{ten}$ Interessensrahmens mit zweiten Grenzpixeln; und
Erzeugen eines elastischen Bilds **durch** Durchführen von Persistenz mit den Spannungen des rekonstruierten $n\text{-}1^{ten}$ Interessensrahmens und der Spannungen des n^{ten} Interessensrahmens.

5. Verfahren nach Anspruch 4, wobei der Schritt des Reformierens des $n\text{-}1^{ten}$ Interessensrahmens Folgendes aufweist:

Suchen von zusätzlichen Pixeln mit einer Spannung von Null zwischen den zweiten Grenzpixeln in dem $n\text{-}1^{ten}$ Interessensrahmen;
Erzeugen von abgeleiteten Spannungen der zusätzlichen Pixel von den Spannungen der zweiten Grenzpixel benachbart dazu in derselben Reihe oder Spalte; und
Festlegen der abgeleiteten Spannung als die Spannung der zusätzlichen Pixel.

6. Computerlesbares Medium, welches ein Programm speichert, das dafür vorgesehen ist, ein Verfahren zum Erzeugen eines elastischen Bilds durchzuführen, wobei das Verfahren Folgendes aufweist:

Erzeugen von Referenzrahmendaten mit reflektierten Signalen von einem Ziel vor dem Aufbringen von Druck auf das Ziel;
Erzeugen von Interessensrahmendaten von einer Vielzahl von Interessensrahmen mit anderen Reflexionssignalen von dem dem Druck ausgesetzten Ziel;
Erzeugen von Verschiebungskarten aus den Interessensrahmen durch Vergleichen der Interessensrahmen mit den Referenzrahmen;
Berechnen von Spannungen der Interessensrahmen unter Verwendung der Verschiebungskarten;
gekennzeichnet durch
Analysieren der Spannungen des Interessensrahmens und Festlegen von Grenzpixeln in dem Interessensrahmen, wobei die Spannungen eines n^{ten} Interessensrahmens analysiert und erste Grenzpixel in dem n^{ten} Interessensrahmen festgelegt werden;
Erlangen zweiter Grenzpixel **durch** Bewegen der Positionen von ersten Grenzpixeln eines $n\text{-}1^{ten}$ Interessensrahmens zu entsprechenden Positionen der ersten Grenzpixel des n^{ten} Interessensrahmens;
Rekonstruieren des $n\text{-}1^{ten}$ Interessensrahmens mit zweiten Grenzpixeln; und
Erzeugen eines elastischen Bilds **durch** Durchführen von Persistenz mit den Spannungen des rekonstruierten $n\text{-}1^{ten}$ Interessensrahmens und der Spannungen des n^{ten} Interessensrahmens.

7. Computerlesbares Medium nach Anspruch 6, wobei der Schritt des Rekonstruierens des $n\text{-}1^{ten}$ Interessensrahmens Folgendes aufweist:

Suchen von zusätzlichen Pixeln mit einer Spannung von Null zwischen den zweiten Grenzpixeln in dem $n\text{-}1^{ten}$ Interessensrahmen;
Erzeugen von abgeleiteten Spannungen der zusätzlichen Pixel von den Spannungen der zweiten Grenzpixel benachbart dazu in derselben Reihe oder Spalte; und
Festlegen der abgeleiteten Spannung als die Spannung der zusätzlichen Pixel.

Revendications

1. Système ultrasonique comportant :

une unité de formation de données de vues (110) configurée pour former des données de référence de vues avec des signaux de référence d'une cible antérieurement à l'application d'une pression sur la cible et des données de vues à intérêt d'une pluralité de vues présentant un intérêt avec d'autres signaux réfléchis de la cible soumise à la pression ;
une unité de déplacement et de formation de plans (130) pour constituer des plans des déplacements des vues

