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(54) **ULTRASOUND SYSTEM AND METHOD FOR PERFORMING VESSEL LABELING**

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(51) **Int. Cl.**
A61B 8/00 (2006.01)

(52) **U.S. Cl.**
USPC **600/443**; 600/437

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

There are disclosed embodiments for an ultrasound system for performing vessel labeling. The ultrasound system comprises: an ultrasound data acquisition unit configured to transmit an ultrasound signal to a target object including vessels, receive an ultrasound echo signal reflected from the target object and form ultrasound data corresponding to the target object; a volume data forming unit configured to form volume data based on the ultrasound data; and a processor configured to form a 3-dimensional ultrasound image based on the volume data, perform vessel segmentation on the 3-dimensional ultrasound image to provide at least one segmented image including at least one segmented vessel, detect at least one vessel junction from the at least one segmented vessel and perform vessel labeling on the at least one segmented image based on the detected at least one vessel junction.

4 Claims, 6 Drawing Sheets

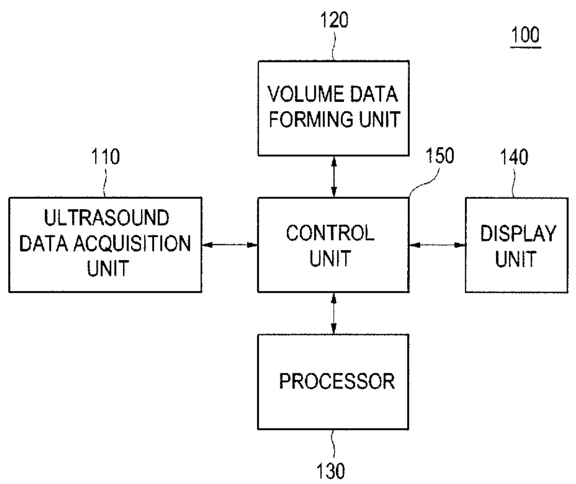


FIG. 1

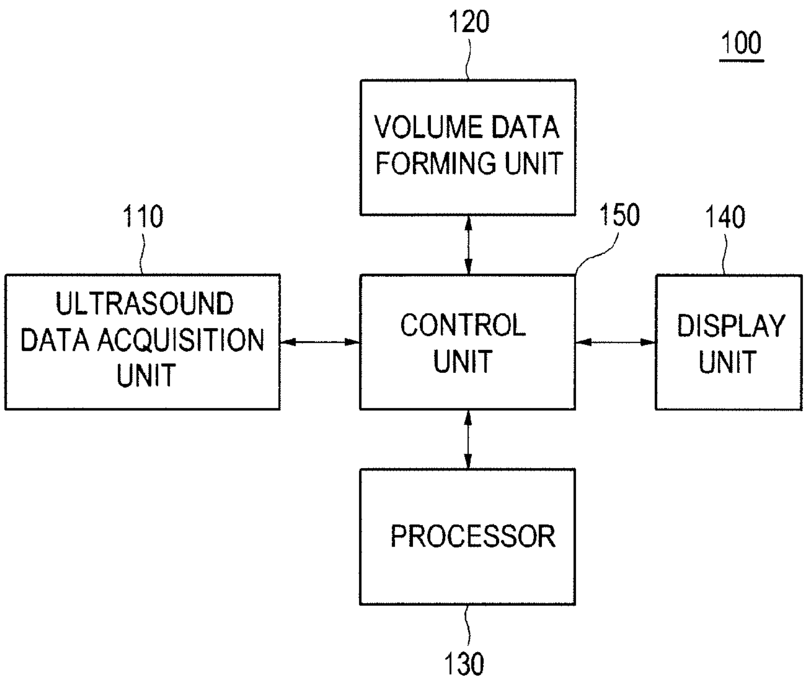

120
100
VOLUME DATA FORMING UNIT
110
150
140
ULTRASOUND DATA ACQUISITION UNIT
CONTROL UNIT
DISPLAY UNIT
PROCESSOR
130

FIG. 2

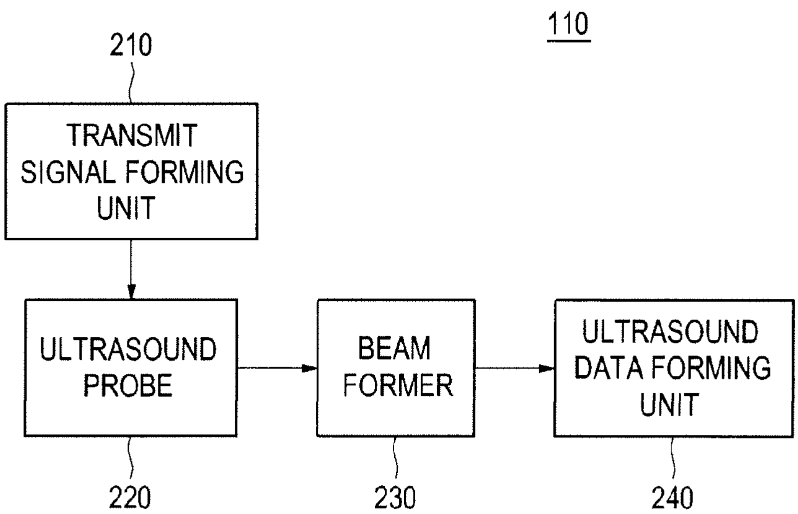

110
210
TRANSMIT SIGNAL FORMING UNIT
ULTRASOUND PROBE
BEAM FORMER
ULTRASOUND DATA FORMING UNIT
220
230
240

FIG. 3

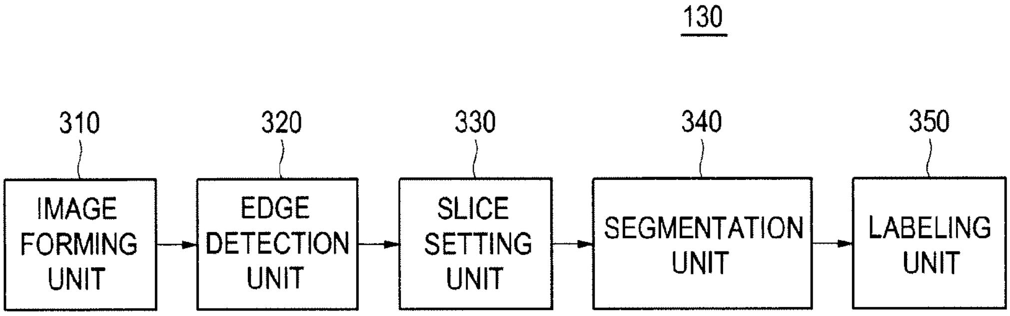
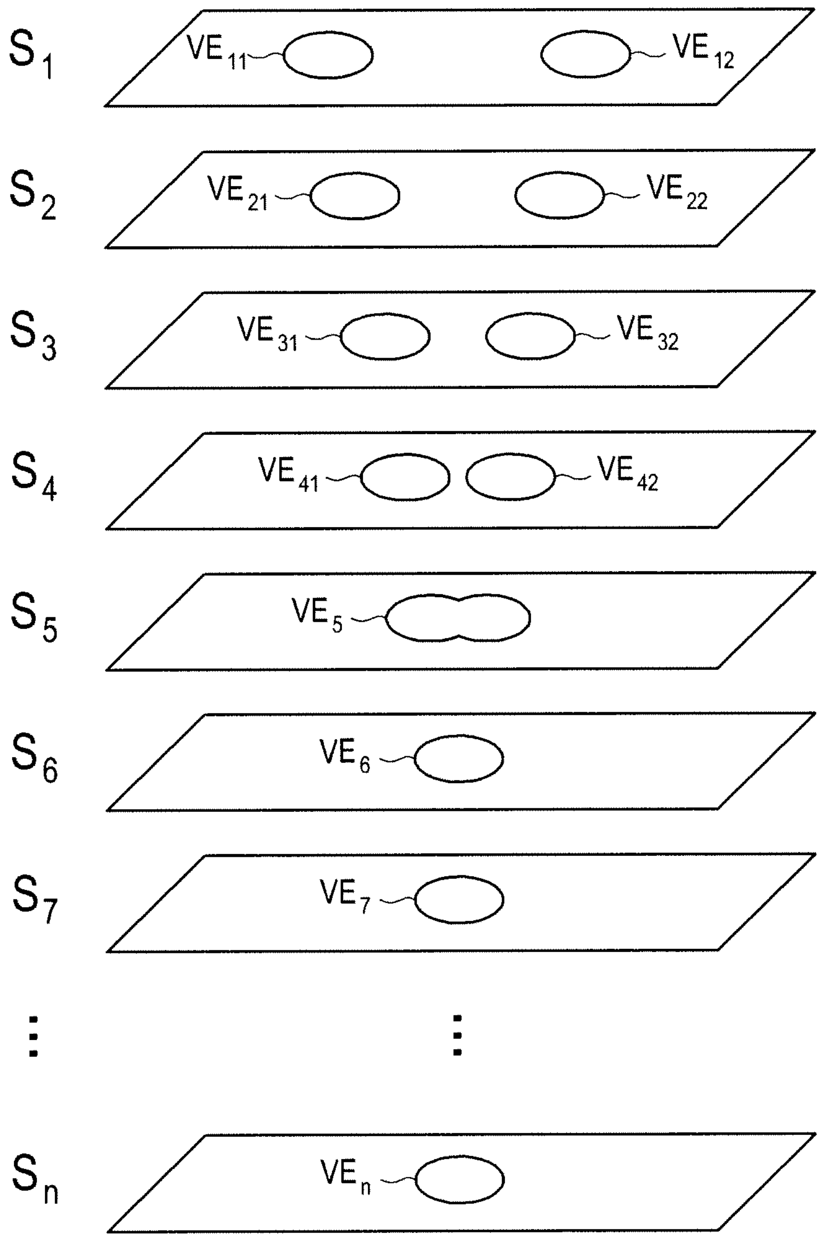

