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(54) Providing user interface in ultrasound system

Bereitstellung einer Benutzerschnittstelle in einem Ultraschallsystem

Fournir une interface utilisateur dans un système à ultrasons

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(73) Proprietor: **Samsung Medison Co., Ltd.**
Gangwon-do 250-870 (KR)

(72) Inventor: **Kim, Hyoung Jin**
135-851 Seoul (KR)

(74) Representative: **Lorenz, Markus**
Lorenz & Kollegen
Patentanwälte Partnerschaftsgesellschaft mbB
Alte Ulmer Straße 2
89522 Heidenheim (DE)

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- **VERA N ET AL: "Visualization of complex flow fields, with application to the interpretation of colour flow doppler images", ULTRASOUND IN MEDICINE AND BIOLOGY, NEW YORK, NY, US, vol. 18, no. 1, 1 January 1992 (1992-01-01), pages 1-9, XP026450892, ISSN: 0301-5629 [retrieved on 1992-01-01]**

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Description

TECHNICAL FIELD

[0001] The present disclosure generally relates to ultrasound systems, and more particularly to providing a user interface for performing a filtering process upon a vector Doppler image in an ultrasound system.

BACKGROUND

[0002] An ultrasound system has become an important and popular diagnostic tool since it has a wide range of applications. Specifically, due to its non-invasive and non-destructive nature, the ultrasound system has been extensively used in the medical profession. Modern high-performance ultrasound systems and techniques are commonly used to produce two-dimensional or three-dimensional ultrasound images of internal features of target objects (e.g., human organs).

[0003] The ultrasound system provides ultrasound images of various modes including a brightness mode image representing reflection coefficients of ultrasound signals (i.e., ultrasound echo signals) reflected from a target object of a living body with a two-dimensional image, a Doppler mode image representing velocity of a moving target object with spectral Doppler by using a Doppler effect, a color Doppler mode image representing velocity of the moving target object with colors by using the Doppler effect, an elastic image representing mechanical characteristics of tissues before and after applying compression thereto and the like.

[0004] The ultrasound system transmits the ultrasound signals to the living body and receives the ultrasound echo signals from the living body to form Doppler signals corresponding to a region of interest, which is set on the brightness mode image. The ultrasound system further forms the color Doppler mode image representing the velocity of the moving target object with colors based on the Doppler signals. In particular, the color Doppler image represents the motion of the target object (e.g., blood flow) with the colors. The color Doppler image is used to diagnose diseases of blood vessels, heart and the like. However, it is difficult to represent an accurate motion of the target object (e.g., blood flow) since the respective colors indicated by a motion value is a function of the velocity of the target object, which moves forward in a transmission direction of the ultrasound signals and moves backward in the transmission direction of the ultrasound signals.

[0005] From US 2011/196237 A1 there are known an apparatus and methods for measuring and analyzing blood flow in vessels in the bodies of living subjects are provided. The true velocity vector, or a projection thereof onto a scan plane, for blood flowing at a location in a vessel is determined from multiple Doppler velocity components. The true velocity vector is displayed as an arrowlike directional marker on an image comprising the vessel. The true velocity magnitude and angle, and scalar blood flow characteristics derived therefrom, are plotted as a functions of time and/or position across the depiction of the blood vessel in the image.

[0006] Moreover, US 2003/013959 A1 discloses a graphical user interface for an ultrasound system. The ultrasound system has operational modes, and the graphical user interface has corresponding icons, tabs, and menu items Image and information fields. The user interface provides several types of graphical elements in a tool bar with intelligent behavior, such as being context sensitive and adaptive, called active objects, for example, tabs, menus, icons, windows of user interaction and data display, and an alphanumeric keyboard.

[0007] Furthermore, also US2009/030321 A1, US 4,768,515 A and US2010/069757 A1 refer to ultrasound systems providing a user interface for performing a filtering process upon a vector Doppler image in an ultrasound system.

[0008] Finally, from Vera N et. al., "Visualization of complex flow fields, with application to the interpretation of colour flow doppler images", Ultrasound in medicine and biology, New ork, NY, US, vo. 18, no. 1, 1 January 1992 (1992-01-01), pages 1-9, XP026450892, ISSN: 0301-5629 an ultrasound visualisation method is known.

[0009] To resolve the above-mentioned problem and to further enhance solutions known from the prior art, an ultrasound system with the features of claim 1 and a method of providing a user interface with the features of claim 5 are provided. Accordingly, a vector Doppler method capable of obtaining the velocity and direction of the blood flow is used. A cross beam-based method of the vector Doppler method acquires velocity magnitude components from at least two different directions, and combine the velocity magnitude components to detect vector information having a two-dimensional or three-dimensional direction information and a magnitude information.

SUMMARY

[0010] There are provided embodiments for providing a user interface for performing a filtering process upon a vector Doppler image.

[0011] In one embodiment of the invention, by way of non-limiting example, an ultrasound system comprises the features of claim 1.

[0012] In another embodiment of the invention, there is provided an ultrasound imaging method, comprising the method steps of claim 4.

[0013] 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

[0014]

FIG. 1 is a block diagram showing an illustrative embodiment of an ultrasound system.
FIG. 2 is a schematic diagram showing an example of a brightness mode image and a first region of interest.
FIG. 3 is a block diagram showing an illustrative embodiment of an ultrasound data acquiring unit.
FIGS. 4 to 7 are schematic diagrams showing examples of transmission directions and reception directions.
FIG. 8 is a schematic diagram showing an example of sampling data and pixels of an ultrasound image.
FIGS. 9 to 12 are schematic diagrams showing examples of performing a reception beam-forming.
FIG. 13 is a schematic diagram showing an example of setting weights.
FIG. 14 is a schematic diagram showing an example of setting a sampling data set.
FIG. 15 is a flow chart showing a process of providing a user interface for a filtering process upon a vector Doppler image.
FIG. 16 is a schematic diagram showing an example of the transmission directions, the reception directions, the vector information and an over-determined problem.
FIG. 17 is a schematic diagram showing an example of the brightness mode image, the vector Doppler image and the user interface.
FIGS. 18 to 20 are schematic diagrams showing an example of the user interface.

DETAILED DESCRIPTION

[0015] A detailed description may be provided with reference to the accompanying drawings. One of ordinary skill in the art may realize that the following description is illustrative only and is not in any way limiting.

[0016] Referring to FIG. 1, an ultrasound system 100 in accordance with an illustrative embodiment is shown. As depicted therein, the ultrasound system 100 includes a user input unit 110.

[0017] The user input unit 110 is configured to receive input information from a user. In one embodiment, the input information includes first input information for setting a first region of interest ROI_1 on a brightness mode image BI, as shown in FIG. 2. The first region of interest ROI_1 includes a color box for obtaining a Doppler mode image. The Doppler mode image includes a vector Doppler image corresponding to motion (i.e., velocity and direction) of a target object. The input information further includes second input information for setting at least one region for representing only the motion of target in a specific direction on the vector Doppler image. However, it should be noted herein that the input information may not be limited thereto. In FIG. 2, the reference numeral BV represents a blood vessel. The user input unit 110 includes a control panel, a track ball, a touch screen, a keyboard, a mouse and the like.

[0018] The ultrasound system 100 further includes an ultrasound data acquiring unit 120. The ultrasound data acquiring unit 120 is configured to transmit ultrasound signals to a living body. The living body includes the target object (e.g., blood flow, blood vessel, heart, etc.). The ultrasound data acquiring unit 120 is further configured to receive ultrasound signals (i.e., ultrasound echo signals) from the living body to acquire ultrasound data corresponding to an ultrasound image.

[0019] FIG. 3 is a block diagram showing an illustrative embodiment of the ultrasound data acquiring unit 120. Referring to FIG. 3, the ultrasound data acquiring unit 120 includes an ultrasound probe 310.

[0020] The ultrasound probe 310 includes a plurality of elements 311 (*see* FIG. 4) for reciprocally converting between ultrasound signals and electrical signals. The ultrasound probe 310 is configured to transmit the ultrasound signals to the living body. The ultrasound signals transmitted from the ultrasound probe 310 are plane wave signals that the ultrasound signals are not focused at a focusing point, or focused signals that the ultrasound signals are focused at the focusing point. However, it should be noted herein that the ultrasound signals may not be limited thereto. The ultrasound probe 310 is further configured to receive the ultrasound echo signals from the living body to output electrical signals (hereinafter referred to as "reception signals"). The reception signals are analog signals. The ultrasound probe 310 includes a convex probe, a linear probe and the like.

[0021] The ultrasound data acquiring unit 120 further includes a transmitting section 320. The transmitting section 320 is configured to control the transmission of the ultrasound signals. The transmitting section 320 is also configured to generate electrical signals (hereinafter referred to as "transmission signals") in consideration of the elements 311.

[0022] In one embodiment, the transmitting section 320 is configured to generate transmission signals (hereinafter referred to as "brightness mode transmission signals") for obtaining the brightness mode image BI in consideration of the elements 311. Thus, the ultrasound probe 310 is configured to convert the brightness mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body, and receive the ultrasound echo signals from the living body to output reception signals (hereinafter referred to as "brightness mode reception signals").

[0023] The transmitting section 320 is further configured to generate transmission signals (hereinafter referred to as "Doppler mode transmission signals") corresponding to an ensemble number in consideration of the elements 311 and at least one transmission direction of the ultrasound signals (i.e., transmission beam). Thus, the ultrasound probe 310 is configured to convert the Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body in the at least one transmission direction, and receive the ultrasound echo signals from the living body to output reception signals (hereinafter referred to as "Doppler mode reception signals"). The ensemble number represents the number of transmitting and receiving the ultrasound signals to and from the living body.

[0024] As one example, the transmitting section 320 is configured to generate the Doppler mode transmission signals corresponding to the ensemble number in consideration of a transmission direction Tx and the elements 311, as shown in FIG. 4. The transmission direction is one of a direction (i.e., 0 degree) perpendicular to a longitudinal direction of the elements 311 to a maximum steering direction of the transmission beam.

[0025] As another example, the transmitting section 320 is configured to generate first Doppler mode transmission signals corresponding to the ensemble number in consideration of a first transmission direction Tx_1 and the elements 311, as shown in FIG. 5. Thus, the ultrasound probe 310 is configured to convert the first Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body in the first transmission direction Tx_1, and receive the ultrasound echo signals from the living body to output first Doppler mode reception signals. The transmitting section 320 is further configured to generate second Doppler mode transmission signals corresponding to the ensemble number in consideration of a second transmission direction Tx_2 and the elements 311, as shown in FIG. 5. Thus, the ultrasound probe 310 is configured to convert the second Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body in the second transmission direction Tx_2, and receive the ultrasound echo signals from the living body to output second Doppler mode reception signals. In FIG. 5, the reference numeral PRI represents a pulse repeat interval.

[0026] In another embodiment, the transmitting section 320 is configured to generate the brightness mode transmission signals for obtaining the brightness mode image BI in consideration of the elements 311. Thus, the ultrasound probe 310 is configured to convert the brightness mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body, and receive the ultrasound echo signals from the living body to output the brightness mode reception signals.

[0027] The transmitting section 320 is further configured to generate the Doppler mode transmission signals corresponding to the ensemble number in consideration of the at least one transmission direction and the elements 311. Thus, the ultrasound probe 310 is configured to convert the Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body, and receive the ultrasound echo signals from the living body to output the Doppler mode reception signals. The ultrasound signals are transmitted in an interleaved transmission scheme. The interleaved transmission scheme will be described below in detail.

[0028] For example, the transmitting section 320 is configured to generate the first Doppler mode transmission signals in consideration of the first transmission direction Tx_1 and the elements 311, as shown in FIG. 6. Thus, the ultrasound probe 310 is configured to convert the first Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, and transmit the ultrasound signals to the living body in the first transmission direction Tx_1. The transmitting section 320 is further configured to generate the second Doppler mode transmission signals in consideration of the second transmission direction Tx_2 and the elements 311, as shown in FIG. 6. Thus, the ultrasound probe 310 is configured to convert the second Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, and transmit the ultrasound signals to the living body in the second transmission direction Tx_2. The ultrasound probe 310 is further configured to receive the ultrasound echo signals (i.e., ultrasound echo signals corresponding to first Doppler mode transmission signals) from the living body to output the first Doppler mode reception signals. The ultrasound probe 310 is further configured to receive the ultrasound echo signals (i.e., ultrasound echo signals corresponding to second Doppler mode transmission signals) from the living body to output the second Doppler mode reception signals.

[0029] Thereafter, the transmitting section 320 is configured to generate the first Doppler mode transmission signals based on the pulse repeat interval, as shown in FIG. 6. Thus, the ultrasound probe 310 is configured to convert the first Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, and transmit the ultrasound signals to the living body in the first transmission direction Tx_1. Then, the transmitting section 320 is further configured to generate the second Doppler mode transmission signals based on the pulse repeat interval, as shown in FIG. 6. Accordingly, the ultrasound probe 310 is configured to convert the second Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, and transmit the ultrasound signals to the living body in the second transmission direction Tx_2. The ultrasound probe 310 is further configured to receive the ultrasound echo signals (i.e., ultrasound echo signals corresponding to first Doppler mode transmission signals) from the living body to output the first Doppler mode reception signals. The ultrasound probe 310 is further configured to receive the ultrasound echo signals (i.e., ultrasound echo signals corresponding to second Doppler mode transmission signals) from the living body to output the second Doppler mode reception signals.

[0030] As described above, the transmitting section 320 is configured to generate the first Doppler mode transmission signals and the second Doppler mode transmission signals corresponding to the ensemble number.

[0031] In yet another embodiment, the transmitting section 320 is configured to generate the brightness mode transmission signals for obtaining the brightness mode image BI in consideration of the elements 311. Thus, the ultrasound probe 310 is configured to convert the brightness mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body, and receive the ultrasound echo signals from the living body to output the brightness mode reception signals.

[0032] The transmitting section 320 is further configured to generate the Doppler mode transmission signals corresponding to the ensemble number in consideration of the at least one transmission direction and the elements 311. Thus, the ultrasound probe 310 is configured to convert the Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body in the at least one transmission direction, and receive the ultrasound echo signals from the living body to output the Doppler mode reception signals. The ultrasound signals are transmitted according to the pulse repeat interval.

[0033] For example, the transmitting section 320 is configured to generate the first Doppler mode transmission signals in consideration of the first transmission direction Tx_1 and the elements 311 based on the pulse repeat interval, as shown in FIG. 7. Thus, the ultrasound probe 310 is configured to convert the first Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to living body in the first transmission direction Tx_1, and receive the ultrasound echo signals from the living body to output the first Doppler mode reception signals. The transmitting section 320 is further configured to generate the second Doppler mode transmission signals in consideration of the second transmission direction Tx_2 and the elements 311 based on the pulse repeat interval, as shown in FIG. 7. Thus, the ultrasound probe 310 is configured to convert the second Doppler mode transmission signals provided from the transmitting section 320 into the ultrasound signals, transmit the ultrasound signals to the living body in the second transmission direction Tx_2, and receive the ultrasound echo signals from the living body to output the second Doppler mode reception signals.

[0034] As described above, the transmitting section 320 is configured to generate the first Doppler mode transmission signals and the second Doppler mode transmission signals corresponding to the ensemble number based on the pulse repeat interval.

[0035] Referring back to FIG. 3, the ultrasound data acquiring unit 120 further includes a receiving section 330. The receiving section 330 is configured to perform an analog-digital conversion upon the reception signals provided from the ultrasound probe 310 to form sampling data. The receiving section 330 is further configured to perform a reception beam-forming upon the sampling data in consideration of the elements 311 to form reception-focused data. The reception beam-forming will be described below in detail.

