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(54) **Clutter signal filtering using eigenvectors in an ultrasound system**

Störechofilterung mit Eigenvektoren in einem Ultraschallsystem

Filtrage de signal d'écho parasite utilisant des vecteurs propres dans un système ultrasonore

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to ultrasound signal processing, and more particularly to clutter signal filtering upon Doppler signals using eigenvectors in an ultrasound system.

BACKGROUND

[0002] Recently, an ultrasound system has been extensively used in the medical field due to its non-invasive and non-destructive nature. Modem high-performance ultrasound imaging diagnostic systems and techniques are commonly used to produce two- or three-dimensional ultrasound images of internal features of patients. In order to provide the ultrasound images, the ultrasound system operates in various image modes such as a brightness mode, a Doppler mode and the like to acquire ultrasound images for diagnosis.

[0003] In the Doppler mode, the ultrasound system provides a color flow image visualizing velocities of moving objects such as blood flow, heart, etc. The color flow image may be formed based on Doppler signals obtained by alternately transmitting and receiving ultrasound signals to and from a target object at a pulse repetition frequency (PRF). The Doppler signals may include low frequency signals (the so-called clutter signals) due to the motion of a cardiac wall or valve of a heart. The clutter signals may have amplitudes, which are over 100 times than those of pure Doppler signals indicative of velocities of the blood flow. The clutter signals may be an obstacle to accurately detecting velocities of the blood flow. Thus, it is required to remove the clutter signals from the Doppler signals for accurate velocity detection of the blood flow. Since the eigenvector-based clutter filtering is carried out by reflecting characteristics of the Doppler signals, the performance of the eigenvector-based clutter filtering may exceed that of the IIR filtering. Thus, it has been required to appropriately set eigenvectors for the enhanced eigenvector-based clutter filtering.

[0004] XP007913995 "Nonparametric clutter rejection in Doppler ultrasound using principal component analysis" by A. Elnokrashy, A. M. Youssef and Y. M. Kadah proposes a new nonparametric technique for clutter rejection. The Doppler data samples is considered using a sufficiently large dynamic range to allow for the clutter rejection to be implemented on the digital side. The Doppler signal is modeled as the summation of the true velocity signal, a clutter component, and a random noise component,

[0005] XP001204504 "Clutter Filters Adapted to Tissue Motion in Ultrasound Color Flow Imaging" by Steinar Bjærum, Hans Torp and Kjell Kristoffersen refers to clutter rejection. According to this document, without sufficient rejection, the detection of low velocity blood flow will be poor, and the velocity estimates will have a large bias. In some situations, e.g., when imaging the coronary arteries or when the operator moves the probe in search for small vessels, there is considerable movement of tissue.

[0006] According to XP031195169 "Eigen-Based Clutter Filters for Color Flow Imaging: Single-Ensemble vs. Multi-Ensemble Approaches" by A.C. H. Yu and L. Løvstakken in designing eigen-based clutter filters for color flow imaging, one of the challengers is to develop an accurate way of estimating the eigen-components that represent clutter in slowtime ensembles. Two provide new insights on the problem, according to this document a comparative analysis on how eigen-filters perform when using eigen-estimation methods that involve multiple ensembles or a single ensemble are presented.

[0007] XP007914001 "Eigen-Based Signal Processing Methods for Ultrasound Color Flow Imaging" by A. C.H. Yu presents a study on the design of new eigen-based signals processing methods for use in color flow imaging. Specifically, the proposed methods are designed to address three main problems in color flow signal processing: the lack of abundant Doppler data samples, the possible presence of wideband Doppler clutter, and the potential flow signal distortions that arise during clutter suppression.

SUMMARY

[0008] Embodiments for setting eigenvectors for clutter signal filtering are disclosed herein. In one embodiments, an ultrasound system includes the features stated in claim 1.

[0009] In another embodiment, a method of setting eigenvectors includes the features stated in claim 3.

[0010] 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 two be used in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is a block diagram showing an illustrative embodiment of an ultrasound system
FIG. 2 is a block diagram showing an illustrative embodiment of a Doppler signal acquisition unit shown in FIG 1.
FIG 3 is a block diagram showing an illustrative embodiment of a processing unit shown in FIG. 2.
FIG. 4 shows graphs indicative of component values of the Doppler signals.
FIG 5 is a graph showing Doppler frequency estimates of the Doppler signals.
FIG. 6 is a graph showing a trajectory of the phase differences computed from the third Doppler signals, which are clutter signals filtered by using two eigenvectors.
FIG. 7 is a graph showing trajectory of the phase differences computed from the third Doppler signals, which are clutter signals filtered by using three eigenvectors.

DETAILED DESCRIPTION

[0012] A detailed description may be provided with reference to the accompanying drawings. One of ordinary skill in the art may realize that the following description is illustrative only and is not in any way limiting. Other embodiments of the present invention may readily suggest themselves to such skilled persons having the benefit of this disclosure.

[0013] Referring to FIG. 1, an illustrative embodiment of an ultrasound system 100 is shown. As depicted therein, the ultrasound system 100 may include a user input unit 110. The user input unit 110 may allow a user to input a user instruction. The user instruction may include information on the position and size of a region of interest (ROI) (e.g., a color box), which the user wants to set on a brightness mode (B-mode) image. The user input unit 110 may include at least one of a control panel, a mouse, a keyboard, a touch screen, etc.

[0014] The ultrasound system 100 may further include a Doppler signal acquisition unit 120. The Doppler signal acquisition unit 120 may be operable to alternately transmit and receive ultrasound signals to and from a target object (e.g., heart, blood flow, etc) in synchronization with a pulse repetition frequency (PRF). The Doppler signal acquisition unit 120 may acquire Doppler signals corresponding to the ROI based on the received ultrasound signals. The acquisition of the Doppler signals will be described in detail by referring to FIG. 2.

[0015] FIG. 2 is a block diagram showing an illustrative embodiment of the Doppler signal acquisition unit 120. Referring to FIG 2, the Doppler signal acquisition unit 120 may include a transmit (Tx) signal generating section 121. The Tx signal generating section 121 may be operable to generate a plurality of Tx signals. The generation of the Tx signals may be controlled by whether the current image mode is a B-mode, a C-mode, a D-mode, etc. In one embodiment, the Tx signal generating section 121 may generate Tx signals for forming a color flow image within the ROI consisting of a plurality of scan lines in the C-mode. The Tx signal generating section 121 may repeatedly generate the Tx signals based on a predetermined ensemble number.

