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(72) Inventors:  
• **Lee, Suk Jin**  
**135-851, Seoul (KR)**  
• **Kim, Jung**  
**135-851, Seoul (KR)**

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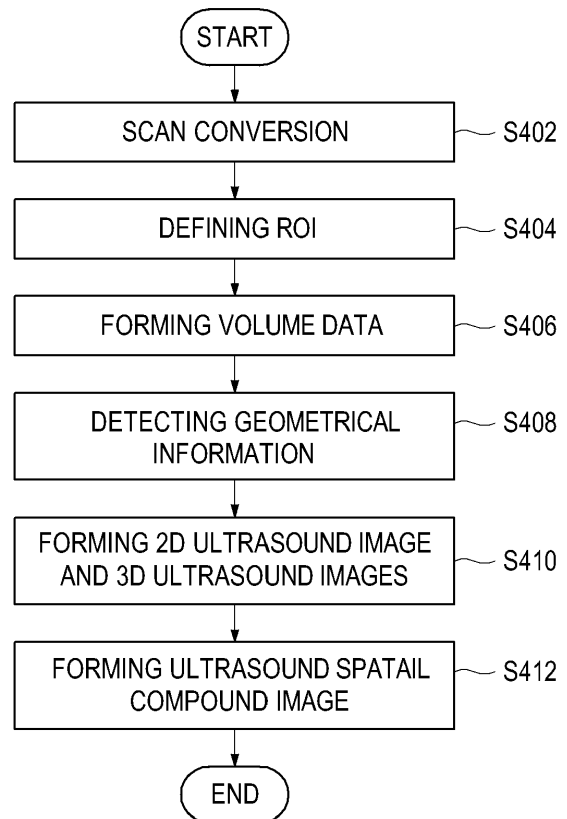
(74) Representative: **Schmid, Wolfgang**  
**Lorenz & Kollegen**  
**Patentanwälte Partnerschaftsgesellschaft**  
**Alte Ulmer Strasse 2**  
**89522 Heidenheim (DE)**

(71) Applicant: **MEDISON CO., LTD.**  
**Gangwon-do 250-875 (KR)**

(54) **Providing an ultrasound spatial compound image in an ultrasound system**

(57) Embodiments for providing an ultrasound spatial compound image are disclosed. In one embodiment, by way of non-limiting example, an ultrasound system comprises: an ultrasound data acquisition unit configured to transmit and receive ultrasound signals to and from a target object to output first ultrasound data and a plurality of sets of second ultrasound data corresponding to a region of interest (ROI); a user input unit configured to receive input information for defining the ROI; and a processing unit in communication with the ultrasound data acquisition unit and the user input unit, the processing unit being configured to form volume data based on the plurality of sets of second ultrasound data, compare the first ultrasound data with the volume data to detect geometric information therein, form a two-dimensional (2D) ultrasound image based on the first ultrasound data, and a first three-dimensional (3D) ultrasound image and a second 3D ultrasound data based on the volume data in consideration of the geometric information, and perform a spatial compound upon the 2D ultrasound image, the first 3D ultrasound image and the second 3D ultrasound image based on the geometric information to form an ultrasound spatial compound image.

**FIG. 4**



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## Description

### TECHNICAL FIELD

**[0001]** The present disclosure generally relates to ultrasound systems, and more particularly to providing an ultrasound spatial compound image of two-dimensional and three-dimensional ultrasound images in an ultrasound system.

### BACKGROUND

**[0002]** 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 (2D) or three-dimensional (3D) ultrasound images of internal features of an object (e.g., human organs).

**[0003]** The ultrasound system may provide the 3D ultrasound image including clinical information such as spatial information and anatomical figures of the target object, which cannot be provided by the 2D ultrasound image. The ultrasound system may transmit ultrasound signals into the target object and receive ultrasound echo signals reflected from the target object. The ultrasound system may further form the 2D ultrasound image based on the ultrasound echo signals. The ultrasound system may further transmit ultrasound signals into the target object and receive ultrasound echo signals reflected from the target object. The ultrasound system may further form volume data corresponding to a region of interest (ROI) defined in the 2D ultrasound image based on the ultrasound echo signals. The ultrasound system may further render the volume data to thereby form the 3D ultrasound image. However, it may be difficult to precisely comprehend a correlation between the 2D ultrasound image and the 3D ultrasound image.