[0036] In one embodiment, the receiving section 330 is configured to perform the analog-digital conversion upon the brightness mode reception signals provided from the ultrasound probe 310 to form sampling data (hereinafter referred to as "brightness mode sampling data"). The receiving section 330 is further configured to perform the reception beam-forming upon the brightness mode sampling data to form reception-focused data (hereinafter referred to as "brightness mode reception-focused data").

[0037] The receiving section 330 is further configured to perform the analog-digital conversion upon the Doppler mode reception signals provided from the ultrasound probe 310 to form sampling data (hereinafter referred to as "Doppler mode sampling data"). The receiving section 330 is further configured to perform the reception beam-forming upon the Doppler mode sampling data to form reception-focused data (hereinafter referred to as "Doppler mode reception-focused data") corresponding to at least one reception direction of the ultrasound echo signals (i.e., reception beam).

[0038] As one example, the receiving section 330 is configured to perform the analog-digital conversion upon the Doppler mode reception signals provided from the ultrasound probe 310 to form the Doppler mode sampling data. The receiving section 330 is further configured to perform the reception beam-forming upon the Doppler mode sampling data to form first Doppler mode reception-focused data corresponding to a first reception direction Rx_1 and second Doppler mode reception-focused data corresponding to a second reception direction Rx_2, as shown in FIG. 4.

[0039] As another example, the receiving section 330 is configured to perform the analog-digital conversion upon the first Doppler mode reception signals provided from the ultrasound probe 310 to form first Doppler mode sampling data corresponding to the first transmission direction Tx_1, as shown in FIG. 5. The receiving section 330 is further configured to perform the reception beam-forming upon the first Doppler mode sampling data to form the first Doppler mode reception-focused data corresponding to the first reception direction Rx_1. The receiving section 330 is also configured to perform the analog-digital conversion upon the second Doppler mode reception signals provided from the ultrasound probe 310 to form second Doppler mode sampling data corresponding to the second transmission direction Tx_2, as shown in FIG. 5. The receiving section 330 is further configured to perform the reception beam-forming upon the second Doppler mode sampling data to form the second Doppler mode reception-focused data corresponding to the second reception direction Rx_2. If the reception direction is perpendicular to the elements 311 of the ultrasound probe 310, then a maximum aperture size is used.

[0040] The reception beam-forming is described with reference to the accompanying drawings.

[0041] In one embodiment, the receiving section 330 is configured to perform the analog-digital conversion upon the reception signals provided through a plurality of channels CH_k, wherein $1 \le k \le N$, from the ultrasound probe 310 to form sampling data $S_{i,j}$, wherein the i and j are a positive integer, as shown in FIG. 8. The sampling data $S_{i,j}$ are stored in a storage unit 140. The receiving section 330 is further configured to detect pixels corresponding to the sampling data based on positions of the elements 311 and positions (orientation) of pixels of the ultrasound image UI with respect to the elements 311. That is, the receiving section 330 selects the pixels, which the respective sampling data are used as pixel data thereof, during the reception beam-forming based on the positions of the elements 311 and the orientation of the respective pixels of the ultrasound image UI with respect to the elements 311. The receiving section 330 is configured to cumulatively assign the sampling data corresponding to the selected pixels as the pixel data.

[0042] For example, the receiving section 330 is configured to set a curve (hereinafter referred to as "reception beam-forming curve") $CV_{6,3}$ for selecting pixels, which the sampling data $S_{6,3}$ are used as the pixel data thereof, during the reception beam-forming based on the positions of the elements 311 and the orientation of the respective pixels of the ultrasound image UI with respect to the elements 311, as shown in FIG. 9. The receiving section 330 is further configured to detect the pixels $P_{3,1}$, $P_{3,2}$, $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{4,5}$, $P_{4,6}$, $P_{4,7}$, $P_{4,8}$, $P_{4,9}$, ... $P_{3,N}$ corresponding to the reception beam-forming curve $CV_{6,3}$ from the pixels $P_{a,b}$ of the ultrasound image UI, wherein $1 \le a \le M$, $1 \le b \le N$. That is, the receiving section 330 selects the pixels $P_{3,1}$, $P_{3,2}$, $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{4,5}$, $P_{4,6}$, $P_{4,7}$, $P_{4,8}$, $P_{4,9}$, ... $P_{3,N}$ on which the reception beam-forming curve $CV_{6,3}$ passes among the pixels $P_{a,b}$ of the ultrasound image UI. The receiving section 330 is also configured to assign the sampling data $S_{6,3}$ to the selected pixels $P_{3,1}$, $P_{3,2}$, $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{4,5}$, $P_{4,6}$, $P_{4,7}$, $P_{4,8}$, $P_{4,9}$, ... $P_{3,N}$, as shown in FIG. 10.

[0043] Thereafter, the receiving section 330 is configured to set a reception beam-forming curve $CV_{6,4}$ for selecting pixels, which the sampling data $S_{6,4}$ are used as the pixel data thereof, during the reception beam-forming based on the positions of the elements 311 and the orientation of the respective pixels of the ultrasound image UI with respect to the elements 311, as shown in FIG. 11. The receiving section 330 is further configured to detect the pixels $P_{2,1}$, $P_{3,1}$, $P_{3,2}$, $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{S,4}$, $P_{5,5}$, $P_{5,6}$, $P_{5,7}$, $P_{5,8}$, $P_{4,9}$, $P_{5,9}$, ... $P_{4,N}$, $P_{3,N}$ corresponding to the reception beam-forming curve $CV_{6,4}$ from the pixels $P_{a,b}$ of the ultrasound image UI. That is, the receiving section 330 selects the pixels $P_{2,1}$, $P_{3,1}$, $P_{3,2}$, $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{5,4}$, $P_{5,5}$, $P_{5,6}$, $P_{5,7}$, $P_{5,8}$, $P_{4,9}$, $P_{5,9}$, ... $P_{4,N}$, $P_{3,N}$ on which the reception beam-forming curve $CV_{6,4}$ passes among the pixels $P_{a,b}$ of the ultrasound image UI. The receiving section 330 is additionally configured to assign the sampling data $S_{6,4}$ to the selected pixels $P_{2,1}$, $P_{3,1}$, $P_{3,2}$, $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{5,4}$, $P_{5,5}$, $P_{5,6}$, $P_{5,7}$, $P_{5,8}$, $P_{4,9}$, $P_{5,9}$, ... $P_{4,N}$, $P_{3,N}$, as shown in FIG. 12. In this way, the respective sampling data, which are used as the pixel data, are cumulatively assigned to the pixels as the pixel data.

[0044] The receiving section 330 is configured to perform the reception beam-forming (i.e., summing) upon the sampling data, which are cumulatively assigned to the respective pixels $P_{a,b}$ of the ultrasound image UI to form the reception-focused data.

[0045] In another embodiment, the receiving section 330 is configured to perform the analog-digital conversion upon the reception signals provided through the plurality of cannels CH_k from the ultrasound probe 310 to form the sampling data $S_{i,j}$, as shown in FIG. 8. The sampling data $S_{i,j}$ are stored in the storage unit 140. The receiving section 330 is further configured to detect pixels corresponding to the sampling data based on the positions of the elements 311 and the positions (orientation) of the pixels of the ultrasound image UI with respect to the elements 311. That is, the receiving section 330 selects the pixels, which the respective sampling data are used as the pixel data thereof, during the reception beam-forming based on the positions of the elements 311 and the orientation of the respective pixels of the ultrasound image UI with respect to the elements 311. The receiving section 330 is configured to cumulatively assign the sampling data corresponding to the selected pixels as the pixel data. The receiving section 330 is further configured to determine pixels existing in the same column among the selected pixels. The receiving section 330 is also configured to set weights corresponding to the respective determined pixels. The receiving section 330 is additionally configured to apply the weights to the sampling data of the respective pixels.

[0046] For example, the receiving section 330 is configured to set the reception beam-forming curve $CV_{6,3}$ for selecting pixels, which the sampling data $S_{6,3}$ are used as the pixel data thereof, during the reception beam-forming based on the positions of the elements 311 and the orientation of the respective pixels of the ultrasound image UI with respect to the elements 311, as shown in FIG. 9. The receiving section 330 is further configured to detect the pixels $P_{3,1}$, $P_{3,2}$, $P_{4,2}$,

$P_{4,3}$, $P_{4,4}$, $P_{4,5}$, $P_{4,6}$, $P_{4,7}$, $P_{4,8}$, $P_{4,9}$, ... $P_{3,N}$ corresponding to the reception beam-forming curve $CV_{6,3}$ from the pixels $P_{a,b}$ of the ultrasound image UI, wherein $1 \le a \le M$, $1 \le b \le N$. That is, the receiving section 330 selects the pixels $P_{3,1}$, $P_{3,2}$ $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{4,5}$, $P_{4,6}$, $P_{4,7}$, $P_{4,8}$, $P_{4,9}$, ... $P_{3,N}$ on which the reception beam-forming curve $CV_{6,3}$ passes among the pixels $P_{a,b}$ of the ultrasound image UI. The receiving section 330 is also configured to assign the sampling data $S_{6,3}$ to the selected pixels $P_{3,1}$, $P_{3,2}$, $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{4,5}$, $P_{4,6}$, $P_{4,7}$, $P_{4,8}$, $P_{4,9}$, ... $P_{3,N}$ as shown in FIG. 10. The receiving section 330 is further configured to determine pixels $P_{3,2}$ and $P_{4,2}$, which exist in the same column among the selected pixels $P_{3,1}$, $P_{3,2}$, $P_{4,2}$, $P_{4,3}$, $P_{4,4}$, $P_{4,5}$, $P_{4,6}$, $P_{4,7}$, $P_{4,8}$, $P_{4,9}$, ... $P_{3,N}$. The receiving section 330 is further configured to calculate a distance W_1 from a center of the determined pixel $P_{3,2}$ to the reception beam-forming curve $CV_{6,3}$ and a distance W_2 from a center of the determined pixel $P_{4,2}$ to the reception beam-forming curve $CV_{6,3}$, as shown in FIG. 13. The receiving section 330 is additionally configured to set a first weight α_1 corresponding to the pixel $P_{3,2}$ based on the distance W_1 and a second weight α_2 corresponding to the pixel $P_{4,2}$ based on the distance W_2. The first weight α_1 and the second weight α_2 are set to be in proportional to or in inverse proportional to the calculated distances. The receiving section 330 is further configured to apply the first weight α_1 to the sampling data $S_{6,3}$ assigned to the pixel $P_{3,2}$ and to apply the second weight α_2 to the sampling data $S_{6,3}$ assigned to the pixel $P_{4,2}$. The receiving section 330 is configured to perform the above process upon the remaining sampling data.

[0047] The receiving section 330 is configured to perform the reception beam-forming upon the sampling data, which are cumulatively assigned to the respective pixels $P_{a,b}$ of the ultrasound image UI to form the reception-focused data.

[0048] In yet another embodiment, the receiving section 330 is configured to perform the analog-digital conversion upon the reception signals provided through the plurality of channels CH_k from the ultrasound probe 310 to form the sampling data $S_{i,j}$, as shown in FIG. 8. The sampling data $S_{i,j}$ are stored in the storage unit 140. The receiving section 330 is further configured to set a sampling data set based on the sampling data $S_{i,j}$. That is, the receiving section 330 sets the sampling data set for selecting pixels, which the sampling data $S_{i,j}$ are used as the pixel data thereof, during the reception beam-forming.

[0049] For example, the receiving section 330 is configured to set the sampling data $S_{1,1}$ $S_{1,4}$, ... $S_{1,t}$, $S_{2,1}$, $S_{2,4}$, ... $S_{2,t}$, ... $S_{p,t}$ as the sampling data set (denoted by a box) for selecting the pixels, which the sampling data $S_{i,j}$ are used as the pixel data thereof, during the reception beam-forming, as shown in FIG. 14.

[0050] The receiving section 330 is further configured to detect the pixels corresponding to the respective sampling data of the sampling data set based on the positions of the elements 311 and the positions (orientation) of the respective pixels of the ultrasound image UI with respect to the elements 311. That is, the receiving section 330 selects the pixels, which the respective sampling data of the sampling data set are used as the pixel data thereof, during the reception beam-forming based on the positions of the elements 311 and the orientation of the respective pixels of the ultrasound image UI with respect to the elements 311. The receiving section 330 is further configured to cumulatively assign the sampling data to the selected pixels in the same manner as the above embodiments. The receiving section 330 is also configured to perform the reception beam-forming upon the sampling data, which are cumulatively assigned to the respective pixels of the ultrasound image UI to form the reception-focused data.

[0051] In yet another embodiment, the receiving section 330 is configured to perform down-sampling upon the reception signals provided through the plurality of channels CH_k from the ultrasound probe 310 to form down-sampled data. As described above, the receiving section 330 is further configured to detect the pixels corresponding to the respective sampling data based on the positions of the elements 311 and the positions (orientation) of the respective pixels of the ultrasound image UI with respect to the elements 311. That is, the receiving section 330 selects the pixels, which the respective sampling data are used as the pixel data thereof, during the reception beam-forming based on the positions of the elements 311 and the orientation of the pixels of the ultrasound image UI with respect to the elements 311. The receiving section 330 is further configured to cumulatively assign the respective sampling data to the selected pixels in the same manner as the above embodiments. The receiving section 330 is further configured to perform the reception beam-forming upon the sampling data, which are cumulatively assigned to the respective pixels of the ultrasound image UI to form the reception-focused data.

[0052] However, it should be noted herein that the reception beam-forming may not be limited thereto.

[0053] Referring back to FIG. 3, the ultrasound data acquiring unit 120 further includes an ultrasound data forming section 340. The ultrasound data forming section 340 is configured to form the ultrasound data corresponding to the ultrasound image based on the reception-focused data provided from the receiving section 330. The ultrasound data forming section 340 is further configured to perform a signal process (e.g., gain control, etc) upon the reception-focused data.

[0054] In one embodiment, the ultrasound data forming section 340 is configured to form ultrasound data (hereinafter referred to as "brightness mode ultrasound data") corresponding to the brightness mode image based on the brightness mode reception-focused data provided from the receiving section 330. The brightness mode ultrasound data include radio frequency data.

[0055] The ultrasound data forming section 340 is further configured to form ultrasound data (hereinafter referred to as "Doppler mode ultrasound data") corresponding to the first region of interest ROI_1 based on the Doppler mode reception-focused data provided from the receiving section 330. The Doppler mode ultrasound data include in-phase/quadrature data. However, it should be noted herein that the Doppler mode ultrasound data may not be limited thereto.

[0056] For example, the ultrasound data forming section 340 forms first Doppler mode ultrasound data based on the first Doppler mode reception-focused data provided from the receiving section 330. The ultrasound data forming section 340 further forms second Doppler mode ultrasound data based on the second Doppler mode reception-focused data provided from the receiving section 330.

[0057] Referring back to FIG. 1, the ultrasound system 100 further includes a processing unit 130 in communication with the user input unit 110 and the ultrasound data acquiring unit 120. The processing unit 130 includes a central processing unit, a microprocessor, a graphic processing unit and the like.

[0058] FIG. 15 is a flow chart showing a process of providing the user interface. The processing unit 130 is configured to form the brightness mode image BI based on the brightness mode ultrasound data provided from the ultrasound data acquiring unit 120, at step S1502 in FIG. 15. The brightness mode image BI is displayed on a display unit 150.

