US 20190159762A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2019/0159762 A1

Li (43) Pub. Date: May 30, 2019

(54) SYSTEM AND METHOD FOR ULTRASOUND ELASTOGRAPHY AND METHOD FOR DYNAMICALLY PROCESSING FRAMES IN REAL TIME

(71) Applicant: **Shenzhen Mindray Bio-Medical Electronics Co., Ltd.**, Shenzhen (CN)

(72) Inventor: **Shuangshuang Li**, Shenzhen (CN)

(21) Appl. No.: **16/262,665**

(22) Filed: **Jan. 30, 2019**

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/724,683, filed on May 28, 2015, which is a continuation of application No. PCT/CN2013/083880, filed on Sep. 22, 2013.

(30) **Foreign Application Priority Data**

Nov. 28, 2012 (CN) 201210495184.4

Publication Classification

(51) **Int. Cl.**

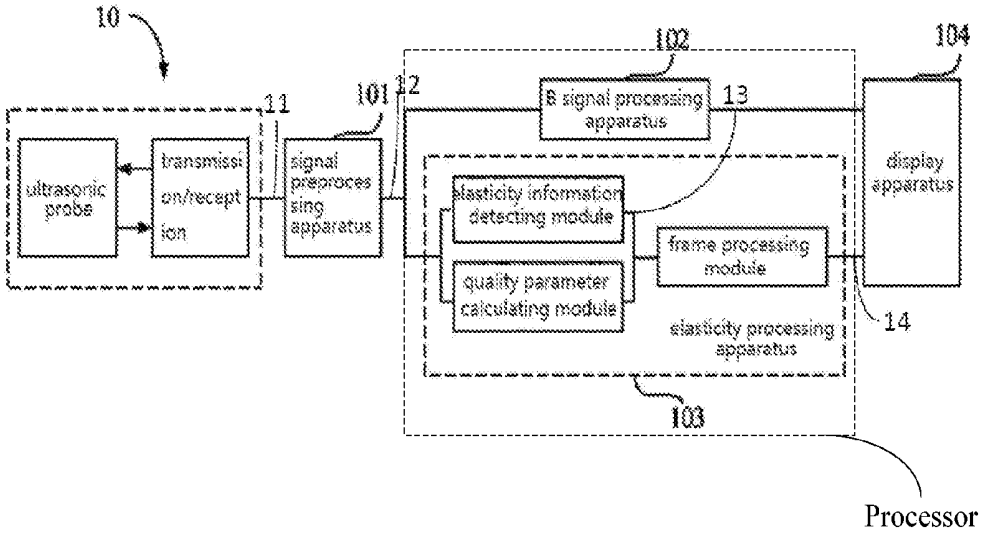
A61B 8/08	(2006.01)
A61B 8/14	(2006.01)
A61B 8/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 8/485*** (2013.01); ***A61B 8/463*** (2013.01); ***A61B 8/5223*** (2013.01); ***A61B 8/14*** (2013.01)

(57) **ABSTRACT**

Disclosed are a system and a method for ultrasound elastography and a method for dynamically processing frames in real time. The system includes an elasticity processing apparatus having an elasticity information detecting module for extracting elasticity information representing the elasticity of a target to be detected; a quality parameter calculating module for calculating at least a quality parameter reflecting quality of each elasticity image corresponding to the elasticity information; and a frame processing module for determining whether to output corresponding elasticity image based on the quality parameter of each elasticity image. When calculating a strain of consecutive images, the parameter reflecting the quality of each image is also computed, through which, the current elasticity image is determined whether to be displayed, thus avoiding the situation that colors of acquired successive elasticity images may vary greatly due to large difference existing in stress.



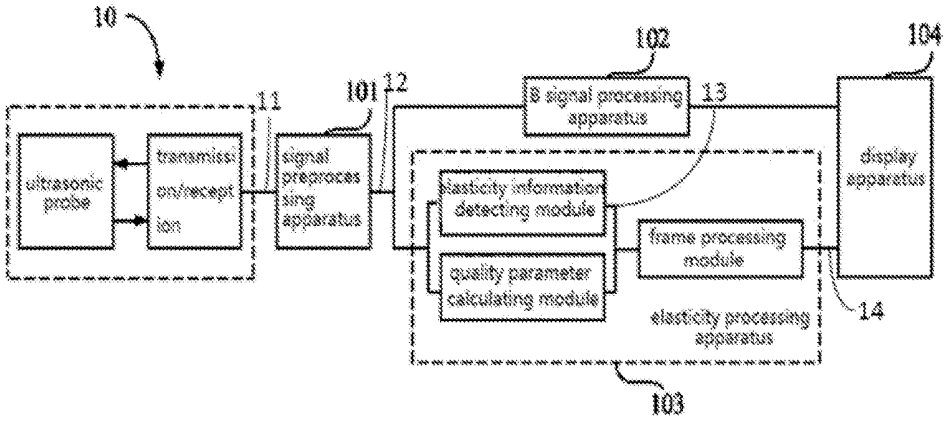

10
11
101
12
102
104
13
ultrasonic probe
transmiss
on/recept
ion
signal
preproces
sing
apparatus
B signal processing apparatus
display apparatus
elasticity information detecting module
frame processing module
quality parameter calculating module
elasticity processing apparatus
14
103

FIG. 1A

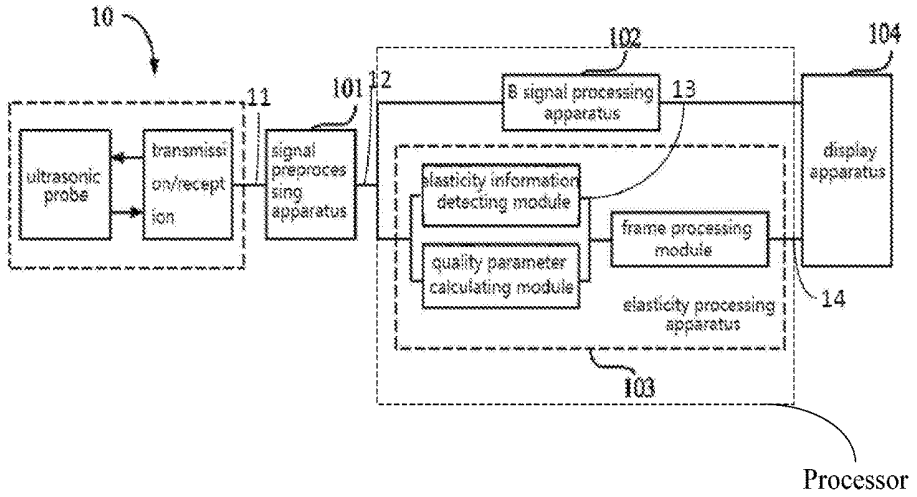

10
11
101
12
102
104
13
ultrasonic probe
transmiss
on/recept
ion
signal
preproces
sing
apparatus
B signal processing apparatus
display apparatus
elasticity information detecting module
frame processing module
quality parameter calculating module
elasticity processing apparatus
14
103
Processor