130
310
320
330
340
350
IMAGE FORMING UNIT
EDGE DETECTION UNIT
SLICE SETTING UNIT
SEGMENTATION UNIT
LABELING UNIT

FIG. 4



S1
VE11
VE12
S2
VE21
VE22
S3
VE31
VE32
S4
VE41
VE42
S5
VE5
S6
VE6
S7
VE7
Sn
VEn

FIG. 5

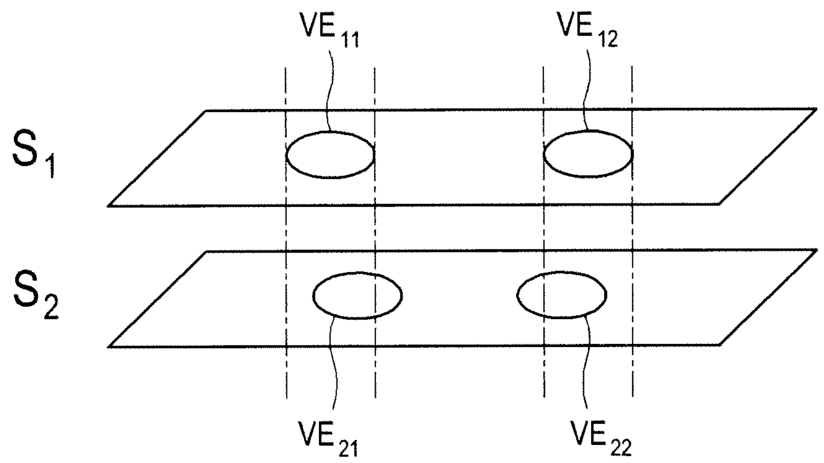
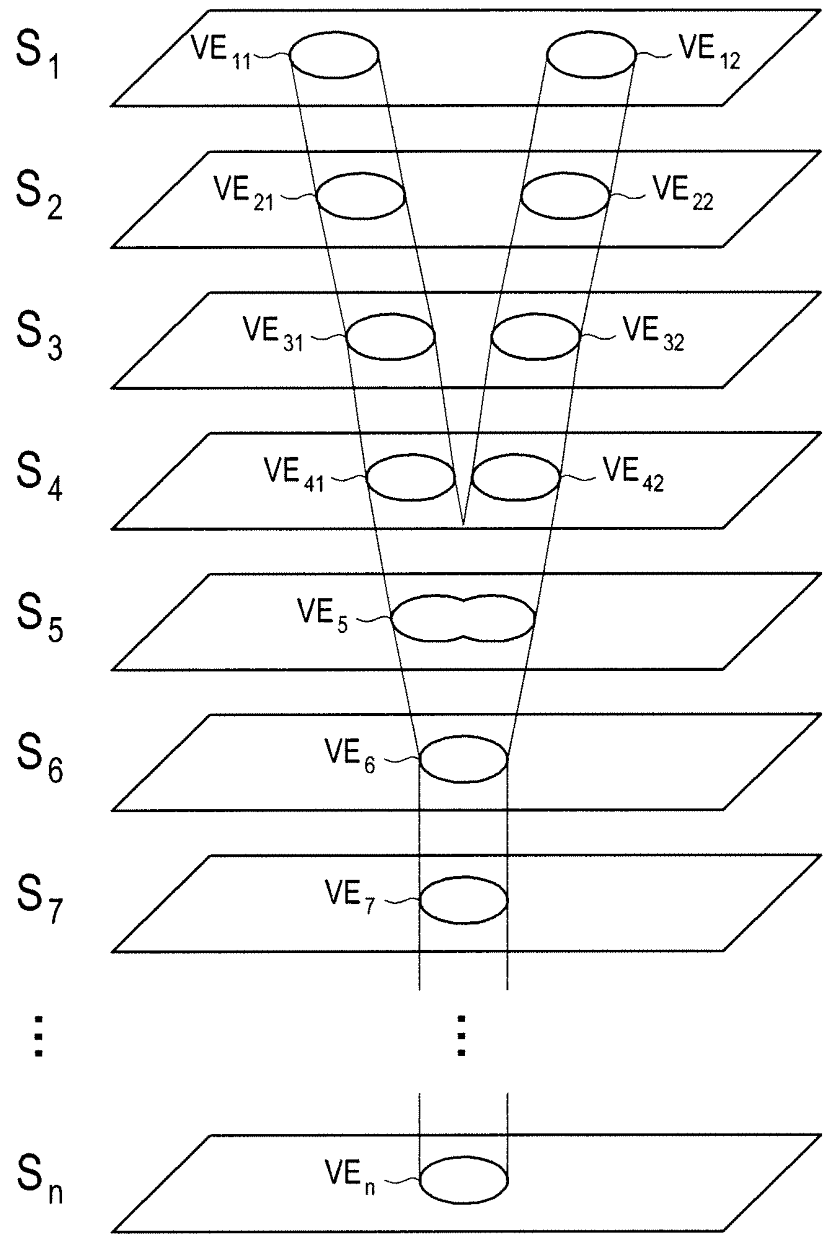
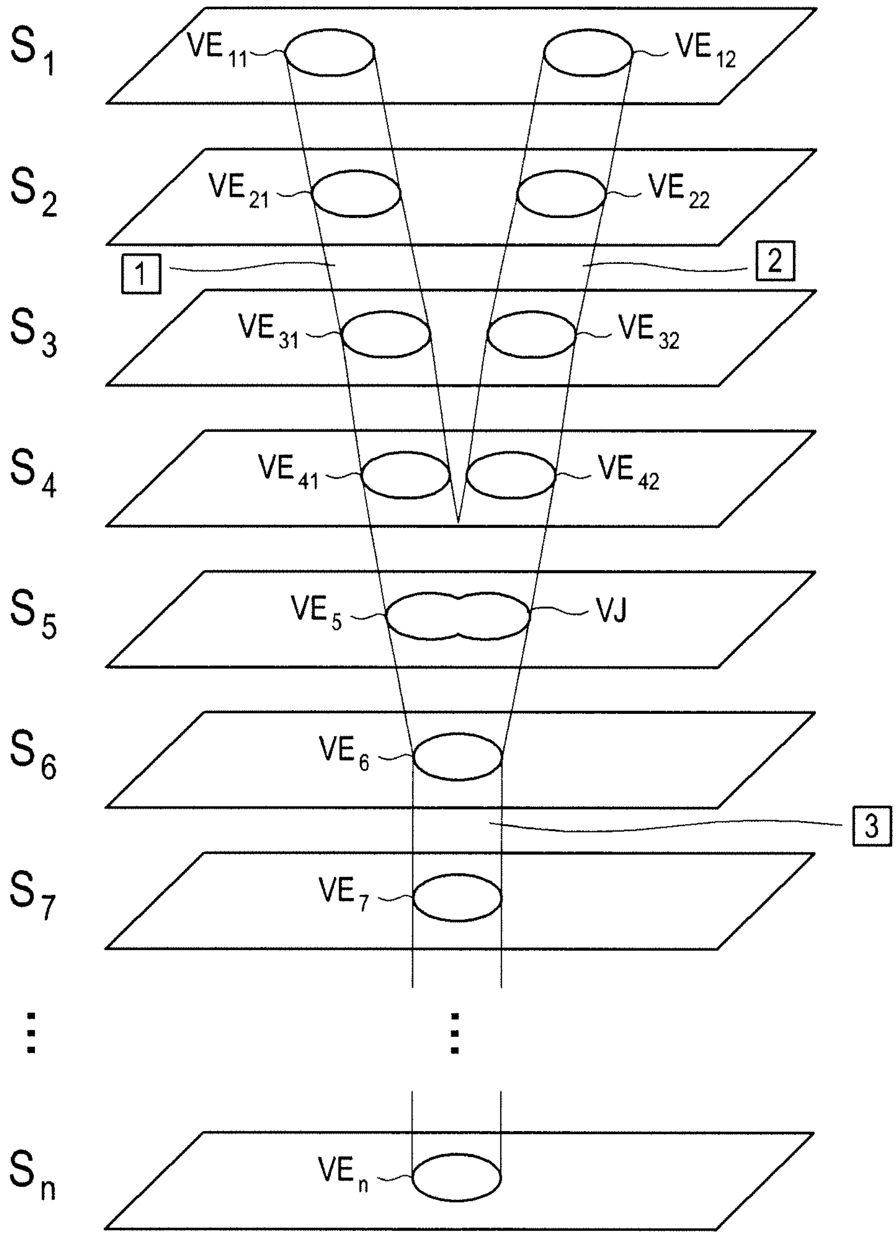