[0059] The processing unit 130 is configured to set the first region of interest ROI_1 on the brightness mode image BI based on the input information (i.e., first input information) provided from the user input unit 110, at step S1504 in FIG. 15. Thus, the ultrasound data acquiring unit 120 is configured to transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to acquire the Doppler mode ultrasound data corresponding to the first region of interest ROI_1.

[0060] The processing unit 130 is configured to form vector information based on the Doppler mode ultrasound data provided from the ultrasound data acquiring unit 120, at step S1506 in FIG. 15. That is, the processing unit 130 forms the vector information corresponding to the motion (i.e., velocity and direction) of the target object based on the Doppler mode ultrasound data.

[0061] Generally, when the transmission direction of the ultrasound signals is equal to the reception direction of the ultrasound echo signals and a Doppler angle is θ, the following relationship is established:

$$X\cos\theta = \frac{C_0 f_d}{2 f_0} \qquad (1)$$

[0062] In equation 1, X represents a reflector velocity (i.e., velocity of target object), Co represents a sound speed in the living body, f_d represents a Doppler shift frequency, and f_0 represents an ultrasound frequency.

[0063] The Doppler shift frequency f_d is calculated by the difference between a frequency of the ultrasound signals (i.e., transmission beam) and a frequency of the ultrasound echo signals (i.e., reception beam). Also, the velocity component $X\cos\theta$ projected to the transmission direction is calculated by equation 1.

[0064] When the transmission direction of the ultrasound signals (i.e., transmission beam) is different from the reception direction of the ultrasound echo signals (i.e., reception beam), the following relationship is established:

$$X\cos\theta_T + X\cos\theta_R = \frac{C_0 f_d}{f_0} \qquad (2)$$

[0065] In equation 2, θ_T represents an angle between the ultrasound signals (i.e., transmission beam) and the blood flow, and θ_R represents an angle between the ultrasound echo signals (i.e., reception beam) and the blood flow.

[0066] FIG. 16 is a schematic diagram showing an example of the transmission directions, the reception directions, the vector information and an over-determined problem. Referring to FIG. 16, when the ultrasound signals (i.e., transmission beam) are transmitted in a first direction D1 and the ultrasound echo signals (i.e., reception beam) are received in the first direction D1, the following relationship is established:

$$\overrightarrow{\alpha_1}\overrightarrow{X} = \alpha_{11}x_1 + \alpha_{12}x_2 = y_1 = X\cos\theta \qquad (3)$$

[0067] In equation 3, $\overrightarrow{\alpha_1} = (\alpha_{11}, \alpha_{12})$ represents a unit vector of the first direction D1, $\vec{X} = (x_1, x_2)$ represents variables, and y_1 is calculated by equation 1.

[0068] When the ultrasound signals (i.e., transmission beam) are transmitted in a second direction D2 and the ultrasound echo signals (i.e., reception beam) are received in a third direction D3, the following relationship is established:

$$(\alpha_{21} + \alpha_{31})x_1 + (\alpha_{22} + \alpha_{32})x_2 = (y_2 + y_3) = X\cos\theta_2 + X\cos\theta_3 \qquad (4)$$

[0069] Equations 3 and 4 assume a two-dimensional environment. However, equations 3 and 4 are expanded to a three-dimensional environment. That is, when expanding equations 3 and 4 to the three-dimensional environment, the following relationship is established:

$$\alpha_{11}x_1 + \alpha_{12}x_2 + \alpha_{13}x_3 = y \qquad (5)$$

[0070] In the case of the two-dimensional environment (i.e., two-dimensional vector), at least two equations are required to calculate the variables x_1 and x_2. For example, when the ultrasound signals (i.e., transmission beam) are transmitted in the third direction D3 and the ultrasound echo signals (i.e., reception beam) are received in the second direction D2 and a fourth direction D4 as shown in FIG. 16, the following equations are established:

$$\begin{aligned}(\alpha_{31} + \alpha_{21})x_1 + (\alpha_{32} + \alpha_{22})x_2 &= (y_3 + y_2)\\ (\alpha_{31} + \alpha_{41})x_1 + (\alpha_{32} + \alpha_{42})x_2 &= (y_3 + y_4)\end{aligned} \qquad (6)$$

[0071] The vector $\vec{X} = (x_1, x_2)$ is calculated by the equations of equation 6.

[0072] When the reception beam-forming is performed in at least two angles (i.e., at least two reception directions), at least two equations are obtained and represented as the over-determined problem, as shown in FIG. 16. The over-determined problem is well known in the art. Thus, it has not been described in detail so as not to unnecessarily obscure the present disclosure. The over-determined problem is solved by a pseudo inverse method, a weighted least square method and the like based on noise characteristics added to the Doppler shift frequency. That is, M×N equations are obtained by M transmission directions and the reception beam-forming of N reception directions at every transmission.

[0073] The processing unit 130 is configured to form a vector Doppler image VDI as shown in FIG. 17 based on the vector information, at step S1508 in FIG. 15. The methods of forming the vector Doppler image VDI are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure.

[0074] The processing unit 130 is configured to compound the brightness mode image BI and the vector Doppler image VDI to form a compound image.

[0075] The processing unit 130 is configured to form the user interface GUI as shown in FIG. 17 based on the vector information, at step S1510 in FIG. 15. The user interface GUI is an interface mapping the vector information corresponding to the motion (i.e., velocity and direction) of the target object to colors. That is, the user interface GUI is an interface for performing a filtering process upon the vector Doppler image VDI. The user interface GUI is displayed on the display unit 150.

[0076] The processing unit 130 is configured to set a second region of interest on the user interface GUI based on the input information (i.e., second input information), at step S1512 in FIG. 15.

[0077] As one example, when the second input information for setting a region RG on the user interface GUI in touch type as shown in FIGS. 18 and 19 is provided from the user input unit 110, the processing unit 130 is configured to set the second region of interest ROI_2 including the region RG corresponding to the second input information with respect to a center of the user interface GUI.

[0078] As another example, the second input information for setting two regions RG_1, RG_2 on the user interface GUI in the touch type as shown in FIG. 20 is provided from the user input unit 110, and the processing unit 130 is configured to set the second region of interest ROI_2 including the two regions RG_1, RG_2 corresponding to the second input information based on the center of the user interface GUI.

[0079] The processing unit 130 is configured to perform a filtering process upon the vector Doppler image VDI based on the second region of interest ROI_2, at step S1514 in FIG. 15. In one embodiment, the processing unit 130 is configured to perform the filtering process for representing only the vector information (i.e., velocity and direction of the target object) corresponding to the second region of interest ROI_2 upon the vector Doppler image VDI. That is, the processing unit 130 performs the filtering process for not representing the vector information not corresponding to the second region of interest ROI_2 upon the vector Doppler image VDI.

[0080] In the above embodiment, the filtering process for representing only the vector information corresponding to the second region of interest ROI_2 is performed upon the vector Doppler image VDI.

[0081] Referring back to FIG. 1, the ultrasound system 100 further includes the storage unit 140. The storage unit 140 stores the ultrasound data (i.e., brightness mode ultrasound data and Doppler mode ultrasound data) acquired by the ultrasound data acquiring unit 120. The storage unit 140 additionally stores the vector information formed by the processing unit 130.

[0082] The ultrasound system 100 further includes the display unit 150. The display unit 150 is configured to display the brightness mode image BI formed by the processing unit 130. The display unit 150 is also configured to display the vector Doppler image VDI formed by the processing unit 130. The display unit 150 is additionally configured to display the user interface GUI formed by the processing unit 130.

Claims

1. An ultrasound system (100), comprising:

    an ultrasound data acquiring unit (120) configured to transmit ultrasound signals to a living body, said living body including a target object and to receive ultrasound data from the living body;
    a user input unit (110);
    a display unit (150);
    a processing unit (130) configured to:

        form a brightness mode image based on the ultrasound data,
        set a first region of interest (ROI_1) on the brightness mode image based on first input information provided from the user input unit (110),
        form vector information of a target object corresponding to the first region of interest (ROI_1) based on Doppler mode ultrasound data corresponding to the motion of the target object, the vector information including a direction and a velocity of the target object;
        form a vector Doppler image based on the vector information;
        compound the brightness mode image and the vector Doppler image to form a compound image;
        form a user interface, mapping the vector information including the velocity and the direction of the motion of the target object to colors, the user interface being circular and touch type;
        set a second region of interest (ROI_2) on the user interface based on second input information, the second region of interest (ROI_2) including a region corresponding to said second input information with respect to the center of the user interface ; and
        wherein in response to the second (ROI 2) being selected, the processing unit (130) is further configured to perform a filtering process upon the vector Doppler image by displaying the vector Doppler image representing only velocities and directions corresponding to the second region of interest from among the vector information of the target object,
        wherein the display unit (150) is configured to display the brightness mode image, the vector Doppler and the user interface; and
        the user input unit (110) is configured to receive input information from a user, the input information includes first input information for setting a first region of interest (ROI_1) on a brightness mode image and second input information for selecting the second region of interest (ROI_2) on the user interface.

2. The ultrasound system (100) of Claim 1, wherein the processing unit (130) is configured to form the vector information corresponding to the velocity and the direction of the target object in consideration of at least one transmission direction and at least one reception direction corresponding to the at least one transmission direction based on the ultrasound data.

3. The ultrasound system (100) of Claim 1, wherein the ultrasound data acquiring unit (120) is configured to transmit ultrasound signals to the living body including the target object in at least one transmission direction, the ultrasound data acquiring unit (120) being further configured to receive ultrasound echo signals from the living body in at least one reception direction to acquire the ultrasound data corresponding to the at least one reception direction.

4. An ultrasound imaging method for the system of claim 1, comprising the steps:

    transmitting ultrasound signals to a living body, said living body including a target object and receiving ultrasound data from the living body;
    forming a brightness mode image based on the ultrasound data;
    setting a first region of interest (ROI_1) on the brightness mode image based on first input information provided from the user input unit (110);

forming vector information of a target object corresponding to the first region of interest (ROI_1) based on Doppler mode ultrasound data corresponding to the motion of the target object, the vector information including a direction and a velocity of the target object;
forming a vector Doppler image based on the vector information;
compounding the brightness mode image and the vector Doppler image to form a compound image;
forming a user interface, mapping the vector information including the velocity and the direction of the motion of the target object to colors, the user interface being circular and touch type;
setting a second region of interest (ROI_2) on the user interface based on second input information, the second region of interest (ROI_2) including a region corresponding to said second input information with respect to the center of the user interface; and
inresponse to the second (ROI_2) being selected, performing a filtering process upon the vector Doppler image by displaying the vector Doppler image representing only velocities and directions corresponding to the second region of interest from among the vector information of the target object and further displaying the brightness mode image, the vector Doppler and the user interface on the display unit; and
receiving input information, the input information includes first input information for setting a first region of interest (ROI_1) on a brightness mode image and second input information for selecting the second region of interest (ROI_2) on the user interface.

5. The method of Claim 4, wherein the step of forming vector information comprises: forming the vector information corresponding to the velocity and the direction of the target object in consideration of at least one transmission direction and at least one reception direction corresponding to the at least one transmission direction based on the ultrasound data.

6. The method of Claim 4, further comprising: transmitting ultrasound signals to a living body including the target object in at least one transmission direction and receiving ultrasound echo signals from the living body in at least one reception direction to acquire the ultrasound data corresponding to the at least one reception direction, prior to performing the step of forming a brightness mode image.

Patentansprüche

1. Ein Ultraschallsystem (100), umfassend:

eine Ultraschalldaten-Erfassungseinheit (120), die so konfiguriert ist, dass sie Ultraschallsignale an einen lebenden Körper sendet, wobei der lebende Körper ein Zielobjekt enthält, und dass sie Ultraschalldaten von dem lebenden Körper empfängt;
eine Benutzereingabe (110);
eine Anzeigeeinheit (150);
eine Verarbeitungseinheit (130), die dazu konfiguriert ist:

ein Helligkeitsmodusbild auf der Grundlage der Ultraschalldaten zu bilden,
eine erste Region von Interesse (ROI1) auf dem Bild des Helligkeitsmodus auf der Grundlage der ersten Eingabeinformationen, die von der Benutzereingabeeinheit (110) bereitgestellt werden, einzustellen;
Vektorinformationen eines Zielobjekts zu bilden, das dem ersten Bereich von Interesse (ROI1) entspricht, auf der Grundlage von Doppler-Modus-Ultraschalldaten, die der Bewegung des Zielobjekts entsprechen, wobei die Vektorinformationen eine Richtung und eine Geschwindigkeit des Zielobjekts umfassen;
ein Vektor-Doppler-Bild basierend auf der Vektorinformation zu bilden, das Bild des Helligkeitsmodus und das Vektor-Doppler-Bild zu einem zusammengesetzten Bild zusammenzusetzen;
eine Benutzerschnittstelle zu bilden, die die Vektorinformation einschließlich der Geschwindigkeit und der Richtung der Bewegung des Zielobjekts in Farben abbildet, wobei die Benutzerschnittstelle kreisförmig und berührend ist,
einen zweiten Bereich von Interesse (ROI_2) auf der Benutzerschnittstelle auf der Grundlage von zweiten Eingabeinformationen festzulegen, wobei der zweite Bereich von Interesse (ROI_2) einen Bereich enthält, der den zweiten Eingabeinformationen in Bezug auf die Mitte der Benutzerschnittstelle entspricht; und
wobei als Reaktion auf die Auswahl des zweiten interessierenden Bereichs (ROI_2) die Verarbeitungseinheit (130) ferner so konfiguriert ist, dass sie einen Filterprozess an dem Vektor-Doppler-Bild durchführt, indem sie das Vektor-Doppler-Bild anzeigt, das nur Geschwindigkeiten und Richtungen entsprechend dem zweiten interessierenden Bereich aus den Vektorinformationen des Zielobjekts darstellt,

wobei die Anzeigeeinheit (150) konfiguriert ist, um das Bild im Helligkeitsmodus, den Vektor-Doppler und die Benutzerschnittstelle anzuzeigen; und
die Benutzereingabeeinheit (110) so konfiguriert ist, dass sie Eingabeinformationen von einem Benutzer empfängt, wobei die Eingabeinformationen erste Eingabeinformationen zum Einstellen eines ersten Bereichs von Interesse (ROI1) auf einem Bild im Helligkeitsmodus und zweite Eingabeinformationen zum Auswählen des zweiten Bereichs von Interesse (ROI_2) auf der Benutzerschnittstelle umfassen.

2. Ultraschallsystem (100) nach Anspruch 1, wobei die Verarbeitungseinheit (130) so konfiguriert ist, dass sie die der Geschwindigkeit und der Richtung des Zielobjektes entsprechende Vektorinformation unter Berücksichtigung mindestens einer Senderichtung und mindestens einer der mindestens einen Senderichtung entsprechenden Empfangsrichtung auf Basis der Ultraschalldaten bildet.

3. Ultraschallsystem (100) nach Anspruch 1, wobei die Ultraschalldatenerfassungseinheit (120) konfiguriert ist, um Ultraschallsignale zu dem lebenden Körper einschließlich des Zielobjekts in mindestens einer Senderichtung zu senden, wobei die Ultraschalldatenerfassungseinheit (120) ferner konfiguriert ist, um Ultraschallechosignale von dem lebenden Körper in mindestens einer Empfangsrichtung zu empfangen, um die der mindestens einen Empfangsrichtung entsprechenden Ultraschalldaten zu erfassen.

