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(54) **ULTRASOUND DISPLAY OF TISSUE, TRACKING AND TAGGING**

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Publication Classification

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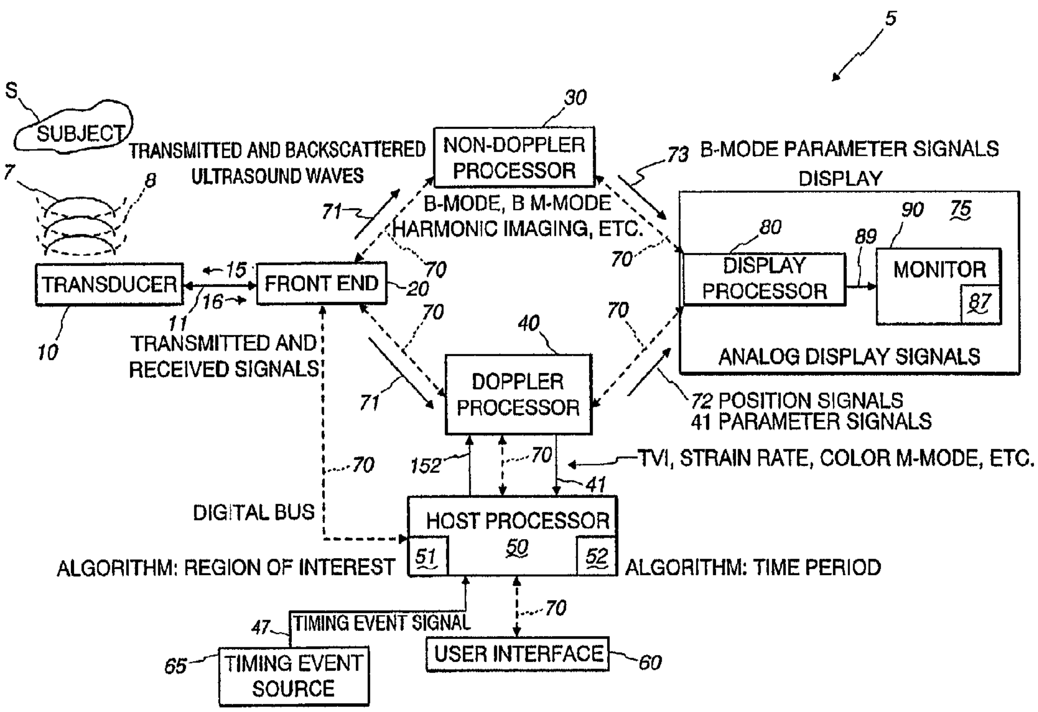
(57) **ABSTRACT**

An ultrasound machine that generates a pattern of indicia corresponding to tracked moving structure, such as a cardiac wall tissue that is displayed on a monitor. The pattern of indicia is generated by displaying a set of tagging symbols related to the tracked movement of the structure over a time period by an apparatus comprising a front-end that generates received signals in response to backscattered ultrasound waves. A Doppler processor generates a spatial set of signals values representing movement within the structure. A non-Doppler processor generates a set of parameter signals representing a spatial set of B-mode values within the structure. A host processor embodies a tracking function to generate a set of tracked movement parameter profiles and motion parameter profiles over a time period corresponding to anatomical locations associated with the set of tagging symbols. A display processor overlays the set of tagging symbols onto an image of the moving structure on a monitor, such as B-mode, showing a pattern of indicia that allows visualization of the expansion and contraction of the moving structure in real-time over the time period.



