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Chang et al.

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(54) **METHOD AND APPARATUS FOR DISPLAYING STEREOSCOPIC INFORMATION RELATED TO ULTRASOUND SECTIONAL PLANE OF TARGET OBJECT**

(71) Applicants: **SAMSUNG ELECTRONICS CO., LTD.**, Gyeonggi-do (KR); **SAMSUNG MEDISON CO., LTD.**, Hongcheon-gun, Gangwon-do (KR)

(72) Inventors: **Eun-jung Chang**, Ansan-si (KR); **Jin-yong Lee**, Seoul (KR)

(73) Assignees: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR); **SAMSUNG MEDISON CO., LTD.**, Hongcheon-gun (KR)

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(58) **Field of Classification Search**

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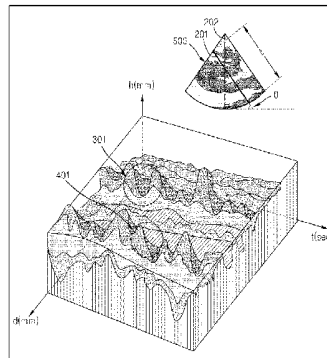
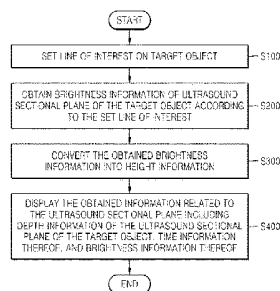
Assistant Examiner — Xilin Guo

(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

A method of displaying stereoscopic information related to an ultrasound sectional plane of a target object includes setting a line of interest on the ultrasound sectional plane of the target object based on a received input; obtaining an ultrasound signal of the ultrasound sectional plane of the target object along the set line of interest; converting the obtained ultrasound signal to represent the stereoscopic information in a three-dimensional manner; and displaying

(Continued)



the stereoscopic information related to the ultrasound sectional plane of the target object.

34 Claims, 9 Drawing Sheets

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H04N 13/00 (2006.01)
- (52) **U.S. Cl.**
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 See application file for complete search history.

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FIG. 1 (PRIOR ART)

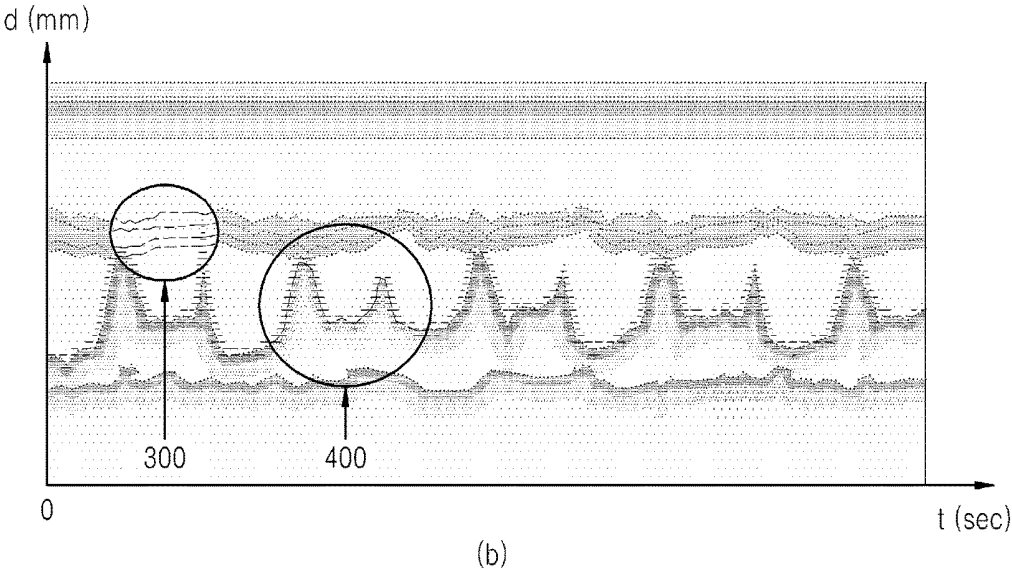
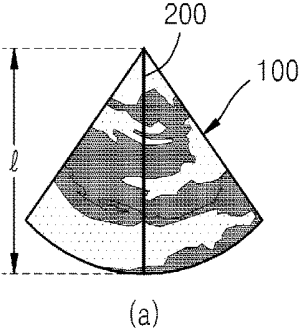


