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(54) **Adaptive clutter filtering in an ultrasound system**

Adaptive Clutterfiltrierung in einem Ultraschallsystem

Filtrage d'écho adaptatif dans un système à ultrasons

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(56) References cited:
**EP-A1- 0 795 296 EP-A1- 2 103 954
EP-A2- 0 316 200 WO-A1-99/58061
KR-A- 20000 073 096 US-A- 5 800 357
US-A1- 2003 073 903**

- **YOO Y M ET AL: "Adaptive clutter filtering for ultrasound color flow imaging", ULTRASOUND IN MEDICINE AND BIOLOGY, NEWYORK, NY, US, vol. 29, no. 9, 1 September 2003 (2003-09-01), pages 1311-1320, XP004463713, ISSN: 0301-5629, DOI: 10.1016/S0301-5629(03)01014-7**
- **HOEKS A P G ET AL: "An efficient algorithm to remove low frequency Doppler signals in digital Doppler systems", ULTRASONIC IMAGING, DYNAMEDIA INC., SILVER SPRING, MD, US, vol. 13, no. 2, 1 April 1991 (1991-04-01), pages 135-144, XP023046551, ISSN: 0161-7346, DOI: 10.1016/0161-7346(91)90080-2 [retrieved on 1991-04-01]**

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Description

TECHNICAL FIELD

[0001] The present disclosure generally relates to ultrasound image processing, and more particularly to adaptive clutter filtering in an ultrasound system.

BACKGROUND

[0002] An ultrasound system has been extensively used in the medical field due to its non-invasive and non-destructive nature. Modern high-performance ultrasound imaging diagnostic systems and techniques are commonly used to produce two-dimensional or three-dimensional ultrasound images of internal features of patients.

[0003] The ultrasound system transmits ultrasound signals to the target objects, receives echo signals reflected from the target objects and provides a color Doppler mode image of the target object based on the echo signals. In the color Doppler mode image, velocities of the target object (e.g., blood flow), which flows toward an ultrasound probe, are indicated in a first color (e.g., red), while velocities of the target object, which flows away from an ultrasound probe, are indicated in a second color (e.g., blue).

[0004] The signal received by the ultrasound probe is converted into a digital signal at a front end. The digital signal is receive-focused to thereby obtain a receive-focused signal. The band of the receive-focused signal is modulated by a mixer and then the receive-focused signal is appropriately decimated so that In-phase/Quadrature (IQ) signal is obtained. This IQ signal is referred to as a baseband IQ signal. The IQ signal may be expressed by the following equation.

$$X_{IQ} = C + F + N \quad (1)$$

wherein X_{IQ} represents an IQ signal, C represents a clutter signal generated from a tissue, F represents a blood flow signal generated from blood flow, and N represents a noise signal generated from the system and exterior.

[0005] Essential information from Equation (1) is information on F, i.e., the blood flow signal. Color Doppler processing represents a process of extracting components on the blood flow signal from the IQ signal and processing the extracted components into data for display on a screen. Clutter filtering is an essential processing step in the color Doppler processing. The clutter filtering is performed to remove a low-band clutter signal from a Doppler signal to thereby extract only a blood flow signal and a noise signal. The filtered Doppler signal contains the blood flow signal and the noise, which are mixed with each other. The noise may be removed through signal processing. Then, the components on the blood flow signal are displayed on a screen.

[0006] Generally, the clutter signal is distributed at a low frequency band, whereas the blood flow signal is distributed at a high frequency band. Thus, a high pass filter should be designed to remove the clutter signal. However, the amplitude of the clutter signal is higher than that of the blood flow signal by 40 - 60 dB. As such, it is not easy to extract only the blood flow signal. Accordingly, a high performance of the high pass filter is required.

[0007] Further, since an effective clutter filtering may be limited due to a small ensemble number, various filtering techniques have been developed. The clutter filter may be classified into a finite impulse response (FIR), an infinite impulse response (IIR) and a Regression. In case of the IIR filter, various initializing techniques such as zero, step, exponential, projection, etc. have been developed to suppress the transient. The Regression-type filter is classified into a polynomial filter, a sinusoidal regression filter and the like.

[0008] Conventionally, a clutter filter is properly selected depending on the application of an ultrasound system and the clutter filtering is performed with only the selected clutter filter. In such a case, i.e., if an identical clutter filter is applied to entire regions within a region of interest, the quality of an ultrasound image may be degraded.

[0009] WO 99/58061 A1 discloses an ultrasonic diagnostic imaging system and method by which a fundamental frequency signal is transmitted into the body and harmonic echo returns are received from the transmission. YP004463713 "Adaptive clutter filtering for ultrasound color flow imaging" by Y M et al describes an adaptive clutter rejection method in which the clutter filter is adaptively selected by considering the desired clutter suppression level, the ensemble size and stop-band cut-off frequency. EP 2 103 954 A1 discloses embodiments for filtering clutter signals from receive signals obtained in a Doppler mode in an ultrasound system. KR 2000 0073096 A relates to a clutter signal filtering apparatus to remove a clutter signal by applying an appropriate clutter filtering algorithm corresponding to each pixel. In EP 0 316 200 A2 a medical Doppler ultrasound imaging system with improved filtering to separate blood flow information from clutter due to heart wall and vessel motion is disclosed.

SUMMARY

[0010] Embodiments for adaptively performing clutter filtering in an ultrasound system are disclosed herein. In one embodiment, by way of non-limiting example, an ultrasound system comprises the features stated in claim 1.

[0011] In another embodiment, a method of adaptively performing clutter filtering, comprises the features stated in claim 7.

[0012] In yet another embodiment, a computer-readable storage medium storing instructions that, when executed by a computer, cause the computer to provide a method of adaptively performing clutter filtering upon in an ultrasound system is provided, the method comprising the features stated in claim 3.

[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 block diagram showing an illustrative embodiment of an ultrasound data acquisition unit.

FIG. 3 is a block diagram showing an illustrative embodiment of a processing unit.

FIG. 4 is a graph showing a relationship between stopband attenuation and stopband width in a clutter filter.

FIG. 5 is a graph showing a relationship between a cutoff frequency and stopband attenuation for setting coefficients of a clutter filter.

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. Other embodiments of the present invention may readily suggest themselves to such skilled persons having the benefit of this disclosure. The term "Doppler mode" described in the following embodiments includes a color Doppler mode, a spectral Doppler mode and the like.

[0016] Referring to FIG. 1, an ultrasound system constructed in accordance with one embodiment is shown therein. The ultrasound system 100 includes a user input unit 110, an ultrasound data acquisition unit 120, a processing unit 130 and a display unit 140.

