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(54) **ULTRASOUND DIAGNOSTIC APPARATUS AND CONTROL METHOD THEREOF**

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(57) **ABSTRACT**

An ultrasound diagnostic apparatus to improve picture quality of images by automatically adjusting image parameters, and a control method thereof are provided. The ultrasound diagnostic apparatus includes an image signal processor to perform envelope detection processing on ultrasound image data, and an image parameter processor to calculate a Time Gain Compensation (TGC) parameter from the envelope detection processed ultrasound image data, adjust the envelope detection processed ultrasound image data based on the TGC parameter, and calculate a Dynamic Range (DR) parameter from the envelope detection processed ultrasound image data adjusted based on the TGC parameter to apply the DR parameter to the envelope detection processed ultrasound image data.

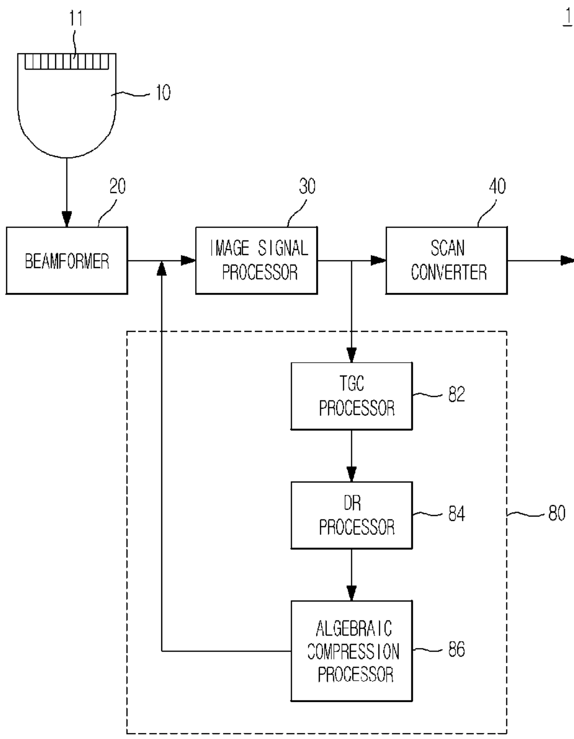


FIG. 1

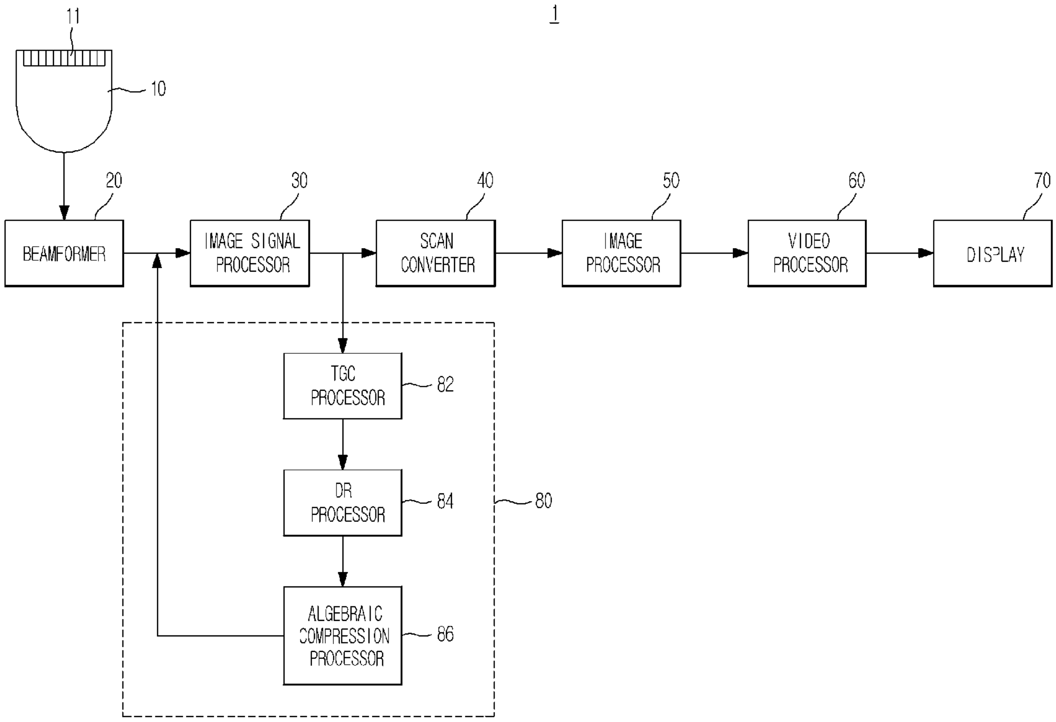

1
11
10
20
BEAMFORMER
30
IMAGE SIGNAL PROCESSOR
40
SCAN CONVERTER
50
IMAGE PROCESSOR
60
VIDEO PROCESSOR
70
DISPLAY
TGC PROCESSOR
82
DR PROCESSOR
84
80
ALGEBRAIC COMPRESSION PROCESSOR
86

FIG. 2

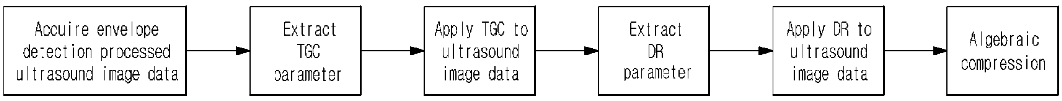

Accuire envelope detection processed ultrasound image data
Extract TGC parameter
Apply TGC to ultrasound image data
Extract DR parameter
Apply DR to ultrasound image data
Algebraic compression