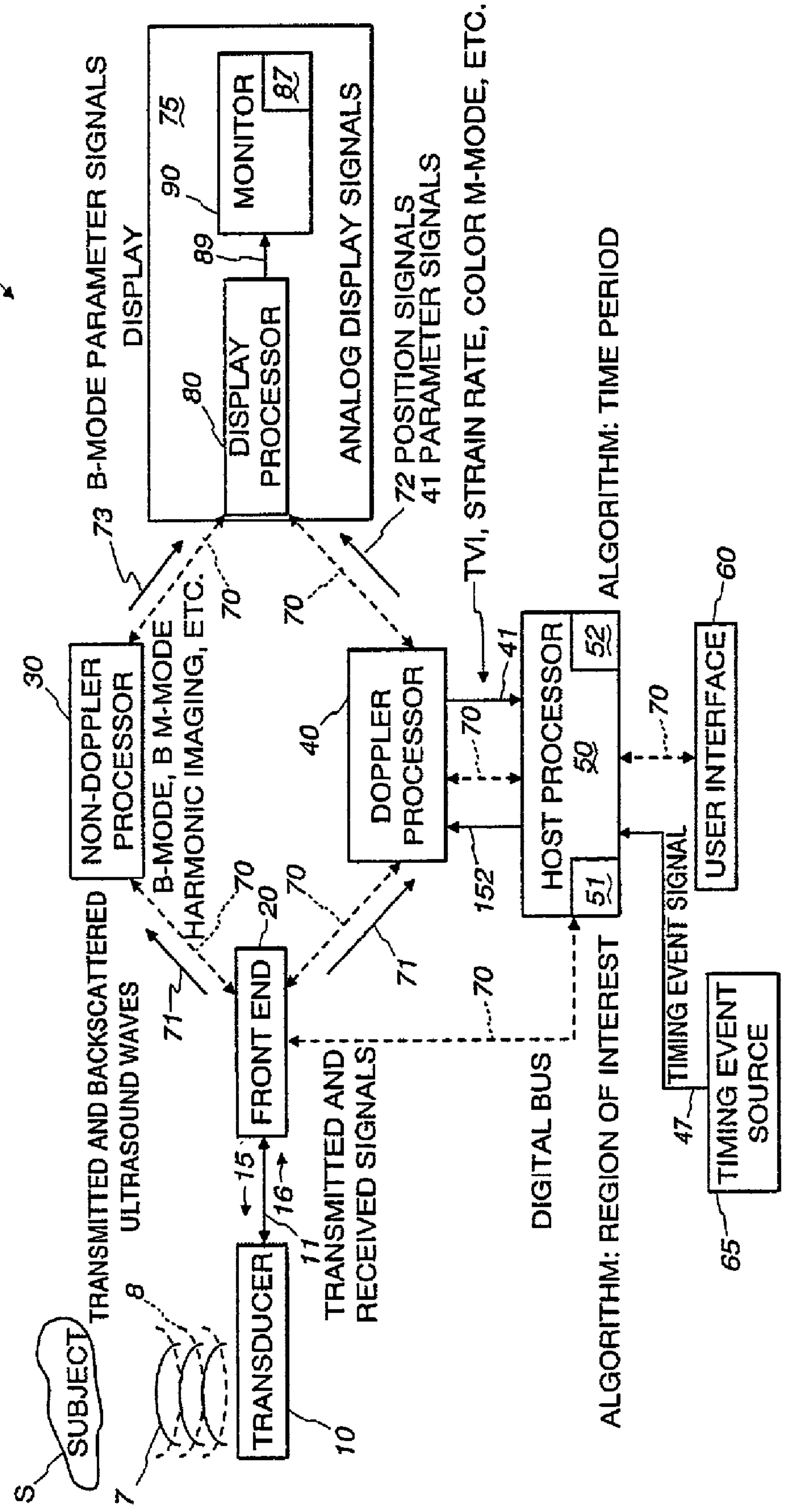

SUBJECT
TRANSDUCER
FRONT END
NON-DOPPLER PROCESSOR
DOPPLER PROCESSOR
HOST PROCESSOR
USER INTERFACE
TIMING EVENT SOURCE
TIMING EVENT SIGNAL
DISPLAY
DISPLAY PROCESSOR
MONITOR
TRANSMITTED AND BACKSCATTERED ULTRASOUND WAVES
TRANSMITTED AND RECEIVED SIGNALS
B-MODE, B M-MODE HARMONIC IMAGING, ETC.
B-MODE PARAMETER SIGNALS
ANALOG DISPLAY SIGNALS
72 POSITION SIGNALS
41 PARAMETER SIGNALS
TVI, STRAIN RATE, COLOR M-MODE, ETC.
ALGORITHM: TIME PERIOD
ALGORITHM: REGION OF INTEREST
DIGITAL BUS
5
S
7
8
10
11
15
16
20
30
40
41
47
50
51
52
60
65
70
71
72
73
75
80
87
89
90
152
Fig. 1

Fig. 2

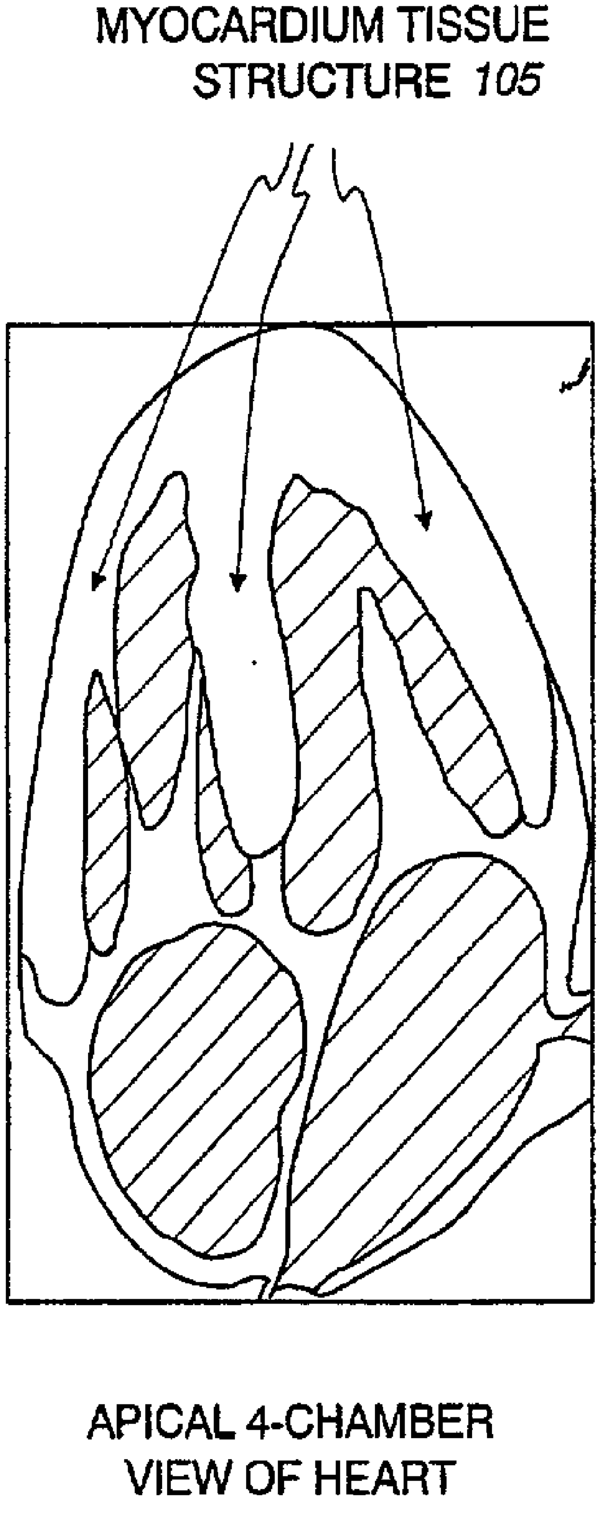
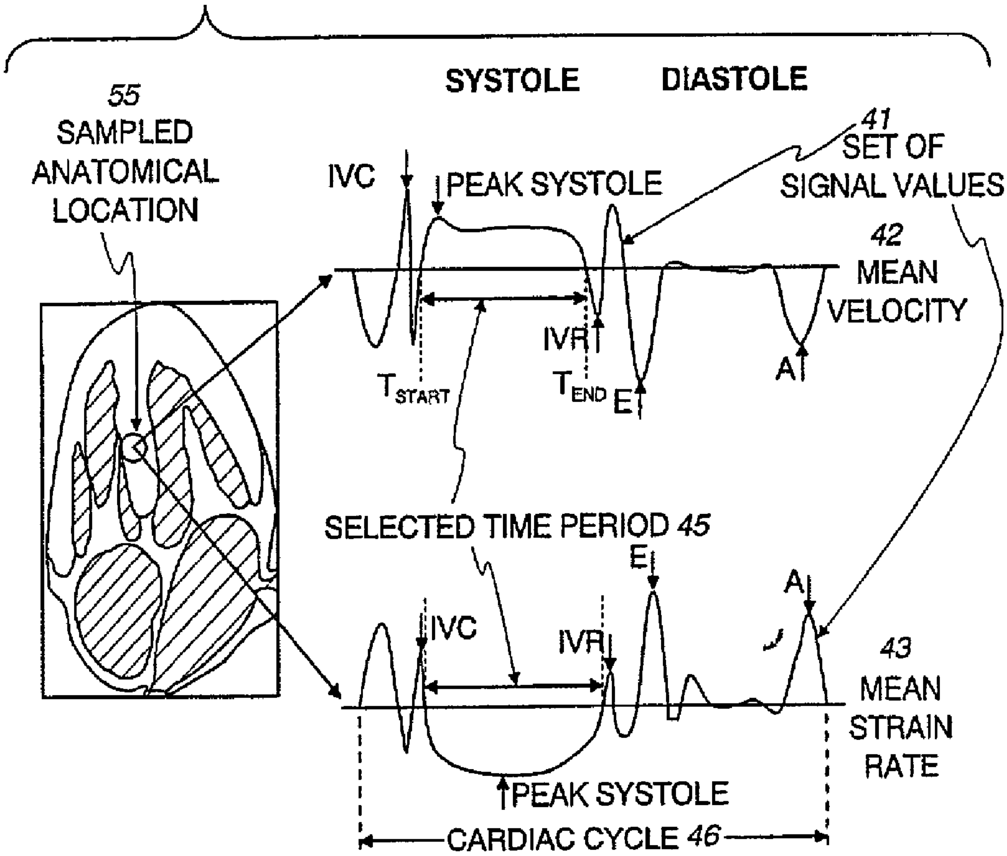
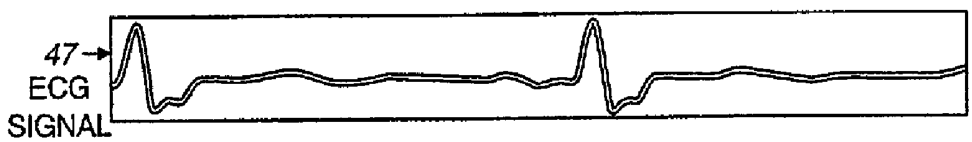

