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(54) Ultrasound diagnostic system for providing elastic image with additional information

(57) There is provided an ultrasound diagnostic system adapted to provide an elastic image with additional information. The ultrasound diagnostic system comprises: a probe for receiving echo signals from a target object, the probe being configured to transfer a pressure applied by an user to the target object; an elastic image processor for producing an elastic image and an additional information related thereto based on each of the echo signals before and after applying the pressure; and a display for displaying the elastic image and the additional information,

which are inputted from the elastic image processor. The additional information includes an elastic image map and a strain ratio of a medium. The elastic image processor calculates the strain ratio based on the echo signals before and after applying the pressure and calculates a constriction speed based on the strain ratio and the frame rate, the elastic image processor being configured to form an elastic image map showing a relationship between the constriction speed and the strain ratio.

Description

[0001] The present invention generally relates to an ultrasound diagnostic system, and more particularly to an ultrasound diagnostic system adapted to provide an elastic image together with additional information.

[0002] Currently, an ultrasound diagnostic system is widely used to inspect a target object for diagnostic purposes. In order to provide an image of a target object, the ultrasound diagnostic system radiates an ultrasound signal to the target object, receives the ultrasound signal reflected from a discontinuous surface of the target object, converts the received ultrasound signal into electrical signals and performs signal processing upon the electrical signals.

[0003] Typically, an elastic imaging technique is used to visualize a characteristic of a tissue in ultrasound medical imaging. Specifically, the elastic imaging technique is utilized because it is widely recognized in the art that the elasticity of the tissue is relevant to a pathological phenomenon. For example, a cancer or a tumor tissue is harder than a general soft tissue. Thus, the cancer or the tumor tissue is less likely to be strained than the general soft tissue against a same amount of external force.

[0004] Generally, it is necessary to obtain data before and after the constriction to measure the elasticity of the tissue. When obtaining the data from a real time ultrasound device, the strained amount of the tissue may vary depending on the constriction force applied by the user, wherein the quality of the elastic image depends on the constriction force and the frame rate of the device. More specifically, in case of a small constriction force, a relative strained amount between media, each having a different elasticity, is not displayed clearly. In case of a large strained amount, however, the quality of the elastic image becomes degraded because a decorrelation in the tissue becomes increased by the constriction. Therefore, an appropriate level of constriction is required to obtain data from a real time ultrasound device. Since the constriction strength varies with the user or the measurement, the user should be provided with information as to which level of constriction should be exerted or has been exerted. The level of constriction can be represented by the constriction speed, which can be calculated from the current frame rate and the currently computed displacement of the tissue.

[0005] In a conventional elastic imaging technique, a relative strained amount of the tissue is represented through using a pseudo color of two-dimensional (2D) image. Accordingly, the conventional elasticity imaging technique is highly helpful to diagnose a diseased portion, which cannot be detected in a B-mode image where a reflection coefficient is represented by using an impedance difference between the tissues.

[0006] However, although the conventional elastic imaging technique has the advantage of being able to visually display the hardness of the tissue, it cannot provide any precise information on the strain ratio. Therefore, in

order to obtain numerical information on the strain ratio, a separate method for displaying a numerical value instead of the image is required.

[0007] In the conventional elastic imaging technique, constrictions and expansions are repeatedly performed to achieve a real time elastic image. Due to such constrictions and expansions, a flash noise is created in case the elastic image is displayed with a color Doppler image or a power Doppler image. Therefore, a method for removing the flash noise is necessary.

[0008] It is, therefore, an object of the present invention to provide an ultrasound diagnostic system for displaying an elastic image along with additional information including the constriction speed and the strain ratio by the constriction, which are used to obtain the elastic image.

[0009] Further, it is another object of the present invention to provide an ultrasound diagnostic system for generating the additional information while producing the elastic image together with the ultrasonic color Doppler

image or the power Doppler image. In accordance with one aspect of the present invention, the ultrasound diagnostic system includes: a probe for receiving first echo signals from a target object, the probe being configured to transfer a pressure applied by an user to the target object and further receive second echo signals from the target object; an elastic image processor for producing an elastic image and additional information related thereto based on the first and second echo signals; and a display unit for displaying the elastic image and the additional information.

[0010] In accordance with another aspect of the present invention, the ultrasound diagnostic system includes: a probe for receiving first echo signals from a target object, the probe being configured to transfer a pressure applied by an user to the target object and further receive second echo signals from the target object; an elastic image processor for producing an elastic image and additional information related thereto based on the first and second echo signals; a Doppler image processor for producing a Doppler image and a Doppler map based on the echo signals; a synthesis image processor for producing a synthesized image by synthesizing the elastic image and the Doppler image, the synthesis image processor being configured to receive the additional information and information on the Doppler map; and a display unit for displaying the synthesized image, the additional information and the Doppler map, which are inputted from the synthesis image processor.

[0011] The above and other objects and features in accordance with the present invention will become apparent from the following descriptions of preferred embodiments given in conjunction with the accompanying drawings, in which:

55 Fig. 1 is a block diagram showing a configuration of an ultrasound diagnostic system constructed in accordance with one embodiment of the present invention.

Fig. 2A shows an elastic image map representing a relationship between a strain and a constriction speed in accordance with one embodiment of the present invention.

Fig. 2B is an exemplary diagram depicting an implementation of the elastic image of Fig. 2A.

Fig. 3A is an exemplary diagram showing a state in which the user selects a line SL on the elastic image. Fig. 3B is a graph showing a strain ratio according to a depth of the selected line of Fig. 3A.

Fig. 4 is an exemplary diagram presenting a numerically computed strain ratio of a selection region on the elastic image.