FIG. 3

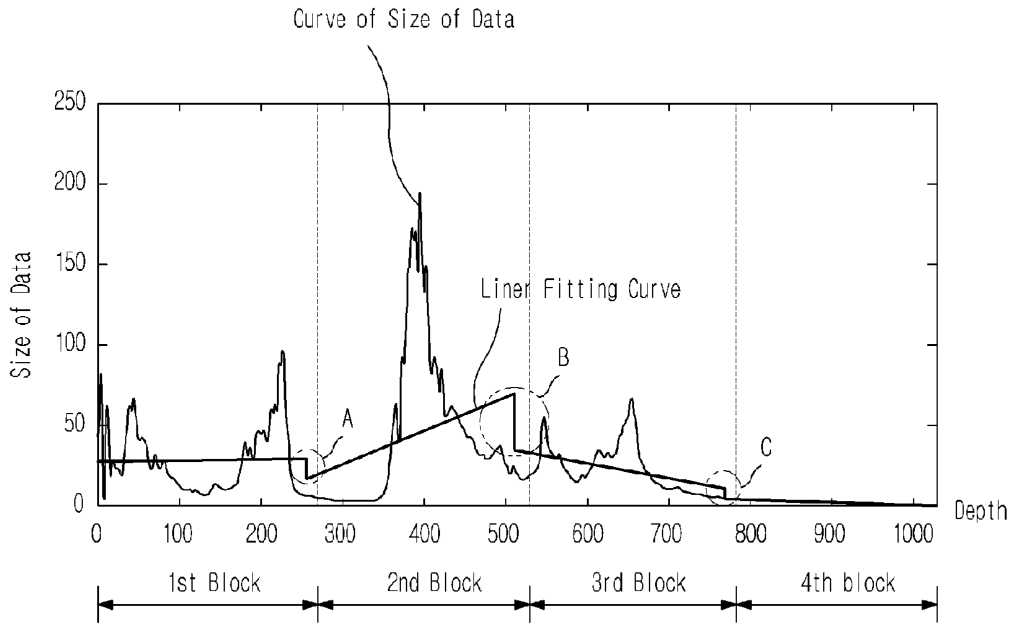

Curve of Size of Data
250
200
150
100
50
0
Size of Data
Liner Fitting Curve
A
B
C
Depth
0
100
200
300
400
500
600
700
800
900
1000
1st Block
2nd Block
3rd Block
4th block

FIG. 4

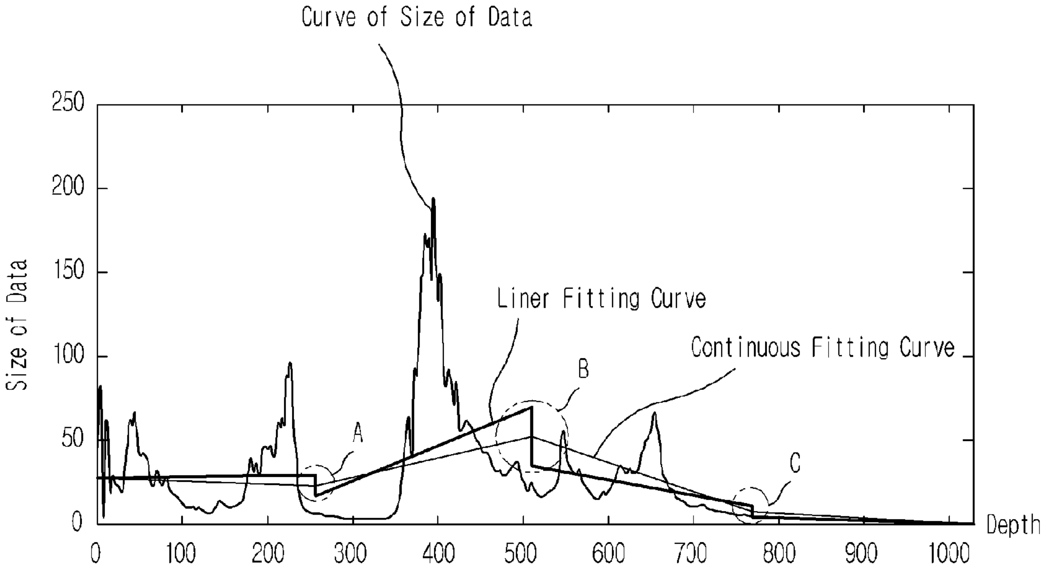
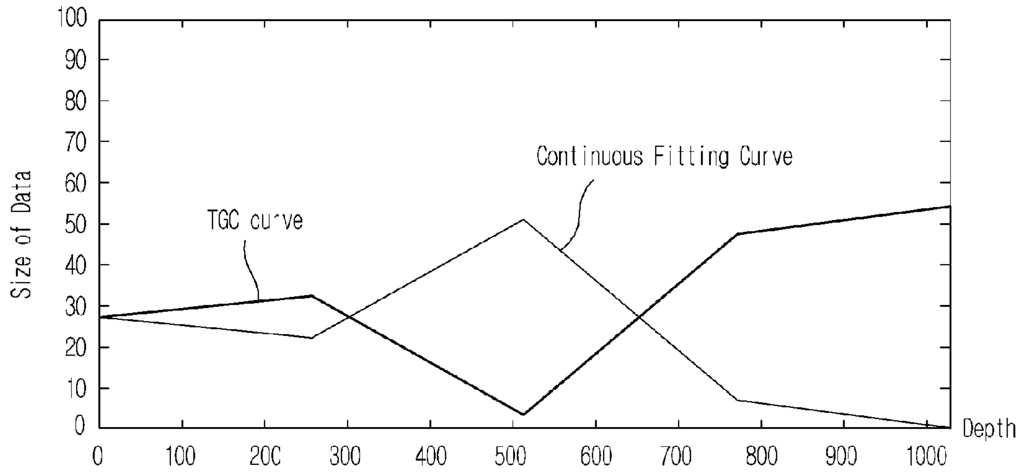

Curve of Size of Data
Liner Fitting Curve
Continuous Fitting Curve
A
B
C
Size of Data
Depth
250
200
150
100
50
0
0
100
200
300
400
500
600
700
800
900
1000

FIG. 5



Size of Data
100
90
80
70
60
50
40
30
20
10
0
Continuous Fitting Curve
TGC curve
0
100
200
300
400
500
600
700
800
900
1000
Depth

FIG. 6

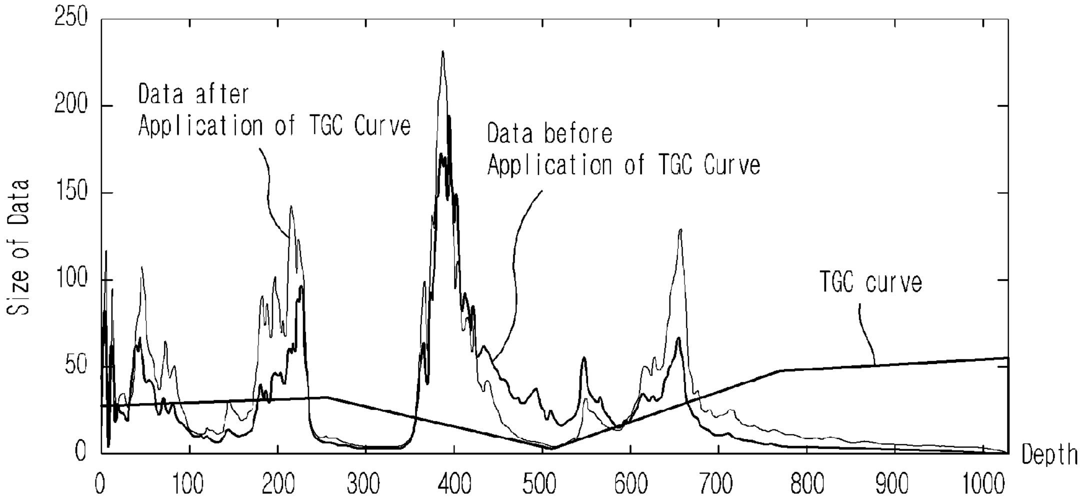

250
200
150
100
50
0
Size of Data
Data after
Application of TGC Curve
Data before
Application of TGC Curve
TGC curve
Depth
0
100
200
300
400
500
600
700
800
900
1000

