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(54) STRETCHING BASED STRAIN IMAGING IN AN ULTRASOUND SYSTEM

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(57) **ABSTRACT**

Embodiments for forming an elastic image in an ultrasound system are disclosed. In one embodiment, a processing unit is configured to control an ultrasound data acquisition unit to perform the transmit/receive operation in a first state where compression is not applied to the target object to thereby obtain a first ultrasound frame data set, and to perform the transmit/receive operation in a second state where compression is applied to the target object to thereby obtain a second ultrasound frame data set. The processing unit is further configured to compute a first strain between the first and second ultrasound frame data sets, perform globally uniform stretching upon the second ultrasound frame data set based on the first strain, and compute a second strain between the first ultrasound frame data set and the stretched second ultrasound frame data set and form an elastic image based on the second strain.

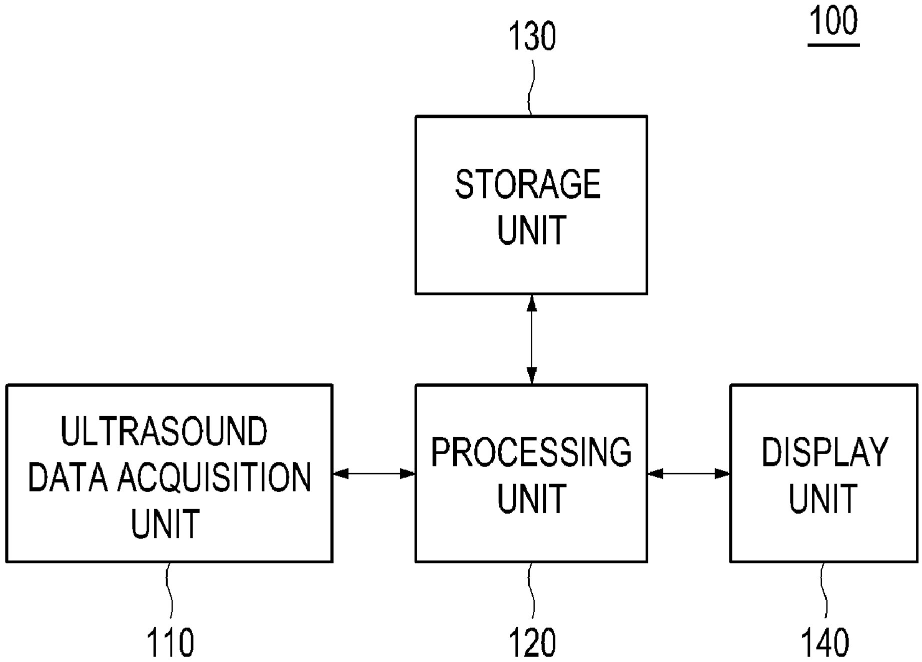


FIG. 1

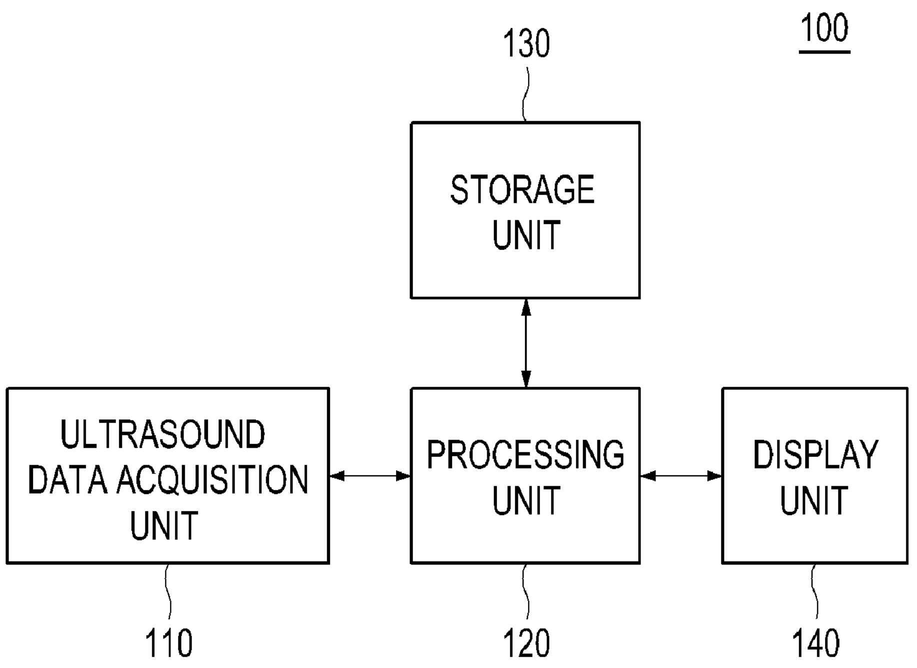

100
130
STORAGE UNIT
ULTRASOUND DATA ACQUISITION UNIT
PROCESSING UNIT
DISPLAY UNIT
110
120
140

FIG. 2

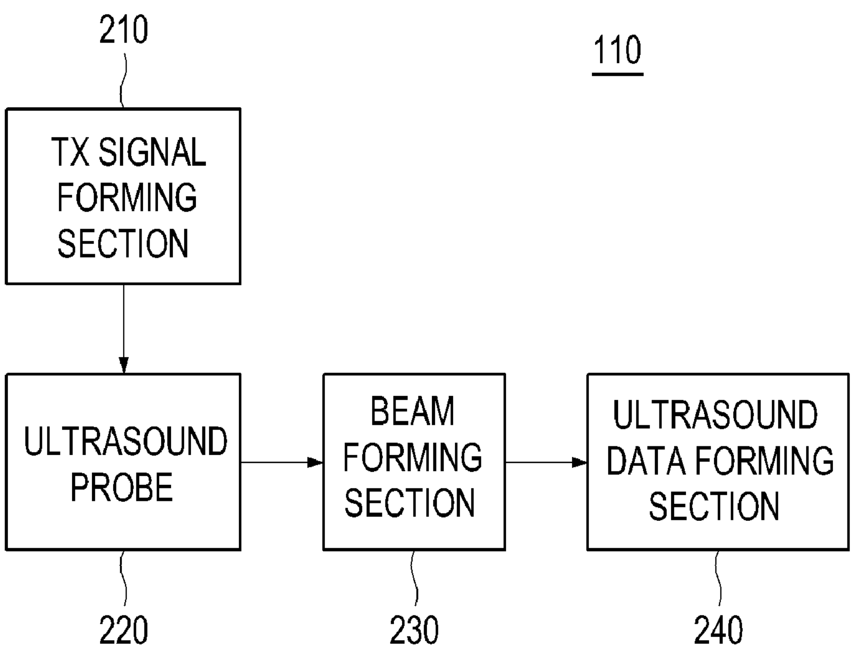

210
110
TX SIGNAL FORMING SECTION
ULTRASOUND PROBE
BEAM FORMING SECTION
ULTRASOUND DATA FORMING SECTION
220