FIG. 2

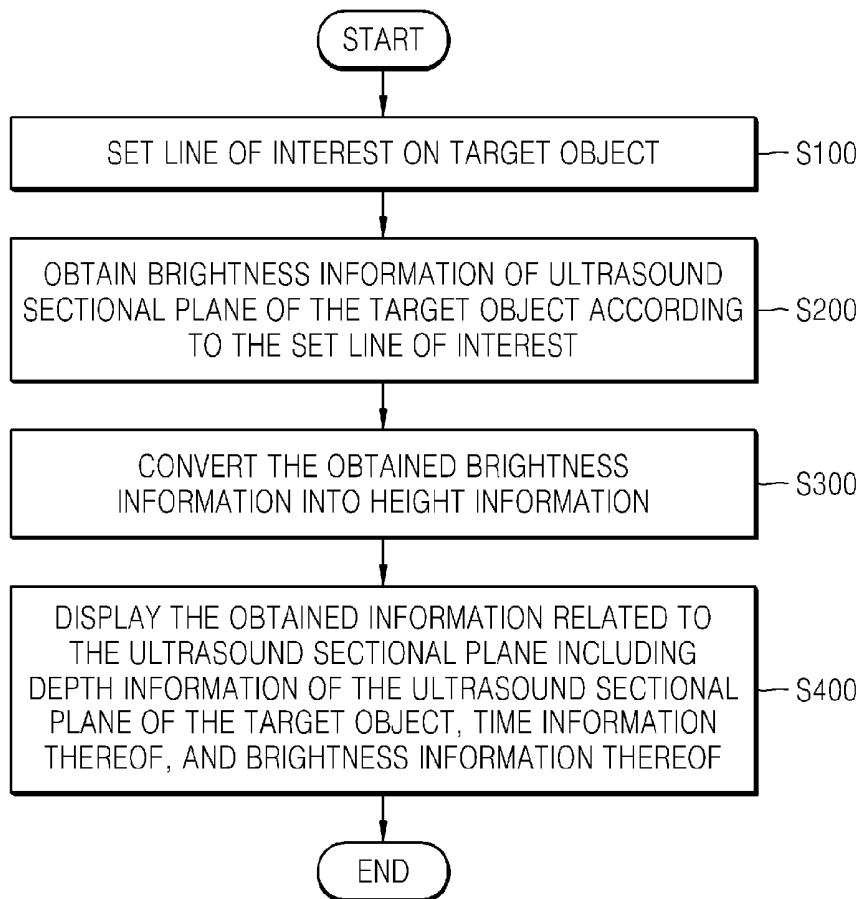


FIG. 3

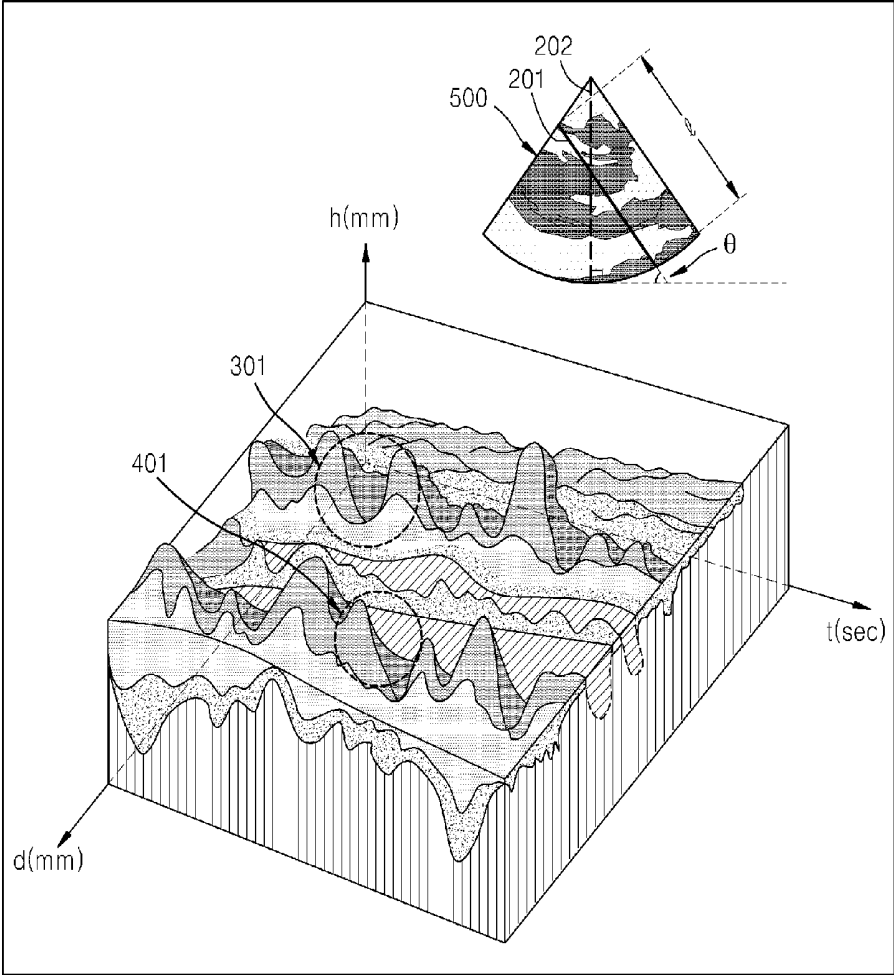


FIG. 4

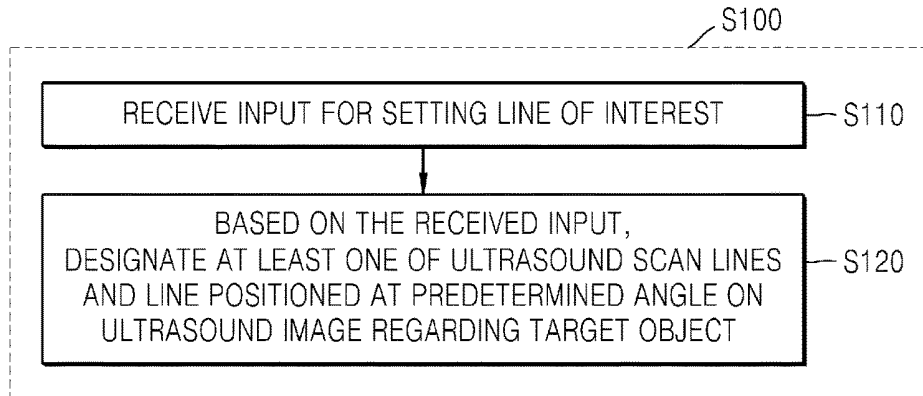


FIG. 5

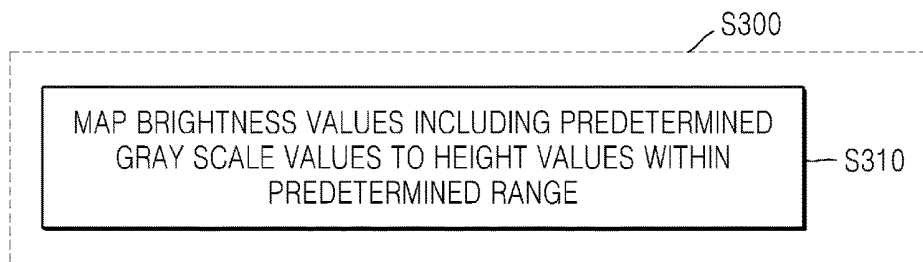


FIG. 6

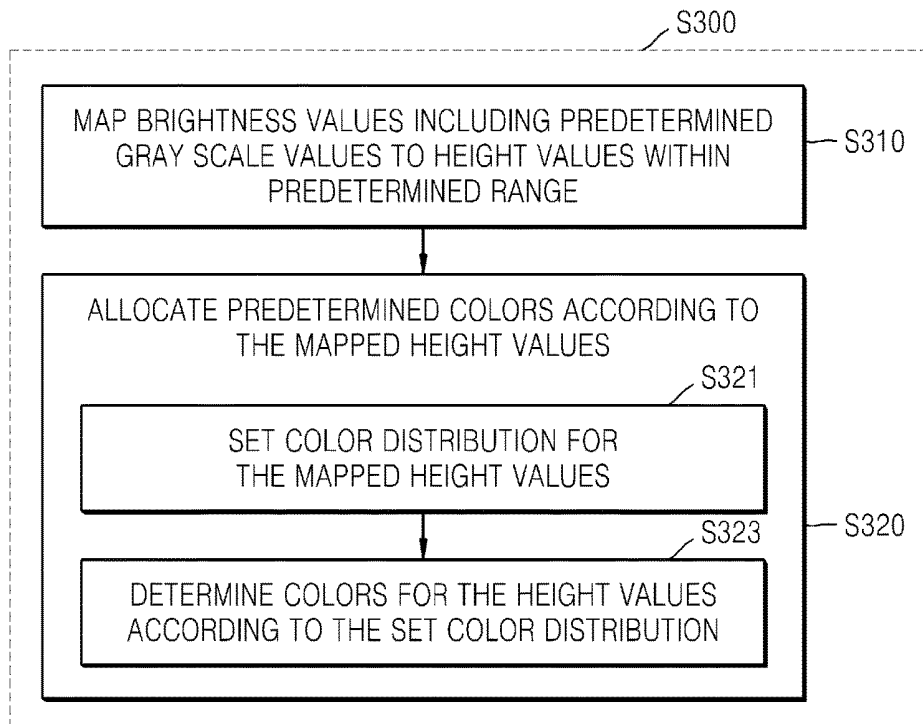


FIG. 7A