### SUMMARY

**[0004]** Embodiments for providing a plurality of slice 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 transmit and receive ultrasound signals to and from a target object to output first ultrasound data and a plurality of sets of second ultrasound data corresponding to a region of interest (ROI); a user input unit configured to receive input information for defining the ROI; and a processing unit in communication with the ultrasound data acquisition unit and the user input unit, the processing unit being configured to form volume data based on the plurality of sets of second ultrasound data, compare the first ultrasound data with the volume data to detect geometric information therein, form

a two-dimensional (2D) ultrasound image based on the first ultrasound data, and a first three-dimensional (3D) ultrasound image and a second 3D ultrasound data based on the volume data in consideration of the geometric information, and perform a spatial compound upon the 2D ultrasound image, the first 3D ultrasound image and the second 3D ultrasound image based on the geometric information to form an ultrasound spatial compound image.

**[0005]** In another embodiment, there is provided a method of providing an ultrasound spatial compound image, comprising: a) acquiring first ultrasound data for forming a two-dimensional (2D) ultrasound image indicative of a target object; b) acquiring a plurality of sets of second ultrasound data to form volume data corresponding to the target object; c) comparing the first ultrasound data with the volume data to detect geometric information therein; d) forming the 2D ultrasound image based on the first ultrasound data, and a first three-dimensional (3D) ultrasound image and a second 3D ultrasound image based on the volume data in consideration of the geometric information; and e) performing a spatial compound upon the 2D ultrasound image, the first 3D ultrasound image and the second 3D ultrasound image based on the geometric information to form an ultrasound spatial compound image.

**[0006]** In yet another embodiment, there is provided a computer readable medium comprising computer executable instructions configured to perform the following acts: a) acquiring first ultrasound data for forming a two-dimensional (2D) ultrasound image indicative of a target object; b) acquiring a plurality of sets of second ultrasound data to form volume data corresponding to the target object; c) comparing the first ultrasound data with the volume data to detect geometric information therein; d) forming the 2D ultrasound image based on the first ultrasound data, and a first three-dimensional (3D) ultrasound image and a second 3D ultrasound image based on the volume data in consideration of the geometric information; and e) performing a spatial compound upon the 2D ultrasound image, the first 3D ultrasound image and the second 3D ultrasound image based on the geometric information to form an ultrasound spatial compound image.

**[0007]** 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

#### **[0008]**

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.

FIG. 3 is a schematic diagram showing an example of acquiring ultrasound data corresponding to a plurality of frames.

FIG. 4 is a flow chart showing a process of forming an ultrasound spatial compound image.

FIG. 5 is a schematic diagram showing an example of volume data.

FIG. 6 is a schematic diagram showing an example of an ultrasound spatial compound image.

#### DETAILED DESCRIPTION

**[0009]** 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.

**[0010]** Referring to FIG. 1, an ultrasound system 100 in accordance with an illustrative embodiment is shown. As depicted therein, the ultrasound system 100 includes an ultrasound data acquisition unit 110. The ultrasound data acquisition unit 110 is configured to transmit and receive ultrasound signals to and from a target object to output ultrasound data.

**[0011]** 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 (Tx) signal generating section 210, an ultrasound probe 220, a beam former 230 and an ultrasound data forming section 240.

**[0012]** The Tx signal generating section 210 is configured to generate Tx signals. In one embodiment, the Tx signal generating section 210 generates first Tx signals for obtaining a frame corresponding to a two-dimensional (2D) ultrasound image indicative of the target object. The Tx signal generating section 210 further generates a plurality of sets of second Tx signals for obtaining a plurality of frames  $F_i$  ( $1 \leq i \leq N$ ) corresponding to a three-dimensional (3D) ultrasound image at every predetermined time, as shown in FIG. 3.

**[0013]** FIG. 3 is a schematic diagram showing an example of acquiring ultrasound data corresponding to the plurality of frames  $F_i$  ( $1 \leq i \leq N$ ). The plurality of frames  $F_i$  ( $1 \leq i \leq N$ ) represent sectional planes of the target object (not shown).

**[0014]** Referring back to FIG. 2, the ultrasound probe 220 includes a plurality of elements (not shown) for reciprocally converting between ultrasound signals and electrical signals. The ultrasound probe 220 is configured to transmit and receive ultrasound signals to and from the target object to output received signals. The received signals are analog signals. The ultrasound probe 220

includes a three-dimensional (3D) mechanical probe, a two-dimensional (2D) array probe and the like. However, it should be noted herein that the ultrasound probe 220 may not be limited thereto.

