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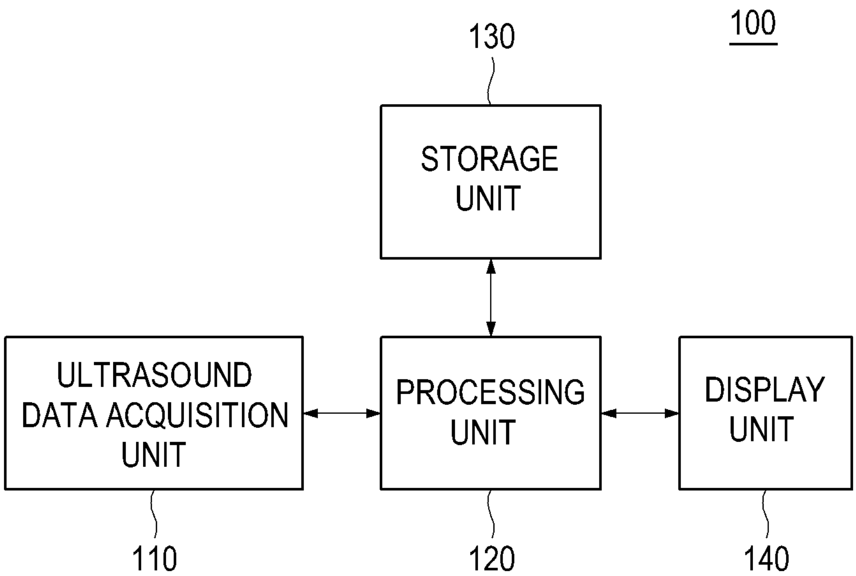
(54) Ultrasound strain imaging

(57) Embodiments for providing a strain image in an ultrasound system are disclosed. In one embodiment, a processing unit sets windows on a pre-compression frame and a post-compression frame, and performs a correlation operation between the first and second frames within the windows to compute displacements for a third frame, wherein the processing unit selects at least one of previously set windows at an $(N-i)^{th}$ row by referring to current windows positioned at a N^{th} row in an axial direction, computes an initial displacement based on displacements corresponding to the selected at least one of windows, and determines a range for moving the current window on the second frame in the axial direction based on the computed initial displacement.

FIG. 1



EP 2 422 705 A1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority from Korean Patent Application No. 10-2010-0081432 filed on August 23, 2010.

TECHNICAL FIELD

[0002] The present disclosure generally relates to ultrasound systems, and more particularly to an ultrasound system configured to provide a strain image.

BACKGROUND

[0003] An ultrasound system has become an important and popular diagnostic tool since it has a wide range of applications. Specifically, due to its non-invasive and non-destructive nature, the ultrasound system has been extensively used in the medical profession. Modern high-performance ultrasound systems and techniques are commonly used to produce two or three-dimensional images of internal features of an object (e.g., human organs).

[0004] Generally, the ultrasound image is displayed in a Brightness-mode (B-mode) by using reflectivity caused by an acoustic impedance difference between the tissues of the target object. However, if the reflectivity of the target object is hardly different from those of the neighboring tissues such as tumor, cancer or the like, then it is not easy to recognize the target object in the B-mode image.

[0005] To cope with the problem of recognizing the tumor, cancer and the like in the B-mode, an ultrasound elasticity imaging has been developed to visualize the mechanical characteristics of the tissues based on differences responsive to pre-compression and post-compression. Such imaging proved very helpful for diagnosing lesions such as tumor and cancer, which otherwise are hardly recognized in the B-mode image. The ultrasound elasticity imaging may utilize the scientific property that the elasticity of the tissues is related to a pathological phenomenon. For example, the tumor or cancer is relatively stiffer than the surrounding normal tissues. Thus, when stress is uniformly applied, a strain of the tumor or cancer may be typically smaller than those of the surrounding tissues. Strain is deformation of a target object due to stress applied per area and Young's modulus may be defined as a ratio of stress over strain. The strain is a differential value of a displacement. The displacement may indicate how much tissues in the target object are moved between pre-compression and post-compression.

[0006] The ultrasound system may set a window on each of the pre-compression frame data and post-compression frame data, and move the window in an axial direction for a correlation operation therebetween, thereby obtaining displacements. In such a case, when a position gap between the windows set on the pre-compression frame data and the post-compression frame data is beyond a range of a phase, a decorrelation error may occur.