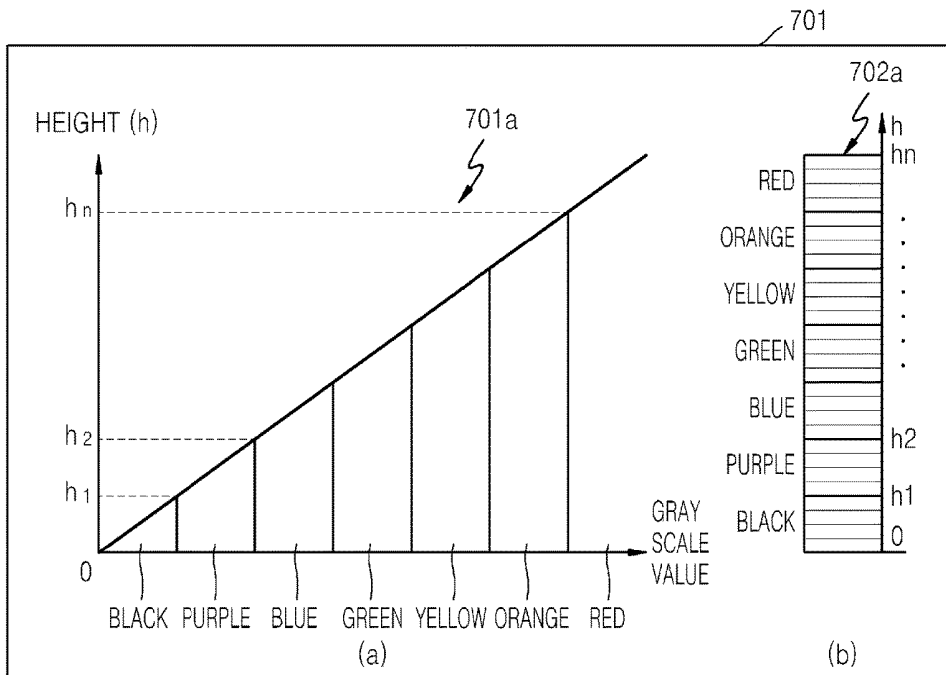


FIG. 7B

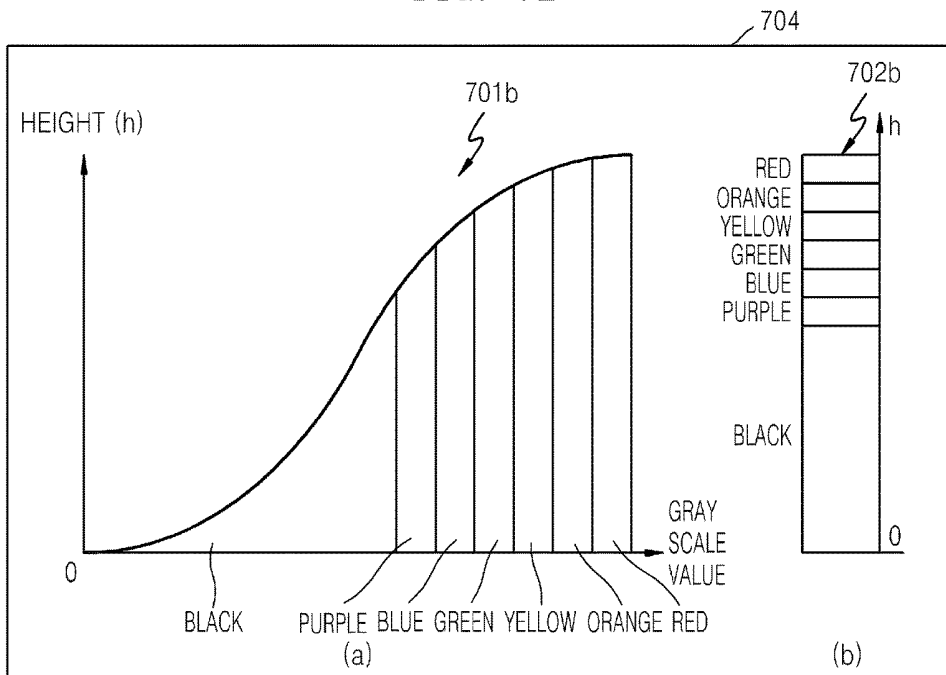


FIG. 7C

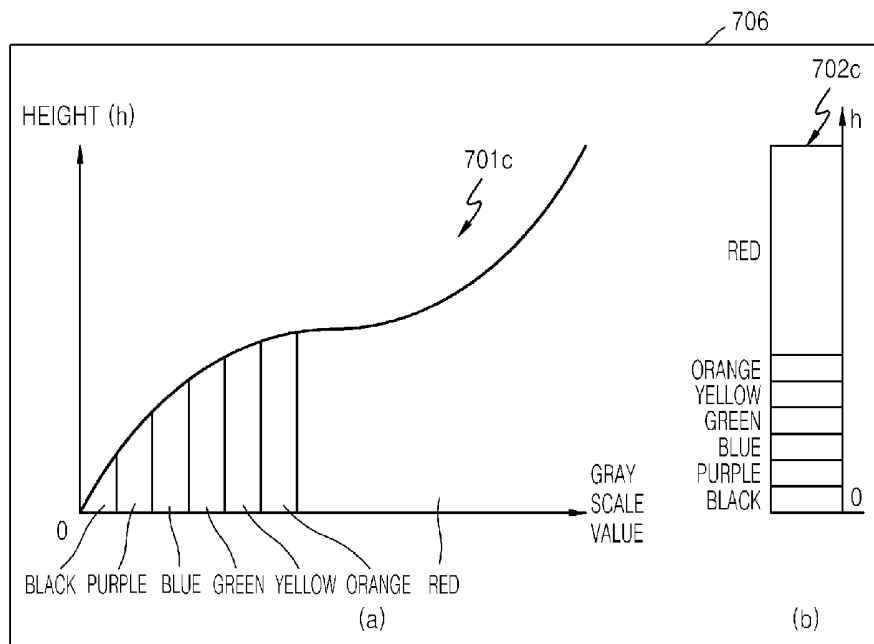


FIG. 8

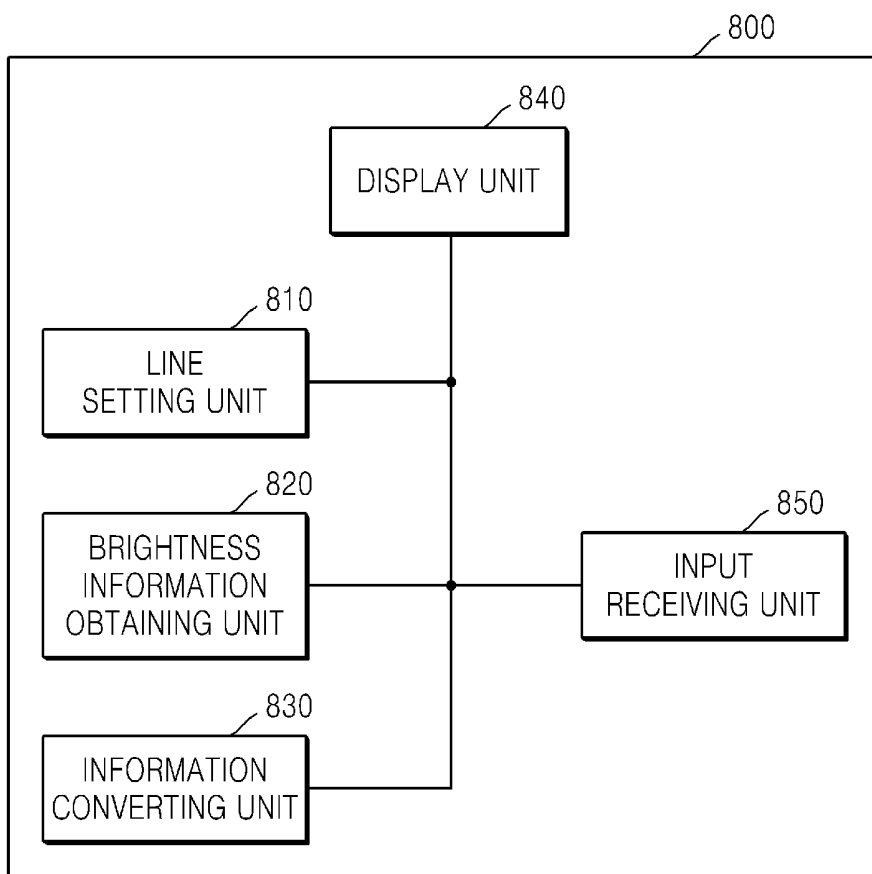


FIG. 9

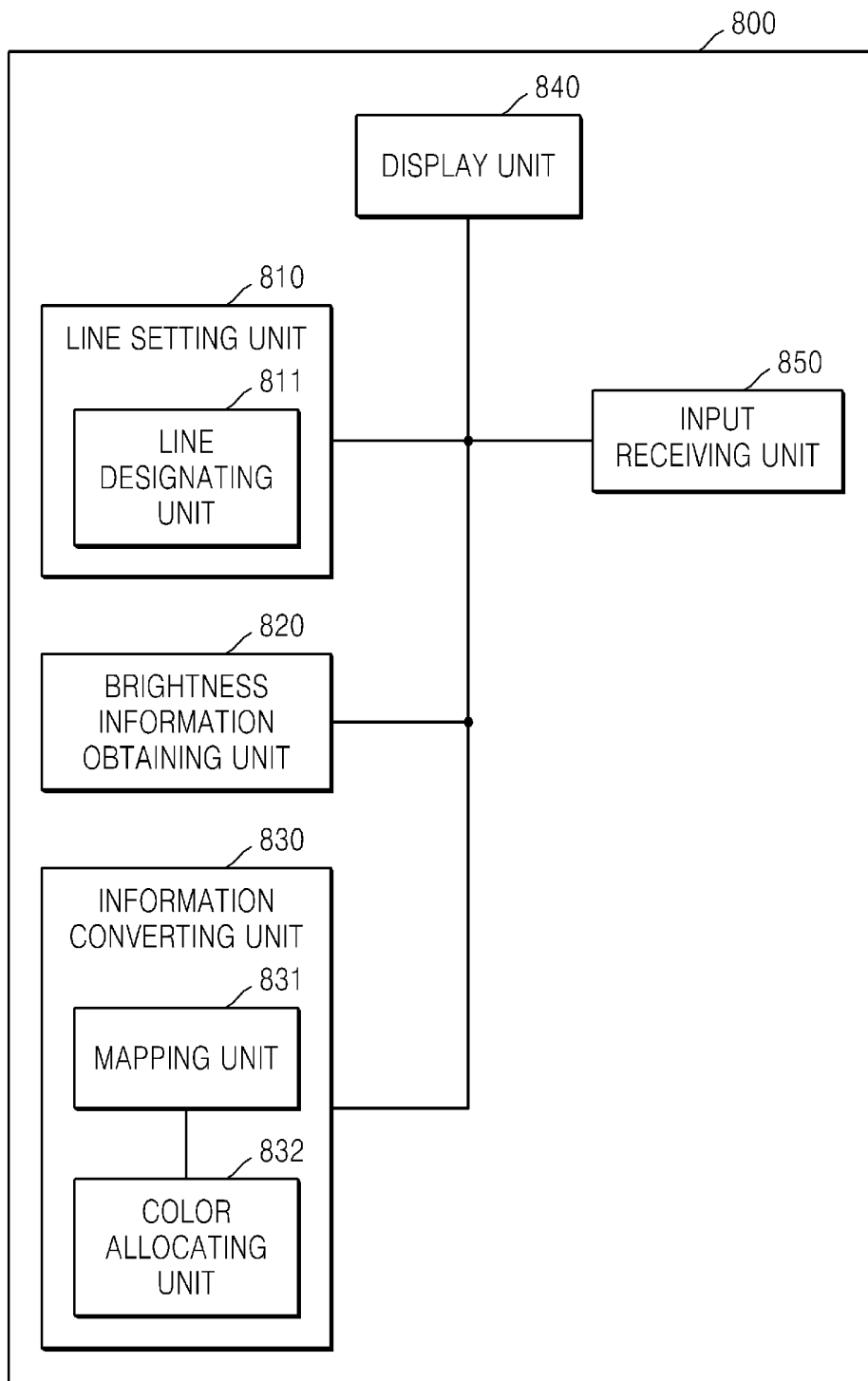
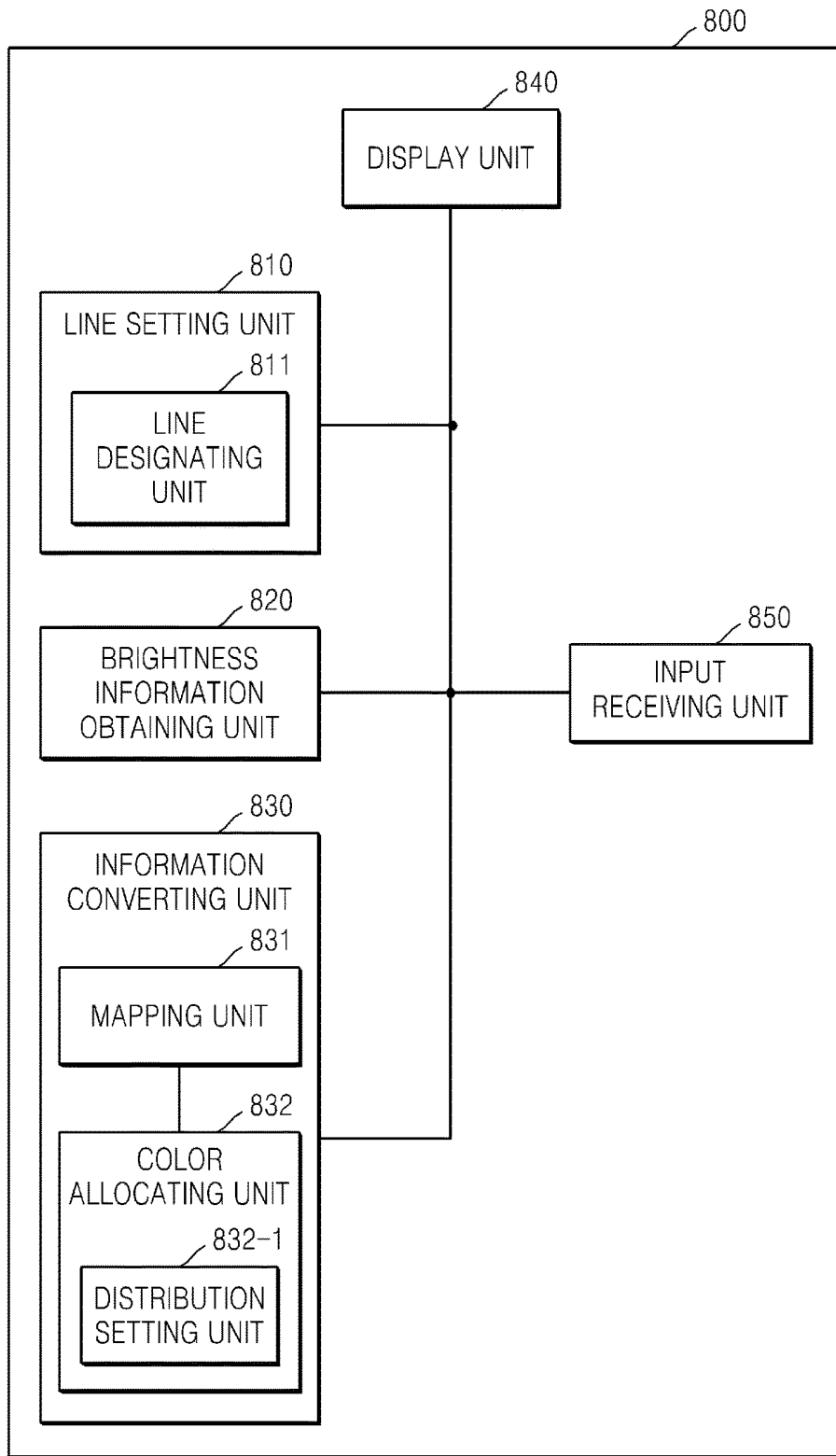