à intérêt en comparaison avec les vues de référence,
une unité de calcul des contraintes (150) pour calculer les contraintes des vues à intérêt en utilisant les plans des déplacements,

caractérisé par une unité locale de traitement d'informations (170) agencée pour analyser la contrainte sur chaque pixel pour
déterminer les pixels de bord, dans lequel l'unité locale de traitement est agencée pour analyser les contraintes d'une $n^{ième}$
vue à intérêt et de fixer les premiers pixels de bord de la $n^{ième}$ vue à intérêt, et d'obtenir
des seconds pixels de bord d'une $n\text{-}1^{iéme}$ vue à intérêt, pour des positions correspondant aux premiers pixels de la $n^{ième}$ vue à intérêt ; et
une unité de traitement d'image (190) agencée pour reconstruire la $n\text{-}1^{iéme}$ vue à intérêt avec les seconds pixels de bord et former une image élastique réalisant la persistance avec les contraintes de la $n\text{-}1^{iéme}$ vue à intérêt reconstruite et les contraintes de la $n^{ième}$ vue à intérêt.

2. Système ultrasonique selon la revendication 1, dans lequel l'unité de traitement d'image (190) est configurée pour rechercher des pixels additionnels ayant une contrainte nulle entre le second pixel de bord de la $n\text{-}1^{iéme}$ vue à intérêt et pour former la contrainte induite du pixel additionnel des contraintes des seconds pixels de bord adjacents dans la même rangée ou la même colonne, l'unité de traitement d'image étant en outre configurée pour fixer la contrainte induite comme étant la contrainte du pixel additionnel.

3. Système ultrasonique selon la revendication 1, comprenant en outre une unité de mémorisation (140, 160, 180) agencée pour mémoriser les plans de déplacements, les contraintes, les positions et les contraintes des premiers et des seconds pixels de bord.

4. Procédé pour former une image élastique, comportant :

la formation de données de vues de référence avec des signaux d'une cible antérieurement à la mise sous pression ;
la formation d'une pluralité de vues à intérêt avec d'autres signaux réfléchis de la cible soumise à la pression ;
la formation de plans de déplacement des vues à intérêt en comparant les vues à intérêt avec les vues de référence,
le calcul des contraintes des vues à intérêt en utilisant les plans des déplacements,
caractérisé par
l'analyse des contraintes des vues à intérêt et la détermination des pixels de bord dans les vues à intérêt, dans lequel les contraintes de la $n^{iéme}$ vue à intérêt sont analysées et les premiers pixels de bord sont fixés dans la $n^{iéme}$ vue à intérêt ;
l'obtention des seconds pixels de bord en déplaçant les positions des premiers pixels de bord d'une $n\text{-}1^{iéme}$ vue à intérêt vers les positions correspondantes des premiers pixels de bord de la $n^{iéme}$ vue à intérêt ;
la reconstruction de la $n\text{-}1^{iéme}$ image à intérêt avec les seconds pixels de bord et former une image élastique réalisant la persistance avec les contraintes de la $n\text{-}1^{iéme}$ vue à intérêt reconstruite et les contraintes de la $n^{iéme}$ vue à intérêt.

5. Procédé selon la revendication 4, dans lequel l'étape de reformation de la $n\text{-}1^{iéme}$ vue à intérêt comprend :

la recherche des pixels additionnels ayant une contrainte nulle entre le second pixel de bord de la $n\text{-}1^{iéme}$ vue à intérêt ;
la formation de contraintes induites des pixels additionnels à partir des contraintes des seconds pixels de bord adjacents dans la même rangée ou la même colonne, et
la fixation de la contrainte induite comme étant la contrainte du pixel additionnel.

6. Un support lisible par un ordinateur stockant un programme agencé pour appliquer le procédé pour former une image élastique, ce procédé comportant :

la formation de données d'une vue de référence avec des signaux réfléchis d'une cible antérieurement à l'application de pression ;
la formation de données de vues à intérêt d'une pluralité de vues à intérêt avec d'autres signaux réfléchis de la cible soumise à pression ;

la formation de plans de déplacement des vues à intérêt en comparant les vues à intérêt avec les vues de référence,

le calcul des contraintes des vues à intérêt en utilisant les plans des déplacements,

caractérisé par

l'analyse des contraintes des vues à intérêt et la détermination des pixels de bord dans les vues à intérêt, dans lequel les contraintes de la $n^{ième}$ vue à intérêt est analysée et les premiers pixels de bord sont fixés dans la $n^{ième}$ vue à intérêt ;

l'obtention des seconds pixels de bord en déplaçant les positions des premiers pixels de bord d'une $n\text{-}1^{iéme}$ vue à intérêt vers les positions correspondantes des premiers pixels de bord de la $n^{ième}$ vue à intérêt ;

la reconstruction de la $n\text{-}1^{iéme}$ image à intérêt et

la formation d'une image élastique en réalisant la persistance avec les contraintes de la $n\text{-}1^{iéme}$ vue à intérêt reconstruite et les contraintes de la $n^{ième}$ vue à intérêt.

