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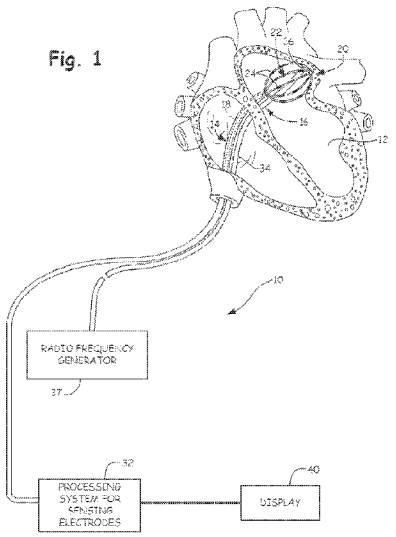
(54) Title: PERSISTENT DISPLAY OF NEAREST BEAT CHARACTERISTICS DURING REAL-TIME OR PLAY-BACK ELECTROPHYSIOLOGY DATA VISUALIZATION

Fig. 1



(57) Abstract: A system and method for mapping an anatomical structure includes sensing activation signals of intrinsic physiological activity with a plurality of electrodes disposed in or near the anatomical structure. A most recent intrinsic event at a selected time is determined based on the sensed activation signals and a persistent display of relevant characteristics is generated based on the sensed activation signals of the most recent intrinsic event. The persistent display is updated upon detection of a subsequent intrinsic event.

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PERSISTENT DISPLAY OF NEAREST BEAT CHARACTERISTICS DURING REAL-TIME OR PLAY-BACK ELECTROPHYSIOLOGY DATA VISUALIZATION

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Provisional Application No. 61/820,142, filed May 6, 2013, which is herein incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to cardiac mapping systems. More specifically, the present disclosure relates to a cardiac mapping system configured to display persistent data visualization during an electrophysiological study.

BACKGROUND

[0003] Diagnosing and treating heart rhythm disorders often involve the introduction of a catheter having a plurality of sensors/probes into a cardiac chamber through the surrounding vasculature. The sensors detect electric activity of the heart at sensor locations in the heart. The electric activity is generally processed into electrogram signals that represent signal propagation through cardiac tissue at the sensor locations.

[0004] Systems can be configured to display the electrical signals detected in the cardiac chamber in a real-time fashion to a physician. However, the activation signals are transient and thus are replaced by a display of the most current electrical activity including uninteresting activity, for example the dormant electrical signals between heart beats. While a visualization of the temporal evolution of these electrical signals can be useful in diagnosing cardiac abnormalities, it may be beneficial to display various characteristics of the electrical signals in a persistent fashion or until a significant change in the electrical signals is detected.

SUMMARY

[0005] Disclosed herein are various embodiments of a method for generating a persistent display of cardiac activation signals sensed by a cardiac catheter, as well as anatomical mapping systems employing such methods.

[0006] In Example 1, a method for mapping an anatomical structure includes sensing activation signals of intrinsic events with a plurality of electrodes disposed in

or near the anatomical structure, determining a most recent intrinsic event at a first time based on the sensed activation signals, generating a persistent display of at least one relevant characteristic of the sensed activation signals of the most recent intrinsic event, and updating the persistent display upon detection of a subsequent intrinsic event.

[0007] In Example 2, the method according to Example 1, wherein the persistent display is generated in real-time as the activation signals are sensed.

[0008] In Example 3, the method according to either Examples 1 or 2, wherein the persistent display is generated off line after a plurality of activation signals are recorded and the most recent intrinsic event is before or after the first time.

[0009] In Example 4, the method according to any of Examples 1-3, wherein the generated persistent display includes at least one of an activation map, a vector field representing an activation pattern during the most recent intrinsic event, a contour map of iso-potential lines during the most recent intrinsic event, and a reliability map of related to onset pick-up times of the activation signals of the most recent intrinsic event.