FIG. 1B

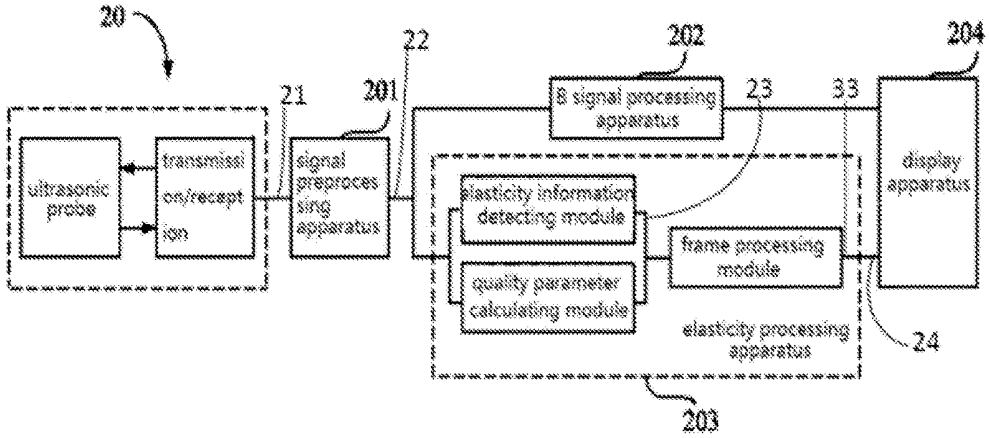


Figure 2A

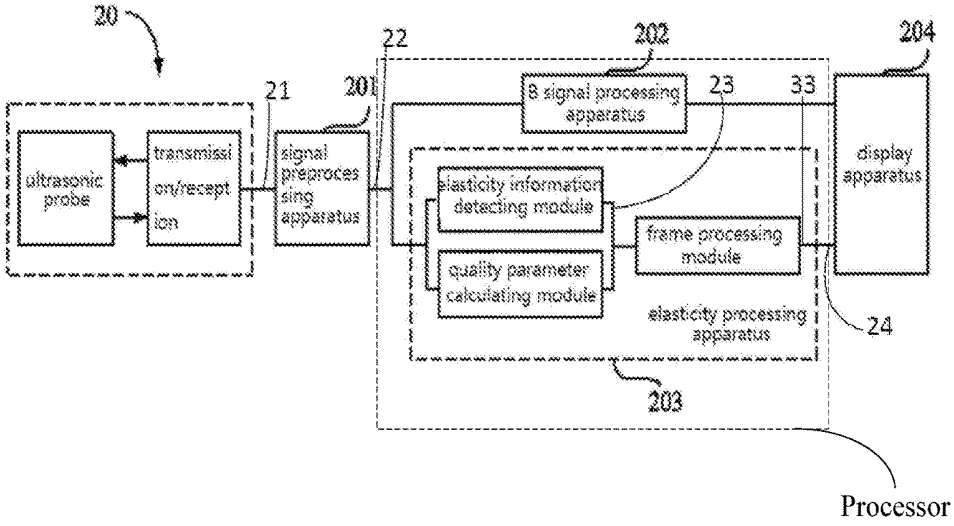


FIG. 2B

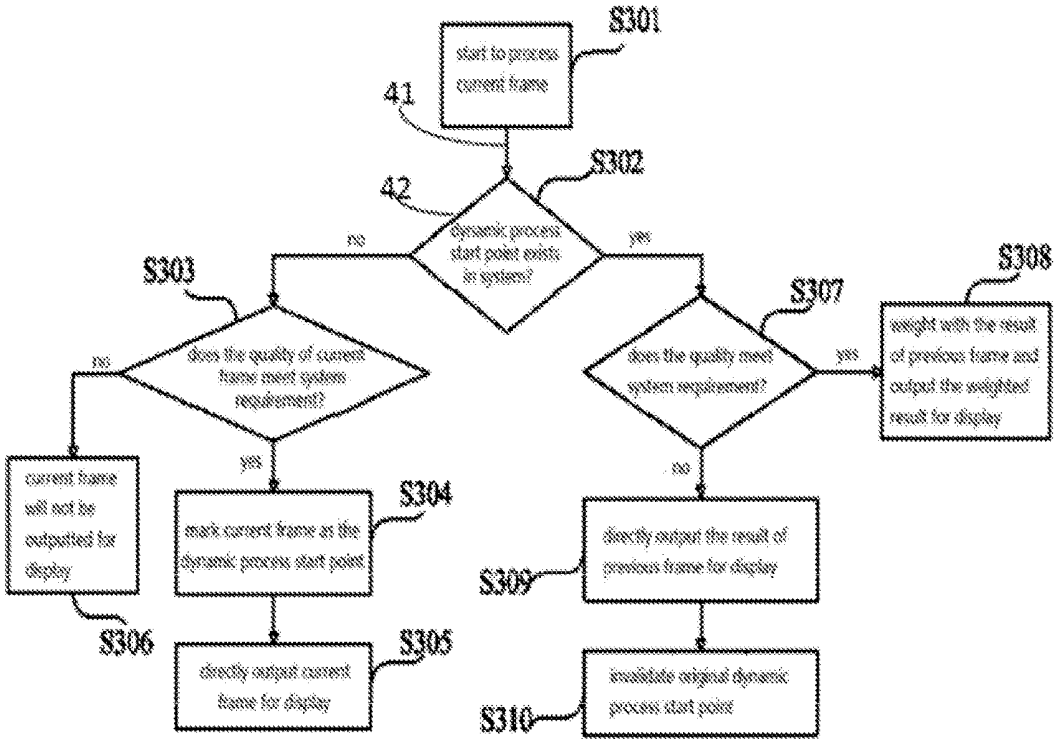

S301
start to process current frame
41
S302
42
dynamic process start point exists in system?
no
yes
S303
does the quality of current frame meet system requirement?
S307
does the quality meet system requirement?
S308
weight with the result of previous frame and output the weighted result for display
no
yes
current frame will not be outputted for display
S306
mark current frame as the dynamic process start point
S304
directly output current frame for display
S305
directly output the result of previous frame for display
S309
invalidate original dynamic process start point
S310

FIG. 3

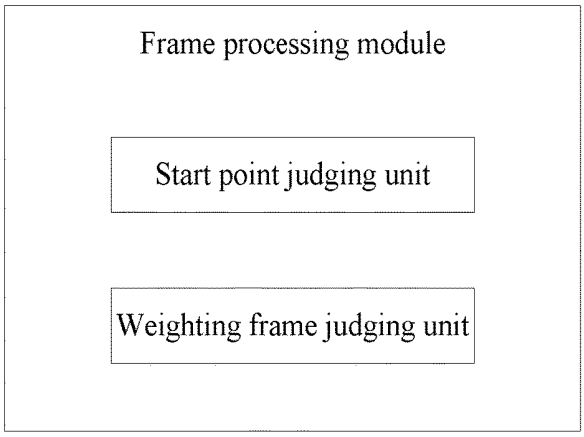

Frame processing module
Start point judging unit
Weighting frame judging unit

FIG. 4

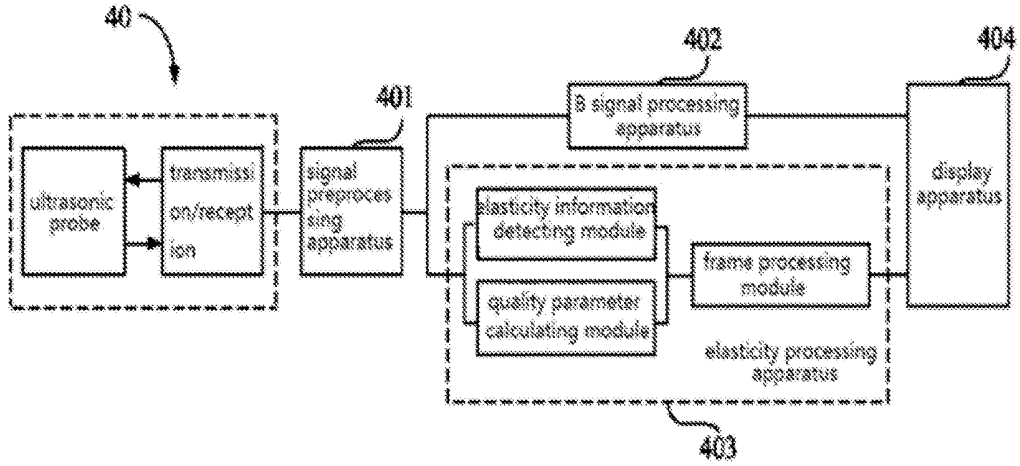

40
401
402
404
ultrasonic probe
transmissi on/recept ion
signal preproces sing apparatus
B signal processing apparatus
display apparatus
elasticity information detecting module
quality parameter calculating module
frame processing module
elasticity processing apparatus
403

FIG. 5A

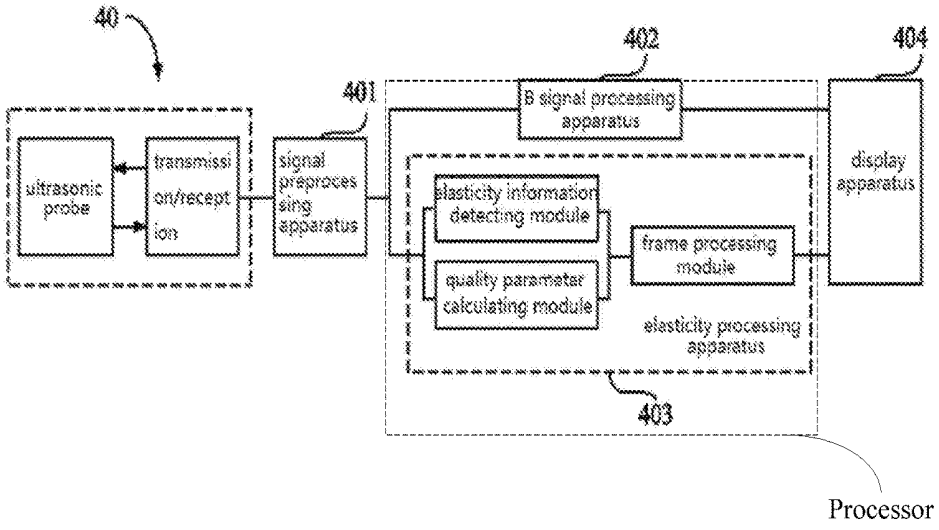

40
401
402
404
ultrasonic probe
transmissi on/recept ion
signal preproces sing apparatus
B signal processing apparatus
display apparatus
elasticity information detecting module
quality parameter calculating module
frame processing module
elasticity processing apparatus
403
Processor