FIG. 10



**METHOD AND APPARATUS FOR
DISPLAYING STEREOSCOPIC
INFORMATION RELATED TO
ULTRASOUND SECTIONAL PLANE OF
TARGET OBJECT**

CROSS-REFERENCE TO RELATED PATENT
APPLICATIONS

This application is a continuation of U.S. patent applica-
tion Ser. No. 14/020,075, filed Sep. 6, 2013, which claims
priority from Korean Patent Applications No. 10-2012-
0098962, filed on Sep. 6, 2012, and No. 10-2013-0071955,
filed on Jun. 21, 2013, in the Korean Intellectual Property
Office, the disclosures of which are incorporated herein by
reference in their entireties.

BACKGROUND

1. Field

Apparatuses and methods consistent with exemplary
embodiments relate to a method and apparatus for display-
ing stereoscopic information related to an ultrasound section-
al plane of a target object, and more particularly, to a
method and apparatus for converting information related to
an ultrasound sectional plane into stereoscopic information
by using ultrasound data and displaying the stereoscopic
information.

2. Description of the Related Art

An ultrasonic diagnosis apparatus transfers an ultrasonic
wave signal from a body surface toward a predetermined
portion inside a body, i.e., a target object, to obtain an image
of a cross-section of hematoceles of soft tissue by using
information of the ultrasonic wave signal that is reflected by
the tissue inside the body.

The ultrasonic diagnosis apparatus is compact, inexpen-
sive, and displays images in real-time. In addition, the
ultrasonic diagnosis apparatus does not cause exposure to
radiation, for example, X-rays, and is thus stable and may be
widely used with other imaging diagnosis apparatuses such
as an X-ray diagnosis apparatus, a computerized tomogra-
phy (CT) scanner, a magnetic resonance imaging apparatus,
or a nuclear medical diagnosis apparatus.

An ultrasound image obtained by an ultrasonic diagnosis
apparatus may be utilized to obtain various measurements
such as a hardness, a size, a volume, a hematoceles moving
velocity, etc. of tissue. To precisely measure a target object,
it is required to clearly understand information regarding
tissue such as boundary lines of tissue, movement of bound-
ary lines, etc. Thus, to obtain precise information regarding
the target object, for example, tissue, information regarding
an ultrasound sectional plane of the target object may be
utilized.

SUMMARY

One or more exemplary embodiments provide a method
and an apparatus for displaying stereoscopic information
related to an ultrasound sectional plane of a target object.

According to an aspect of an exemplary embodiment,
provided is a method of displaying stereoscopic information
related to an ultrasound sectional plane of a target object,
the method including: setting a line of interest on the ultrasound
sectional plane of the target object based on a received input;
obtaining an ultrasound signal of the ultrasound sectional
plane of the target object along the set line of interest;
converting the obtained ultrasound signal to represent the

stereoscopic information in a three-dimensional manner;
and displaying the stereoscopic information related to the
ultrasound sectional plane of the target object.

The stereoscopic information may include an M-mode
image related to the ultrasound sectional plane of the target
object.

The stereoscopic information related to the ultrasound
sectional plane of the target object may include depth
information, capture time information, and brightness infor-
mation of the ultrasound sectional plane of the target object,
and the depth information may include information about a
position of the target object along the set line of interest on
the ultrasound sectional plane.

The setting may include, based on the received input,
determining the line of interest based on at least one from
among an ultrasound scan line and a line extending at a
predetermined angle, the ultrasound scan line and the line
being on the same ultrasound sectional plane.

The displaying may include displaying the information
related to the ultrasound sectional plane in a stereoscopic
space by using the depth information as a first axis, the
capture time information as a second axis, and height
information converted from the brightness information as a
third axis.

According to an aspect of another exemplary embodi-
ment, provided is a method of displaying a three-dimen-
sional M-mode image related to an ultrasound sectional
plane of a target object, the method including: setting a line
of interest on the ultrasound sectional plane of the target
object based on a received input; obtaining brightness infor-
mation of the ultrasound sectional plane of the target object
along the set line of interest; converting a two-dimensional
M-mode image related to the ultrasound sectional plane of
the target object into the three-dimensional M-mode image
based on the obtained brightness information; and display-
ing the three-dimensional M-mode image related to the
ultrasound sectional plane of the target object.

The three-dimensional M-mode image related to the ultra-
sound sectional plane of the target object may include depth
information, capture time information, and brightness infor-
mation of the ultrasound sectional plane of the target object,
and the depth information may include information about a
position of the target object along the set line of interest on
the ultrasound sectional plane.

The setting may include, based on the received input,
determining the line of interest based on at least one from
among an ultrasound scan line and a line extending at a
predetermined angle, the ultrasound scan line and the line
being on the same ultrasound sectional plane.

The displaying may include displaying the three-dimen-
sional M-mode image related to the ultrasound sectional
plane in a stereoscopic space by using the depth information
as a first axis, the capture time information as a second axis,
and height information converted from the brightness infor-
mation as a third axis.

According to an aspect of still another exemplary embodi-
ment, provided is a method of displaying a three-dimen-
sional image representing location and motion information
of an ultrasound sectional plane of a target object, the
method including: setting a line of interest on the ultrasound
sectional plane of the target object based on a received input;
obtaining brightness information of the ultrasound sectional
plane of the target object along the set line of interest;
converting a two-dimensional image representing the loca-
tion and the motion information by using the brightness
information into the three-dimensional image representing
the location and the motion information by using height

information corresponding to the brightness information; and displaying the three-dimensional image based on the height information.

The three-dimensional image representing the location and the motion information of the ultrasound sectional plane of the target object may include depth information, capture time information, and the brightness information of the ultrasound sectional plane of the target object, and the depth information may include information about a position of the target object along the set line of interest on the ultrasound sectional plane.

The setting may include, based on the received input, determining the line of interest based on at least one from among an ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

The converting may include, mapping the obtained brightness information including predetermined gray scale values to height values of a predetermined range.

The converting may include allocating predetermined colors to the mapped height values.

The allocating may include setting a color distribution of the predetermined colors with respect to the predetermined range of the mapped height values; and allocating the predetermined colors to the displayed image according to the set color distribution.

The displaying may include displaying the information related to the ultrasound sectional plane in a stereoscopic space by using the depth information as a first axis, the capture time information as a second axis, and the height information converted from the brightness information as a third axis.

According to an aspect of still another exemplary embodiment, provided is an apparatus for displaying stereoscopic information related to an ultrasound sectional plane of a target object, the apparatus including: a line setting determiner configured to set a line of interest on the ultrasound sectional plane of the target object based on a received input; a brightness information obtainer configured to obtain ultrasound signal of the ultrasound sectional plane of the target object along the set line of interest; an information converter configured to convert the obtained ultrasound signal to representing the stereoscopic information in a three-dimensional manner; and a display configured to display the stereoscopic information related to the ultrasound sectional plane of the target object.

The stereoscopic information may include an M-mode image related to the ultrasound sectional plane of the target object.

The stereoscopic information related to the ultrasound sectional plane of the target object may include depth information, capture time information, and brightness information of the ultrasound sectional plane of the target object, and the depth information may include information about a position of the target object along the set line of interest on the ultrasound sectional plane.