230
240

FIG. 3

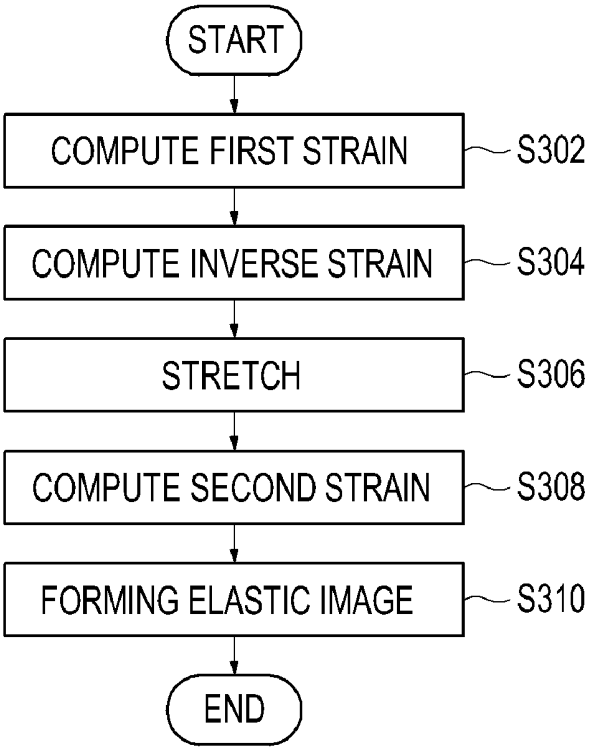
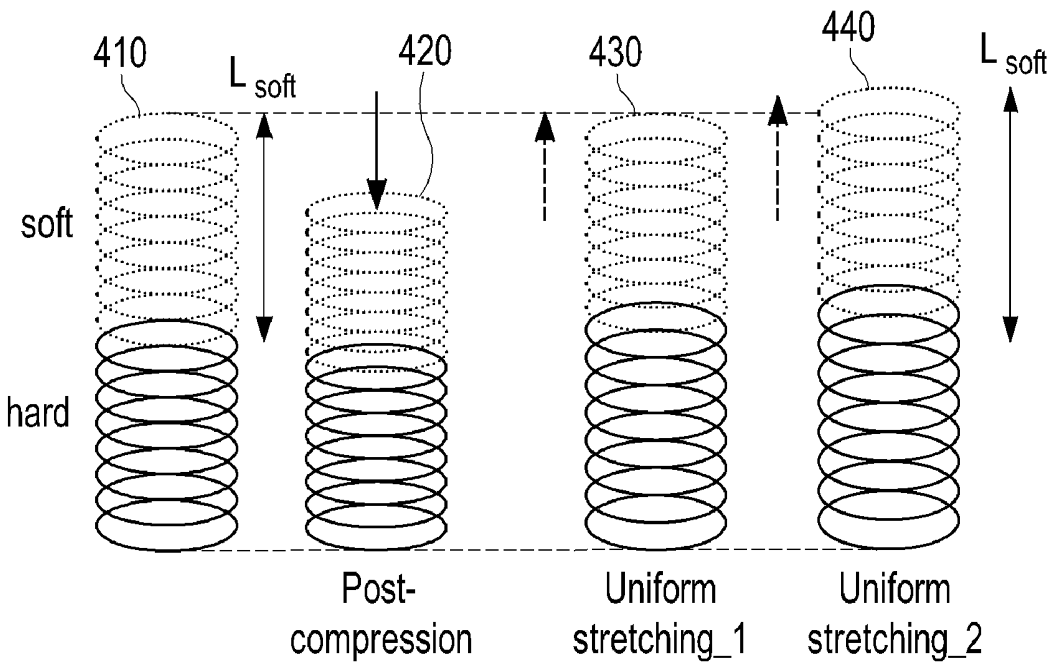

START
COMPUTE FIRST STRAIN
S302
COMPUTE INVERSE STRAIN
S304
STRETCH
S306
COMPUTE SECOND STRAIN
S308
FORMING ELASTIC IMAGE
S310
END

FIG. 4


410
420
430
440
L soft
L soft
soft
hard
Post-
compression
Uniform
stretching_1
Uniform
stretching_2

STRETCHING BASED STRAIN IMAGING IN AN ULTRASOUND SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority from Korean Patent Application No. 10-2010-0095702 filed on Oct. 1, 2010, the entire subject matter of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure generally relates to strain imaging, and more particularly to stretching based strain imaging in an ultrasound system.