[0017] The user input unit 110 receives a user request from a user. In one embodiment, the user request includes a first user request for setting a region of interest (ROI) on a brightness mode (B-mode) image. Also, the user request further includes a second user request for adjusting coefficients of a clutter filter to filter out a clutter signal from a Doppler signal for each of pixels constructing a Doppler mode image. The filter coefficients include a cutoff frequency, stopband attenuation and the like.

[0018] The ultrasound data acquisition unit 120 is configured to transmit ultrasound beams to a target object and receive ultrasound echoes reflected from the target object to thereby form ultrasound data representative of the target object. An operation of the ultrasound acquisition unit 120 will be described in detail by referring to FIG. 2.

[0019] FIG. 2 is a block diagram showing an illustrative embodiment of the ultrasound data acquisition unit 120. Referring to FIG. 2, the ultrasound data acquisition unit 120 includes a transmit (Tx) signal forming section 122. The Tx signal forming section 122 is configured to generate a plurality of Tx signals and apply delays to the Tx signals. The delays of the Tx signals may be controlled according to an image mode such as a brightness mode, a Doppler mode and the like, which may be provided in the ultrasound system. In one embodiment, the Tx signals include first Tx signals for the brightness mode and second Tx signals for the Doppler mode.

[0020] The ultrasound data acquisition unit 120 further includes an ultrasound probe 124, which is coupled to the Tx signal forming section 122. The ultrasound probe 124 may include an array transducer containing a plurality of transducer elements for reciprocal conversion between electric signals and ultrasound signals. The ultrasound probe 124 is configured to transmit ultrasound signals in response to the Tx signals. The ultrasound probe 124 is further configured to receive ultrasound echoes reflected from the target object to thereby output receive signals. In one embodiment, the receive signals include first receive signals obtained in response to the first Tx signals and second receive signals obtained in response to the second Tx signals.

[0021] The ultrasound data acquisition unit 120 further includes a beam forming section 126, which is coupled to the ultrasound probe 124. The beam forming section 126 is configured to digitize the receive signals to obtain digital signals. The beam forming section 126 is further configured to apply delays to the digital signals in consideration of distances

between the elements of the ultrasound probe 124 and focal points. Thereafter, the beam forming section 126 is further configured to sum the delayed digital signals to form receive-focused signals. In one embodiment, the beam forming section 126 forms a first receive-focused signal based on the first receive signals and a second receive-focused signal based on the second receive signals.

[0022] The ultrasound data acquisition unit 120 further includes an ultrasound data forming section 128, which is coupled to the beam forming section 126. The ultrasound data forming section 128 is configured to form ultrasound data based on the receive-focused signals. In one embodiment, the ultrasound data forming section 128 is configured to form first ultrasound data based on the first receive-focused signal. The first ultrasound data may include radio frequency data. However, the first ultrasound data may not be limited thereto. The ultrasound data forming section 128 may be configured to form second ultrasound data based on the second receive-focused signal. The second ultrasound data may include in-phase/quadrature data (i.e., ensemble data). However, the second ultrasound data may not be limited thereto.

[0023] Referring back to FIG. 1, the processing unit 130, which is coupled to the user input unit 110 and the ultrasound data acquisition unit 120, is configured to form a Doppler signal based on the second ultrasound data. The processing unit 130 is further configured to adaptively perform clutter filtering upon the Doppler signal for each of pixels constructing a Doppler mode image to filter out the clutter signal from the Doppler signal. The processing unit 130 is further configured to form a Doppler mode image based on the Doppler signal with the clutter signal filtered out. Also, the processing unit 130 is further configured to form a B-mode image based on the first ultrasound data.

[0024] FIG. 3 is a block diagram showing an illustrative embodiment of a processing unit. Referring to Fig. 3, the processing unit 130 includes a Doppler signal forming section 131, a coefficient adjusting section 132, a filtering section 133, a noise removing section 134 and an image forming section 135.

[0025] The Doppler signal forming section 131 is configured to perform signal processing such as decimation, modulation and the like, upon the second ultrasound data, which are provided from the ultrasound data acquisition unit 120, to thereby form a Doppler signal corresponding to a plurality of pixels of a Doppler mode image. The Doppler signal includes a blood flow signal caused by the blood flow, a clutter signal caused by the motion of tissues such as cardiac wall, cardiac valve and the like, and a noise signal.

[0026] The coefficient adjusting section 132 is configured to analyze the Doppler signal, which is provided from the Doppler signal forming section 131, to adjust coefficients of a clutter filter for clutter filtering upon the Doppler signal for each pixel.

[0027] The blood flow signal is a signal necessary for forming the Doppler mode image so that the clutter signal and the noise signal have to be removed from the Doppler signal. Amplitude has an order wherein clutter signal > blood flow signal > the noise signal. To efficiently remove the clutter signal, stopband attenuation and stopband width, which are coefficients of the clutter filter, should be appropriately determined. In one embodiment, the stopband attenuation and the stopband width may be determined according to characteristics of the clutter signal. The stopband width is determined by a bandwidth of the clutter signal and the stopband attenuation is determined by amplitude of the clutter signal. However, the stopband attenuation and the stopband width have a trade off in relation. That is, if the stopband attenuation is increased, then the stopband width is decreased. However, if the stopband attenuation is decreased, then the stopband width is increased.

[0028] FIG. 4 is a graph showing a relationship between the stopband attenuation and the stopband width in the clutter filter. As shown in FIG. 4, two curved lines represent frequency responses of different clutter filters having the same cutoff frequency of 0.16 pulse repetition frequency (prf). A solid line represents a frequency response of a clutter filter having stopband attenuation of 80 dB and a stopband width of 0.025 prf. Further, a dotted line represents a frequency response of a clutter filter having stop band attenuation of 50 dB and a stopband width of 0.055 prf.

[0029] Also, determining the cutoff frequency, which is another filter coefficient, is an essential process in designing the clutter filter. If the cutoff frequency is relatively low, then a blood flow signal corresponding to a slow speed may be preserved well. On the other hand, if the cutoff frequency is relatively high, then a wider stopband width may be secured while the blood flow signal corresponding to the slow speed is attenuated. This is so that clutter filter performance for removing the clutter signal may be improved. Thus, it is required to appropriately determine the cutoff frequency during the clutter filtering process.

