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Brown et al.

(54) **DEFORMABLE REGISTRATION FOR TISSUE ANALYTICS**

(75) Inventors: **Heather Anne Brown**, Shelbyville, KY (US); **Robert Royea**, Redwood City, CA (US)

(73) Assignee: **QI IMAGING, LLC**, Redwood City, CA (US)

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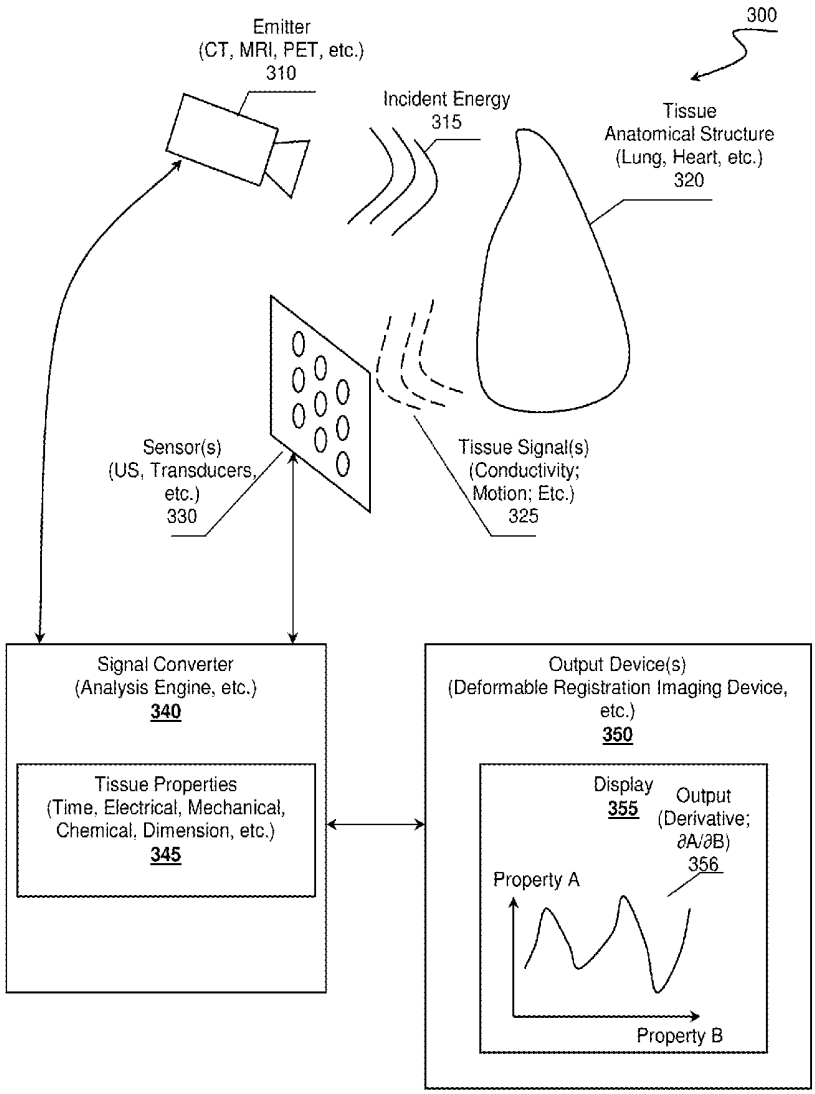
USPC **600/407**

(57) **ABSTRACT**

A tissue analysis system is disclosed. Tissue analysis systems include sensors that acquire signals originating from a target tissue and representative of a tissue property. A signal converter converts the signals to property measurements. An analysis engine can derive a variation of one tissue property with respect to another property and present the variation within a deformable registration imaging devices.