[0016] The Doppler signal acquisition unit 120 may further include an ultrasound probe 122 containing a plurality of elements for reciprocally converting ultrasound signals and electrical signals. The ultrasound probe 122 may be operable to transmit ultrasound signals into a target object in response to the Tx signals. The ultrasound probe 122 may be further operable to receive echo signals reflected from the target object to thereby output electrical receive signals, which are analog signals. The transmission and reception of the ultrasound signals are alternately carried out to output a plurality of electrical receive signals.

[0017] The Doppler signal acquisition unit 120 may further include a beam forming section 123. The beam forming section 123 may be operable to convert the electrical receive signals into digital signals. The beam forming section 123 may be further operable to apply delays to the digital signals in consideration of distances between the elements and focal points, thereby outputting digital receive-focused signals.

[0018] The Doppler signal acquisition unit 120 may further include a Doppler signal forming section 124 that may be operable to form Doppler signals based on the digital receive-focused signals. In one embodiment, the Doppler signals may include in-phase Doppler signals and quadrature phase signals. The Doppler signals may also include clutter signals. Hereinafter, these Doppler signals may be referred to as "first Doppler signals." The Doppler signal acquisition unit 120 may form the first Doppler signals as many as the predetermined ensemble number for each of the scan lines within the ROI.

[0019] The ultrasound system 100 may further include a processing unit 130 coupled to the Doppler signal acquisition unit 120. The processing unit 130 may be operable to set at least one eigenvector based on the first Doppler signals. The processing unit 130 may be further operable to perform clutter signal filtering upon the first Doppler signals by using eigenvectors thereof to remove the clutter signals. The processing unit 130 may be operable to form a color flow image by using the Doppler signals from which the clutter signals are filtered out. The operation of the processing unit 130 will be described in detail by referring to FIG 3.

[0020] FIG 3 is a block diagram showing an illustrative embodiment of the processing unit 130. Referring to FIG 3, the processing unit 130 may include a covariance matrix computing section 131. The covariance matrix computing section 131 may be operable to compute a covariance matrix by using the plurality of first Doppler signals provided from the Doppler signal acquisition unit 120. In one embodiment, the covariance matrix computing section 131 may be operable to select one of the scan lines, which are included in the ROI, and compute the covariance matrix by using the first Doppler signals corresponding to the entire pixels on the selected scan line. In another embodiment, the covariance matrix computing section 131 may be operable to select one of the scan lines, and compute the covariance matrix by using the first Doppler signals corresponding to a predetermined number of pixels on the selected scan line. In yet another embodiment, the covariance matrix computing section 131 may be operable to compute the covariance matrix by using the first Doppler signals corresponding to the entire pixels of the scan lines on the ROI. The covariance matrix may be computed by using various well-known methods. Thus, the detailed descriptions thereof will be omitted herein.

[0021] For the sake of convenience, a method of computing the covariance matrix by using the first Doppler signals corresponding to the entire pixels on the selected one scan line will be described. The processing unit 130 may further include an eigenvector computing section 132. The eigenvector computing section 132 may be operable to compute a plurality of eigenvalues by using the computed covariance matrix and eigenvectors corresponding to the respective eigenvalues. The eigenvalues and eigenvectors may be computed by using various well-known methods. As such, the detailed explanations thereof will be omitted herein.

[0022] The processing unit 130 may further include an eigenvector setting section 133. The eigenvector setting section 133 may be operable to set at least one eigenvector for performing clutter signal filtering upon the first Doppler signals by using the plurality of eigenvectors (or both eigenvalues and eigenvectors). In one embodiment, the eigenvector setting section 133 may project the first Doppler signals corresponding to the respective pixels on the selected scan line along the respective eigenvectors. Hereinafter, the projected first Doppler signals will be referred to as "second Doppler signals." The second Doppler signals may be obtained as many as the number of the eigenvectors. The eigenvector setting section 133 may be operable to compute component values from the second Doppler signals for the respective pixels. In one embodiment, the component values may be projected values of the second Doppler signals along the respective eigenvectors. The component values (C_{ij}) may be computed by using the following equation.

$$C_{ij} = S_i^* e_j \qquad (1)$$

wherein S_i represents a first Doppler signal corresponding to an i^{th} pixel and e_j represents a j^{th} eigenvector.

[0023] For example, the eigenvector setting section 133 may be operable to compute an inner product through the equation (1) for the first Doppler signals corresponding to the respective pixels on the selected scan line and eigenvectors e_1-e_{10} computed in the eigenvector computing section 132, thereby computing the component values of the second Doppler signals for the respective pixels. The eigenvector setting section 133 may be further operable to compute correlation values between the component values of the first Doppler signals and the component values of the second Doppler signals (i.e., amplitudes of the first and second Doppler signals). The eigenvector setting section 133 may compare the computed correlation values with a predetermined threshold to detect the component values of the second Doppler signals greater than the predetermined threshold. The eigenvector setting section 133 may be operable to set the eigenvectors corresponding to the detected component values as eigenvectors for clutter signal filtering.

[0024] FIG. 4 shows graphs indicative of component values of the Doppler signals. In FIG 4, reference numerals "211-220" show graphs indicative of component values of the second Doppler signals (hereinafter, referred to as "first component graphs"). Further, reference numeral "230" shows a graph indicative of component values of the first Doppler signals (hereinafter, referred to as "second component graph"). In FIG 4, a horizontal direction (X-axis) represents positions of the pixels (i.e., depths) and a vertical direction (Y-axis) represents the component values (i.e., amplitudes) of the Doppler signals. The portions of relatively large component values may correspond to blood vessels, which may be a possible source of the clutter signals.

[0025] As such, in one embodiment, the eigenvector setting section 133 may be operable to detect the component values of the second Doppler signals whose correlation values are greater than the predetermined threshold (e.g., the component values corresponding to first graphs 219 and 220 in FIG 4). The eigenvector setting section 133 may be further operable to set eigenvectors corresponding to the component values e_9-e_{10} of the detected second Doppler signals as the eigenvectors for the clutter signal filtering.