[0007] Conventionally, the ultrasound system is configured to determine an initial displacement from a current position of the window (i.e., displacement that has already been computed in an axial direction at a current position of the window) and move the window by the initial displacement to compute a displacement in order to remove the decorrelation error. In such a case, however, if an error in the initial displacement occurs, then an error is maintained in an axial direction. Thus, a dropout, i.e., a horizontal line in a strain image, may be generated.

SUMMARY

[0008] Embodiments for forming correcting a dropout in strain imaging in an ultrasound system are disclosed herein. In one embodiment, by way of non-limiting example, an ultrasound system comprises: an ultrasound data acquisition unit configured to acquire first ultrasound data for a first frame wherein compression is not applied to a target object and second ultrasound data for a second frame wherein compression is applied to the target object; and a processing unit configured to set windows on the respective first and second frames, move the windows in axial and lateral directions and perform a correlation operation between the first and second frames within the windows to compute displacements to determine pixel values of a third frame, the processing unit being further configured to form a strain image based on the computed displacements, wherein the processing unit is configured to select at least one of previously set windows at an $(N-i)^{th}$ row by referring to current windows positioned at a N^{th} row in an axial direction on the respective first and second frames, compute an initial displacement based on displacements corresponding to the selected at least one of windows, and determine a range for moving the current window on the second frame in the axial direction based on the computed initial displacement, wherein N is an integer greater than 1 and i is an integer greater than 0 but less than N.

[0009] In another embodiment, a method of providing a strain image, comprises: a) acquiring first ultrasound data for a first frame wherein compression is not applied to a target object; b) acquiring second ultrasound data for a second frame wherein compression is applied to the target object; c) setting windows on the respective first and second frames; d) moving the windows in axial and lateral directions and performing a correlation operation between the first and second frames within the windows to compute displacements to determine pixel values of a third frame, wherein the step d) includes selecting at least one of previously set windows at an $(N-i)^{th}$ row by referring to current windows positioned at a N^{th} row in an axial direction on the respective first and second frames, computing an initial displacement based on displacements corresponding to the selected at least one of windows, and determining a range for moving the current window on the second frame in the axial direction based on the computed initial displacement, wherein N is an integer greater than 1 and i is an integer greater than 0 but less than N; and e) forming a strain image based on the computed displacements.

[0010] In yet another embodiment, there is provided a computer-readable storage medium storing instructions that, when executed by a computer, cause the computer to perform a method of providing a strain image, the method comprising: a) acquiring first ultrasound data for a first frame where compression is not applied to a target object; b) acquiring second ultrasound data for a second frame where compression is applied to the target object; c) setting windows on the respective first and second frames; d) moving the windows in axial and lateral directions and performing a correlation operation between the first and second frames within the windows to compute displacements to determine pixel values of a third frame, wherein the step d) includes selecting at least one of previously set windows at an $(N-i)^{th}$ row by referring to current windows positioned at a N^{th} row in an axial direction on the respective first and second frames, computing an initial displacement based on displacements corresponding to the selected at least one of windows, and determining a range for moving the current window on the second frame in the axial direction based on the computed initial displacement, wherein N is an integer greater than 1 and i is an integer greater than 0 but less than N; and e) forming a strain image based on the computed displacements.

[0011] The Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG 1 is a block diagram showing an illustrative embodiment of an ultrasound system.

FIG 2 is a block diagram showing an illustrative embodiment of an ultrasound data acquisition unit of FIG 1.

FIGS. 3 to 5 are diagrams showing examples of determining an initial displacement.

DETAILED DESCRIPTION

[0013] 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.

[0014] Referring to FIG 1, an ultrasound system constructed in accordance with one embodiment is shown. The ultrasound system 100 includes an ultrasound data acquisition unit 110, a processing unit 120, a storage unit 130 and a display unit 140.

[0015] The ultrasound data acquisition unit 110 is configured to transmit ultrasound beams to a target object and receive ultrasound echoes reflected from the target object to thereby form ultrasound data representative of the target obj ect. An operation of the ultrasound acquisition unit will be described in detail by referring to FIG 2.

[0016] FIG 2 is a block diagram showing an illustrative embodiment of the ultrasound data acquisition unit 110. Referring to FIG 2, the ultrasound data acquisition unit 110 includes a transmit signal forming section 210. The transmit signal forming section 210 generates a plurality of transmit signals and apply delays to the transmit signals.