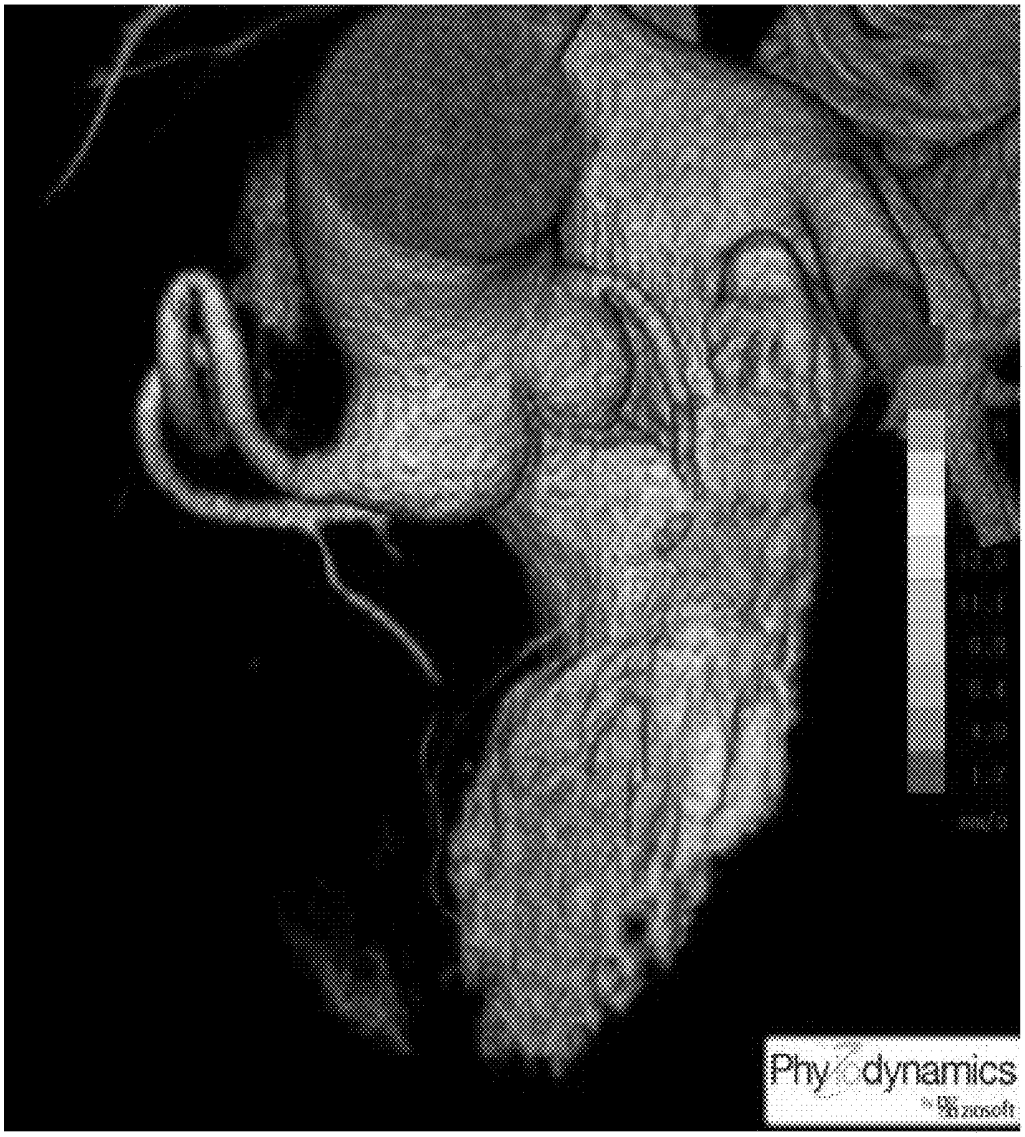


Figure 1

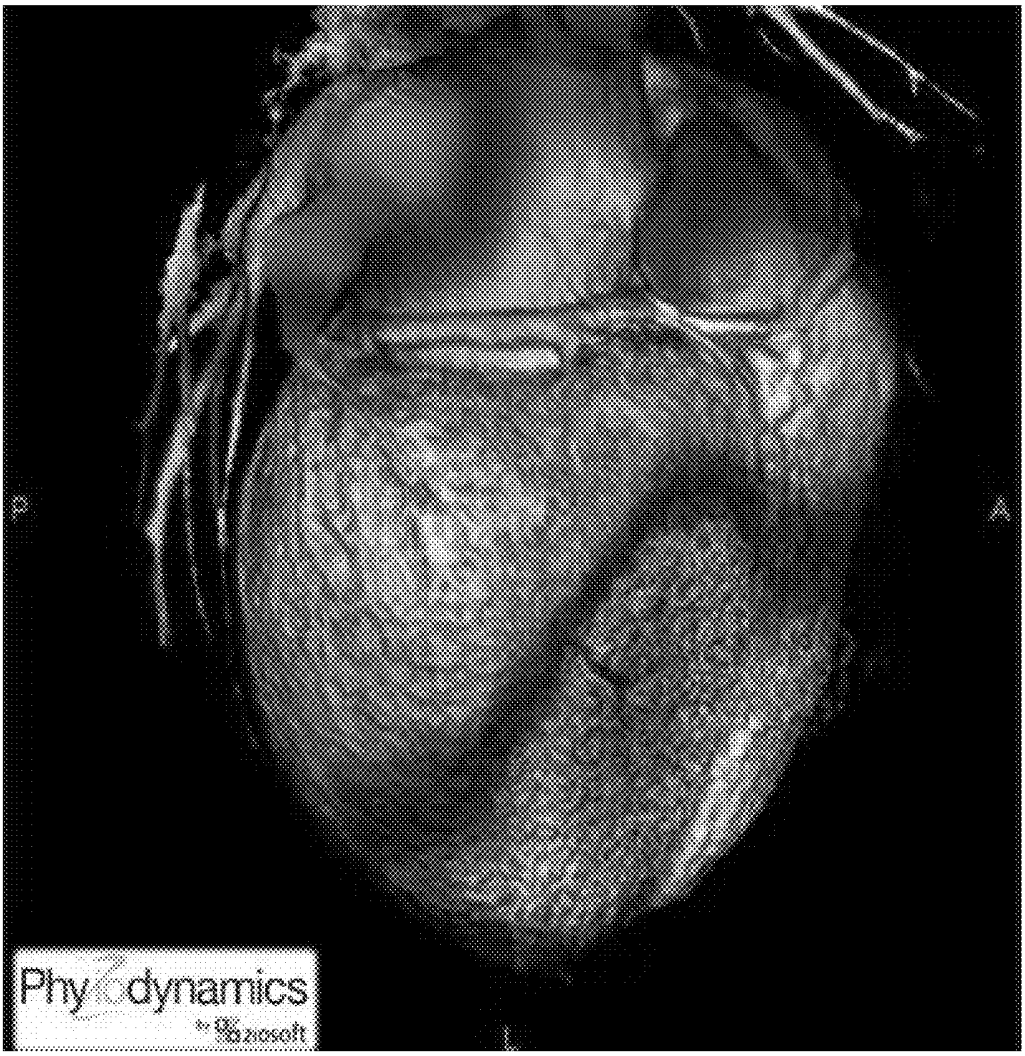


Figure 2

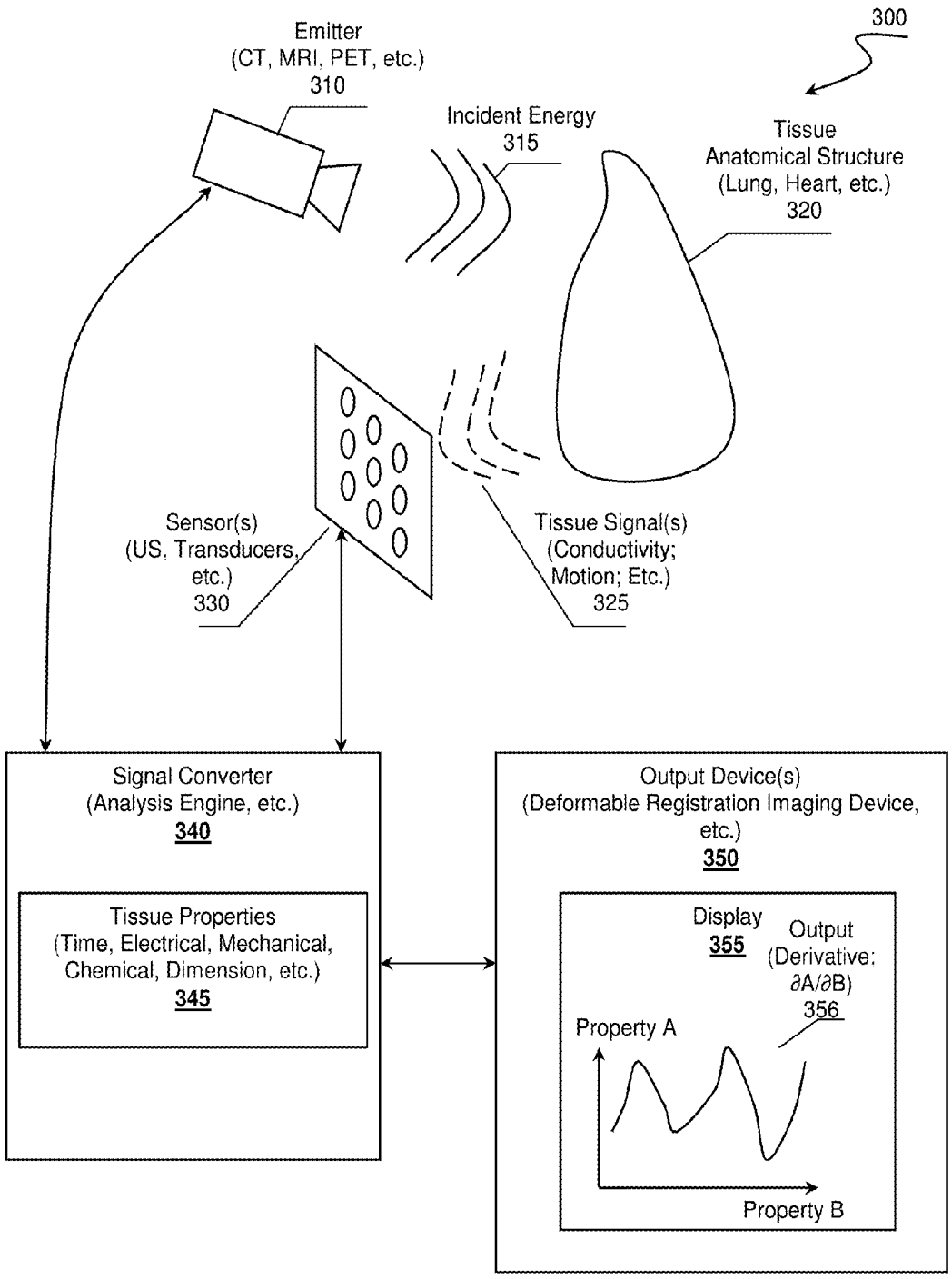

300
Emitter
(CT, MRI, PET, etc.)
310
Incident Energy
315
Tissue
Anatomical Structure
(Lung, Heart, etc.)
320
Sensor(s)
(US, Transducers,
etc.)
330
Tissue Signal(s)
(Conductivity;
Motion; Etc.)
325
Signal Converter
(Analysis Engine, etc.)
340
Tissue Properties
(Time, Electrical, Mechanical,
Chemical, Dimension, etc.)
345
Output Device(s)
(Deformable Registration Imaging Device,
etc.)
350
Display
355
Output
(Derivative:
∂A/∂B)
356
Property A
Property B