7. Un support lisible par un ordinateur selon la revendication 6, dans lequel l'étape de reconstruction de la $n\text{-}1^{iéme}$ vue à intérêt comprend :

la recherche des pixels additionnels ayant une contrainte nulle entre le second pixel de bord de la $n\text{-}1^{ième}$ vue à intérêt ;

la formation de contraintes induites des pixels additionnels à partir des contraintes des seconds pixels de bord adjacents dans la même rangée ou la même colonne, et

la fixation de la contrainte induite comme étant la contrainte du pixel additionnel.

FIG. 1
(PRIOR ART)

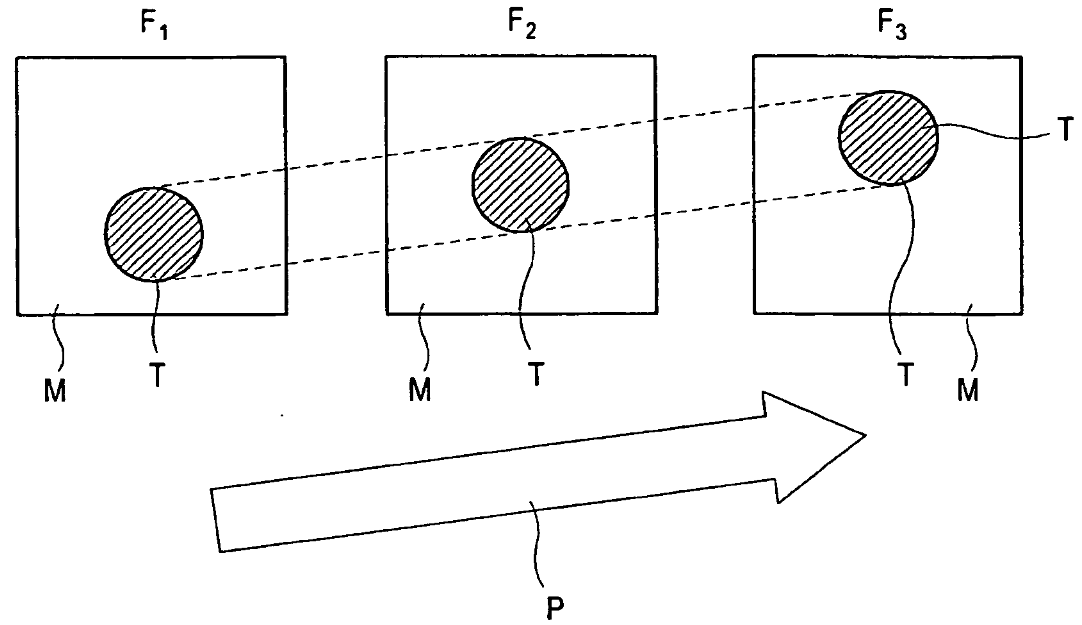


FIG. 2

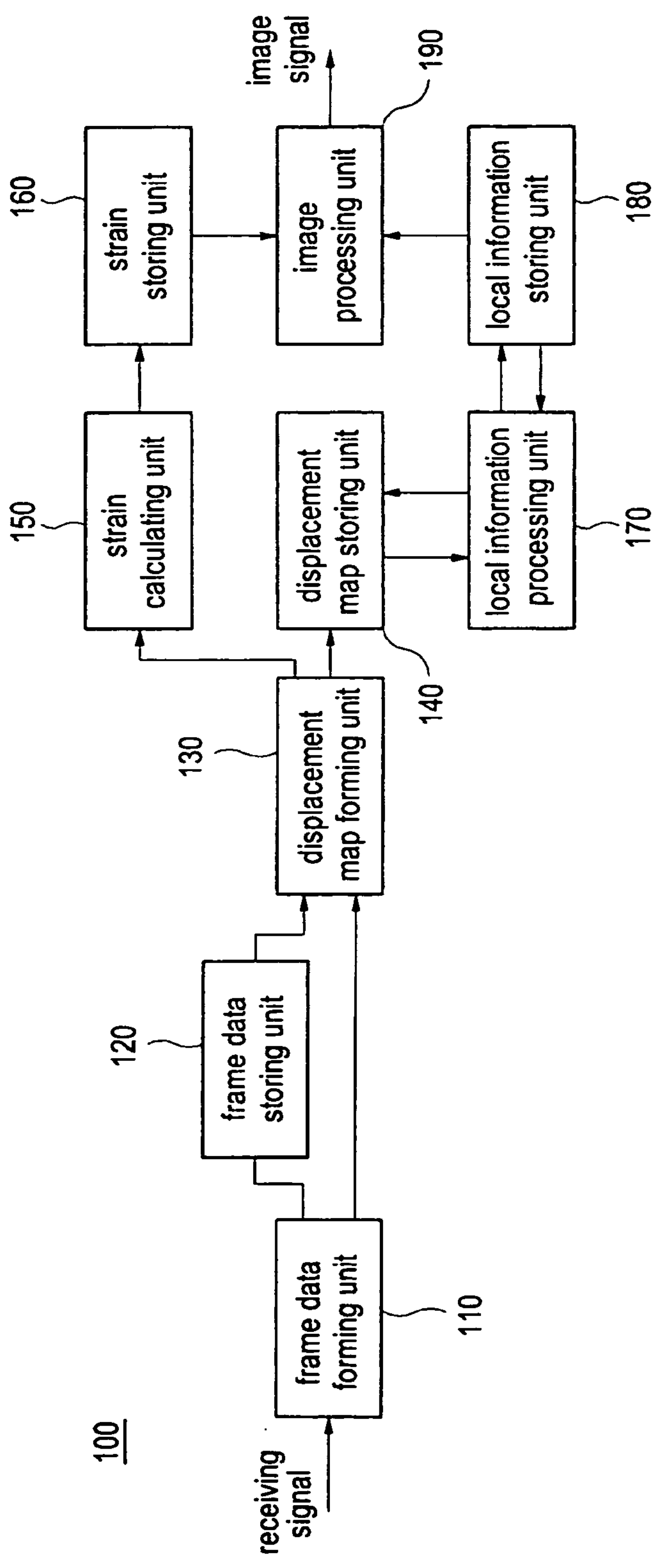

100
receiving signal
frame data forming unit
110
frame data storing unit
120
displacement map forming unit
130
displacement map storing unit
140
strain calculating unit
150
strain storing unit
160
local information processing unit
170
local information storing unit
180
image processing unit
190
image signal