[0026] FIG 5 is a graph showing Doppler frequency estimates of the Doppler signals. In FIG. 5, reference numeral "310" represents Doppler frequencies of original Doppler signals obtained at a vessel portion (i.e., first Doppler signals). Further, reference numeral "320" represents Doppler frequencies of the Doppler signals resulting from the clutter signal filtering upon the first Doppler signals using the eigenvectors e_9 and e_{10}, which are set in the eigenvector setting section 133. Reference numeral "330" represents Doppler frequencies of the Doppler signals resulting from the clutter signal filtering upon the first Doppler signals using the eigenvector e_{10}, which has been set in the eigenvector setting section 133. As shown in FIG 5, the clutter signal filtering using the eigenvectors e_9 and e_{10} has a better performance than the clutter signal filtering using the eigenvector e_{10}.

[0027] In another embodiment, the eigenvector setting section 133 may be operable to perform the clutter signal filtering upon the first Doppler signals by sequentially using the eigenvectors computed in the eigenvector computing section 132 to thereby form clutter signal filtered Doppler signals (hereinafter, referred to as "third Doppler signals"). In this case, the first Doppler signals may be filtered in an order determined by the magnitudes of the eigenvalues of the respective eigenvectors. The eigenvector setting section 133 may be further operable to compute component values of the third Doppler signals for each of the pixels. In one embodiment, by way of non-limiting example, the component values may be a phase difference between third Doppler signals corresponding to an n^{th} sample (or ensemble) and a $(n-1)^{th}$ sample (or ensemble) at each of the pixels, wherein n is a positive integer equal to or greater than 2. The eigenvector setting section 133 may be further operable to set eigenvectors for clutter signal filtering by using the computed component values. The eigenvector setting section 133 may be operable to set an eigenvector, which makes the phase difference kept to have the same sign, as the eigenvector for the clutter signal filtering.

[0028] For example, assuming that a blood flows at a constant velocity during a scanning time, the phase differences of the Doppler signals may not be changed. That is, the phase differences may be maintained to have the same sign. The eigenvector setting section 133 may be operable to perform the clutter signal filtering upon the first Doppler signals by using the eigenvector having the largest eigenvalue (e.g., eigenvector e_{10}) among the plurality of eigenvectors e_1 to e_{10} to form the third Doppler signals. The eigenvector setting section 133 may be further operable to compute phase differences between the third Doppler signals corresponding to an n^{th} sample (or ensemble) and a $(n+1)^{th}$ sample (or ensemble) for each of the pixels. The eigenvector setting section 133 may be operable to detect a sign change of the detected phase differences. If the detected sign change is not maintained in the same sign, i.e., the sign is changed from plus (+) to minus (-) or vice versa, then the clutter signal filtering may be performed upon the first Doppler signals by using the eigenvectors having the first and second largest eigenvalues, e.g., eigenvectors e_{10} and e_9 to form the third Doppler signals. Thereafter, the eigenvector setting section 133 may be operable to detect a sign change of the phase differences for the third Doppler signals in the same manner described above.

[0029] FIG 6 is a graph showing a trajectory of the phase differences of the third Doppler signals, in which the clutter signals are filtered by using two eigenvectors e_9 and e_{10}. If the sign change of the detected phase differences is not maintained in the same sign, as shown in TABLE 1, then the eigenvector setting section 133 may be operable to perform the clutter signal filtering upon the first Doppler signals by using the eigenvectors having the first to third largest eigenvalues, e.g., eigenvectors e_8-e_{10}, to form the third Doppler signals. Thereafter, the eigenvector setting section 133 may detect a sign change of the phase differences for the third Doppler signals.

[TABLE 1]

Sign change of phase differences																		
Filtering with eigenvectors e_9 and e_{10}									Filtering with eigenvectors e_8 to e_{10}									
-	-	+	-	-	···	-	-	-	-	-	-	-	-	-	···	-	-	-

[0030] FIG. 7 is a graph showing a trajectory of phase differences of the third Doppler signals, in which the clutter signals are filtered by using the three eigenvectors e_8 to e_{10}. If it is determined that the sign change of the detected phase differences is maintained in the same sign, i.e., the sign of the phase differences is not changed, then the eigenvector setting section 133 may set the eigenvectors of the eigenvectors e_8 to e_{10} as the eigenvectors for the clutter signal filtering. In FIGS. 6 and 7, PCA represents an abbreviation of Principal Component Analysis.

[0031] In one embodiment, although it is described above that the eigenvectors for the clutter signal filtering are set by using the eigenvectors in a magnitude order of the eigenvalues of the entire eigenvectors in order to detect the sign change of the phase differences, the setting of the eigenvectors for the clutter signal filtering may not be limited thereto. In another embodiment, the eigenvectors for the clutter signal filtering may be set by using the eigenvectors in a magnitude order of the eigenvalues of the eigenvectors corresponding to the component values e_9-e_{10} of the detected second Doppler signals in FIG 4.

[0032] The processing unit 130 may further include a filtering section 134. The filtering section may be operable to perform the clutter signal filtering upon the first Doppler signals by using the eigenvectors set in the eigenvector setting section 133. The processing unit 130 may further include an image forming section 135. The image forming section 135 may be operable to form a color flow image by using the Doppler signals with the clutter signals filtered.

[0033] The ultrasound system 100 may further include a display unit 140. The display unit 140 may be embodied with any display capable of displaying the ultrasound images such as a B-mode image, a color flow image and the like. In one embodiment, the display unit 140 may include at least one of a CRT monitor, a LCD monitor and the like.

[0034] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the scope of the principles of this disclosure. More particularly, numerous variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

Claims

1. An ultrasound system (100), comprising:

a Doppler signal acquisition unit (120) configured to transmit and receive ultrasound signals to and from a target object to acquire first Doppler signals; and
a processing unit (130) configured to compute a plurality of eigenvectors by using the fist Doppler signals and form second Doppler signals corresponding to directions of the computed eigenvectors, respectively;
characterized in that the processing unit (130) is further configured to compute amplitudes of the respective second Doppler signals and amplitudes of me first Doppler signals, compute correlations between the amplitudes of the second Doppler signals and the amplitudes of the first Doppler signals, detect the amplitudes of the second Doppler signals whose correlation is greater than a predetermined threshold and set eigenvectors corresponding to the detected amplitudes of the second Doppler signals as eigenvectors for clutter signals filtering among the plurality of eigenvectors.

