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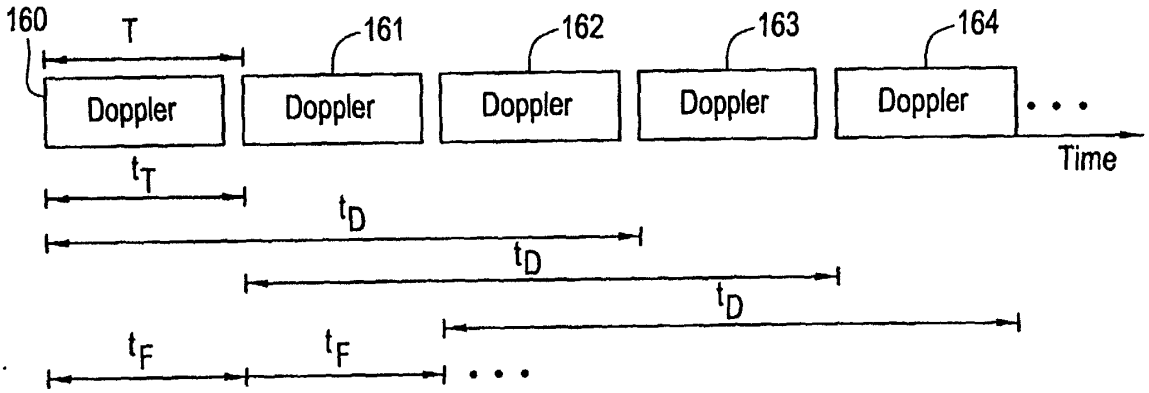
(54) Method and apparatus for providing real-time calculation and display of tissue deformation in ultrasound imaging

(57) An ultrasound system and method for calculation and display of tissue deformation parameters are disclosed. An ultrasound acquisition technique that allows a high frame rate in tissue velocity imaging or strain rate imaging is employed. With this acquisition technique the same ultrasound pulses are used for the tissue image and the Doppler based image. A sliding window technique (160,161,162,163,164) is used for processing. The tissue deformation parameter strain is also determined by an accumulation of strain rate estimates for consecutive frames over an interval. The interval may be a triggered interval generated by, for example, an R-wave in an ECG trace. The strain calculation (150) may be improved by moving the sample volume from which the strain rate is accumulated from frame-to-frame according to the relative displacement of the tissue within the original sample volume. The relative displacement of the tissue is determined by the instantaneous tissue velocity of the sample volume. An estimation of strain rate (150) based upon a spatial derivative of tissue velocity is improved by adaptively varying the spatial offset, *dr*. The spatial offset, *dr*, can be maximized to cover the entire tissue segment (e.g., heart wall width) while still keeping both of the sample volumes at each end of the offset within the tissue segment. This may be accomplished by determining whether various parameters (e.g., grayscale value, absolute power estimate, magnitude of the auto-correlation function with unity temporal lag and/or magnitude of strain correlation) of the sample volumes within in the spatial offset are above a given threshold.

EP 1 079 240 A3

FIG. 4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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 6794

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A	* abstract; figures 1-5 * * page 1420 * * page 1422, left-hand column *	9	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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X : particularly relevant if taken alone
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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 00 30 6794

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-2

   Particular time interleaved beamline acquisition scanning scheme for high frame rate acquisition and processing

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2. claim: 3

   Method for generating tissue deformation information

   ---

3. claim: 4

   Adaptive spatial offset strain estimator

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4. claim: 5

   Method for constructing a weighted strain rate

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5. claim: 6

   Method for un-aliasing of velocity estimates while maintaining spatial resolution

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6. claim: 7

   Method for estimating tissue velocity

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7. claim: 8

   Method for quantitative stress echo based on strain rate imaging

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8. claim: 9

   Method for angle correction of strain rate estimates

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9. claim: 10

   Real-time ECG-trigged strain imaging

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 30 6794

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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专利名称(译)	用于在超声成像中提供组织变形的实时计算和显示的方法和装置		
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申请(专利权)人(译)	GE vingmed超声AS		
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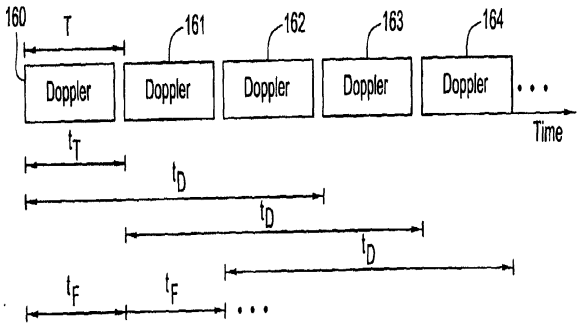
优先权	09/432061 1999-11-02 US 60/150265 1999-08-23 US		
其他公开文献	EP1079240A2		
外部链接	Espacenet		

摘要(译)

公开了一种用于计算和显示组织变形参数的超声系统和方法。采用允许组织速度成像或应变率成像中的高帧速率的超声采集技术。利用这种采集技术，相同的超声脉冲用于组织图像和基于多普勒的图像。滑动窗口技术（160,161,162,163和164）用于处理。组织变形参数应变还通过在一个间隔内连续帧的应变率估计的累积来确定。该间隔可以是由例如ECG迹线中的R波产生的触发间隔。应变计算（150）可以通过根据原始样本体积内的组织的相对位移移动从帧到帧累积应变率的样本体积来改善。组织的相对位移由样品体积的瞬时组织速度确定。通过自适应地改变空间偏移，改善了基于组织速度的空间导数的应变率（150）的估计。空间偏移量dr可以最大化以覆盖整个组织片段（例如，心脏壁宽度）同时仍保持组织片段内偏移的每个末端处的两个样品体积。这可以通过确定空间偏移内的样本体积的各种参数（例如，灰度值，绝对功率估计，具有单位时间滞后的自相关函数的大小和/或应变相关的大小）是否高于a来实现。给定门槛。可以使用基于具有不同空间偏移的双样本应变率估计器的加权和的广义应变率估计器来估计应变率（150）。权重与每个空间偏移的应变率相关估计的大小成比例，因此减小了噪声（即，相关性差的）样本的影响。公开了一种改进的信号相关估计器，其使用除了通常的时间滞后之外的空间滞后。从组织速度发现空间滞后。改进的信号相关估计器可用于估计应变率和组织速度。可以以减少混叠同时保持空间分辨率的方式估计组织速度。接收的超声信号的三个副本在三个中心频率进行带通滤波。三个中心频率的中间以超声信号的二次谐波为中心。从在外部中心频率处滤波的两个信号估计参考组织速度。参考组织速度用于从由以二次谐波为中心的信号估计的多个组织速度中选择组织速度。公开了一种基于来自样本体积周围的小感兴趣区域的组织速度数据来估计（150）在任何方向上的应变率的方法，不一定沿着超声波束（144）。定量组织变形参数，例如组织速度，组织速度积分，应变率和/或应变，可以作为时间和/或空间位置的函数被呈现

FIG. 4



（152），用于诸如应力回波的应用。例如，三个不同应力水平的应变率或应变值可以相对于心动周期内的时间绘制在一起。可以针对各种参数绘制从应变速率或应变速度导出的参数，例如峰值收缩壁增厚百分比压力水平。