4. Ultraschall-Abbildungsverfahren für das System nach Anspruch 1, umfassend die Schritte:

Übertragen von Ultraschallsignalen an einen lebenden Körper, wobei der lebende Körper ein Zielobjekt enthält, und Empfangen von Ultraschalldaten von dem lebenden Körper;
Erzeugen eines Helligkeitsmodusbildes auf der Grundlage der Ultraschalldaten;
Einstellen eines ersten Bereichs von Interesse (ROI1) auf dem Bild im Helligkeitsmodus auf der Grundlage von ersten Eingabeinformationen, die von der Benutzereingabeeinheit (110) bereitgestellt werden;
Bilden von Vektorinformationen eines Zielobjekts, die dem ersten Bereich von Interesse (ROI1) entsprechen, auf der Grundlage von Doppler-Modus-Ultraschalldaten, die der Bewegung des Zielobjekts entsprechen, wobei die Vektorinformationen eine Richtung und eine Geschwindigkeit des Zielobjekts enthalten;
Bilden eines Vektor-Doppler-Bildes basierend auf der Vektorinformation, Zusammensetzen des Helligkeitsmodus-Bildes und des Vektor-Doppler-Bildes zu einem zusammengesetzten Bild;
Bilden einer Benutzerschnittstelle, Abbilden der Vektorinformation einschließlich der Geschwindigkeit und der Richtung der Bewegung des Zielobjekts in Farben, wobei die Benutzerschnittstelle kreisförmig und berührend ist,
Festlegen eines zweiten Bereichs von Interesse (ROI_2) auf der Benutzerschnittstelle auf der Grundlage von zweiten Eingabeinformationen, wobei der zweite Bereich von Interesse (ROI_2) einen Bereich enthält, der den zweiten Eingabeinformationen in Bezug auf die Mitte der Benutzerschnittstelle entspricht; und
als Reaktion auf die Auswahl des zweiten interessierenden Bereichs (ROI2), Durchführen eines Filterprozesses auf dem Vektor-Doppler-Bild durch Anzeigen des Vektor-Doppler-Bildes, das nur Geschwindigkeiten und Richtungen entsprechend dem zweiten Bereich von Interesse aus den Vektorinformationen des Zielobjekts darstellt, und ferner Anzeigen des Bildes im Helligkeitsmodus, des Vektor-Dopplers und der Benutzerschnittstelle; und
die Eingabeinformationen umfassen erste Eingabeinformationen zur Einstellung eines ersten Bereichs von Interesse (ROI1) auf einem Bild im Helligkeitsmodus und eine zweite Eingabeinformation zur Auswahl des zweiten Bereichs von Interesse (ROI_2) auf der Benutzeroberfläche.

5. Verfahren nach Anspruch 4, wobei der Schritt des Bildens von Vektorinformation umfasst:
Bilden der der Geschwindigkeit und der Richtung des Zielobjektes entsprechenden Vektorinformation unter Berücksichtigung mindestens einer Senderichtung und mindestens einer der mindestens einen Senderichtung entsprechenden Empfangsrichtung auf der Basis der Ultraschalldaten.

6. Verfahren nach Anspruch 4, weiter umfassend:
Senden von Ultraschallsignalen zu einem lebenden Körper, der das Zielobjekt enthält, in mindestens einer Senderichtung und Empfangen von Ultraschall-Echosignalen von dem lebenden Körper in mindestens einer Empfangsrichtung, um die Ultraschalldaten entsprechend der mindestens einen Empfangsrichtung zu erfassen, bevor der Schritt der Bildung eines Helligkeitsmodusbildes durchgeführt wird.

Revendications

1. Système à ultrasons (100), comprenant :

une unité d'acquisition de données ultrasonores (120) configurée pour transmettre des signaux ultrasonores à un corps vivant, ledit corps vivant comprenant un objet cible et pour recevoir des données ultrasonores du corps vivant ;
une unité d'entrée utilisateur (110) ;
une unité d'affichage (150) ;
une unité de traitement (130) configurée pour :

former une image en mode luminosité à partir des données ultrasonores, définir une première région d'intérêt (ROI_1) sur l'image en mode luminosité sur la base des premières informations d'entrée fournies par l'unité d'entrée utilisateur (110),
former des informations vectorielles d'un objet cible correspondant à la première région d'intérêt (ROI_1) sur la base de données ultrasonores en mode Doppler correspondant au mouvement de l'objet cible, les informations vectorielles comprenant une direction et une vitesse de l'objet cible ;
former une image Doppler vectorielle sur la base des informations vectorielles ;
combiner l'image en mode luminosité et l'image Doppler vectorielle pour former une image combinée ;
former une interface utilisateur, cartographier les informations vectorielles, y compris la vitesse et la direction du mouvement de l'objet cible, en couleurs, l'interface utilisateur étant circulaire et de type tactile ;
définir une seconde région d'intérêt (ROI_2) sur l'interface utilisateur sur la base des secondes informations d'entrée, la seconde région d'intérêt (ROI_2) comprenant une région correspondant auxdites secondes informations d'entrée par rapport au centre de l'interface utilisateur ; et

dans lequel en réponse à la sélection de la seconde (ROI_2), l'unité de traitement (130) est en outre configurée pour effectuer un processus de filtrage sur l'image Doppler vectorielle en affichant l'image Doppler vectorielle représentant uniquement les vitesses et les directions correspondant à la seconde région d'intérêt parmi les informations vectorielles de l'objet cible,
dans lequel l'unité d'affichage (150) est configurée pour afficher l'image en mode luminosité, le vecteur Doppler et l'interface utilisateur ; et
l'unité d'entrée utilisateur (110) est configurée pour recevoir des informations d'entrée d'un utilisateur, les informations d'entrée comprennent des premières informations d'entrée pour définir une première région d'intérêt (ROI_1) sur une image en mode luminosité et des secondes informations d'entrée pour sélectionner la seconde région d'intérêt (ROI_2) sur l'interface utilisateur.

2. Système à ultrasons (100) selon la revendication 1, dans lequel l'unité de traitement (130) est configurée pour former les informations vectorielles correspondant à la vitesse et à la direction de l'objet cible en tenant compte d'au moins une direction de transmission et d'au moins une direction de réception correspondant à ladite au moins une direction de transmission basée sur les données ultrasonores.

3. Système à ultrasons (100) selon la revendication 1, dans lequel l'unité d'acquisition de données ultrasonores (120) est configurée pour transmettre des signaux ultrasonores au corps vivant comprenant l'objet cible dans au moins une direction de transmission, l'unité d'acquisition de données ultrasonores (120) étant en outre configurée pour recevoir des signaux d'écho ultrasonores du corps vivant dans au moins une direction de réception pour acquérir les données ultrasonores correspondant à ladite au moins une direction de réception.

4. Procédé d'imagerie ultrasonore pour le système selon la revendication 1, comprenant les étapes :

transmettre des signaux ultrasonores à un corps vivant, ledit corps vivant comprenant un objet cible et recevoir des données ultrasonores du corps vivant ; former une image en mode luminosité à partir des données ultrasonores ;
définir une première région d'intérêt (ROI_1) sur l'image en mode luminosité sur la base des premières informations d'entrée fournies par l'unité d'entrée utilisateur (110) ;
former des informations vectorielles d'un objet cible correspondant à la première région d'intérêt (ROI_1) sur la base de données ultrasonores en mode Doppler correspondant au mouvement de l'objet cible, les informations vectorielles comprenant une direction et une vitesse de l'objet cible ;
former une image Doppler vectorielle sur la base des informations vectorielles ; combiner l'image en mode luminosité et l'image Doppler vectorielle pour former une image combinée ;
former une interface utilisateur, cartographier les informations vectorielles, y compris la vitesse et la direction du mouvement de l'objet cible, en couleurs, l'interface utilisateur étant circulaire et de type tactile ;
définir une seconde région d'intérêt (ROI_2) sur l'interface utilisateur sur la base des secondes informations

d'entrée, la seconde région d'intérêt (ROI_2) comprenant une région correspondant auxdites secondes informations d'entrée par rapport au centre de l'interface utilisateur ; et
en réponse à la sélection de la seconde (ROI_2), effectuer un processus de filtrage sur l'image Doppler vectorielle en affichant l'image Doppler vectorielle représentant uniquement les vitesses et les directions correspondant à la seconde région d'intérêt parmi les informations vectorielles de l'objet cible, et afficher en outre l'image en mode luminosité, le vecteur Doppler et l'interface utilisateur sur l'unité d'affichage; et
recevoir des informations d'entrée, les informations d'entrée comprennent des premières informations d'entrée pour définir une première région d'intérêt (ROI_1) sur une image en mode luminosité et des secondes informations d'entrée pour sélectionner la seconde région d'intérêt (ROI_2) sur l'interface utilisateur.

5. Procédé selon la revendication 4, dans lequel l'étape de formation d'informations vectorielles comprend :
la formation des informations vectorielles correspondant à la vitesse et à la direction de l'objet cible en tenant compte d'au moins une direction de transmission et d'au moins une direction de réception correspondant à ladite moins une direction de transmission basée sur les données ultrasonores.

6. Procédé selon la revendication 4, comprenant en outre :
la transmission des signaux ultrasonores à un corps vivant comprenant l'objet cible dans au moins une direction de transmission et la réception des signaux d'écho ultrasonores du corps vivant dans au moins une direction de réception pour acquérir les données ultrasonores correspondant à ladite au moins une direction de réception, avant d'effectuer l'étape de formation d'une image en mode luminosité.