2. The ultrasound system (100) of Claim 1, wherein the professing unit (130) includes:

a covariance matrix computing section (131) configured to compute a covariance matrix by using the first Doppler signals;
an eigenvector computing section (132) configured to compute the plurality of eigenvectors based on the computed covariance matrix;
an eigenvector setting section (133) configured to compute inner product for the first Doppler signals and the plurality of eigenvectors to compute the amplitudes of the second Doppler signals for respective eigenvector directions and set the eigenvectors for the clutter signal filtering among the plurality of eigenvectors based on the correlation between the amplitudes of the first Doppler signals and the amplitudes of each of the second Doppler signals;
a filtering section (134) configured to perform the clutter signal filtering upon the plurality of first Doppler signals by using the eigenvectors for the clutter signal filtering; and
an image forming section (135) configured to form a color flow image based on the clutter signal filtered Doppler signals.

3. A method of setting eigenvectors to provide a color flow image, comprising:

a) transmitting and receiving ultrasound signals to and from a target object to acquire first Doppler signals;
b) computing a plurality of eigenvectors by using the first Doppler signals; and
c) forming second Doppler signals corresponding to directions of the computed eigenvectors,
characterized by comprising:
d) computing amplitudes of the respective second Doppler signals;
e) computing correlations between the amplitudes of the second Doppler signals and amplitudes of the first Doppler signals;
f) detecting the amplitude of the second Doppler signals whose correlation is greater than a predetermined threshold; and
g) setting eigenvectors corresponding to the detected amplitudes of the second Doppler signals as eigenvector for clutter signal filtering among the plurality of eigenvectors.

4. The method of Claim 3, wherein the step b) includes:

computing covariance matrixes by using the first Doppler signals: and
computing the plurality of eigenvector by using the covariance matrixes.

5. The method of Claim 3, wherein the step c) includes computing an inner product between the first Doppler signals and the plurality of eigenvectors to compute the amplitudes of the second Doppler signals in respective directions of the eigenvectors.

6. The method of one of Claim 3, further comprising:

e) performing the clutter signals filtering upon the plurality of first Doppler signals by using the eigenvectors for the clutter signal filtering;
f) forming a color flow image based on the clutter signal filtered Doppler signals; and
g) displaying the color flow image.

Patentansprüche

1. Ultraschallsystem (100), welches Folgendes aufweist:

eine Doppler-Signalerlangungseinheit (120), welche dafür vorgesehen ist,
Ultraschallsignale zu einem Zielobjekt zu übertragen und von demselben zu empfangen, um erste Doppler-Signale zu erlangen; und
eine Verarbeitungseinheit (130), die dafür vorgesehen ist, eine Vielzahl von Eigenvektoren durch Verwenden der ersten Doppler-Signale zu berechnen und
zweite Doppler-Signale zu bilden, welche den Richtungen der jeweiligen berechneten Eigenvektoren entsprechen,
dadurch gekennzeichnet, dass
die Verarbeitungseinheit (130) des Weiteren dafür vorgesehen ist, Amplituden der jeweiligen zweiten Doppler-Signale und Amplituden der ersten Doppler-Signale zu berechnen, Übereinstimmungen zwischen den Amplituden der zweiten Doppler-Signale und den Amplituden der ersten Doppler-Signale zu berechnen, die Amplituden der zweiten Doppler-Signale, deren Übereinstimmung größer als ein vorbestimmter Grenzwert ist, zu detektieren und Eigenvektoren, welche mit den detektierten Amplituden der zweiten Doppler-Signale korrespondieren, als Eigenvektoren für ein Filtern von Stördatensignalen unter der Vielzahl von Eigenvektoren festzulegen.

2. Ultraschallsystem (100) nach Anspruch 1, wobei die Verarbeitungseinheit (130) Folgendes aufweist:

einen Kovarianz-Matrix-Berechnungsabschnitt (131), welcher dafür vorgesehen ist, eine Kovarianz-Matrix unter Verwendung der ersten Doppler-Signale zu berechnen;
einen Eigenvektor-Berechnungsabschnitt (132), welcher dafür vorgesehen ist,
die Vielzahl von Eigenvektoren basierend auf der berechneten Kovarianz-Matrix zu berechnen; 1 einen Eigenvektor-Festlegungsabschnitt (133), welcher dafür vorgesehen ist, das innere Produkt bzw. Skalarprodukt für die ersten Doppler-Signale und die Vielzahl von Eigenvektoren zu berechnen, die Amplituden der zweiten Doppler-Signale für entsprechende Eigenvektorrichtungen zu berechnen und die Eigenvektoren für das Filtern der Stördatensignale unter der Vielzahl von Eigenvektoren basierend auf der Übereinstimmung zwischen den Amplituden der ersten Doppler-Signale und den Amplituden von jedem der zweiten Doppler-Signale festzulegen;
einen Filterabschnitt (134), der dafür vorgesehen ist, das Filtern der Stördatensignale an der Vielzahl von ersten Doppler-Signalen unter Verwendung der Eigenvektoren für das Filtern der Stördatensignale durchzuführen; und
einen Bilderzeugungsabschnitt (135), der dafür vorgesehen ist, ein Farbströmungsbild basierend auf den Stördatensignal gefilterten Doppler-Signalen zu erzeugen.

3. Verfahren zum Festlegen von Eigenvektoren, um ein Farbströmungsbild zu schaffen, welches Folgendes aufweist:

a) Übertragen von Ultraschallsignalen zu einem Zielobjekt und Empfangen derselben, um erste Doppler-Signale zu erlangen;
b) Berechnen einer Vielzahl von Eigenvektoren unter Verwendung der ersten Doppler-Signale; und
c) Bilden von zweiten Doppler-Signalen, welche den Richtungen der berechneten Eigenvektoren entsprechen,
gekennzeichnet durch die folgenden Schritte:
d) Berechnen von Amplituden der jeweiligen zweiten Doppler-Signale;
e) Berechnen von Übereinstimmungen zwischen den Amplituden der zweiten Doppler-Signale und den Amplituden der ersten Doppler-Signale;
f) Detektieren der Amplituden der zweiten Doppler-Signale, deren Übereinstimmung größer als ein vorbestimmter Grenzwert ist; und
g) Festlegen von Eigenvektoren, welche den detektierten Amplituden der zweiten Doppler-Signale entsprechen, als Eigenvektoren für ein Filtern von Stördatensignalen unter der Vielzahl von Eigenvektoren.