Figure 3

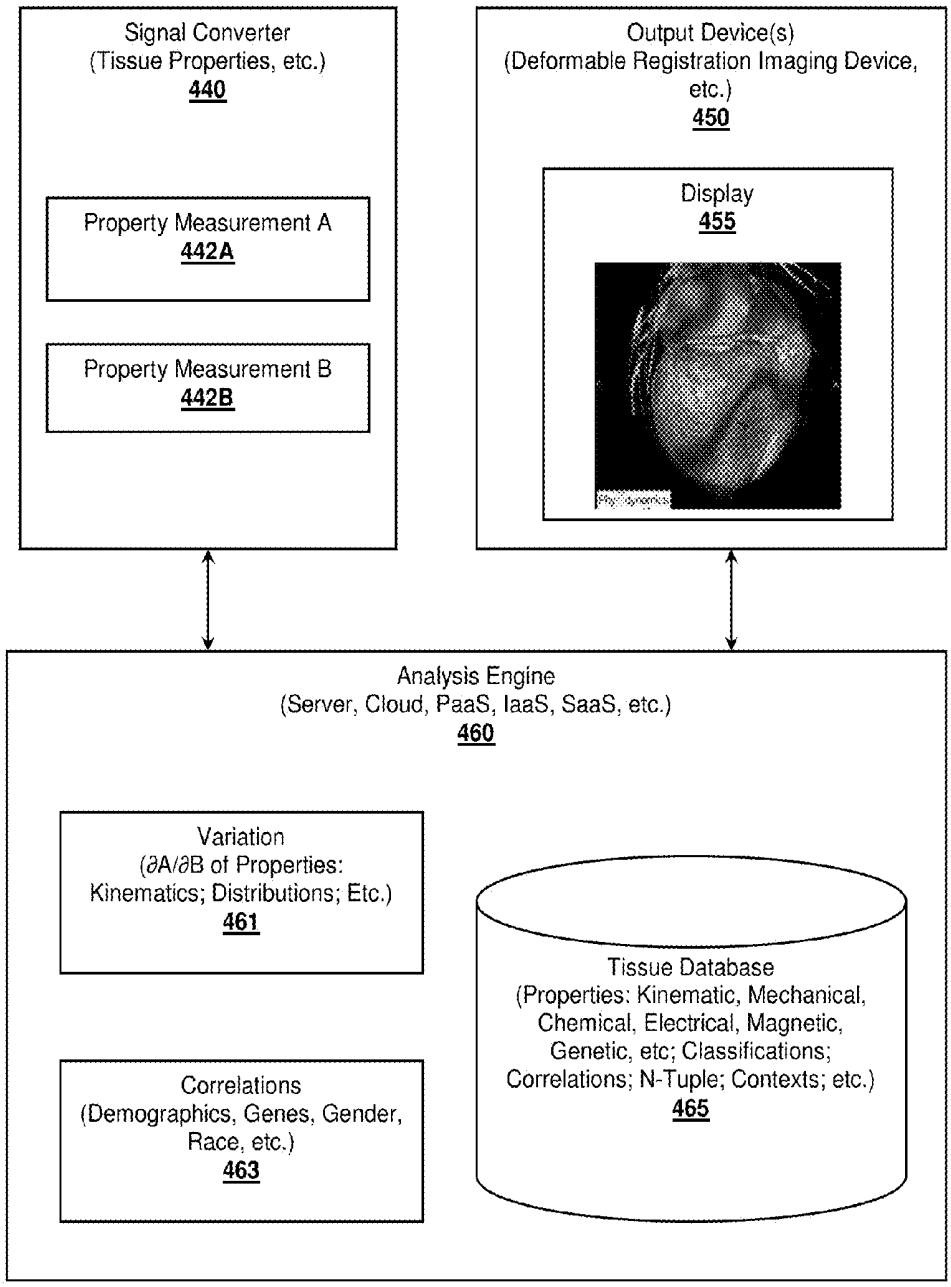

Signal Converter
(Tissue Properties, etc.)
440
Property Measurement A
442A
Property Measurement B
442B
Output Device(s)
(Deformable Registration Imaging Device, etc.)
450
Display
455
Analysis Engine
(Server, Cloud, PaaS, IaaS, SaaS, etc.)
460
Variation
(∂A/∂B of Properties:
Kinematics; Distributions; Etc.)
461
Correlations
(Demographics, Genes, Gender, Race, etc.)
463
Tissue Database
(Properties: Kinematic, Mechanical, Chemical, Electrical, Magnetic, Genetic, etc; Classifications; Correlations; N-Tuple; Contexts; etc.)
465