[0030] FIG. 5 is a graph showing a relationship between a cutoff frequency and stopband attenuation for determining coefficients of the clutter filter. The stopband attenuation is an independent variable and the cutoff frequency is a dependent variable determined according to the stopband attenuation. The coefficient adjusting section 132 is configured to determine the cutoff frequency and the stopband attenuation of the clutter filter as the following process.

[0031] The coefficient adjusting section 132 is configured to determine an upper limit and a lower limit of a threshold of the cutoff frequency in consideration of a range for removing the clutter signal. In one embodiment, the coefficient adjusting section 132 is configured to determine a maximum cutoff frequency CF_{max} for maximally removing the clutter signal as well as to determine a minimum cutoff frequency CF_{min} for minimally removing the clutter signal to show the blood flow of a relative slow speed, which is desired to observe, in the Doppler mode image, even if a large amount of

the clutter signal remains. The maximum cutoff frequency $CF_{\max}$ represents the upper limit of the threshold of the cutoff frequency and the minimum cutoff frequency $CF_{\min}$ represents the lower limit of the threshold.

[0032] In one embodiment, a velocity v of the blood flow may be computed by the following equation.

$$v = \frac{c}{2 \cos \theta} \frac{f_d}{f_o} \quad (1)$$

wherein θ represents an angle between an ultrasound beam and a flowing direction of the blood flow, c is an acoustic velocity, f_d represent a Doppler shift frequency and f_o represents a transmit frequency.

[0033] Assuming that the cutoff frequency is CF_o , a detectable velocity of the blood flow may be computed as the following equation.

$$v = \frac{c}{2 \cos \theta} \frac{CF_o}{f_o} \quad (2)$$

[0034] Thus, if the minimum velocity $V_{\min}$ of the blood flow to be detected is determined, then the minimum cutoff frequency $CF_{\min}$ may be computed as the following equation.

$$CF_{\min} = 2 \cos \theta \cdot f_o \cdot \frac{v_{\min}}{c} \quad (3)$$

[0035] Further, as described above, the maximum cutoff frequency $CF_{\max}$ is determined to maximally remove the clutter signal based on Doppler signal distribution on a frequency domain. Also, the maximum cutoff frequency $CF_{\max}$ may be empirically determined by considering components on the clutter signal.

[0036] The coefficient adjusting section 132 is further configured to determine an upper limit and a lower limit of a threshold of the stopband attenuation according to a power of the Doppler signal. In one embodiment, the coefficient adjusting section 132 is configured to compute a power of the Doppler signal for each pixel. The coefficient adjusting section 132 is also configured to determine a maximum power as maximum stopband attenuation $SBA_{\max}$ and a minimum power as minimum stopband attenuation $SBA_{\min}$. The coefficient adjusting section 132 is configured to determine the maximum stopband attenuation $SBA_{\max}$ as an upper limit of the threshold of the stopband attenuation and to determine the minimum stopband attenuation $SBA_{\min}$ as a lower limit of the threshold of the stopband attenuation.

[0037] Further, the coefficient adjusting section 132 is configured to determine first coordinates and second coordinates on a coordinate system associating the cutoff frequency with the stopband attenuation. The first coordinates are determined by the lower limit of the threshold of the stopband attenuation and the lower limit of the threshold of the cutoff frequency, while the second coordinates are determined by the upper limit of the threshold of the stopband attenuation and the upper limit of the threshold of the cutoff frequency.

[0038] The coefficient adjusting section 132 is further configured to set a path between first and second coordinates ($SBA_{\min}$, $CF_{\min}$) and ($SBA_{\max}$, $CF_{\max}$). Referring to FIG. 5, if the path is set like path A, then the blood flow of weak amplitude may be more clearly indicated while the performance of removing the clutter signal is degraded. If the path is set like path C, then a high performance of removing the clutter signal is expected. However, the blood flow signal of weak amplitude may be attenuated so that loss of information on the blood flow may be increased. Thus, an appropriate path may be close to path B at which the cutoff frequency and the stopband attenuation are proportional to each other. As for the path B, the stopband width may be a constant form at each cutoff frequency. Also, a more appropriate path may be set by using empirical methods.

[0039] The coefficient adjusting section 132 is configured to set the stopband attenuation for each pixel according to amplitude of the clutter signal contained in the Doppler signal, which is provided from the Doppler signal forming section 131. The coefficient adjusting section 132 is configured to compute the cutoff frequency for each pixel corresponding to the stopband attenuation for each pixel based on the proportional path set between the first coordinates ($SBA_{\min}$, $CF_{\min}$) and the second coordinates ($SBA_{\max}$, $CF_{\max}$). The coefficient adjusting section 132 is configured to adjust the cutoff frequency of the clutter filter based on the computed cutoff frequencies.

[0040] In one embodiment, the coefficient adjusting section 132 is configured to be at least one of the filter coefficients of the clutter filter such as cutoff frequency and stopband attenuation in response to the second user request, which is provided by the user input unit 110.

[0041] The filtering section 133 is configured to perform clutter filtering upon the Doppler signal for each pixel by using the stopband attenuation and the cutoff frequency, which have been adjusted for each pixel in the coefficient adjusting

section 132, to remove the clutter signal therefrom.

[0042] The noise removing section 134 is configured to set a predetermined power threshold to remove a noise signal from the Doppler signal in which the clutter signal has been filtered out. In such a case, if the filtering section 133 is configured to decrease the amplitude of the clutter signal instead of completely removing the clutter signal during the clutter filter, then the clutter signal may be removed together with the noise signal in the noise removing section 134.

[0043] The image forming section 135 is configured to form a Doppler mode image by using the Doppler signal in which the clutter signal and the noise signal have been removed. The image forming section 135 may be configured to perform various processing such as scan conversion and the like to form the Doppler mode image.

[0044] Referring back to FIG. 1, the display unit 140, which is coupled to the processing unit 130, is configured to display the Doppler mode image. The display unit 140 may include at least one of a cathode ray tube display, a liquid crystal display, an organic light emit diode display and the like.