FIG. 7

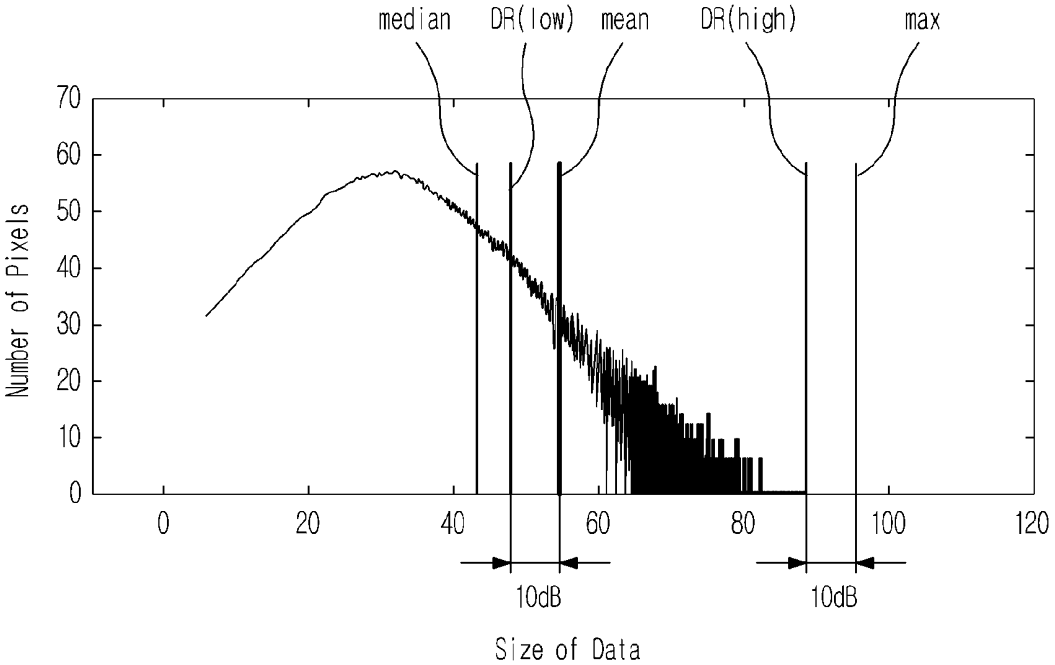

median
DR(low)
mean
DR(high)
max
70
60
50
40
30
20
10
0
Number of Pixels
0
20
40
60
80
100
120
10dB
10dB
Size of Data

