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YOO(10) **Pub. No.: US 2012/0053463 A1**(43) **Pub. Date: Mar. 1, 2012**(54) **PROVIDING ULTRASOUND SPATIAL
COMPOUND IMAGES IN AN ULTRASOUND
SYSTEM****Publication Classification**(51) **Int. Cl.**
A61B 8/13 (2006.01)(52) **U.S. Cl.** **600/443**(57) **ABSTRACT**(75) **Inventor: Jae Heung YOO, Seoul (KR)**(73) **Assignee: SAMSUNG MEDISON CO.,
LTD.**(21) **Appl. No.: 13/196,497**(22) **Filed: Aug. 2, 2011**(30) **Foreign Application Priority Data**

Aug. 31, 2010 (KR) 10-2010-0084944

Embodiments for providing ultrasound spatial compound images are disclosed. In one embodiment, by way of non-limiting example, an ultrasound system comprises: an ultrasound data acquisition unit configured to acquire ultrasound data for a periodically moving target object; and a processing unit in communication with the ultrasound data acquisition unit, the processing unit being configured to form a plurality of ultrasound images based on the ultrasound data, detect moving periods of the target object based on the ultrasound images, reconstruct the ultrasound images corresponding to each of the moving periods and perform spatial compounding upon the reconstructed ultrasound images to form ultrasound spatial compound images.