[0017] The ultrasound data acquisition unit 110 further includes an ultrasound probe 220, which is coupled to the transmit signal forming section 210. The ultrasound probe 220 includes an array transducer containing a plurality of transducer elements for reciprocal conversion between electric signals and ultrasound signals. The ultrasound probe 220 is configured to transmit ultrasound signals in response to the transmit signals. The ultrasound probe 220 is further configured to receive ultrasound echoes reflected from the target object to thereby output receive signals. In one embodiment, the receive signals include first receive signals obtained without applying compression to the target object and second receive signals obtained with applying compression to the target object. The compression is applied by using the ultrasound probe 220. In such a case, a compression plate may be mounted around a front side of the ultrasound probe 220. In another embodiment, an additional device for compressing the target object may be employed.

[0018] The ultrasound data acquisition unit 110 further includes a beam forming section 230, which is coupled to the ultrasound probe 220. The beam forming section 230 is configured to digitize the electrical receive signals into digital signals. The beam forming section 230 also applies delays to the digital signals in consideration of distances between the elements of the ultrasound probe 220 and focal points. The beam forming section 230 further sums the delayed digital signals to form receive-focused signals. In one embodiment, the beam forming section 230 forms first receive-focused signals based on the first receive signals and second receive-focused signals based on the second receive signals.

[0019] The ultrasound data acquisition unit 110 further includes an ultrasound data forming section 240, which is coupled to the beam forming section 230. The ultrasound data forming section 240 is configured to form ultrasound frame data sets corresponding to a plurality of frames based on the receive-focused signals. The ultrasound frame data sets include RF data sets or in-phase/quadrature (IQ) data sets. However, the ultrasound data may not be limited thereto. The ultrasound data forming section 240 is further configured to perform a variety of signal processing (e.g., gain adjustment, filtering, etc.) upon the receive-focused signals. In one embodiment, the ultrasound data include a first ultrasound frame data set formed based on the first receive-focused signals and a second ultrasound frame data set formed based on the second receive-focused signals.

[0020] Referring back to FIG 1, the processing unit 120, which is coupled to the ultrasound data acquisition unit 110, is configured to set windows having predetermined sizes on a first frame corresponding to the first ultrasound data and a second frame corresponding to the second ultrasound data, respectively. The processing unit 120 is further configured to move the windows set on the respective first and second frames in lateral and axial directions of the frames and perform a correlation operation between the windows to compute displacements in the corresponding windows for forming a frame corresponding to a strain image (hereinafter, referred to as "third frame"). In one embodiment, when the window is currently positioned at a location corresponding to an N^{th} row in an axial direction in the third frame F3, the processing unit 120 is configured to select predetermined numbers of windows, which were set at a $(N-i)^{th}$ row, by referring to the currently positioned window, wherein N is an integer greater than 1 and i is an integer equal to or greater than 1. The processing unit 120 is configured to determine an initial displacement for moving the window on the second frame based on the displacements within the predetermined numbers of windows. The initial displacement may be a displacement for moving the window on the second frame without causing a decorrelation error.

[0021] In one embodiment, the processing unit 120 is configured to select predetermined numbers (e.g., five) of windows (hatched regions), which were previously set to determine pixel values at a $(N-1)^{th}$ row C_{N-1} of the third frame F3 on the respective first and second frames, by referring to a current window, which is set to determine pixel values at an N^{th} row C_N in an axial direction, as shown in FIG 3. The processing unit 120 is configured to determine an initial displacement based on displacements associated with the selected five windows. In such a case, the initial displacement for a first row C_1 may be determined according to the conventional method. In one embodiment, the initial displacement may a median value of displacements at the selected windows; however, it may not be limited thereto.

[0022] In another embodiment, the processing unit 120 is configured to select one window (hatched region), which was set to determine pixel values at a $(M-k)^{th}$ row C_{M-k} of the third frame F3 on the respective first and second frames, by referring to a current window, which is set to determine pixel values at an N^{th} row of the third frame in an axial direction, as shown in FIG 4, wherein k is an integer greater than 1. The processing unit 120 is further configured to determine a displacement corresponding to the selected window as an initial displacement.

[0023] In another embodiment, the processing unit 120 is configured to select predetermined numbers of windows (hatched regions), which were set at a $(M-k)^{th}$ row C_{M-k} in the third frame F3, by referring to a current window, which is set at an N^{th} row in an axial direction, as shown in FIG 5, wherein k is an integer greater than 1. The processing unit 120 is further configured to determine an initial displacement based on displacements at the selected windows. The initial displacement may a median value of displacements at the selected windows.