FIG. 1

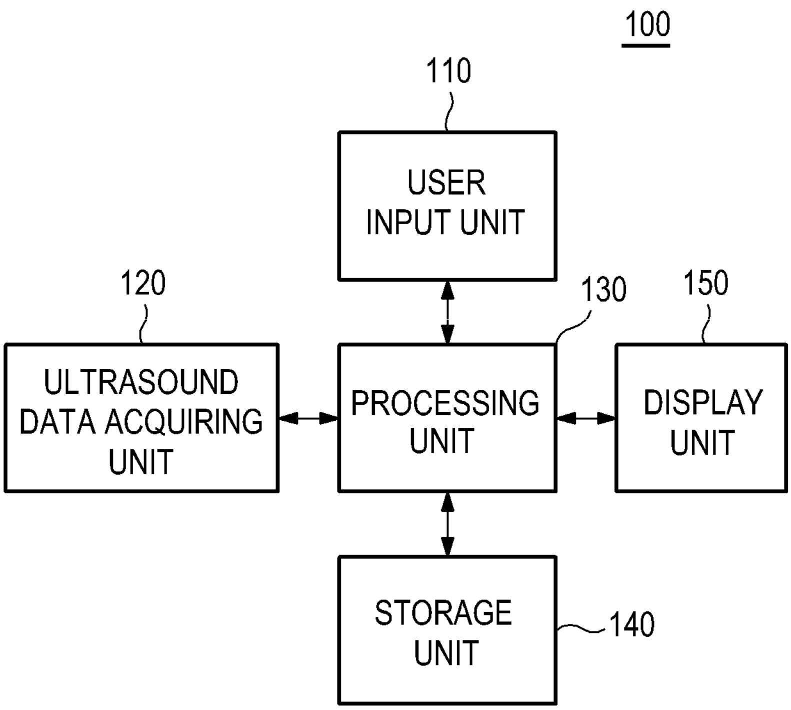

100
110
USER INPUT UNIT
120
ULTRASOUND DATA ACQUIRING UNIT
130
PROCESSING UNIT
150
DISPLAY UNIT
STORAGE UNIT
140

FIG. 2

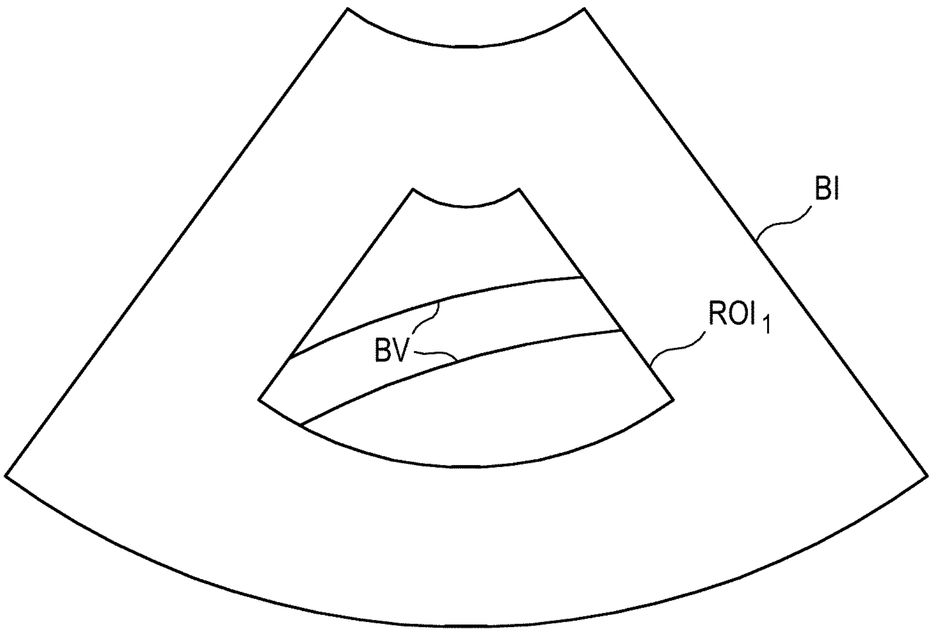

BI
ROI 1
BV

FIG. 3

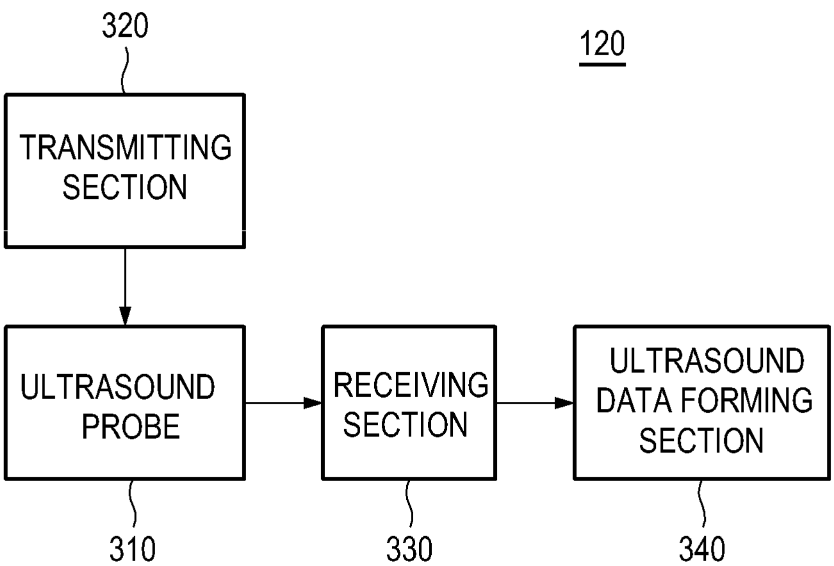

320
120
TRANSMITTING SECTION
ULTRASOUND PROBE
RECEIVING SECTION
ULTRASOUND DATA FORMING SECTION
310
330
340

FIG. 4

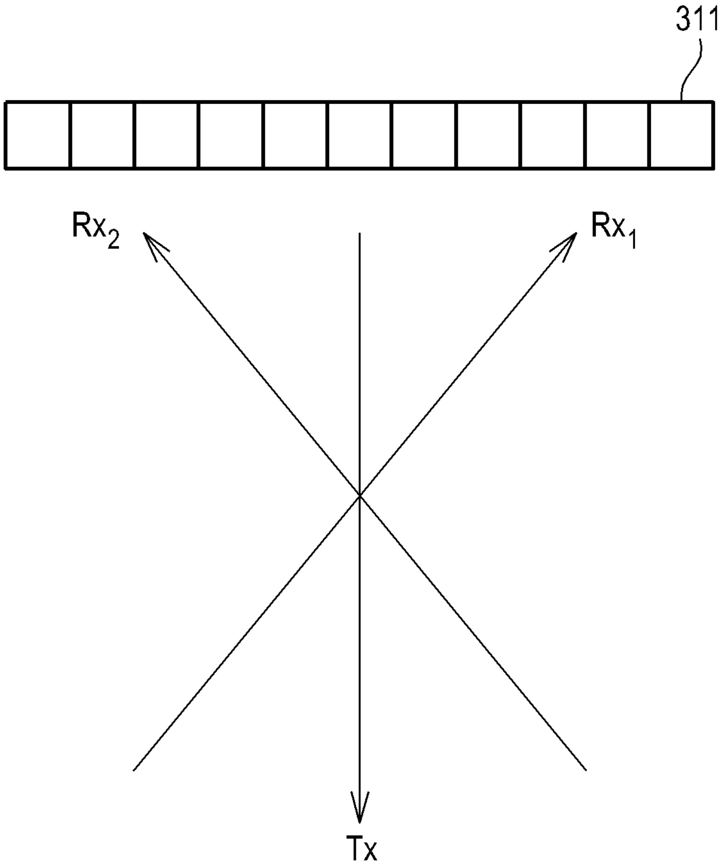


FIG. 5

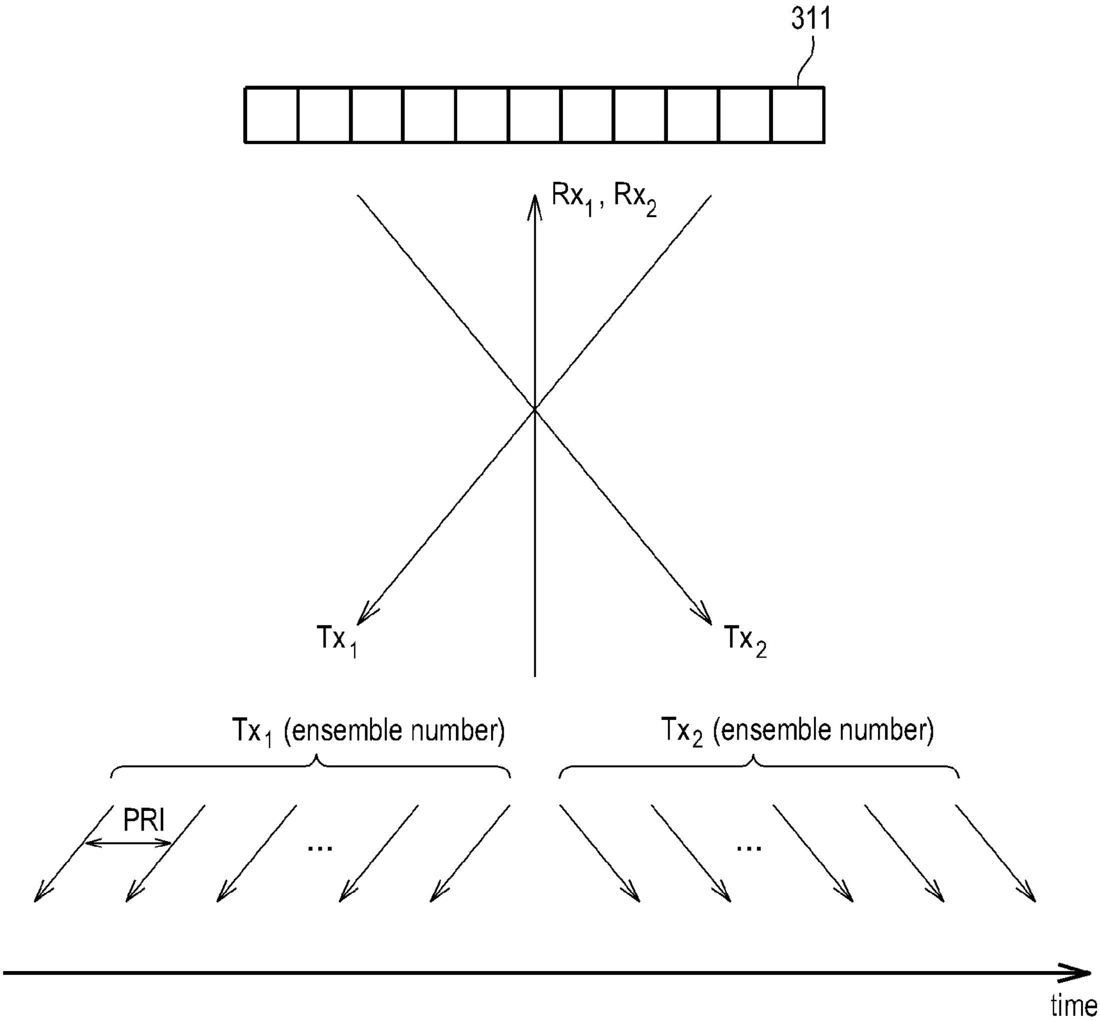

311
Rx1, Rx2
Tx1
Tx2
Tx1 (ensemble number)
Tx2 (ensemble number)
PRI
...
...
time

FIG. 6

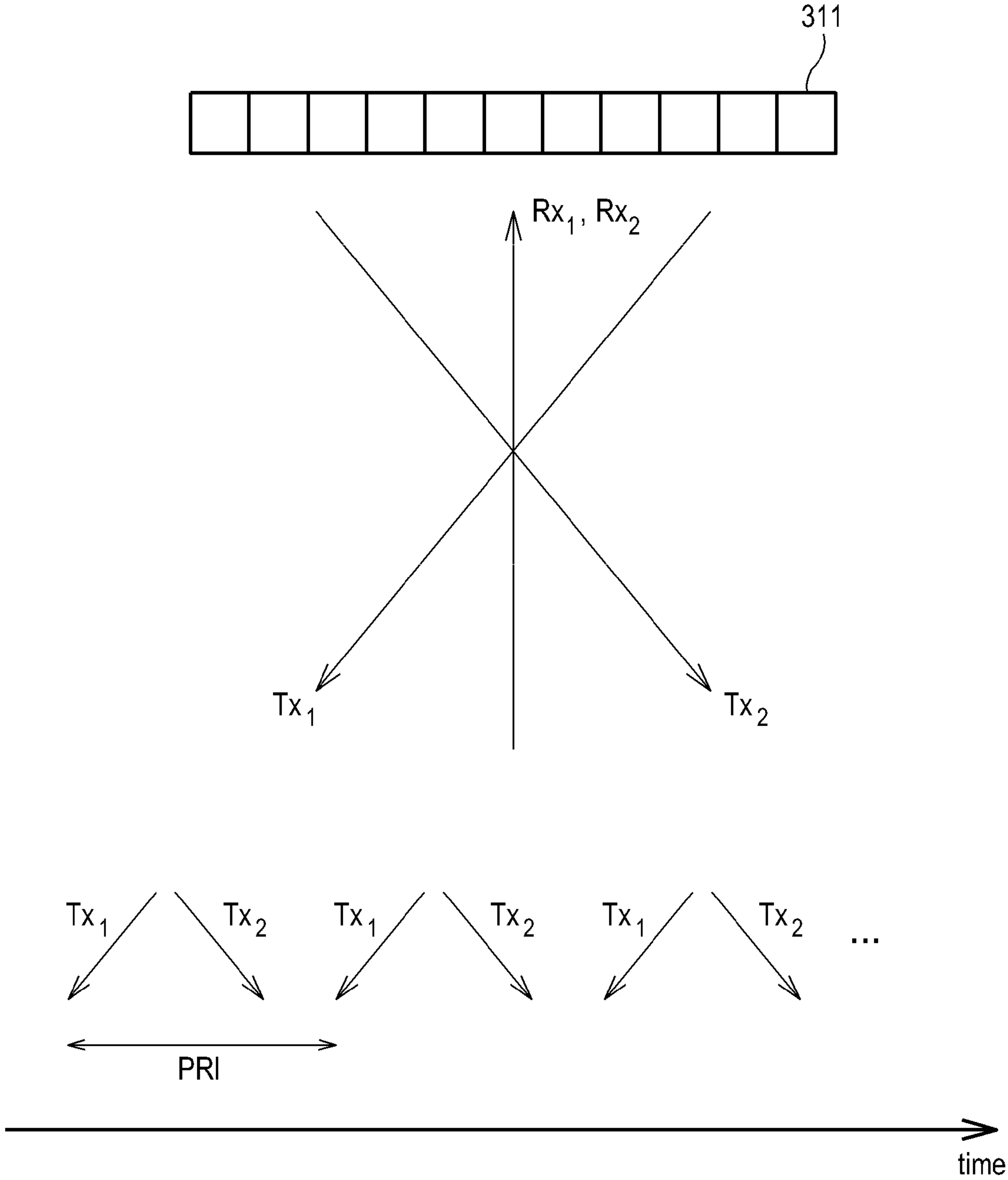


FIG. 7

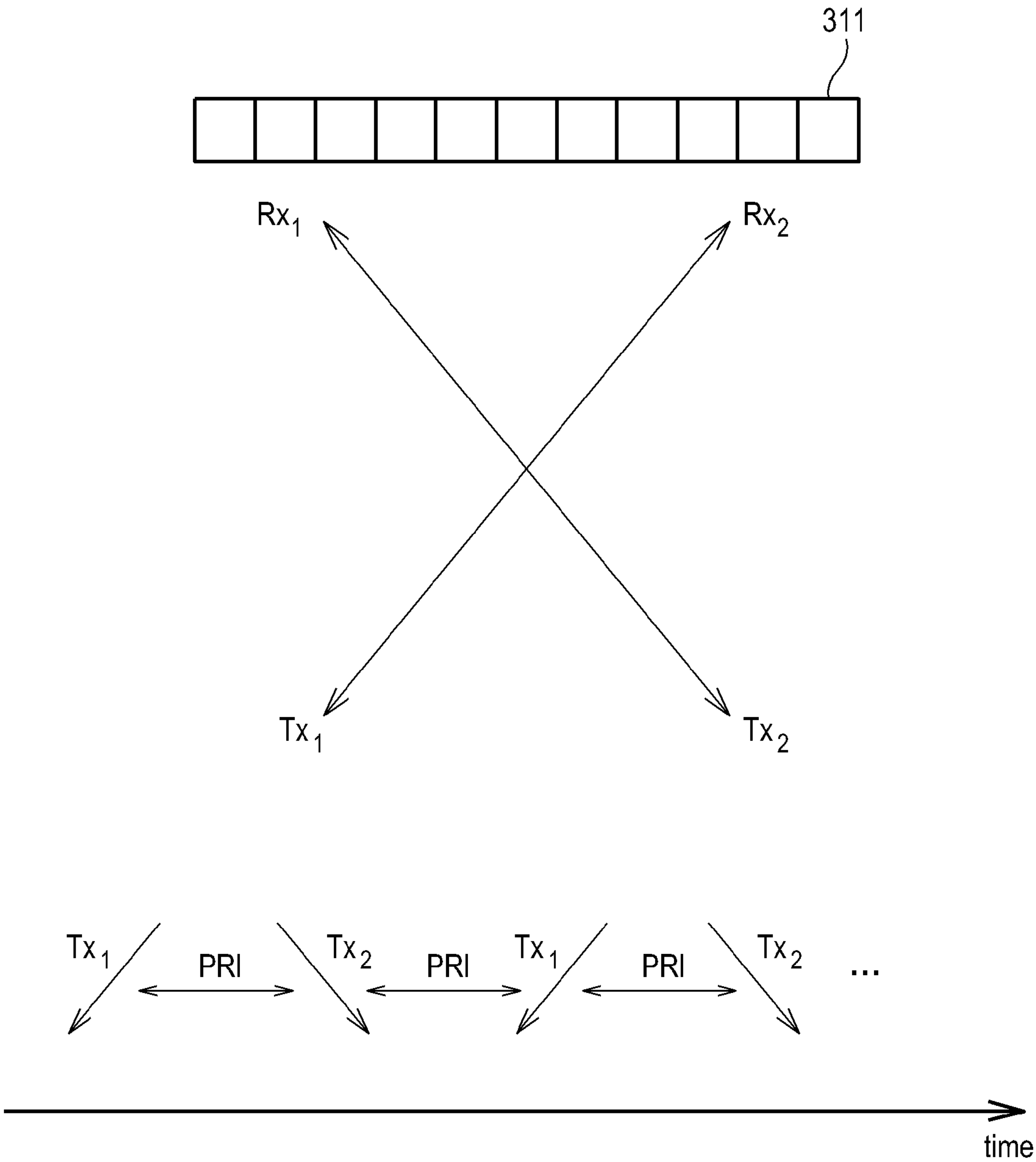


FIG. 8

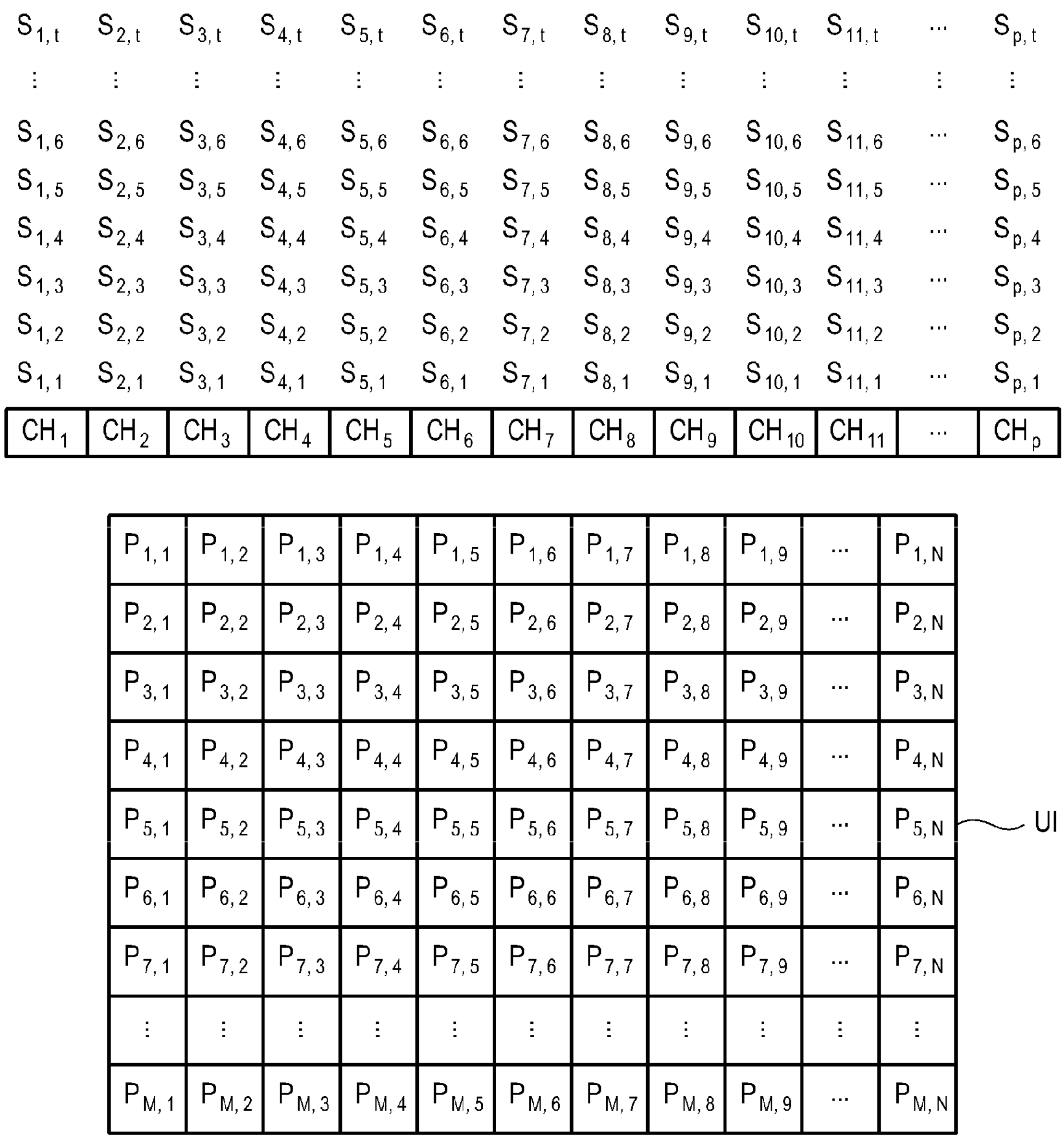

$S_{1,t}$ $S_{2,t}$ $S_{3,t}$ $S_{4,t}$ $S_{5,t}$ $S_{6,t}$ $S_{7,t}$ $S_{8,t}$ $S_{9,t}$ $S_{10,t}$ $S_{11,t}$ ... $S_{p,t}$
$S_{1,6}$ $S_{2,6}$ $S_{3,6}$ $S_{4,6}$ $S_{5,6}$ $S_{6,6}$ $S_{7,6}$ $S_{8,6}$ $S_{9,6}$ $S_{10,6}$ $S_{11,6}$ ... $S_{p,6}$
$S_{1,5}$ $S_{2,5}$ $S_{3,5}$ $S_{4,5}$ $S_{5,5}$ $S_{6,5}$ $S_{7,5}$ $S_{8,5}$ $S_{9,5}$ $S_{10,5}$ $S_{11,5}$ ... $S_{p,5}$
$S_{1,4}$ $S_{2,4}$ $S_{3,4}$ $S_{4,4}$ $S_{5,4}$ $S_{6,4}$ $S_{7,4}$ $S_{8,4}$ $S_{9,4}$ $S_{10,4}$ $S_{11,4}$ ... $S_{p,4}$
$S_{1,3}$ $S_{2,3}$ $S_{3,3}$ $S_{4,3}$ $S_{5,3}$ $S_{6,3}$ $S_{7,3}$ $S_{8,3}$ $S_{9,3}$ $S_{10,3}$ $S_{11,3}$ ... $S_{p,3}$
$S_{1,2}$ $S_{2,2}$ $S_{3,2}$ $S_{4,2}$ $S_{5,2}$ $S_{6,2}$ $S_{7,2}$ $S_{8,2}$ $S_{9,2}$ $S_{10,2}$ $S_{11,2}$ ... $S_{p,2}$