**[0015]** In one embodiment, the ultrasound probe 220 transmits ultrasound signals into the target object in response to the first Tx signals provided from the Tx signals generating section 210. The ultrasound probe 220 further receives ultrasound echo signals reflected from the target object to thereby output first received signals to form a 2D ultrasound image. The ultrasound probe 220 further transmits ultrasound signals into the target object in response to the second Tx signals provided from the Tx signal generating section 210. The ultrasound probe 220 further receives ultrasound echo signals reflected from the target object to thereby output second received signals to form volume data.

**[0016]** The beam former 230 is configured to convert the received signals provided from the ultrasound probe 220 into digital signals. The beam former 230 further applies delays to the digital signals in consideration of distances between the elements and focal points to thereby output digital receive-focused signals.

**[0017]** In one embodiment, the beam former 230 converts the first received signals provided from the ultrasound probe 220 into first digital signals. The beam former 230 further applies delays to the first digital signals in consideration of the distances between the elements and the focal points to thereby output first digital receive-focused signals. The beam former 230 further converts the second received signals provided from the ultrasound probe 220 into second digital signals. The beam former 230 further applies delays to the second digital signals in consideration of the distances between the elements and the focal points to thereby output second digital receive-focused signals.

**[0018]** The ultrasound data forming section 240 is configured to form ultrasound data based on the digital receive-focused signals. The ultrasound data forming section 240 further performs various signal processing (e.g., gain adjustment) upon the digital receive-focused signals.

**[0019]** In one embodiment, the ultrasound data forming section 240 forms first ultrasound data based on the first digital receive-focused signals. The first ultrasound data are stored in a storage unit 140 in FIG. 1. The ultrasound data forming section 240 further forms a plurality of sets of second ultrasound data corresponding to the plurality of frames  $F_i$  ( $1 \leq i \leq N$ ) based on the plurality of second digital receive-focused signals provided from the beam former 230. The plurality of sets of second ultrasound data are stored in the storage unit 140 shown in FIG. 1.

**[0020]** Referring back to FIG. 1, the ultrasound system 100 further includes a user input unit 120. The user input unit 120 is configured to receive input information from a user. In one embodiment, the input information includes first input information for defining a region of interest

(ROI), as well as second input information for rotating an ultrasound spatial compound image. The user input unit 120 includes a control panel, a mouse, a keyboard and the like. However, it should be noted herein that the user input unit 120 may not be limited thereto.

**[0021]** The ultrasound system 100 further includes a processing unit 130 in communication with the ultrasound data acquisition unit 110 and the user input unit 120. The processing unit 130 includes a central processing unit, a microprocessor, a graphic processing unit and the like. However, it should be noted herein that the processing unit 130 may not be limited thereto.

**[0022]** FIG. 4 is a flow chart showing a process of forming the ultrasound spatial compound image. The processing unit 130 is configured to perform a scan-conversion upon the first ultrasound data formed by the ultrasound data forming section 240 to form an ultrasound image, at step 402 in FIG. 4.

**[0023]** The processing unit 130 is configured to define the ROI in the ultrasound image based on the input information (i.e., first input information) provided from the user input unit 120, at step S404 in FIG. 4.

**[0024]** The processing unit 130 is configured to synthesize the plurality of sets of second ultrasound data corresponding to the plurality of frames  $F_i$  ( $1 \leq i \leq N$ ) to thereby form volume data 510 as shown in FIG. 5, at step S406 in FIG. 4. The volume data are stored in the storage unit 140 as shown in FIG. 1.

**[0025]** FIG. 5 is a schematic diagram showing an example of the volume data 510. The volume data 510 include a plurality of voxels (not shown) having brightness values. In FIG. 5, reference numerals 521 to 523 represent an A plane, a B plane and a C plane. The A plane 521, the B plane 522 and the C plane 523 are mutually orthogonal. Also, in FIG. 5, the axial direction is a Tx direction of the ultrasound signals, the lateral direction is a longitudinal direction of the elements, and the elevation direction is a swing direction of the elements, i.e., a depth direction of the 3D ultrasound image.

**[0026]** The processing unit 130 is configured to compare the first ultrasound data with the volume data 510 to detect geometric information therein, at step S408 in FIG. 4. In one embodiment, the processing unit 130 detects similarities between the first ultrasound data and each of the second ultrasound data. The processing unit 130 further compares the similarities to detect a maximum similarity. The processing unit 130 further detects a position of second ultrasound data corresponding to the maximum similarity from the volume data 510. The processing unit 130 further sets the detected position as the geometric information between the first ultrasound data and the volume data 510.