[0045] 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 claims. 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 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:

an ultrasound data acquisition unit (120) configured to transmit ultrasound signals to a target object and receive ultrasound echoes reflected from the target object to thereby acquire ultrasound data; and
a processing unit (130) configured to form a Doppler signal corresponding to each of a plurality of pixels constructing a Doppler mode image based on the ultrasound data,
wherein

the processing unit (130) being further configured to adjust coefficients of a clutter filter for each of the pixels based on characteristics of the Doppler signal for each of the pixels for performing clutter filtering upon the Doppler signal, the coefficients including a cutoff frequency and stopband attenuation,

characterized in that

the processing unit is further configured to:

determine minimum and maximum cutoff frequencies and minimum and maximum stopband attenuations based on the characteristics of the Doppler signal,
determine a first coordinate having the minimum cutoff frequency and the minimum stopband attenuation and a second coordinate having the maximum cutoff frequency and the maximum stopband attenuation on a coordinate system associating the cutoff frequency with the stopband attenuation, and
determine a path connecting the first coordinate and the second coordinate,

wherein the processing unit is further configured to set a particular stopband attenuation and a particular cutoff frequency for a particular pixel according to amplitude of a clutter signal contained in the Doppler signal and the path connecting the first coordinate and the second coordinate.

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

a coefficient adjusting section (132) configured to analyze the characteristics of the Doppler signal for each of the pixels to adjust the coefficients of the clutter filter;

a filtering section (133) configured to perform the clutter filtering upon the Doppler signal for each of the pixels by using the adjusted coefficients to remove the clutter signal from the Doppler signal; and

a noise removing section (134) configured to set a predetermined power threshold to remove a noise signal from the Doppler signal with the clutter signal filtered out.

3. The ultrasound system (100) of Claim 2, wherein the coefficient adjusting section (132) is configured to determine the minimum and the maximum cutoff frequencies based on a range for removing the clutter signal, and wherein the coefficient adjusting section is configured to determine the minimum and the maximum stopband attenuations based on a power of the Doppler signal.

4. The ultrasound system (100) of Claim 3, wherein the coefficient adjusting section (132) is configured to set a maximum power of the Doppler signal as the maximum stopband attenuation and a minimum power of the Doppler signal as the minimum stopband attenuation.

5. The ultrasound system (100) of Claim 4, wherein the coefficient adjusting section (132) is configured to determine the path to be a proportional path between the first and second coordinates, wherein the stopband attenuation is an independent variable and the cutoff frequency is a dependent variable.

6. The ultrasound system (100) of Claim 1, wherein the processing unit (130) is configured to determine the particular stopband attenuation for the particular pixel based on amplitude of the clutter signal and to determine the particular cutoff frequency corresponding to the determined particular stopband attenuation on the path to adjust the cutoff frequency of the clutter filter.

7. A method of adaptively performing clutter filtering, comprising:

- a) acquiring ultrasound data indicative of a target object; and
- b) forming a Doppler signal corresponding to each of a plurality of pixels constructing a Doppler mode image based on the ultrasound data;
- c) adjusting coefficients of a clutter filter for each of the pixels based on characteristics of the Doppler signal for each of the pixels for performing clutter filtering upon the Doppler signal, the coefficient including a cutoff frequency and stopband attenuation, **characterised in that** c) comprises:

- determining minimum and maximum cutoff frequencies and minimum and maximum stopband attenuations based on the characteristic of the Doppler signal,
- determining a first coordinate having the minimum cutoff frequency and the minimum stopband attenuation and a second coordinate having the maximum cutoff frequency and the maximum stopband attenuation on a coordinate system associating the cutoff frequency with the stopband attenuation, and
- determining a path connecting the first coordinate and the second coordinate,
- setting a particular stopband attenuation and a particular cutoff frequency for a particular pixel according to amplitude of a clutter signal contained in the Doppler signal and to the path connecting the first coordinate and the second coordinate.

8. The method of Claim 7, wherein the step c) includes:

- c1) analyzing the characteristics of the Doppler signal for each of the pixels to adjust the coefficients of the clutter filter;
- c2) performing the clutter filtering upon the Doppler signal for each of the pixels by using the adjusted coefficients to remove the clutter signal from the Doppler signal; and
- c3) setting a predetermined power threshold to remove a noise signal from the Doppler signal with the clutter signal filtered out.

9. The method of Claim 8, wherein the step c1) includes:

- determining the minimum and the maximum cutoff frequencies based on a range for removing the clutter signal; and
- determining the minimum and the maximum stopband attenuations based on a power of the Doppler signal.

10. The method of Claim 9, wherein the step c1) includes:

- determining a maximum power of the Doppler signal as the maximum stopband attenuation; and
- determining a minimum power of the Doppler signal as the minimum stopband attenuation.

11. The method of Claim 10, wherein the step c1) further includes:

- determining the path to be a proportional path between the first and second coordinates, wherein the stopband attenuation is an independent variable and the cutoff frequency is a dependent variable.

12. The method of Claim 7, wherein the step c) includes:

determining the particular stopband attenuation for the particular pixel based on amplitude of the clutter signal;
and
determining the particular cutoff frequency corresponding to the determined particular stopband attenuation on
the path to adjust the cutoff frequency of the clutter filter.

13. A computer-readable storage medium storing instructions that, when executed by a computer, cause the computer to provide a method of claim 7.

Patentansprüche

1. Ultraschallsystem (100), welches Folgendes aufweist:

eine Ultraschalldatenerlangungseinheit (120), welche dafür vorgesehen ist, Ultraschallsignale zu einem Zielobjekt zu übertragen und von dem Zielobjekt reflektierte Ultraschallechos zu empfangen, um dadurch Ultraschalldaten zu erhalten; und
eine Verarbeitungseinheit (130), die dafür vorgesehen ist, ein Doppler-Signal zu bilden, das jedem einer Vielzahl von Pixeln entspricht, die ein Doppler-Modusbild basierend auf den Ultraschalldaten erzeugen, wobei die Verarbeitungseinheit (130) des Weiteren dafür vorgesehen ist, Koeffizienten eines Clutterfilters für jedes der Pixel basierend auf Eigenschaften des Doppler-Signals für jedes der Pixel anzupassen bzw. einzustellen, um eine Clutterfilterung an dem Doppler-Signal durchzuführen, wobei die Koeffizienten eine Grenzbzw. Abschaltfrequenz und eine Sperrdämpfung beinhalten,
dadurch gekennzeichnet, dass
die Verarbeitungseinheit des Weiteren für Folgendes vorgesehen ist:

Ermitteln minimaler und maximaler Abschaltfrequenzen und minimaler und maximaler Sperrdämpfungen basierend auf den Eigenschaften des Doppler-Signals,
Ermitteln einer ersten Koordinate, welche die minimale Abschaltfrequenz und die minimale Sperrdämpfung aufweist, und einer zweiten Koordinate, welche die maximale Abschaltfrequenz und die maximale Sperrdämpfung aufweist, auf einem Koordinatensystem, das die Abschaltfrequenz mit der Sperrdämpfung in Zusammenhang bringt, und
Ermitteln eines Pfads, welcher die erste Koordinate und die zweite Koordinate miteinander verbindet, wobei die Verarbeitungseinheit des Weiteren dafür vorgesehen ist, eine bestimmte Sperrdämpfung und eine bestimmte Abschaltfrequenz für ein bestimmtes Pixel gemäß einer Amplitude eines Cluttersignals, das in dem Doppler-Signal enthalten ist, und dem Pfad, welcher die erste Koordinate und die zweite Koordinate miteinander verbindet, festzulegen.