Figure 4

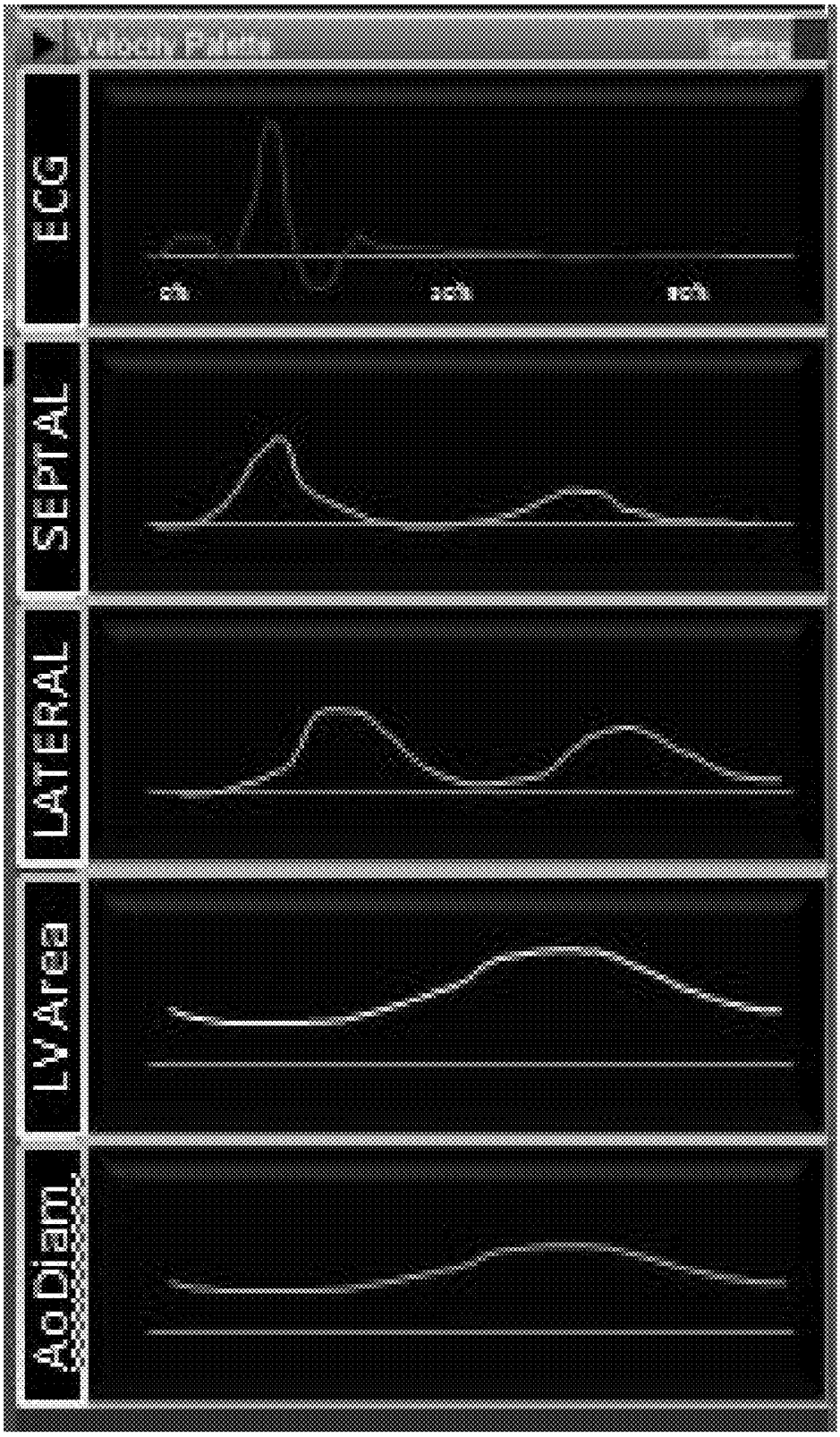


Figure 5

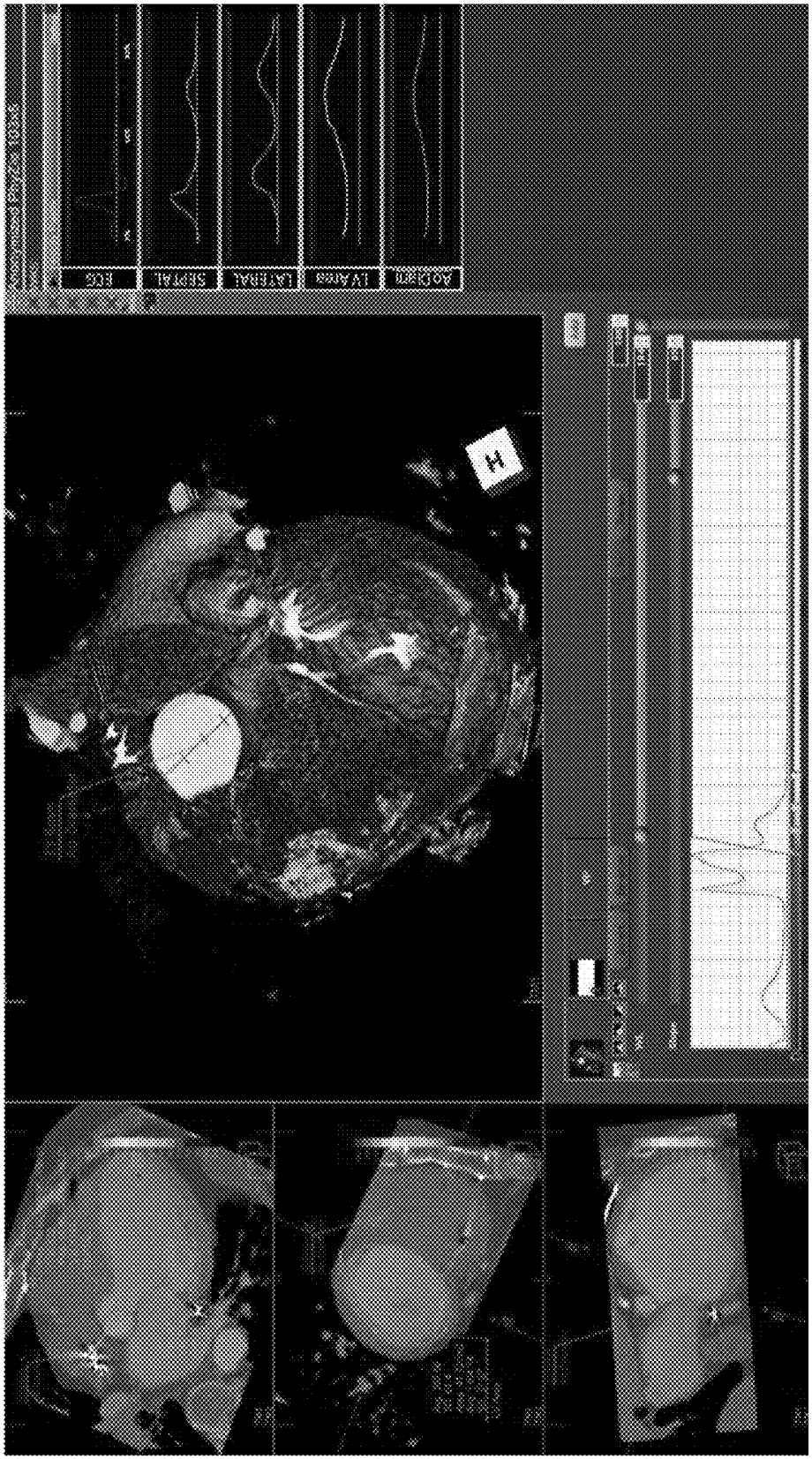


Figure 6

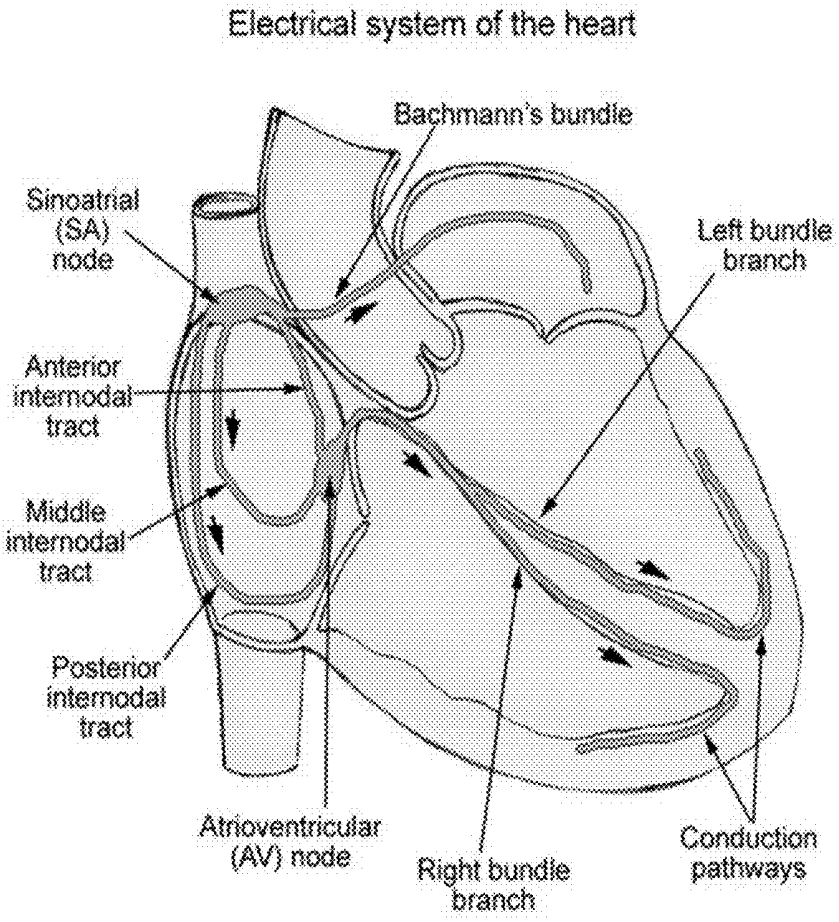

Electrical system of the heart
Bachmann's bundle
Sinoatrial (SA) node
Left bundle branch
Anterior internodal tract
Middle internodal tract
Posterior internodal tract
Atrioventricular (AV) node
Right bundle branch
Conduction pathways

Figure 7

DEFORMABLE REGISTRATION FOR TISSUE ANALYTICS

[0001] This application claims priority to U.S. provisional applications having serial numbers:

[0002] 61/529,109, 61/528,949, and 61/528,984, filed Aug. 30, 2011;

[0003] 61/529,556, and 61/529,610, filed Aug. 31, 2011;

[0004] 61/532,923, 61/532,944, and 61/532,988 filed Sep. 9, 2011; and

[0005] 61/543,644 filed Oct. 5, 2011.

[0006] These and all other extrinsic materials discussed herein are incorporated by reference in their entirety. Where a definition or use of a term in an incorporated reference is inconsistent or contrary to the definition of that term provided herein, the definition of that term provided herein applies and the definition of that term in the reference does not apply.

FIELD OF THE INVENTION

[0007] The field of the invention is tissue analytics technologies.

BACKGROUND

[0008] Serial data sets that are acquired to examine variability of tissue characteristics with respect to time are used to evaluate cardiac motion, neurovascular flow, respiratory motion, urinary collection system filling or other physiological processes that can be captured with time-sequence imaging. Although standard advanced imaging software systems have enabled clinicians to qualitatively assess the physiological motion by interpolating (e.g., blurring, fading, etc.) from one phase data set to the next to generate a movie-like (i.e. cine) view, such imaging system fail to actual representations of tissue motion.

[0009] Both velocity and acceleration have been discussed in medical literature as potentially valuable information with clinical relevance (Hashimoto et al., 2004; Paulev and Pedersen, 1973). However, known systems fail to provide such information in a clinical setting. This and all other extrinsic materials discussed herein are incorporated by reference in their entirety. Where a definition or use of a term in an incorporated reference is inconsistent or contrary to the definition of that term provided herein, the definition of that term provided herein applies and the definition of that term in the reference does not apply.

[0010] In view that deformable registration allows imaging of true motion of a tissue, the disclosed techniques developed by the Applicants allow for displaying tissue velocity, acceleration, or other higher order time derivates in a clinical environment. Further, the Applicants have appreciated that such techniques can be applied to provide kinematic information relating to a target tissue in the clinical environment. For example, although other known imaging techniques (e.g., rigid registration) present tissue information related to tissues, there appears to be a lack of effort toward using such motion-based information obtained from imaging systems to classify tissues based tissue kinematic signals or based on statistical aggregation of tissue kinematics across populations or across other types of tissue contexts.

[0011] Unless the context dictates the contrary, all ranges set forth herein should be interpreted as being inclusive of their endpoints and open-ended ranges should be interpreted to include only commercially practical values. Similarly, all lists of values should be considered as inclusive of intermediate values unless the context indicates the contrary.

[0012] Thus, there is still a need for additional medical imaging technologies capable of displaying variation of one tissue characteristic (e.g., displacement) relative to another characteristic (e.g., time).

SUMMARY OF THE INVENTION