**[0027]** The processing unit 130 is configured to form a two-dimensional (2D) ultrasound image based on the first ultrasound data, and 3D ultrasound images based on the volume data 510 in consideration of the geometric information, at step S410 in FIG. 4.

**[0028]** In one embodiment, the processing unit 130

performs the scan conversion upon the first ultrasound data to form the 2D ultrasound image 610 as shown in FIG. 6. The processing unit 130 further extracts a portion of the volume data 510 corresponding to a first region, which is located on a front of the geometric information in the elevation direction (i.e., -z direction as shown in FIG. 6) of the volume data 510. The processing unit 130 further renders the extracted portion of the volume data 510 corresponding to the first region to form a 3D ultrasound image ("a first 3D ultrasound image") 620 as shown in FIG. 6. The processing unit 130 further performs a color rendering upon the extracted portion of the volume data 510. The methods of performing the color rendering are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present invention. The processing unit 130 further performs an alpha blending processing upon the first 3D ultrasound image 620 to set a transparency of the first 3D ultrasound image 620. The processing unit 130 further extracts the remaining portion of the volume data 510 corresponding to a second region, which is located on a back of the geometric information in the elevation direction (i.e., +z direction as shown in FIG. 6) of the volume data 510. The processing unit 130 further renders the extracted remaining portion of the volume data 510 corresponding to the second region to form a 3D ultrasound image ("a second 3D ultrasound image") 630 as shown in FIG. 6. The processing unit 130 further performs a color rendering upon the extracted remaining portion of the volume data 510. The processing unit 130 further performs an alpha blending processing upon the second 3D ultrasound image 630 to set a transparency of the second 3D ultrasound image 630.

**[0029]** The processing unit 130 is configured to perform a spatial compound upon the 2D ultrasound image 610 and the 3D ultrasound images 620 and 630 to form the ultrasound spatial compound image 600 as shown in FIG. 6, at step S412 in FIG. 4.

**[0030]** Optionally, the processing unit 130 further rotates the ultrasound spatial compound image 600 based on the input information (i.e., second input information) provided from the user input unit 120.

**[0031]** Referring back to Figure 1, the ultrasound system 100 further includes the storage unit 140. The storage unit 140 stores the first ultrasound data and the plurality of sets of second ultrasound data acquired from the ultrasound data acquisition unit 110. The storage unit 140 further stores the volume data 510 formed by the processing unit 130.

**[0032]** The ultrasound system 100 further includes a display unit 150. The display unit 150 displays the 2D ultrasound image formed by the processing unit 130. The display unit 150 further displays the ultrasound spatial compound image formed by the processing unit 130. The display unit 150 further displays the 3D ultrasound images formed by the processing unit 130.

**[0033]** 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 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 transmit and receive ultrasound signals to and from a target object to output first ultrasound data and a plurality of sets of second ultrasound data corresponding to a region of interest (ROI); a user input unit configured to receive input information for defining the ROI; and a processing unit in communication with the ultrasound data acquisition unit and the user input unit, the processing unit being configured to form volume data based on the plurality of sets of second ultrasound data, compare the first ultrasound data with the volume data to detect geometric information therein, form a two-dimensional (2D) ultrasound image based on the first ultrasound data, and a first three-dimensional (3D) ultrasound image and a second 3D ultrasound data based on the volume data in consideration of the geometric information, and perform a spatial compound upon the 2D ultrasound image, the first 3D ultrasound image and the second 3D ultrasound image based on the geometric information to form an ultrasound spatial compound image.

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

detect similarities between the first ultrasound data and each of the second ultrasound data; compare the similarities to detect a maximum similarity; detect a position of second ultrasound data corresponding to the maximum similarity from the volume data; and set the detected position as the geometric information between the first ultrasound data and the volume data.

### 3. The ultrasound system of Claim 1, wherein the

processing unit is configured to:

extract a portion of the volume data corresponding to a first region based on the geometric information from the volume data, wherein the first region locates on a front of the geometric information in an elevation direction of the volume data;

render the extracted portion of the volume data corresponding to the first region to form the first 3D ultrasound image;

extract a remaining portion of the volume data corresponding to a second region based on the geometric information from the volume data, wherein the second region locates on a back of the geometric information in the elevation direction of the volume data; and

render the extracted remaining portion of the volume data corresponding to the second region to form the second 3D ultrasound image.