$S_{1,1}$ $S_{2,1}$ $S_{3,1}$ $S_{4,1}$ $S_{5,1}$ $S_{6,1}$ $S_{7,1}$ $S_{8,1}$ $S_{9,1}$ $S_{10,1}$ $S_{11,1}$ ... $S_{p,1}$
CH_1 CH_2 CH_3 CH_4 CH_5 CH_6 CH_7 CH_8 CH_9 CH_{10} CH_{11} ... CH_p
$P_{1,1}$ $P_{1,2}$ $P_{1,3}$ $P_{1,4}$ $P_{1,5}$ $P_{1,6}$ $P_{1,7}$ $P_{1,8}$ $P_{1,9}$ ... $P_{1,N}$
$P_{2,1}$ $P_{2,2}$ $P_{2,3}$ $P_{2,4}$ $P_{2,5}$ $P_{2,6}$ $P_{2,7}$ $P_{2,8}$ $P_{2,9}$ ... $P_{2,N}$
$P_{3,1}$ $P_{3,2}$ $P_{3,3}$ $P_{3,4}$ $P_{3,5}$ $P_{3,6}$ $P_{3,7}$ $P_{3,8}$ $P_{3,9}$ ... $P_{3,N}$
$P_{4,1}$ $P_{4,2}$ $P_{4,3}$ $P_{4,4}$ $P_{4,5}$ $P_{4,6}$ $P_{4,7}$ $P_{4,8}$ $P_{4,9}$ ... $P_{4,N}$
$P_{5,1}$ $P_{5,2}$ $P_{5,3}$ $P_{5,4}$ $P_{5,5}$ $P_{5,6}$ $P_{5,7}$ $P_{5,8}$ $P_{5,9}$ ... $P_{5,N}$
UI
$P_{6,1}$ $P_{6,2}$ $P_{6,3}$ $P_{6,4}$ $P_{6,5}$ $P_{6,6}$ $P_{6,7}$ $P_{6,8}$ $P_{6,9}$ ... $P_{6,N}$
$P_{7,1}$ $P_{7,2}$ $P_{7,3}$ $P_{7,4}$ $P_{7,5}$ $P_{7,6}$ $P_{7,7}$ $P_{7,8}$ $P_{7,9}$ ... $P_{7,N}$
$P_{M,1}$ $P_{M,2}$ $P_{M,3}$ $P_{M,4}$ $P_{M,5}$ $P_{M,6}$ $P_{M,7}$ $P_{M,8}$ $P_{M,9}$ ... $P_{M,N}$

FIG. 9

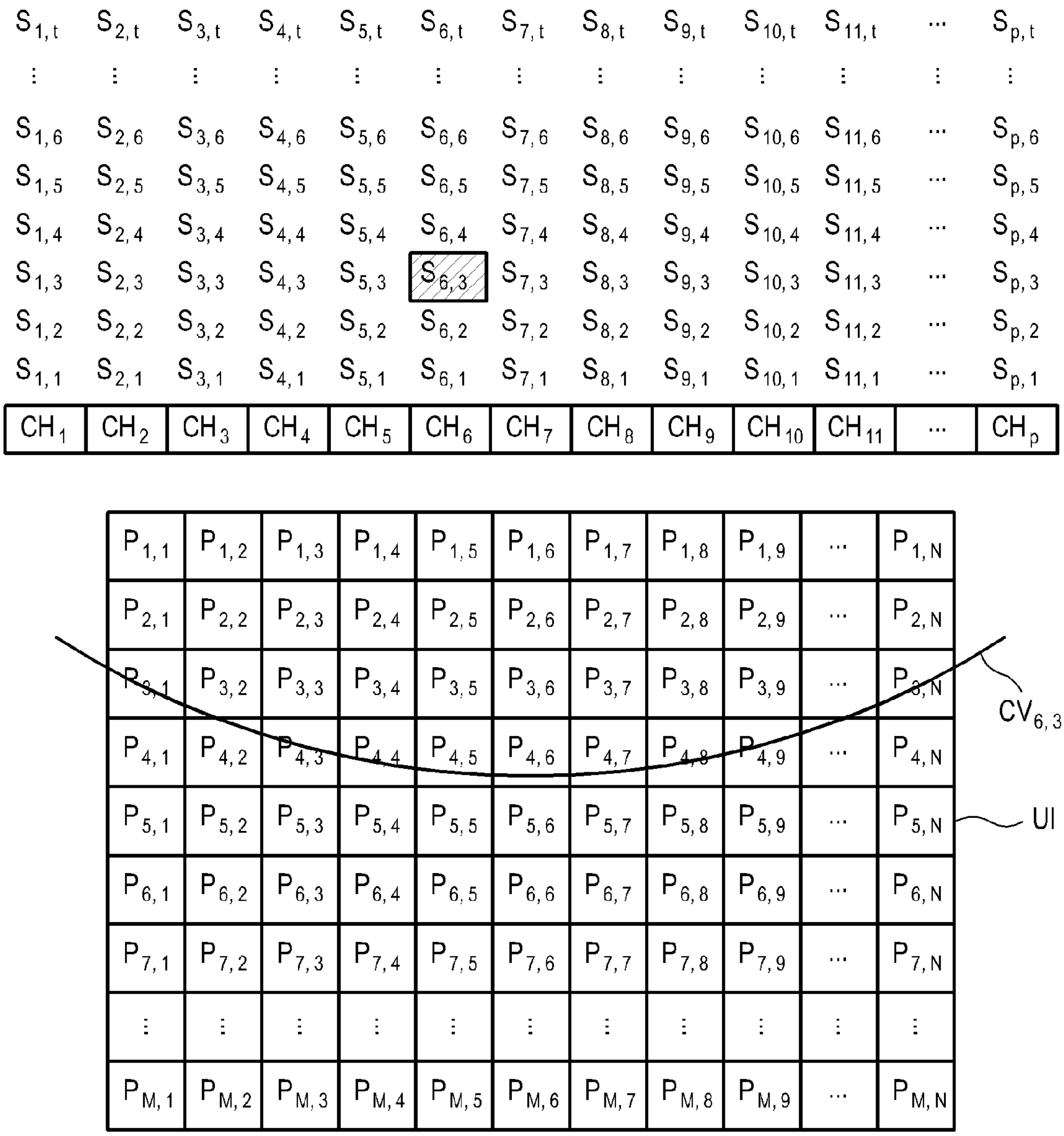

S1, t S2, t S3, t S4, t S5, t S6, t S7, t S8, t S9, t S10, t S11, t ... Sp, t
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 ... CHp
P1, 1 P1, 2 ... P1, N
PM, 1 ... PM, N
CV6, 3
UI

FIG. 10

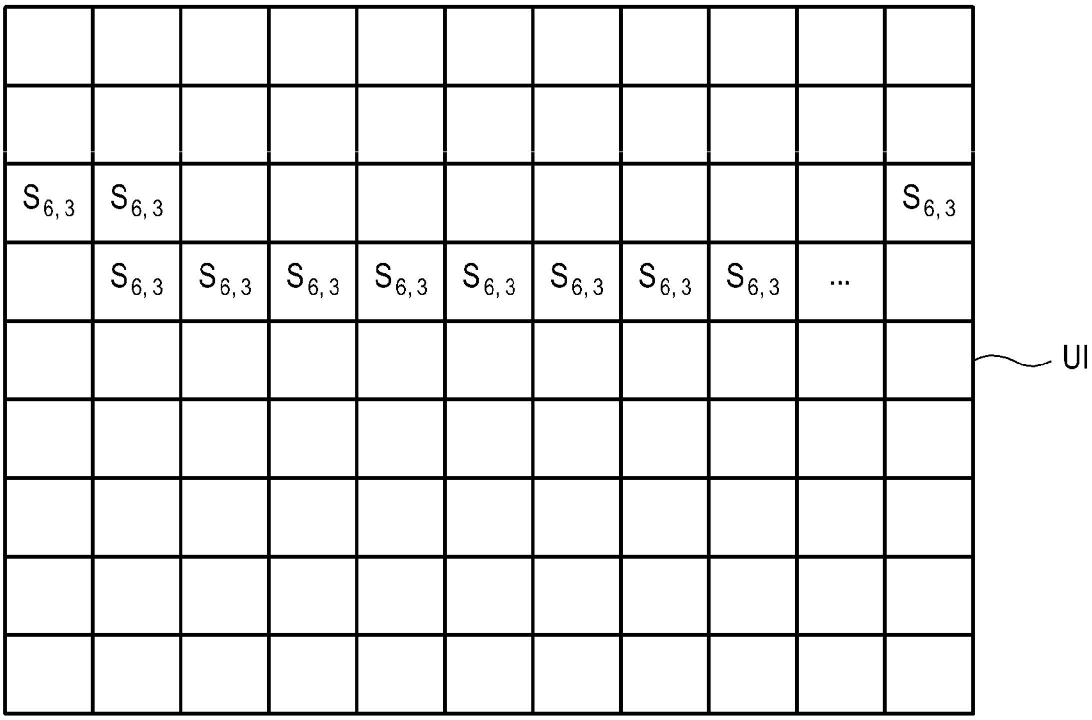


FIG. 11

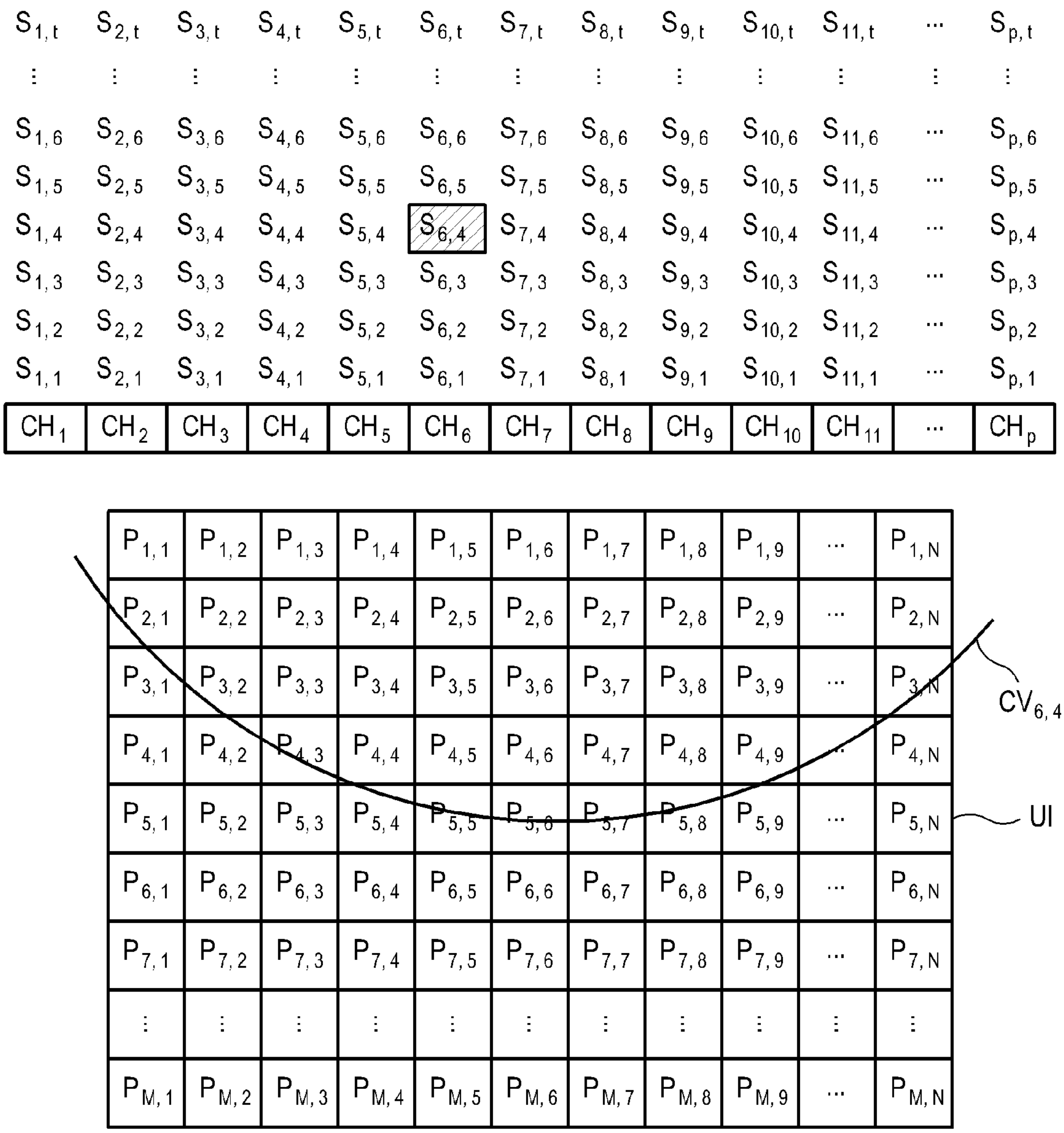

CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 ... CHp
S6,4
P1,1 P1,2 ... P1,N
PM,1 ... PM,N
CV6,4
UI