FIG. 8

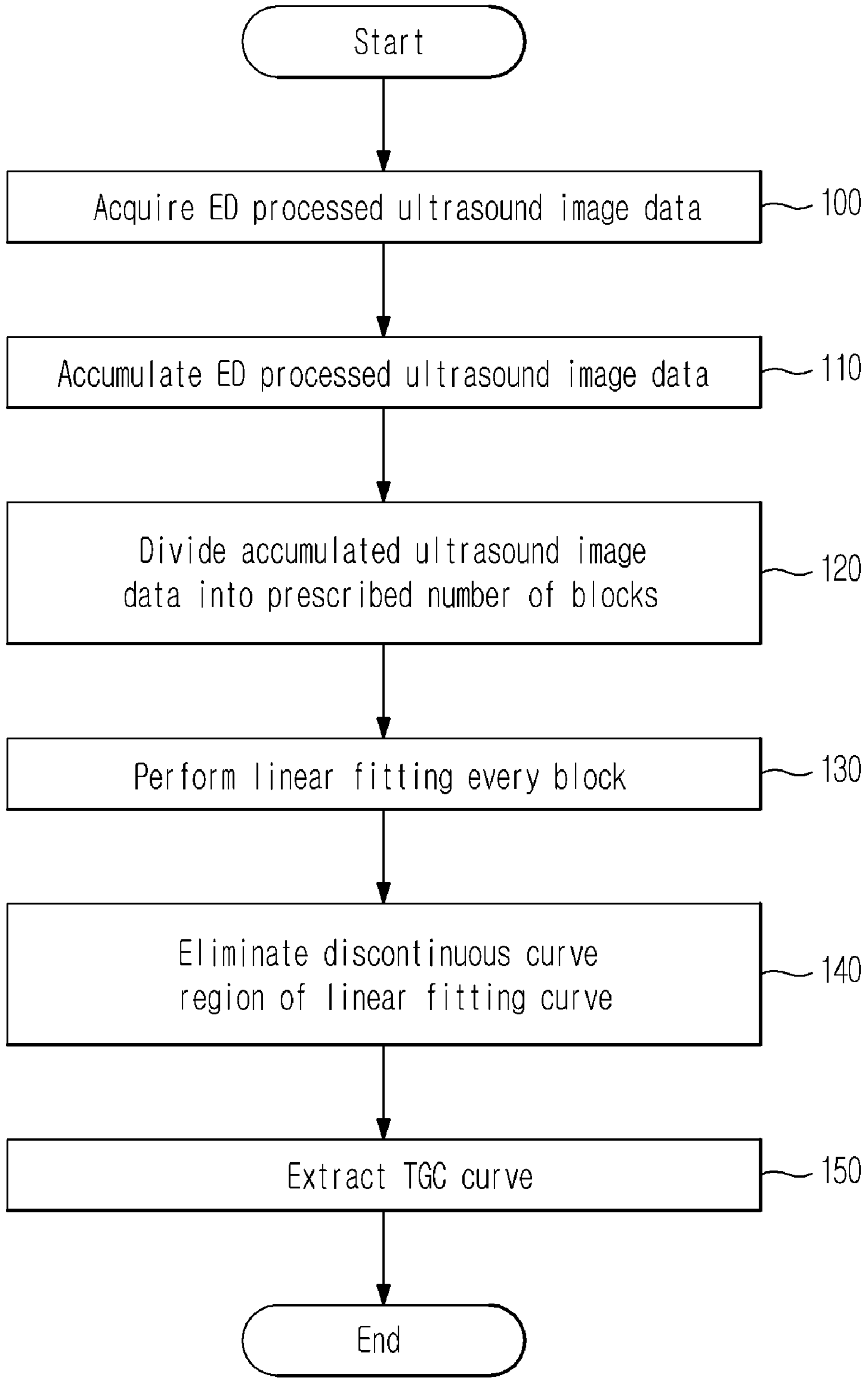
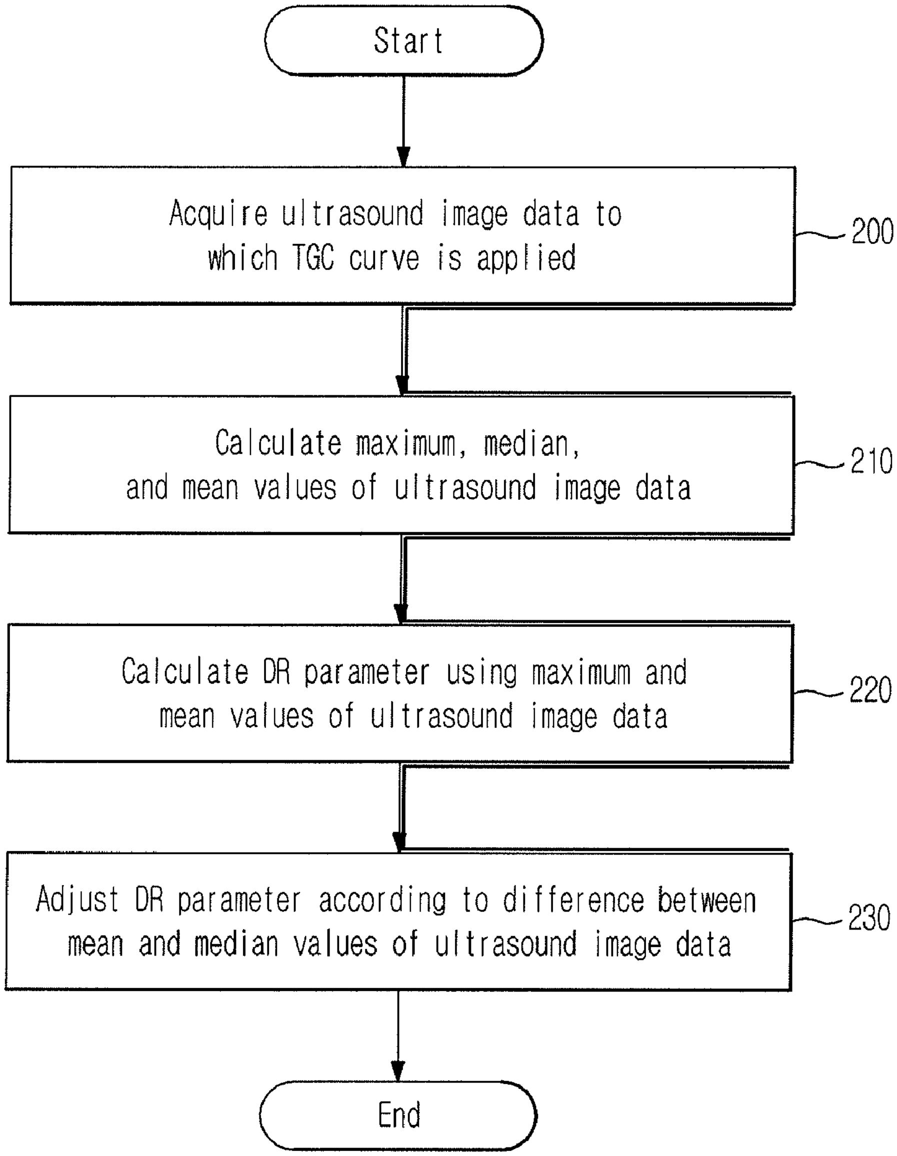

Start
Acquire ED processed ultrasound image data
100
Accumulate ED processed ultrasound image data
110
Divide accumulated ultrasound image data into prescribed number of blocks
120
Perform linear fitting every block
130
Eliminate discontinuous curve region of linear fitting curve
140
Extract TGC curve
150
End

FIG. 9


Start
Acquire ultrasound image data to which TGC curve is applied
200
Calculate maximum, median, and mean values of ultrasound image data
210
Calculate DR parameter using maximum and mean values of ultrasound image data
220
Adjust DR parameter according to difference between mean and median values of ultrasound image data
230
End

ULTRASOUND DIAGNOSTIC APPARATUS AND CONTROL METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from Korean Patent Application No. 10-2010-0117786, filed on Nov. 25, 2010 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] 1. Field

[0003] Apparatuses and methods consistent with exemplary embodiments relate to an ultrasound diagnostic apparatus, and a control method thereof.

[0004] 2. Description of the Related Art

[0005] An ultrasound diagnostic apparatus is one of important diagnostic systems which have a wide variety of applications. Especially, ultrasound systems are used extensively in the field of medicine due to the noninvasive and nondestructive nature with respect to an object. Recent high-performance ultrasound systems are used to generate two- or three-dimensional images of the interior of an object.

[0006] To observe an object, it is necessary to acquire an optimal ultrasound image which shows the object clearly. To this end, an ultrasound system adjusts image parameters such as gain, Dynamic Range (DR), and Time Gain Compensation (TGC) according to a setting value input by a user to adjust the brightness, resolution, contrast, etc. of an ultrasound image.

[0007] In a conventional ultrasound diagnostic apparatus, a user must directly fine-tune image parameters minutely in order to acquire an optimal ultrasound image, thereby causing fatigue and increasing time to acquire an ultrasound image due to a complicated control procedure.

SUMMARY

[0008] Exemplary embodiments provide an ultrasound diagnostic apparatus to improve picture quality of images by automatically adjusting image parameters, and a control method thereof.

[0009] In accordance with an aspect of an exemplary embodiment, there is provided an ultrasound diagnostic apparatus including an image signal processor to perform envelope detection processing upon ultrasound image data, and an image parameter processor to calculate a Time Gain Compensation (TGC) parameter from the envelope detection processed ultrasound image data, adjust the envelope detection processed ultrasound image data based on the TGC parameter, and calculate a Dynamic Range (DR) parameter from the envelope detection processed ultrasound image data adjusted based on the TGC parameter to apply the DR parameter to the envelope detection processed ultrasound image data.