[0013] The inventive subject matter provides apparatus, systems and methods in which variations of one tissue characteristic (e.g., time, displacement, density, strain, stress, temperature, etc.) with respect to a different tissue characteristic can be displayed as an image in conjunction with a tissue image. Various objects, features, aspects and advantages of the inventive subject matter will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing figures in which like numerals represent like components.

[0014] Another aspect of the inventive subject matter includes a kinematics tissue analysis engine to measure a tissue's kinematics. The kinematics of tissues can be used to classify the tissue as belonging to one or more classes (e.g., a demographic, a control group, a family, a disease, etc.). The engine preferably communicatively couples with a tissue database storing tissue objects representative of different tissues and having tissue properties. Tissue properties can cover a wide spectrum of tissue attributes, possibly including mechanical properties, biological properties, proteomic properties, disease state, chemical properties, electrical properties, magnetic properties, information properties, or genetic properties. The engine can measure specific variations including kinematics of a target tissue (e.g., heart, lung, muscles, etc.) and can establish one or more correlations between the tissue properties and the kinematics. Thus, the analysis engine establishes a kinematic landscape of individuals or tissue classes in a similar fashion as genomic information establishes a genetic landscape of individuals or populations based on gene data.

[0015] Various objects, features, aspects and advantages of the inventive subject matter will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing figures in which like numerals represent like components.

BRIEF DESCRIPTION OF THE DRAWING

[0016] FIG. **1** is an image of a tissue superimposed with tissue acceleration using deformable registration techniques.

[0017] FIG. **2** is an image of cardiac tissue superimposed with tissue acceleration using deformable registration techniques.

[0018] FIG. **3** is a schematic of a tissue analysis ecosystem.

[0019] FIG. **4** is a schematic of a tissue analysis engine capable of establishing correlations among variations in tissue properties with tissue classifications.

[0020] FIG. **5** illustrates presenting tissue kinematics as a function of time.

[0021] FIG. **6** illustrates incorporating tissue kinematics via a user interface.

[0022] FIG. **7** illustrates how electrical signals propagate through a heart.

DETAILED DESCRIPTION

[0023] It should be noted that while the following description is drawn to a computer/server based tissue analysis system, various alternative configurations are also deemed suitable and may employ various computing devices including servers, interfaces, systems, databases, agents, peers, engines, controllers, or other types of computing devices operating individually or collectively. One should appreciate the computing devices comprise a processor configured to execute software instructions stored on a tangible, non-transitory computer readable storage medium (e.g., hard drive, solid state drive, RAM, flash, ROM, etc.). The software instructions preferably configure the computing device to provide the roles, responsibilities, or other functionality as discussed below with respect to the disclosed apparatus. In especially preferred embodiments, the various servers, systems, databases, or interfaces exchange data using standardized protocols or algorithms, possibly based on HTTP, HTTPS, AES, public-private key exchanges, web service APIs, known financial transaction protocols, or other electronic information exchanging methods. Data exchanges preferably are conducted over a packet-switched network, the Internet, LAN, WAN, VPN, or other type of packet switched network.