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 such as the elasticity of the same in the ultrasound system. Such imaging was proven to be very helpful for diagnosing lesions such as tumor and cancer, which would otherwise be hardly recognized in the B-mode image, in soft tissues (e.g., breast). 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. When a strain image visualizing the strains measured in the target object (also called an "elastic image") is displayed on a display unit, relatively stiff portions may be indicated darkly and relatively soft portions may be indicated brightly for visual recognition. Thus, since the stiff portion at which lesion or cancer exists is displayed darkly, a contrast therein may be lowered.

SUMMARY

[0006] Embodiments for forming a strain image with enhanced contrast at hard regions of a target object in an ultrasound system are disclosed herein. In one embodiment, by way of non-limiting example, an ultrasound system may comprise: an ultrasound data acquisition unit configured to perform a transmit/receive operation including transmitting ultrasound signals to a target object and receiving ultrasound echoes reflected from the target object to thereby acquire ultrasound frame data; and a processing unit configured to control the ultrasound data acquisition unit to perform the transmit/receive operation in a first state where compression is not applied to the target object to thereby obtain a first ultrasound frame data set, the processing unit being further configured to control the ultrasound data acquisition unit to perform the transmit/receive operation in a second state where compression is applied to the target object to thereby obtain a second ultrasound frame data set, the processing unit being configured to compute a first strain between the first and second ultrasound frame data sets and perform globally uniform stretching upon the second ultrasound frame data set based on the first strain, the processing unit being further configured to compute a second strain between the first ultrasound frame data set and the stretched second ultrasound frame data set and form an elastic image based on the second strain.

[0007] In another embodiment, a method of forming a strain image in an ultrasound system, may comprise: a) acquiring first ultrasound frame data set from a target object without applying compression to the target object; b) acquiring second ultrasound frame data set from a target object with applying compression to the target object; c) computing a first strain between the first and second ultrasound frame data set; d) performing globally uniform stretching upon the second ultrasound frame data set based on the first strain; e) computing a second strain between the first ultrasound frame data set and the stretched second ultrasound frame data set; and f) forming a strain image based on the second strain.

[0008] In yet another embodiment, a computer-readable storage medium storing instructions that, when executed by a computer, cause the computer to provide a method of forming an elastic image based on first ultrasound frame data set acquired from a target object without applying compression to the target object and second ultrasound frame data set acquired from the target object with applying compression to the target object in an ultrasound system is provided, wherein the method comprises: computing a first strain between the first and second ultrasound frame data set; performing globally uniform stretching upon the second ultrasound frame data set based on the first strain; computing a second strain between the first ultrasound frame data set and the stretched second ultrasound frame data set; and forming a strain image based on the second strain.

[0009] 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

[0010] FIG. **1** is a block diagram showing an illustrative embodiment of an ultrasound system.

[0011] FIG. **2** is a block diagram showing an illustrative embodiment of an ultrasound data acquisition unit of FIG. **1**.

[0012] FIG. **3** is a flowchart showing an illustrative embodiment of forming a strain image.

[0013] FIG. **4** is a schematic diagram showing an example of performing globally uniform stretching upon ultrasound data acquired from a target object with applying compression to the target object.

DETAILED DESCRIPTION

[0014] 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.

[0015] Referring to FIG. **1**, an ultrasound system constructed in accordance with one embodiment is shown. The ultrasound system **100** may include an ultrasound data acquisition unit **110**, a processing unit **120**, a storage unit **130** and a display unit **140**.

[0016] The ultrasound data acquisition unit **110** may be 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 object. An operation of the ultrasound acquisition unit will be described in detail by referring to FIG. **2**.

[0017] 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** may include a transmit (Tx) signal forming section **210**. The Tx signal forming section **210** may generate a plurality of Tx signals and apply delays to the Tx signals.

[0018] The ultrasound data acquisition unit **110** may further include an ultrasound probe **220**, which is coupled to the Tx signal forming section **210**. The ultrasound probe **220** may include an array transducer containing a plurality of transducer elements for reciprocal conversion between electric signals and ultrasound signals. The ultrasound probe **220** may be configured to transmit ultrasound signals in response to the Tx signals. The ultrasound probe **220** may be further configured to receive ultrasound echoes reflected from the target object to thereby output receive signals. In one embodiment, the receive signals may include first receive signals obtained without applying compression to the target object and second receive signals obtained with applying compression to the target object.