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

einen Koeffizienteneinstellabschnitt (132), der dafür vorgesehen ist, die Eigenschaften des Doppler-Signals für jedes der Pixel zu analysieren, um die Koeffizienten des Clutterfilters einzustellen;
einen Filterabschnitt (133), der dafür vorgesehen ist, das Clutterfiltern an dem Doppler-Signal für jedes der Pixel durch Verwenden der eingestellten Koeffizienten durchzuführen, um das Cluttersignal aus dem Doppler-Signal zu entfernen; und
einen Geräuschentfernungsabschnitt (134), der dafür vorgesehen ist, einen vorbestimmten Leistungsgrenzwert festzulegen, um ein Geräuschsignal aus dem Doppler-Signal zu entfernen, wobei das Cluttersignal herausgefiltert ist.

3. Ultraschallsystem (100) nach Anspruch 2, wobei der Koeffizienteneinstellabschnitt (132) dafür vorgesehen ist, die minimalen und die maximalen Abschaltfrequenzen basierend auf einem Bereich zum Entfernen des Cluttersignals zu ermitteln, und wobei der Koeffizienteneinstellabschnitt dafür vorgesehen ist, die minimalen und die maximalen Sperrdämpfungen basierend auf einer Leistung des Doppler-Signals zu ermitteln.

4. Ultraschallsystem (100) nach Anspruch 3, wobei der Koeffizienteneinstellabschnitt (132) dafür vorgesehen ist, eine maximale Leistung des Doppler-Signals als die maximale Sperrdämpfung und eine minimale Leistung des Doppler-Signals als die minimale Sperrdämpfung festzulegen.

5. Ultraschallsystem (100) nach Anspruch 4, wobei der Koeffizienteneinstellabschnitt (132) dafür vorgesehen ist, den

Pfad derart festzulegen, dass es ein proportionaler Pfad zwischen den ersten und zweiten Koordinaten ist, wobei die Sperrdämpfung eine unabhängige Variable und die Abschaltfrequenz eine abhängige Variable ist.

6. Ultraschallsystem (100) nach Anspruch 1, wobei die Verarbeitungseinheit (130) dafür vorgesehen ist, die jeweilige Sperrdämpfung für den jeweiligen Pixel basierend auf der Amplitude des Cluttersignals zu ermitteln und die jeweilige Abschaltfrequenz entsprechend der ermittelten jeweiligen Sperrdämpfung auf dem Pfad zu ermitteln, um die Abschaltfrequenz des Clutterfilters einzustellen.

7. Verfahren zur adaptiven Durchführung einer Clutterfilterung, welches Folgendes aufweist:

- a) Erlangen von Ultraschalldaten, die informatorisch für ein Zielobjekt sind; und
- b) Erzeugen eines Doppler-Signals entsprechend jedem einer Vielzahl von Pixeln, die ein Doppler-Modusbild basierend auf den Ultraschalldaten erzeugen;
- c) Anpassen bzw. Einstellen von Koeffizienten eines Clutterfilters für jedes der Pixel basierend auf den Eigenschaften des Doppler-Signals für jedes der Pixel zum Durchführen einer Clutterfilterung an dem Doppler-Signal, wobei die Koeffizienten eine Grenz- bzw. Abschaltfrequenz und eine Sperrdämpfung beinhalten, **dadurch gekennzeichnet, dass**
- c) Folgendes aufweist:

Ermitteln minimaler und maximaler Abschaltfrequenzen und minimaler und maximaler Sperrdämpfungen basierend auf den Eigenschaften des Doppler-Signals,
Ermitteln einer ersten Koordinate, welche die minimale Abschaltfrequenz und die minimale Sperrdämpfung aufweist, und einer zweiten Koordinate, welche die maximale Abschaltfrequenz und die maximale Sperrdämpfung aufweist, auf einem Koordinatensystem, das die Abschaltfrequenz mit der Sperrdämpfung in Zusammenhang bringt, und
Ermitteln eines Pfads, welcher die erste Koordinate und die zweite Koordinate miteinander verbindet,
Festlegen einer bestimmten Sperrdämpfung und einer bestimmten Abschaltfrequenz für ein bestimmtes Pixel gemäß einer Amplitude eines Cluttersignals, das in dem Doppler-Signal enthalten ist, und dem Pfad, welcher die erste Koordinate und die zweite Koordinate miteinander verbindet.

8. Verfahren nach Anspruch 7, wobei der Schritt c) Folgendes aufweist:

- c1) Analysieren der Eigenschaften des Doppler-Signals für jedes der Pixel, um die Koeffizienten des Clutterfilters einzustellen; und
- c2) Durchführen des Clutterfilterns an dem Doppler-Signal für jedes der Pixel durch Verwenden der eingestellten Koeffizienten, um das Cluttersignal aus dem Doppler-Signal zu entfernen; und
- c3) Festlegen eines vorbestimmten Leistungsgrenzwerts, um ein Geräuschsignal aus dem Doppler-Signal zu entfernen, wobei das Cluttersignal herausgefiltert ist.

9. Verfahren nach Anspruch 8, wobei der Schritt c1) Folgendes aufweist:

Ermitteln der minimalen und der maximalen Abschaltfrequenzen basierend auf einem Bereich zum Entfernen des Cluttersignals; und
Ermitteln der minimalen und der maximalen Sperrdämpfungen basierend auf einer Leistung des Doppler-Signals.

10. Verfahren nach Anspruch 9, wobei der Schritt c1) Folgendes aufweist:

Festlegen einer maximalen Leistung des Doppler-Signals als die maximale Sperrdämpfung; und
Festlegen einer minimalen Leistung des Doppler-Signals als die minimale Sperrdämpfung.

11. Verfahren nach Anspruch 10, wobei der Schritt c1) Folgendes aufweist:

Festlegen des Pfads derart, dass es ein proportionaler Pfad zwischen den ersten und zweiten Koordinaten ist, wobei die Sperrdämpfung eine unabhängige Variable und die Abschaltfrequenz eine abhängige Variable ist.