[0024] One should appreciate that the disclosed techniques provide many advantageous technical effects including generating one or more signals representative of tissue property variation. The signals configure one or more output devices to present a rendering of the tissue property variations.

[0025] The following discussion provides many example embodiments of the inventive subject matter. Although each embodiment represents a single combination of inventive elements, the inventive subject matter is considered to include all possible combinations of the disclosed elements. Thus if one embodiment comprises elements A, B, and C, and a second embodiment comprises elements B and D, then the inventive subject matter is also considered to include other remaining combinations of A, B, C, or D, even if not explicitly disclosed.

[0026] As used herein, and unless the context dictates otherwise, the term "coupled to" is intended to include both direct coupling (in which two elements that are coupled to each other contact each other) and indirect coupling (in which at least one additional element is located between the two elements). Therefore, the terms "coupled to" and "coupled with" are used synonymously. Within the context of this document, the terms "coupled to" and "coupled with" are also used euphemistically to mean "communicatively coupled with" where two or more devices are able to exchange data among each other, possibly over a network.

[0027] Ziosoft (www.ziosoftinc.com) has pioneered systems and methods for deformable registration as described in the following issued co-owned patents and published patent applications. The disclosed techniques build upon these foundational works.

[0028] U.S. Pat. No. 7,310,095; U.S. Pat. No. 7,420,575; U.S. Pat. No. 7,424,140; U.S. Pat. No. 7,502,025; U.S. Pat. No. 7,529,396; U.S. Pat. No. 7,574,027; U.S. Pat. No. 7,576,741; U.S. Pat. No. 7,616,205; U.S. Pat. No. 7,620,224; U.S. Pat. No. 7,623,695; U.S. Pat. No. 7,639,855; U.S. Pat. No. 7,639,867; U.S. Pat. No. 7,647,593; U.S. Pat. No. 7,653,231; U.S. Pat. No. 7,689,018; U.S. Pat. No. 7,706,588; U.S. Pat. No. 7,738,701; U.S. Pat. No. 7,778,451; U.S. Pat. No. 7,782,507; U.S. Pat. No. 7,796,835; U.S. Pat. No. 7,817,877; U.S. Pat. No. 7,825,924; U.S. Pat. No. 7,853,057; U.S. Pat. No. 7,860,284; U.S. Pat. No. 7,860,949; U.S. Pat. No. 7,869,638; U.S. Pat. No. 7,873,197; U.S. Pat. No. 7,907,763

[0029] and

[0030] U.S. 2006/0155800; U.S. 2007/0223832; U.S. 2008/0075346; U.S. 2008/0101672; U.S. 2008/0136815; U.S. 2008/0170768; U.S. 2008/0297509; U.S. 2009/0003668; U.S. 2009/0019400; U.S. 2009/0119609; U.S. 2009/0129642; U.S. 2009/0174729; U.S. 2009/0290769; U.S. 2010/0007663; U.S. 2010/0142788; U.S. 2011/0075888; U.S. 2011/0075896; WO 2011/037853; WO 2011/037860.

[0031] The disclosed approach utilizes a calculation of and display of time varying tissue characteristics as an approach to assess tissue health, classify tissues, or otherwise analyze tissues. For example, the disclosed techniques can be used to assess cardiac health through observation of variations in cardiac tissue properties over space (e.g., length, width, depths, area, volume, etc.) or over time (e.g., kinematics). With respect to kinematics (e.g., speed, velocity, acceleration, jerk, snap, etc.), a tissue that is moving through time can be visualized in 4D, as represented on a two dimensional display. Consider an example of physical displacement. Based on a transform generated from deformable registration, displacement can be quantified per unit time phase where the quantified displacement per unit time can be considered a time derivative of displacement. Any order derivative can be visualized by overlaying a parametric map of the derivative over each 3D data set, possibly on a voxel-by-voxel basis. The parametric map can be scaled or centered to show specific absolute or relative values of the time-derivative across the tissue.

[0032] For example, patients with cardiac arrhythmias (i.e., irregularities in the heartbeat) frequently have more than one electrical origin of the heartbeat (i.e., foci). Electrophysiologists may look to define the region of cardiac tissue that accelerates (i.e., second time derivative of displacement) first as an indicator of electrical activation. These regions of interest may represent isolated foci which then the electrophysiologist can ablate. FIG. **1** illustrates cardiac tissue overlaid with grayscale contours indicating acceleration of the cardiac tissue as derived based on the disclosed techniques.

[0033] Another cardiac application example include preoperative assessment for placement of electrical leads for pacemakers. Using parametric maps of time-based derivatives, or even spatial-based derivatives, the physician is enabled to look for regions of low velocity or acceleration as indicators of infarcted tissue to avoid placement of the electrical lead or stunned (i.e., hibernating) tissue for ideal lead placement as illustrated in FIG. **2** based on the disclosed techniques.

[0034] Although several examples have been presented with respect to cardiac tissue, one should appreciate that the disclose techniques apply equally to other tissues or anatomical structures. Consider the lungs. Tissue deformation of lungs for patients undergoing mechanical ventilation can be measured to determine if the amount of ventilation is appropriate or damaging to the lung (e.g., ventilator-induced lung injury). Inspiratory or expiratory phases can be acquired through an imaging modality via deformable registration. By registering the anatomical markers within the lung (i.e., the airway) the displacement and percent of displacement (i.e., mechanical strain) can be calculated (Hoffman & Chon, 2005). Thus, one can leverage variation of one property of a

tissue with other properties of the tissue for diagnostic or clinical purposes rather than limiting analysis to just time based variations.

[0035] In the field of oncology, mass volume is frequently used as an indicator for cancer progression or efficacy of treatment. Specific tissue changes can be characterized with deformable registration so that the percent change in captured signal is calculated between voxels. Such information can indicate intralesional non-morphological (e.g., molecular, chemical, etc.) changes indicative of metabolic activity.

[0036] In FIG. **3**, tissue analysis system **300** provides infrastructure for analyzing one or more target tissues and the tissue's associated properties. Target tissue **320** typically includes a tissue of a patient (e.g., human, animal, mammal, etc.) within a subject area of interest. In preferred embodiments, emitter **310** generates or emits incident energy **315** toward the subject tissue area. Incident energy **315** interacts, directly or indirectly, with target tissue **320** thereby generating one or more tissue signals **325** in responses to the interaction. Tissue signals **325** are considered representative of tissue properties depending on the nature of incident energy **315**. For example, acoustic or kinetic energy can yield mechanical properties or physical properties, while electromagnetic energy can yield electrical properties or possibly chemical properties.

[0037] Tissue analysis system **300** preferably comprises at least one sensor **330** configured to receive at least one of tissue signals **325**. Sensor **330** is typically complementary to the modality of tissue signals **325**. For example, in embodiments where tissue signals **325** include acoustic signals, sensors **330** can comprises one or more ultrasound transducers. The type or nature of the sensors **330** covers a broad spectrum of sensor types. Examples include imaging sensors, CCDs, Hall Effect probes, chemical sensors, spectrometers, stress or strain sensors, or other types of sensors. In some embodiments sensors **330** can include a sensor array possibly comprising a heterogeneous set of sensors where each different type of sensor receives different modalities of tissue signals **325**. Thus, multiple signal modalities allows for analysis of one tissue property with respect to another tissue property, although multiple signal modalities are not necessarily required from such an analysis.