FIG. 6



S1
S2
S3
S4
S5
S6
S7
Sn
VE11
VE12
VE21
VE22
VE31
VE32
VE41
VE42
VE5
VE6
VE7
VEn

FIG. 7



S_1
VE_{11}
VE_{12}
S_2
VE_{21}
VE_{22}
1
2
S_3
VE_{31}
VE_{32}
S_4
VE_{41}
VE_{42}
S_5
VE_5
VJ
S_6
VE_6
3
S_7
VE_7
S_n
VE_n

ULTRASOUND SYSTEM AND METHOD FOR PERFORMING VESSEL LABELING

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from Korean Patent Application No. 10-2009-0073365, filed on Aug. 10, 2009, the entire subject matter of which is incorporated herein by reference.

TECHNICAL FIELD

The present disclosure generally relates to ultrasound systems, and more particularly to an ultrasound system and method for automatically performing vessel labeling.

BACKGROUND

An ultrasound system has been extensively used for acquiring internal information of a target object due to its non-invasive and non-destructive nature. Since the ultrasound system may provide a high resolution image without any surgical treatment, it has proven to be very helpful in the medical profession.

Generally, the ultrasound system may provide 3-dimensional ultrasound images including clinical information such as spatial information and anatomical information, which 2-dimensional ultrasound images do not include. The ultrasound system may operate to transmit an ultrasound signal to a target object, receive the ultrasound signal reflected from the target object (i.e., ultrasound echo signal) and acquire ultrasound data. The ultrasound system may form volume data by using the acquired ultrasound data and provide a 3-dimensional image through rendering of the formed volume data.

Also, the ultrasound system may perform segmentation on the 3-dimensional ultrasound image and extract an object of interest from the 3-dimensional ultrasound image. However, if a structure of vessel is complicated after performing segmentation, then it is difficult to recognize a specific vessel among many vessels as well as to locate vessel connection points (or junctions).

SUMMARY

There are disclosed embodiments of an ultrasound system and a method adapted to perform segmentation of vessel and automatically labeling on the vessel. In one embodiment, by way of non-limiting example, the ultrasound system comprises: an ultrasound data acquisition unit configured to transmit an ultrasound signal to a target object including vessels, receive an ultrasound echo signal reflected from the target object and form ultrasound data corresponding to the target object; a volume data forming unit configured to form volume data based on the ultrasound data; and a processor configured to form a 3-dimensional ultrasound image based on the volume data, perform vessel segmentation on the 3-dimensional ultrasound image to provide at least one segmented image including at least one segmented vessel, detect at least one vessel junction from the at least one segmented vessel and perform vessel labeling on the at least one segmented image based on the detected at least one vessel junction.

In another embodiment, a method of performing segmentation of vessels, comprises: a) transmitting an ultrasound signal to a target object including vessels and receiving an ultrasound echo signal reflected from the target object to thereby form ultrasound data corresponding to the target object; b) forming volume data based on the ultrasound data; c) forming a 3-dimensional ultrasound image based on the volume data; d) performing vessel segmentation on the 3-dimensional ultrasound image to provide at least one segmented image including at least one segmented vessel; e) detecting at least one vessel junction from the at least one segmented vessel; and f) performing vessel labeling on the at least one segmented image based on the detected at least one vessel junction.