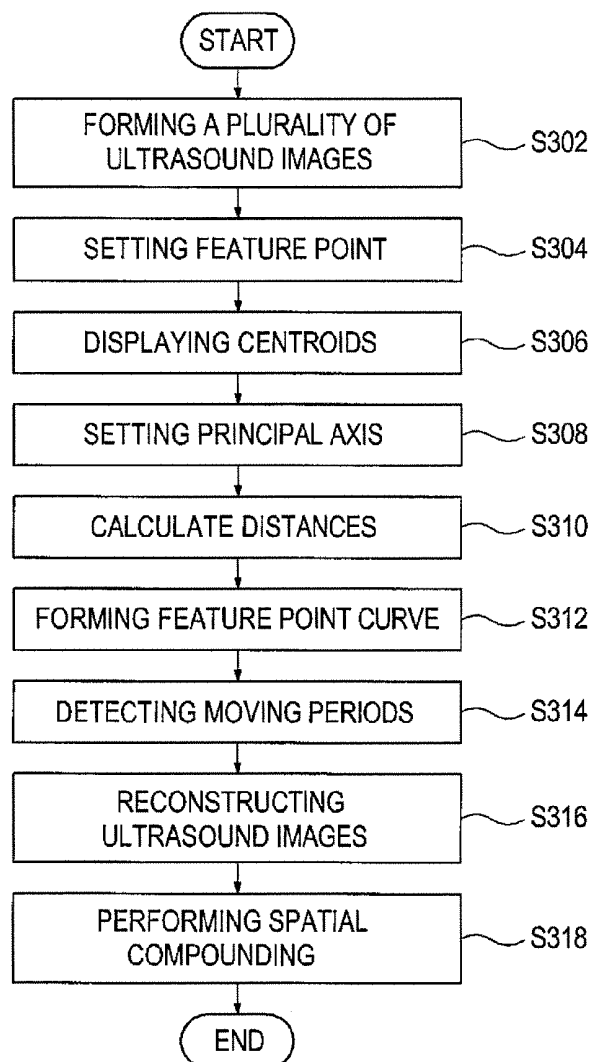


FIG. 1

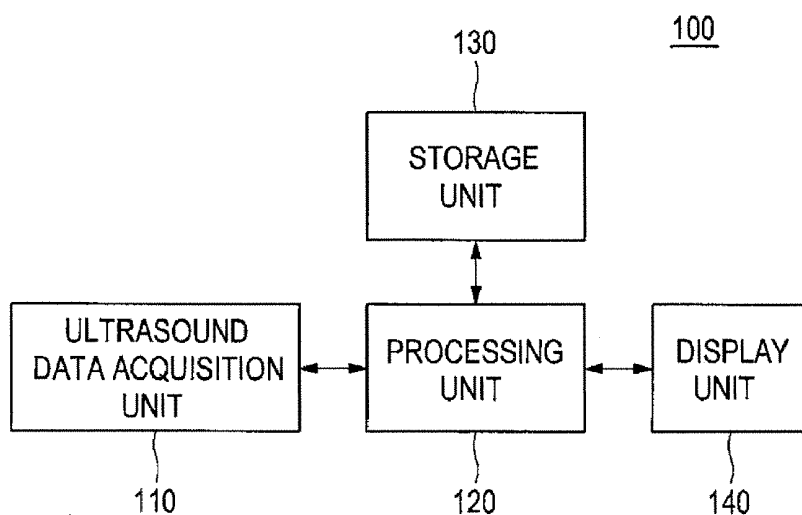


FIG. 2

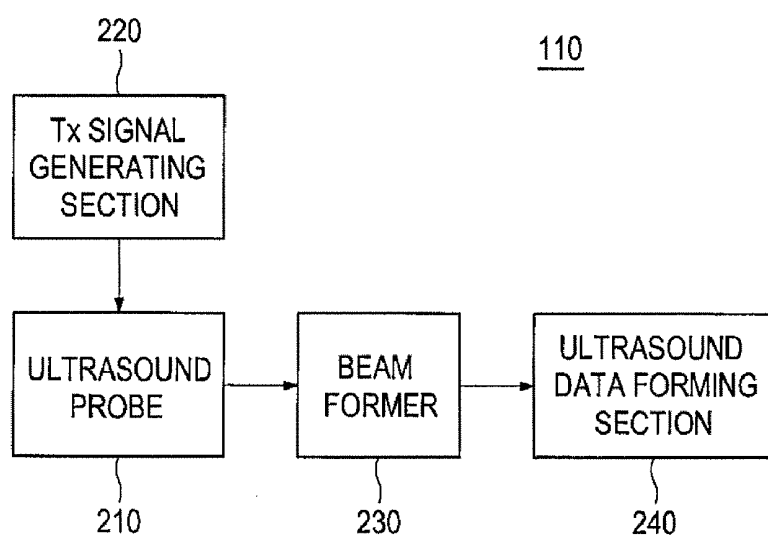


FIG. 3

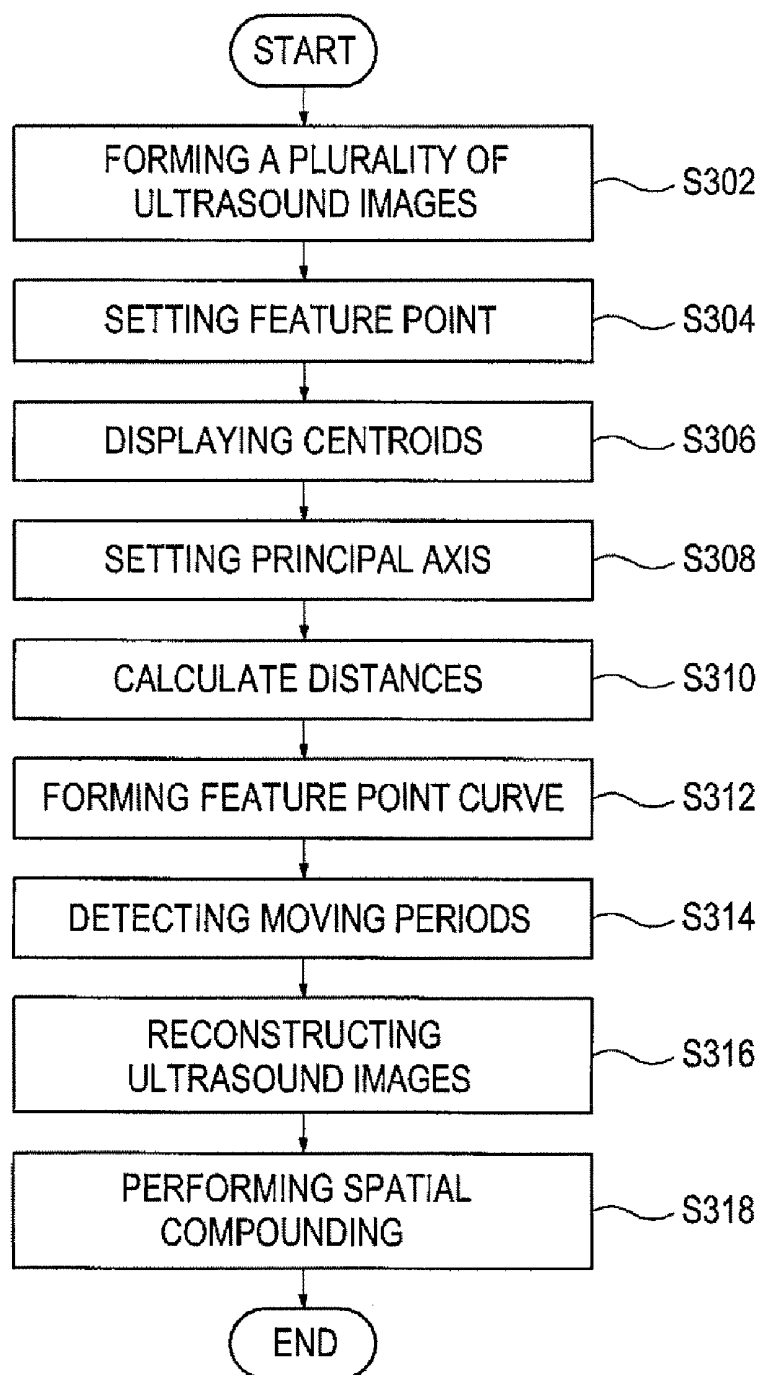


FIG. 4

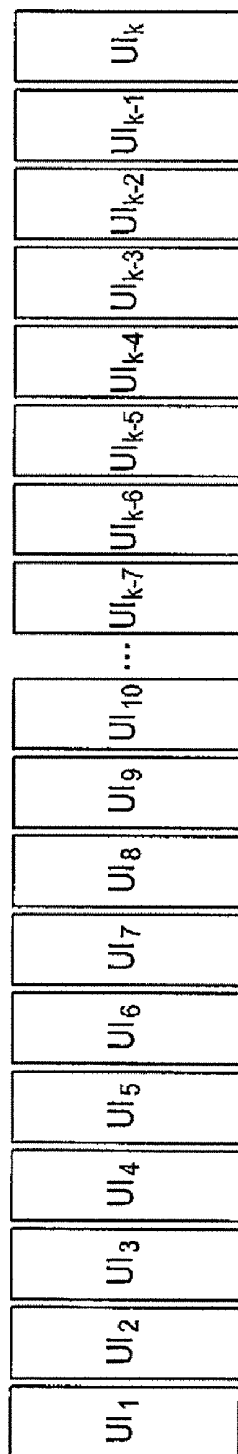


FIG. 5

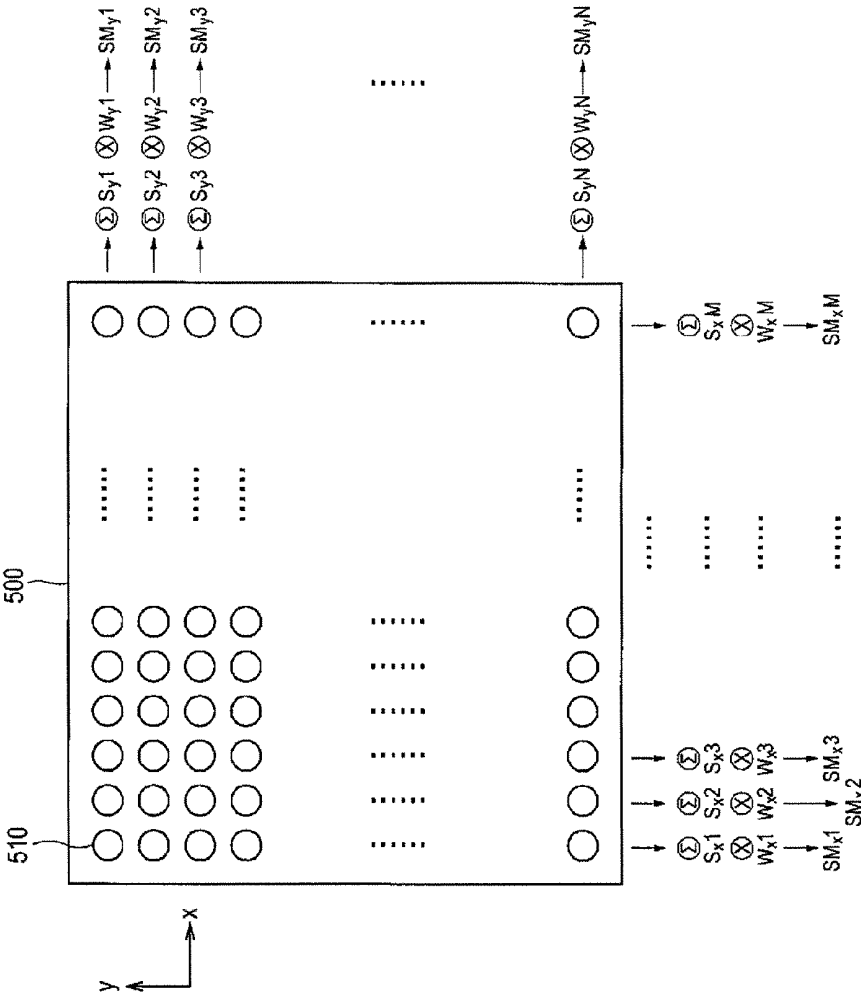


FIG. 6

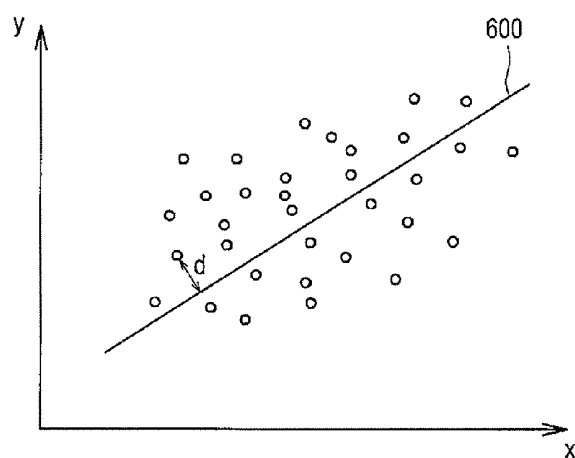