12. Verfahren nach Anspruch 7, wobei der Schritt c) Folgendes aufweist:

Ermitteln der jeweiligen Sperrdämpfung für den jeweiligen Pixel basierend auf der Amplitude des Cluttersignals;
und
Ermitteln der jeweiligen Abschaltfrequenz entsprechend der ermittelten Sperrdämpfung auf dem Pfad, um die
Abschaltfrequenz des Clutterfilters einzustellen.

13. Computerlesbares Speichermedium, welches Befehle speichert, die, wenn sie durch einen Computer ausgeführt werden, bewirken, dass der Computer ein Verfahren nach Anspruch 7 ausführt.

Revendications

1. Système à ultrasons (100), comprenant :

une unité d'acquisition de données ultrasonores (120) configurée pour émettre des signaux ultrasonores vers un objet cible et recevoir des échos ultrasonores réfléchis par un objet cible afin d'acquérir des données ultrasonores ; et
une unité de traitement (130) configurée pour former un signal Doppler correspondant à chacun d'une pluralité de pixels construisant une image en mode Doppler sur la base des données ultrasonores,
dans lequel

l'unité de traitement (130) est en outre configurée pour ajuster les coefficients d'un filtre de fouillis pour chacun des pixels sur la base de caractéristiques du signal Doppler pour chacun des pixels afin d'effectuer un filtrage de fouillis sur le signal Doppler, les coefficients comprenant une fréquence de coupure et une atténuation de bande d'arrêt,

caractérisé en ce que

l'unité de traitement est en outre configurée pour :

déterminer des fréquences de coupure minimum et maximum et des atténuations de bande d'arrêt minimum et maximum sur la base des caractéristiques du signal Doppler,

déterminer une première coordonnée ayant la fréquence de coupure minimum et l'atténuation de bande d'arrêt minimum et une deuxième coordonnée ayant la fréquence de coupure maximum et l'atténuation de bande d'arrêt maximum sur un système de coordonnées associant la fréquence de coupure à l'atténuation de bande d'arrêt, et

déterminer un trajet reliant la première coordonnée à la deuxième coordonnée,

dans lequel l'unité de traitement est en outre configurée pour définir une atténuation de bande d'arrêt particulière et une fréquence de coupure particulière pour un pixel particulier en fonction de l'amplitude d'un signal de fouillis contenu dans le signal Doppler et du trajet reliant la première coordonnée à la deuxième coordonnée.

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

une section d'ajustement de coefficient (132) configurée pour analyser les caractéristiques du signal Doppler pour chacun des pixels afin d'ajuster les coefficients du filtre de fouillis ;

une section de filtrage (133) configurée pour effectuer le filtrage de fouillis sur le signal Doppler pour chacun des pixels en utilisant les coefficients ajustés afin d'éliminer le signal de fouillis du signal Doppler ; et

une section d'élimination du bruit (134) configurée pour définir un seuil de puissance prédéterminé permettant d'éliminer un signal de bruit du signal Doppler dont le signal de fouillis a été éliminé par filtrage.

3. Système à ultrasons (100) selon la revendication 2, dans lequel la section d'ajustement de coefficient (132) est configurée pour déterminer les fréquences de coupure minimum et maximum sur la base d'une gamme d'élimination du signal de fouillis, et dans lequel la section d'ajustement de coefficient est configurée pour déterminer les atténuations de bande d'arrêt minimum et maximum sur la base d'une puissance du signal Doppler.

4. Système à ultrasons (100) selon la revendication 3, dans lequel la section d'ajustement de coefficient (132) est configurée pour définir une puissance minimum et maximum du signal Doppler en tant qu'atténuation de bande d'arrêt maximum et une puissance minimum du signal Doppler en tant qu'atténuation de bande d'arrêt minimum.

5. Système à ultrasons (100) selon la revendication 4, dans lequel la section d'ajustement de coefficient (132) est configurée pour déterminer le trajet comme étant un trajet proportionnel entre les première et deuxième coordonnées

dans lequel l'atténuation de bande d'arrêt est une variable indépendante et la fréquence de coupure est une variable dépendante.

6. Système à ultrasons (100) selon la revendication 1, dans lequel l'unité de traitement (130) est configurée pour déterminer l'atténuation de bande d'arrêt particulière pour le pixel particulier sur la base de l'amplitude du signal de fouillis et pour déterminer la fréquence de coupure particulière correspondant à l'atténuation de bande d'arrêt déterminée sur le trajet afin d'ajuster la fréquence de coupure du filtre de fouillis.

7. Procédé destiné à effectuer de manière adaptative un filtrage de fouillis, consistant à :

- a) acquérir des données ultrasonores représentatives d'un objet cible ; et
- b) former un signal Doppler correspondant à chacun d'une pluralité de pixels construisant une image en mode Doppler sur la base des données ultrasonores ;
- c) ajuster des coefficients d'un filtre de fouillis pour chacun des pixels sur la base de caractéristiques du signal Doppler pour chacun des pixels afin d'effectuer un filtrage de fouillis sur le signal Doppler, le coefficient comprenant une fréquence de coupure et une atténuation de bande d'arrêt,

caractérisé en ce que

l'étape c) consiste à :

déterminer des fréquences de coupure minimum et maximum et des atténuations de bande d'arrêt minimum et maximum sur la base des caractéristiques du signal Doppler,
 déterminer une première coordonnée ayant la fréquence de coupure minimum et l'atténuation de bande d'arrêt minimum et une deuxième coordonnée ayant la fréquence de coupure maximum et l'atténuation de bande d'arrêt maximum sur un système de coordonnées associant la fréquence de coupure à l'atténuation de bande d'arrêt, et
 déterminer un trajet reliant la première coordonnée à la deuxième coordonnée,
 définir une atténuation de bande d'arrêt particulière et une fréquence de coupure particulière pour un pixel particulier en fonction de l'amplitude d'un signal de fouillis contenu dans le signal Doppler et du trajet reliant la première coordonnée à la deuxième coordonnée.

8. Procédé selon la revendication 7, dans lequel l'étape c) consiste à :

- c1) analyser les caractéristiques du signal Doppler pour chacun des pixels afin d'ajuster les coefficients du filtre de fouillis ;
- c2) effectuer le filtrage de fouillis sur le signal Doppler pour chacun des pixels en utilisant les coefficients ajustés afin d'éliminer le signal de fouillis du signal Doppler ; et
- c3) définir un seuil de puissance prédéterminé pour éliminer un signal de bruit du signal Doppler dont le signal de fouillis a été éliminé par filtrage.