[0010] In Example 5, the method according to any of Examples 1-4, further includes determining an onset time for the most recent activation signal at each of the plurality of electrodes, calculating a median onset time based on an average of the determined onset times, and identifying the subsequent intrinsic event according to the calculated median onset time.

[0011] In Example 6, the method according to any of Examples 1-5, further includes calculating a quadratic mean for the most recent activation signal for each of the plurality of electrodes, determining a peak value from a sum of the quadratic means, and identifying the subsequent intrinsic event according to the determined peak value.

[0012] In Example 7, the method according to any of Examples 1-6, further includes determining an onset time for the most recent activation signal at each of the plurality of electrodes, convolving the onset times with a Gaussian function, identifying the subsequent intrinsic event according to the convolution.

[0013] In Example 8, the method according to any of Examples 1-7, further includes determining a morphology for each intrinsic event, comparing the morphology of the most recent intrinsic event with a previous intrinsic event, and

updating the persistent display based on changes in morphology between the most recent and previous intrinsic event.

[0014] In Example 9, the method according to any of Examples 1-8, wherein the persistent display is updated upon the detection of a plurality of subsequent intrinsic events.

[0015] In Example 10, a method for cardiac mapping includes sensing activation signals of cardiac activity with a plurality of electrodes disposed in or near in myocardial tissue, detecting a most recent heart beat based on the sensed activation signals generating a persistent display of at least one relevant characteristic associated with the sensed activation signals of the most recent heart beat, and updating the persistent display upon detection of a subsequent heart beat.

[0016] In Example 11, the method according to Example 10, wherein the generated persistent display includes at least one of an activation map during the most recent heart beat, a vector field representing an activation pattern during the most recent heart beat, a contour map of iso-potential lines during the most recent heart beat, and a reliability map of related to onset pick-up times of the activation signals related to the most recent heart beat.

[0017] In Example 12, the method according to either Examples 10 or 11, further included determining an onset time for a most recent activation signal at each of the plurality of electrodes, calculating a median onset time based on an average of the determined onset times, and detecting the subsequent heart beat based on the calculated median onset time.

[0018] In Example 13, the method according to any of Examples 10-12, further includes calculating a quadratic mean for a most recent activation signal for each of the plurality of electrodes, determining a peak value from a sum of the quadratic means, and detecting the subsequent heart beat based on the determined peak value.

[0019] In Example 14, the method according to any of Examples 10-13, further includes determining an onset time for a most recent activation signal for each of the plurality of electrodes, convolving the onset times with a Gaussian function, and detecting the subsequent heart beat according to the convolution.

[0020] In Example 15, the method according to any of Examples 10-14, further includes determining a morphology for each heart, comparing the morphology of the most recent heart beat with a previous heart beat, and updating the persistent

display based on changes in morphology between the most recent and previous heart beat.

[0021] In Example 16, an anatomical mapping system includes a plurality of mapping electrodes configured to detect activation signals of intrinsic events within an anatomical structure, each of the plurality of mapping electrodes having an electrode location, and a processing system associated with the plurality of mapping electrodes, the processing system configured to record the detected activation signals and associate at least one of the plurality of mapping electrodes with each recorded activation signal, the processing system further configured to determine a most recent intrinsic event, to generate a persistent display of at least one relevant characteristic of the detected activation signals of the most recent intrinsic event, and to update the persistent display with at least one relevant characteristic of a subsequent intrinsic event.

[0022] In Example 17, the anatomical system according to Example 16, wherein the persistent display includes at least one of a vector field representing an activation pattern during the most recent intrinsic event, a contour map of iso-potential lines during the most recent intrinsic event, and a reliability map of onset pick-up times of the most recent intrinsic event.

[0023] In Example 18, the anatomical system according to either of Examples 16 or 17, wherein, to determine the most recent intrinsic event, the processing system is further configured to determine an onset time for the most recent activation signal at each of the plurality of electrodes, and to calculate a median onset time based on an average of the determined onset times.