MYOCARDIUM TISSUE
STRUCTURE 105
APICAL 4-CHAMBER
VIEW OF HEART

Fig. 3



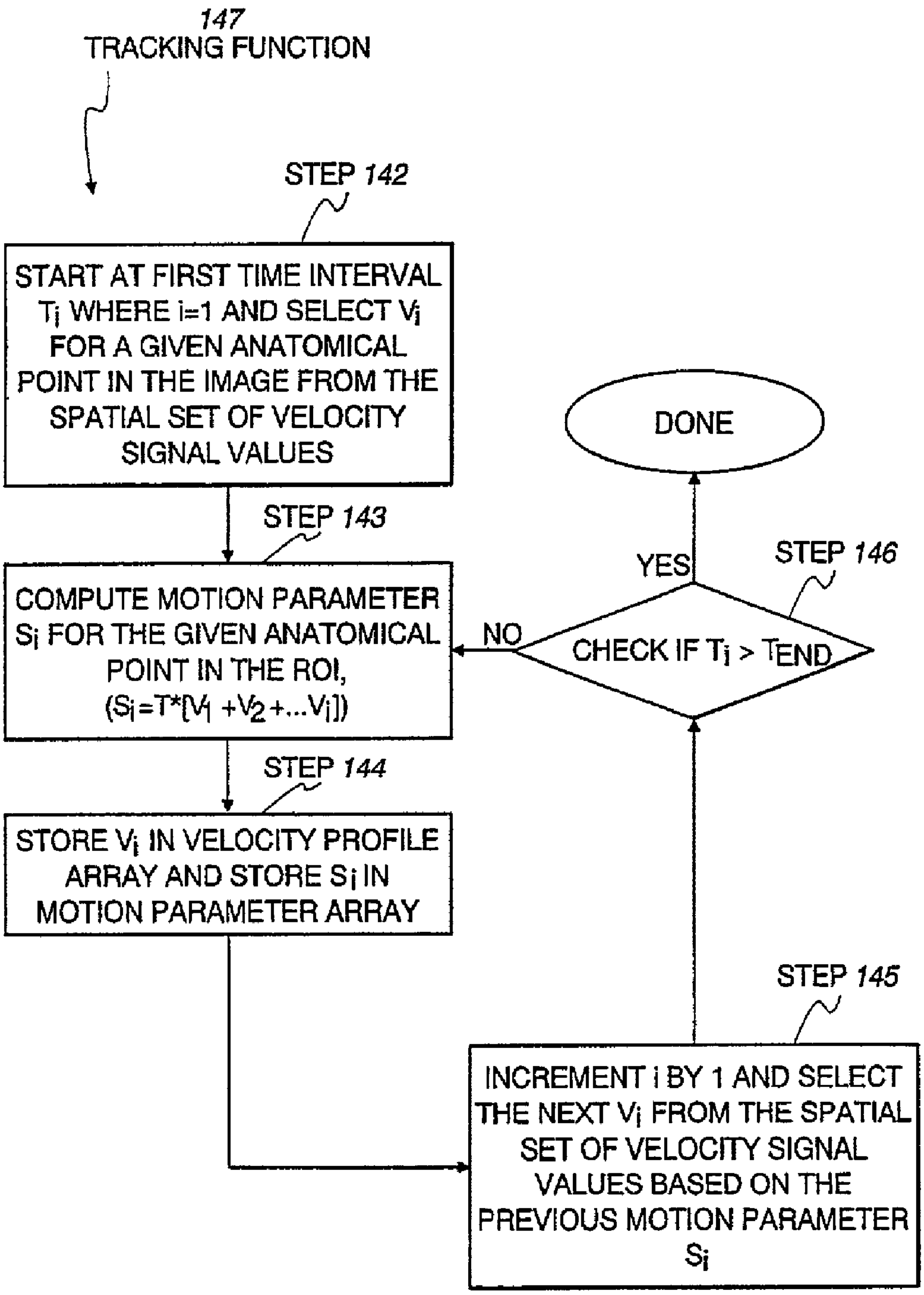
SYSTOLE
DIASTOLE
55
SAMPLED ANATOMICAL LOCATION
IVC
PEAK SYSTOLE
41
SET OF SIGNAL VALUES
42
MEAN VELOCITY
IVR
T_{START}
T_{END}
E
A
SELECTED TIME PERIOD 45
E
A
IVC
IVR
43
MEAN STRAIN RATE
PEAK SYSTOLE
CARDIAC CYCLE 46

Fig. 4



47
ECG SIGNAL

Fig. 5


147
TRACKING FUNCTION
STEP 142
START AT FIRST TIME INTERVAL Ti WHERE i=1 AND SELECT Vi FOR A GIVEN ANATOMICAL POINT IN THE IMAGE FROM THE SPATIAL SET OF VELOCITY SIGNAL VALUES
STEP 143
COMPUTE MOTION PARAMETER Si FOR THE GIVEN ANATOMICAL POINT IN THE ROI, (Si=T*[V1 +V2+...Vi])
STEP 144
STORE Vi IN VELOCITY PROFILE ARRAY AND STORE Si IN MOTION PARAMETER ARRAY
DONE
YES
STEP 146
NO
CHECK IF Ti > TEND
STEP 145
INCREMENT i BY 1 AND SELECT THE NEXT Vi FROM THE SPATIAL SET OF VELOCITY SIGNAL VALUES BASED ON THE PREVIOUS MOTION PARAMETER Si