Fig. 5 is a block diagram showing a configuration of an ultrasound diagnostic system constructed in accordance with another embodiment of the present invention.

Fig. 6 is an exemplary diagram showing a new frame formed by an interpolation in comparison with a frame having a noise over a threshold value.

Fig. 7 is an exemplary diagram showing a synthesized image of the elastic image and the color Doppler image.

Fig. 8 is an exemplary diagram depicting an image resulting from synthesizing the elastic image and the power Doppler image.

Fig. 9 is an exemplary diagram presenting a strain ratio of the elastic image, the constriction speed and the blood flow information of the Doppler as a single color map.

Fig. 10 is an exemplary diagram separately representing the Doppler map and the elastic image map showing the strain ratio of the elastic image and the constriction speed.

[0012] Hereinafter, the embodiments of the present invention will be described by referring to the attached drawings.

[0013] Referring to Fig. 1, an ultrasound diagnostic system 100, which is constructed in accordance with one embodiment of the present invention, includes a probe 101, a controller 102, an elastic image processor 103, a monitor 104 and a user interface unit 105.

[0014] The probe 101 transmits an ultrasound signal to a target object and receives an ultrasonic signal (echo signal) reflected from the target object. The probe is also configured to transfer a pressure applied by a user to the target object.

[0015] The controller 102 controls an overall operation of the ultrasound diagnostic system 100. Particularly, the controller 102 provides a previously set frame rate to the elastic image processor 103.

[0016] The elastic image processor 103 calculates a strain ratio of a medium based on the echo signal inputted from the probe 101. That is, the elastic image processor 103 calculates the strain ratio of the medium based on a change in the echo signals before and after applying the pressure. Additionally, the elastic image processor 103

calculates a constriction speed based on the calculated strain ratio and the frame rate information provided by the controller 102 and makes an elastic image map E01 (i.e., a pseudo color map showing information on the constriction speed and the strain ratio). The constriction speed (mm/sec) can be calculated by multiplying the frame rate (frames/sec) and a displacement (mm/frame) computed from a current frame. Fig. 2A shows an elastic image map representing a relationship between the strain and the constriction speed in accordance with one embodiment of the present invention. Fig. 2B is an exemplary diagram depicting an implemented aspect of Fig. 2A. As shown in Figs. 2A and 2B, an entire span of the constriction speed may be divided into predetermined number of steps. The information on the strain ratio can be represented through using a 256 or 512 number of steps.

[0017] The monitor 104 is provided with the above-mentioned elastic image map showing the information on the constriction speed and the strain ratio.

[0018] In accordance with another embodiment of the present invention, the strain ratio of the region selected by the user may be provided in the form of numerical values. That is, if the user selects any region from the elastic image through the user interface unit 105, the numerical information on the strain ratio of the selected region is provided.

Fig. 3A is an exemplary diagram showing a state in which the user selects a line SL on the elastic image and Fig. 3B is a graph showing the strain ratio according to a depth of the selected line of Fig. 3A. As shown in Fig. 4, in case the user selects two random regions, the strain ratios of the selected regions (I and II) are calculated and accordingly the numerical information is provided to the user.

The numerical information may include a variance, an average and a standard deviation of the strain ratio, wherein the strain ratio versus a position in the selected region can be provided in the form of a graph.

[0019] The Doppler image displays an amount of frequency shift together with a diffusion intensity of the signal so that a dynamic function of a living body can be observed. Particularly, the color Doppler and the power Doppler images are obtained by demodulating the received signal and performing digital processing thereon so as to depict a blood flow in a heart or a large blood vessel as a real time 2-D image.

[0020] In the color Doppler image a cross section of tissue is presented by a black and white B-mode image and the blood flow is displayed with colors. The blood flows running into and against a direction of the radiated ultrasonic beam are displayed with warm color (red series) and cold color (blue series), respectively. The power Doppler image can represent information on the blood flow by displaying the power of the blood flow with a different brightness of color.

[0021] In accordance with another embodiment of the present invention, the ultrasound diagnostic system is provided, which presents an image with the Doppler im-

age and the elastic image synthesized, together with the constriction speed of the target object set at the time of obtaining the elastic image. The ultrasound diagnostic system according to this embodiment facilitates the exact diagnosis of a diseased portion.

[0022] As shown in Fig. 5, an ultrasound diagnostic system 200, which is constructed in accordance with another embodiment of the present invention, includes a probe 201, a controller 202, an image processor 203, a monitor 204 and a user interface unit 205. The image processor 203 includes an elastic image processor 203A, a Doppler image processor 203B and a synthesis image processor 203C.

[0023] Since the functions of the probe 201, the controller 202, the elastic image processor 203A, the monitor 204 and the user interface unit 205 are identical to those of the probe 101, the controller 102, the elastic image processor 103 and the monitor 104 and the user interface 105, respectively, the detailed descriptions of the above-mentioned elements are omitted herein.

[0024] The Doppler image processor 203B corresponds to the color Doppler image processor or the power Doppler image processor. The Doppler image processor 203B produces the color Doppler image/the power Doppler image (hereinafter referred to as the Doppler image) and the Doppler image map based on the echo signal inputted from the probe 201. The Doppler image map shows the speed or the power of the blood flow by a color map. Due to the repeated constriction and restoration of the target object for obtaining the elastic image, the flash noise may occur to the Doppler image. For each frame of the Doppler image obtained, the Doppler image processor 203B checks the quantity of a flash noise occurrence, removes the frame having the flash noise over a threshold value and replaces the removed frame with a new frame formed by an interpolation by using frames before and after the removed frame. Fig. 6 shows the new frame FI formed by the interpolation in comparison with the frame FR having a noise over the threshold value.