FIG. 5B

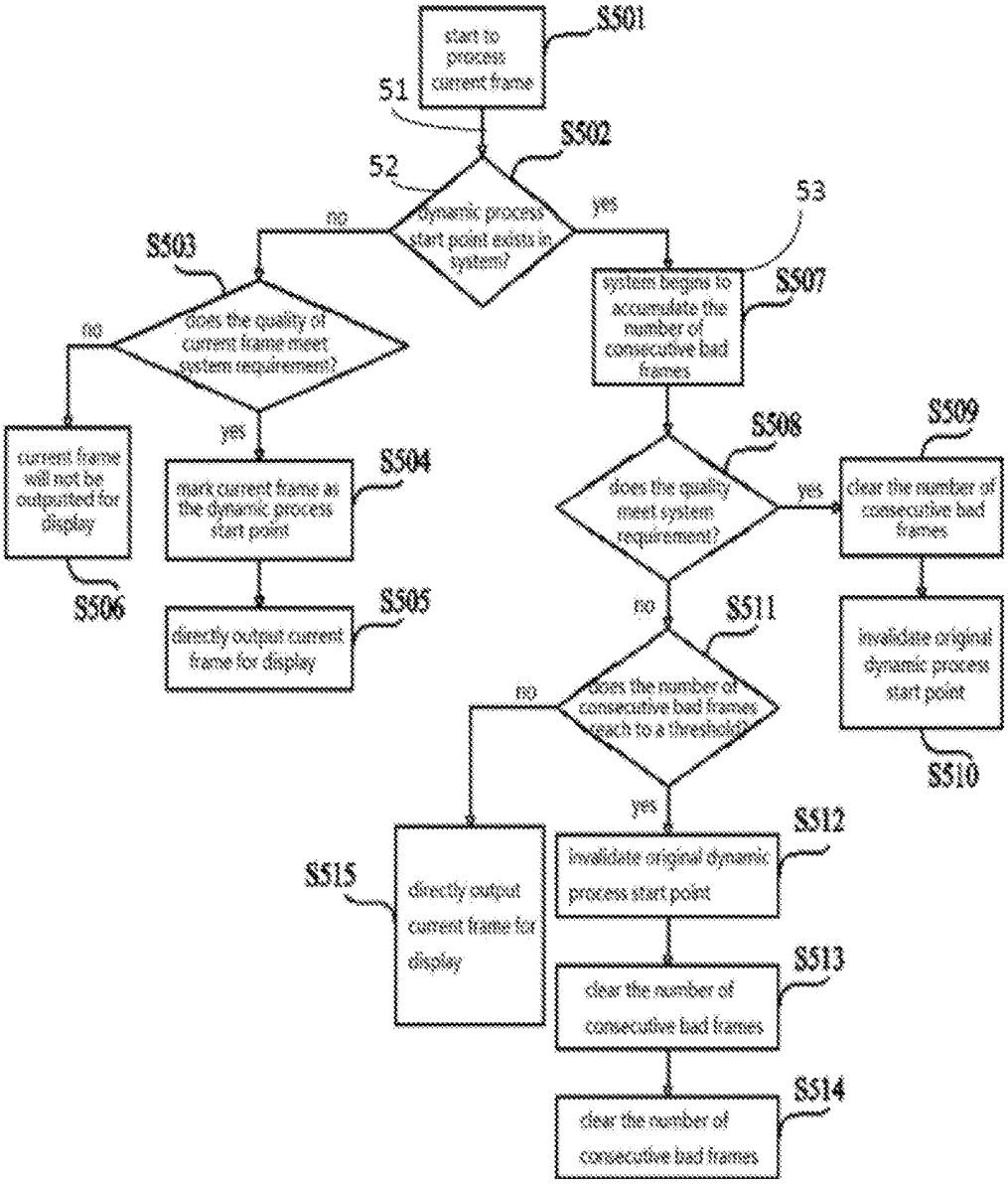

start to process current frame
S501
51
S502
52
dynamic process start point exists in system?
no
yes
53
S503
system begins to accumulate the number of consecutive bad frames
S507
does the quality of current frame meet system requirement?
no
yes
current frame will not be outputted for display
S506
mark current frame as the dynamic process start point
S504
directly output current frame for display
S505
S508
does the quality meet system requirement?
yes
S509
clear the number of consecutive bad frames
invalidate original dynamic process start point
S510
no
S511
does the number of consecutive bad frames reach to a threshold?
no
yes
S515
directly output current frame for display
S512
invalidate original dynamic process start point
S513
clear the number of consecutive bad frames
S514
clear the number of consecutive bad frames

FIG. 6

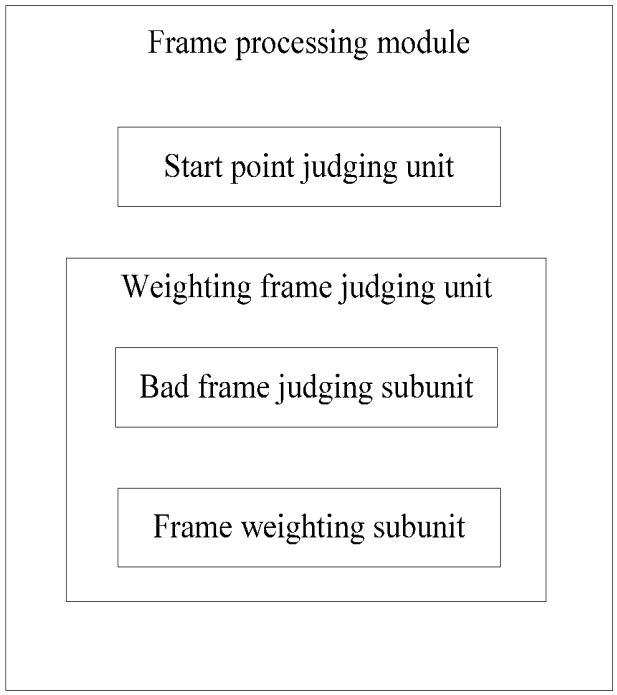

Frame processing module
Start point judging unit
Weighting frame judging unit
Bad frame judging subunit
Frame weighting subunit

FIG.7

SYSTEM AND METHOD FOR ULTRASOUND ELASTOGRAPHY AND METHOD FOR DYNAMICALLY PROCESSING FRAMES IN REAL TIME

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This is a continuation-in-part of U.S. patent application Ser. No. 14/724,683, filed on May 28, 2015, for "SYSTEM AND METHOD FOR ULTRASOUND ELASTOGRAPHY AND METHOD FOR DYNAMICALLY PROCESSING FRAMES IN REAL TIME," which is a continuation of Patent Cooperation Treaty Application No. PCT/CN2013/083880, filed on Sep. 22, 2013, which claims priority and benefit of Chinese Patent Application No. 201210495184.14, filed on Nov. 28, 2012. These applications are hereby incorporated by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to ultrasound imaging, and in particular to systems and methods for ultrasound elastography and methods for dynamically processing frames in real time in ultrasound imaging.

BACKGROUND

[0003] In ultrasound elastography, a commonly used ultrasound imaging technology, a target tissue is slightly compressed with a probe or a pressure is formed on the tissue by means of breathing or blood vessel to acquire two frames of an ultrasonic echo signal before and after the compression. A strain is generated along the direction of the compression within the tissue when the tissue is compressed, and the distribution of the strain in the tissue is varied due to uneven distribution of the Young's modulus inside the tissue. Thereafter, the strain of the tissue is detected through one or more techniques and outputted to an interface in the form of an image to help a doctor to diagnose or treat illnesses, such as breast cancer. Since the strain is inversely related to the Young's modulus under a pressure (or stress), for different soft tissues, the strain variations therebetween may reflect the dissimilarity of the Young's modulus therebetween, i.e., the elasticity difference. By use of an atlas (e.g., gray atlas or color atlas) for mapping, different strain values correspond to different colors, so that a qualitative judgment on the hardness of different soft tissues can be obtained through strain image to help in clinical diagnoses. Thus, ultrasound elastography is also known as strain imaging.

[0004] However, for a same tissue, the strain may be varied due to different stresses. Within a certain range, the greater the stress, the greater the strain. During one operation of compressing and relaxing the tissue evenly, the stress corresponding to every elasticity image may not be constant, and sometimes may even be quite different due to unfamiliar operation of a probe. Therefore, the colors can vary greatly among the acquired successive elasticity images (or strain images). In addition, too much stress may lead to too large deformation of the tissue and decreased correlation between two frames of the ultrasonic echo signal obtained before and after the compression, thus resulting in inaccurate calculated strain values. Less stress can lead to too small deformation of the tissue, which may be lower than the resolution of echo detected by an ultrasound system, thus resulting in poor image contrast. Accordingly, the elasticity images may be displayed unstably, which can cause difficulty in clinical judgment on the hardness of the tissue.

SUMMARY

[0005] The present disclosure provides a system and a method for ultrasound elastography, and a method for dynamically processing frames in real time in ultrasound imaging.

[0006] According to one aspect of the present disclosure, a system for ultrasound elastography is provided, including an elasticity processing apparatus for performing an elasticity process to received signals. The elasticity processing apparatus may include: an elasticity information detecting module for extracting elasticity information representing the elasticity of a target to be detected; a quality parameter calculating module for calculating at least a quality parameter reflecting quality of each elasticity image corresponding to the elasticity information; and a frame processing module for determining whether to output corresponding elasticity image based on the quality parameter of each elasticity image.

[0007] According to another aspect of the present disclosure, a method for ultrasound elastography is provided, having an elasticity processing step for extracting elasticity information representing the elasticity of a target to be detected from received signals, calculating at least a quality parameter reflecting quality of each elasticity image corresponding to the elasticity information, and determining whether to output corresponding elasticity image based on the quality parameter of each elasticity image.

[0008] According to yet another aspect of the present disclosure, a method for dynamically process frames in real time in ultrasound imaging is provided, including: calculating at least a quality parameter reflecting the quality of each image; judging whether there exists a dynamic process start point frame. The dynamic process start point frame may be defined as a frame with quality parameter meeting preset quality requirement. If no dynamic process start point frame exists, judging whether the quality parameter of current image meets the preset quality requirement. If the quality parameter of current image fails to meet the preset quality requirement, the current image is not outputted; if the quality parameter of current image meets the preset quality requirement, the current image is outputted and regarded as the dynamic process start point frame. If the dynamic process start point frame exists, according to the result of judging whether the quality parameter of current image meets the preset quality requirement, determining whether to weight the current image and previous image and output the weighted result.

[0009] In the present disclosure, when calculating a strain of consecutive images, the parameter reflecting the quality of each image can also be computed, through which, the current elasticity image can be determined whether to be displayed. With no current elasticity image outputted, a message of recollecting images due to improper operation can be provided to a user; while with output the previous image as the current image, the displayed image can be an image with quality that meets preset requirement, thus avoiding the situation that colors of acquired successive elasticity images may vary greatly due to large difference existing in stress.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIGS. **1**A and **1**B are schematic block diagrams of a system for ultrasound elastography;

[0011] FIGS. **2**A and **2**B are schematic block diagrams of a system for ultrasound elastography;

[0012] FIG. **3** is a schematic flow chart related to frame processing module of the embodiment illustrated in FIGS. **2**A and **2**B;

[0013] FIG. **4** is a schematic block diagram for a frame processing module;

[0014] FIGS. **5**A and **5**B are schematic block diagrams of a system for ultrasound elastography; and

[0015] FIG. **6** is a schematic flow chart related to frame processing module of the embodiment illustrated in FIGS. **5**A and **5**B.

[0016] FIG. **7** is another schematic block diagram for a frame processing module.

DETAILED DESCRIPTION

[0017] The present disclosure will be further described by the following detailed description of specific embodiments with the accompanying drawings.