4. Verfahren nach Anspruch 3, wobei der Schritt b) Folgendes aufweist:

Berechnen von Kovarianz-Matrizen unter Verwendung der ersten Doppler-Signale; und
Berechnen der Vielzahl von Eigenvektoren unter Verwendung der Kovarianz-Matrizen.

5. Verfahren nach Anspruch 3, wobei der Schritt c) das Berechnen eines inneren Produkts bzw. Skalarprodukts zwischen den ersten Doppler-Signalen und der Vielzahl von Eigenvektoren beinhaltet, um die Amplituden der zweiten Doppler-Signale in jeweiligen Richtungen der Eigenvektoren zu berechnen.

6. Verfahren nach Anspruch 3, welches des Weiteren Folgendes aufweist:

e) Durchführen der Filterung der Stördatensignale an der Vielzahl von ersten Doppler-Signalen unter Verwendung der Eigenvektoren für die Filterung von Stördatensignalen;
f) Erzeugen eines Farbströmungsbilds basierend auf den störechofiltrierten Doppler-Signalen; und
g) Anzeigen des Farbströmungsbilds.

Revendications

1. Système à ultrasons (100), comprenant :

une unité d'acquisition de signaux Doppler (120) configurée pour émettre et recevoir des signaux ultrasoniques de et vers un objet cible pour acquérir des premiers signaux Doppler, et
une unité de traitement (130) configurée pour calculer une pluralité de vecteurs propres en utilisant les premiers signaux Doppler et pour former des seconds signaux Doppler correspondant respectivement à des directions des vecteurs propres calculés,
caractérisé en ce que l'unité de traitement (130) est en outre configurée pour calculer des amplitudes des seconds signaux Doppler respectifs et
des amplitudes des premiers signaux Doppler, pour calculer des corrélations entre les amplitudes des seconds signaux Doppler et les amplitudes des premiers signaux Doppler, pour détecter les amplitudes des seconds signaux Doppler dont la corrélation est supérieure à un seuil prédéterminé et pour fixer des vecteurs propres correspondant aux amplitudes détectées des seconds signaux Doppler comme vecteurs propres pour le filtrage des signaux parasites parmi la pluralité de vecteurs propres.

2. Système à ultrasons (100) de la revendication 1, dans lequel l'unité de traitement (130) comprend :

une section de calcul d'une matrice de covariance (131) configurée pour calculer une matrice de covariance en utilisant les premiers signaux Doppler,
une section de calcul de vecteurs propres (132) configurée pour calculer la pluralité de vecteurs propres sur la base de la matrice de covariance calculée,
une section de fixation de vecteurs propres (133) configurée pour calculer un produit scalaire pour les premiers signaux Doppler et la pluralité de vecteurs propres pour calculer les amplitudes des seconds signaux Doppler pour les directions de vecteurs propres respectives, et fixer les vecteurs propres pour le filtrage de signaux parasites parmi la pluralité de vecteurs propres sur la base de la corrélation entre les amplitudes des premiers signaux Doppler et les amplitudes de chacun des seconds signaux Doppler,
une section de filtrage (134) configurée pour effectuer le filtrage des signaux parasites sur la pluralité de premiers signaux Doppler en utilisant les vecteurs propres pour le filtrage des signaux parasites, et
une section de formation d'image (135) configurée pour former une image de flux coloré sur la base des signaux Doppler filtrés des signaux parasites.

3. Procédé de définition de vecteurs propres pour créer une image de flux coloré comprenant :

a) l'émission et la réception de signaux ultrasonique vers et d'un objet cible pour acquérir des premiers signaux Doppler,
b) le calcul d'une pluralité de vecteurs propres en utilisant les premiers signaux Doppler, et
c) la formation de seconds signaux Doppler correspondant à des directions des vecteurs propres calculés,
caractérisé en ce qu'il comprend :
d) le calcul des amplitudes des seconds signaux Doppler respectifs;

e) le calcul de corrélations entre les amplitudes des seconds signaux Doppler et les amplitudes des premiers signaux Doppler,
f) la détection des amplitudes des seconds signaux Doppler dont la corrélation est supérieure à un seuil prédéterminé, et
g) la fixation de vecteurs propres correspondant aux amplitudes détectées des seconds signaux Doppler comme vecteurs propres pour le filtrage des signaux parasites parmi la pluralité de vecteurs propres.

4. Procédé de la revendication 3, dans lequel l'étape b) comprend :

le calcul de matrices de covariance en utilisant les premiers signaux Doppler, et
le calcul de la pluralité de vecteurs propres en utilisant les matrices de covariance.

5. Procédé de la revendication 3, dans lequel l'étape c) comprend le calcul d'un produit scalaire entre les premiers signaux Doppler et la pluralité de vecteurs propres pour calculer les amplitudes des seconds signaux Doppler dans des directions respectives des vecteurs propres.

6. Procédé de la revendication 3, comprenant en outre:

e) l'exécution du filtrage des signaux parasites sur la pluralité de premiers signaux Doppler en utilisant les vecteurs propres pour le filtrage des signaux parasites,
f) la formation d'une image de flux coloré sur la base des signaux Doppler filtrés des signaux parasites, et
g) l'affichage de l'image de flux coloré.