### 4. The ultrasound system of Claim 1, wherein the processing unit is further configured to perform a color rendering upon the extracted portion of the volume data corresponding to the first region and the extracted remaining portion of the volume data corresponding to the second region.

### 5. The ultrasound system of Claim 1, wherein the processing unit is further configured to perform an alpha blending processing upon the first 3D ultrasound image and the second 3D ultrasound image.

### 6. A method of providing an ultrasound spatial compound image, comprising:

a) acquiring first ultrasound data for forming a two-dimensional (2D) ultrasound image indicative of a target object;

b) acquiring a plurality of sets of second ultrasound data to form volume data corresponding to the target object;

c) comparing the first ultrasound data with the volume data to detect geometric information therein;

d) forming the 2D ultrasound image based on the first ultrasound data, and a first three-dimensional (3D) ultrasound image and a second 3D ultrasound image based on the volume data in consideration of the geometric information; and

e) performing a spatial compound upon the 2D ultrasound image, the first 3D ultrasound image and the second 3D ultrasound image based on the geometric information to form an ultrasound spatial compound image.

### 7. The method of Claim 6, wherein the step c) comprises:

detecting similarities between the first ultrasound data and each of the second ultrasound data;  
 comparing the similarities to detect a maximum similarity;  
 detecting a position having the maximum similarity from the volume data; and  
 setting the detected position as the geometric information therein.

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8. The method of Claim 6, wherein the step d) comprises:

performing a scan conversion upon the first ultrasound data to form the 2D ultrasound data;  
 extracting a portion of the volume data corresponding to a first region based on the geometric information from the volume data, wherein the first region locates on a front of the geometric information in an elevation direction of the volume data;  
 rendering the extracted portion of the volume data corresponding to the first region to form the first 3D ultrasound image;  
 extracting a remaining portion of the volume data corresponding to a second region based on the geometric information from the volume data, wherein the second region locates on a back of the geometric information in the elevation direction of the volume data; and  
 rendering the extracted remaining portion of the volume data corresponding to the second region to form the second 3D ultrasound image.

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9. The method of Claim 8, wherein the step d) further comprises:

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performing a color rendering upon the extracted portion of the volume data corresponding to the first region and the extracted remaining portion of the volume data corresponding to the second region.

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10. The method of Claim 8, wherein the step d) further comprises:

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performing an alpha blending processing upon the first 3D ultrasound image and the second 3D ultrasound image.