First Embodiment

[0018] A system **10** for ultrasound elastography of this embodiment schematically shown in FIG. **1** a may includes an ultrasonic probe, a signal preprocessing apparatus **101**, a B signal processing apparatus **102**, an elasticity processing apparatus **103** and a display apparatus **104**. The probe can emit an ultrasonic beam and receive ultrasonic echo signals based on a predefined scanning rule. The received echo signals can be preprocessed by the signal preprocessing apparatus **101**, wherein the signal preprocessing may include beam forming process, and processes like signal amplification, analog-to-digital conversion and orthogonal decomposition can also be included. Radio frequency (RF) signal outputted by the signal preprocessing apparatus **101** can be passed to a plurality of parallel processing apparatuses including the B signal processing apparatus **102** and the elasticity processing apparatus **103**, as well as other parallel processing modules such as flow signal processing module. The plurality of parallel processing apparatuses can be implemented by a processor. Image signals parallel processed by the B signal processing apparatus **102** and the elasticity processing apparatus **103** can be sent to the display apparatus **104** for outputting and displaying. The display apparatus **104** may display corresponding content based on a user's selection, for example, only displaying gray image of human tissue processed by the B signal processing apparatus **102**, or only displaying elasticity image reflecting elasticity information acquired through the elasticity processing apparatus **103**, or simultaneously displaying both the gray image and the elasticity image. In this embodiment, the emission and reception of the probe, the signal preprocessing apparatus, the B signal processing apparatus and the display apparatus can be realized by related techniques. Other processing apparatuses known to those skilled in the art can also be added, which will not be described in detail herein. Of course, the B signal processing apparatus can be omitted in the system of this embodiment. The elasticity processing apparatus **103** may comprise an elasticity information detecting module, a quality parameter calculating module and a frame processing module.

[0019] The elasticity information detecting module can be configured to extract elasticity information representing the elasticity of a target to be detected, which can be realized by a variety of conventional methods of extracting elasticity information. For example, a commonly used method for extracting elasticity information can be implemented based on cross-correlation between RF signals, which is achieved by rapidly detecting the displacement between two adjacent frames of RF signals with sum of absolute difference (SAD), and then calculating a gradient along longitudinal direction (i.e., the propagation direction of the ultrasonic wave) on the displacement field to acquire strain information. Other ways to detect displacement can be adopted, such as sum of squared difference (SSD), and so on. The elasticity information obtained by the elasticity information detecting module can finally be displayed, that is, the strain information may be outputted for obtaining an elasticity image, thereby achieving visually distinguishing tissues having different elasticity features.

[0020] The quality parameter calculating module can be configured for calculating at least a quality parameter reflecting the quality of each elasticity image (i.e. elasticity information). Here, the quality of each elasticity image can represent the reliability of each elasticity image, such that a reliable elasticity image can be outputted to a user through the display apparatus. The calculation of the quality parameter can be performed simultaneously when detecting the elasticity information. The quality parameter of the embodiment may include a parameter representing deformation degree or a deformation degree parameter for short and/or a parameter representing quality detected based on cross correlation or a cross correlation detecting quality parameter for short.

[0021] (1) Deformation Degree Parameter

[0022] For the elasticity information detecting module, with too small deformation of the tissue, the displacement may be too small, affecting signal noise ratio (SNR) of the images; while with too large deformation of the tissue, the correlation between both signals obtained before and after the compression may be weakened, leading to increased inaccuracy of detecting the elasticity information. In addition, during acquiring image signals by the probe, the compression operation exerted on the tissue by the probe may be a continuous process. In a continuous compression operation on a tissue, the strain information of elasticity may be varied due to different deformations of the tissue, leading to great difference generated among adjacent multiple elasticity images and unstable images. Therefore, the deformation degree parameter may be regarded as one of the parameters used to evaluate each elasticity image in this embodiment.

[0023] The deformation degree parameter may be an average strain value corresponding to the current elasticity image calculated in real time, that is, computing the average value of the strain data from a region of interest (ROI) of the current frame or from each sampling position within the whole scanning planar region, thus obtaining the average strain value Strain_mean. If the average strain value Strain_mean is within a range specified by the system (for example Strain_mean is less than a preset threshold based on experience), it may represent that the deformation degree is proper.

[0024] (2) Cross Correlation Detecting Quality Parameter

[0025] Since the elasticity information detecting module can detect the displacement based on the cross correlation between two adjacent frames of ultrasonic echo signals and acquire the longitudinal gradient based on the displacement to obtain the strain information, the accuracy of the displacement may play a role in the accuracy of the strain information, which eventually affects the SNR and contrast of the elasticity image. With larger cross correlation between two frames of signals, the detected SNR may be higher and the detected result may be more accurate. If both frames of signals are almost uncorrelated to each other, the detected result may be inaccurate. In this aspect, the cross correlation detecting quality parameter may be regarded as one of the parameters used to evaluate each elasticity image in this embodiment. The cross correlation detecting quality parameter may be a score of the current frame acquired by corresponding scoring rule selected by the method of displacement detection adopted in the elasticity information detecting module.

[0026] During detecting the displacement, for a signal at a sampling position in one frame of the ultrasonic echo signals, it may be needed to search the most correlated position within a search area of another frame of the ultrasonic echo signals. Taking employment of SAD to determine cross correlation as an example, the most correlated position can be the position corresponded to the least SAD value, and the difference between the position and corresponding original sampling position can be the displacement of the sampling position, which is similar to the techniques employed in conventional image matching methods. It can be appreciated that, when adopting SSD to determine the cross correlation, the most correlated position corresponds to the least SSD value and when adopting correlation coefficient (CC) to determine the cross correlation, the most correlated position corresponds to the greatest CC value.

[0027] The cross correlation detection parameter is described here with example of using SAD to determine cross correlation. For every sampling position of each frame, the maximal SAD value SAD_max and the minimal SAD value SAD_min corresponding to every position within a search area may be recorded, and the quality score of the search area can be computed by:

[0028] I. presetting upper and lower limits of the distribution of SAD in the system, i.e., [SAD_Low, SAD_High], and SAD_Low<SAD_High; SAD_Low and SAD_High values can be predetermined by performing ultrasound elastography on a model tissue. For example, the user can compress the model tissue with too large or too small compression force to obtain the SAD_HIGH and SAD_LOW values. In some embodiments, the user can manually enter two values before ultrasound elastography, and the ultrasound system may then calculate the score_SAD using the entered values as temporary SAD_HIGH and SAD_LOW values. When the user decides that the target in the elasticity image is clear enough to match his/her quality requirement, the entered values can be set as the SAD_HIGH and SAD_LOW values of the system. In this way, a specific range defined by the SAD_HIGH and SAD_LOW values can be determined.

[0029] II. calculating a first score score1 having a value within [0,1] for evaluating the distance between the maximal SAD value of a position within current search area and the upper limit. The closer the distance, the higher the score. For example,

```
score1=(SAD_max-SAD_min)/(SAD_High-SAD_
    min);
```

[0030] III. calculating a second score score2 having a value within [0, 1] for evaluating the distance between the minimal SAD value of a position within current search area and the lower limit. The closer the distance, the higher the score. For example,

```
score2=(SAD_max-SAD_min)/(SAD_max-SAD_
    Low);
```

[0031] IV. weighting score1 and score2, and taking the weighted result as the quality score score_SAD of current search. For example, score_SAD=score1*p+score2*(1−p), where p is a preset parameter ranged with 0.about.1 in the system. The weighted result is a value within [0, 1]. Then score_SAD may be multiplied by 100 to be extended to the range of [0, 100]. Of course, the quality score can also be immune from being such extension or being extended to other intervals, which can be determined based on a user's customs.

[0032] V. averaging the quality scores of all sampling positions of current frame, and obtaining the final quality score Score_mean of the frame. The higher the score, the better the quality of the search. There can be a preset score threshold in the system. If the score is higher than the threshold, the detected displacement of the frame may satisfy system requirements.

[0033] The aforesaid description refers to the method for detecting displacement based on SAD. With the foregoing description, those skilled in the art can appreciate that other methods for detecting displacement can be employed according to the actual to select corresponding scoring method for scoring the quality detected by cross correlation. The detailed computing steps about scoring mentioned above is for purpose of clear explanation that the object of the present disclosure is to score the cross correlation detection quality, not to limit the present disclosure. Further, the mentioned preset score threshold, the upper and lower limits of the distribution of SAD, the preset parameters and so on can be automatically set by the ultrasound system, or be directly set by a user through a user interface.

[0034] In one embodiment, any one of the deformation degree parameter and the cross correlation detecting quality parameter, or the combination thereof, can be adopted to determine whether the quality parameter of current frame meets the system requirement, that is, when the absolute value of the calculated Strain_mean is within a range specified by the system and the value of Score_mean is higher than a score threshold specified by the system, the quality parameter of the current frame may meet the system requirement.

[0035] After performing the elasticity information detecting module and the quality parameter calculating module, the elasticity information and the quality parameters of every consecutive frame may be sent to the frame processing module in real time for enhancing the stability among the frames. The frame processing module may be configured for determining whether to output the corresponding elasticity image based on the quality parameter of the elasticity information of each frame. In some embodiments, it is determined whether the quality parameter meets a preset

quality requirement, where the preset quality requirement may refer to that a deformation degree parameter, e.g., an average strain value, is within a first acceptable range, and/or a cross correlation detecting quality parameter, e.g., a score value detained described below, is within a second acceptable range. The first acceptable range may be predefined by performing ultrasound elsatography on a model. The second acceptable range may also be predefined by performing ultrasound elsatography on a model. For example, the second acceptable range may be defined by SAD_HIGH and SAD_LOW. In some embodiments, the second acceptable range may be a value of [0, 1].

[0036] The method for determining whether to output elasticity image in the frame processing module in the embodiment may comprise: if the quality parameter of the current frame to be processed fails to meet the preset quality requirement of the system, for example, the absolute value of the average strain value Strain_mean is outside a range specified by the system, or the score value Score_mean of the cross correlation detecting quality parameter is lower than a score threshold specified by the system, then the frame processing module may not output the elasticity image of current frame to the display apparatus, or may output the qualified elasticity image of previous frame as the elasticity image of current frame to the display apparatus.