[0024] Referring back to FIG 1, the processing unit 120 is configured to determine a moving range of the window on the second frame in an axial direction based on the determined initial displacement and move the window on the second frame based on the moving range. The processing unit 120 is configured to compute a displacement at the moved window and form a strain image based on the displacement. Since the formation of the strain image based on the displacement is performed by using various well-known methods, its detailed explanation will be omitted herein.

[0025] The storage unit 130 is configured to store the ultrasound data acquired in the ultrasound data acquisition unit 110. The storage unit 130 is configured to further store the displacements, which are computed in the processing unit 120. The display unit 140 is configured to display the strain image, which is formed in the processing unit 120. Also, the display unit 140 displays the frames formed in the processing unit 120.

[0026] In another embodiment, there is provided a computer-readable storage medium storing instructions that, when executed by a computer, cause the computer to perform a method of providing a strain image, the method comprising: a) acquiring first ultrasound data for a first frame where compression is not applied to a target object; b) acquiring second ultrasound data for a second frame where compression is applied to the target object; c) setting windows on the respective first and second frames; d) moving the windows in axial and lateral directions and performing a correlation operation between the first and second frames within the windows to compute displacements to determine pixel values of a third frame, wherein the step d) includes selecting at least one of previously set windows at an $(N-i)^{th}$ row by referring to current windows positioned at a N^{th} row in an axial direction on the respective first and second frames, computing an initial displacement based on displacements corresponding to the selected at least one of windows, and determining a range for moving the current window on the second frame in the axial direction based on the computed initial displacement, wherein N is an integer greater than 1 and i is an integer greater than 0 but less than N; and e) forming a strain image based on the computed displacements.

[0027] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, numerous variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

Claims

1. An ultrasound system, comprising:

an ultrasound data acquisition unit configured to acquire first ultrasound data for a first frame wherein compression is not applied to a target object and
second ultrasound data for a second frame wherein compression is applied to the target obj ect; and
a processing unit configured to set windows on the respective first and second frames, move the windows in axial and lateral directions and perform a correlation operation between the first and second frames within the windows to compute displacements to determine pixel values of a third frame, the processing unit being further configured to form a strain image based on the computed displacements,
wherein the processing unit is configured to select at least one of previously set windows at an $(N-i)^{th}$ row by referring to current windows positioned at a N^{th} row in an axial direction on the respective first and second frames,
compute an initial displacement based on displacements corresponding to the selected at least one of windows, and determine a range for moving the current window on the second frame in the axial direction based on the computed initial displacement, wherein N is an integer greater than 1 and i is an integer greater than 0 but less than N.

2. The ultrasound system of Claim 1, wherein the processing unit is configured to select previously set windows adjacent to the current window at an $(N-1)^{th}$ row.

3. The ultrasound system of Claim 1, wherein the processing unit is configured to select one previously set window positioned at an identical column to the current window at an $(N-k)^{th}$ row.

4. The ultrasound system of Claim 1, wherein the processing unit is configured to select a plurality of previously set windows positioned at an $(N-k)^{th}$ row.

5. The ultrasound system of Claim 1, wherein the initial displacement includes a median value of displacements.

6. A method of providing a strain image, comprising:

a) acquiring first ultrasound data for a first frame wherein compression is not applied to a target object;
b) acquiring second ultrasound data for a second frame wherein compression is applied to the target object;
c) setting windows on the respective first and second frames;
d) moving the windows in axial and lateral directions and performing a correlation operation between the first and second frames within the windows to compute displacements to determine pixel values of a third frame, wherein the step d) includes selecting at least one of previously set windows at an $(N-i)^{th}$ row by referring to current windows positioned at a N^{th} row in an axial direction on the respective first and second frames, computing an initial displacement based on displacements corresponding to the selected at least one of windows, and determining a range for moving the current window on the second frame in the axial direction based on the computed initial displacement, wherein N is an integer greater than 1 and i is an integer greater than 0 but less than N; and
e) forming a strain image based on the computed displacements.

7. The method of Claim 6, wherein the step d) including selecting previously set windows adj acent to the current window at an $(N-1)^{th}$ row.

8. The method of Claim 6, wherein the step d) includes selecting one previously set window positioned at an identical column to the current window at an $(N-k)^{th}$ row.