FIG. 7

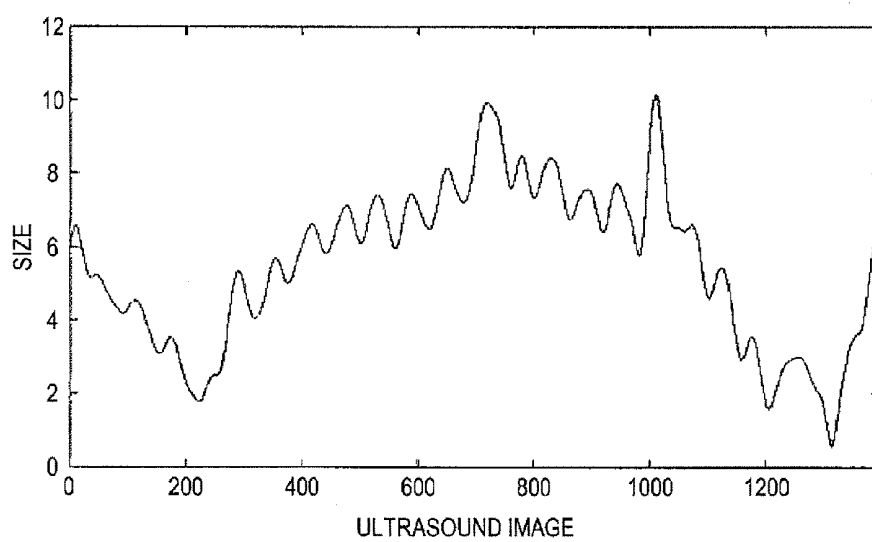
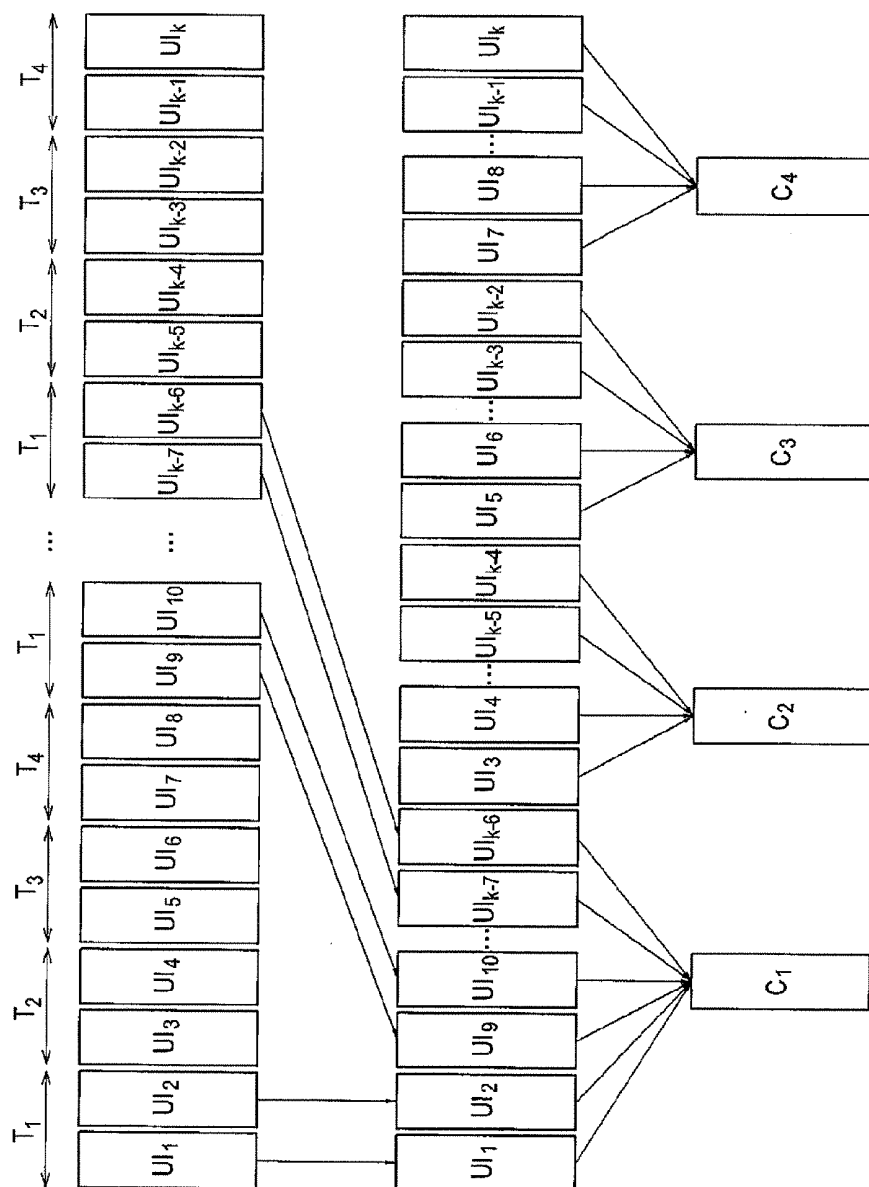


FIG. 8



PROVIDING ULTRASOUND SPATIAL COMPOUND IMAGES IN AN ULTRASOUND SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority from Korean Patent Application No. 10-2010-0084944 filed on Aug. 31, 2010, the entire subject matter of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure generally relates to ultrasound systems, and more particularly to providing ultrasound spatial compound images 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-dimensional or three-dimensional ultrasound images of internal features of a target object (e.g., human organs).