[0037] The condition where the elasticity image of current frame is not outputted implies that it may be needed to recollect image(s) due to a user's improper operation. The condition where the elasticity image of previous frame is displayed as the elasticity image of current frame may mean that all the displayed images may have qualities that meet a preset requirement, thereby avoiding the situation that colors of the acquired successive elasticity image vary due to large difference existing in the stress, and finally improving the stability of the elasticity images, which may simplify the recognition or judgment of elasticity image in clinical practice.

[0038] One embodiment of the method for ultrasound elastography in the present disclosure corresponds to the aforesaid embodiment of the system for ultrasound elastography. The method may comprise:

[0039] a transmitting and receiving step **11** for emitting an ultrasonic beam and receiving ultrasonic echo signals by a probe based on a predefined scanning rule under elasticity imaging mode;

[0040] a signal preprocessing step **12** for preprocessing the received ultrasonic echo signals, the signal preprocessing including beam forming process;

[0041] an elasticity processing step **13** for extracting elasticity information reflecting the target to be detected, computing the quality parameter reflecting the quality of each elasticity image corresponding to the elasticity information, and according to the quality parameter of each elasticity image, determining whether to output the corresponding elasticity image;

[0042] a display step **14** for displaying the outputted image.

[0043] The above steps can be implemented with reference to the corresponding modules described in the aforesaid embodiment of the system for ultrasound elastography, which will not be repeated herein. Further, the abovementioned method embodiment can also comprise a step of processing B signal for generating a gray image of the target to be detected.

Second Embodiment

[0044] A system **20** for ultrasound elastography of this embodiment schematically shown in FIG. **2***a* may comprise: an ultrasonic probe, a signal preprocessing apparatus **201**, a B signal processing apparatus **202**, an elasticity processing apparatus **203** and a display apparatus **204**.

[0045] The ultrasonic probe, the signal preprocessing apparatus **201**, the B signal processing apparatus **202** and the display apparatus **204** may be similar to the ultrasonic probe, the signal preprocessing apparatus **101**, the B signal processing apparatus **102** and the display apparatus **104** in the first embodiment respectively, which will not be repeated herein. The elasticity processing apparatus **203** still may comprise an elasticity information detecting module, a quality parameter calculating module and a frame processing module. The elasticity information detecting module and the quality parameter calculating module may be similar to the elasticity information detecting module and the quality parameter calculating module in the first embodiment respectively, which will also not to be described herein. The frame processing module of the elasticity processing apparatus **203** in the embodiment may also be configured for according to the quality parameter of each elasticity image, determining whether to output the elasticity image of corresponding frame, however, the way to determine whether to output the elasticity image is different from that in the first embodiment.

[0046] In this embodiment, the way to determine whether to output the elasticity image in the frame processing module may refer to several key steps, that is, the frame processing module may comprise a start point judging unit for determining a dynamic process start point in real time, a weighting frame judging unit for judging whether to weight frames. Furthermore, the result of dynamic inter frames process of previous frame, which is outputted for display, may need to be stored to assist the process of the current frame. Specifically, for the current frame passed into the frame processing module, if there is no dynamic process start point currently, it may be needed to search the dynamic process start point firstly. The method for judging dynamic process start point in real time needed to be performed now may comprise:

[0047] a) if the quality parameter of current frame fails to meet a predefined system requirement, the data of the current frame may not be outputted, that is, the elasticity image of the current frame may not be outputted;

[0048] b) if the quality parameter of current frame meets the predefined system requirement, that is, the absolute value of the calculated Strain_mean may be within a range specified by the system and at the same time the score of the cross correlation detecting quality parameter i.e. Score_mean is higher than a score threshold specified by the system, then the data of current frame may be outputted, and the current frame may be regarded as the dynamic process start point known as a start point frame. Each frame behind the current frame may need to be judged whether to be weighted.

[0049] The aforesaid judging the dynamic process start point may be performed when the system needs to search the start point (i.e. no searching start point or the original searching start point has been invalided), while the judgment on frame weighting may be performed after the system has found the dynamic process start point frame.

[0050] The method for determining whether to weight frames may be as follows:

[0051] A) if the quality parameter of current frame meets a preset system requirement, weighting the current frame and the result of the previous frame (i.e. previous image), outputting the weighted result and displaying the same. Weighting coefficients can be used to weight the current frame and the result of the previous frame, where the weighting coefficient of each frame of the current frame and the result of the previous frame may represent a percentage of each frame in the weighted result. In some embodiments, the weighting coefficients of both frames can be a value within [0, 1]. In some embodiments, the weighting coefficients of both frames can be specified by the system. In some embodiments, the system may provide several predefined weighting coefficients, so that a user can select from the several predefined weighting coefficients according to a desired image requirement. In a weighting method, provided that the result of previous frame is R(i−1), the data of current frame is D(i), where i represents the current frame number, k is the weighting coefficient specified by the system, then the result of weighted frames is:

$$R(i)=R(i-1)*k+D(i)*(1-k),$$

where, the more the weighting coefficient k is close to a value of 1, the result of weighted frame R(i) can be more stable.

[0052] B) if the quality parameter of current frame fails to meet the preset system requirement, outputting the result of previous frame as the data of current frame to the display apparatus, simultaneously invalidating the original dynamic process start point, and clearing the number of consecutive bad frames.

[0053] The specific process involved in the frame processing module shown in FIG. **3** may comprise:

[0054] a step S**301**, starting to process the inputted current frame,

[0055] a step S**302**, judging whether the system exists a dynamic process start point, if yes, turning to perform step S**307**, if no, turning to perform step S**303**,

[0056] a step S**303**, judging whether the quality parameter of current frame meets a quality requirement preset by the system, if yes, turning to perform step S**304**, if no, turning to perform step S**306**,

[0057] a step S**304**, marking the current frame as the dynamic process start point, and proceeding to perform step S**305**,

[0058] a step S**305**, directly outputting the data of current frame,

[0059] a step S**306**, not outputting the data of current frame. It can be understood that the step S**301** may be repeated to be performed after the step S**306**, that is, performing a new round of judgment on a new received and inputted frame.

[0060] a step S**307**, judging whether the quality parameter of current frame meets the system requirement, if yes, turning to perform step S**308**, if no, turning to perform step S**309**,

[0061] a step S**308**, weighting the current processing frame and the result of previous frame, and outputting the weighted result. It can be understood that, the step S**301** may be repeated after the step S**308**, that is, performing a new round of judgment on a new received and inputted frame.

[0062] a step S**309**, directly outputting the result of previous frame, and proceeding to perform step S**310**,

[0063] a step S**310**, invalidating the original dynamic process start point (that is at the next round of judgment, the current dynamic process start point may not be existed). It can be understood that, the step S**301** may be repeated after the step S**310**, that is, performing a new round of judgment on a new received and inputted frame.

[0064] Those skilled in the art can change the sequence of above steps without affecting the design of the above procedure, for example, the execution sequence of the step S**309** and the step S**310** can be reversed, or the step S**309** and step S**310** can be performed simultaneously at a specific implementation. Under the condition that there is no dynamic process start point in the system, nor the quality parameter of current frame satisfying system requirement, the elasticity image may not be displayed in the system, so as to inform a user to recollect image by adjusting his/her operation.

[0065] The frame process module of the embodiment is actually configured for searching a dynamic process start point, after finding the start point, based on the quality of the frame, selectively to perform whether to weight with the result of previous frame for outputting the weighted result or to directly output the result of previous frame, thus ensuring the quality of outputted image. If the image is originated from strain data having similar deformation degrees and accurate and reliable search result, the stability of the outputted image may be enhanced, thus simplifying the recognition or judgment of the elasticity image in clinical practice.

[0066] One embodiment of the method for ultrasound elastography in the present disclosure is similar to the aforesaid second embodiment of the system for ultrasound elastography. The method may comprise:

[0067] a step **21** for emitting an ultrasonic beam and receiving ultrasonic echo signals by a probe based on a predefined scanning rule under elasticity imaging mode;

[0068] a step **22** for processing the received ultrasonic echo signals, the signal preprocessing including beam forming process;

[0069] a step **23** for extracting the elasticity information reflecting the target to be detected, computing the quality parameter reflecting the quality of each elasticity image corresponding to the elasticity information, and according to the quality parameter of each elasticity image, determining whether to output the corresponding elasticity image, wherein when determining whether to output the elasticity image, several substeps may be adopted such as judging dynamic process start point in real time and judging whether to weight frames;

[0070] a step **24** for displaying the outputted image.

[0071] The above steps can be implemented with reference to the corresponding modules described in the aforesaid embodiment of the system for ultrasound elastography, which will not be repeated herein. Further, the abovementioned method embodiment can also comprise a step of processing B signal for generating a gray image of the target to be detected.

Third Embodiment

[0072] A system **40** for ultrasound elastography of this embodiment schematically shown in FIG. **5***a* may comprise: an ultrasonic probe, a signal preprocessing apparatus **401**, a

B signal processing apparatus **402**, an elasticity processing apparatus **403** and a display apparatus **404**.