[0019] The ultrasound data acquisition unit **110** may further include a beam forming section **230**, which is coupled to the ultrasound probe **220**. The beam forming section **230** may be configured to digitize the electrical receive signals into digital signals. The beam forming section **230** may also apply 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** may further sum the delayed digital signals to form receive-focused signals. In one embodiment, the beam forming section **230** may form first receive-focused signals based on the first receive signals and second receive-focused signals based on the second receive signals.

[0020] The ultrasound data acquisition unit **110** may further include an ultrasound data forming section **240**, which is coupled to the beam forming section **230**. The ultrasound data forming section **240** may be configured to form ultrasound frame data sets corresponding to a plurality of frames based on the receive-focused signals. The ultrasound frame data sets may 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** may be 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 may 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.

[0021] Referring back to FIG. **1**, the processing unit **120**, which is coupled to the ultrasound data acquisition unit **110**, may be embodied with at least one of a central processing unit, a microprocessor, a graphic processing unit and the like. However, the processing unit **120** may not be limited thereto. The processing unit **120** may be configured to control the ultrasound data acquisition unit **110** to perform the transmit/receive operation in a first state where compression is not applied to the target object to thereby obtain the first ultrasound frame data set. Further, the processing unit **120** may be configured to control the ultrasound data acquisition unit **110** to perform the transmit/receive operation in a second state where compression is applied to the target object to thereby obtain the second ultrasound frame data set. The processing unit **120** may be configured to form a strain image (i.e., elastic image) based on the first and second ultrasound frame data sets. The formation process of the strain image will be described in detail by referring to FIG. **3**.

[0022] FIG. **3** is a flowchart showing an illustrative embodiment of forming the strain image. Referring to FIG. **3**, the processing unit **120** may be configured to compute strains between the first ultrasound frame data set and the second ultrasound frame data set at S**302**. The ultrasound frame data set obtained without applying compression to the target object, i.e., the first ultrasound frame data set, and the ultrasound frame data set obtained with applying compression to the target object, i.e., the second ultrasound frame data set, are defined by the following equations for modeling the compression of medium within the target object.

$$x_{pre}(t)=r(t)$$

$$x_{post}(t)=r(at) \tag{1}$$

wherein $x_{pre}(t)$ represents the first ultrasound frame data set, $x_{post}(t)$ represents the second ultrasound frame data set, r(t) and r(at) represent envelopes of the first and second frame data sets and a represents a compression coefficient for scaling in the time axis.

[0023] Assuming that a length of the medium without the compression applied is L_0 and a length of the medium with the compression applied is L, a strain s and the compression coefficient a may be computed by the following equations.

$$s = \frac{L_0 - L}{L_0} \tag{2}$$

$$a = \frac{1}{1-s} \cong 1 + s.$$

[0024] Thus, the strain s and the compression coefficient a for the soft medium (e.g., soft tissues) and the hard medium (e.g., tumor, cancer, etc.) may be represented by the following equations.

$$s_{soft} > s_{hard}$$

$$a_{soft} > a_{hard} \tag{3}$$

wherein s_{soft} represents a strain of the soft medium, s_{hard} represent a strain of the hard medium, a_{soft} represents a compression coefficient of the soft medium and a_{hard} represents a compression coefficient of the hard medium. Thus, if the target object is compressed, then $s>0$ and $a>1$, and if the target object is stretched, then $s<0$ and $a<1$.