[0004] The ultrasound system may transmit and receive ultrasound signals to and from a living body to thereby form a 2D (two-dimensional) ultrasound image or a 3D (three-dimensional) ultrasound image. Various techniques have been studied to enhance resolution of the ultrasound image. A spatial compounding is known as one of such techniques.

[0005] The spatial compounding is an imaging technique for forming a compound image by combining ultrasound images. That is, the ultrasound system forms a plurality of ultrasound images and performs the spatial compounding upon the ultrasound images to form an ultrasound spatial compound image.

[0006] However, the ultrasound spatial compound image may not be useful in certain cases, e.g., when observing a moving target object such as a heart, a fetus in the uterus, etc. in real time. That is, there is a problem in that an excessive blurring occurs in the ultrasound spatial compound image due to the motion of the target object.

SUMMARY

[0007] Embodiments for providing ultrasound spatial compound images 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 ultrasound data for a periodically moving target object; and a processing unit in communication with the ultrasound data acquisition unit, the processing unit being configured to form a plurality of ultrasound images based on the ultrasound data, detect moving periods of the target object based on the ultrasound images, reconstruct the ultrasound images corresponding to each of the moving periods and perform spatial compounding upon the reconstructed ultrasound images to form ultrasound spatial compound images.

[0008] In another embodiment, there is provided a method of providing ultrasound spatial compound images, comprising: a) acquiring ultrasound data for a periodically moving target object; b) forming a plurality of ultrasound images

based on the ultrasound data; c) detecting moving periods of the target object based on the ultrasound images; d) reconstructing the ultrasound images corresponding to each of the moving periods; and e) performing a spatial compounding upon the reconstructed ultrasound images to form ultrasound spatial compound images.

[0009] In yet another embodiment, there is provided a computer readable medium comprising computer executable instructions configured to perform the following acts: a) acquiring ultrasound data for a periodically moving target object; b) forming a plurality of ultrasound images based on the ultrasound data; c) detecting moving periods of the target object based on the ultrasound images; d) reconstructing the ultrasound images corresponding to each of the moving periods; and e) performing a spatial compounding upon the reconstructed ultrasound images to form ultrasound spatial compound images.

[0010] This 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

[0011] FIG. 1 is a block diagram showing an illustrative embodiment of an ultrasound system.

[0012] FIG. 2 is a block diagram showing an illustrative embodiment of an ultrasound data acquisition unit.

[0013] FIG. 3 is a flow chart showing a process of forming ultrasound spatial compound images.

[0014] FIG. 4 is a schematic diagram showing an example of ultrasound images.

[0015] FIG. 5 is a schematic diagram showing an example of setting a feature point on an ultrasound image.

[0016] FIG. 6 is a schematic diagram showing an example of forming a feature point curve based on distances between principal axis and feature points.

[0017] FIG. 7 is a schematic diagram showing an example of the feature point curve.

[0018] FIG. 8 is a schematic diagram showing an example of forming ultrasound spatial compound images based on moving periods of a target object.

DETAILED DESCRIPTION

[0019] 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.

[0020] Referring to FIG. 1, an ultrasound system **100** in accordance with an illustrative embodiment is shown. As depicted therein, the ultrasound system **100** may include an ultrasound data acquisition unit **110**. The ultrasound data acquisition unit **110** may be configured to transmit and receive ultrasound signals to and from a living body and output ultrasound data. The living body may include a plurality of target objects (e.g., blood vessels, a heart, etc.).

[0021] 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 an ultrasound probe **210**. The ultrasound probe

210 may include a plurality of elements (not shown) for reciprocally converting between ultrasound signals and electrical signals. The ultrasound probe **210** may be configured to transmit ultrasound signals to the living body. The ultrasound probe **210** may be further configured to receive ultrasound signals (i.e., ultrasound echo signals) from the living body to output received signals. The received signals may be analog signals. The ultrasound probe **210** may include a three-dimensional probe, a two-dimensional array probe, a convex probe and the like.

[0022] The ultrasound data acquisition unit **110** may further include a transmit (Tx) signal generating section **220**. The Tx signal generating section **220** may be configured to control the transmission of the ultrasound signals. The Tx signal generating section **220** may be further configured to generate electrical signals ("Tx signals") for obtaining an ultrasound image in consideration of the elements and focal points. The ultrasound image may include a brightness mode image. However, it should be noted herein that the ultrasound image may not be limited thereto.