[0073] The ultrasonic probe, the signal preprocessing apparatus **401**, the B signal processing apparatus **402** and the display apparatus **404** may be similar to the ultrasonic probe, the signal preprocessing apparatus **101**, the B signal processing apparatus **102** and the display apparatus **104** in the first embodiment respectively, which will not be repeated herein. The elasticity processing apparatus **403** still may comprise an elasticity information detecting module, a quality parameter calculating module and a frame processing module. The elasticity information detecting module and the quality parameter calculating module are similar to the elasticity information detecting module and the quality parameter calculating module in the second embodiment respectively, which will also not to be described herein. The frame processing module of the elasticity processing apparatus **403** in the embodiment can also be configured for according to the quality parameter of each elasticity image, determining whether to output the elasticity image of corresponding frame; however, unlike the second embodiment, the frame weighted judging unit here further may comprise a bad frame judging subunit for judging the number of consecutive bad frames and a frame weighting subunit for performing weighting. The method for real-time judging a dynamic process start point in the start point judging unit of the frame processing module is similar to that in the second embodiment, which will not be repeated herein. Similarly, the judgment of dynamic process start point mentioned above can be performed when the system needs to search the start point (i.e. no searching start point or the original searching start point has been invalided), while the judgment on frame weighting may be performed after the system has found the dynamic process start point frame. It can be understood that the result of the dynamic inter frames process of previous frame which is outputted for display needs to be stored to assist the process of the current frame.

[0074] Once the dynamic process start point is found out, from the start point frame, the number of consecutive bad frames failed to meet the system requirement may be needed to be accumulated to assist the process of subsequent frames. Here, the term "the number of consecutive bad frames" may refer to the number of consecutive frames with quality that fails to satisfy a preset quality requirement. Once a frame with quality satisfying the system requirement comes up, the number of consecutive bad frames may be cleared, followed with performing frame weighting. The number of consecutive bad frames may be re-accumulated when a frame with quality that fails to satisfy the system requirement comes up.

[0075] The method for determining whether to weight frames may be as follows:

[0076] A) if the quality parameter of current frame meets a preset system requirement, weighting the current frame and the result of the previous frame, outputting the weighted result and displaying the same. Weighting coefficients can be used to weight the current frame and the result of the previous frame, where the weighting coefficient of each frame of the current frame and the result of the previous frame may represent a percentage of each frame in the weighted result. In some embodiments, the weighting coefficients of both frames can be a value within [0, 1]. In some embodiments, the weighting coefficients of both frames can be specified by the system. In some embodiments, the system may provide several predefined weighting coefficients, so that a user can select from the several predefined weighting coefficients according to a desired image requirement. In a weighting method, provided that the result of previous frame is R(i−1), the data of current frame is D(i), where i represents the current frame number, k is the weighting coefficient specified by the system, then the result of weighted frames may be computed by:

$$R(i)=R(i-1)*k+D(i)*(1-k),$$

where, the more the weighting coefficient k is close to a value of 1, the result of weighted frame R(i) can be more stable.

[0077] B) if the quality parameter of current frame fails to meet the preset system requirement, it may be involved with determining the number of consecutive bad frames. There are two situations: (1) if the accumulated number of consecutive bad frames is less than a preset threshold (the preset threshold is set based on experience in an example), outputting the result of previous frame as the data of current frame; (2) if the accumulated number of consecutive bad frames is greater than the preset threshold, the system may not output the data of current frame, instead, it may invalidate the original dynamic process start point, search a dynamic process start point from the subsequent frames, and clear the number of consecutive bad frames; thus the above process is carried out in a dynamic cycle.

[0078] The specific process involved in the frame processing module shown in FIG. **6** may comprise:

[0079] a step S**501**, starting to process the inputted current frame,

[0080] a step S**502**, judging whether the system exists a dynamic process start point, if yes, turning to perform step S**507**, if no, turning to perform step S**503**,

[0081] a step S**503**, judging whether the quality parameter of current frame meets a quality requirement preset by the system, if yes, turning to perform step S**504**, if no, turning to perform step S**506**,

[0082] a step S**504**, marking the current frame as the dynamic process start point, and proceeding to perform step S**505**,

[0083] a step S**505**, directly outputting the data of current frame,

[0084] a step S**506**, not outputting the data of current frame. It can be understood that the step S**501** may be repeated after the step S**506**, that is, performing a new round of judgment on a new received and inputted frame.

[0085] a step S**507**, beginning to accumulate the number of consecutive bad frames, and proceeding step S**508**,

[0086] a step S**508**, judging whether the quality parameter of current frame meets the system requirement, if yes, turning to perform step S**509**, if no, turning to perform step S**511**,

[0087] a step S**509**, clearing the number of consecutive bad frames, and proceeding step S**510**,

[0088] a step S**510**, weighting the current processing frame and the result of previous frame, and outputting the weighted result. It can be understood that, the step S**501** may be repeated after the step S**510**, that is, performing a new round of judgment on a new received and inputted frame.

[0089] a step S**511**, judging whether the number of consecutive bad frames reaches a preset threshold, if yes, turning to perform step S**512**, if no, turning to perform step S**515** to directly output the result of previous frame,

[0090] a step **S512**, invalidating the original dynamic process start point (that is at the next round of judgment, the current dynamic process start point does not exist), and proceeding to step **S513**,

[0091] a step **S513**, clearing the number of consecutive bad frames,

[0092] a step **S514**, not outputting the data of current frame. It can be understood that the step **S501** may be repeated after the step **S514**, that is, performing a new round of judgment on a new received and inputted frame.

[0093] Those skilled in the art can change the sequence of above steps without affecting the design of the above procedure, for example, the execution sequence of the step **S309** and the step **S310** can be reversed, or the step **S309** and step **S310** can be performed simultaneously at a specific implementation. Under the condition that there is no dynamic process start point in the system, nor the quality parameter of current frame satisfying system requirement, the elasticity image may not be displayed in the system, so as to inform a user to recollect image by adjusting his/her operation.

[0094] One embodiment of the method for ultrasound elastography in the present disclosure is similar to the aforesaid third embodiment of the system for ultrasound elastography. The method may comprise:

[0095] a step **31** for emitting an ultrasonic beam and receiving ultrasonic echo signals by a probe based on a predefined scanning rule under elasticity imaging mode;

[0096] a step **32** for processing the received ultrasonic echo signals, the signal preprocessing including beam forming process;

[0097] a step **33** for extracting the elasticity information reflecting the target to be detected, computing the quality parameter reflecting the quality of each elasticity image corresponding to the elasticity information, and according to the quality parameter of each elasticity image, determining whether to output the corresponding elasticity image, wherein when determining whether to output the elasticity image, several substeps may be adopted such as judging dynamic process start point in real time, judging whether to weight frames and determining the number of consecutive bad frames;

[0098] a step **34** for displaying the outputted image.

[0099] The above steps can be implemented with reference to the corresponding modules described in the aforesaid embodiment of the system for ultrasound elastography, which will not be repeated herein. Further, the abovementioned method embodiment can also comprise a step of processing B signal for generating a gray image of the target to be detected.

[0100] In this embodiment, under the elasticity imaging mode, by means of emitting an ultrasonic beam and receiving ultrasonic echo signals by a probe according to a predefined scanning rule, outputting RF signal through beamforming, extracting elasticity information through the elasticity information detecting module, calculating parameters reflecting quality of elasticity information of each frame through the quality parameter calculating module, carrying out a further process in the frame processing module, and outputting final elasticity image, the stability among the frames can be enhance. The frame processing module may be actually used for searching the dynamic process start point, after finding out the start point, based on the quality of the frame, selectively performing whether to weight the current frame and the result of previous frame or directly output the result of previous frame. Once consecutive bad frames occur, a new start point may be search again. This may be a real-time dynamic cycle, which finally ensures the quality of outputted image of the system. If the image is originated from strain data having similar deformation degrees and accurate and reliable search result, the stability of the outputted image can be enhanced, thus simplifying the recognition or judgment of the elasticity image in clinical practice.

Fourth Embodiment

[0101] The method for dynamically process frames in real time in ultrasound imaging in the embodiment may comprise:

[0102] a step **41** for calculating the quality parameter reflecting the quality of each image;

[0103] a step **42** for judging whether there exists a dynamic process start point frame in the ultrasound imaging system, the dynamic process start point frame being defined as a frame with quality parameter that meets preset quality requirement, when no dynamic process start point frame existed, judging whether the quality parameter of the current frame meets the preset quality requirement, if no, the current image being not outputted, if yes, the current image being outputted and regarded as the dynamic process start point frame.

[0104] a step **43** for when the dynamic process start point frame is existed via the step **42**, judging whether the quality parameter of the current image meets the preset quality requirement, if no, outputting the result of previous frame as the data of current frame, simultaneously, invalidating the original dynamic process start point, if yes, weighting the current frame and the result of previous frame and outputting the weighted result.

[0105] The detailed process of the steps **42** and **43** can refer to the flow chart illustrated in FIG. **3**, which will not be repeated herein. It can be understood that the system needs to store the dynamic process result of the previous frame for assisting the output and display of current frame. For the ultrasound imaging under the elasticity imaging mode, the involved quality parameter can be the deformation degree parameter and the cross correlation detecting quality parameter mentioned in the second embodiment, and the preset quality parameter may be related to those parameters; while for the ultrasound imaging under non-elasticity image mode, the quality parameter involved in the step **41** can be other parameters for evaluating the image quality, such as SNR and contrast of the image. Of course, the preset quality parameter may be related to the adopted parameters.

[0106] The frame processing module of the embodiment may be actually configured for searching dynamic process start point, after finding the start point, based on the quality of the frame, selectively performing whether to weight the current frame and the result of previous frame or directly output the result of previous frame, thus ensuring the quality of outputted images of the system, and enhancing the stability of outputted images of the system.

Fifth Embodiment

[0107] The method for dynamically process frames in real time in ultrasound imaging in the embodiment may comprise:

[0108] a step **51** for calculating the quality parameter reflecting the quality of each image;

[0109] a step **52** for judging whether there exists a dynamic process start point frame in the ultrasound imaging system, the dynamic process start point frame being defined as a frame with quality parameter that meets preset quality requirement, when no dynamic process start point frame existed, judging whether the quality parameter of the current frame meets the preset quality requirement, if no, the current image being not outputted, if yes, the current image being outputted and regarded as the dynamic process start point frame.