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

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 block diagram showing an illustrative embodiment of a processor.

FIG. **4** is a schematic diagram showing an example of a plurality of slices and vessel edges.

FIG. **5** is a schematic diagram showing an example of location difference between vessel edges on adjacent slices.

FIG. **6** is a schematic diagram showing an example of segmentation of vessel.

FIG. **7** is a schematic diagram showing an example of labeled vessels.

DETAILED DESCRIPTION

A detailed description may be provided with reference to the accompanying drawings.

FIG. **1** is a block diagram showing an illustrative embodiment of an ultrasound system **100** which embodies the methods of the present invention. The ultrasound system **100** comprises an ultrasound data acquisition unit **110**, a volume data forming unit **120**, a processor **130**, a display unit **140** and a control unit **150**.

The ultrasound data acquisition unit **110** may be operable to transmit an ultrasound signal to a target object, and receive the ultrasound signal (i.e., ultrasound echo signal) reflected from the target object to thereby acquire ultrasound data.

FIG. **2** is a block diagram showing an illustrative embodiment of the ultrasound data acquisition unit **110**. The ultrasound data acquisition unit **110** may include a transmit signal forming unit **210**, an ultrasound probe **220** including a plurality of transducer elements (not shown), a beam former **230** and an ultrasound data forming unit **240**.

The transmit signal forming unit **210** may be operable to form a transmit signal to be applied to each of the transducer elements of the ultrasound probe **220**. By way of a non-limiting example, the positions and focusing points of the transducer elements may be considered in forming the transmit signal. In one embodiment, the transmit signal may include a transmit signal for acquiring a plurality of frames of the target object.

The ultrasound probe **220** may operate to convert the transmit signal provided by the transmit signal forming unit **210** into an ultrasound signal and transmit it to the target object.

The ultrasound probe **220** may further operate to receive the ultrasound echo signal reflected from the target object and form a receive signal.

The beam former **230** may be configured to form a digital signal through analog-to-digital conversion of the receive signal provided by the ultrasound probe **220**. The beam former **230** may operate to perform receive-focusing upon the digital signal in consideration of the positions and focusing points of the transducer elements, and form a receive-focused signal thereby.

The ultrasound data forming unit **240** may be configured to form ultrasound data of the target object using the receive-focused signal provided by the beam former **230**. In one embodiment, the ultrasound data may comprise RF (radio frequency) data and IQ (in-phase/quadrature) data.

Referring back to FIG. **1**, the volume data forming unit **120** may operate to form volume data by using the ultrasound data provided by the ultrasound acquisition unit **110**. The volume data may comprise a plurality of frames and a plurality of voxels having brightness values.

The processor **130** may operate to form a 3-dimensional ultrasound image including vessels in the target object by using the volume data provided by the volume data forming unit **120**, and perform segmentation of the vessels and vessel labeling by using the 3-dimensional ultrasound image.

FIG. **3** is a block diagram showing an illustrative embodiment of the processor **130**. The processor **130** comprises an image forming unit **310**, an edge detection unit **320**, a slice setting unit **330**, a segmentation unit **340** and a labeling unit **350**.

The image forming unit **310** may operate to form the 3-dimensional ultrasound image through rendering of the volume data provided by the volume data foaming unit **120**. In one embodiment, the rendering may comprise ray-casting rendering, surface rendering, etc.

The edge detection unit **320** may operate to detect vessel edges through performing edge detection on the 3-dimensional ultrasound image provided by the image forming unit **310**. In one embodiment, the vessel edges may be detected by using an edge mask such as a Sobel mask, a Prewitt mask, a Robert mask, a Canny mask, etc. Also, the vessel edges may be detected from the difference of eigen values by using a structure tensor.

The slice setting unit **330** may operate to set a plurality of slices S_0 to S_n on the 3-dimensional ultrasound image in which the vessel edges were detected, as illustrated in FIG. **4**. In one embodiment, the plurality of slices may comprise slices corresponding to the plurality of frames.

The segmentation unit **340** may be configured to perform segmentation of the vessels based on a degree of registration between the respective vessels on the adjacent slices. In one embodiment, the segmentation unit **340** may operate to compare the location of vessels on adjacent slices by using the vessel edges and perform segmentation of the vessels. An illustrative operation of the segmentation unit **340** will be described with reference to FIGS. **4** to **6**.