The apparatus may further include an input receiver configured to receive the input for setting the line of interest, and the line setting determiner, based on the received input, may determine the line of interest based on at least one from among an ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

The display may display the information related to the ultrasound sectional plane in a stereoscopic space by using the depth information as a first axis, the capture time

information as a second axis, and height information converted from the ultrasound signal as a third axis.

According to an aspect of still another exemplary embodiment, provided is an apparatus for displaying a three-dimensional M-mode image related to an ultrasound sectional plane of a target object, the apparatus including: a line setting determiner configured to set a line of interest on the ultrasound sectional plane of the target object based on a received input; a brightness information obtainer configured to obtain brightness information of the ultrasound sectional plane of the target object along the set line of interest; an information converter configured to convert a two-dimensional M-mode image related to the ultrasound sectional plane of the target object into the three-dimensional M-mode image based on the obtained brightness information; and a display configured to display the three-dimensional M-mode image related to the ultrasound sectional plane of the target object.

The three-dimensional M-mode image related to the ultrasound sectional plane of the target object may include depth information, capture time information, and brightness information of the ultrasound sectional plane of the target object, and the depth information may include information about a position of the target object along the set line of interest on the ultrasound sectional plane.

The apparatus may further include an input receiver configured to receive the input for setting the line of interest, and the line setting determiner, based on the received input, may determine the line of interest based on at least one from among an ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

The display may display the three-dimensional M-mode image related to the ultrasound sectional plane in a stereoscopic space by using the depth information as a first axis, the capture time information as a second axis, and height information converted from the brightness information as a third axis.

According to an aspect of still another exemplary embodiment, provided is an apparatus for displaying a three-dimensional image representing location and motion information of an ultrasound sectional plane of a target object, the apparatus including: a line setting determiner configured to set a line of interest on the ultrasound sectional plane of the target object based on a received input; a brightness information obtainer configured to obtain brightness information of the ultrasound sectional plane of the target object along the set line of interest; an information converter configured to convert a two-dimensional image representing the location and the motion information by using the brightness information into the three-dimensional image representing the location and the motion information by using height information corresponding to the brightness information; and a display configured to display the three-dimensional image in a three-dimensional manner based on the height information. The three-dimensional image representing the location and the motion information of the ultrasound sectional plane of the target object may include depth information, capture time information, and brightness information of the ultrasound sectional plane of the target object, and the depth information may include information about a position of the target object along the set line of interest on the ultrasound sectional plane.

The apparatus may further include an input receiver configured to receive the input for setting the line of interest, and the line setting determiner, based on the received input, may determine the line of interest based on at least one from

among an ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

The information converter may include a mapping part configured to map the obtained brightness information including predetermined gray scale values to height values of a predetermined range.

The information converter may include a color allocator configured to allocate predetermined colors to the mapped height values.

The color allocator may include a distribution setting determiner configured to set a color distribution of the predetermined colors with respect to the predetermined range of the mapped height values, and the color allocator may allocate the predetermined colors to the displayed image according to the set color distribution.

The display may display the image related to the ultrasound sectional plane in a stereoscopic space by using the depth information as a first axis, the capture time information as a second axis, and the height information converted from the brightness information as a third axis.

According to an aspect of still another exemplary embodiment, provided is a non-transitory computer readable recording medium having recorded thereon a program for executing any one of the above methods.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. 1 illustrates two-dimensional (2D) information related to an ultrasound sectional plane of a target object according to the related art;

FIG. 2 is a flowchart illustrating a method of displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment;

FIG. 3 illustrates stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment;

FIG. 4 illustrates a method of setting a line of interest according to an exemplary embodiment;

FIG. 5 illustrates a method of converting brightness information of an ultrasound sectional plane into height information thereof according to an exemplary embodiment;

FIG. 6 illustrates a method of allocating colors corresponding to height information according to an exemplary embodiment;

FIGS. 7A through 7C illustrate graphs for explaining mapping gray scale values to height values and status bars for explaining a color distribution with respect to height information according to an exemplary embodiment;

FIG. 8 is a block diagram of an apparatus for displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment;

FIG. 9 is a detailed block diagram of an apparatus for displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment; and

FIG. 10 is a further detailed block diagram of an apparatus for displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment.

DETAILED DESCRIPTION

Hereinafter, exemplary embodiments will now be described more fully with reference to the accompanying

drawings. The exemplary embodiments may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. For example, configuring elements that are singular forms may be executed in a distributed fashion, and also, configuring elements that are distributed may be combined and then executed. In the following description, well-known functions or constructions are not described in detail since they would obscure the disclosure with unnecessary detail. Also, throughout the specification, like reference numerals in the drawings denote like elements.

Most terms used in this specification are general terms well known in the art and defined in consideration of functions, however, some terms may vary according to intention of those of ordinary skill in the art, usual practices, or introduction of new technologies in the art. Also, specified terms may be selected by the applicant at his or her discretion, and in this case, the detailed meanings thereof will be described in relevant parts of the description herein. Thus, the terms used in the specification should not be understood as simple names but based on the substantial meanings of the terms and the overall description herein.

Throughout the specification, it will also be understood that when a component "includes" or "comprises" an element, unless there is a particular description contrary thereto, it should be understood that the component does not exclude another element but may further include another element. In addition, terms such as "unit", "module", or the like are used refer to units that perform at least one function or operation, and the units may be implemented as hardware or software or as a combination of hardware and software.

Throughout the specification, an "ultrasound image" refers to an image of a target object obtained using an ultrasonic wave. The target object may refer to a portion of a body. For example, the target object may be an organ such as a liver, a heart, a uterus, a brain, a breast, or a stomach, or may be an embryo.

The ultrasound image may be obtained in various ways. For example, the ultrasound image may be at least one of a brightness (B) mode image, a color (C) mode image, a doppler (D) mode image, and a motion (M) mode image. Also, according to an exemplary embodiment, the ultrasound image may be a 2-dimensional (2D) image or a 3-dimensional (3D) image.

Throughout the specification, a "user" may refer to a medical specialist such as a doctor, a nursing staff, a clinical pathologist, or a medical imaging specialist, but not limited thereto.

Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

FIG. 1 illustrates 2D information related to an ultrasound sectional plane of a target object according to the related art. Information, as shown in (b), regarding tissue of the target object with respect to the ultrasound sectional plane obtained along a scan line **200** may be obtained from an ultrasound image **100**, as shown in (a), of the target object. For example, in a case where an ultrasound apparatus operates in an M mode, location and motion information of tissue detected along the scan line **200** may be 2-dimensionally represented with respect to a capture time of the ultrasound image **100**.

Referring to FIG. 1, a motion of tissues detected along the scan line **200** in the ultrasound image **100** of, for example,

a heart, may be obtained based on location information d of tissues captured with respect to a time t and represented as a brightness value. In FIG. 1, the scan line **200** has a length l , and thus, a maximum value of the location information d of tissues along the scan line **200** in the ultrasound image **100** may correspond to the length l of the scan line **200**.

In other words, an M mode image may be 2-dimensionally displayed as a brightness value relative to the time t (e.g., a time axis) and location information d (e.g., a depth axis). For example, as shown in FIG. 1, the information regarding the ultrasound sectional plane of the target object may be displayed as different brightness values according to the capture time t and a location of corresponding tissue.

Thus, a related art method provides the information regarding the ultrasound sectional plane of the ultrasound image **100** as the brightness value. Therefore, data analysis and measurement results regarding the ultrasound image **100** may be varied according to a resolution of the ultrasound image and a skill level of a user of the ultrasound apparatus. For example, in a case where a brightness value of tissue is not known, as shown in **300** of FIG. 1, or a degree of definition of tissue is lower, as shown in **400** of FIG. 1, accuracy and utility of the ultrasound image **100** may be significantly reduced and reliability of data analysis and measurement of the ultrasound image **100** are also reduced.

Further, since a range of a brightness value which can be recognized by a human eye is limited, the data analysis and measurement result may not be accurate. To compensate for such limitation, for example, a higher resolution, a higher definition image, or a more accurate display method may be required.

Therefore, exemplary embodiments may provide a method of displaying stereoscopic information related to the ultrasound sectional plane of the ultrasound image **100** using a brightness value, such that analysis and measurement of data may be performed more accurately compared to the related art.

Furthermore, exemplary embodiments may facilitate analysis of data by using a color in representing brightness information of an ultrasound sectional plane of the target object. Also, exemplary embodiments may adjust a color distribution when detailed observation is desired, thereby enhancing representation and accurate analysis of data.

FIG. 2 is a flowchart illustrating a method of displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment.

FIG. 3 illustrates stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment.

Referring to FIG. 2, the method of displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment may include setting a line of interest on a target object (operation **S100**), obtaining brightness information of the ultrasound sectional plane of the target object according to the set line of interest (operation **S200**), converting the obtained brightness information into height information (operation **S300**), and displaying the stereoscopic information related to the ultrasound sectional plane of the target object based on the converted height information (operation **S400**).

The information related to the ultrasound sectional plane may include, but not limited thereto, depth information, capture time information, and brightness information of the ultrasound sectional plane of the target object. Here, as shown in FIG. 3, the information related to the ultrasound

sectional plane may be represented in a 3-dimensional manner using a depth axis, a height axis, and a time axis.

An ultrasound image **500** of the target object may include a substantially arc-shaped image such as, for example, an image obtained by using a convex probe, a substantially rectangular image such as, for example, an image obtained by using a linear probe, etc. For illustrative purposes, it is illustrated in FIG. 3 that the ultrasound image **500** has a substantially arc-shaped image.