FIG. 3

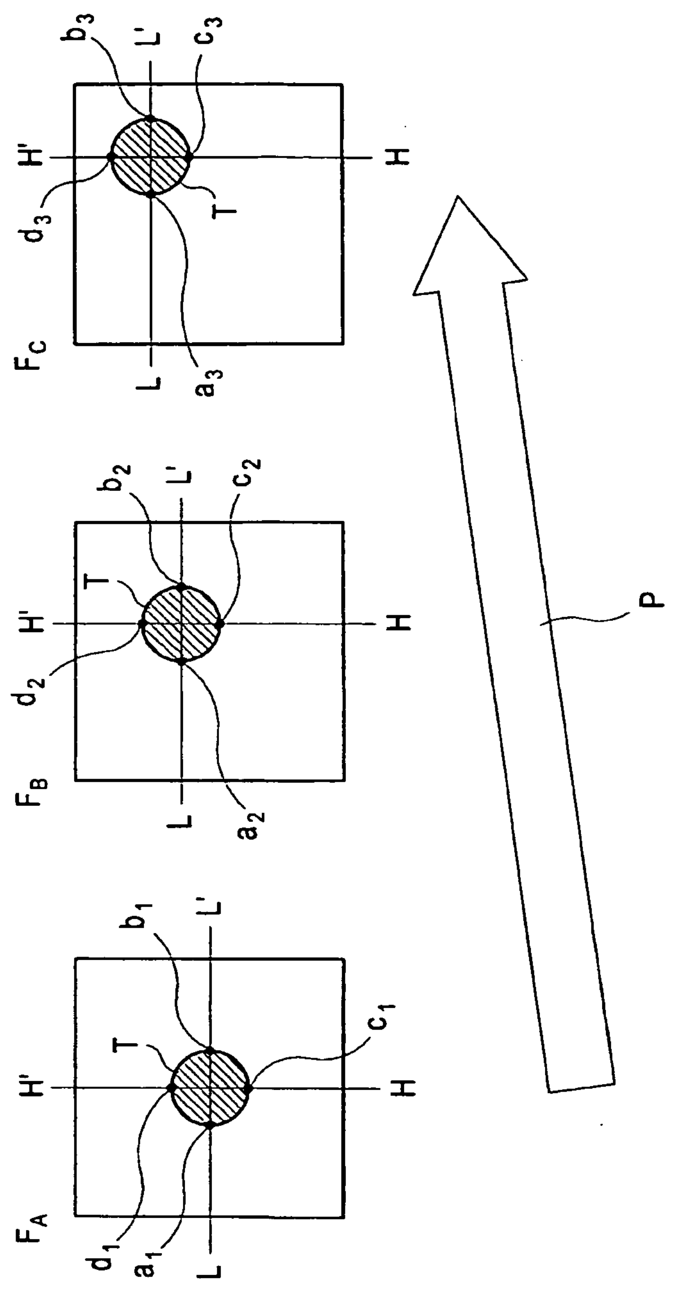


FIG. 4

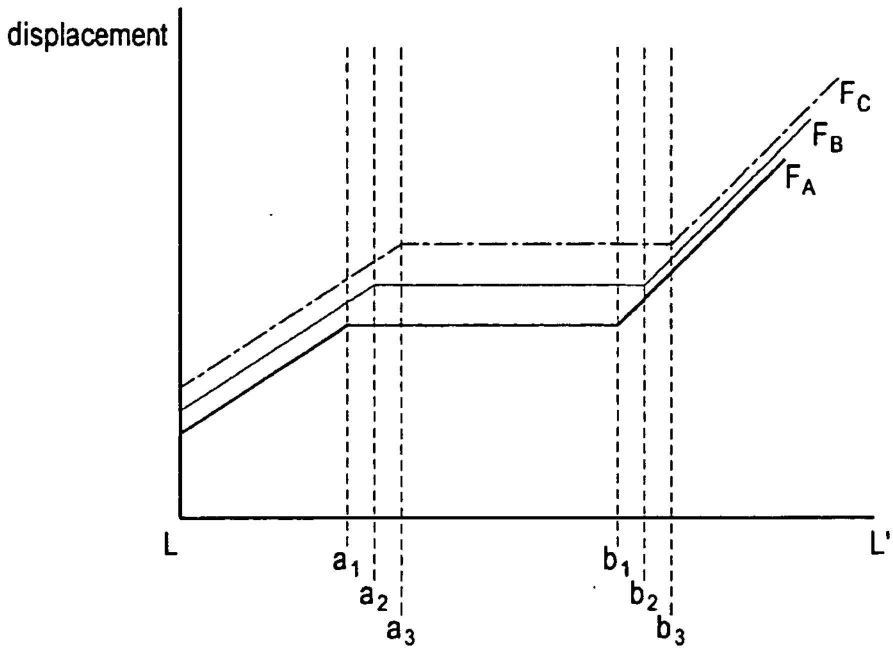


FIG. 5

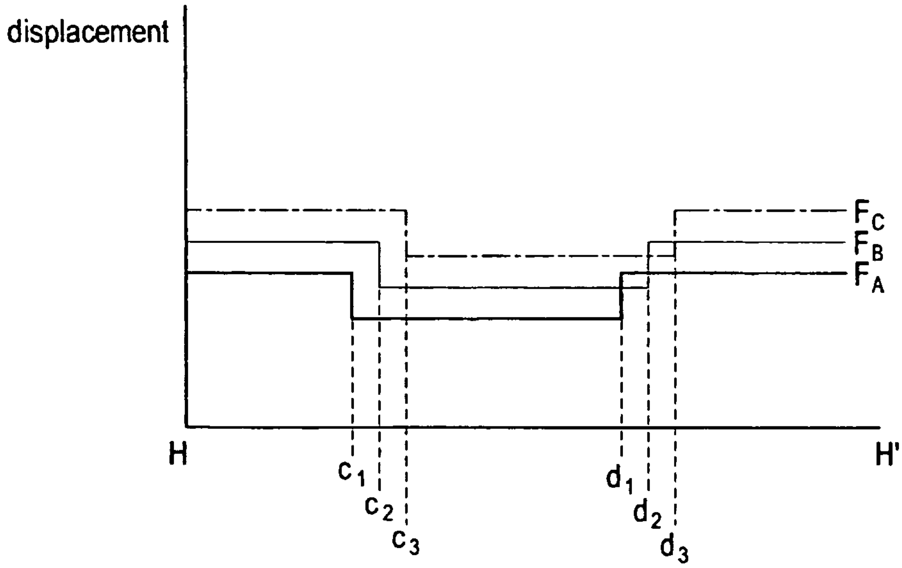

displacement
Fc
FB
FA
H
H'
c1
c2
c3
d1
d2
d3

FIG. 6

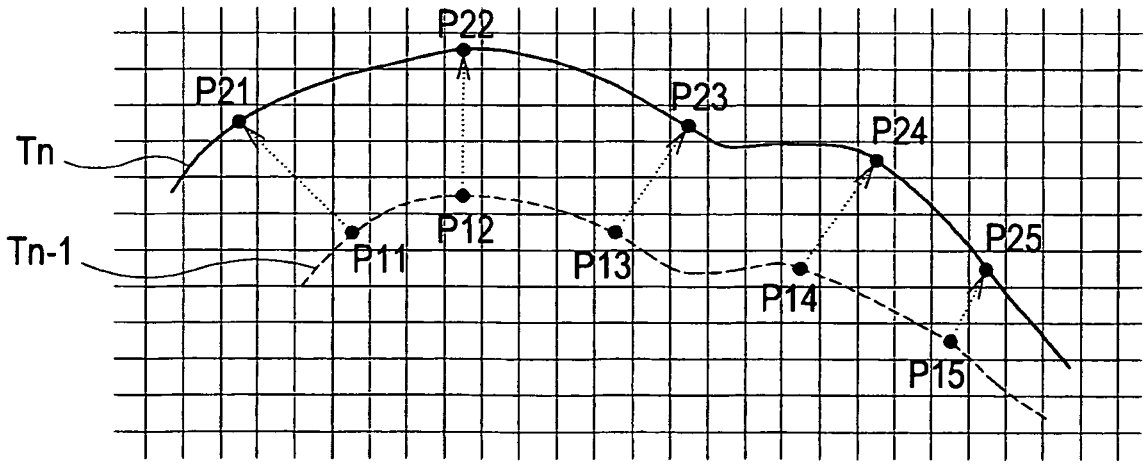

Tn
Tn-1
P21
P22
P23
P24
P25
P11
P12
P13
P14
P15

FIG. 7

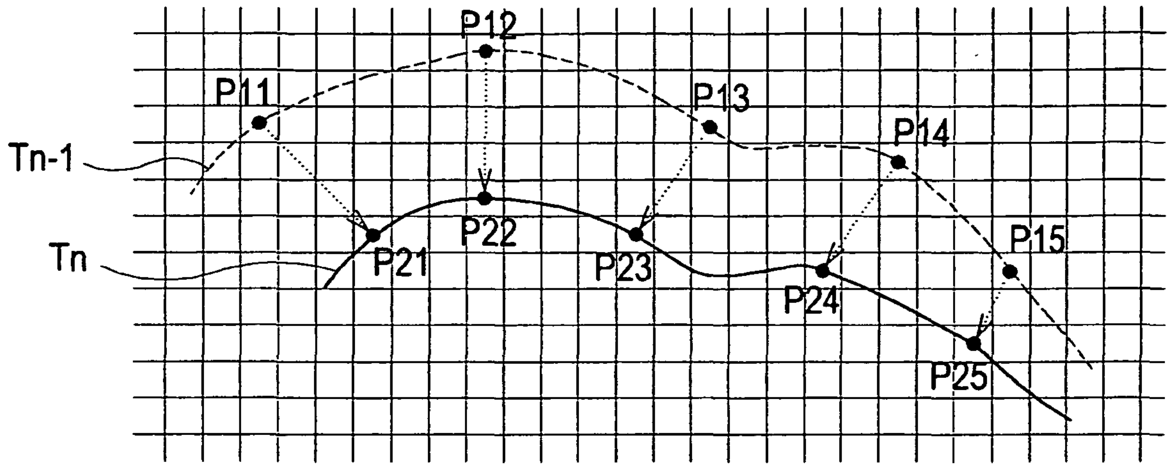


FIG. 8

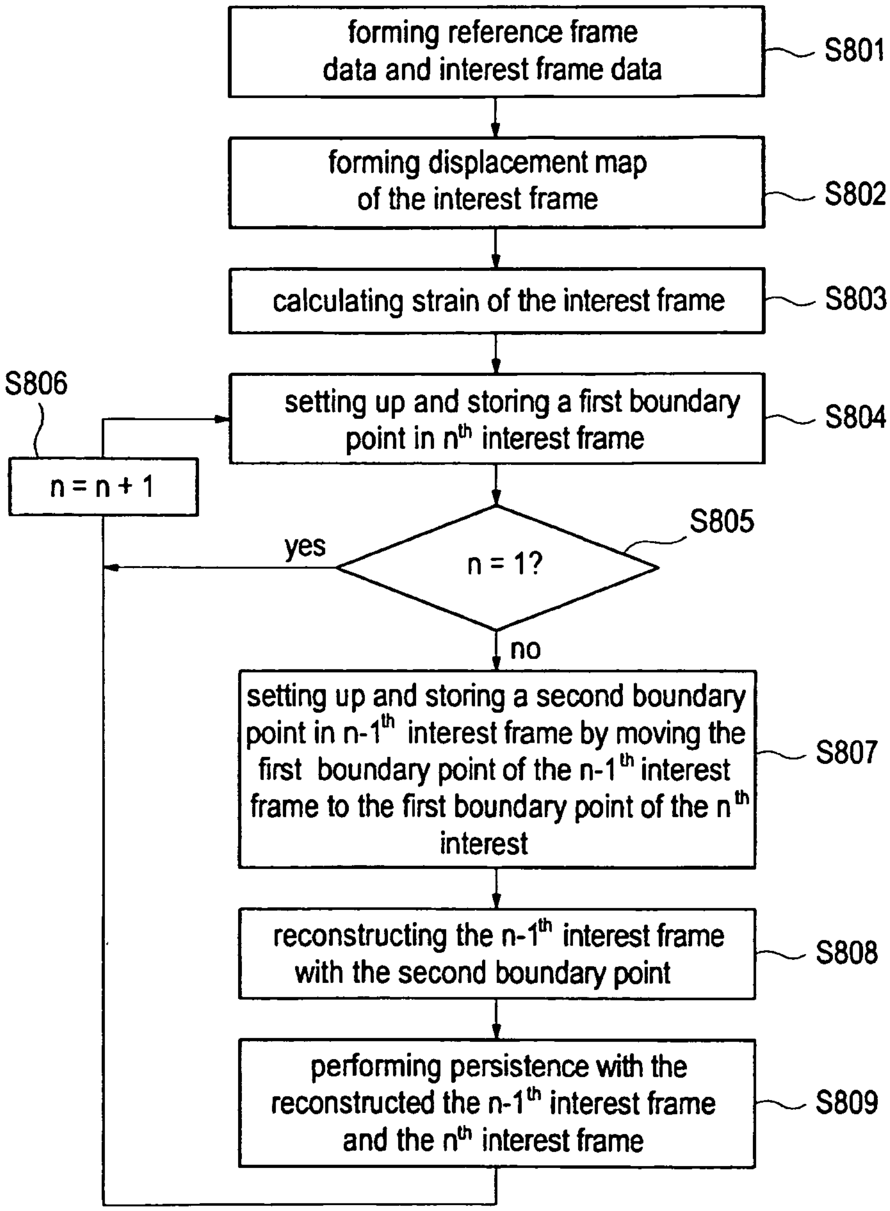

forming reference frame data and interest frame data
S801
forming displacement map of the interest frame