The segmentation unit **340** may operate to analyze a first slice S_1 and detect vessel edges VE_{11}, VE_{12} on the first slice S_1.

The segmentation unit **340** may operate to analyze a second slice S_2 and detect vessel edges VE_{21}, VE_{22} on the second slice S_2. The segmentation unit **340** may operate to detect location difference between the vessel edges on the adjacent slices (i.e., the first slice S_1 and the second slice S_2), as illustrated in FIG. **5**. Specifically, the segmentation unit **340** may operate to detect the location difference between the vessel edge VE_{11} of the first slice S_1 and the vessel edge VE_{21} of the second slice S_2, as well as the location difference between the vessel edge VE_{11} of the first slice S_1 and the vessel edge VE_{22} of the second slice S_2. Further, the segmentation unit **340** may operate to detect the location difference between the vessel edge VE_{12} of the first slice S_1 and the vessel edge VE_{21} of the second slice S_2, as well as the location difference between the vessel edge VE_{12} of the first slice S_1 and the vessel edge VE_{22} of the second slice S_2. When the location difference between the vessel edge VE_{11} of the first slice S_1 and the vessel edge VE_{21} of the second slice S_2 and the location difference between the vessel edge VE_{12} of the first slice S_1 and the vessel edge VE_{22} of the second slice S_2 are equal to or less than a predetermined threshold, and the location difference between the vessel edge VE_{11} of the first slice S_1 and the vessel edge VE_{22} of the second slice S_2 and the location difference between the vessel edge VE_{12} of the first slice S_1 and the vessel edge VE_{21} of the second slice S_2 are more than the predetermined threshold, the segmentation unit **340** may connect the vessel edge VE_{21} of the second slice S_2 with the vessel edge VE_{11} of the first slice S_1, and connect the vessel edge VE_{22} of the second slice S_2 with the vessel edge VE_{12} of the first slice S_1. The segmentation unit **340** may perform the same operation with respect to a third slice S_3 and a fourth slice S_4, as described above.

The segmentation unit **340** may operate to analyze a fifth slice S_5 and detect a vessel edge VE_5 on the fifth slice S_5. The segmentation unit **340** may operate to detect the location difference between the vessel edges on the adjacent slices (i.e., the fourth slice S_4 and the fifth slice S_5). When the location difference between the vessel edge VE_{41} of the fourth slice S_4 and the vessel edge VE_5 of the fifth slice S_5 and the location difference between the vessel edge VE_{42} of the fourth slice S_4 and the vessel edge VE_5 of the fifth slice S_5 are equal to or less than the predetermined threshold, the segmentation unit **340** may connect the vessel edge VE_5 of the fifth slice S_5 with the vessel edges VE_{41}, VE_{42} of the fourth slice S_4.

The segmentation unit **340** may operate to analyze a sixth slice S_6 and detect a vessel edge VE_6 on the sixth slice S_6. The segmentation unit **340** may operate to detect the location difference between the vessel edges on the adjacent slices (i.e., the fifth slice S_5 and the sixth slice S_6). When the location difference between the vessel edge VE_5 of the fifth slice S_5 and the vessel edge VE_6 of the sixth slice S_6 are equal to or less than the predetermined threshold, the segmentation unit **340** may connect the vessel edge VE_6 of the sixth slice S_6 with the vessel edge VE_5 of the fifth slice S_5.

The segmentation unit **340** may perform the same operation with respect to a seventh slice S_7 to an nth slice S_n, as described above in order to perform segmentation of the vessels, as illustrated in FIG. **6**.

Although in the aforementioned embodiment, segmentation of vessels is performed by setting a plurality of slices on the 3-dimensional ultrasound image and calculating location differences between the edges of the vessels on each adjacent pair of the slices, the present invention is certainly not limited thereto. In another embodiment, segmentation of a vessel may be performed using another well-known method of segmentation.

The labeling unit **350** may operate to detect vessel junctions using edges of vessels on a respective plurality of slices after segmentation of vessels and perform vessel labeling based on the detected vessel junctions. In one embodiment, labeling unit **350** may operate to detect a vessel junction VJ analyzing a respective plurality of slices, as illustrated in FIG. **7**. The vessel junction VJ may comprise a junction where one vessel diverges to at least two vessels or at least two vessels join and merge to one vessel. The labeling unit **350** may operate to perform vessel labeling based on the vessel junction VJ. Although in FIG. **7**, vessel labeling is performed based on the vessel junction VJ with number, the present invention is certainly not limited thereto. In another embodiment, vessel labeling may be performed with at least one of number, text and color.