[0025] The processing unit **120** may be further configured to compute a strain s with which to perform globally uniform stretching (hereinafter referred to as "reverse strain") at S**304**. The second ultrasound frame data set may be defined by the following equations that model the compression of medium.

$$x_{post\text{-}soft}(t)=r(a_{soft}t),$$
$$x_{post\text{-}hard}(t)=r(a_{hard}t) \tag{4}$$

wherein $x_{post\ soft}(t)$ represents the second ultrasound frame data set corresponding to the soft medium and $x_{post\ hard}(t)$ represents the second ultrasound frame data set corresponding to the hard medium.

[0026] If the second ultrasound frame data set $x_{post\text{-}soft}(t)$ and $x_{post\ hard}(t)$ are stretched by a compression coefficient a_{global}, then the second ultrasound frame data set may be expressed by the following equations.

$$x_{post\text{-}soft\text{-}global}(t)=r(a_{soft}\cdot a_{global}t),$$
$$x_{post\text{-}hard\text{-}global}(t)=r(a_{hard}\cdot a_{global}t) \tag{5}$$

wherein $x_{post\text{-}hard\text{-}global}(t)$ represents an ultrasound frame data set obtained by stretching the second ultrasound frame data set $x_{post\text{-}soft}(t)$ corresponding to the soft medium by the compression coefficient a_{global} and $x_{post\text{-}hard\text{-}global}(t)$ represents an ultrasound frame data set obtained by stretching the second ultrasound frame data set $x_{post\text{-}hard}(t)$ corresponding to the hard medium by the compression coefficient a_{global}.

[0027] Thus, with the adjustment of the compression coefficient a_{global}, an identical effect to compressing the medium in the target object by different coefficients may be achieved. If the compression coefficient a_{global} is adjusted such that $a_{soft}\cdot a_{global}=1$ then the soft medium may be indicated as if the compression was not applied and the hard medium may be indicated as being stretched due to the relationship $a_{hard}\cdot a_{global}<1<a_{hard}$. As such, hardness and softness may be inversely indicated in the strain image compared to the conventional strain image.

[0028] FIG. **4** is a schematic diagram showing an example of performing globally uniform stretching upon the second ultrasound frame data set. Referring to FIG. **4**, if the globally uniform stretching is performed upon the second ultrasound frame data set, then the soft medium, which is relatively more prone to deformation, may be restored to an original state. However, the hard medium, which is relatively less to deformation, may be more stretched than an original state.

[0029] That is, after the process, which renders the stretching process with an adjusted degree of the globally uniform stretching, to restore the soft medium to the original state, if the strain is computed according to the conventional elasticity imaging, then the hard medium may be indicated as a soft region in the strain image. When a length of the soft medium in the first ultrasound frame data set **410** obtained without the compression applied is L_{soft} (see FIG. **4**), the second ultrasound frame data set **420** obtained with the compression applied should be stretched by a reverse strain greater than a strain present in the second ultrasound frame data set to restore the length of the soft medium. Reference numeral "**430**" in FIG. **4** represents the second ultrasound frame data set, which is stretched by a reverse strain identical to the strain caused in the second ultrasound frame data set, while reference numeral "**440**" represents the second ultrasound frame data set stretched by a reverse strain greater than the strain present in the second ultrasound frame data set and to the degree that a length of the soft medium becomes L_{soft}.

[0030] Referring back to FIG. **3**, the processing unit **120** may be further configured to perform the globally uniform stretching upon the second ultrasound frame data set based on the reverse strain to thereby form globally and uniformly stretched second ultrasound frame data set at S**306**. The processing unit **120** may be configured to compute a strain between the first ultrasound frame data set and the stretched second ultrasound frame data set at S**308**, and form an elastic image by using the computed strain at S**310**.

[0031] The storage unit **130**, which is coupled to the ultrasound data acquisition unit **110** via the processing unit **120**, is configured to store the ultrasound data acquired in the ultrasound data acquisition unit **110**. Also, the storage unit **130** may be configured to store the computed strain. The display unit **140** may display the elastic image, which has been formed in the processing unit **120**. The display unit **140** may include at least one of a cathode ray tube (CRT) display, a liquid crystal display (LCD), an organic light emitting diode (OLED) display and the like.