[0023] In one embodiment, the Tx signal generating section **220** may be configured to generate Tx signals for obtaining a plurality of ultrasound images. Thus, the ultrasound probe **210** may be configured to convert the Tx signals provided from the Tx signal generating section **220** into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output the received signals.

[0024] The ultrasound data acquisition unit **110** may further include a beam former **230**. The beam former **230** may be configured to convert the received signals provided from the ultrasound probe **210** into digital signals. The beam former **230** may be further configured to apply delays to the digital signals in consideration of the elements and the focal points to thereby output digital receive-focused signals.

[0025] The ultrasound data acquisition unit **110** may further include an ultrasound data forming section **240**. The ultrasound data forming section **240** may be configured to form ultrasound data corresponding to each of the ultrasound images based on the digital receive-focused signals provided from the beam former **230**. The ultrasound data may include radio frequency data. However, it should be noted herein that the ultrasound data may not be limited thereto. The ultrasound data forming section **240** may be further configured to perform signal processing (e.g., gain control, etc) upon the digital receive-focused signals.

[0026] Although it is described above that the ultrasound data acquisition unit **110** may be configured to acquire the ultrasound data by transmitting and receiving the ultrasound signals to and from the living body, the ultrasound data acquisition unit **110** may be further configured to acquire the ultrasound data from an external or internal storage unit (not shown) connected to the ultrasound system **100**.

[0027] Referring back to FIG. 1, the ultrasound system **100** may further include a processing unit **120** in communication with the ultrasound data acquisition unit **110**. The processing unit **120** may include a central processing unit, a microprocessor or a graphic processing unit. However, it should be noted herein that the processing unit **120** may not be limited thereto.

[0028] FIG. 3 is a flow chart showing a process of forming ultrasound spatial compound images. The processing unit **120** may be configured to form a plurality of ultrasound images $UI_1, UI_2 \dots UI_K$ as shown in FIG. 4, based on the

ultrasound data provided from the ultrasound data acquisition unit **110**, at step **S302** in FIG. 3.

[0029] The processing unit **120** may be configured to set a feature point on each of the ultrasound images at step **S304** in FIG. 3. The feature point may be set by using a common feature on each of the ultrasound images. In one embodiment, the feature point may be set by using a centroid of brightness values constituting each of the ultrasound images. A method of determining the centroid of the brightness values will be described by using an ultrasound image **500**, which has $M \times N$ pixels **510**, as shown in FIG. 5.

[0030] FIG. 5 is a schematic diagram showing an example of setting the feature point on the ultrasound image **500**. For the sake of convenience, it will be described that the ultrasound image **500** is placed on the X-Y plane of rectangular coordinate system in which the X coordinates of the ultrasound image **500** ranges from 1 to M and the Y coordinates of the ultrasound image **500** ranges from 1 to N. The processing unit **120** may be configured to vertically sum the pixel values at each of the X coordinates 1 to M in the ultrasound image **500**. That is, assuming that brightness values in the ultrasound image **500** are represented by P_{XY} , the processing unit **120** may be configured to sum $P_{X1}, P_{X2} \dots P_{XN}$ to thereby output first sums $Sx1-SxM$ corresponding to the respective X coordinates. Subsequently, the processing unit **120** may be further configured to multiply the first sums $Sx1-SxM$ by weights W_x1-W_xM , respectively, to thereby output first weighted sums $SMx1-SMxM$. In one embodiment, the weights W_x1-W_xM may be determined by arbitrary values, which increase or decrease at a constant interval. For example, the numbers 1-M may be used as the weight values W_x1-W_xM . The processing unit **120** may be further configured to sum all of the first sums $Sx1-SxM$ to thereby output it as a second sum value, as well as sum all of the first weighted sums $SMx1-SMxM$ to thereby output it as a third sum value. The processing unit **120** may be further configured to divide the third sum value by the second sum value. It may then set the division result as the centroid on the X axis.

[0031] Also, the processing unit **120** may be configured to horizontally sum the pixel values at each of the Y coordinates 1-N in the ultrasound image **500**. That is, assuming that brightness values in the ultrasound image **500** are represented by P_{XY} , the processing unit **120** may be configured to sum $P_{1Y}, P_{2Y} \dots P_{MY}$ to thereby output fourth sums $Sy1-SyN$ corresponding to the respective Y coordinates. Subsequently, the processing unit **120** may be further configured to multiply the fourth sums $Sy1-SyN$ by weights W_y1-W_yN , respectively, to thereby output second weighted sums $SMy1-SMyN$. In one embodiment, the weights W_y1-W_yN may be determined by arbitrary values, which increase or decrease at a constant interval. For example, the numbers 1-N may be used as the weight values W_y1-W_yN . The processing unit **120** may be further configured to sum all of the fourth sums $Sy1-SyN$ to thereby output a fifth sum, as well as sum all of the second weighted sums $SMy1-SMyN$ to thereby output a sixth sum. The processing unit **120** may be further configured to divide the sixth sum by the fifth sum and then set the division result as the centroid on the Y axis.