[0024] In Example 19, the anatomical system according to any of Examples 16-18, wherein, to determine the most recent intrinsic event, the processing system is further configured to calculate a quadratic mean for the most recent activation signal for each of the plurality of electrodes, and to determine a peak value from a sum of the quadratic means.

[0025] In Example 20, the anatomical system according to any of Examples 16-19, wherein, to determine the most recent intrinsic event, the processing system is further configured to determine an onset time for the most recent activation signal at each of the plurality of electrodes, and to convolve the onset times with a Gaussian function.

[0026] While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. 1 is a schematic view of an embodiment of a system for accessing a targeted tissue region in the body for diagnostic and therapeutic purposes.

[0028] FIG. 2 is a schematic view of an embodiment of a mapping catheter having a basket functional element carrying structure for use in association with the system of FIG. 1.

[0029] FIG.3 is a schematic side view of an embodiment of the basket functional element including a plurality of mapping electrodes .

[0030] FIG. 4 illustrates a persistent display of relevant characteristics of activation signals sensed by the system of FIG. 1 at a first time.

[0031] FIG. 5 illustrates the persistent display of FIG. 4 at a subsequent time.

[0032] While the invention is amenable to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and are described in detail below. The intention, however, is not to limit the invention to the particular embodiments described. On the contrary, the invention is intended to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

[0033] FIG. 1 is a schematic view of a system 10 for accessing a targeted tissue region in the body for diagnostic or therapeutic purposes. FIG. 1 generally shows the system 10 deployed in the left ventricle of the heart. Alternatively, system 10 can be deployed in other regions of the heart, such as the left atrium, right atrium, or right ventricle. While the illustrated embodiment shows the system 10 being used for ablating myocardial tissue, the system 10 (and the methods described herein) may alternatively be configured for use in other tissue ablation applications, such as procedures for ablating tissue in the prostrate, brain, gall bladder, uterus, and other regions of the body, including in systems that are not necessarily catheter-based.

[0034] The system 10 includes a mapping probe 14 and an ablation probe 16. In FIG. 1, each is separately introduced into the selected heart region 12 through a vein or artery (e.g., the femoral vein or artery) through suitable percutaneous access. Alternatively, the mapping probe 14 and ablation probe 16 can be assembled in an integrated structure for simultaneous introduction and deployment in the heart region 12.

[0035] The mapping probe 14 has a flexible catheter body 18. The distal end of the catheter body 18 carries a three-dimensional multiple electrode structure 20. In the illustrated embodiment, the structure 20 takes the form of a basket defining an open interior space 22 (see FIG. 2), although other multiple electrode structures could be used wherein the geometry of the electrode structure and electrode locations are known. The multiple electrode structure 20 carries a plurality of mapping electrodes 24 each having an electrode location and channel. Each electrode 24 is configured to sense intrinsic physiological activity in the anatomical region on which the ablation procedure is to be performed. In some embodiments, the electrodes 24 are configured to detect activation signals of the intrinsic physiological activity within the anatomical structure, e.g., the activation times of cardiac activity.

[0036] The electrodes 24 are electrically coupled to a processing system 32. A signal wire (not shown) is electrically coupled to each electrode 24 on the basket structure 20. The wires extend through the body 18 of the probe 14 and electrically couple each electrode 24 to an input of the processing system 32, as will be described later in greater detail. The electrodes 24 sense intrinsic electrical activity in the anatomical region, e.g., myocardial tissue. The sensed activity, e.g. activation signals, is processed by the processing system 32 to assist the physician by generating an anatomical map, e.g., action potential duration (APD) map or an activation map, to identify the site or sites within the heart appropriate for ablation. The processing system 32 identifies a near-field signal component, i.e. activation signals associated with local activation and originating from the tissue adjacent to the mapping electrode 24, from an obstructive far-field signal component, i.e. activation signals originating from non-adjacent tissue, within the sensed activation signals. For example, in an atrial study, the near-field signal component includes activation signals originating from atrial myocardial tissue whereas the far-field signal component includes activation signals originating from the ventricular myocardial

tissue. The near-field activation signal component can be further analyzed to find the presence of a pathology and to determine a location suitable for ablation for treatment of the pathology, e.g., ablation therapy.