[0032] 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.

What is claimed is:

1. An ultrasound system, comprising:

an ultrasound data acquisition unit configured to perform a transmit/receive operation including transmitting ultrasound signals to a target object and receiving ultrasound echoes reflected from the target object to thereby acquire ultrasound frame data; and

a processing unit configured to control the ultrasound data acquisition unit to perform the transmit/receive operation in a first state where compression is not applied to the target object to thereby obtain a first ultrasound frame data set and control the ultrasound data acquisition unit to perform the transmit/receive operation in a second state where compression is applied to the target object to thereby obtain a second ultrasound frame data set, the processing unit being configured to compute a first strain between the first and second ultrasound frame data sets and perform globally uniform stretching upon the second ultrasound frame data set based on the first strain, the processing unit being further configured to compute a second strain between the first ultrasound frame data set and the stretched second ultrasound frame data set and form an elastic image based on the second strain.

2. The ultrasound system of claim **1**, wherein the processing unit is further configured to compute a reverse strain for the globally uniform stretching based on the first strain and perform the globally uniform stretching upon the second ultrasound frame data set based on the reverse strain.

3. A method of forming an elastic image in an ultrasound system, comprising:

a) acquiring first ultrasound frame data set from a target object without applying compression to the target object;

b) acquiring second ultrasound frame data set from a target object with applying compression to the target object;

c) computing a first strain between the first and second ultrasound frame data sets;

d) performing globally uniform stretching upon the second ultrasound frame data set based on the first strain;

e) computing a second strain between the first ultrasound frame data set and the stretched second ultrasound frame data set; and

f) forming an elastic image based on the second strain.

4. The method of claim **3**, wherein the step d) includes:

computing a reverse strain for the globally uniform stretching based on the first strain; and

performing the globally uniform stretching upon the second ultrasound frame data set based on the reverse strain.

5. A computer-readable storage medium storing instructions that, when executed by a computer, cause the computer to provide a method of forming an elastic image based on first ultrasound frame data set acquired from a target object without applying compression to the target object and second ultrasound frame data set acquired from the target object with applying compression to the target object in an ultrasound system, the method comprising:

computing a first strain between the first and second ultrasound frame data sets;

performing globally uniform stretching upon the second ultrasound frame data set based on the first strain;

computing a second strain between the first ultrasound frame data set and the stretched second ultrasound frame data set; and

forming an elastic image based on the second strain.

* * * * *

patsnap

专利名称(译)	在超声系统中基于拉伸的应变成像		
公开(公告)号	US20120083694A1	公开(公告)日	2012-04-05
申请号	US13/075972	申请日	2011-03-30
申请(专利权)人(译)	MEDISON CO. , LTD.		
当前申请(专利权)人(译)	三星MEDISON CO. , LTD.		
[标]发明人	JEONG MOK KUN PARK SANG SHIK KWON SUNG JAE		
发明人	JEONG, MOK KUN PARK, SANG SHIK KWON, SUNG JAE		
IPC分类号	A61B8/00		
CPC分类号	A61B8/085 A61B8/485 G06T2207/30096 G06T7/0012 G06T2207/10132 A61B8/5238		
优先权	1020100095702 2010-10-01 KR		
外部链接	Espacenet USPTO		

摘要(译)

公开了用于在超声系统中形成弹性图像的实施例。在一个实施例中，处理单元被配置为控制超声数据获取单元在不对目标对象施加压缩的第一状态下执行发射/接收操作，从而获得第一超声帧数据集，并且执行在对目标对象施加压缩的第二状态下进行发送/接收操作，从而获得第二超声帧数据集。处理单元还被配置为计算第一和第二超声帧数据集之间的第一应变，基于第一应变对第二超声帧数据集执行全局均匀拉伸，以及计算第一超声帧数据集之间的第二应变和伸展的第二超声帧数据集，并基于第二应变形成弹性图像。