FIG. 12

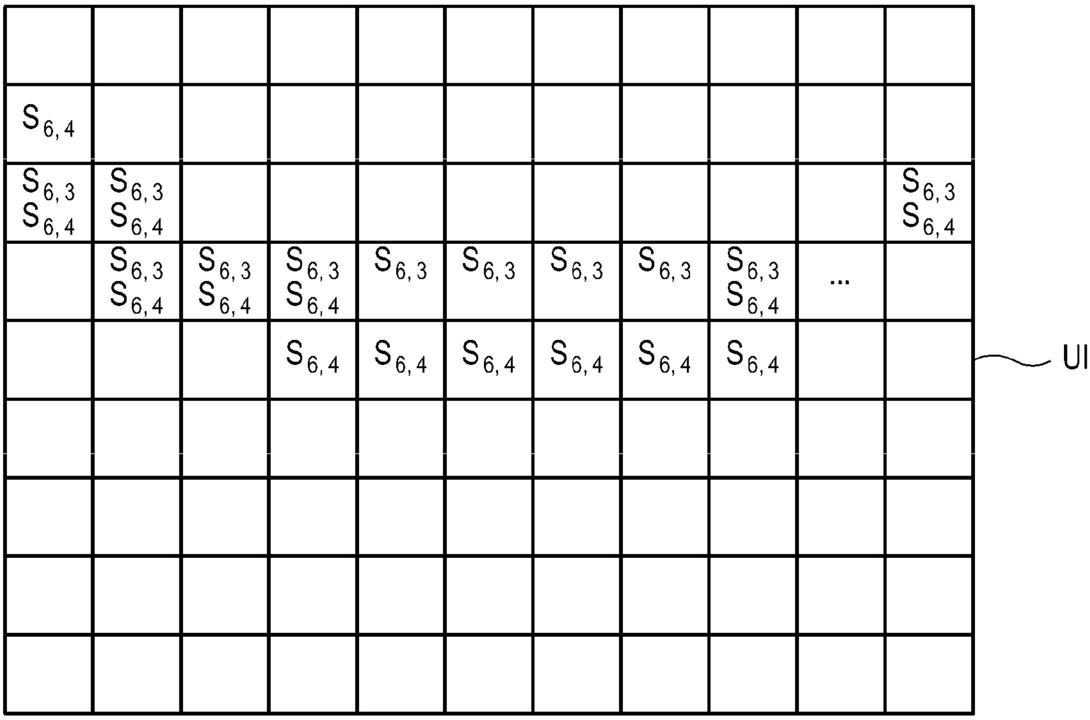

$S_{6,4}$
$S_{6,3}$ $S_{6,4}$
$S_{6,3}$ $S_{6,4}$
$S_{6,3}$ $S_{6,4}$
$S_{6,3}$ $S_{6,4}$
$S_{6,3}$ $S_{6,4}$
$S_{6,3}$ $S_{6,4}$
$S_{6,3}$
$S_{6,3}$
$S_{6,3}$
$S_{6,3}$
$S_{6,3}$ $S_{6,4}$
...
$S_{6,4}$
$S_{6,4}$
$S_{6,4}$
$S_{6,4}$
$S_{6,4}$
$S_{6,4}$
UI

FIG. 13

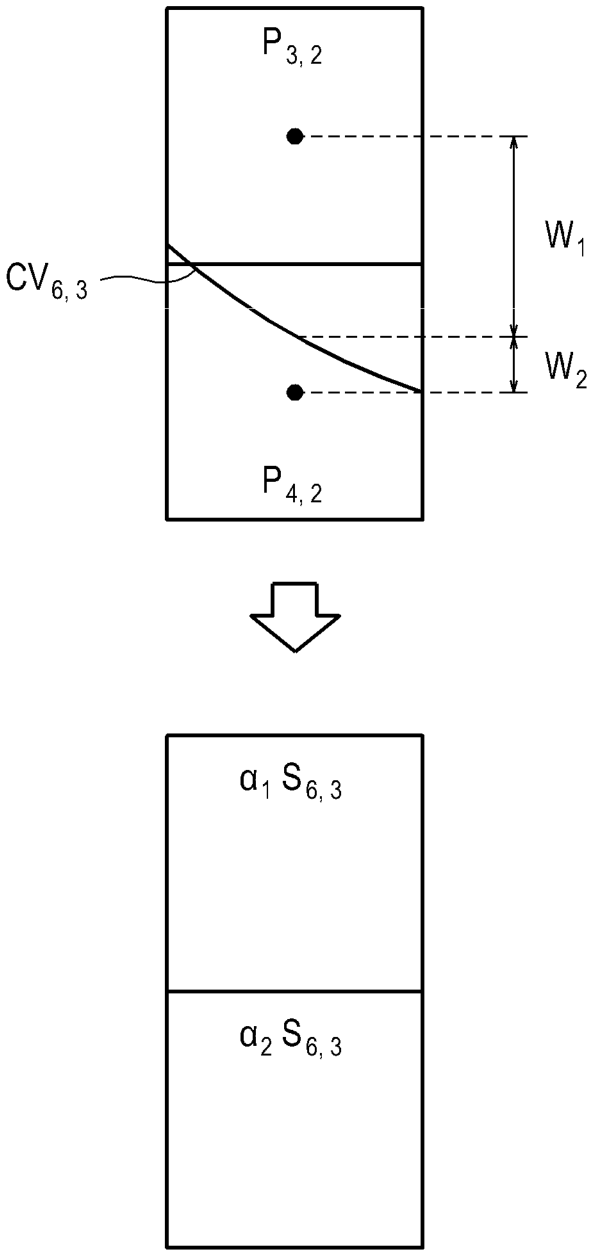
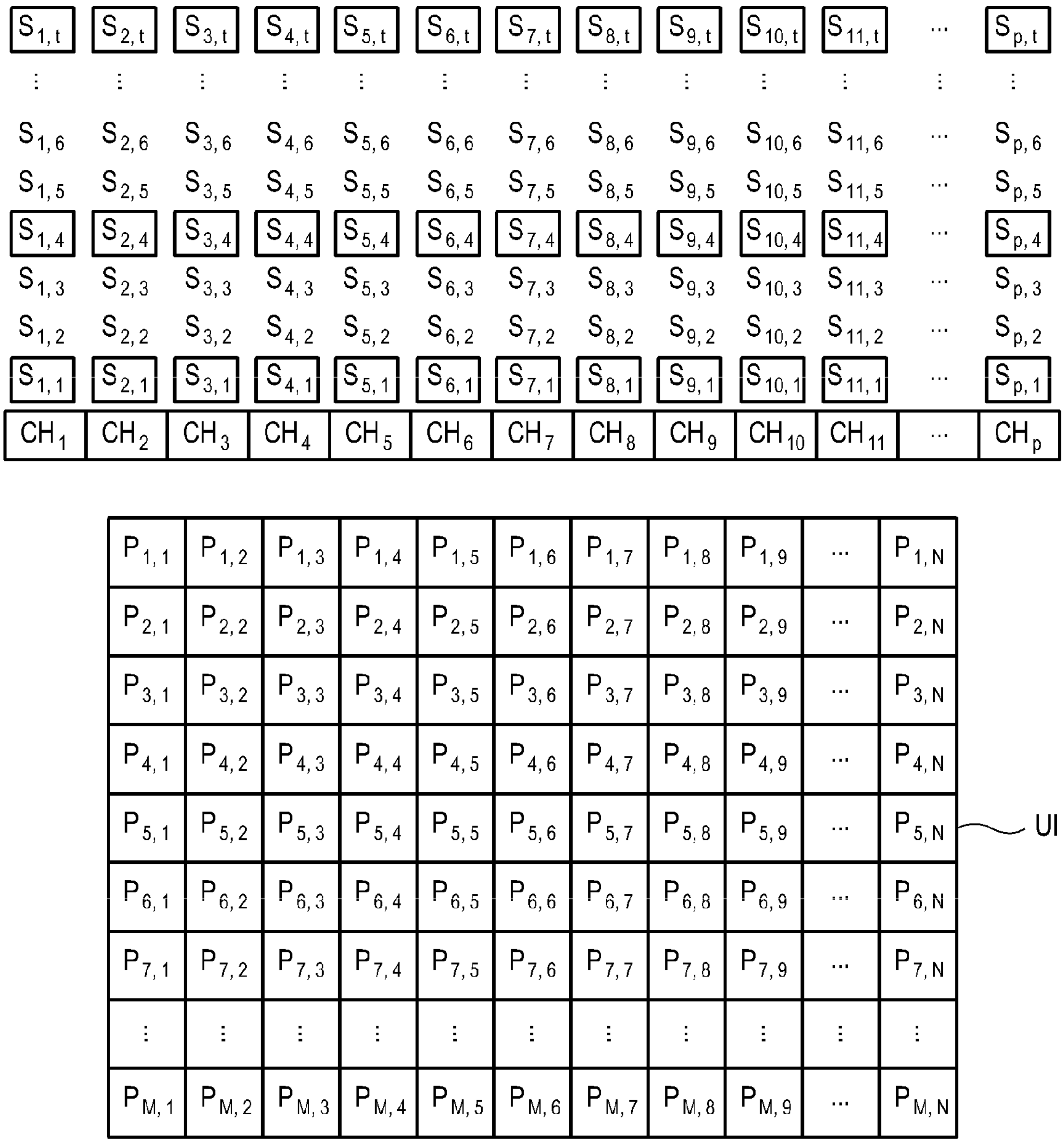


FIG. 14



S1, t S2, t S3, t S4, t S5, t S6, t S7, t S8, t S9, t S10, t S11, t ··· Sp, t
S1, 6 S2, 6 S3, 6 S4, 6 S5, 6 S6, 6 S7, 6 S8, 6 S9, 6 S10, 6 S11, 6 ··· Sp, 6
S1, 5 S2, 5 S3, 5 S4, 5 S5, 5 S6, 5 S7, 5 S8, 5 S9, 5 S10, 5 S11, 5 ··· Sp, 5
S1, 4 S2, 4 S3, 4 S4, 4 S5, 4 S6, 4 S7, 4 S8, 4 S9, 4 S10, 4 S11, 4 ··· Sp, 4
S1, 3 S2, 3 S3, 3 S4, 3 S5, 3 S6, 3 S7, 3 S8, 3 S9, 3 S10, 3 S11, 3 ··· Sp, 3
S1, 2 S2, 2 S3, 2 S4, 2 S5, 2 S6, 2 S7, 2 S8, 2 S9, 2 S10, 2 S11, 2 ··· Sp, 2
S1, 1 S2, 1 S3, 1 S4, 1 S5, 1 S6, 1 S7, 1 S8, 1 S9, 1 S10, 1 S11, 1 ··· Sp, 1
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 ··· CHp
P1, 1 P1, 2 P1, 3 P1, 4 P1, 5 P1, 6 P1, 7 P1, 8 P1, 9 ··· P1, N
P2, 1 P2, 2 P2, 3 P2, 4 P2, 5 P2, 6 P2, 7 P2, 8 P2, 9 ··· P2, N
P3, 1 P3, 2 P3, 3 P3, 4 P3, 5 P3, 6 P3, 7 P3, 8 P3, 9 ··· P3, N
P4, 1 P4, 2 P4, 3 P4, 4 P4, 5 P4, 6 P4, 7 P4, 8 P4, 9 ··· P4, N
P5, 1 P5, 2 P5, 3 P5, 4 P5, 5 P5, 6 P5, 7 P5, 8 P5, 9 ··· P5, N
UI
P6, 1 P6, 2 P6, 3 P6, 4 P6, 5 P6, 6 P6, 7 P6, 8 P6, 9 ··· P6, N
P7, 1 P7, 2 P7, 3 P7, 4 P7, 5 P7, 6 P7, 7 P7, 8 P7, 9 ··· P7, N
PM, 1 PM, 2 PM, 3 PM, 4 PM, 5 PM, 6 PM, 7 PM, 8 PM, 9 ··· PM, N

FIG. 15

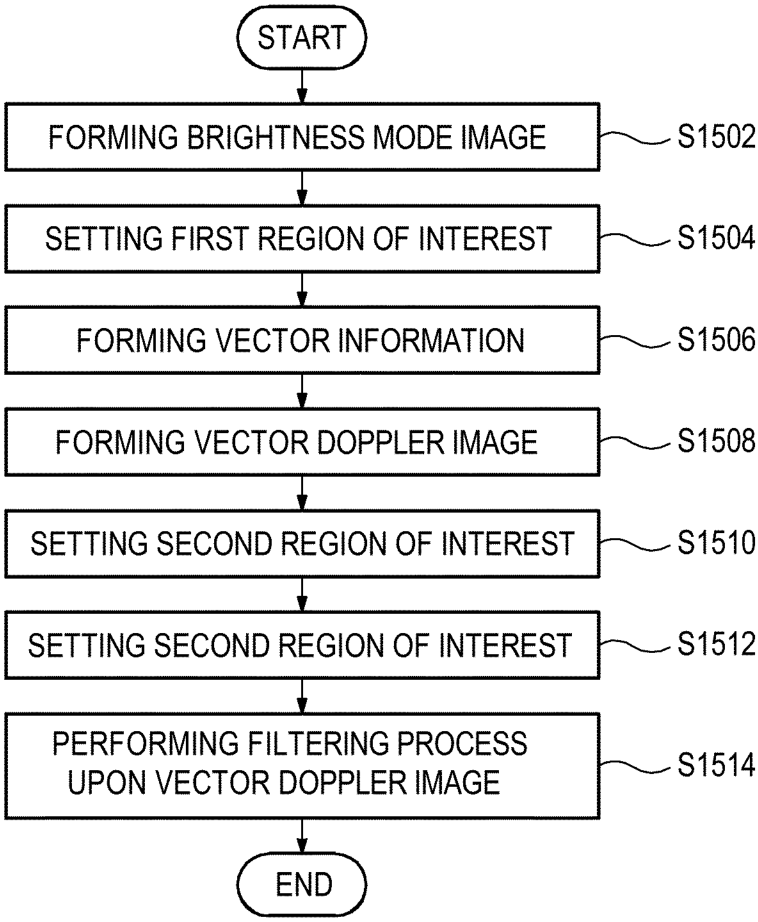
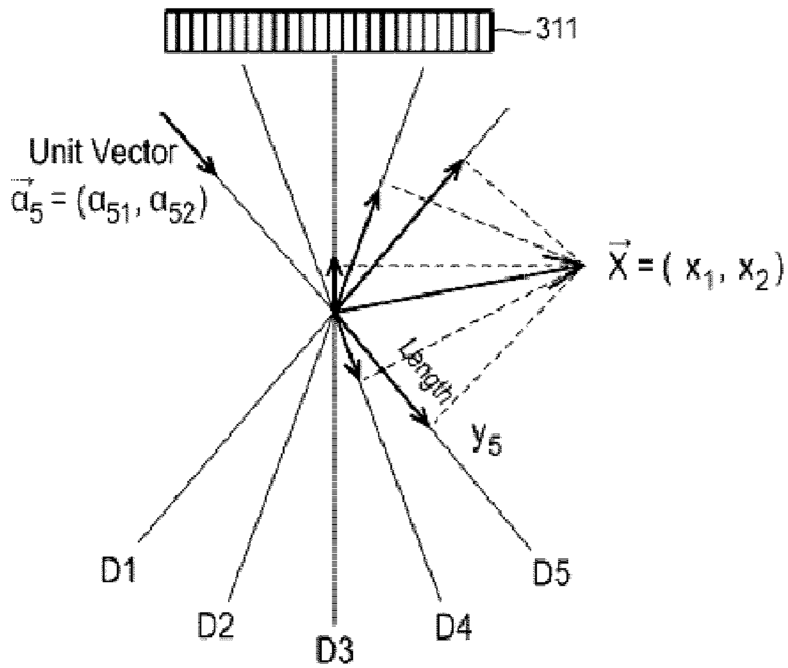