Referring back to FIG. **1**, the display unit **140** may operate to display the 3-dimensional ultrasound image formed by the processor. The display unit **140** may further operate to display the 3-dimensional ultrasound image on which the processor **130** performed segmentation of the vessels. In one embodiment, the display unit **140** may include a liquid crystal display (LCD), a cathode ray tube (CRT) or any other device capable of displaying an image.

The control unit **150** may operate to control acquisition of the ultrasound data, and formation of the volume data and the 3-dimensional ultrasound image. The control unit **150** may further operate to control image processing of the 3-dimensional ultrasound image (i.e., segmentation of the vessels and vessel labeling).

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 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 transmit an ultrasound signal to a target object including vessels, receive an ultrasound echo signal reflected from the target object and form ultrasound data corresponding to the target object;

a volume data forming unit configured to form volume data based on the ultrasound data; and

a processor configured to form a 3-dimensional ultrasound image based on the volume data, perform edge detection on the 3-dimensional ultrasound image to detect edges of the vessels, set a plurality of slices on the edge-detected 3-dimensional ultrasound image, calculate differences in location between edges of the vessels on each adjacent pair of the slices, compare the calculated location differences with a predetermined threshold and connect edges based on a result of the comparison, perform vessel segmentation of the vessels based on the connected edges to form segmented vessels, detect at least one vessel junction from the segmented vessels and perform vessel labeling on the segmented vessels based on the detected at least one vessel junction.

2. The ultrasound system of claim **1**, wherein the processor is configured to perform the vessel labeling on the segmented vessels with at least one of a number, text and color.

3. A method of performing segmentation of vessels, comprising steps of:

transmitting an ultrasound signal to a target object including vessels and receiving an ultrasound echo signal reflected from the target object to thereby form ultrasound data corresponding to the target object;

forming volume data based on the ultrasound data;

forming a 3-dimensional ultrasound image based on the volume data;

performing edge detection on the 3-dimensional ultrasound image to detect edges of the vessels;

setting a plurality of slices on the edge-detected 3-dimensional ultrasound image;

calculating differences in location between edges of the vessels on each adjacent pair of the slices;

comparing the calculated location differences with a predetermined threshold and connecting edges based on a result of the comparison;

performing vessel segmentation of the vessels based on the connected edges to form segmented vessels;

detecting at least one vessel junction from the segmented vessels; and

performing vessel labeling on the segmented vessels based on the detected at least one vessel junction.

4. The method of claim **3**, wherein the step of performing vessel labeling, comprises the step of:

performing the vessel labeling on the segmented vessels with at least one of number, text and color.

* * * * *

专利名称(译)	超声系统和用于执行血管标记的方法		
公开(公告)号	US8517947	公开(公告)日	2013-08-27
申请号	US12/852363	申请日	2010-08-06
[标]申请(专利权)人(译)	YOO JAE乡 HYUN董GYU 李光HEE		
申请(专利权)人(译)	YOO，JAE HEUNG HYUN，董GYU LEE，KWANG HEE		
当前申请(专利权)人(译)	三星MEDISON CO.，LTD.		
[标]发明人	YOO JAE HEUNG HYUN DONG GYU LEE KWANG HEE		
发明人	YOO, JAE HEUNG HYUN, DONG GYU LEE, KWANG HEE		
IPC分类号	A61B8/00		
CPC分类号	A61B5/02007 A61B8/14 A61B8/483 G06T7/0097 G06T7/0083 G06T2207/30101 G06T2207/10136 G06T2207/20164 G06T7/12 G06T7/174		
代理机构(译)	MCDERMOTT WILL & EMERY LLP		
优先权	1020090073365 2009-08-10 KR		
其他公开文献	US20110034807A1		
外部链接	Espacenet USPTO		

摘要(译)

公开了用于执行血管标记的超声系统的实施例。超声系统包括：超声数据获取单元，被配置为将超声信号发送到包括血管的目标对象，接收从目标对象反射的超声回波信号，并形成与目标对象相对应的超声数据;体数据形成单元，被配置为基于超声数据形成体数据;处理器，被配置为基于体数据形成三维超声图像，对三维超声图像执行血管分割以提供包括至少一个分割血管的至少一个分割图像，从中检测至少一个血管结。至少一个分段血管并基于检测到的至少一个血管连接在至少一个分割图像上执行血管标记。