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FIG. 1

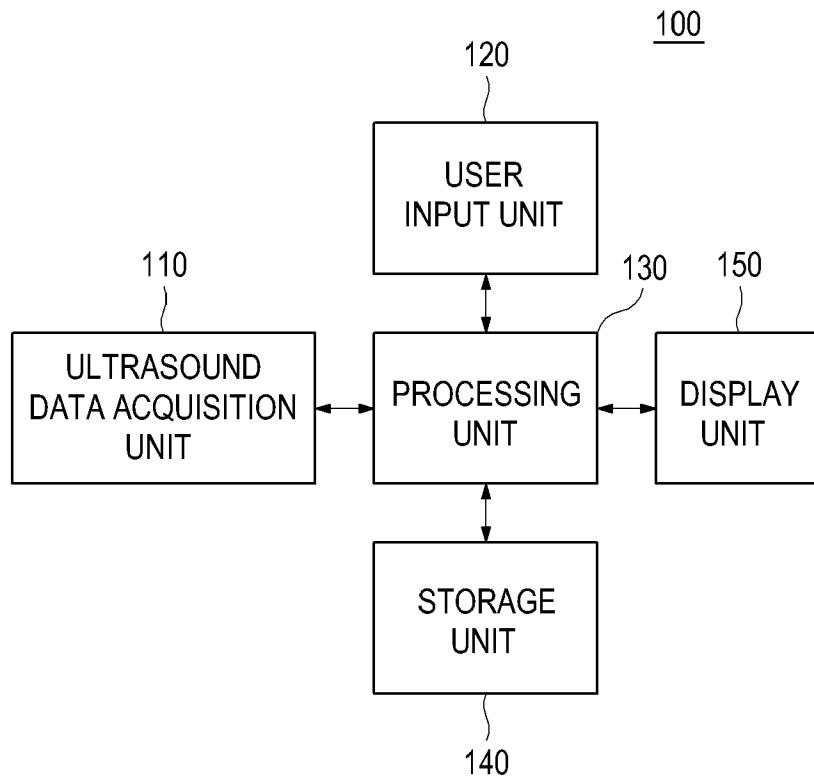


FIG. 2

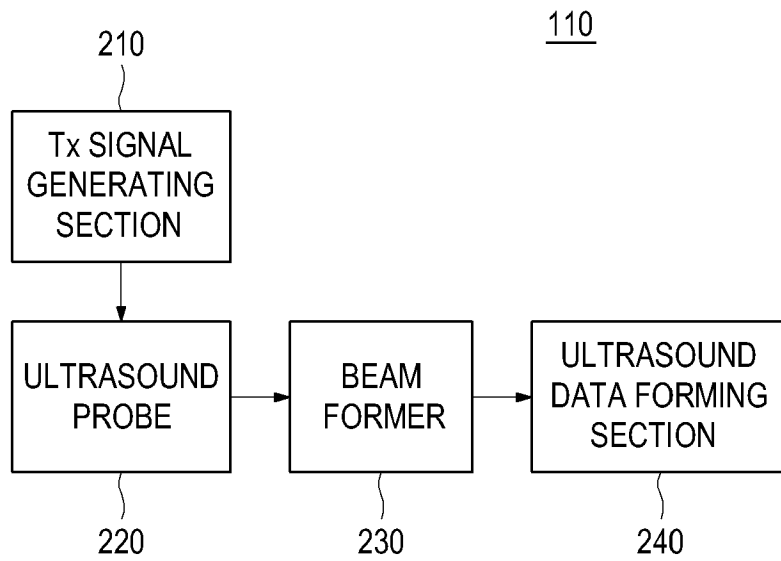


FIG. 3