START
FORMING BRIGHTNESS MODE IMAGE
S1502
SETTING FIRST REGION OF INTEREST
S1504
FORMING VECTOR INFORMATION
S1506
FORMING VECTOR DOPPLER IMAGE
S1508
SETTING SECOND REGION OF INTEREST
S1510
SETTING SECOND REGION OF INTEREST
S1512
PERFORMING FILTERING PROCESS
UPON VECTOR DOPPLER IMAGE
S1514
END

FIG. 16



$$\begin{cases} \alpha_{11}x_1 + \alpha_{12}x_2 = y_1 \\ \alpha_{21}x_1 + \alpha_{22}x_2 = y_2 \\ \vdots \\ \alpha_{n1}x_1 + \alpha_{n2}x_2 = y_n \end{cases}$$

If
Tx1 (D1), Rx1(D3)
Tx2 (D2), Rx2(D3)

$$\begin{cases} (\alpha_{11} + \alpha_{31})x_1 + (\alpha_{12} + \alpha_{32})x_2 = (y_1 + y_3) \\ (\alpha_{21} + \alpha_{31})x_1 + (\alpha_{22} + \alpha_{32})x_2 = (y_2 + y_3) \\ \vdots \end{cases}$$

$$\vec{y} = A\vec{x} + \vec{n}$$

$$\vec{x}_{opt} = \arg\min_{\vec{x}}(\vec{y} - A\vec{x} - \vec{n})$$

Over-Determined Problem

Pseudo Inverse Method

$$\vec{x}_{opt} = (A^T A)^{-1} A^T \vec{y}$$

FIG. 17

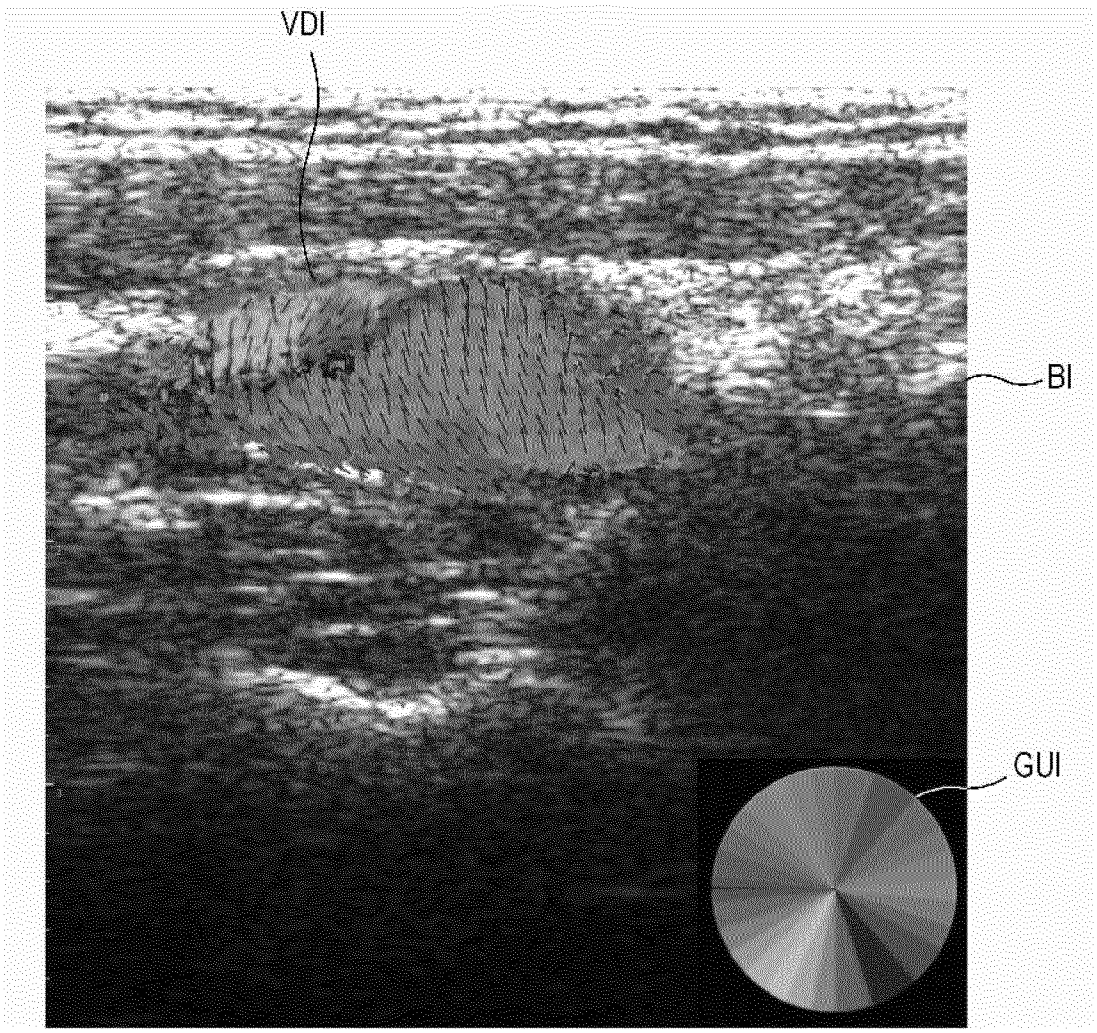


FIG. 18

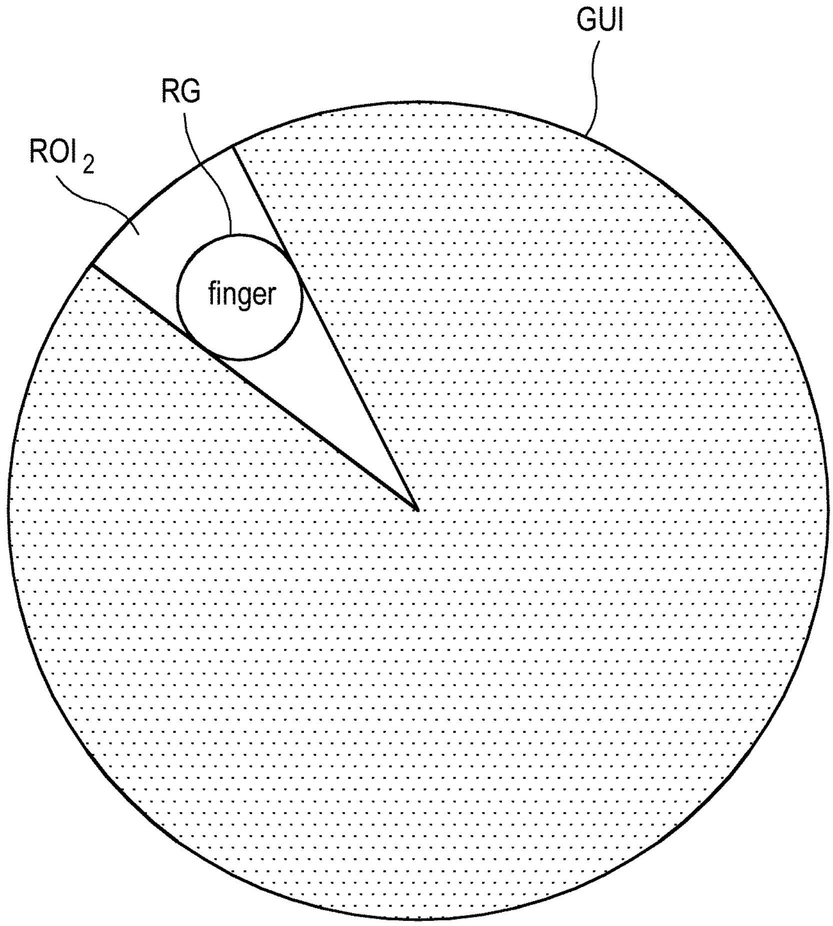


FIG. 19

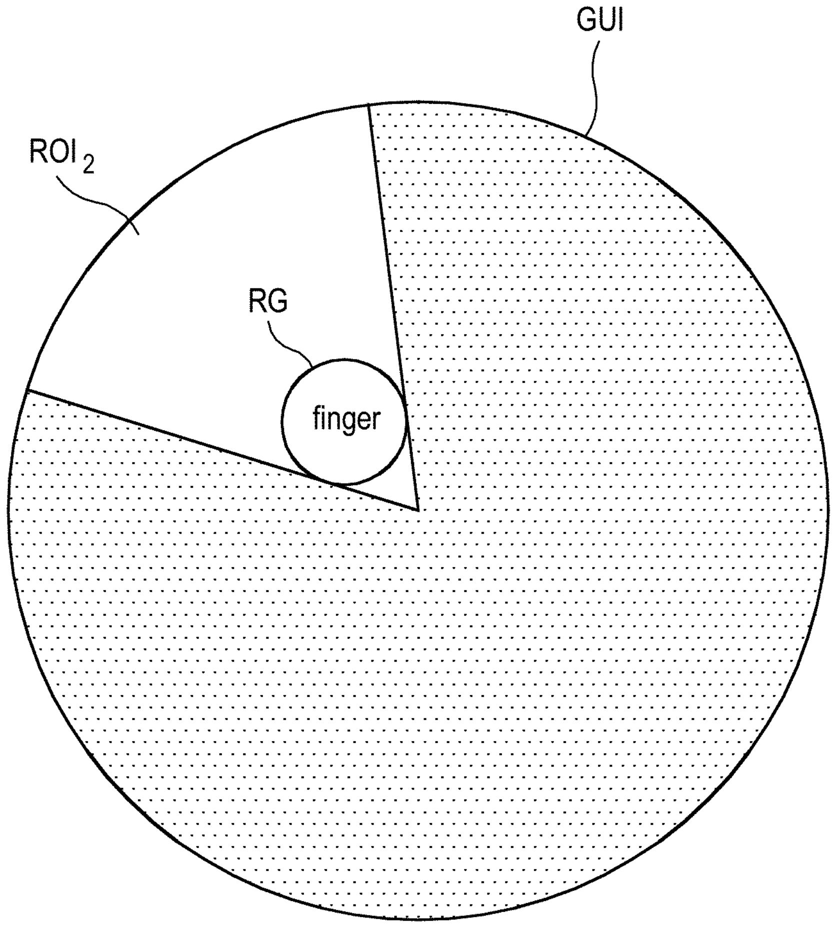
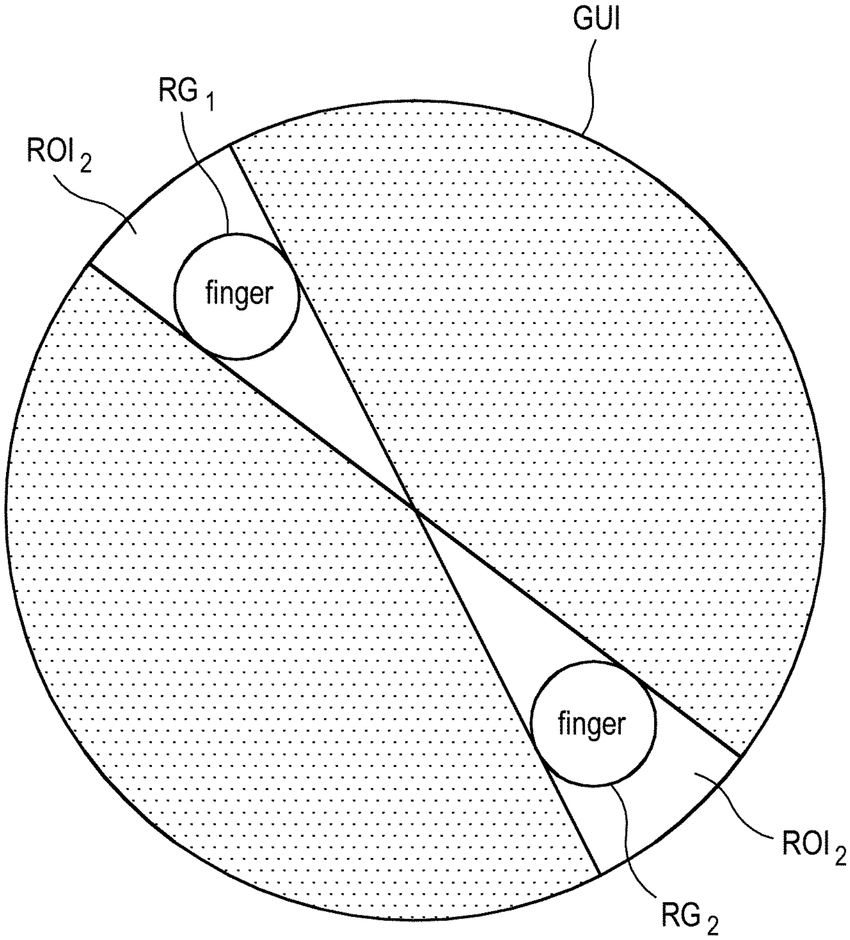


FIG. 20



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2011196237 A1 **[0005]**
- US 2003013959 A1 **[0006]**
- US 2009030321 A1 **[0007]**
- US 4768515 A **[0007]**
- US 2010069757 A1 **[0007]**

Non-patent literature cited in the description

- **VERA N.** Visualization of complex flow fields, with application to the interpretation of colour flow doppler images. *Ultrasound in medicine and biology,* 01 January 1992, vol. 18 (1), 1-9 **[0008]**

专利名称(译)	在超声系统中提供用户界面		
公开(公告)号	EP2609868B1	公开(公告)日	2020-03-18
申请号	EP2012199541	申请日	2012-12-27
[标]申请(专利权)人(译)	三星麦迪森株式会社		
申请(专利权)人(译)	三星MEDISON CO.，LTD.		
当前申请(专利权)人(译)	三星MEDISON CO.，LTD.		
[标]发明人	KIM HYOUNG JIN		
发明人	KIM, HYOUNG JIN		
IPC分类号	A61B8/06 A61B8/08 A61B8/00		
CPC分类号	A61B8/06 A61B8/463 A61B8/465 A61B8/469 A61B8/488 G01S7/52063 G01S7/52071 G01S7/52073 G01S15/8984 G10K11/341 A61B8/08 A61B8/13 G01S7/52095 G01S15/8988 G06K9/46		
代理机构(译)	LORENZ，MARKUS		
优先权	1020110144476 2011-12-28 KR		
其他公开文献	EP2609868A1		
外部链接	Espacenet		

摘要(译)

提供了用于提供用于对矢量多普勒图像执行滤波处理的用户界面的实施例。 在一个实施例中，作为非限制性示例，超声系统包括：处理单元，被配置为基于与目标对象相对应的超声数据形成目标对象的向量信息，并形成用于对向量多普勒执行滤波处理的用户界面。 基于矢量信息的图像。

$$X\cos\theta = \frac{C f_d}{2 f_0} \quad (1)$$