FIG. 4 illustrates a method of setting a line of interest according to an exemplary embodiment.

Referring to FIG. 4, setting the line of interest on the target object (operation **S100**) of FIG. 2 may include receiving an input for setting the line of interest (operation **S110**) and, based on the received input, designating at least one of an ultrasound scan line and a line extending at a predetermined angle on an ultrasound image of the target object as the line of interest (operation **S120**).

Referring to FIG. 3, the line of interest may include at least one of an ultrasound scan line and a line **201** extending at a predetermined angle θ on the ultrasound image **500** according to the input.

The input may be received from outside of an ultrasound apparatus by using a signal input unit such as a keyboard, a mouse, a joystick, etc., and may be previously stored in a storage (not shown) connected to an input receiving unit of the ultrasound apparatus or applied in real time to the ultrasound apparatus during a process of obtaining the ultrasound image **500**. In an exemplary embodiment, the storage may be a memory.

The line **201** extending at the predetermined angle θ on the ultrasound image **500** may be used to obtain an ultrasound sectional plane of the target object at the predetermined angle θ . For example, the predetermined angle θ may be an angle formed by the line **201** and a tangential line at a lowest end portion of the ultrasound image **500**. For example, as shown in FIG. 3, in a case where the designated line is a center scan line **202** among ultrasound scan lines, the predetermined angle θ may be a right angle perpendicular to a tangential line at the lowest portion of the ultrasound image **500**.

Also, the predetermined angle θ may be determined as 180 degree when the designated line and the lower end portion of the ultrasound image **500** are parallel to each other. In this case, the center scan line **202** may be perpendicular to the line **201**.

When the line of interest is set, the information related to the ultrasound sectional plane of the target object may be obtained according to the set line of interest. The information related to the ultrasound sectional plane may include depth information d , capture time information t , and brightness information of the ultrasound sectional plane of the target object. In an exemplary embodiment, the brightness information may be converted into height information to be displayed in stereoscopic information, as described above.

The depth information d of the ultrasound sectional plane may include location information of tissue of the target object included in the ultrasound sectional plane along the line of interest on the ultrasound image **500**. For example, as shown in an axis d of FIG. 3, a location of the tissue of the target object included in the ultrasound sectional plane may be relatively determined with respect to a start point of the designated line in the ultrasound image **500**, and the location information of the tissue of the target object may be represented as the depth information d of the ultrasound sectional plane. For example, the depth information of the start point is zero and the depth information of an end point may

correspond to a length l of the designated line. The depth information d of the ultrasound sectional plane may be represented in millimeters (mm), but not limited thereto.

The capture time information t of the ultrasound sectional plane may include information regarding a time at which the ultrasound image **500** is obtained. For example, the time information t of the ultrasound sectional plane may include an ultrasound capture time of the target object. The time information t of the ultrasound sectional plane may be represented in seconds (sec), but not limited thereto.

The information related to the ultrasound sectional plane may include the brightness information of the ultrasound sectional plane. For example, to observe movements of heart muscles and valves in an ultrasound image of the heart, a line of interest may be set on the ultrasound image of the heart and the depth information d of the ultrasound sectional plane of the target object, i.e., the heart, may be measured with respect to time along the set line of interest on the ultrasound sectional plane of the heart. Accordingly, the information related to the ultrasound sectional plane with respect to the heart may be obtained.

A change in the brightness of an ultrasound image at the same location, i.e., having the same depth, with respect to time represents movements of a target object, e.g., the heart muscles and valves. In other words, the change in the brightness of the ultrasound image with respect to time may represent the movement of heart muscles and valves with respect to time. As shown in **301** and **401** of FIG. 3, by using the brightness information indicating the movements of corresponding tissue of the target object, boundaries of tissues and degrees of movements thereof may be more clearly identified.

FIG. 5 illustrates a method of converting the brightness information of an ultrasound sectional plane into the height information h according to an exemplary embodiment.

The operation of converting the obtained brightness information into the height information h (operation **S300**) of FIG. 2 may include mapping brightness values including predetermined gray scale values to height values within a predetermined range (operation **S310**).

For example, the brightness information of the ultrasound sectional plane may be defined as gray scale values from 0 to 255, but not limited thereto. Alternatively, the brightness information of the ultrasound sectional plane may be defined as gray scale values from 0 to 511, but not limited thereto.

The height information h may include information regarding height values to which the gray scale values are mapped and information regarding colors used to represent the corresponding height values. The height values of the height information h may be represented in millimeters (mm), but not limited thereto.

In the operation of mapping the brightness values including predetermined gray scale values to the height values within a predetermined range (operation **S310**) according to an exemplary embodiment, gray scale values, for example, from 0 to 255 may be mapped to the height information h having height values, for example, from 0 mm to 255 mm. However, it should be noted that this is merely an example and the height information h may have different height values corresponding to the gray scale values.

For example, in a case where a gray scale value "0" is defined as a gray scale value indicating a black color that is a darkest color value, the gray scale value "0" may be mapped to, for example, a lowest value of the height information h . In a case where a gray scale value "255" is defined as a gray scale value indicating a white color that is

a brightest color value, the gray scale value "255" may be mapped to, for example, a highest value of the height information h .

On the other hand, in a case where the gray scale value "0" is used as a gray scale value indicating the white color that is the brightest color value, the brightest color value may be mapped to, for example, the lowest value of the height information h , and in a case where the gray scale value "255" is a gray scale value indicating the black color that is the darkest color value, the darkest color value may be mapped to, for example, the highest value of the height information h .

Alternatively, in the operation of mapping the gray scale values to the height values within the predetermined range (operation **S310**), gray scale values from 0 to 511 may be mapped to height information h having height values from 0 to 255. Here, for example, in a case where gray scale values exceeding 255 are rare, the gray scale values exceeding 255 may be collectively mapped to the height value of 255. Accordingly, mapping of the height information h may be efficient in that additional height values are not required to represent the rare gray scale values.

FIG. 6 illustrates a method of allocating colors corresponding to the height information h according to an exemplary embodiment.

The operation of converting the obtained brightness information into the height information h (operation **S300**) according to an exemplary embodiment may include allocating predetermined colors according to mapped height values (operation **S320**).

For example, a plurality of different colors may be allocated according to the height values that are mapped in operation **S310** (operation **S320**). In an exemplary embodiment, seven colors such as, for example, black, purple, blue, green, yellow, orange, and red, may be respectively allocated to predetermined ranges of height values. That is, for example, the black color may be allocated to a range of height values from 0 to 36 among the height values 0 to 255, the purple color may be allocated to a range of height values from 37 to 73, and the blue color may be allocated to a range of height values from 74 to 110, etc.

In an exemplary embodiment, three or more different colors may be uniformly allocated to the height values.

In a case where colors are allocated with respect to a range of height values, an allocation status of colors with respect to a range of height values may be provided as a bar on a screen. This will be described in detail later with reference to FIGS. 7A to 7C.

Also, as shown in FIG. 6, the operation of allocating predetermined colors according to the mapped height values (operation **S320**) according to an exemplary embodiment may include setting a color distribution among the height values (operation **S321**) and determining colors for corresponding height values according to the set color distribution (operation **S323**).

FIGS. 7A through 7C illustrate graphs for explaining mapping gray scale values to height values and status bars for explaining a color distribution with respect to height information according to an exemplary embodiment.

Referring to FIG. 7A, a graph, as shown in (a), shows a mapping relationship **701a** between gray scale values and height values, in which gray scale values are substantially proportionally mapped to the height values. Colors substantially uniformly distributed with respect to height values according to a uniform color distribution method may also be provided in a form of a bar **702a** on a screen. For

example, the uniform color distribution may be previously set as default in a storage (not shown) of an ultrasound apparatus.

The gray scale mapping and color distribution may be differently determined according to different ranges of height values. Referring to FIG. 7B, for example, a graph 701b, as shown in (a), shows a mapping relationship between the gray scale values and the height values, in which gray scale values are disproportionately mapped to height values, i.e., the mapping has a greater slope of increase in lower gray scale values than higher gray scale values. Also, a status bar 702b, as shown in (b), may be provided, in which colors are distributed among height values such that more colors are allocated to higher height values than lower height values. That is, the higher height values may be represented in more variety of colors. Referring to FIG. 7C, a graph 701c, as shown in (a), shows a mapping relationship 701c between the gray scale values and the height values, in which gray scale values are disproportionately mapped to height values, i.e., the mapping has a greater slope of increase in higher gray scale values than lower gray scale values. Also, a status bar 702c, as shown in (b), may be provided, in which colors are distributed among height values such that more colors are allocated to lower height values than higher height values. That is, the lower height values may be represented in more variety of colors.

Thus, in an exemplary embodiment, more colors may be distributed among higher brightness values of the ultrasound image of the target object, as shown in the graph 701b of FIG. 7B, and thus a brighter part in the ultrasound image may be more finely displayed in various colors. In other words, a plurality of colors are densely distributed in a part corresponding to higher brightness values, thereby facilitating observation and analysis of a corresponding part by using a more rapid color change with respect to a height change.

Also, in another exemplary embodiment, more colors may be distributed among lower brightness values of the ultrasound image of the target object, as shown in the graph 701c of FIG. 7C, and thus a darker part in the ultrasound image may be displayed in various colors (702c), thereby facilitating observation and analysis of a corresponding part by using a more rapid color change with respect to a height change.