9. Procédé selon la revendication 8, dans lequel l'étape c1) consiste à :

déterminer les coefficients de coupure minimum et maximum sur la base d'une gamme d'élimination du signal de fouillis ; et
 déterminer les atténuations de bande d'arrêt minimum et maximum sur la base d'une puissance du signal Doppler.

10. Procédé selon la revendication 9, dans lequel l'étape c1) consiste à :

définir une puissance maximum du signal Doppler en tant qu'atténuation de bande d'arrêt maximum ; et
 déterminer une puissance minimum du signal Doppler en tant qu'atténuation de bande d'arrêt minimum.

11. Procédé selon la revendication 10, dans lequel l'étape c1) consiste en outre à :

déterminer le trajet comme étant un trajet proportionnel entre les première et deuxième coordonnées, dans lequel l'atténuation de bande d'arrêt est une variable indépendante et la fréquence de coupure est une variable dépendante.

12. Procédé selon la revendication 7, dans lequel l'étape c) consiste à :

déterminer l'atténuation de bande d'arrêt particulière pour le pixel particulier sur la base de l'amplitude du signal de fouillis ; et

5 déterminer la fréquence de coupure particulière correspondant à l'atténuation de bande d'arrêt particulière déterminée sur le trajet afin d'ajuster la fréquence de coupure du filtre de fouillis.

13. Support de stockage lisible par ordinateur stockant des instructions qui, lorsqu'elles sont exécutées par ordinateur, amènent l'ordinateur à mettre en oeuvre un procédé selon la revendication 7.