[0010] The image parameter processor may include a TGC processor to calculate the TGC parameter, and the TGC processor may calculate a TGC curve for the envelope detection processed ultrasound image data and apply the TGC curve to the envelope detection processed ultrasound image data.

[0011] The TGC processor may calculate the TGC curve for the envelope detection processed ultrasound image data by accumulating the envelope detection processed ultrasound image data, dividing the accumulated envelope detection processed ultrasound image data into a prescribed number of blocks, performing linear fitting with respect to each block, and calculating a curve corresponding to an implicit function of a linear fitting curve derived by performing the linear fitting.

[0012] The TGC processor may adjust the linear fitting curve using a mean value of a discontinuous curve region so as to eliminate the discontinuous curve region when the discontinuous curve region is present on the linear fitting curve.

[0013] The TGC processor may determine the TGC curve by calculating a curve corresponding to an implicit function of the adjusted linear fitting curve.

[0014] The TGC processor may determine that the envelope detection processed ultrasound image data is noise if the envelope detection processed ultrasound image data to which the TGC curve is applied is less than a first reference after applying the TGC curve to the envelope detection processed ultrasound image data.

[0015] The TGC processor may lower a size of the envelope detection processed ultrasound image data by dividing the envelope detection processed ultrasound image data judged to be noise by a second reference value when the envelope detection processed ultrasound image data is judged to be noise.

[0016] The second reference value may be a TGC curve value multiplied by the envelope detection processed ultrasound image data judged to be noise or an arbitrary value predetermined during design.

[0017] The image parameter processor may include a DR processor to calculate a DR parameter, and the DR processor may calculate the DR parameter using a maximum value, a mean value, and a median value of the envelope detection processed ultrasound image data adjusted based on the TGC parameter.

[0018] The DR processor may determine a value obtained by subtracting a prescribed value from the maximum value of the envelope detection processed ultrasound image data as a high value and determine a value obtained by subtracting a prescribed value from the mean value of the envelope detection processed ultrasound image data as a low value.

[0019] The DR processor may adjust the DR parameter according to a difference between a mean value and a median value of the envelope detection processed ultrasound image data.

[0020] The DR processor may adjust the DR parameter by increasing the high value as the difference between the mean value and the median value is increased.

[0021] In accordance with an aspect of another exemplary embodiment, there is provided a control method of an ultrasound diagnostic apparatus including performing envelope detection processing upon ultrasound image data, extracting a TGC parameter from the envelope detection processed ultrasound image data, adjusting the envelope detection processed ultrasound image data based on the TGC parameter, and calculating a DR parameter from the envelope detection processed ultrasound image data adjusted based on the TGC parameter to apply the DR parameter to the envelope detection processed ultrasound image data.

[0022] The extraction of a TGC parameter may include accumulating the envelope detection processed ultrasound image data, dividing the accumulated envelope detection processed ultrasound image data into a prescribed number of blocks, performing linear fitting with respect to each block, and calculating a TGC curve corresponding to an implicit function of a linear fitting curve derived by performing the linear fitting.

[0023] The adjustment of the envelope detection processed ultrasound image data based on the TGC parameter may include applying the TGC curve to the envelope detection processed ultrasound image data.

[0024] The control method may further include determining that the envelope detection processed ultrasound image data is noise if the envelope detection processed ultrasound image data to which the TGC curve is applied is less than a first reference value after applying the TGC curve to the envelope detection processed ultrasound image data.

[0025] The control method may further include lowering a size of the envelope detection processed ultrasound image data by dividing the envelope detection processed ultrasound image data judged to be noise by a second reference value when the envelope detection processed ultrasound image data is judged to be noise.

[0026] The control method may further include adjusting the linear fitting curve using a mean value of a discontinuous curve region so as to eliminate the discontinuous curve region when the discontinuous curve region is present on the linear fitting curve.

[0027] The calculation of a DR parameter from the envelope detection processed ultrasound image data may include calculating the DR parameter using a maximum value, a mean value, and a median value of the envelope detection processed ultrasound image data adjusted based on the TGC parameter.

[0028] The calculation of a DR parameter may include determining a value obtained by subtracting a prescribed value from the maximum value of the envelope detection processed ultrasound image data as a high value and determining a value obtained by subtracting a prescribed value from the mean value of the envelope detection processed ultrasound image data as a low value.

[0029] The control method may further include adjusting the calculated DR parameter according to a difference between a mean value and a median value of the envelope detection processed ultrasound image data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] These and/or other aspects will become apparent and more readily appreciated from the following description of the exemplary embodiments, taken in conjunction with the accompanying drawings of which:

[0031] FIG. **1** is a block diagram of an ultrasound diagnostic apparatus according to an exemplary embodiment;

[0032] FIG. **2** is a block diagram of an image parameter processor of an ultrasound diagnostic apparatus according to an exemplary embodiment;

[0033] FIG. **3** is a graph to describe a TGC parameter extraction method in an ultrasound diagnostic apparatus according to an exemplary embodiment;

[0034] FIG. **4** is a graph to describe a method of eliminating a discontinuous region of a linear fitting curve of the graph of FIG. **3**;

[0035] FIG. **5** is a graph illustrating a TGC curve corresponding to an implicit function of a continuous fitting curve shown in the graph of FIG. **4**;

[0036] FIG. **6** is a graph illustrating the application of a TGC curve to ultrasound image data;

[0037] FIG. **7** is a graph to describe a DR parameter extraction method in an ultrasound diagnostic apparatus according to an exemplary embodiment;

[0038] FIG. **8** is a control flow chart of a TGC curve extracting operation of an image parameter processor of an ultrasound diagnostic apparatus according to an exemplary embodiment; and

[0039] FIG. **9** is a control flow chart of a DR parameter calculating operation of an image parameter processor of an ultrasound diagnostic apparatus according to an exemplary embodiment.

DETAILED DESCRIPTION

[0040] Reference will now be made in detail to the exemplary embodiments, examples of which are illustrated in the accompanying drawings.

[0041] FIG. **1** is a block diagram of an ultrasound diagnostic apparatus according to an exemplary embodiment.

[0042] An ultrasound diagnostic apparatus **1** may include a probe **10**, a beamformer **20**, an image signal processor **30**, a scan converter **40**, an image processor **50**, a video processor **60**, a display **70**, and an image parameter processor **80**. The image signal processor **30**, the image processor **50**, the video processor **60**, and the image parameter processor **80** may be integrated into at least one processor.

[0043] The probe **10** may include a plurality of one or two-dimensional transducers **11**. The probe **10** appropriately delays input times of pulses input to the respective transducers **11** to transmit a focused ultrasound beam to an object (not shown) along a transmission scan line. Ultrasound echo signals reflected from the object are input to the respective transducers **11** with different reception times and the respective transducers **11** generate the input ultrasound echo signals.