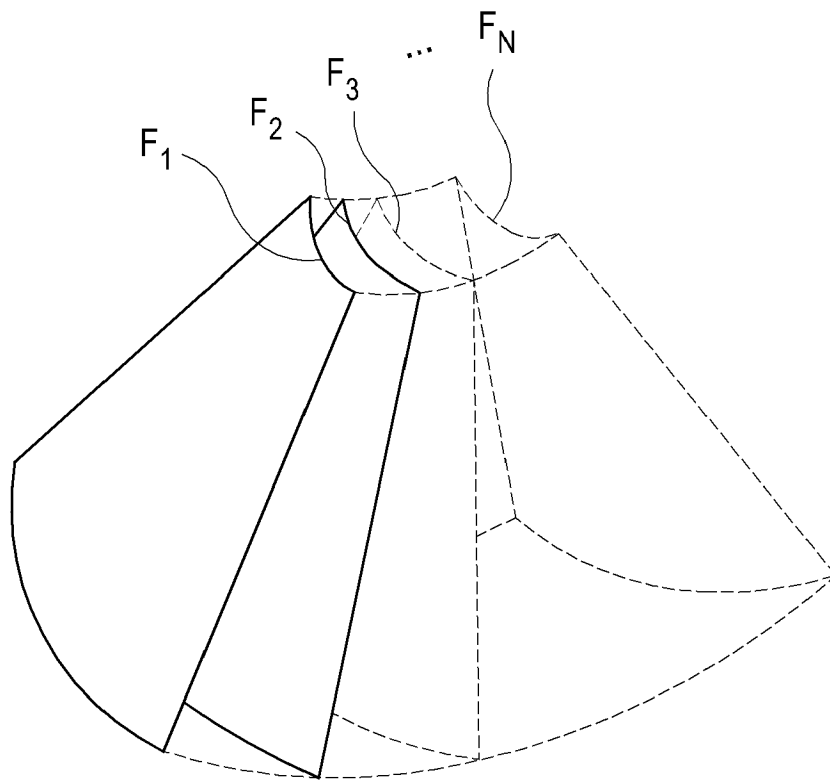


FIG. 4

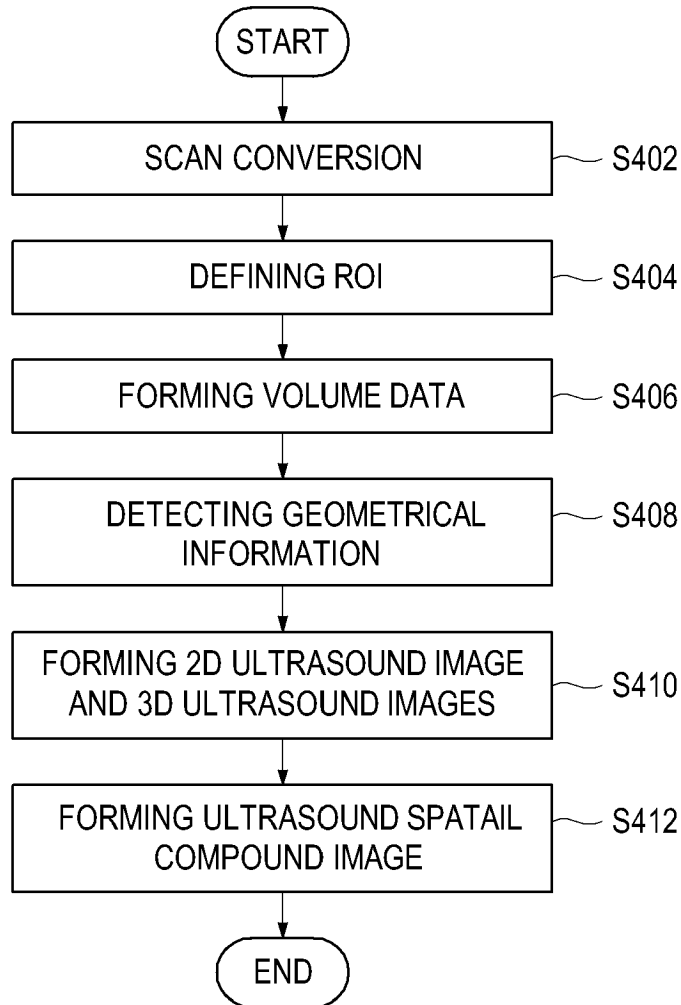


FIG. 5

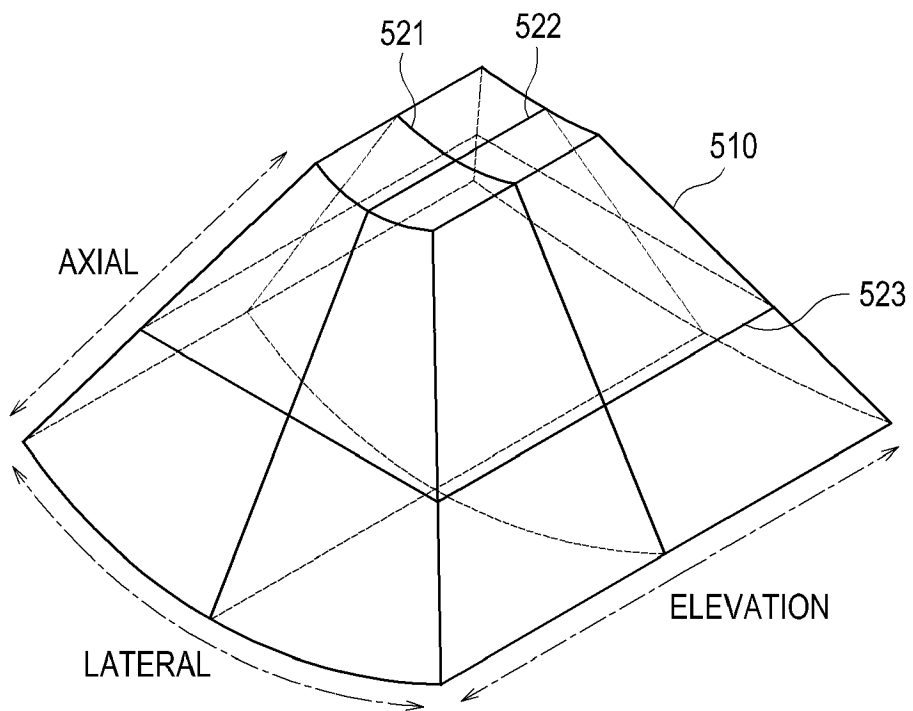
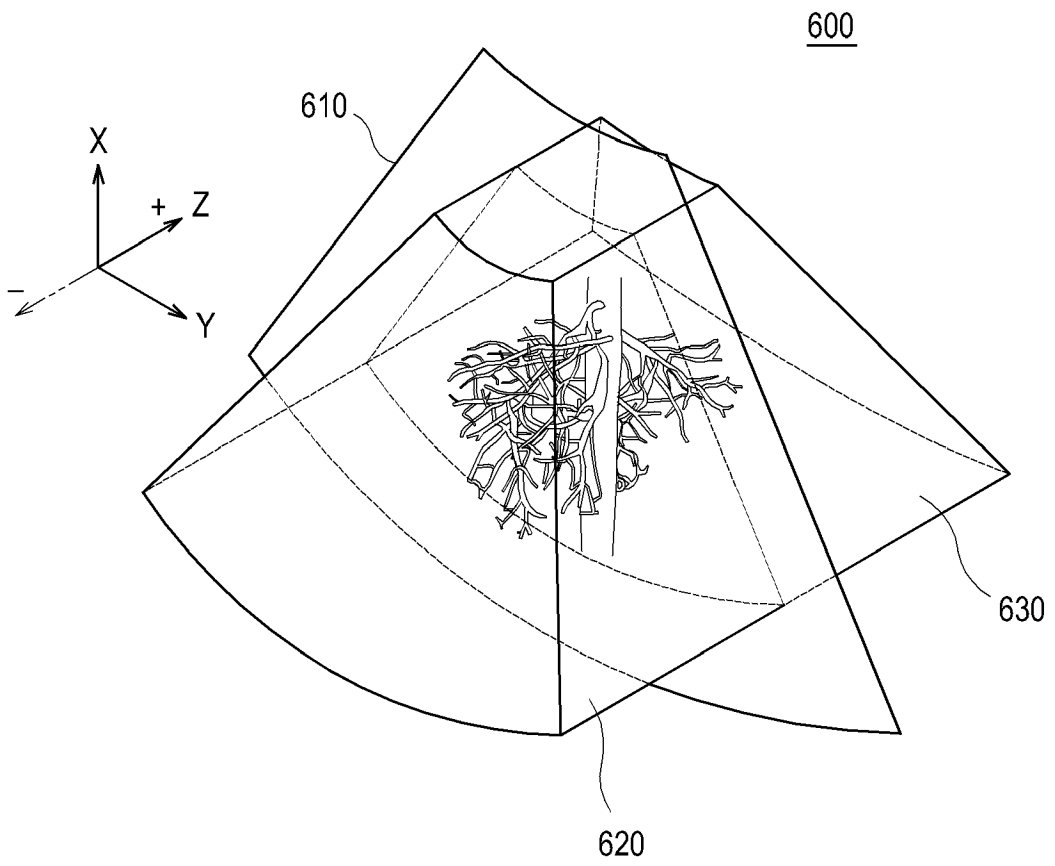