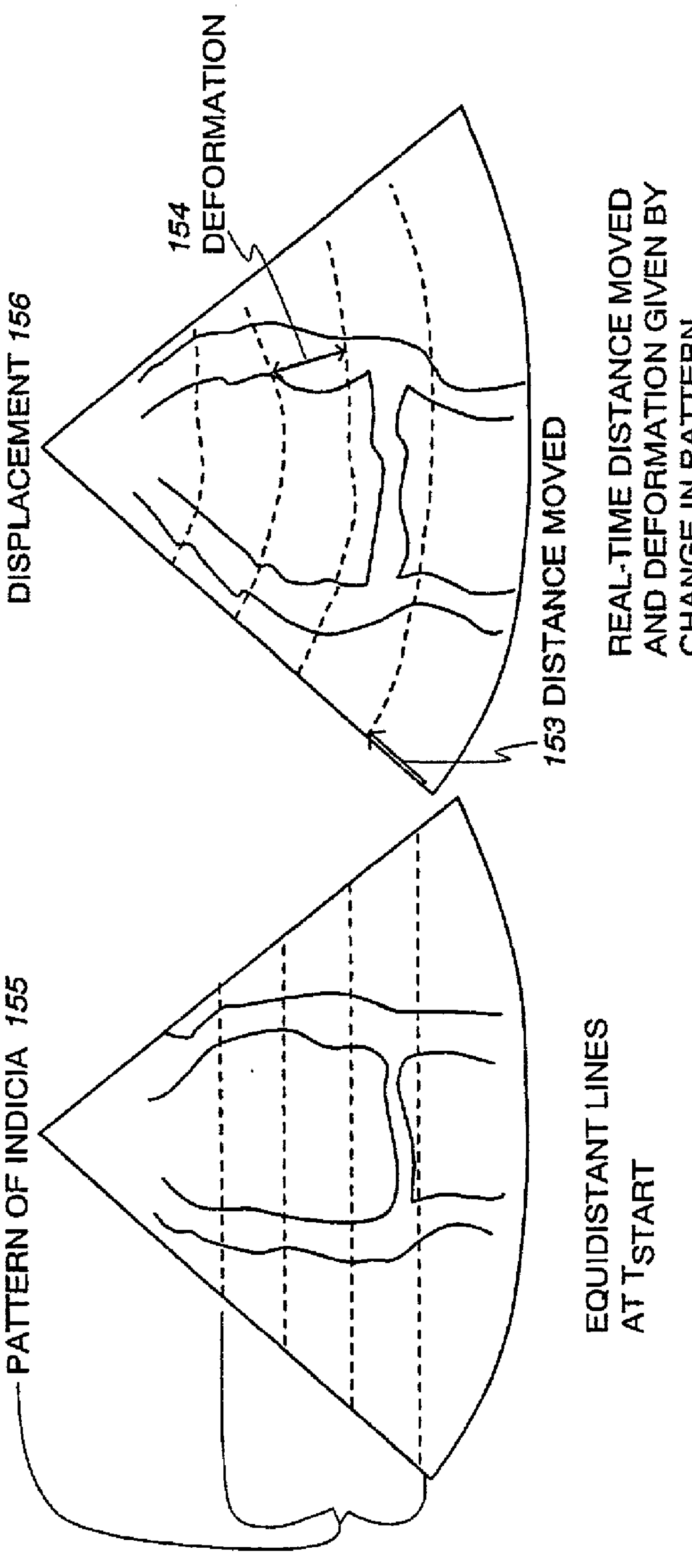
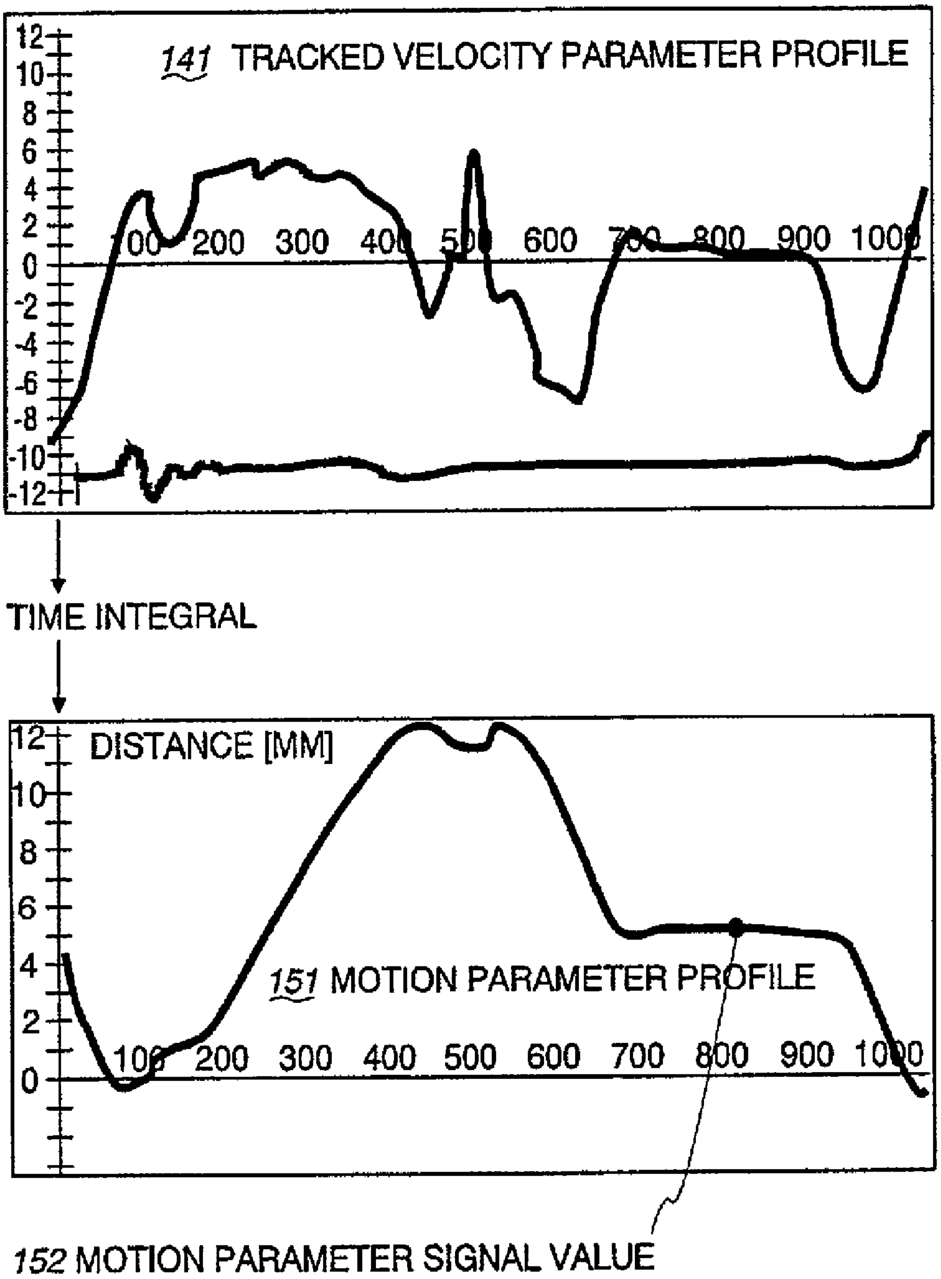