[0110] a step **53** for when the dynamic process start point frame is existed via the step **52**, beginning to accumulate the number of consecutive bad frames. The number of consecutive bad frames may refer to the number of consecutive frames with quality that fails to satisfy a preset quality requirement. Once a frame with quality satisfying the system's requirement comes up, the number of consecutive bad frames may be cleared, followed with performing frame weighting, i.e. weighting the current frame and the result of previous frame and outputting the weighted result. The number of consecutive bad frames can be re-accumulated when a frame with quality that fails to satisfy the system requirement comes up.

[0111] a step **54** for under the situation that the quality parameter of current frame fails to meet the system requirement, and the number of consecutive bad frames reaches to a preset threshold (usually set based on experience), invalidating the original dynamic process start point, clearing the number of consecutive bad frames, followed with no data of current frame being outputted; while under the situation that the quality parameter of current frame fails to meet the system requirement, and the number of consecutive bad frames does not reach to a preset threshold (usually set based on experience), outputting the result of previous frame as the data of current frame.

[0112] The detailed process of the steps **5254** can refer to the flow chart illustrated in FIG. **5**, which will not be repeated herein. It can be understood that the system needs to store the dynamic process result of the previous frame for assisting the output and display of current frame. For the ultrasound imaging under the elasticity imaging mode, the involved quality parameter can be the deformation degree parameter and the cross correlation detecting quality parameter mentioned in the second embodiment, and the preset quality parameter can be related to those parameters; while for the ultrasound imaging under non-elasticity image mode, the quality parameter involved in the step **51** can be other parameters for evaluating the image quality, such as SNR and contrast of the image. Of course, the preset quality parameter can be related to the adopted parameters.

[0113] The method for dynamically processing frames in real time in ultrasound imaging in the embodiment may be actually configured for searching dynamic process start point, after finding the start point, based on the quality of the frame, selectively performing whether to weight the current frame and the result of previous frame or directly output the result of previous frame. Once consecutive bad frames occur, a new start point may be searched again. This may be a real-time dynamic cycle, which finally ensures the quality of outputted image of the system and the relevance among consecutive images. If the image is originated from strain data having similar deformation degrees and accurate and reliable search result, the stability of the outputted image can be enhanced, thus simplifying the recognition or judgment of the elasticity image in clinical practice.

[0114] In summary, according to the method or system provided in the abovementioned embodiments, the output and display of consecutive frames can be determined dynamically with controlling of output thereof in real time, the qualified frames performed with being weighted may increase the correlation among adjacent frames, with selectively deleting bad frames at the same time. When a large amount of bad frames appears, the user may be informed to recollect images due to improper operation, thus greatly increasing the stability of the elasticity image and simplifying the recognition or judgment of the elasticity image in clinical practice.

[0115] Those skilled in the art can appreciate that, all and part of the steps of methods in the aforesaid embodiments can be achieved by instructing related hardware through a program, where the program can be stored in a computer-readable storage medium which may include read-only memory, random access memory, disk or CD-ROM.

[0116] Though the present disclosure has been described in detailed by way of specified examples, the examples are used for helping to appreciate the present disclosure, not to limit the present disclosure. Those skilled in the art can change the above specified embodiments based on the spirit of the present disclosure.

[0117] This disclosure has been made with reference to various exemplary embodiments including the best mode. However, those skilled in the art will recognize that changes and modifications may be made to the exemplary embodiments without departing from the scope of the present disclosure. For example, various operational steps, as well as components for carrying out operational steps, may be implemented in alternate ways depending upon the particular application or in consideration of any number of cost functions associated with the operation of the system, e.g., one or more of the steps may be deleted, modified, or combined with other steps.

[0118] Additionally, as will be appreciated by one of ordinary skill in the art, principles of the present disclosure may be reflected in a computer program product on a computer-readable storage medium having computer-readable program code means embodied in the storage medium. Any tangible, non-transitory computer-readable storage medium may be utilized, including magnetic storage devices (hard disks, floppy disks, and the like), optical storage devices (CD-ROMs, DVDs, Blu-Ray discs, and the like), flash memory, and/or the like. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions that execute on the computer or other programmable data processing apparatus create means for implementing the functions specified. These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture, including implementing means that implement the function specified. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the

computer or other programmable apparatus to produce a computer-implemented process, such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions specified.

[0119] While the principles of this disclosure have been shown in various embodiments, many modifications of structure, arrangements, proportions, elements, materials, and components, which are particularly adapted for a specific environment and operating requirements, may be used without departing from the principles and scope of this disclosure. These and other changes or modifications are intended to be included within the scope of the present disclosure.

[0120] The foregoing specification has been described with reference to various embodiments. However, one of ordinary skill in the art will appreciate that various modifications and changes can be made without departing from the scope of the present disclosure. Accordingly, this disclosure is to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope thereof. Likewise, benefits, other advantages, and solutions to problems have been described above with regard to various embodiments. However, benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, a required, or an essential feature or element. As used herein, the terms "comprises," "comprising," and any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, a method, an article, or an apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, system, article, or apparatus. Also, as used herein, the terms "coupled," "coupling," and any other variation thereof are intended to cover a physical connection, an electrical connection, a magnetic connection, an optical connection, a communicative connection, a functional connection, and/or any other connection.

[0121] Those having skill in the art will appreciate that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.

1. A system for ultrasound elastography, comprising:

an ultrasonic probe that emits an ultrasonic beam to a target to be detected and receives ultrasonic echoes from the target to obtain received signals;

a processor that performs an elasticity process on the received signals from the ultrasonic probe to obtain a plurality of elasticity images; and

a display device that displays one or more of the plurality of elasticity images;

wherein the processor is configured to:

extract elasticity information representing the elasticity of the target from a plurality of elasticity images corresponding to the received signals from the ultrasonic probe;

calculate at least a quality parameter reflecting quality of each elasticity image of the plurality of elasticity images corresponding to the elasticity information;

identify whether a dynamic process start point frame exists in a sequence of corresponding frames of the plurality of elasticity images; and

determine whether to output a corresponding elasticity image of the plurality of elasticity images based on both whether the dynamic process start point exists in the sequence of corresponding frames of the plurality of elasticity images and the quality parameter of each elasticity image;

wherein the display device is further configured to display the corresponding elasticity image, that is determined to be outputted by the processor, of the plurality of elasticity images.

2. The system for ultrasound elastography according to claim **1**, wherein, if no dynamic process start point frame exists, the processor is further configured to:

judge whether the quality parameter of a current frame meets the preset quality requirement;

refrain from outputting the current frame if the quality parameter of current frame fails to meet the preset quality requirement;

output the current frame as the corresponding elasticity image if the quality parameter of the current frame meets the preset quality requirement, and wherein the current frame is regarded as the dynamic process start point frame if the quality parameter of the current frame meets the preset quality requirement; and

wherein, if it is determined that the dynamic process start point frame exists in the sequence of corresponding frames of the plurality of elasticity images, the processor is further configured to:

determine whether to weight the current frame and a previous image and output the weighted result according to the result of judging whether the quality parameter of the current frame meets the preset quality requirement.

3. The system for ultrasound elastography according to claim **2**, wherein the processor is further configured to:

after determining the existence of dynamic process start point by the start point judging unit, accumulate a number of consecutive bad frames, the number of consecutive bad frames being defined as the number of consecutive frames with quality that fails to satisfy a preset quality requirement, under the situation that the quality parameter of the current frame meets the preset quality requirement, determine whether the number of consecutive bad frames reaches a preset threshold, if the number of consecutive bad frames reaches a preset threshold, invalidate the dynamic process start point, clear the number of consecutive bad frames, followed with the current frame being not outputted, if the number of consecutive bad frames does not reach a preset threshold, output the previous image as the current frame; and

after determining that the quality parameter of current frame meets the preset quality requirement by the bad frame judging subunit, clear the number of consecutive bad frames, weight the current frame and the previous image, and output the weighted result.

4. The system for ultrasound elastography according to claim **1**, the dynamic process start point frame is defined as a frame with a quality parameter that meets a preset quality requirement;

5. The system for ultrasound elastography according to claim 1, wherein the quality parameter comprises at least one of a deformation degree parameter and a cross correlation detecting quality parameter; the deformation degree parameter is an average strain value corresponding to current image; the cross correlation detecting quality parameter is a score of current frame acquired by corresponding scoring rule selected by a method of displacement detection adopted in the elasticity information detecting module.

6. The system for ultrasound elastography according to claim 5, wherein the method of displacement detection adopted in the processor refers to absolute value and sum of absolute difference (SAD), the score is computed by:

calculating a first score, where the first score is configured for evaluating a distance between a maximal SAD value of a position within a current search area and an upper limit of a distribution of SAD values;

calculating a second score, where the second score is configured for evaluating a distance between a minimal SAD value of a position within current search area and a lower limit of the distribution of SAD values;

weighting the first score and the second score, and taking the weighted result as a quality score of current search;

averaging the quality scores of all sampling positions of the current frame, and obtaining a final quality score of the current frame.

7. The system for ultrasound elastography according to claim 6, wherein

the first score is calculated as:

score1=(SAD_max−SAD_min)/(SAD_High−SAD_min),

the second score is calculated as:

score2=(SAD_max−SAD_min)/(SAD_max−SAD_Low),

weighting the first score and the second score are weighted as: score_SAD=score1*p+score2*(1−p),

where score1 is the first score, score2 is the second score, SAD_max is a maximal SAD value of a current search area, SAD_min is a minimal SAD value of the current search area, SAD_High is an upper limit of a SAD distribution preset by the system, SAD_Low is a lower limit of the SAD distribution preset by the system, score_SAD is the quality score of current search, p is a weighting coefficient preset by the system.