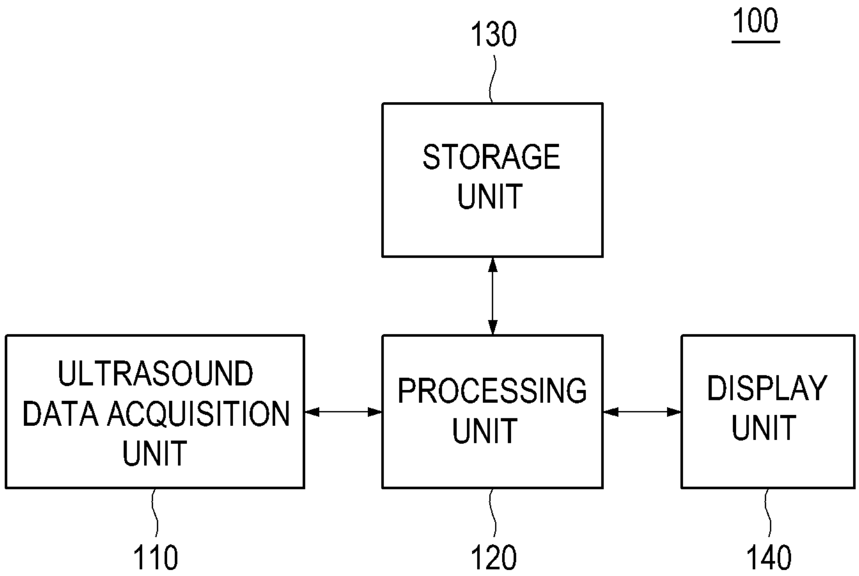
9. The method of Claim 6, wherein the step d) includes selecting a plurality of previously set windows positioned at an $(N-k)^{th}$ row.

10. The method of Claim 6, wherein the initial displacement includes a median value of displacements.

11. A computer-readable storage medium storing instructions that, when executed by a computer, cause the computer to perform a method of providing a strain image, the method comprising:

a) acquiring first ultrasound data for a first frame wherein compression is not applied to a target object;
b) acquiring second ultrasound data for a second frame wherein compression is applied to the target object;
c) setting windows on the respective first and second frames;
d) moving the windows in axial and lateral directions and performing a correlation operation between the first and second frames within the windows to compute displacements to determine pixel values of a third frame, wherein the step d) includes selecting at least one of previously set windows at an $(N-i)^{th}$ row by referring to current windows positioned at a N^{th} row in an axial direction on the respective first and second frames, computing an initial displacement based on displacements corresponding to the selected at least one of windows, and determining a range for moving the current window on the second frame in the axial direction based on the computed initial displacement, wherein N is an integer greater than 1 and i is an integer greater than 0 but less than N; and
e) forming a strain image based on the computed displacements.

FIG. 1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130
STORAGE UNIT
ULTRASOUND DATA ACQUISITION UNIT
PROCESSING UNIT
DISPLAY UNIT
110
120
140