PATTERN OF INDICIA 155
EQUIDISTANT LINES
AT T_{START}
DISPLACEMENT 156
154
DEFORMATION
153 DISTANCE MOVED
REAL-TIME DISTANCE MOVED
AND DEFORMATION GIVEN BY
CHANGE IN PATTERN

Fig. 6

Fig. 7


141 TRACKED VELOCITY PARAMETER PROFILE
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
100 200 300 400 500 600 700 800 900 1000
TIME INTEGRAL
DISTANCE [MM]
151 MOTION PARAMETER PROFILE
152 MOTION PARAMETER SIGNAL VALUE

ULTRASOUND DISPLAY OF TISSUE, TRACKING AND TAGGING

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The applicants claimed priority based on provisional application No. 60/297,572 filed Jun. 12, 2001 in the names of Bjorn Olstad, Steinar Bjaerum, and Kjell Kristoffersen.

BACKGROUND OF INVENTION

[0002] Certain embodiments of the present invention relate to an ultrasound machine for tracking and tagging moving structure. More particularly, certain embodiments relate to the tracking and tagging of moving cardiac tissue for visualization of expansion and contraction processes of the tissue.

[0003] Echocardiography is a branch of the ultrasound field that is currently a mixture of subjective image assessment and extraction of key quantitative parameters of cardiac wall function has been hampered by a lack of well-established parameters that may be used to increase the accuracy and objectivity in the assessment of, for example, coronary artery diseases. Stress echo is such an example. It has been shown that the subjective part of wall motion scoring in stress echo is highly dependent on operator training and experience. It has also been shown that inter-observer variability between echo-centers is unacceptably high due to the subjective nature of the wall motion assessment.

[0004] Much technical and clinical research has focused on the problem and has aimed at defining and validating quantitative parameters. Encouraging clinical validation studies have been reported, which indicate a set of new potential parameters that may be used to increase objectivity and accuracy in the diagnosis of, for instance, coronary artery diseases. Many of the new parameters have been difficult or impossible to assess directly by visual inspection of the ultrasound images generated in real-time. The quantification has required a post-processing step with tedious, manual analysis to extract the necessary parameters.

[0005] Assessment of the expansion and contraction of moving anatomical structure is no exception. Time intensive post-processing techniques or complex, computation intensive real time techniques have been tried in the prior art.

[0006] A need exists for a simpler, real-time technique for visualization and assessment of cardiac wall motion by viewing the expansion and contraction of the cardiac tissue.

SUMMARY OF INVENTION

[0007] An embodiment of the present invention provides an ultrasound system for generating an image responsive to moving cardiac structure by tracking and tagging the structure in order to directly visualize the expansion and contraction processes of the structure within the image on a display in real time.

[0008] An apparatus is provided in an ultrasound machine for generating an image responsive to moving structure of a subject and for generating a representation of displacement of the moving structure. In such an environment, a front-end is arranged to transmit ultrasound energy into the structure and then to generate received signals in response to ultrasound waves backscattered from the structure over a period of time. A display is arranged to display the image of the moving structure in response to the received signals. A user interface is arranged to enable a user of the machine to overlay the image on the display with a first pattern of indicia corresponding to sampled anatomical locations within the moving structure. A processor is responsive to the received signals to generate parameter signals representing displacement of the anatomical locations corresponding to the pattern of indicia during at least a portion of the time period and is responsive to the parameter signals to generate a second pattern of indicia corresponding to the displacement of the anatomical locations and to overlay the second pattern of indicia on the image on the display to provide real-time visualization of the displacement.

[0009] A method is also provided in an ultrasound machine for generating an image responsive to moving structure of a subject and for generating a representation of displacement of the moving structure. In such an environment, the method comprises transmitting ultrasound waves into the structure and generating received signals in response to ultrasound waves backscattered from the structure over a period of time. The image of the moving structure is displayed in response to the received signals. A user of the machine is able to overlay the image with a first pattern of indicia corresponding to sampled anatomical locations within the moving structure. Parameter signals are generated representing displacement of the anatomical locations corresponding to the pattern of indicia during at least a portion of the time period in response to the received signals. A second pattern of indicia is generated corresponding to the displacement of the anatomical locations in response to the parameter signals and is overlaid on the image to provide real-time visualization of the displacement.

[0010] Certain embodiments of the present invention afford an approach to visualize, by using the foregoing techniques, the contraction and expansion of moving anatomical structure in real-time with a degree of convenience and accuracy previously unattainable in the prior art.

BRIEF DESCRIPTION OF DRAWINGS

[0011] **FIG. 1** is a schematic block diagram of an ultrasound machine made in accordance with an embodiment of the present invention.

[0012] **FIG. 2** is a schematic cross-sectional view of the human heart including myocardium tissue.

[0013] **FIG. 3** is a schematic cross-sectional view of the heart shown in **FIG. 2** also graphically representing mean velocity and mean strain rate profiles as a function of time, measured longitudinally in an apical view for a sampled anatomical location in accordance with an embodiment of the present invention.

[0014] **FIG. 4** illustrates an exemplary ECG signal that may be generated by a timing event source and used by the machine in **FIG. 1** to identify a time interval in accordance with an embodiment of the present invention.

[0015] **FIG. 5** is a flowchart of the longitudinal tracking function executed by the machine shown in **FIG. 1** that generates the graphs shown in **FIG. 7** in accordance with an embodiment of the present invention.