8. A system for ultrasound elastography, comprising:

an ultrasonic probe that emits an ultrasonic beam to a target to be detected and receives ultrasonic echoes from the target to obtain received signals;

a processor that performs an elasticity process on the received signals from the ultrasonic probe to obtain a plurality of elasticity images; and

a display device that displays one or more of the plurality of elasticity images;

wherein the processor is configured to:

extract elasticity information representing the elasticity of the target from a plurality of elasticity images corresponding to the received signals from the ultrasonic probe;

calculate at least a quality parameter reflecting reliability of each elasticity image of the plurality of elasticity images corresponding to the elasticity information;

identify whether a dynamic process start point frame exists in a sequence of corresponding frames of the plurality of elasticity images, wherein the dynamic process start point frame is defined as a frame with a quality parameter that meets a preset quality requirement; and

determine, when it is determined that the dynamic process start point frame exists in the sequence of corresponding frames of the plurality of elasticity images, whether to weight a current frame and a previous image and output a weighted result according to a result of judging whether the quality parameter of the current frame meets the preset quality requirement;

wherein the display device is further configured to display the weighted result when it is determined to output the weighted result of the current frame and the previous frame.

9. The system for ultrasound elastography according to claim 8, wherein when it is determined that the dynamic process start point frame exists in the sequence of corresponding frames of the plurality of elasticity images, the processor is further configured to:

accumulate a number of consecutive bad frames, the number of consecutive bad frames being defined as the number of consecutive frames with quality that fails to satisfy a preset quality requirement;

determine whether the quality parameter of the current frame meets the preset quality requirement; and

weight the current frame and the previous image and output the weighted result when it is determined that the quality parameter of the current frame meets the preset quality requirement.

10. The system for ultrasound elastography according to claim 9, wherein it is determined that the quality parameter of the current frame fails to meet the preset quality requirement after determining the existence of the dynamic process start point, the process is further configured to:

determine whether the number of consecutive bad frames reaches a preset threshold;

invalidate the dynamic process start point, clear the number of consecutive bad frames and refrain from outputting the current frame when the number of consecutive bad frames reaches the preset threshold; and

output the previous image as the current frame when the number of consecutive bad frames does not reach the preset threshold.

11. The system for ultrasound elastography according to claim 8, wherein when it is determined that no dynamic process start point frame exists, the processor is further configured to:

judge whether the quality parameter of the current frame meets the preset quality requirement;

refrain from outputting the current frame when the quality parameter of current frame fails to meet the preset quality requirement;

output the current frame as the corresponding elasticity image and set the current frame as the dynamic process start point frame when the quality parameter of the current frame meets the preset quality requirement.

12. The system for ultrasound elastography according to claim 8, wherein the quality parameter comprises at least one of a deformation degree parameter and a cross correlation detecting quality parameter; the deformation degree

parameter is an average strain value corresponding to current image; the cross correlation detecting quality parameter is a score of current frame acquired by corresponding scoring rule selected by a method of displacement detection adopted in the elasticity information detecting module.

13. The system for ultrasound elastography according to claim **12**, wherein the method of displacement detection adopted in the processor refers to absolute value and sum of absolute difference (SAD), the score is computed by:

calculating a first score, where the first score is configured for evaluating a distance between a maximal SAD value of a position within a current search area and an upper limit of a distribution of SAD values;

calculating a second score, where the second score is configured for evaluating a distance between a minimal SAD value of a position within current search area and a lower limit of the distribution of SAD values;

weighting the first score and the second score, and taking the weighted result as a quality score of current search;

averaging the quality scores of all sampling positions of the current frame, and obtaining a final quality score of the current frame.

14. The system for ultrasound elastography according to claim **13**, wherein

the first score is calculated as:

$$score1=(SAD\_max-SAD\_min)/(SAD\_High-SAD\_min),$$

the second score is calculated as:

$$score2=(SAD\_max-SAD\_min)/(SAD\_max-SAD\_Low),$$

weighting the first score and the second score are weighted as: $score\_SAD=score1*p+score2*(1-p)$,

where score1 is the first score, score2 is the second score, SAD_max is a maximal SAD value of a current search area, SAD_min is a minimal SAD value of the current search area, SAD_High is an upper limit of a SAD distribution preset by the system, SAD_Low is a lower limit of the SAD distribution preset by the system, score_SAD is the quality score of current search, p is a weighting coefficient preset by the system.

15. A system for ultrasound elastography, comprising an elasticity processing apparatus for performing an elasticity process on received signals; the elasticity processing apparatus comprising:

an elasticity information detecting module for extracting elasticity information representing the elasticity of a target to be detected from a plurality of elasticity images corresponding to the received signals from an ultrasonic probe;

a quality parameter calculating module for calculating at least a quality parameter reflecting quality of each elasticity image of the plurality of elasticity images corresponding to the elasticity information;

a start point judging unit for identifying whether a dynamic process start point exists in a sequence of corresponding frames of the plurality of elasticity images; and

a frame processing module for determining whether to output a corresponding elasticity image of the plurality of elasticity images based on both whether the dynamic process start point exists in the sequence of corresponding frames of the plurality of elasticity images and the quality parameter of each elasticity image.

16. The system for ultrasound elastography according to claim **15**, wherein:

the dynamic process start point is a dynamic process start point frame defined as a frame with a quality parameter that meets a preset quality requirement, and if no dynamic process start point frame exists, the frame processing module further configured to:

judge whether the quality parameter of a current frame meets the preset quality requirement;

refrain from outputting the current frame if the quality parameter of current frame fails to meet the preset quality requirement;

output the current frame as the corresponding elasticity image if the quality parameter of the current frame meets the preset quality requirement, and wherein the current frame is regarded as the dynamic process start point frame if the quality parameter of the current frame meets the preset quality requirement; and

a weighting frame judging unit for, after determining the existence of the dynamic process start point by the start point judging unit, according to the result of judging whether the quality parameter of the current frame meets the preset quality requirement, determining whether to weight the current frame and a previous image and output the weighted result.

17. The system for ultrasound elastography according to claim **16**, wherein the weighting frame judging unit comprises:

a bad frame judging subunit for, after determining the existence of dynamic process start point by the start point judging unit, accumulating a number of consecutive bad frames, the number of consecutive bad frames being defined as the number of consecutive frames with quality that fails to satisfy a preset quality requirement, under the situation that the quality parameter of the current frame meets the preset quality requirement, determining whether the number of consecutive bad frames reaches a preset threshold, if the number of consecutive bad frames reaches a preset threshold, invalidating the dynamic process start point, clearing the number of consecutive bad frames, followed with the current frame being not outputted, if the number of consecutive bad frames does not reach a preset threshold, outputting the previous image as the current frame; and

a frame weighting subunit for, after determining that the quality parameter of current frame meets the preset quality requirement by the bad frame judging subunit, clearing the number of consecutive bad frames, weighting the current frame and the previous image, and outputting the weighted result.

18. The system for ultrasound elastography according to claim **15**, wherein the quality parameter comprises at least one of a deformation degree parameter and a cross correlation detecting quality parameter; the deformation degree parameter is an average strain value corresponding to current image; the cross correlation detecting quality parameter is a score of current frame acquired by corresponding scoring rule selected by a method of displacement detection adopted in the elasticity information detecting module.

19. The system for ultrasound elastography according to claim **18**, wherein the method of displacement detection

adopted in the elasticity information detecting module refers to absolute value and sum of absolute difference (SAD), the score is computed by:

calculating a first score, where the first score is configured for evaluating a distance between a maximal SAD value of a position within a current search area and an upper limit of a distribution of SAD values;

calculating a second score, where the second score is configured for evaluating a distance between a minimal SAD value of a position within current search area and a lower limit of the distribution of SAD values;

weighting the first score and the second score, and taking the weighted result as a quality score of current search;

averaging the quality scores of all sampling positions of the current frame, and obtaining a final quality score of the current frame.

20. The system for ultrasound elastography according to claim **19**, wherein

the first score is calculated as:

score1=(SAD_max—SAD_min)/(SAD_High—SAD_min),

the second score is calculated as:

score2=(SAD_max—SAD_min)/(SAD_max—SAD_Low),

weighting the first score and the second score are weighted as: score_SAD=score1*p+score2*(1−p),

where score1 is the first score, score2 is the second score, SAD_max is a maximal SAD value of a current search area, SAD_min is a minimal SAD value of the current search area, SAD_High is an upper limit of a SAD distribution preset by the system, SAD_Low is a lower limit of the SAD distribution preset by the system, score_SAD is the quality score of current search, p is a weighting coefficient preset by the system.

* * * * *

专利名称(译)	用于超声弹性成像的系统和方法以及用于实时动态处理帧的方法		
公开(公告)号	US20190159762A1	公开(公告)日	2019-05-30
申请号	US16/262665	申请日	2013-09-22
[标]申请(专利权)人(译)	深圳迈瑞生物医疗电子股份有限公司		
申请(专利权)人(译)	深圳迈瑞生物医疗电子股份有限公司.		
当前申请(专利权)人(译)	深圳迈瑞生物医疗电子股份有限公司.		
[标]发明人	LI SHUANGSHUANG		
发明人	LI, SHUANGSHUANG		
IPC分类号	A61B8/08 A61B8/14 A61B8/00		
CPC分类号	A61B8/485 A61B8/14 A61B8/5223 A61B8/463 G01S7/52042 G01S7/52071 G16H50/30		
优先权	201210495184.4 2012-11-28 CN		
外部链接	Espacenet USPTO		

摘要(译)

公开了一种用于超声弹性成像的系统和方法以及用于实时动态处理帧的方法。该系统包括弹性处理装置，该弹性处理装置具有弹性信息检测模块，用于提取表示待检测目标的弹性的弹性信息;质量参数计算模块，用于至少计算反映与弹性信息对应的每个弹性图像的质量的质量参数;帧处理模块，用于根据每个弹性图像的质量参数确定是否输出相应的弹性图像。在计算连续图像的应变时，还计算反映每个图像质量的参数，通过该参数确定是否显示当前弹性图像，从而避免了获取的连续弹性图像的颜色由于压力存在很大差异。