[0037] The processing system 32 includes dedicated circuitry (e.g., discrete logic elements and one or more microcontrollers; application-specific integrated circuits (ASICs); or specially configured programmable devices, such as, for example, programmable logic devices (PLDs) or field programmable gate arrays (FPGAs)) for receiving and/or processing the acquired activation signals. In some embodiments, the processing system 32 includes a general purpose microprocessor and/or a specialized microprocessor (e.g., a digital signal processor, or DSP, which may be optimized for processing activation signals) that executes instructions to receive, analyze and display information associated with the received activation signals. In such implementations, the processing system 32 can include program instructions, which when executed, perform part of the signal processing. Program instructions can include, for example, firmware, microcode or application code that is executed by microprocessors or microcontrollers. The above-mentioned implementations are merely exemplary, and the reader will appreciate that the processing system 32 can take any suitable form.

[0038] In some embodiments, the processing system 32 may be configured to measure the intrinsic electrical activity in the myocardial tissue adjacent to the electrodes 24. For example, in some embodiments, the processing system 32 is configured to detect intrinsic electrical activity associated with a dominant rotor in the anatomical feature being mapped. Studies have shown that dominant rotors have a role in the initiation and maintenance of atrial fibrillation, and ablation of the rotor path and/or rotor core may be effective in terminating the atrial fibrillation. In either situation, the processing system 32 processes the sensed activation signals to isolate the near-field signal component and generate an APD map based on the isolated near-field signal component. The APD map may be used by the physician to identify a site suitable for ablation therapy.

[0039] The ablation probe 16 includes a flexible catheter body 34 that carries one or more ablation electrodes 36. The one or more ablation electrodes 36 are electrically connected to a radio frequency (RF) generator 37 that is configured to deliver ablation energy to the one or more ablation electrodes 36. The ablation probe 16 is movable with respect to the anatomical feature to be treated, as well as

the structure 20. The ablation probe 16 is positionable between or adjacent to electrodes 24 of the structure 20 as the one or more ablation electrodes 36 are positioned with respect to the tissue to be treated.

[0040] The processing system 32 outputs to a device 40 the generated APD map for viewing by a physician. In the illustrated embodiment, device 40 is a CRT, LED, or other type of display, or a printer. The device 40 presents the APD map in a format most useful to the physician. In addition, the processing system 32 may generate position-identifying output for display on the device 40 that aids the physician in guiding the ablation electrode(s) 36 into contact with tissue at the site identified for ablation.

[0041] FIG. 2 illustrates an embodiment of the mapping catheter 14 including electrodes 24 at the distal end suitable for use in the system 10 shown in FIG. 1. The mapping catheter 14 has a flexible catheter body 18, the distal end of which carries the three dimensional structure 20 configured to carry the mapping electrodes or sensors 24. The mapping electrodes 24 sense intrinsic electrical activity, e.g., activation signals, in the myocardial tissue, the sensed activity is then processed by the processing system 32 to assist the physician in identifying the site or sites having a heart rhythm disorder or other myocardial pathology via a generated and displayed APD map. This process is commonly referred to as mapping. This information can then be used to determine an appropriate location for applying appropriate therapy, such as ablation, to the identified sites, and to navigate the one or more ablation electrodes 36 to the identified sites.

[0042] The illustrated three-dimensional structure 20 comprises a base member 41 and an end cap 42 between which flexible splines 44 generally extend in a circumferentially spaced relationship. As discussed above, the three dimensional structure 20 takes the form of a basket defining an open interior space 22. In some embodiments, the splines 44 are made of a resilient inert material, such as Nitinol metal or silicone rubber, and are connected between the base member 41 and the end cap 42 in a resilient, pretensed condition, to bend and conform to the tissue surface they contact. In the illustrated embodiment, eight splines 44 form the three dimensional structure 20. Additional or fewer splines 44 could be used in other embodiments. As illustrated, each spline 44 carries eight mapping electrodes 24. Additional or fewer mapping electrodes 24 could be disposed on each spline 44 in other embodiments of the three dimensional structure 20. In the illustrated

embodiment, the three dimensional structure 20 is relatively small (e.g., 40 mm or less in diameter). In alternative embodiments, the three dimensional structure 20 is even smaller or larger (e.g., 40 mm in diameter or greater).