[0038] Tissue signals **325** include information related to different tissue properties. For example, one tissue property could include conductivity, possibly measured as a result of RF electromagnetic incident energy **315** interacting with tissue **320**. A second tissue property could include size, shape, or dimension of tissue **320** as measured from ultrasound or X-Ray energy. The two properties can be analyzed to determine a variation of one property (e.g., conductivity) with respect to a second property (e.g., time, shape, area, etc.). Such variations can be beneficial for diagnostic analysis.

[0039] Signal converter **340** couples with sensors **330** and is preferably configured to convert tissue signals **325** into one or more measured properties **345** of target tissue **320** where the measure properties **325** a representative of a corresponding tissue property. The conversion techniques applied to tissue signals **325** depend on the nature of tissue signals **325** and can leverage known techniques. For example, standard ultrasound imaging techniques can be used to determine size, shape, dimension, density or other properties of target tissue **320**. X-Rays, CT, MRI, or other electromagnetic-based imaging techniques can be used to can be used to derive electrical measured properties of target tissue **320**.

[0040] Tissue properties **345** can be considered complex manageable objects within the system where each tissue property **345** can have one or more variations with respect to other tissue properties **345**. In some scenarios tissue properties **345** can vary with time, vary with location, vary with shape, or other tissue property. For example, tissue properties **345** could include electrical resistance, possibly measured through MRI, other electrical property. Consider a beating heart as an example. The electrical resistance of the cardiac tissue can vary with time through the cycle of a heartbeat, possibly due to blood flow through the cardiac tissue. Further, the resistance of the cardiac tissue can vary across the surface of the cardiac tissue or even through the volume of the cardiac tissue. One should appreciate that resistance in the previous example is merely one type of electrical property of a tissue and one should also appreciate that target tissue **320** can have many different types of properties.

[0041] A variation in property of target tissue **320** can take on many different forms. In some embodiments, the variation comprises a derivative of one measured property (property A) with respect to a second measured property (property B), where the derivative (i.e., $\partial A/\partial B$) is considered a measured value based on observed differences (i.e., $\Delta A/\Delta B$). Within the context of this document, one should appreciate that the term "derivative" encompasses a calculated value as well as a measured or observed value. More preferred embodiments utilize a time derivative of a tissue property (i.e., $\partial A/\partial t$) where the time derivative is measured with respect to an observation time. Thus, a variation can include a speed ($|\partial A/\partial t|$), a velocity ($\partial A/\partial t$), acceleration ($\partial^2 A/\partial t^2$), a jerk ($\partial^3 A/\partial t^3$), or higher order derivatives, where "A" represents a tissue property. One should appreciate that "A" can include other tissue properties beyond displacement.

[0042] Although some embodiments utilize time derivatives as a variation of tissue properties, one should also appreciate that other types of derivatives beyond time derivatives can also be utilized. For example, a spatial derivative (e.g., length (x), width (y), depth (z), area, volume, etc.) with respect to density can be presented as a variation of tissue properties. All tissue properties and their variations are contemplated. Example tissue properties can comprise mechanical properties (e.g., displacement, density, strain, stress, sheer, compression, tension, etc.), chemical properties (e.g., pH, reactivity, etc.), biometric properties (e.g., perfusion, patency, etc.), electrical properties (e.g., conductivity, resistance, inductance, etc.), or temporal properties.

[0043] System **300** preferably includes deformable registration system configured to display a variation as output **356** (e.g., a derivative, difference, etc.) between a first measured tissue property and a second measured tissue property. For example, such a system can display a variation of tissue pH with respect to tissue stress even while the tissue image is in motion. In the example shown, output **356** is rendered on display **355** of output device **350**, which operates as a deformable registration imaging system.

[0044] For further clarity, FIG. **4** illustrates that a tissue analysis system can include analysis engine **460** coupled with signal converter **440** and output device **450**. Analysis engine **440** preferably couples with one or more tissue database **465** configured to store properties of target tissues. In view that multiple tissue properties can be measured, the measured properties can be stored as an N-tuple in tissue database **465**, which allows for analyzing one property value against other property values on a voxel-by-voxel basis. For example, data-

base **465** can store all known measured tissue properties (e.g., physical, electrical, mechanical, chemical, temporal, etc.) at the voxel level. Analysis engine **460** can then derive a desired variation **461** of tissue properties from one voxel to another and from one time observation to another. Variation **461**, or a representation of the variation **461**, can be presented on display **455**. In some embodiments, variation **461** is presented as a false color contour graphic as illustrated.

[0045] Although analysis engine **460** can operate in real-time, it should be appreciated that analysis engine **460** can also operate off-line, possibly as a research tool. For example, as statistics are developed across a population of target tissues, analysis engine **460** can analyze possible variations **461** with respect to other aspects of the target tissue to determine if one or more correlations **463** exist. Additional aspects of the target tissue can include an analysis context under which the tissue is being examined. Example analysis contexts can include tissue disease state, tissue health state, a wellness program, a clinical study, a wellness program, a clinical study, a treatment program, a control group, a population study, a diagnosis procedure, or a post operative study.

[0046] Contemplated systems can also provide image representations to display desired tissue properties. For example, when presenting variations among non-temporal properties (e.g., pH versus conductivity), the system can map one of the non-temporal properties to a time axis to create a video showing pH-conductivity variation as a video sequence. Another approach includes providing a stack plot showing relative values of non-temporal variations by heights of data points. Still further, when displayed in 3D, possibly in a volumetric display or augmented reality display, properties or variations can be mapped to viewer orientation. As a person changes their orientation or position relative to a viewed model, the presented data can change accordingly to show updated values. Thus a healthcare provider can literally walk through multi-dimensional data.

[0047] An especially preferred type of variation **461** includes tissue kinematics. Tissue kinematics represent variations of physical or mechanical nature of a tissue with respect to time. Thus, tissue kinematics represent time derivatives of physical or mechanical properties of the target tissue. Analysis engine **460** can quantitatively evaluate tissue kinematic data over large populations of data to determine if features within tissue kinematics have correlations **463** to classification of tissues. For example, correlations **463** can map to demographics, a gene sequence, a control group, a clinical group, a disease, a family, a species, or other classification. Such an approach gives rise to mapping out a "kinome" of a tissue type, which can then possibly be used for diagnosis.

[0048] Tissue kinematics data can be plotted across all phases (i.e. time) or with respect to other data. Individual points of interest (i.e., single voxel, 1D), regions (i.e., area, 2D) of interest, or volumes of interest (i.e., 3D) can be manually or automatically defined. Contemplated analyses engines can use the points of interest to configure a display to present or render desired tissue kinematic signals against time as illustrated in FIG. **5**. Such renderings can be incorporated into a user interface as illustrated in FIG. **6**, exported as a CSV output or serialized format, or other forms of output.