[0032] Although it is described that the feature point is set by using the centroid of brightness values constituting each of the ultrasound images, the feature point setting is certainly not limited thereto.

[0033] Once the setting of the centroid is complete for all of the ultrasound images, the processing unit **120** may be con-

figured to set centroids on the X-Y coordinate system, at step S306 in FIG. 3 and then set a principal axis 600 thereon as shown in FIG. 6, at step S308 in FIG. 3.

[0034] FIG. 6 is a schematic diagram showing an example of forming the feature point curve based on distances between the principal axis and feature points. The processing unit 120 may be configured to calculate distances “d” from the principal axis 600 to each of the centroids, at step S310 in FIG. 3.

[0035] FIG. 7 is a schematic diagram showing an example of a feature point curve. The processing unit 120 may be configured to form the feature point curve by using the computed distances as shown in FIG. 7, at step S312 in FIG. 3.

[0036] The processing unit 120 may be configured to detect moving periods of the target object by using peak points in the graph shown in FIG. 7, at step S314 in FIG. 3. In one embodiment, the processing unit 120 may be configured to calculate the gradients in the feature point curve in FIG. 7. The processing unit 120 may be further configured to calculate zero cross points, the gradient of which changes from positive to negative, and then detect the zero cross points having a similar distance, to thereby detect periods of the detected zero cross points to the moving periods T_1 , T_2 , T_3 and T_4 of the target object as shown in FIG. 8.

[0037] The processing unit 120 may be configured to reconstruct ultrasound images corresponding to each of the moving periods, at step S316 in FIG. 3. In one embodiment, the processing unit 120 may be configured to reconstruct the ultrasound images UI_1 , UI_2 , UI_9 , $UI_{10} \dots UI_{K-7}$ and UI_{K-6} corresponding to the moving period T_1 from the ultrasound images UI_1 to UI_K , as shown in FIG. 8. The processing unit 120 may be further configured to reconstruct the ultrasound images UI_3 , $UI_4 \dots UI_{K-5}$ and UI_{K-4} corresponding to the moving period T_2 from the ultrasound images UI_1 to UI_K , as shown in FIG. 8. The processing unit 120 may be further configured to reconstruct the ultrasound images UI_5 , $UI_6 \dots UI_{K-3}$ and UI_{K-2} corresponding to the moving period T_3 from the ultrasound images UI_1 to UI_K , as shown in FIG. 8. The processing unit 120 may be further configured to reconstruct the ultrasound images UI_7 , $UI_8 \dots UI_{K-1}$ and UI_K corresponding to the moving period T_4 from the ultrasound images UI_1 to UI_K , as shown in FIG. 8.

[0038] Further, while the ultrasound images are being acquired by scanning the living body, the target object (e.g., expectant mother or fetus) may be moved. This makes it difficult to accurately detect the heartbeat of the fetus. Accordingly, the processing unit 120 may be further configured to compensate the motion of the expectant mother or the fetus by matching the brightness of pixels. The detailed description relating to the method of compensating the motion is omitted herein since the conventional methods may be used.

[0039] The processing unit 120 may be configured to perform spatial compounding upon the reconstructed ultrasound images corresponding to each of the moving periods to form ultrasound spatial compound images, at step S318 in FIG. 3. In one embodiment, the processing unit 120 may be configured to perform the spatial compounding upon the reconstructed ultrasound images UI_1 , UI_2 , UI_9 , $UI_{10} \dots UI_{K-7}$ and UI_{K-6} corresponding to the moving period T_1 to form the ultrasound spatial compound image C_1 corresponding to the moving period T_1 , as shown in FIG. 8. The processing unit 120 may be further configured to perform the spatial compounding upon the reconstructed ultrasound images UI_3 , $UI_4 \dots UI_{K-5}$ and UI_{K-4} corresponding to the moving period T_2 to

form the ultrasound spatial compound image C_2 corresponding to the moving period T_2 , as shown in FIG. 8. The processing unit 120 may be further configured to perform the spatial compounding upon the reconstructed ultrasound images UI_5 , $UI_6 \dots UI_{K-3}$ and UI_{K-2} corresponding to the moving period T_3 to form the ultrasound spatial compound image C_3 corresponding to the moving period T_3 , as shown in FIG. 8. The processing unit 120 may be further configured to perform the spatial compounding upon the reconstructed ultrasound images UI_7 , $UI_8 \dots UI_{K-1}$ and UI_K corresponding to the moving period T_4 to form the ultrasound spatial compound image C_4 corresponding to the moving period T_4 , as shown in FIG. 8.

[0040] Referring again to FIG. 1, the ultrasound system 100 may further include a storage unit 130. The storage unit 130 may store the ultrasound data acquired by the ultrasound data acquisition unit 110. The storage unit 130 may further store the ultrasound images formed by processing unit 120.

[0041] The ultrasound system 100 may further include a display unit 140. The display unit 140 may be configured to display the ultrasound spatial compound images formed by the processing unit 120. The display unit 140 may be further configured to display the ultrasound images formed by the processing unit 120.