[**0016**] **FIG. 6** illustrates displays generated at two different points in time showing tissue displacement with patterns of indicia generated by the machine in **FIG. 1** using the function flowcharted in **FIG. 5** in accordance with an embodiment of the present invention.

[**0017**] **FIG. 7** shows graphs of a tracked velocity parameter profile and a motion parameter profile generated by the tracking function flowcharted in **FIG. 5** in accordance with an embodiment of the present invention.

[**0018**] The foregoing summary, as well as the following detailed description of certain embodiments of the present invention, will be better understood when read in conjunction with the appended drawings. It should be understood, however, that the present invention is not limited to the arrangements and instrumentality shown in the attached drawings.

DETAILED DESCRIPTION

[**0019**] An embodiment of the present invention enables tracking of moving structure and real-time visualization of contraction and expansion of the moving structure. As used herein, structure means non-liquid and non-gas matter, such as cardiac wall tissue.

[**0020**] An embodiment of the present invention offers improved, real-time visualization and assessment of the displacement of wall tissue. Displacement may be, for example, distance moved by the structure or deformation of the moving structure. The moving structure is characterized by a pattern of indicia (set of tagging symbols) overlaid onto an image of the moving structure. The characterization of the moving tissue is accomplished, in part, by generating a set of signal values derived from movement of the structure, such as mean longitudinal velocity.

[**0021**] **FIG. 1** is a schematic block diagram of an embodiment of the present invention comprising an ultrasound machine **5**. A transducer **10** is used to transmit ultrasound waves **7** (solid curves in **FIG. 1**) into a subject S by converting electrical analog signals **15** to ultrasonic energy, and to receive ultrasound waves **8** (dashed curves in **FIG. 1**) backscattered from the subject S by converting ultrasonic energy to analog electrical signals **16**.

[**0022**] A front-end **20** comprising a receiver, transmitter, and beamformer, is used to create the transmitted waveforms, beam patterns and receiver filtering techniques used for the various imaging modes. Front-end **20** performs the functions by converting digital data to analog data and vice versa. Front-end **20** interfaces at an analog interface to transducer **10** and interfaces at a digital interface over a digital bus **70** to a non-Doppler processor **30** and a Doppler processor **40** and a host processor **50**. Digital bus **70** may comprise several digital sub-buses, each sub-bus having its own unique configuration and providing digital data interfaces to various parts of the ultrasound machine **5**.

[**0023**] Non-Doppler processor **30** comprises amplitude detection functions and data compression functions used for imaging modes such as B-mode, B M-mode, and harmonic imaging. Doppler processor **40** comprises clutter filtering functions and movement parameter estimation functions used for imaging modes such as tissue velocity imaging (TVI), strain rate imaging (SRI), and color M-mode. The two processors, **30** and **40**, accept received signal digital data **71** from the front-end **20**, process the data into sets of signal values **41** (**FIG. 3**), and pass the values to processor **50** and/or a display **75** over digital bus **70**. The estimated signal values may be created using the received signals **71** in frequency bands centered at the fundamental, harmonics, or sub-harmonics of the transmitted signals in a manner known to those skilled in the art.

[**0024**] Display **75** comprises scan-conversion functions, color mapping functions, and tissue/flow arbitration functions, performed by a display processor **80** which accepts digital signals **41** (**FIG. 3**) and **73** from processors **30** and **40**. Digital data **72**, representing a location of a pattern of indicia **155**, is accepted from host processor **50**. Display processor **80** processes, maps, and formats the digital data for display, converts the digital display data to analog display signals **89**, and passes the analog display signals **89** to a monitor **90**.

[**0025**] Monitor **90** accepts the analog display signals **89** from display processor **80** and displays the resultant image **87** to the operator on monitor **90**.

[**0026**] A user interface **60** allows user commands to be input by the operator to the ultrasound machine **5**. User interface **60** comprises a keyboard, mouse, switches, knobs, buttons, track ball, and on screen menus (not shown).

[**0027**] Host processor **50** is the main, central processor of the ultrasound machine **5** and interfaces to various other parts of the ultrasound machine **5** through digital bus **70**. Host processor **50** executes the various data algorithms and functions for the various imaging modes. Digital data and commands may be transmitted and received between the host processor **50** and other various parts of the ultrasound machine **5**. The functions performed by processor **50** may be performed by multiple processors or may be integrated into processors **30**, **40**, or **80**, or any combination thereof.

[**0028**] In an embodiment of the present invention, an operator uses transducer **10** to transmit ultrasound energy into the appropriate anatomical structure, such as cardiac tissue **105** (see **FIG. 2**), of the subject in an imaging mode (such as TVI mode interleaved with B-mode) that yields a desired set of signal values **41** (see **FIG. 3**) of the anatomical structure **105**. As shown in **FIG. 3**, the set of signal values **41** typically comprises longitudinal estimates of mean tissue velocity **42** and mean tissue strain rate **43**.

[**0029**] Ultrasound energy is received into transducer **10** and signals are received into front-end **20** in response to ultrasound waves **8** backscattered from the structure **105**. The received signals **71** are sent from front-end **20** to Doppler processor **40** and Non-Doppler processor **30** over digital bus **70**. Many sets of signal values **41** (such as mean velocity **42**) and B-mode signals **73** (such as amplitude) are generated from the received signals **71** over a segmented time period **45** (**FIG. 3**) by Doppler processor **40** and Non-Doppler processor **30**.

[**0030**] The operator selects, through the user interface **60**, a desired time interval **45** to process, such as systole, which is a sub-interval of the cardiac cycle **46** (see **FIG. 3**).

[**0031**] The time interval is designated by T_{start} and T_{end}. The time interval is determined from a timing signal **47** generated from a timing event source **65** (**FIG. 1**) and/or from characteristic signatures of the set of signal values **41**. An example of such a timing signal is an electrocardiogram (ECG) signal (see **FIG. 4**). Those skilled in ultrasound also know how to derive timing events from signals of other sources such as a phonocardiogram signal, a pressure wave signal, a pulse wave signal, or a respiratory signal. Ultrasound modalities such as spectrum Doppler or M-modes may also be used to obtain timing information.

[**0032**] T_{start} is typically selected by the operator as an offset from the R-event in the ECG signal. T_{end} is set such that the time interval covers a selected portion of the cardiac cycle such as systole. It is also possible to select a time period **45** corresponding to the complete cardiac cycle **46**. Another possibility is to limit the time period **45** to the systolic time period in order to display a pattern of indicia (tagging symbols) optimized for visualization of systolic motion. Other sub-intervals of the cardiac cycle **46** may also be applied.