[0049] As a concrete use case of tissue kinematics, consider the conduction system of the heart. The conduction system of the electrical signal propagates through the heart in a systematic fashion as illustrated in FIG. **7**. Currently the gold standard for determining the electrical activity of the heart is electrophysiological mapping where a healthcare provider measures the electrical activity inside the heart using an endovascular approach. Similar mappings can be accomplished by mapping of tissue acceleration of the myocardium based on the disclosed techniques. The EKG characterizes the cumulative electrical activity of the heart. The acceleration, or other time derivative, of specific locations can be plotted, possibly voxel-by-voxel, in relationship to the cardiac cycle in time and provide physical relationships of how structures move in relationship to each other during the cardiac cycle. The delay between peak acceleration, or other measures, can be determined by placing calipers at two peaks of the graph. Areas that accelerate in sequential fashion would indicate the course of the electrical signal. For example, in FIG. **5** the peak acceleration in the lateral wall occurs after the septal wall which indicates it is electrically activated after the septum. This can be correlated to EP mapping.

[0050] Ruptures of aortic aneurysms have high mortality and are tracked based on size, maximum diameter for example. One concern about thoracic aortic aneurysms (TAA) of the ascending aorta is their elasticity because they have to withstand the greatest change in volume as the heart pumps blood into the aorta. Examining sequential cross-sectional areas of interest as signals may be indicative of rupture. The change in diameter, area, velocity or other time derivative as traced through the cardiac cycle provides a quantization of wall dynamics. A particular wave pattern may be indicative of rupture and help healthcare providers determine whether to intervene or monitor the aneurysm.

[0051] Another representation of aortic wall mechanics may be visualized with the combined use of segmentation and deformable registration methods. Aortic wall deformation as characterized by strain has been proven to be an indicator of disease (Dernellis and Panaretou, 2005). Using deformable registration of phase-acquired aortic volumes, the change in length between arbitrarily defined voxels can be automatically calculated over the cardiac cycle. Strain can be calculated for every voxel in a volumetric data set. Segmentation methods allow the removal of extraneous tissue surrounding the aorta and direct visualization of strain patterns on the aortic wall.

[0052] Further, the kinematics of the heart, or other tissue, can be analyzed with respect other tissue properties to determine if the tissue falls within an a priori or user defined tissue class. As discussed above, the class could include stressed-tissue. For example, the kinematics of a tissue can indicate primary conditions of the tissue (e.g., infected, cancerous, etc.), secondary conditions where the tissue exhibits changes in kinematics due to indirect causes, tertiary conditions, or other issues. Example tissue kinematics can include a beating of a heart, a swelling the target tissue, a peristalsis, a respiration, a filling of a cavity, emptying of a cavity, a movement of a joint, a skin movement, an eye movement, a fluid flow through a lumen of a anatomical structure, or other type of kinematics.

[0053] Contemplated analysis engines **460** can be used to establish correlations **463** between tissue properties and kinematics of the tissues. Engine **460** accesses tissue database **465** storing tissue properties and tissue kinematics. Engine **460** can further classify the tissues according to their properties and seeks to find correlations **463** between tissue classes and tissue kinematics. Correlations can be established various techniques include multivariate analysis, genetic algorithms, cluster analysis, or other techniques. Establishing correla-

tions between tissue classes and tissue kinematics provides healthcare providers additional insight into possible tissue maladies, diagnosis, or other tissue related conditions.

[0054] It should be apparent to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the scope of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced. Where the specification claims refers to at least one of something selected from the group consisting of A, B, C . . . and N, the text should be interpreted as requiring only one element from the group, not A plus N, or B plus N, etc.

What is claimed is:

1. A tissue analysis system, comprising:

at least one sensor configured to receive at least one signal representative of a first tissue property and a second tissue property of at least a portion of a target tissue;

a signal converter coupled with the at least one sensor and configured to convert the at least one signal into a first property measurement of the first tissue property and a second property measurement of the second tissue property; and

a deformable registration imaging device coupled with the signal converter and configured to present an image representative of a variation of the first tissue property relative to the second tissue property dependent on the first property measurement and the second property measurement.

2. The system of claim **1**, wherein the at least one sensor comprises a sensor array.

3. The system of claim **2**, wherein a first sensor receives a first signal representative of the first tissue property, and a second different sensor receives a second signal representative of the second tissue property.

4. The system of claim **1**, wherein the second property measurement comprises an observation time.

5. The system of claim **4**, wherein the variation comprises a time derivative of the first tissue property with respect to the observation time.

6. The system of claim **5**, wherein the time derivative comprises a velocity of the portion of the tissue.

7. The system of claim **5**, wherein the time derivative comprises an acceleration of the portion of the tissue.

8. The system of claim **5**, wherein the time derivative comprises a higher order time derivative than the acceleration of the portion of the tissue.

9. The system of claim **1**, wherein the variation comprises at least a first order derivative of the first tissue property relative to the second tissue property.

10. The system of claim **1**, further comprising an analysis engine coupled with the signal converter and the deformable registration imaging device, where the analysis engine is configured to store the first property measurement and the second property measurement in an N-tuple associated with the target tissue.

11. The system of claim **10**, wherein the analysis engine is further configured to derive the variation of the first tissue property relative to the second tissue property dependent on the first property measurement and the second property measurement

12. The system of claim **10**, wherein the analysis engine if further configured to derive a correlation between the variation and an analysis context of the target tissue.

13. The system of claim **12**, wherein the analysis context comprises at least one of the following: a wellness program, a clinical study, a treatment program, a control group, a population study, a diagnosis procedure, a planning procedure, and a post operative study.

14. The system of claim **1**, wherein the variation comprises a tissue kinematic.

15. The system of claim **14**, wherein the tissue kinematic comprises at least one of the following: a beating of a heart, a swelling the target tissue, a peristalsis, a respiration, a filling of a cavity, emptying of a cavity, a movement of a joint, a skin movement, an eye movement, and a fluid flow through a lumen of an anatomical structure.

16. The system of claim **14**, further comprising an analysis engine configured to derive a correlation between the tissue kinematic and a classification of the target tissue.

17. The system of claim **16**, wherein the classification includes at least one of the following: a demographic, a gene sequence, a control group, a clinical group, a disease, a family, and a species.

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专利名称(译)	可变形的组织分析登记		
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申请号	US13/600055	申请日	2012-08-30
[标]申请(专利权)人(译)	希瑟安妮布朗 royea罗伯特		
申请(专利权)人(译)	BROWN，希瑟ANNE ROYEA，ROBERT		
当前申请(专利权)人(译)	齐成像，有限责任公司		
[标]发明人	BROWN HEATHER ANNE ROYEA ROBERT		
发明人	BROWN, HEATHER ANNE ROYEA, ROBERT		
IPC分类号	A61B5/00		
CPC分类号	A61B5/7425 A61B6/463 A61B8/463 A61B5/053 A61B5/0035 A61B5/0059 G06F19/3437 A61B5/004 A61B5/055 A61B6/032 A61B6/037 A61B8/08 A61B5/0044 A61F2/00 G16H50/50		
优先权	61/528949 2011-08-30 US 61/529610 2011-08-31 US 61/543644 2011-10-05 US 61/532923 2011-09-09 US 61/529109 2011-08-30 US 61/532944 2011-09-09 US 61/532988 2011-09-09 US 61/528984 2011-08-30 US 61/529556 2011-08-31 US		
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摘要(译)

公开了一种组织分析系统。组织分析系统包括获取源自靶组织并代表组织特性的信号的传感器。信号转换器将信号转换为属性测量值。分析引擎可以导出一种组织特性相对于另一特性的变化，并且在可变形配准成像设备内呈现变化。