FIG. 2

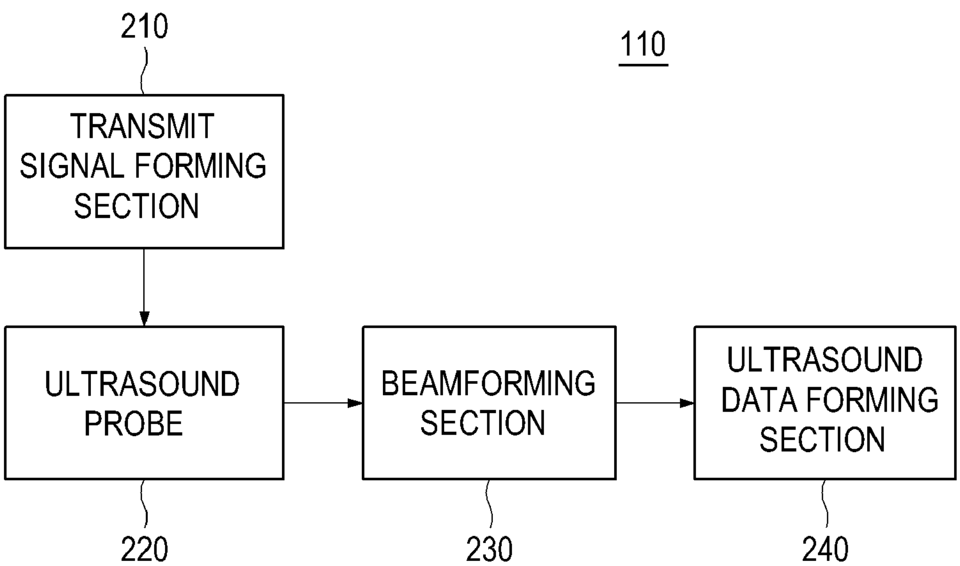

210
110
TRANSMIT SIGNAL FORMING SECTION
ULTRASOUND PROBE
BEAMFORMING SECTION
ULTRASOUND DATA FORMING SECTION
220
230
240

FIG. 3

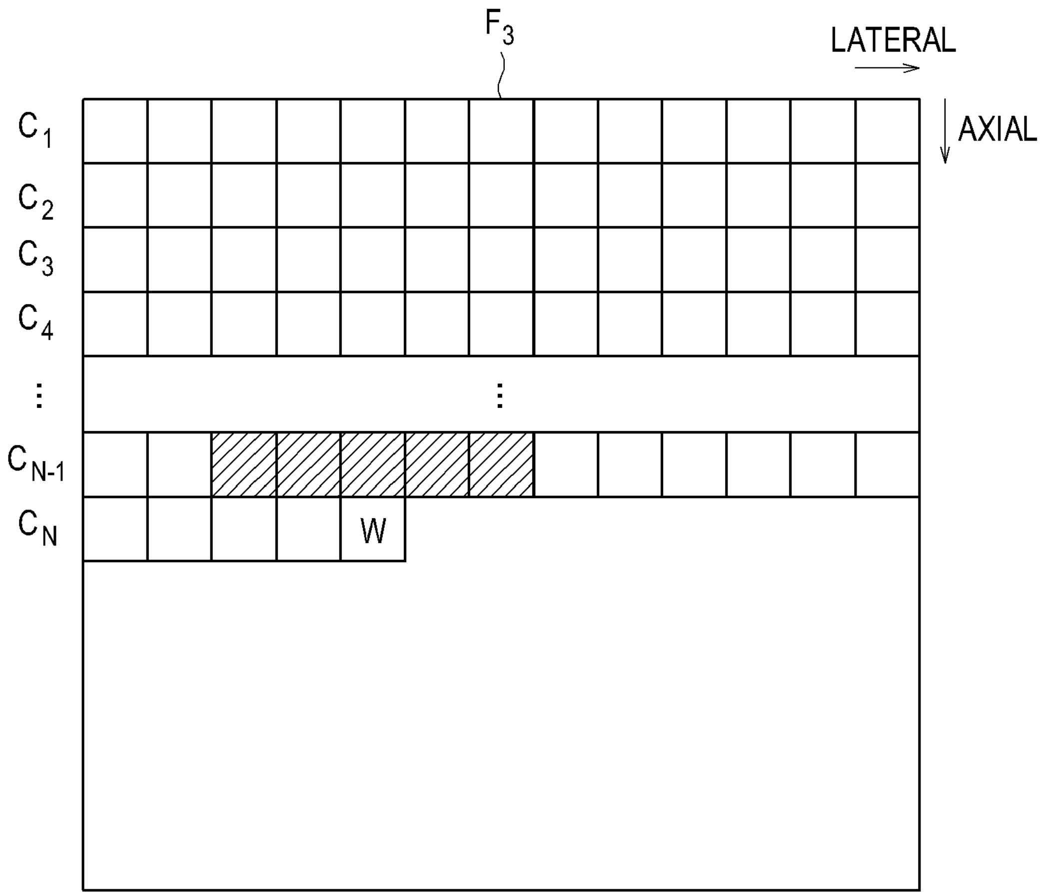


FIG. 4

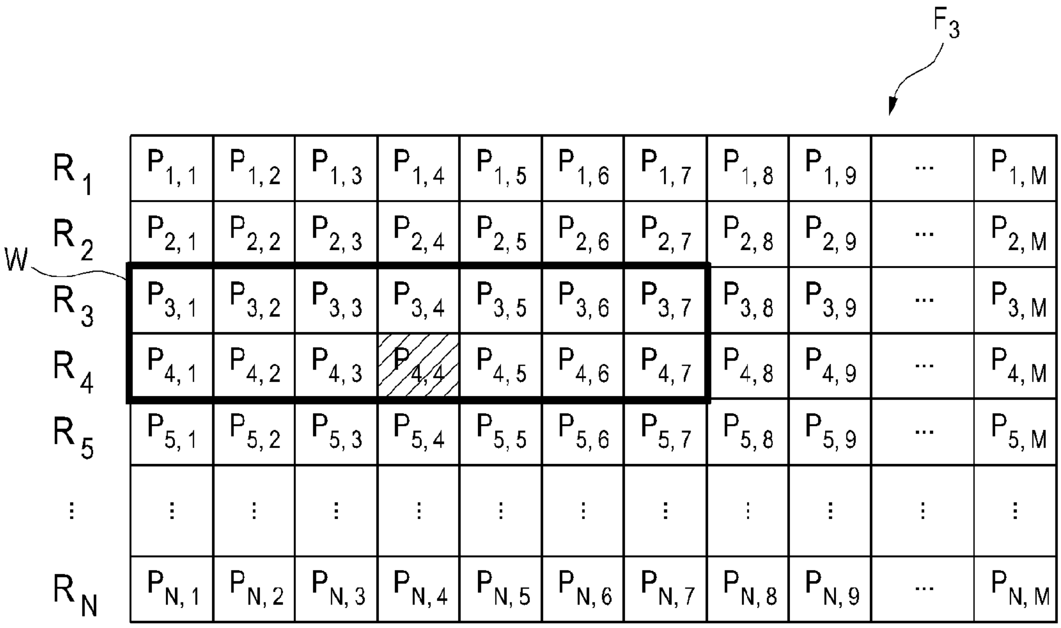

F_3
W
R_1 $P_{1,1}$ $P_{1,2}$ $P_{1,3}$ $P_{1,4}$ $P_{1,5}$ $P_{1,6}$ $P_{1,7}$ $P_{1,8}$ $P_{1,9}$ ... $P_{1,M}$
R_2 $P_{2,1}$ $P_{2,2}$ $P_{2,3}$ $P_{2,4}$ $P_{2,5}$ $P_{2,6}$ $P_{2,7}$ $P_{2,8}$ $P_{2,9}$ ... $P_{2,M}$
R_3 $P_{3,1}$ $P_{3,2}$ $P_{3,3}$ $P_{3,4}$ $P_{3,5}$ $P_{3,6}$ $P_{3,7}$ $P_{3,8}$ $P_{3,9}$ ... $P_{3,M}$
R_4 $P_{4,1}$ $P_{4,2}$ $P_{4,3}$ $P_{4,4}$ $P_{4,5}$ $P_{4,6}$ $P_{4,7}$ $P_{4,8}$ $P_{4,9}$ ... $P_{4,M}$
R_5 $P_{5,1}$ $P_{5,2}$ $P_{5,3}$ $P_{5,4}$ $P_{5,5}$ $P_{5,6}$ $P_{5,7}$ $P_{5,8}$ $P_{5,9}$ ... $P_{5,M}$
R_N $P_{N,1}$ $P_{N,2}$ $P_{N,3}$ $P_{N,4}$ $P_{N,5}$ $P_{N,6}$ $P_{N,7}$ $P_{N,8}$ $P_{N,9}$ ... $P_{N,M}$