FIG. 6



|               |   |         |            |
|---------------|---|---------|------------|
| 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       | <a href="#">EP2333724A2</a>   | 公开(公告)日 | 2011-06-15 |
| 申请号           | EP2010192103  | 申请日     | 2010-11-22 |
| 申请(专利权)人(译)   | MEDISON CO. , LTD.  |         |            |
| 当前申请(专利权)人(译) | MEDISON CO. , LTD.  |         |            |
| [标]发明人        | LEE SUK JIN<br>KIM JUNG   |         |            |
| 发明人           | LEE, SUK JIN<br>KIM, JUNG   |         |            |
| IPC分类号        | G06T17/00 G01S7/52 A61B8/00 A61B8/08 A61B8/13 G01S15/89   |         |            |
| CPC分类号        | G01S15/8993 A61B8/085 A61B8/13 A61B8/469 A61B8/5215 A61B8/5253 G01S7/52063 G01S7/52071 G01S7/52074 G06T7/0012 |         |            |
| 代理机构(译)       | SCHMID , WOLFGANG   |         |            |
| 优先权           | 1020090121590 2009-12-09 KR   |         |            |
| 其他公开文献        | EP2333724A3   |         |            |
| 外部链接          | <a href="#">Espacenet</a>   |         |            |

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，被配置为向目标对象发送超声信号和从目标对象接收超声信号，以输出对应的第一超声数据和多组第二超声数据到感兴趣的区域 ( ROI ) ;用户输入单元，被配置为接收用于定义ROI的输入信息;处理单元，其与超声数据获取单元和用户输入单元通信，处理单元被配置为基于多组第二超声数据形成体数据，将第一超声数据与体数据进行比较以检测几何其中的信息，基于第一超声数据形成二维 ( 2D ) 超声图像，并且考虑到几何信息，基于体数据形成第一三维 ( 3D ) 超声图像和第二3D超声数据，以及基于几何信息对2D超声图像，第一3D超声图像和第二3D超声图像执行空间复合，以形成超声空间复合图像。

FIG. 4