[0044] The beamformer **20** focuses the ultrasound echo signals transmitted by the respective transducers **11** of the probe on the object, and adds time delays to the ultrasound echo signals which are reflected from the object and input to the respective transducers **11** to focus the ultrasound echo signals.

[0045] The image signal processor **30**, for example a digital signal processor (DSP), performs envelope detection processing to detect the size of the ultrasound echo signals based on the ultrasound echo signals focused by the beamformer **20**, thereby forming ultrasound image data. That is, the image signal processor **30** forms the ultrasound image data based on location information of a plurality of points on each scan line and data obtained from the respective points. The ultrasound image data includes coordinates on an X-Y coordinate system of each point, angle information of each scan line with respect to a vertical scan line, and data obtained from each point. Performing the envelope detection processing upon a signal is disclosed in detail in U.S. Pat. No. 6,689,060, the disclosure of which is incorporated by reference.

[0046] The scan converter **40** scan-converts the ultrasound image data so that the ultrasound image data generated from the image signal processor **30** may be displayed on a display region of the display **70**.

[0047] The image processor **50** performs various types of image processing, for example B-mode and M-mode Doppler image processing, upon the scan-converted ultrasound image data generated by the scan converter **40** in order to display an ultrasound image in a form desired by a user on the display **70**.

[0048] The video processor **60** processes the scan-converted ultrasound image data so as to be displayed on the display **70** as an ultrasound image and transmits the processed ultrasound image data to the display **70**.

[0049] The display **70** displays the ultrasound image data generated from the video processor **60** as an ultrasound image.

[0050] The image parameter processor **80** includes a TGC processor **82**, a DR processor **84**, and an algebraic compression processor **86**.

[0051] The TGC processor **82** calculates a TGC parameter from the envelope-detection (ED) processed ultrasound image data generated from the image signal processor **30**. The function and operation of the TGC processor **82** will be described in detail later with reference to FIG. **3**.

[0052] The DR processor **84** calculates a DR parameter from the ED processed ultrasound image data to which a TGC curve generated from the TGC processor **82** is applied. The DR parameter refers to an image parameter to adjust the contrast of an ultrasound image. The function and operation of the DR processor **84** will be described in detail later with reference to FIG. **7**.

[0053] The algebraic compression processor **86** performs algebraic compression using a logarithmic function on the ED processed ultrasound image data. As a value of the DR parameter is increased, the slope of the logarithmic function is increased and thus the contrast of the ED processed ultrasound image data is increased. The algebraic compression processor **86** performs algebraic compression on the ED processed ultrasound image data to which the TGC parameter and the DR parameter are applied.

[0054] FIG. **2** is a block diagram of an image parameter processor of an ultrasound diagnostic apparatus according to an exemplary embodiment, FIG. **3** is a graph to describe a TGC parameter extraction method in an ultrasound diagnostic apparatus according to an exemplary embodiment, FIG. **4** is a graph to describe a method of eliminating a discontinuous region of a linear fitting curve of the graph of FIG. **3**, FIG. **5** is a graph illustrating a TGC curve corresponding to an implicit function of a continuous fitting curve shown in the graph of FIG. **4**, FIG. **6** is a graph illustrating the application of a TGC curve to ultrasound image data, and FIG. **7** is a graph to describe a DR parameter extraction method in an ultrasound diagnostic apparatus according to an exemplary embodiment.

[0055] The image parameter processor **80** calculates a TGC parameter and a DR parameter upon receiving ED processed ultrasound image data from the image signal processor **30**, and applies the calculated parameters to the whole frame of the ED processed ultrasound image data.

[0056] The TGC processor **82** extracts the TGC parameter from the ED processed ultrasound image data. Hereinafter, a method for the TGC processor **82** to extract the TGC parameter will be described in detail.

[0057] Referring to FIG. **3**, the TGC processor **82** accumulates the ED processed ultrasound image data in a horizontal direction. Here, the horizontal direction of the ED processed ultrasound image data is perpendicular to the depth direction of the ED processed ultrasound image data. In FIG. **3**, the axis of abscissa denotes the depth of the ED processed ultrasound image data and the axis of ordinate denotes the size (that is, amplitude) of the ED processed ultrasound image data located in a horizontal direction at the same depth. The size of ED processed ultrasound image data is proportional to brightness.

[0058] The TGC processor **82** divides the accumulated ED processed ultrasound image data into a prescribed number of blocks. In FIG. **3**, the accumulated ED processed ultrasound image data is divided into four blocks.

[0059] The TGC processor **82** performs linear fitting upon the amplitude of the ED processed ultrasound image data every block so as to recognize a trend in the amplitude of the ED processed ultrasound image data. Linear fitting of the amplitude of ED processed ultrasound image data corresponds to curve fitting of the ED process ultrasound image data. The TGC processor **82** may divide a non-linear curve of an input signal into a plurality of pieces to perform fitting by applying a piecewise linear function every piece and may generate a linear output according to the slope of a non-linear curve of each piece. Curve fitting of a signal is applying a piecewise linear function to the signal so as to recognize a trend in the signal. If the TGC processor **82** performs curve fitting on the ED processed ultrasound image data, a linear fitting curve is generated.

[0060] The TGC processor **82** eliminates discontinuous curve regions such as points A, B, and C shown in FIG. **3**. The TGC processor **82** uses a mean value of a discontinuous curve region in order to eliminate a discontinuous curve region of a linear fitting curve. The TGC processor **82** adjusts the linear fitting curve using a mean value of a discontinuous curve region (that is, a median value of the amplitude of data) as a connecting point.

[0061] Referring to FIG. **4**, it will be appreciated that a continuous fitting curve is obtained by connecting median values (or mean values) of the amplitudes of accumulated ED processed ultrasound image data at discontinuous points A, B, and C. Meanwhile, when a fitting curve is discontinuous, extracted ED processed ultrasound image data has a boundary.

[0062] Referring to FIG. **5**, the TGC processor **82** extracts a TGC curve. The TGC processor **82** extracts a TGC curve corresponding to an implicit function of a continuous fitting curve. When a linear fitting curve calculated in a previous procedure is continuous, the TGC processor **82** extracts a curve corresponding to an implicit function of the linear fitting curve as a TGC curve. When a linear fitting curve calculated in a previous procedure is discontinuous, the TGC processor **82** extracts, as a TGC curve, a curve corresponding to an implicit function of a continuous fitting curve which has corrected the linear fitting curve using the above-described method.