FIG. 4

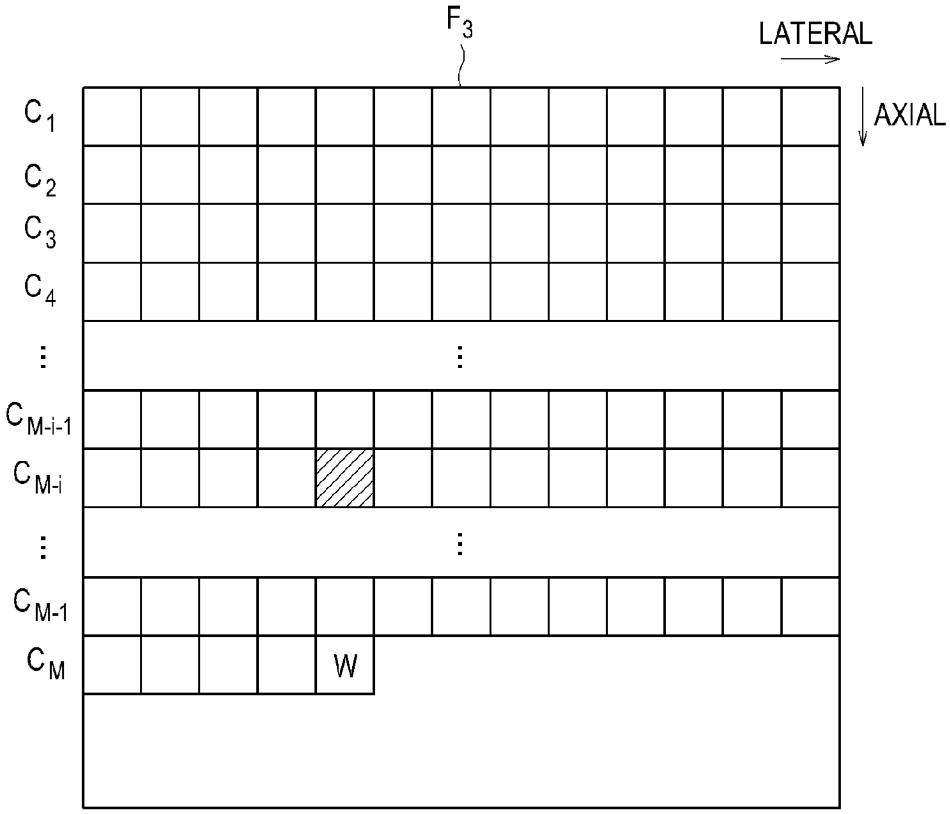
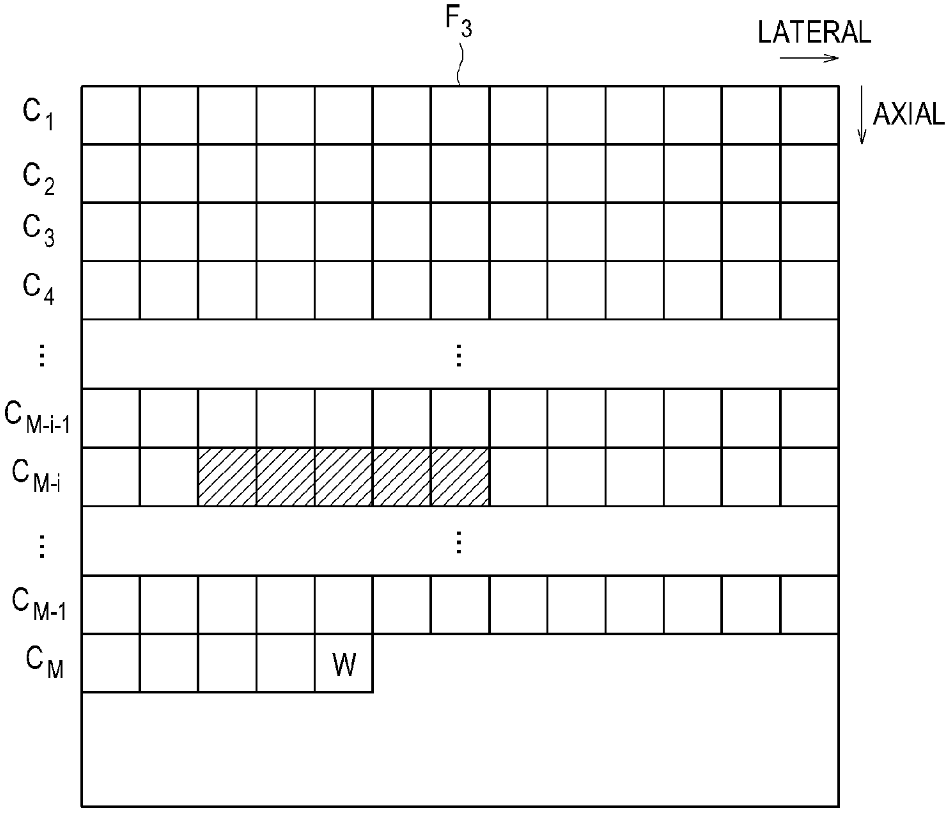


FIG. 5



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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 7150

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 January 2012	Daoukou, Eleni

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CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 7150

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 January 2012	Daoukou, Eleni

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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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L : document cited for other reasons
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20-01-2012

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专利名称(译)	超声应变成像		
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代理机构(译)	SCHMID，WOLFGANG		
优先权	1020100081432 2010-08-23 KR		
其他公开文献	EP2422705B1		
外部链接	Espacenet		

摘要(译)

公开了用于在超声系统中提供应变图像的实施例。在一个实施例中，处理单元在预压缩帧和压缩后帧上设置窗口，并在窗口内的第一帧和第二帧之间执行相关操作以计算第三帧的位移，其中处理单元选择通过参考位于轴向上的第N行的当前窗口，在第（Ni）行中预先设置窗口中的至少一个，基于与所选择的至少一个窗口相对应的位移来计算初始位移，并确定基于计算出的初始位移，在轴向上移动第二帧上的当前窗口。

FIG. 1