Referring to FIG. 2, the operation of displaying the stereoscopic information related to the ultrasound sectional plane of the target object based on the height information h (operation S400) may include displaying the stereoscopic information related to the ultrasound sectional plane in a stereoscopic space by using the depth information d as a first axis, the capture time information t as a second axis, and the brightness information as a third axis. For example, as shown in FIG. 3, the stereoscopic information related to the ultrasound sectional plane may be displayed with respect to a plane formed by an axis of the depth information d, an axis of the capture time information t, and a height axis of brightness values of the ultrasound sectional plane of the target object.

FIG. 8 is a block diagram of an apparatus 800 for displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment.

Referring to FIG. 8, the apparatus 800 according to an exemplary embodiment may include a line setting unit (or a line setting determiner) 810, a brightness information obtaining unit (or brightness information obtainer) 820, an

information converting unit (or information converter) 830, and a display unit (or display) 840.

The apparatus 800 according to an exemplary embodiment may further include an input receiving unit (or input receiver) 850 for receiving an input.

The information related to the ultrasound sectional plane may include depth information d, the capture time information t, and the brightness information of the ultrasound sectional plane of the target object.

The image obtaining unit (not shown) may obtain the ultrasound image 500 with respect to the target object by using, for example, an echo signal obtained by irradiating ultrasonic waves to the target object. The ultrasound image 500 of the target object may include a substantially arc-shaped image such as, for example, an image obtained by using a convex probe, a rectangular image such as, for example, an image obtained by using a linear probe, etc. The obtained ultrasound image 500 may be displayed on the display unit 840.

The line setting unit 810 may set a line of interest on the ultrasound image 500 of the target object. The line of interest may be set based on an input received through the input receiving unit 850.

The brightness information obtaining unit 820 may obtain the information related to the ultrasound sectional plane including the brightness information of the ultrasound sectional plane of the target object along the set line of interest.

The information converting unit 830 may convert gray scale values indicating the brightness information of the ultrasound sectional plane into the height information h.

For example, the brightness information of the ultrasound sectional plane may be defined as gray scale values from 0 to 255 or from 0 to 511, but not limited thereto.

The height information h may include information regarding height values to which the gray scale values are mapped and information regarding colors used to represent the height values.

The display unit 840 may display the information related to the ultrasound sectional plane according to the set height information h. As shown in FIG. 3, the display unit 840 may display the information related to the ultrasound sectional plane in a stereoscopic space by using the depth information d as a first axis, the capture time information t as a second axis, and the brightness information as a third axis.

Meanwhile, when the display unit 840 is configured as a touch screen including a touch pad, the display unit 840 may be used as an input unit as well as an output unit. The display unit 840 may include, for example, a liquid crystal display (LCD), a thin film transistor-liquid crystal display (TFT-LCD), an organic light-emitting diode (OLED), a flexible display, a 3D display, or an electrophoretic display.

The input receiving unit 850 may receive an input for setting a line of interest. The input receiving unit 850 may include, for example, a key pad, a dome switch, a touch pad, a jog wheel, a jog switch, or the like, but not limited thereto. When the input receiving unit 850 is configured as a touch pad, the touch pad may be of, for example, a contact type electrostatic capacitive method, a pressure resistive layer method, an infrared ray sensing method, a surface ultrasonic wave conduction method, an integration type tension measurement method, a piezo effect method, or the like. When the display unit 840 is configured as the touch screen including a touch pad as described above, the touch screen may also operate as the input receiving unit 850, and thus the input receiving unit 850 may not be separately provided. In an exemplary embodiment, the input receiving unit 850 may also include a microphone for receiving an audio signal.

For example, an input may be received through a click or a touch on a predetermined button or the like provided on the input receiving unit **850**. For example, an input may be received through a click of a line selection function button (not shown). Also, when the input receiving unit **850** is configured as a touch pad, an input may be received through a gesture such as a “tap”, “double tap”, “drag and drop”, etc. An input may also be received in an audio form such as, for example, a user’s voice.

Here, the line setting unit **810**, the brightness information obtaining unit **820**, and information converting unit **830** may be provided in separate controllers or integrated into a same controller (not shown). The controller may be, for example, a central processing unit (CPU).

FIG. **9** is a detailed block diagram of an apparatus for displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment.

The line setting unit **810** may include a line designating unit **811** that designates a line of interest based on an input received from the input receiving unit **850**.

The line of interest may include at least one of ultrasound scan lines and a line extending at a predetermined angle on the ultrasound image **500** according to the input from the input receiving unit **850**.

The input may be received from outside of an ultrasound apparatus **800** through the input receiving unit **850**. The input receiving unit **850** may be, for example, a keyboard, a mouse, a joystick, etc. The input may be previously stored in a storage (not shown) connected to the input receiving unit **850** of the ultrasound apparatus **800** or applied to the ultrasound apparatus **800** in real time during a process of obtaining the ultrasound image **500**.

The brightness information obtaining unit **820** may obtain information related to an ultrasound sectional plane including brightness information of the ultrasound sectional plane of a target object along the designated set line of interest.

The information converting unit **830** may include a mapping unit (or mapping part) **831** that maps gray scale values to height values according to a predetermined range thereof. The information converting unit **830** may further include a color allocating unit (or color allocator) **832** that allocates colors to the mapped height values.

For example, the mapping unit **831** may map gray scale values from 0 to 255 to the height values from 0 to 255.

For example, in a case where a gray scale value “0” is defined as the gray scale value indicating a black color that is the darkest color value, the mapping unit **831** may map the gray scale value “0” to a lowest value of the height information *h*. In a case where a gray scale value “255” is defined as the gray scale value indicating a white color that is the brightest color value, the mapping unit **861** may map the gray scale value “255” to a highest value of the height information *h*.

On the other hand, in a case where the gray scale value “0” is used as the gray scale value indicating the white color that is the brightest color value, the mapping unit **831** may map the gray scale value “0”, i.e., a brightest color value to the lowest value of the height information *h*, and the gray scale value “255” indicating the black color to the highest value of the height information *h*.

Also, for example, the mapping unit **831** may map gray scale values from 0 to 511 to the height values from 0 to 255. Here, for example, in a case where gray scale values exceeding 255 are rare, the gray scale values exceeding 255 may be collectively mapped to the height value of 255. Accordingly, mapping of the height information *h* may be

efficient in that additional height values are not required to represent the rare gray scale values.

The color allocating unit **832** may allocate a plurality of different colors according to height values. In a case where colors are allocated to heights, the color allocating unit **832** may provide a color allocation status bar showing color allocation with respect to heights.

FIG. **10** is a further detailed block diagram of an apparatus for displaying stereoscopic information related to an ultrasound sectional plane of a target object according to an exemplary embodiment.

The color allocating unit **832** may further include a distribution setting unit **832-1** that sets a color distribution with respect to height values.

The distribution setting unit **832-1** may set different color distributions with respect to height values based on an input used to set a color distribution received from the input receiving unit **850**.

In an exemplary embodiment, the color distribution may be differently set according to a user input.

Also, in an exemplary embodiment, the color distribution may be determined according to a previously set color distribution. For example, the previously set color distribution may represent an increased number of colors at height values to which higher brightness values are mapped. That is, if an ultrasound image of a target object includes a brighter part, the brighter part may be represented in a variety of colors, compared to a darker part.

The color allocating unit **832** may determine colors according to height values according to the set color distribution. In other words, as shown in FIGS. **7A** through **7C**, the color allocating unit **832** according to an exemplary embodiment may determine a color corresponding to each range of height values according to the set color distribution.

The description related to the above-described method may be applied to an apparatus according to an exemplary embodiment. Thus, the description of the apparatus as described with reference to the above-described method will not be repeated here.

The exemplary embodiments may be written as computer programs that may be implemented in general-use digital computers that execute the programs using a computer readable recording medium.

Examples of the computer readable recording medium include a read-only memory (ROM), a random-access memory (RAM), a compact disc read-only memory (CD-ROM), a magnetic tape, a floppy disk, an optical data storage device, etc. The computer readable recording medium may also be distributed over network coupled computer systems so that the computer readable code is stored and executed in a distributed fashion.

The foregoing exemplary embodiments and advantages are merely exemplary and are not to be construed as limiting. The present teaching can be readily applied to other types of apparatuses. Also, the description of the exemplary embodiments is intended to be illustrative, and not to limit the scope of the claims, and many alternatives, modifications, and variations will be apparent to those skilled in the arts.

What is claimed is:

1. A method of displaying stereoscopic information related to an ultrasound sectional plane of a target object, the method comprising:

- setting a line of interest on the ultrasound sectional plane of the target object based on a received input;
- obtaining an ultrasound signal of the ultrasound sectional plane of the target object along the set line of interest;

converting the obtained ultrasound signal to represent the stereoscopic information in a three-dimensional manner; and

displaying the stereoscopic information related to the ultrasound sectional plane of the target object in a stereoscopic space,

wherein the displaying the stereoscopic information comprises displaying information in which brightness values of the ultrasound sectional plane of the target object along the set line are represented by height values on a first axis of the stereoscopic space.

2. The method of claim 1, wherein the stereoscopic information comprises an M-mode image related to the ultrasound sectional plane of the target object.

3. The method of claim 1, wherein the stereoscopic information related to the ultrasound sectional plane of the target object further comprises capture time information, and brightness information of the ultrasound sectional plane of the target object.