[0025] The synthesis image processor 203C produces the synthesized image by synthesizing the elastic image and the Doppler image delivered from the elastic image processor 203A and the Doppler image processor 203B, respectively. The synthesis image processor 203C provides the monitor 204 with the Doppler image map received from the Doppler image processor 203B and at least one of the strain ratio, the constriction speed and the pseudo color map from the elastic image processor 203A, together with the synthesized image.

[0026] Fig. 7 is an exemplary diagram showing the image resulting from synthesizing the elastic image A and the color Doppler image B. Fig. 8 is an exemplary diagram depicting the image A with the elastic image and the power Doppler image C synthesized.

[0027] The Doppler image map and the elastic image map can be displayed together with the synthesized image. The Doppler image map and the elastic image map

can be represented as a single map. The strain ratio and the constriction speed of the elastic image, as well as the blood flow and the power, are configured 3-dimensionally and shown as a single color map, as shown in Fig. 9.

5 Alternatively, as shown in Fig. 10, the Doppler image map (left side of Fig. 10), which indicates the strain ratio vs. the constriction speed, and the elastic image map (right side of Fig. 10) can be shown separately.

[0028] As described above, the present invention can **10** provide specific information on the strain ratio of the elastic image. That is, the information on the constriction speed and the strain ratio can be observed by referring to a single pseudo color map, which provides the images of the constriction speed and the strain ratio simultaneously to allow the optimum elastic image of the tissue to be obtained.

[0029] Further, the trial and error due to the mistake **15** of the user can be reduced in the process of obtaining the elastic image to provide an optimum and stable elastic image.

[0030] Furthermore, the result of the strain ratio can **20** be displayed with numerical values to show an elasticity difference between the tissues and help diagnose a diseased portion having a minute elasticity difference.

[0031] Moreover, the elastic image and the Doppler **25** image are represented simultaneously so that the hard tissue such cancer cell can be observed along with the blood vessel developed around the tissue, which is beneficial to the diagnosis.

[0032] When a high intensity focused ultrasound (HI-FU) is adopted, the ultrasound diagnostic system constructed in accordance with the present invention may be used to observe the remaining blood vessel after burning the diseased portion by a high intensity ultrasonic **30** wave.

[0033] In the ultrasound diagnosis system constructed **35** in accordance with the present invention, the information on the constriction speed can be observed by referring to a single color map to allow the user to obtain the optimized elastic image.

[0034] Further, the frame having a high flash noise can **40** be removed to obtain a high quality of the image.

[0035] While the present invention has been shown **45** and described with respect to a preferred embodiment, those skilled in the art will recognize that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the appended claims.

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Claims

1. An ultrasound diagnostic system, comprising:

55 a probe for receiving first echo signals from a target object, the probe being configured to transfer a pressure applied by an user to the target object and further receive second echo

signals from the target object;
 an elastic image processor for producing an elastic image and additional information related thereto based on the first and second echo signals; and
 a display unit for displaying the elastic image and the additional information.

2. The system of Claim 1, wherein the additional information includes an elastic image map and a strain ratio of a medium. 5

3. The system of Claim 1, further comprising a controller for providing a previously set frame rate to the elastic image processor. 10

4. The system of Claim 3, wherein the elastic image processor calculates the strain ratio based on the echo signals before and after applying the pressure and calculates a constriction speed based on the strain ratio and the frame rate, the elastic image processor being configured to form an elastic image map showing a relationship between the constriction speed and the strain ratio. 15

5. The system of any one of Claims 1 to 4, further comprising a user interface unit for receiving a selection region from the user, wherein the elastic image processor provides information on the strain ratio of the selection region. 20

6. An ultrasound diagnostic system, comprising:
 a probe for receiving first echo signals from a target object, the probe being configured to transfer a pressure applied by an user to the target object and further receive second echo signals from the target object;
 an elastic image processor for producing an elastic image and additional information related thereto based on the first and second echo signals; 35
 a Doppler image processor for producing a Doppler image and a Doppler map based on the echo signals; 40
 a synthesis image processor for producing a synthesized image by synthesizing the elastic image and the Doppler image, the synthesis image processor being configured to receive the additional information and information on the Doppler map; and 45
 a display unit for displaying the synthesized image, the additional information and the Doppler map inputted from the synthesis image processor. 50

7. The system of Claim 6, wherein the Doppler image processor checks a quantity of a flash noise occur- 55
 rence in each frame of the Doppler image and removes the frame having the flash noise over a threshold value, the Doppler image processor being configured to replace the removed frame with a new frame formed by an interpolation by using frames before and after the removed frame.

8. The system of Claim 6, wherein the additional information includes an elastic image map and a strain ratio of a medium. 10

9. The system of Claim 7, further comprising a controller for providing a previously set frame rate to the elastic image processor. 15

10. The system of Claim 9, wherein the elasticity image processor calculates the strain ratio based on the echo signals and information related to the pressure and calculates a constriction speed based on the strain ratio and the frame rate, the elasticity image processor being configured to form an elastic image map showing a relationship between the constriction speed and the strain ratio. 20

11. The system of any one of Claims 6 to 10, further comprising a user interface unit for receiving a selection region from the user, wherein the elastic image processor provides information on the strain ratio of the selection region. 25