[**0033**] **FIG. 3** graphically illustrates typical sets of signal values **41** for velocity **42** and strain rate **43** which may be segmented into desired time periods based on signature characteristics. For reference, the profiles in **FIG. 3** are annotated with the times corresponding to: IVC=isovolumetric contraction, IVR=isovolumetric relaxation, E=early diastolic velocity, and A=late diastolic velocity. Caution should be taken in the selection of the time interval such that, for example, motion in the IVC or IVR period may be excluded from the analysis, if desired. An automatic function may be implemented to recognize and exclude the unwanted events from the time interval.

[**0034**] In other possible embodiments, the time interval may be selected automatically or as a combination of manual and automatic methods. For example, the time period **45** may be determined automatically with an algorithm **52** (see **FIG. 1**) embedded in host processor **50**. The algorithm **52** may use well-known techniques of analyzing the sets of signal values **41**, as shown in **FIG. 3**, looking for key signal signature characteristics and defining a time period **45** based on the characteristics, or similarly, analyzing the ECG signal **47** (**FIG. 4**).

[**0035**] The spatial set of signal values **41** representing the movement of the structure **105** is sent from Doppler processor **40** to host processor **50**, where a tracking function **147** is applied to the set of signal values **41**. **FIG. 5** is a flow chart of the tracking function **147**.

[**0036**] The operator brings up onto the display and positions, through user interface **60**, a pattern of indicia **155** (a set of tagging symbols), typically configured in the form of parallel lines or a grid (see **FIG. 6**). The operator then initiates, through user interface **60**, real-time tracking of every sampled anatomical location associated with an element of the pattern of indicia over the selected time period **45** of the cardiac cycle **46**. The association is established by host processor **50** where each element of the pattern of indicia **155** is correlated to the anatomical locations beneath the pattern of indicia **155** at time T_{start}.

[**0037**] As an introduction to the tracking function **147**, a tracked velocity parameter profile **141** (V_1, V_2, . . . , V_n) (**FIG. 7**) for a given sampled anatomical location **55** in the myocardium **105**, is created over the time period T_{start} to T_{end} by converting the spatial set of velocity values **42** into a motion parameter profile **151** in time using host processor **50** by computing the series of time integrals (S_1, S_2 . . . , S_n) where:

$$S_{i=T}*(V_1+V_2+ \ldots +V_i) \qquad \text{[Equation 1]}$$

[**0038**] and where T is the time delay between two consecutive velocity measurements (T is typically based on the frame rate of the imaging mode). S_i (motion parameter signal value) **152** (**FIG. 7**) is then the longitudinal distance in mm (from reference time T_{start} location) that a sample of tissue in the myocardium has moved at time segment T_i, thus allowing the isolated tissue sample to be tracked longitudinally (along the ultrasound beam) over the time interval T_{start} to T_{end} by host processor **50**. The start end tracking function **147** estimates the new anatomical location of the tracked sample of tissue after every time segment T_i. The element of the pattern of indicia **155** is displayed at that spatial location where the tracking function has determined the corresponding anatomical location has moved to for the next time interval T_i. This is done for each tracked location and correlated element of the pattern of indicia in the image. The upper part of **FIG. 7** shows a resultant tracked velocity parameter profile **141** of an anatomical location in the image as a function of time for a complete cardiac cycle **46**. The lower part of **FIG. 7** shows the corresponding resultant longitudinal motion parameter profile **151** (integrated velocity profile, S_1, S_2, . . . S_n) of the same anatomical location in the image. Motion along the ultrasound beam n may be accurately tracked with the technique by generating the appropriate velocity parameter profiles for the corresponding anatomical locations. The tracked velocity parameter profile **141** and motion parameter profile **151** for each anatomical location are stored in the memory of host processor **50** as arrays of values.

[**0039**] Two-dimensional velocity estimation may be used for accurate tracking when a substantial part of the motion of the structure is orthogonal to the beam. Other tracking techniques may be employed as well.

[**0040**] The specific steps of one tracking function **147** are now described for a given anatomical location within the image. A spatial set of mean velocity signal values **42** is estimated so that the motion parameter signal values S_i **152** may be calculated for tracking. The mean velocity values are generated by Doppler processor **40** in a well-known manner.

[**0041**] Referring to **FIG. 5**, in step **142** of tracking function **147**, processor **50** selects V_i for a given anatomical location at a given spatial position in the image from a spatial set of velocity signal values correlated to the location of an element of the pattern of indicia and corresponding to time interval T_i where i=1 (T_1 is T_{start}).

[**0042**] In step **143** of tracking function **147**, processor **50** computes the motion parameter signal value S_i **152** for the given anatomical location by summing mean velocity values as follows:

$$S_i T*(V_1+V_2+ \ldots +V_i) \qquad \text{[Equation 1]}$$

[**0043**] (Note that for i=1, S_1=T*V_1)

[**0044**] In step **144** of tracking function **147**, processor **50** stores V_i in tracked velocity parameter profile array **141** and S_i is stored in motion parameter profile array **151** along with the current spatial position of the anatomical location. Other estimated parameters, such as strain rate **43**, corresponding to the tracked anatomical location may be computed and stored in respective tracked profile arrays as well if desired allowing for display of the pattern of indicia **155**, for example, overlaid onto a strain rate image. Strain rate is simply computed for each spatial location as it normally is in the SRI mode and the results of the tracking function are used to select the spatial strain rate values that correspond to a tracked anatomical location.

[0045] In step **145** of tracking function **147**, i is incremented by one (corresponding to the next sample time, T seconds later) and the next V_i is selected from the spatial set of velocity signal values **42** based on the motion parameter signal value S_i **152** previously computed and the previous spatial position of the anatomical location (S_i represents the longitudinal spatial movement in millimeters of the anatomical location over time interval $T_i=i*T$).

[0046] Host processor **50** sends the new position information **72** of the pattern of indicia **157** to display processor **80**. Display processor **80** re-configures the pattern for display at the new positions. The new position of the pattern is updated and displayed after each new tracked element in the motion parameter profile array is added allowing a constant update of the displayed pattern within the time interval T_{start} to T_{end}. The underlying image (e.g. B-mode image) is displayed with the updated pattern of indicia **157** overlaid such that there is spatial alignment between the anatomical locations in the underlying image and the updated pattern of indicia.

[0047] In step **146** of tracking function **147**, the function checks to see if T_{end} has been end exceeded. If T_{end} has not been exceeded, the function proceeds back to step **143** end and computes the next motion parameter signal value S_i in the series using Equation 1. The iterative process is followed until the full arrays of the tracked velocity parameter profile **141**, the motion parameter profile **151**, and any other desired parameter profile have been created and stored over the complete time interval T_{start} to T_{end}.