4. The method of claim 1, wherein the setting comprises: based on the received input, determining the line of interest based on at least one from among an ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

5. The method of claim 3, wherein the displaying the stereoscopic information further comprises:

displaying height information, converted from the brightness information corresponding to the brightness values, on the first axis of the stereoscopic space, displaying the capture time information on a second axis of the stereoscopic space, and displaying information related to the ultrasound sectional plane in the stereoscopic space by using information about a position of the target object along the set line of interest as a third axis.

6. A non-transitory computer readable recording medium having recorded thereon on a program for executing the method of claim 1.

7. A method of displaying a three-dimensional M-mode image related to an ultrasound sectional plane of a target object, the method comprising:

setting a line of interest on the ultrasound sectional plane of the target object based on a received input;

obtaining brightness information including brightness values of the ultrasound sectional plane of the target object along the set line of interest;

converting a two-dimensional M-mode image related to the ultrasound sectional plane of the target object into the three-dimensional M-mode image based on the obtained brightness information; and

displaying the three-dimensional M-mode image related to the ultrasound sectional plane of the target object in a stereoscopic space,

wherein the displaying the three-dimensional M-mode image comprises displaying information in which the brightness values of the ultrasound sectional plane of the target object along the set line are represented by height values on a first axis of the stereoscopic space.

8. The method of claim 7, wherein the three-dimensional M-mode image related to the ultrasound sectional plane of the target object further comprises capture time information, and brightness information of the ultrasound sectional plane of the target object.

9. The method of claim 7, wherein the setting comprises: based on the received input, determining the line of interest based on at least one from among an ultrasound

scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

10. The method of claim 8, wherein the displaying the three-dimensional M-mode image further comprises:

displaying height information, converted from the brightness information corresponding to the brightness values, on the first axis of the stereoscopic space, displaying the capture time information on a second axis of the stereoscopic space, and displaying information related to the ultrasound sectional plane in the stereoscopic space by using information about a position of the target object along the set line of interest as a third axis.

11. A non-transitory computer readable recording medium having recorded thereon on a program for executing the method of claim 7.

12. A method of displaying a three-dimensional image representing a location and motion information of an ultrasound sectional plane of a target object, the method comprising:

setting a line of interest on the ultrasound sectional plane of the target object based on a received input;

obtaining brightness information including brightness values of the ultrasound sectional plane of the target object along the set line of interest;

converting a two-dimensional image representing the location and the motion information by using the brightness information into the three-dimensional image representing the location and the motion information by using height information corresponding to the brightness information; and

displaying the three-dimensional image based on the height information in a stereoscopic space,

wherein the displaying the three-dimensional image comprises displaying information in which the brightness values of the ultrasound sectional plane are represented by height values on a first axis of the stereoscopic space.

13. The method of claim 12, wherein the three-dimensional image further comprises capture time information, and the brightness information of the ultrasound sectional plane of the target object.

14. The method of claim 12, wherein the setting comprises:

based on the received input, determining the line of interest based on at least one from among an ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

15. The method of claim 12, wherein the converting comprises:

mapping the obtained brightness information including predetermined gray scale values to the height values of a predetermined range.

16. The method of claim 15, wherein the converting comprises:

allocating predetermined colors to the mapped height values.

17. The method of claim 16, wherein the allocating comprises:

setting a color distribution of the predetermined colors with respect to the predetermined range of the mapped height values; and

allocating the predetermined colors to the displayed image according to the set color distribution.

18. The method of claim 13, wherein the displaying the three-dimensional image comprises:

displaying height information converted from the brightness information corresponding to the brightness values on the first axis of the stereoscopic space, displaying the capture time information on a second axis of the stereoscopic space, and displaying information related to the ultrasound sectional plane in the stereoscopic space by using information about a position of the target object along the set line of interest as a third axis.

19. A non-transitory computer readable recording medium having recorded thereon a program for executing the method of claim 12.

20. An apparatus for displaying stereoscopic information related to an ultrasound sectional plane of a target object, the apparatus comprising:

a line setting determiner configured to set a line of interest on the ultrasound sectional plane of the target object based on a received input;

a brightness information obtainer configured to obtain brightness information including brightness values of the ultrasound sectional plane of the target object along the set line of interest;

an information converter configured to convert the obtained ultrasound signal to representing the stereoscopic information in a three-dimensional manner; and a display configured to display the stereoscopic information related to the ultrasound sectional plane of the target object in a stereoscopic space,

wherein the display is further configured to display the stereoscopic information such that information in which the brightness values of the ultrasound sectional plane of the target object along the set line are represented by height values on a first axis of the stereoscopic space.

21. The apparatus of claim 20, wherein the stereoscopic information comprises an M-mode image related to the ultrasound sectional plane of the target object.

22. The apparatus of claim 20, wherein the stereoscopic information related to the ultrasound sectional plane of the target object further comprises capture time information, and the brightness information of the ultrasound sectional plane of the target object.

23. The apparatus of claim 20, further comprising:

an input receiver configured to receive an input for setting the line of interest,

wherein the line setting determiner, based on the received input for setting the line of interest, determines the line of interest based on at least one from among an ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

24. The apparatus of claim 22, wherein the display displays height information converted from the brightness information corresponding to the brightness values on the first axis of the stereoscopic space, the capture time information on a second axis of the stereoscopic space, and information related to the ultrasound sectional plane in the stereoscopic space by using information about a position of the target object along the set line of interest as a third axis.

25. An apparatus for displaying a three-dimensional M-mode image related to an ultrasound sectional plane of a target object, the apparatus comprising:

a line setting determiner configured to set a line of interest on the ultrasound sectional plane of the target object based on a received input;

a brightness information obtainer configured to obtain brightness information including brightness values of the ultrasound sectional plane of the target object along the set line of interest;

an information converter configured to convert a two-dimensional M-mode image related to the ultrasound sectional plane of the target object into the three-dimensional M-mode image based on the obtained brightness information; and

a display configured to display the three-dimensional M-mode image related to the ultrasound sectional plane of the target object in a stereoscopic space,

wherein the display is further configured to display the three-dimensional M-mode image such that information in which the brightness values of the ultrasound sectional plane of the target object along the set line are represented by height values on a first axis of the stereoscopic space.

26. The apparatus of claim 25, wherein the three-dimensional M-mode image related to the ultrasound sectional plane of the target object further comprises capture time information, and the brightness information of the ultrasound sectional plane of the target object.

27. The apparatus of claim 25, further comprising:

an input receiver configured to receive an input for setting the line of interest,

wherein the line setting determiner, based on the received input for setting the line of interest, determines the line of interest based on at least one from among an ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

28. The apparatus of claim 26, wherein the display displays the capture time information on a second axis of the stereoscopic space, and displays height information converted from the brightness information on a third axis of the stereoscopic space.

29. An apparatus for displaying a three-dimensional image representing a location and motion information of an ultrasound sectional plane of a target object, the apparatus comprising:

a line setting determiner configured to set a line of interest on the ultrasound sectional plane of the target object based on a received input;

a brightness information obtainer configured to obtain brightness information including brightness values of the ultrasound sectional plane of the target object along the set line of interest;

an information converter configured to convert a two-dimensional image representing the location and the motion information by using the brightness information into the three-dimensional image representing the location and the motion information by using height information including height values corresponding to the brightness values of the ultrasound sectional plane of the target object along the set line; and

a display configured to display the three-dimensional image in a three-dimensional manner based on the height information such that the brightness values of the ultrasound sectional plane of the target object along the set line are represented by the height values on a first axis of the stereoscopic space.

30. The apparatus of claim 29, wherein the three-dimensional image comprises the height information, converted from the brightness information corresponding to the brightness values, on the first axis of the stereoscopic space, capture time information, the brightness information of the

ultrasound sectional plane of the target object, and information related to the ultrasound sectional plane in the stereoscopic space by using information about a position of the target object along the set line of interest as a third axis.

31. The apparatus of claim **29**, further comprising: 5
an input receiver configured to receive an input for setting the line of interest,

wherein the line setting determiner, based on the received input for setting the line of interest, determines the line of interest based on at least one from among an 10
ultrasound scan line and a line extending at a predetermined angle, the ultrasound scan line and the line being on the same ultrasound sectional plane.

32. The apparatus of claim **29**, wherein the information converter comprises: 15

a mapping part configured to map the obtained brightness information including predetermined gray scale values to the height values of a predetermined range.

33. The apparatus of claim **32**, wherein the information converter comprises: 20

a color allocator configured to allocate predetermined colors to the mapped height values.

34. The apparatus of claim **33**, wherein the color allocator comprises:

a distribution setting determiner configured to set a color 25
distribution of the predetermined colors with respect to the predetermined range of the mapped height values, wherein the color allocator allocates the predetermined colors to the displayed image according to the set color distribution. 30

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当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD. 三星MEDISON CO. , LTD.		
[标]发明人	CHANG EUN JUNG LEE JIN YONG		
发明人	CHANG, EUN-JUNG LEE, JIN-YONG		
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代理机构(译)	萨格鲁MION , PLLC		
审查员(译)	THOMPSON , 詹姆斯		
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摘要(译)

一种显示与目标对象的超声截面相关的立体信息的方法包括：基于接收的输入在目标对象的超声截面上设置关注线;沿着设定的感兴趣线获得目标物体的超声截面的超声信号;转换获得的超声信号以三维方式表示立体信息;并显示与目标对象的超声截面相关的立体信息。