Fig. 1

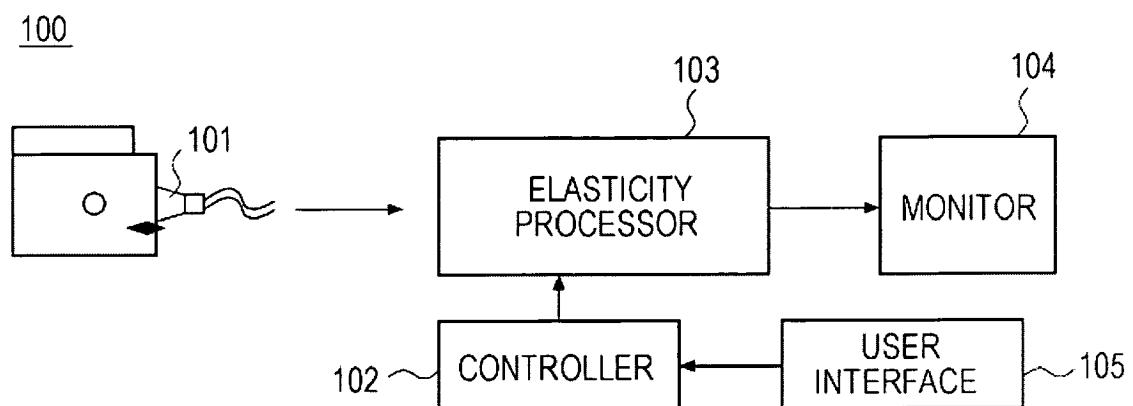


Fig. 2A

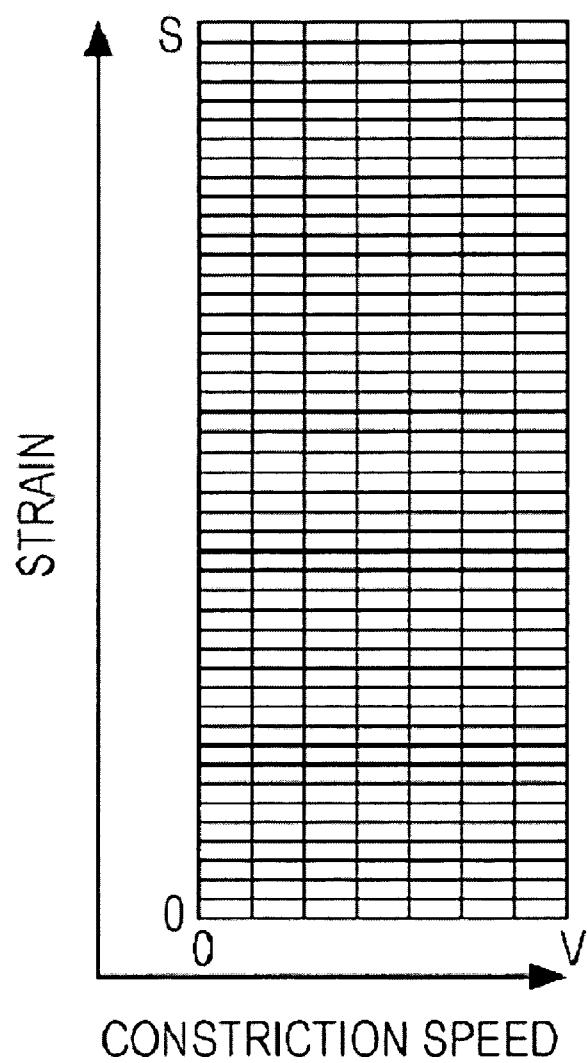


Fig. 2B

E01

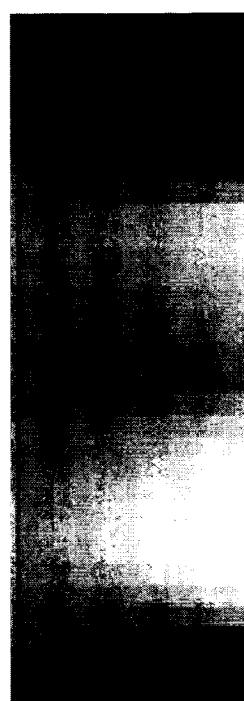


Fig. 3A