[0063] The TGC processor **82** applies a TGC curve to the ED processed ultrasound image data. If the TGC curve is applied to the ED processed ultrasound image data, uniformity of the ED processed ultrasound image data may be increased.

[0064] Referring to FIG. **6**, it may be appreciated that the amplitude of the ED processed ultrasound image data which is attenuated according to depth may be compensated by the application of the TGC curve to the ED processed ultrasound image data.

[0065] After the application of the TGC curve to the ED processed ultrasound image data, if the amplitude of the ED processed ultrasound image data is less than a preset first reference value, the TGC processor **82** determines that the ED processed ultrasound image data is noise. If the ED processed ultrasound image data to which the TGC curve is applied is judged to be noise, the TGC processor **82** lowers the amplitude of the ED processed ultrasound image data by dividing the ED processed ultrasound image data by a TGC value or by a preset second reference value. The preset second reference value is determined in consideration of the first reference value by a designer.

[0066] The DR processor **84** sets a DR parameter using the ED processed ultrasound image data to which the TGC curve is applied. Referring to FIG. **7**, the DR processor **84** sets a DR parameter using a maximum value, a mean value, and a median value of the ED processed ultrasound image data to which the TGC curve is applied.

[0067] The maximum value of the ED processed ultrasound image data to which the TGC curve is applied indicates a value of the ED processed ultrasound image data having the largest pixel value. A mean value of the ED processed ultrasound image data to which the TGC curve is applied indicates a value calculated in consideration of the size of the ED processed ultrasound image data and the number of ED processed ultrasound image data (or pixels) having that size. For example, if the number of the ED processed ultrasound image data having a size of 'a' is 2 and if the number of data having a size of 'b' is 3, then the mean value of data is (a*2+b*3)/(2+3). A median value of the ED processed ultrasound image data to which the TGC curve is applied indicates a value corresponding to the middle of the largest value and the smallest value of the ED processed ultrasound image data. For example, if the largest value of the ED processed ultrasound image data is 100 and if the smallest value of the ED processed ultrasound image data is 0, then a median value of the EC processed ultrasound image data is 50.

[0068] As indicated in the following Equation 1, the DR processor **84** may determine, as a high value of a DR parameter, a value obtained by subtracting a prescribed value, for example 10 dB, from the maximum value of the ED processed ultrasound image data to which the TGC curve is applied. The DR processor **84** may determine, as a low value of a DR parameter, a value obtained by subtracting a prescribed value, for example 10 dB, from the mean value of the ED processed ultrasound image data to which the TGC curve is applied.

$$DR\_high\_offset = max - 10\ dB{:}\ high\ value$$

$$DR\_low\_offset = mean - 10\ dB{:}\ low\ value \qquad [Equation\ 1]$$

[0069] The DR processor **84** may correct a DR parameter considering the difference between the mean value of the ED processed ultrasound image data to which the TGC curve is applied and the median value of the ED processed ultrasound image data to which the TGC curve is applied.

[0070] The DR processor **84** determines that the bigger the difference between the mean value of the ED processed ultrasound image data to which the TGC curve is applied and the median value of the ED processed ultrasound image data to which the TGC curve is applied is, the more information of the ED processed ultrasound image data having a larger size includes. Accordingly, the DR processor **84** varies a DR parameter by increasing a high value of a DR determined by Equation 1. A varied degree of the high value of the DR is preset according to the difference between a mean value and a median value of data. For instance, if the difference between a mean value and a median value of data is 20 dB, a high value may be increased by 5 dB and if the difference therebetween is 30 dB, a high value may be increased by 8 dB.

[0071] FIG. **8** is a control flow chart to describe a TGC curve extracting operation of an image parameter processor of an ultrasound diagnostic apparatus according to an exemplary embodiment.

[0072] The TGC processor **82** acquires ED processed ultrasound image data from the image signal processor **30** in step **100**. The ED processed ultrasound image data may also be called an envelope signal.

[0073] The TGC processor **82** accumulates the ED processed ultrasound image data in a horizontal direction in step **110**. Namely, the TGC processor **82** accumulates a mean size of the ED processed ultrasound image data by detecting pixels existing at the same depth at each region of the ED processed ultrasound image data.

[0074] Next, the TGC processor **82** divides the accumulated ED processed ultrasound image data into a prescribed number of blocks in step **120**.

[0075] The TGC processor **82** performs linear fitting upon the amplitude of data every block in step **130**. Linear fitting of the amplitude of the ED processed ultrasound image data is applying a piecewise linear function to a signal so as to recognize a trend in the signal. If the TGC processor **82** performs the linear fitting upon the ED processed ultrasound image data, a linear fitting curve is generated.

[0076] The TGC processor **82** eliminates a discontinuous curve region of the linear fitting curve in step **140**. To eliminate the discontinuous curve region of the linear fitting curve, the TGC processor **82** uses a mean value of the discontinuous curve region. The TGC processor **82** corrects the linear fitting curve using a mean value of the discontinuous curve region (that is, a median value of the size of data) as a connecting point.

[0077] The TGC processor **82** extracts a TGC curve corresponding to an implicit function of the linear fitting curve in step **150**.

[0078] FIG. **9** is a control flow chart to describe a DR parameter calculating operation of an image parameter processor of an ultrasound diagnostic apparatus according to an exemplary embodiment.

[0079] The DR processor **84** acquires the ED processed ultrasound image data to which a TGC curve is applied from the TGC processor **82** in step **200**.

[0080] The DR processor **84** calculates a maximum value, a mean value, and a median value of the ED processed ultrasound image data to which the TGC curve is applied in step **210**.

[0081] The DR processor **84** determines, as a high value of a DR parameter, a value obtained by subtracting a prescribed value from the maximum value of the ED processed ultrasound image data to which the TGC curve is applied and determines, as a low value of the DR parameter, a value obtained by subtracting a prescribed value from the mean value of the ED processed ultrasound image data to which the TGC curve is applied in step **220**.

[0082] The DR processor **84** adjusts the DR parameter by increasing a high value of a DR determined according to the difference between the mean value of the ED processed ultrasound image data to which the TGC curve is applied and the median value of the ED processed ultrasound image data to which the TGC curve is applied in step **230**.

[0083] According to an aspect of an exemplary embodiment, since image parameters may be automatically adjusted, a user may diagnose ultrasound images more accurately and conveniently.

[0084] Although a few exemplary embodiments have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the inventive concept, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. An ultrasound diagnostic apparatus comprising:

an image signal processor which performs envelope detection processing on ultrasound image data; and

an image parameter processor which calculates a Time Gain Compensation (TGC) parameter from the envelope detection processed ultrasound image data, adjusts the envelope detection processed ultrasound image data based on the TGC parameter, and calculates a Dynamic Range (DR) parameter from the adjusted envelope detection processed ultrasound image data to apply the DR parameter to the adjusted envelope detection processed ultrasound image data.