FIG. 1

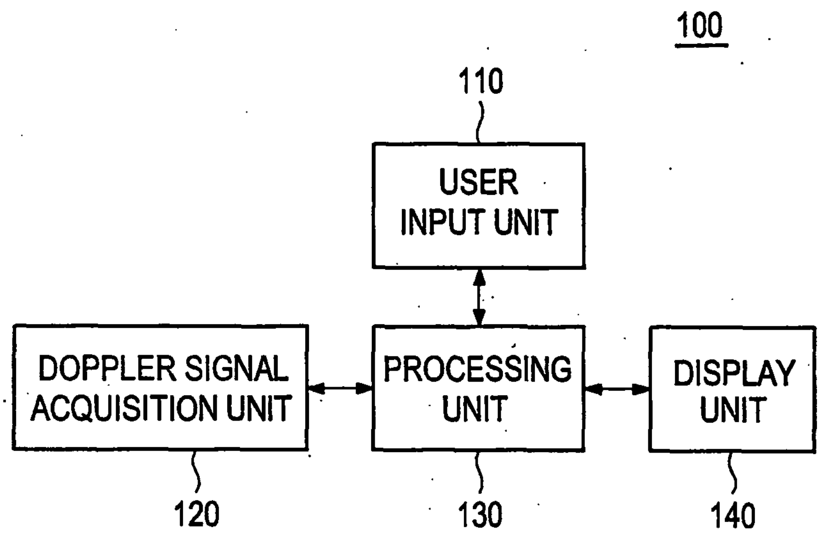

100
110
USER INPUT UNIT
DOPPLER SIGNAL ACQUISITION UNIT
PROCESSING UNIT
DISPLAY UNIT
120
130
140

FIG. 2

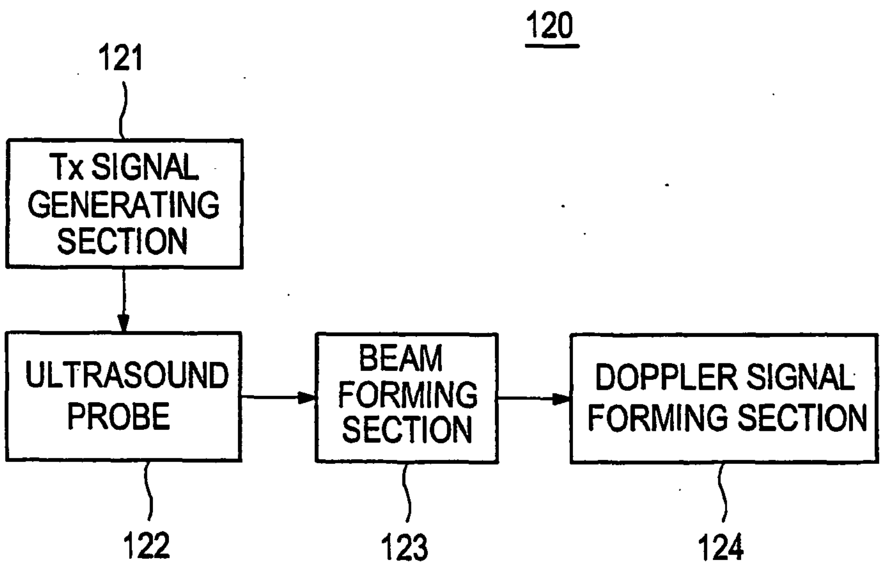

120
121
Tx SIGNAL GENERATING SECTION
ULTRASOUND PROBE
BEAM FORMING SECTION
DOPPLER SIGNAL FORMING SECTION
122
123
124

FIG. 3

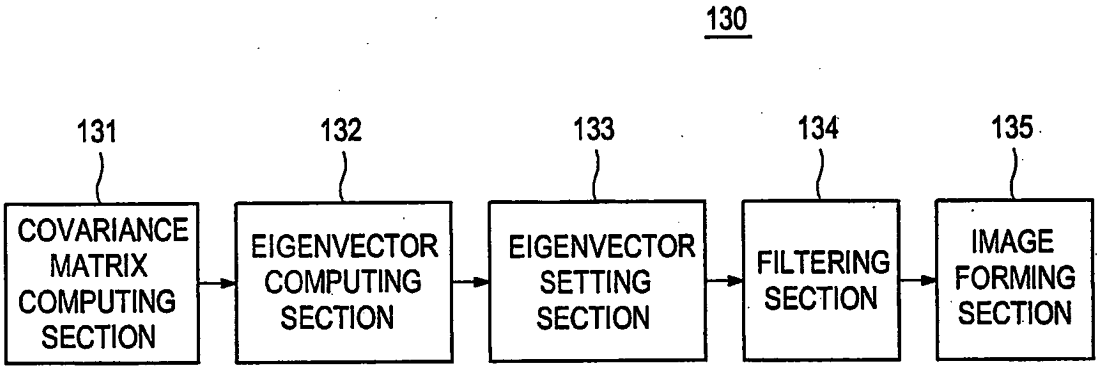

130
131
132
133
134
135
COVARIANCE MATRIX COMPUTING SECTION
EIGENVECTOR COMPUTING SECTION
EIGENVECTOR SETTING SECTION
FILTERING SECTION
IMAGE FORMING SECTION