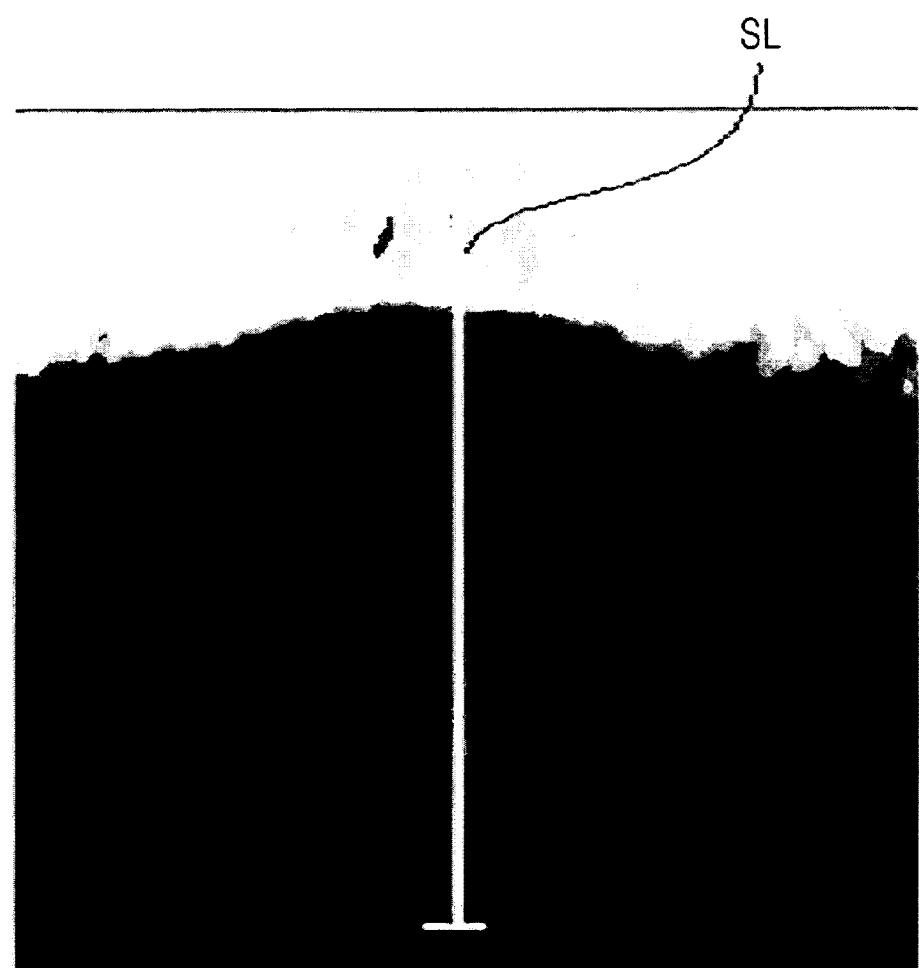


Fig. 3B

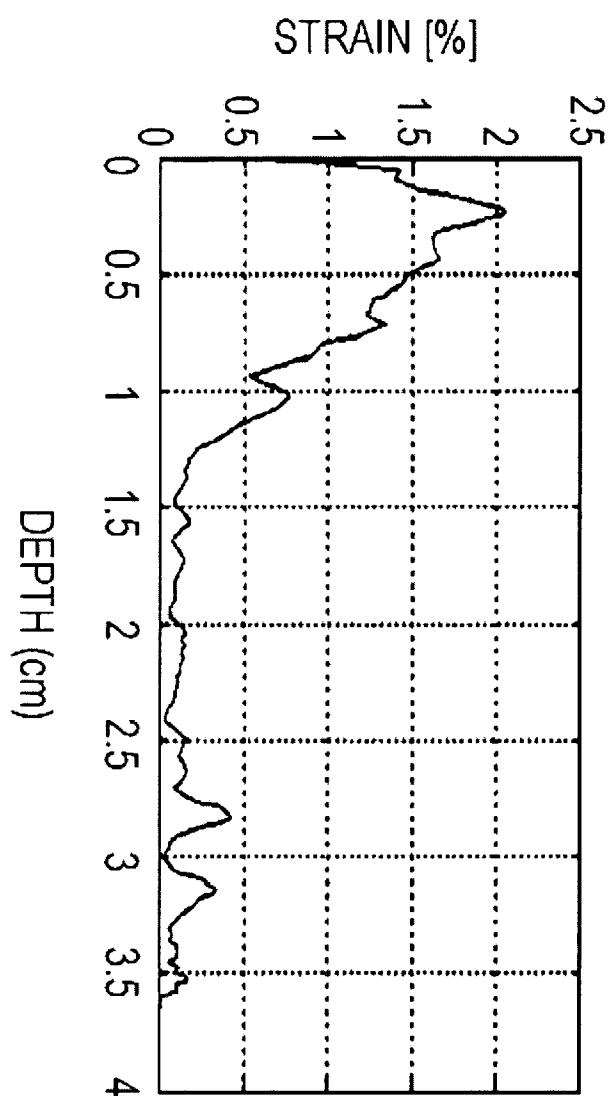


Fig. 4

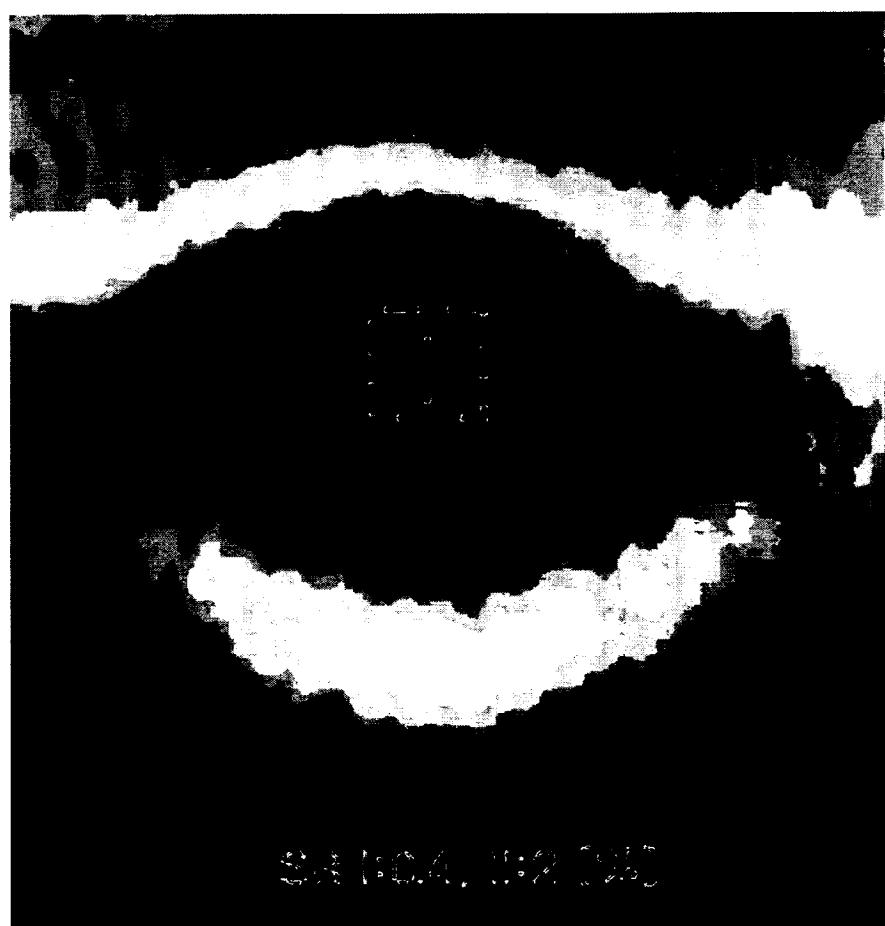


Fig. 5

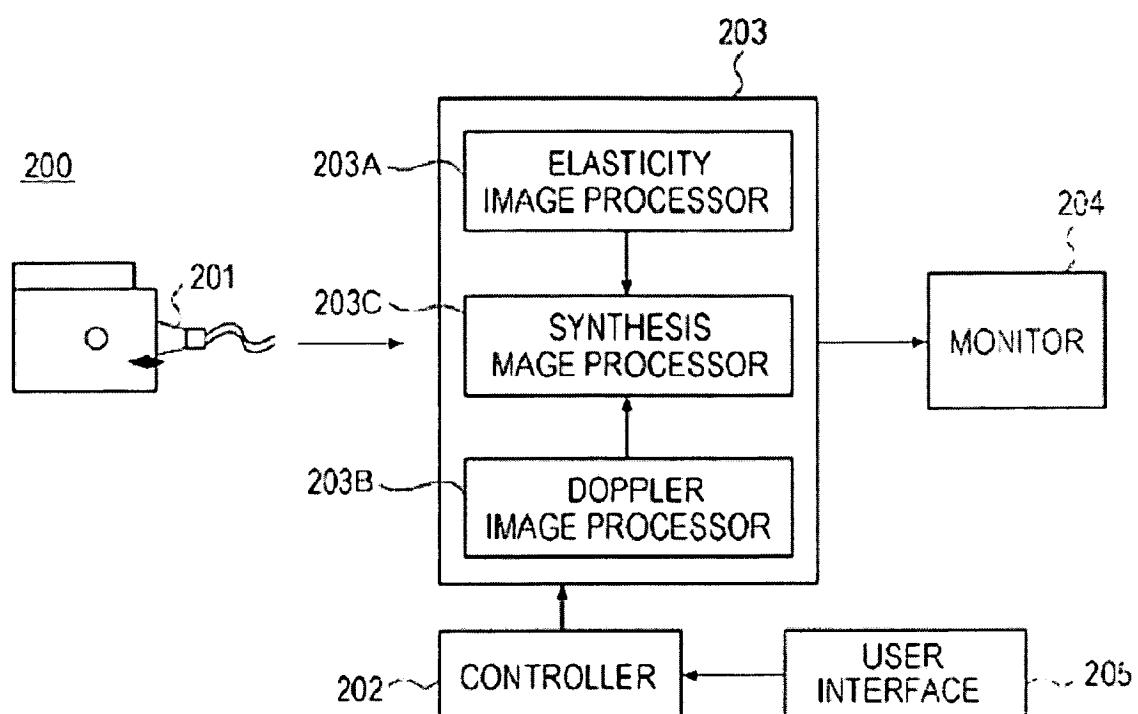


Fig. 6