[0048] The tracking function **147** is performed simultaneously for each anatomical location in the image that corresponds to an element in the pattern of indicia **155** (set of tagging symbols).

[0049] **FIG. 6** illustrates the function of generating a display of a pattern of indicia **155** (tagging symbols), in rectangular coordinate geometry, overlaid onto a B-mode image of cardiac tissue. The left side of **FIG. 6** illustrates a 1-dimensional pattern where equidistant dashed horizontal lines are used to form the pattern corresponding to time T_{start} and is the zero displacement position of the pattern which is positioned by the operator. Another good candidate for the pattern would be to use an equidistant set of lines with constant depth in the polar geometry representation of the ultrasound image. Also, a 2-dimensional grid may be used, which might consist of both horizontal and vertical lines. The right side of **FIG. 6** illustrates the display of a frame within the selected time interval T_{start} to T_{end} of the cardiac cycle where the start end positions of the elements of the pattern have been updated to visualize the displacement **156** (distance moved **153** and deformation **154**) of the tracked anatomical locations within the cardiac structure **105**. The pattern has been changed to correspond to the displacement of the heart tissue. Those skilled in the art will know how to program processor **50** using tracking function **147** (**FIG. 5**) to achieve the display shown in **FIG. 6**.

[0050] Care should be taken by the operator to adjust the Nyquist frequency of the imaging mode such that aliasing does not occur. With aliasing present in the velocity data, erroneous tracking results occur. Alternatively, well known automatic aliasing correction techniques may be employed. An embodiment of the method may be applied to any imaging mode of the ultrasound machine **5** for moving structure (e.g. B-mode, TVI, SRI, etc).

[0051] In summary, certain embodiments of the present invention afford an approach to more easily visualize the displacement of tissue, including expansion and contraction, in a two-dimensional pattern overlaid onto an image of cardiac structure. While the invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

1. In an ultrasound machine for generating an image responsive to moving structure of a subject, apparatus representing displacement of the moving structure comprising:

a front-end arranged to transmit ultrasound waves into the structure and to generate received signals in response to ultrasound waves backscattered from the structure over a time period;

a display arranged to display the image of the moving structure in response to the received signals;

a user interface enabling a user of the machine to overlay the image on the display with a first pattern of indicia corresponding to sampled anatomical locations within the moving structure; and

a processor responsive to the received signals to generate parameter signals representing displacement of the anatomical locations corresponding to the pattern of indicia during at least a portion of the time period and responsive to the parameter signals to generate a second pattern of indicia corresponding to the displacement of the anatomical locations and to overlay the second pattern of indicia on the image on the display.

2. The apparatus of claim 1 wherein the moving structure comprises cardiac tissue.

3. The apparatus of claim 1 wherein the displacement represents one of distance moved by the moving structure and deformation of the moving structure.

4. The apparatus of claim 1 wherein the image is displayed with a predetermined geometry and the first pattern of indicia comprises a set of lines in the predetermined geometry.

5. The apparatus of claim 4 wherein the set of lines comprises dashed lines.

6. The apparatus of claim 4 wherein the lines are equidistant apart.

7. The apparatus of claim 1 wherein the processor generates the parameter signals by summing a set of signal values representing mean velocities of the moving structure over at least of portion of the time period.

8. The apparatus of claim 1 wherein the time period comprises at least a portion of a cardiac cycle selectable by a user of the machine including at least one of systole, diastole, IVC, IVR, E-wave, and A-wave.

9. The apparatus of claim 8 wherein the portion of the cardiac cycle is selectable from at least one of a set of signal values and a timing event signal comprising at least one of an ECG signal, a phonocardiogram signal, a pressure wave signal, a pulse wave signal, and a respiratory signal.

10. The apparatus of claim 1 wherein the image is one of a B-mode image, a combined B-mode/TVI image, a combined B-mode/SRI image, a TVI image, and an SRI image.

11. In an ultrasound machine for generating an image responsive to moving structure of a subject, a method of representing displacement of the moving structure comprising:

transmitting ultrasound waves into the structure;

generating received signals in response to ultrasound waves backscattered from the structure over a time period;

displaying the image of the moving structure in response to the received signals;

enabling a user of the machine to overlay the image on the display with a first pattern of indicia corresponding to sampled anatomical locations within the moving structure;

generating parameter signals representing displacement of the anatomical locations corresponding to the pattern of indicia during at least a portion of the time period in response to the received signals; and

generating a second pattern of indicia corresponding to the displacement of the anatomical locations in response to the parameter signals and displaying the second pattern of indicia overlaid on the image.

12. The method of claim 11 wherein the moving structure comprises cardiac tissue.

13. The method of claim 11 wherein the displacement represents the distance moved by the moving structure and deformation of the moving structure.

14. The method of claim 11 wherein the image is displayed with a predetermined geometry and the first pattern of indicia comprises a set of lines in the predetermined geometry.

15. The method of claim 14 wherein the set of lines comprises dashed lines.

16. The method of claim 14 wherein the lines are equidistant apart.

17. The method of claim 11 wherein said generating the parameter signals comprises summing a set of signal values representing mean velocities of the moving structure over at least a portion of the time period.

18. The method of claim 11 wherein the time period comprises at least a portion of a cardiac cycle selectable by a user of the machine.

19. The method of claim 18 wherein the portion of the cardiac cycle is selectable from at least one of a set of signal values and a timing event signal comprising at least one of an ECG signal, a phonocardiogram signal, a pressure wave signal, a pulse wave signal, and a respiratory signal.

20. The method of claim 11 wherein the image is one of a B-mode image, a combined B-mode/TVI image, a combined B-mode/SRI image, a TVI image, and an SRI image.

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patsnap

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摘要(译)

一种超声机，其产生对应于跟踪的移动结构的标记图案，例如显示在监视器上的心脏壁组织。通过包括响应于反向散射超声波产生接收信号的前端的设备在一段时间内显示与结构的跟踪运动相关的一组标记符号来生成标记的模式。多普勒处理器生成表示结构内运动的信号值的空间集合。非多普勒处理器生成表示结构内的B模式值的空间集合的参数信号集合。主处理器实现跟踪功能以在对应于与该组标记符号集相关联的解剖位置的时间段内生成一组跟踪的移动参数分布图和运动参数分布图。显示处理器将该组标记符号叠加在监视器上的移动结构的图像上，例如B模式，示出允许在时间上实时地可视化移动结构的膨胀和收缩的标记图案期。