FIG. 4

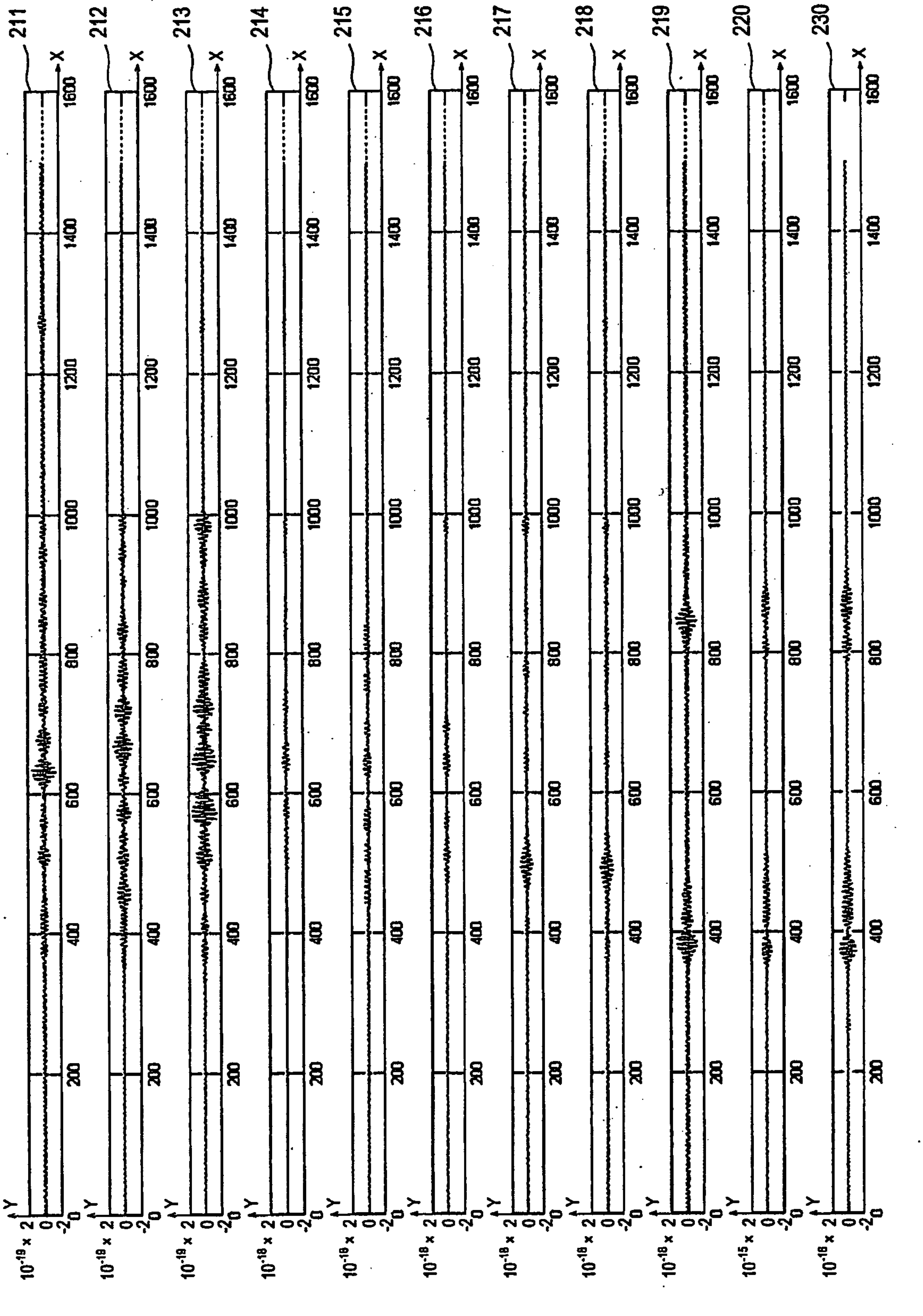


FIG. 5

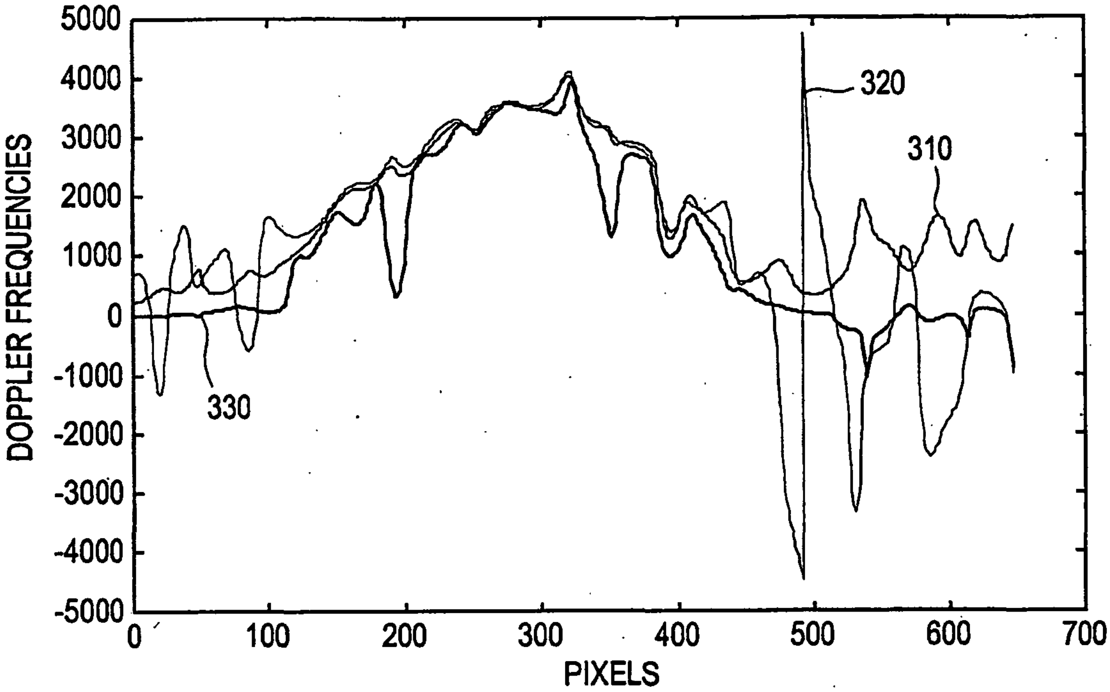

5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
DOPPLER FREQUENCIES
0
100
200
300
400
500
600
700
PIXELS
320
310
330