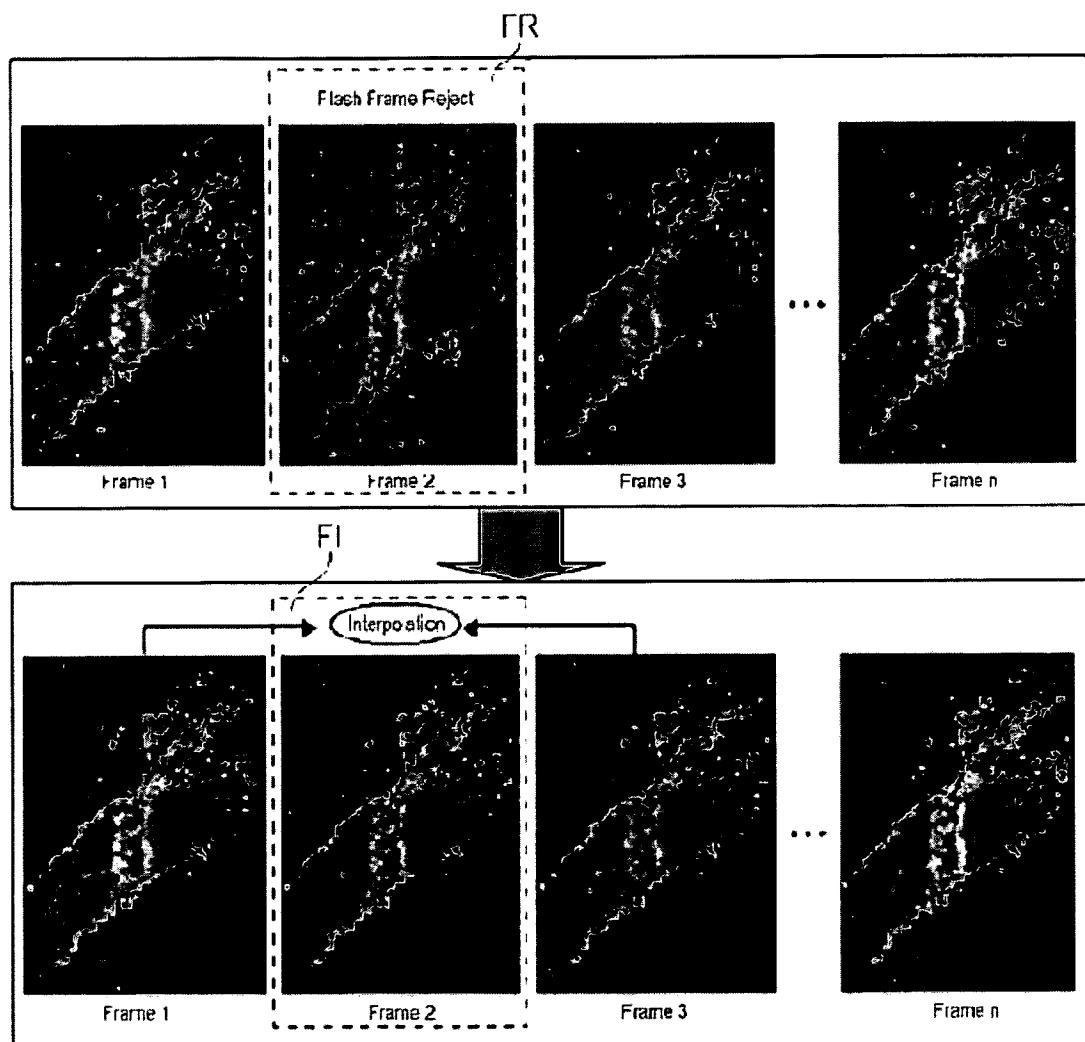


Fig. 7

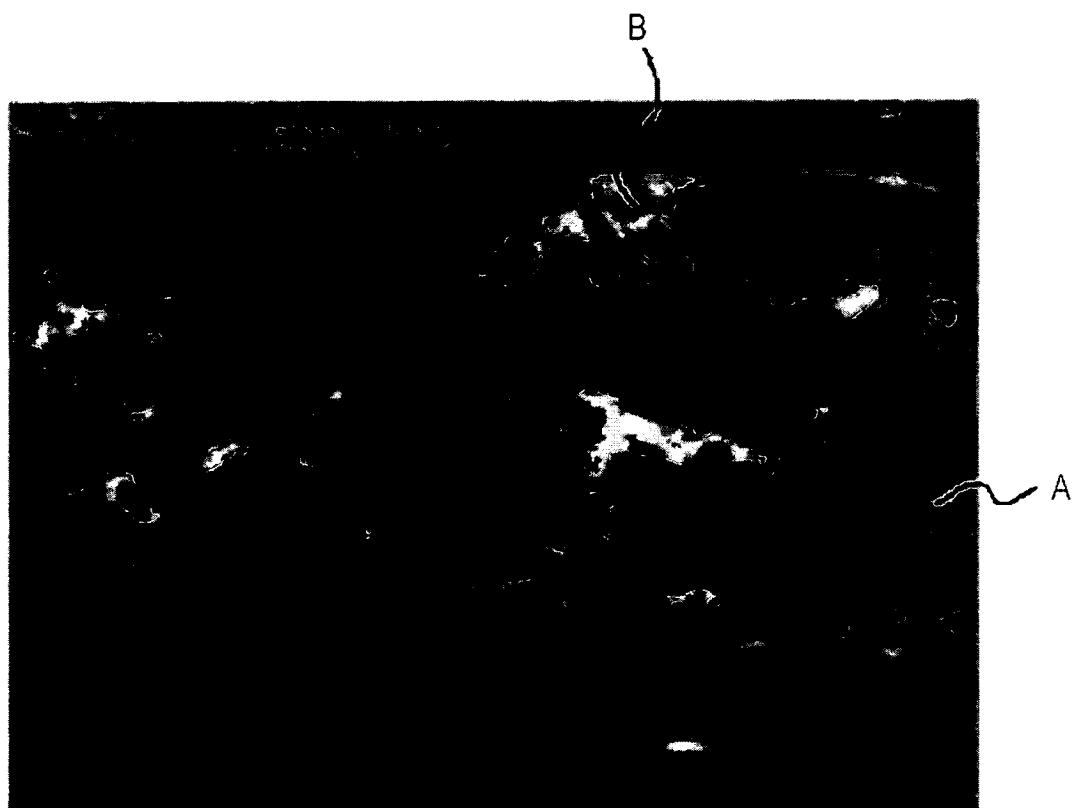


Fig. 8



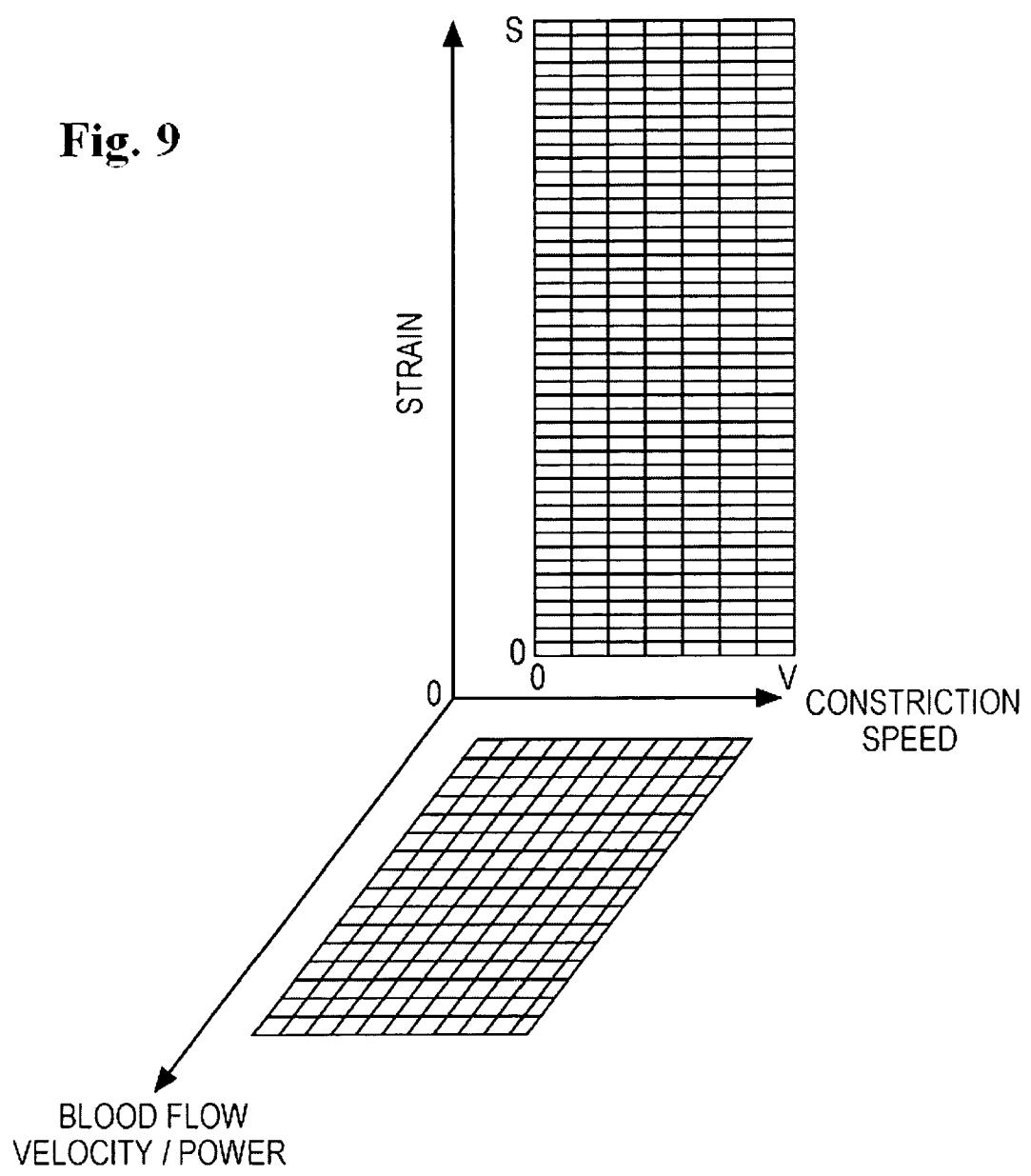
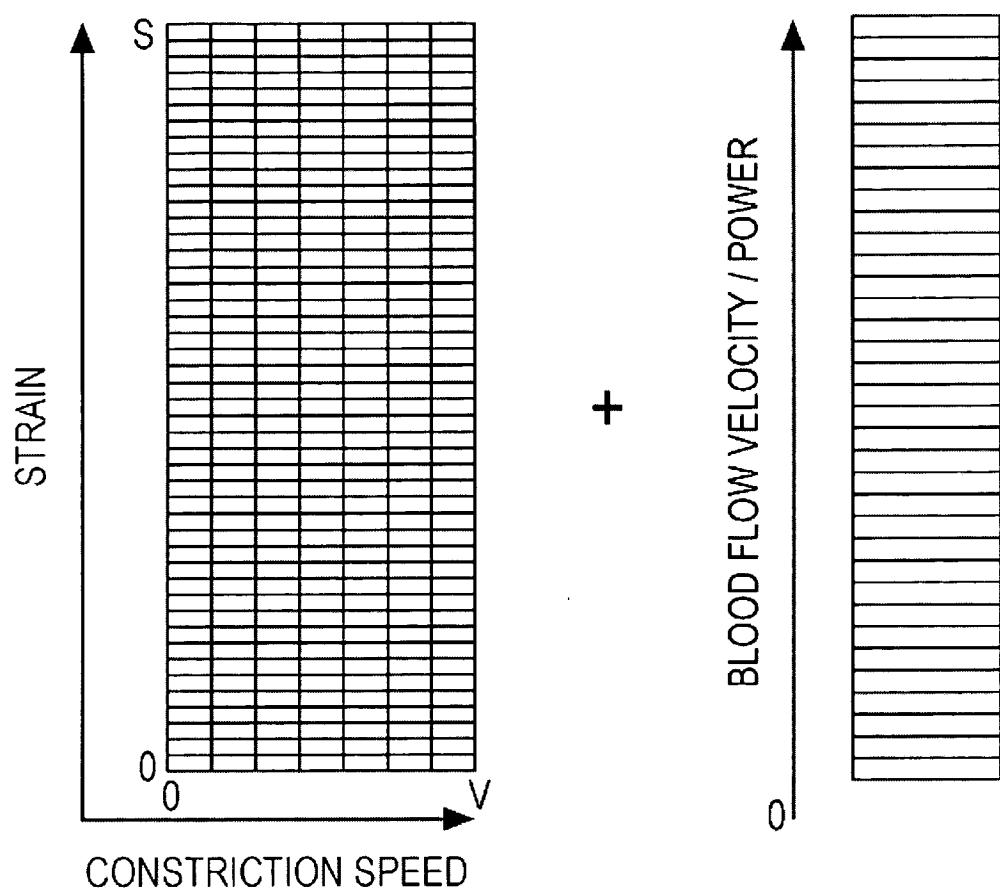


Fig. 10



专利名称(译)	超声诊断系统，用于为弹性图像提供附加信息		
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摘要(译)

提供了一种超声诊断系统，其适于向弹性图像提供附加信息。超声诊断系统包括：探测器，用于接收来自目标对象的回波信号，探测器被配置为将用户施加的压力传递到目标对象；弹性图像处理器，用于在施加压力之前和之后基于每个回波信号产生弹性图像和与其相关的附加信息；以及用于显示从弹性图像处理器输入的弹性图像和附加信息的显示器。附加信息包括弹性图像映射和介质的应变比。弹性图像处理器基于施加压力之前和之后的回波信号计算应变比，并基于应变比和帧速率计算收缩速度，弹性图像处理器被配置为形成弹性图像映射，其示出了之间的关系。收缩速度和应变比。

Fig. 1