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FIG. 1

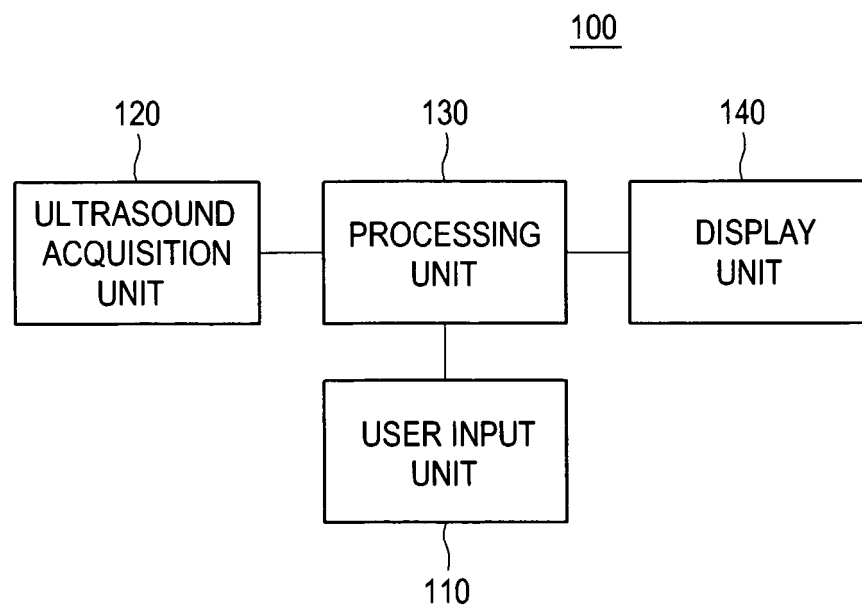


FIG. 2

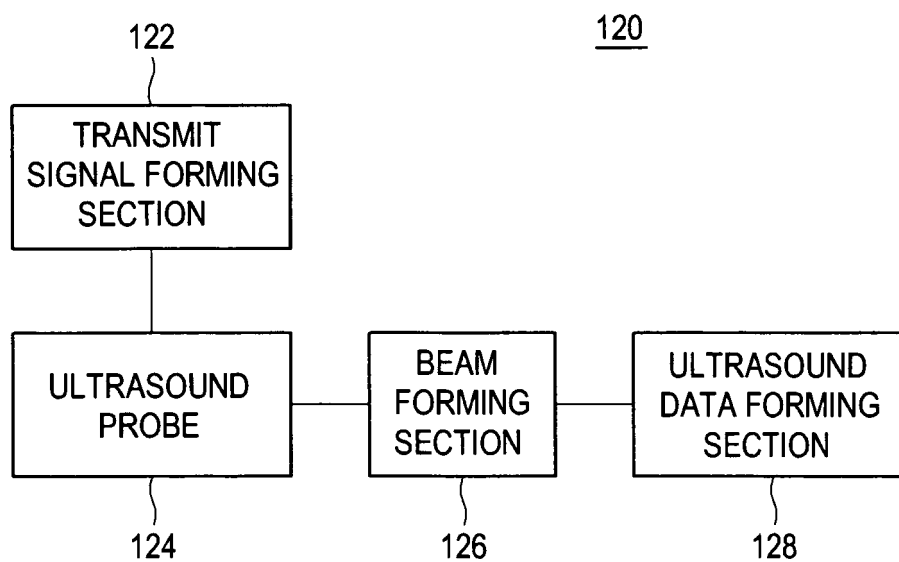


FIG. 3

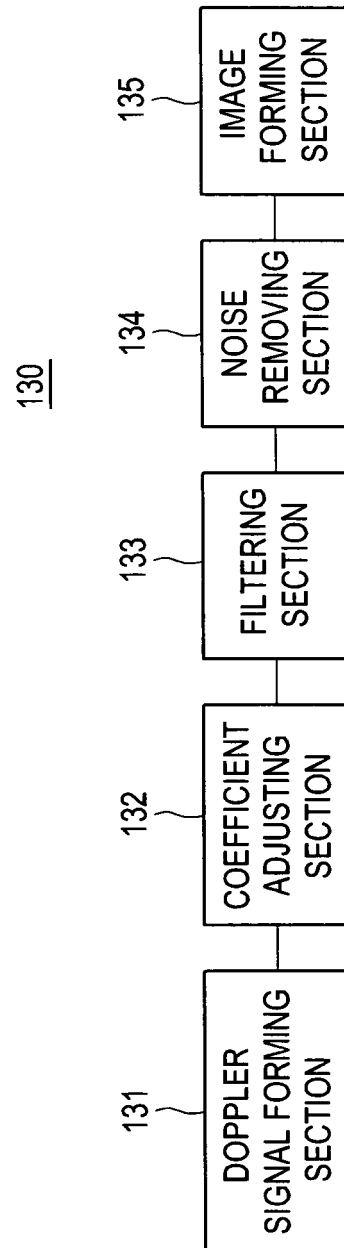


FIG. 4

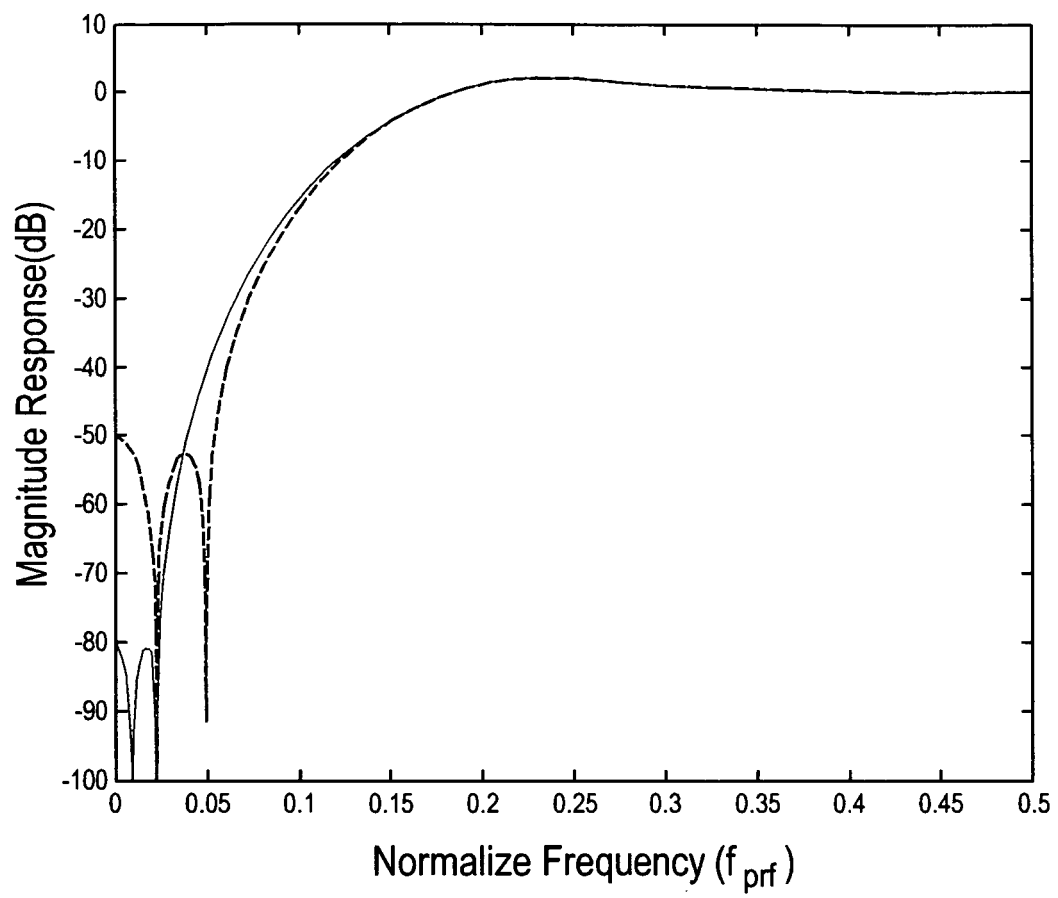
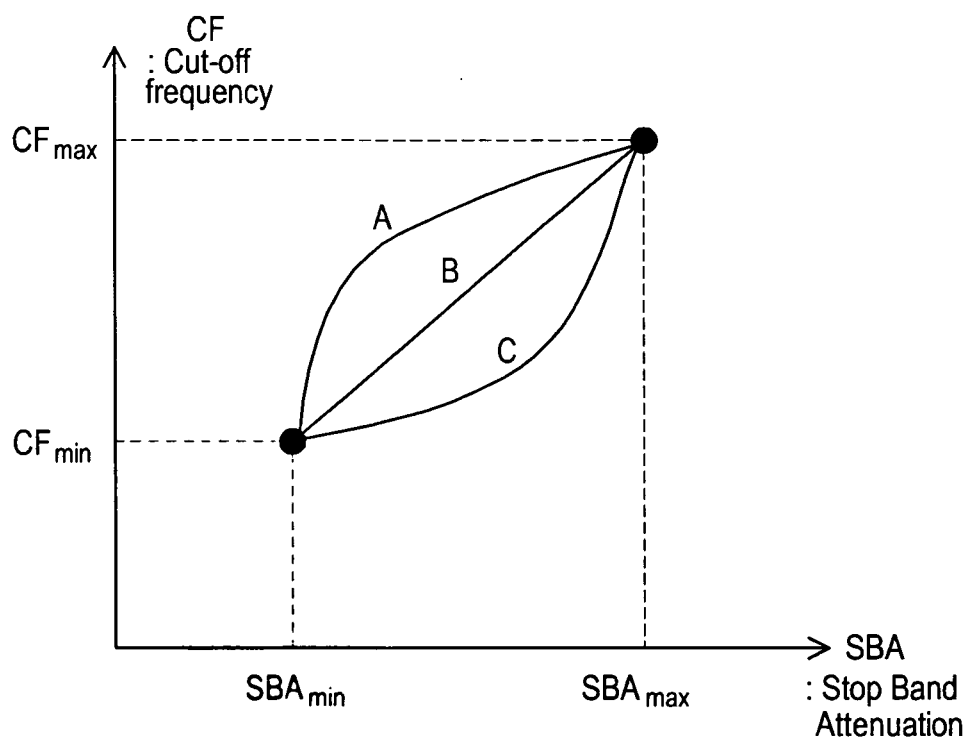


FIG. 5



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 9958061 A1 [0009]
- EP 2103954 A1 [0009]
- KR 20000073096 A [0009]
- EP 0316200 A2 [0009]

Non-patent literature cited in the description

- **Y M.** Adaptive clutter filtering for ultrasound color flow imaging [0009]

专利名称(译)	超声系统中的自适应杂波滤波		
公开(公告)号	EP2397867B1	公开(公告)日	2016-02-10
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[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.		
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外部链接	Espacenet		

摘要(译)

公开了用于在超声系统中自适应地执行杂波滤波的实施例。在一个实施例中，超声系统包括：超声数据获取单元，被配置为将超声信号发送到目标对象并接收从目标对象反射的超声回波，从而获取超声数据；处理单元，被配置为基于超声数据形成与构成多普勒模式图像的多个像素中的每一个相对应的多普勒信号，以及基于多普勒信号的每个特性调整杂波滤波器的系数。用于对多普勒信号执行杂波滤波的像素。

$$X_{ij} = C + F + N$$