FIG. 6

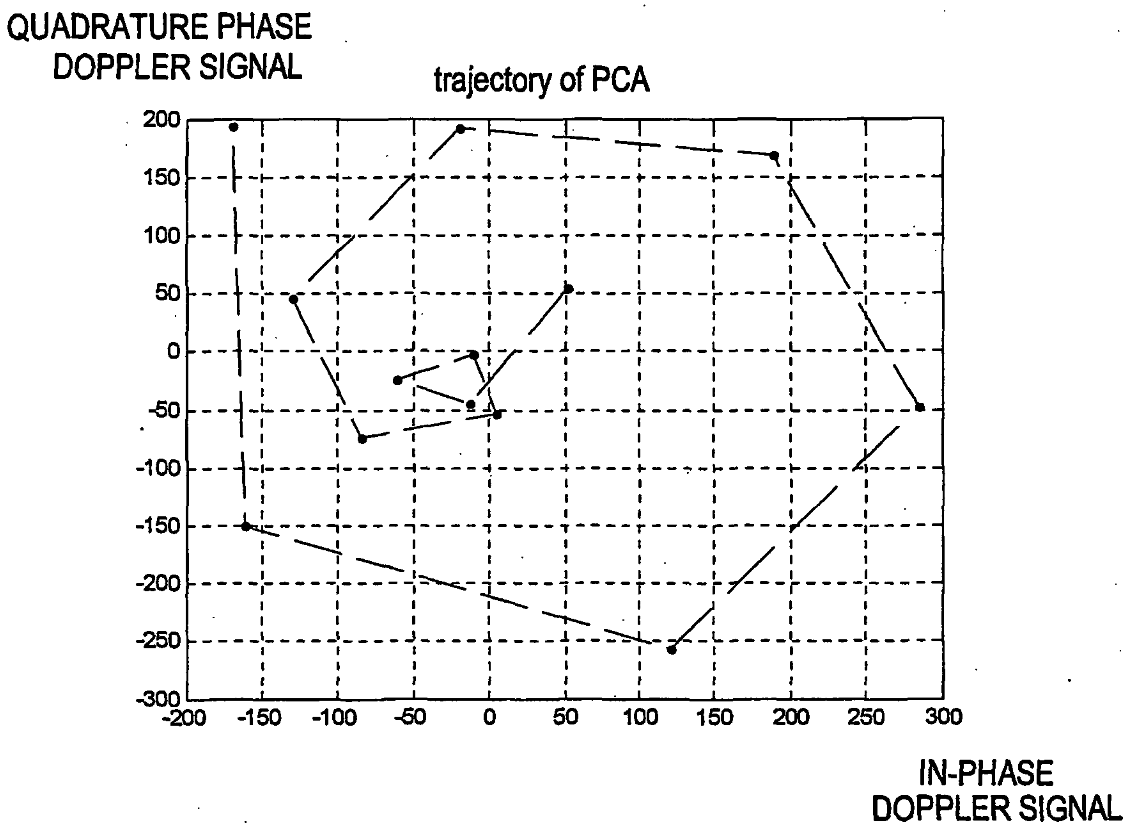
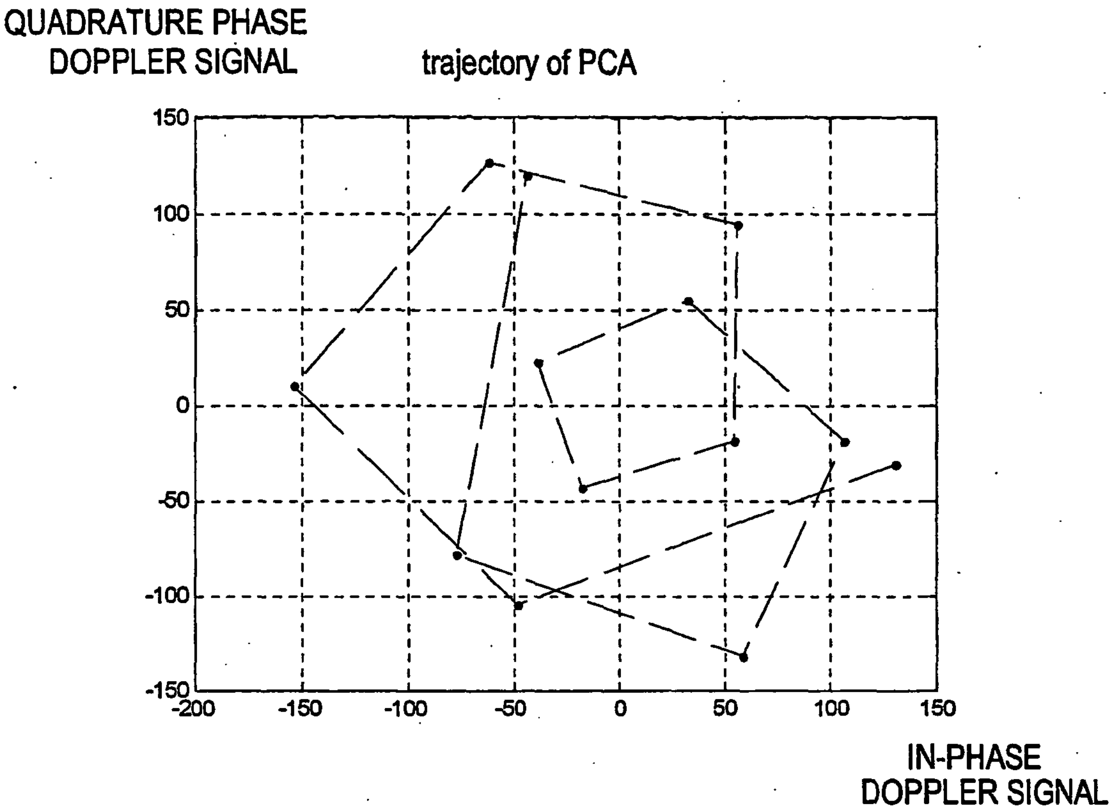

QUADRATURE PHASE
DOPPLER SIGNAL
trajectory of PCA
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-200
-150
-100
-50
0
50
100
150
200
250
300
IN-PHASE
DOPPLER SIGNAL

FIG. 7


QUADRATURE PHASE DOPPLER SIGNAL
trajectory of PCA
150
100
50
0
-50
-100
-150
-200
-150
-100
-50
0
50
100
150
IN-PHASE DOPPLER SIGNAL

REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

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- **A.C. H. Yu ; L. Løvstakken.** *Eigen-Based Clutter Filters for Color Flow Imaging: Single-Ensemble vs. Multi-Ensemble Approaches* **[0006]**
- **A. C.H. Yu.** *Eigen-Based Signal Processing Methods for Ultrasound Color Flow Imaging* **[0007]**

专利名称(译)	在超声系统中使用特征向量的杂波信号滤波		
公开(公告)号	[EP2245988B1](EP2245988B1)	公开(公告)日	2012-04-04
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申请(专利权)人(译)	MEDISON CO.，LTD.		
当前申请(专利权)人(译)	三星MEDISON CO.，LTD.		
[标]发明人	KIM TAE YUN SONG SEONG HO		
发明人	KIM, TAE YUN SONG, SEONG HO		
IPC分类号	A61B8/08 G01S15/89		
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代理机构(译)	SCHMID，WOLFGANG		
优先权	1020090038079 2009-04-30 KR 1020090128886 2009-12-22 KR		
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摘要(译)

公开了用于在超声系统中从多普勒信号设置用于杂波信号滤波的特征向量的实施例。在一个实施例中，超声系统包括：多普勒信号获取单元，被配置为向目标对象发送超声信号和从目标对象接收超声信号以获取第一多普勒信号;处理单元，用于通过所述第一多普勒信号计算多个特征向量，并形成与所计算的特征向量的方向对应的第二多普勒信号，所述处理单元还用于计算所述第二多普勒信号的分量值，并设置特征向量用于杂波通过使用计算的分量值在多个特征向量之间进行信号滤波。

$$C_{ij} = S_i' e_j \qquad (1)$$