[0042] In another embodiment, the present invention may provide a computer readable medium comprising computer executable instructions configured to perform the following acts: a) acquiring ultrasound data for a periodically moving target object; b) forming a plurality of ultrasound images based on the ultrasound data; c) detecting moving periods of the target object based on the ultrasound images; d) reconstructing the ultrasound images corresponding to each of the moving periods; and e) performing a spatial compounding upon the reconstructed ultrasound images to form ultrasound spatial compound images. The computer readable medium may comprise a floppy disk, a hard disk, a memory, a compact disk, a digital video disk, etc.

[0043] 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 acquire ultrasound data for a periodically moving target object; and

a processing unit in communication with the ultrasound data acquisition unit, the processing unit being configured to form a plurality of ultrasound images based on the ultrasound data, detect moving periods of the target object based on the ultrasound images, reconstruct the ultrasound images corresponding to each of the moving periods and perform spatial compounding upon the reconstructed ultrasound images to form ultrasound spatial compound images.

2. The ultrasound system of claim 1, wherein the processing unit is configured to:

set a feature point on each of the ultrasound images based on brightness values of pixels included therein;
form a feature point curve based on the feature points; and
detect the moving periods of the target object based on the feature point curve.

3. The ultrasound system of claim 2, wherein the processing unit is configured to set a centroid of the brightness values on each of the ultrasound images to the feature point.

4. The ultrasound system of claim 2, wherein the processing unit is configured to:

set a principal axis based on positions of the feature points;
and
form the feature point curve based on distances between the feature points and the principal axis.

5. The ultrasound system of claim 2, wherein the processing unit is configured to:

calculate gradients from the feature point curve;
detect zero crossing points that a sign of the gradient changes from positive to negative; and
determine the moving period based on intervals between the detected zero crossing points.

6. The ultrasound system of claim 2, wherein the processing unit is further configured to compensate the motion of the target object.

7. A method of providing ultrasound spatial compound images, comprising:

a) acquiring ultrasound data for a periodically moving target object;
b) forming a plurality of ultrasound images based on the ultrasound data;
c) detecting moving periods of the target object based on the ultrasound images;
d) reconstructing the ultrasound images corresponding to each of the moving periods; and
e) performing a spatial compounding upon the reconstructed ultrasound images to form ultrasound spatial compound images.

8. The method of claim 7, wherein the step c) comprises:

c1) setting a feature point on each of the ultrasound images based on brightness values of pixels included therein;
c2) forming a feature point curve based on the feature points; and
c3) detecting the moving periods of the target object based on the feature point curve.

9. The method of claim 8, wherein the step c1) comprises: setting a centroid of the brightness values on each of the ultrasound images to the feature point.

10. The method of claim 8, wherein the step c2) comprises: setting a principal axis based on positions of the feature points; and

forming the feature point curve based on distances between the feature points and the principal axis.

11. The method of claim 8, wherein the step c3) comprises: calculating gradients from the feature point curve;
detecting zero crossing points that a sign of the gradient changes from positive to negative; and
determining the moving period based on intervals between the detected zero crossing points.

12. The method of claim 8, wherein the step c) further comprises:

compensating the motion of the target object.

13. A computer readable medium comprising computer executable instructions configured to perform following acts:

a) acquiring ultrasound data for a periodically moving target object;
b) forming a plurality of ultrasound images based on the ultrasound data;
c) detecting moving periods of the target object based on the ultrasound images;
d) reconstructing the ultrasound images corresponding to each of the moving periods; and
e) performing a spatial compounding upon the reconstructed ultrasound images to form ultrasound spatial compound images.

* * * * *

专利名称(译)	在超声系统中提供超声空间复合图像		
公开(公告)号	US20120053463A1	公开(公告)日	2012-03-01
申请号	US13/196497	申请日	2011-08-02
[标]申请(专利权)人(译)	三星麦迪森株式会社		
申请(专利权)人(译)	三星MEDISON CO. , LTD.		
当前申请(专利权)人(译)	三星MEDISON CO. , LTD.		
[标]发明人	YOO JAE HEUNG		
发明人	YOO, JAE HEUNG		
IPC分类号	A61B8/13		
CPC分类号	A61B8/0866 A61B8/5238 G01S15/8995 G01S15/8977 G01S7/52087		
优先权	1020100084944 2010-08-31 KR		
外部链接	Espacenet USPTO		

摘要(译)

公开了用于提供超声空间复合图像的实施例。在一个实施例中，作为非限制性示例，超声系统包括：超声数据获取单元，被配置为获取周期性移动的目标对象的超声数据；处理单元，用于与超声数据采集单元通信，处理单元，用于基于超声数据形成多个超声图像，基于超声图像检测目标对象的运动周期，重建对应于超声图像的超声图像每个移动周期并对重建的超声图像执行空间复合以形成超声空间复合图像。