S802
calculating strain of the interest frame
S803
setting up and storing a first boundary point in n^th interest frame
S804
S806
n = n + 1
yes
n = 1?
S805
no
setting up and storing a second boundary point in n-1^th interest frame by moving the first boundary point of the n-1^th interest frame to the first boundary point of the n^th interest
S807
reconstructing the n-1^th interest frame with the second boundary point
S808
performing persistence with the reconstructed the n-1^th interest frame and the n^th interest frame
S809

FIG. 9

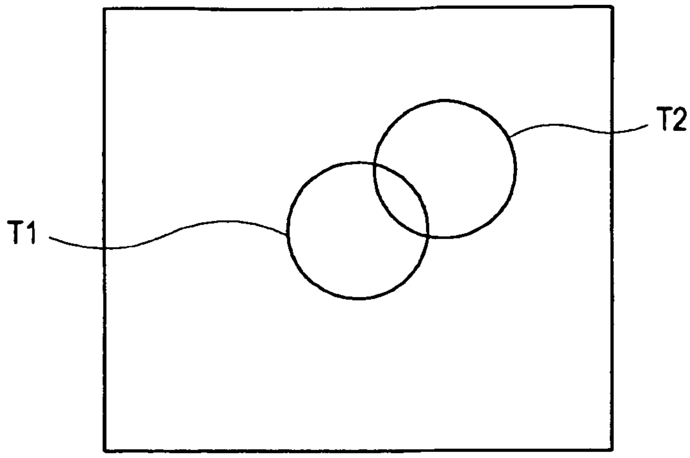
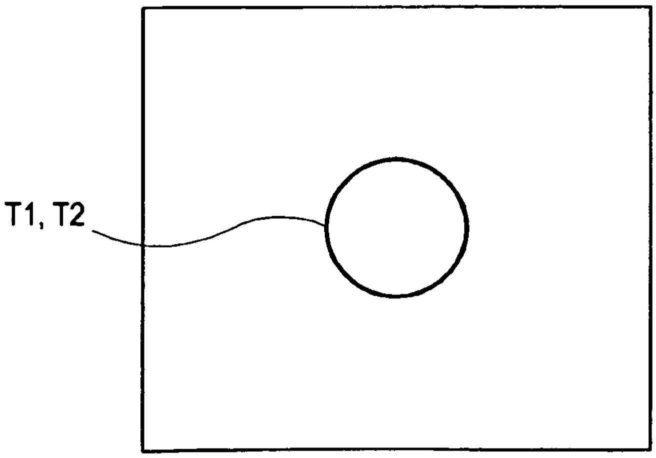


FIG. 10



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6508768 B1 **[0007]**

Non-patent literature cited in the description

- **PESAVENTO ; LORENZ.** *Real time strain imaging and in-vivo applications in prostate cancer* **[0009]**

专利名称(译)	超声系统和形成能够防止变形的弹性图像的方法		
公开(公告)号	EP1972281B1	公开(公告)日	2015-05-27
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当前申请(专利权)人(译)	三星MEDISON CO. , LTD.		
[标]发明人	HYUN DONG GYU JEONG MOK KUN		
发明人	HYUN, DONG GYU JEONG, MOK KUN		
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代理机构(译)	SCHMID , WOLFGANG		
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其他公开文献	EP1972281A1		
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摘要(译)

本发明涉及一种能够防止弹性图像失真的超声系统和形成弹性图像的方法。在将在先前兴趣帧中设置的边界像素移动到当前兴趣帧中的边界像素之后，执行前一帧和当前帧的持久性。这样可以减小弹性图像的失真并且可以增加信噪比。

$$S_n(i,j) = P \times S_{n-1}(i,j) + (1-P) \times X_n(i,j) \quad \text{Eq.(1)}$$