2. The ultrasound diagnostic apparatus according to claim **1**, wherein the image parameter processor comprises a TGC processor which calculates the TGC parameter by calculating a TGC curve for the envelope detection processed ultrasound image data, and applying the TGC curve to the envelope detection processed ultrasound image data.

3. The ultrasound diagnostic apparatus according to claim **2**, wherein the TGC processor calculates the TGC curve for the envelope detection processed ultrasound image data by accumulating the envelope detection processed ultrasound image data, dividing the accumulated envelope detection processed ultrasound image data into a prescribed number of blocks, performing linear fitting with respect to each block, and calculating a curve corresponding to an implicit function of a linear fitting curve derived by performing the linear fitting.

4. The ultrasound diagnostic apparatus according to claim **3**, wherein the TGC processor adjusts the linear fitting curve using a mean value of a discontinuous curve region so as to eliminate the discontinuous curve region when the discontinuous curve region is present on the linear fitting curve.

5. The ultrasound diagnostic apparatus according to claim **4**, wherein the TGC processor calculates the TGC curve by calculating a curve corresponding to an implicit function of the adjusted linear fitting curve.

6. The ultrasound diagnostic apparatus according to claim **2**, wherein the TGC processor determines that the envelope detection processed ultrasound image data is noise if the envelope detection processed ultrasound image data to which the TGC curve is applied is less than a first reference value after applying the TGC curve to the envelope detection processed ultrasound image data.

7. The ultrasound diagnostic apparatus according to claim **6**, wherein the TGC processor lowers a size of the envelope detection processed ultrasound image data by dividing the envelope detection processed ultrasound image data judged to be noise by a second reference value when the envelope detection processed ultrasound image data is judged to be noise.

8. The ultrasound diagnostic apparatus according to claim **7**, wherein the second reference value is a TGC curve value multiplied by the envelope detection processed ultrasound image data judged to be noise or an arbitrary value predetermined during design.

9. The ultrasound diagnostic apparatus according to claim **1**, wherein the image parameter processor comprises a DR processor which calculates a DR parameter by calculating the DR parameter using a maximum value, a mean value, and a median value of the adjusted envelope detection processed ultrasound image data.

10. The ultrasound diagnostic apparatus according to claim **9**, wherein the DR processor determines a value obtained by subtracting a prescribed value from the maximum value of the adjusted envelope detection processed ultrasound image data as a high value of the DR parameter, and determines a value obtained by subtracting a prescribed value from the mean value of the adjusted envelope detection processed ultrasound image data as a low value of the DR parameter.

11. The ultrasound diagnostic apparatus according to claim **10**, wherein the DR processor adjusts the DR parameter according to a difference between a mean value and a median value of the envelope detection processed ultrasound image data.

12. The ultrasound diagnostic apparatus according to claim **11**, wherein the DR processor adjusts the DR parameter by increasing the high value of the DR parameter as the difference between the mean value of the envelope detection processed ultrasound image and the median value of the envelope detection processed ultrasound image is increased.

13. A control method of an ultrasound diagnostic apparatus, comprising:

performing envelope detection processing on ultrasound image data;

extracting a Time Gain Compensation (TGC) parameter from the envelope detection processed ultrasound image data;

adjusting the envelope detection processed ultrasound image data based on the TGC parameter; and

calculating a Dynamic Range (DR) parameter from the adjusted envelope detection processed ultrasound image data to apply the DR parameter to the envelope detection processed ultrasound image data.

14. The control method according to claim **13**, wherein the extracting the TGC parameter comprises accumulating the envelope detection processed ultrasound image data, dividing the accumulated envelope detection processed ultrasound image data into a prescribed number of blocks, performing linear fitting with respect to each block, and calculating a TGC curve corresponding to an implicit function of a linear fitting curve derived by performing the linear fitting.

15. The control method according to claim **14**, wherein the adjusting the envelope detection processed ultrasound image data based on the TGC parameter comprises applying the TGC curve to the envelope detection processed ultrasound image data.

16. The control method according to claim **15**, further comprising determining that the envelope detection processed ultrasound image data is noise if the envelope detection processed ultrasound image data to which the TGC curve is applied is less than a first reference value after applying the TGC curve to the envelope detection processed ultrasound image data.

17. The control method according to claim **16**, further comprising lowering a size of the envelope detection processed ultrasound image data by dividing the envelope detection processed ultrasound image data judged to be noise by a second reference value when the envelope detection processed ultrasound image data is judged to be noise.

18. The control method according to claim **14**, further comprising adjusting the linear fitting curve using a mean value of a discontinuous curve region so as to eliminate the discontinuous curve region when the discontinuous curve region is present on the linear fitting curve.

19. The control method according to claim **13**, wherein the calculating the DR parameter from the adjusted envelope detection processed ultrasound image data comprises calculating the DR parameter using a maximum value, a mean value, and a median value of the adjusted envelope detection processed ultrasound image data.

20. The control method according to claim **19**, wherein the calculating the DR parameter comprises determining a value obtained by subtracting a prescribed value from the maximum value of the adjusted envelope detection processed ultrasound image data as a high value and determining a value obtained by subtracting a prescribed value from the mean value of the adjusted envelope detection processed ultrasound image data as a low value.

21. The control method according to claim **20**, further comprising adjusting the calculated DR parameter according to a difference between a mean value and a median value of the envelope detection processed ultrasound image data.

22. An ultrasound diagnostic apparatus comprising:

a probe including a plurality of transducers which generate ultrasound echo signals;

an image signal processor which performs envelope detection to detect a size of the ultrasound echo signals forming ultrasound image data;

an image parameter processor which calculates a Time Gain Compensation (TGC) parameter from the ultrasound image data formed by the image signal processor, calculates an image parameter to adjust contrast of the ultrasound image, and applies the calculated image parameter to the ultrasound image data.

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摘要(译)

提供了一种通过自动调整图像参数来提高图像的图像质量的超声波诊断装置及其控制方法。超声诊断设备包括：图像信号处理器，用于对超声图像数据执行包络检测处理;以及图像参数处理器，用于根据包络检测处理的超声图像数据计算时间增益补偿（TGC）参数，调整包络检测处理的超声图像基于TGC参数的数据，并且根据基于TGC参数调整的包络检测处理的超声图像数据计算动态范围（DR）参数，以将DR参数应用于包络检测处理的超声图像数据。