[0043] A slidable sheath 50 is movable along the major axis of the catheter body 18. Moving the sheath 50 forward (i.e., toward the distal end) causes the sheath 50 to move over the three dimensional structure 20, thereby collapsing the structure 20 into a compact, low profile condition suitable for introduction into and/or removal from an interior space of an anatomical structure, such as, for example, the heart. In contrast, moving the sheath 50 rearward (i.e., toward the proximal end) exposes the three dimensional structure 20, allowing the structure 20 to elastically expand and assume the pretensed position illustrated in FIG. 2. Further details of embodiments of the three dimensional structure 20 are disclosed in U.S. Pat. No. 5,647,870, entitled "Multiple Electrode Support Structures," which is hereby expressly incorporated herein by reference in its entirety.

[0044] A signal wire (not shown) is electrically coupled to each mapping electrode 24. The wires extend through the body 18 of the mapping catheter 20 into a handle 54, in which they are coupled to an external connector 56, which may be a multiple pin connector. The connector 56 electrically couples the mapping electrodes 24 to the processing system 32. Further details on mapping systems and methods for processing signals generated by the mapping catheter are discussed in U.S. Patent No. 6,070,094, entitled "Systems and Methods for Guiding Movable Electrode Elements within Multiple-Electrode Structure," U.S. Patent No. 6,233,491, entitled "Cardiac Mapping and Ablation Systems," and U.S. Patent No. 6,735,465, entitled "Systems and Processes for Refining a Registered Map of a Body Cavity," the disclosures of which are hereby expressly incorporated herein by reference.

[0045] It is noted that other multi-electrode structures could be deployed on the distal end of the mapping catheter 14. It is further noted that the multiple mapping electrodes 24 may be disposed on more than one structure rather than, for example, the single mapping catheter 14 illustrated in FIG. 2. For example, if mapping within the left atrium with multiple mapping structures, an arrangement comprising a coronary sinus catheter carrying multiple mapping electrodes and a basket catheter carrying multiple mapping electrodes positioned in the left atrium may be used. As another example, if mapping within the right atrium with multiple mapping structures, an arrangement comprising a decapolar catheter carrying

multiple mapping electrodes for positioning in the coronary sinus, and a loop catheter carrying multiple mapping electrodes for positioning around the tricuspid annulus may be used.

[0046] Although the mapping electrodes 24 have been described as being carried by dedicated mapping probes, such as the mapping catheter 14, the mapping electrodes may be carried on non-mapping dedicated probes or multifunction probes. For example, an ablation catheter, such as the ablation catheter 16, can be configured to include one or more mapping electrodes 24 disposed on the distal end of the catheter body and coupled to the signal processing system 32 and guidance system (*Not shown in the figures)*. As another example, the ablation electrode at the distal end of the ablation catheter may be coupled to the signal processing system 32 to also operate as a mapping electrode.

[0047] To illustrate the operation of the system 10, FIG. 3 is a schematic side view of an embodiment of the basket structure 20 including a plurality of mapping electrodes 24. In the illustrated embodiment, the basket structure includes 64 mapping electrodes 24. The mapping electrodes 24 are disposed in groups of eight electrodes (labeled 1, 2, 3, 4, 5, 6, 7, and 8) on each of eight splines (labeled A, B, C, D, E, F, G, and H). While an arrangement of sixty-four mapping electrodes 24 is shown disposed on a basket structure 20, the mapping electrodes 24 may alternatively be arranged in different numbers, on different structures, and/or in different positions. In addition, multiple basket structures can be deployed in the same or different anatomical structures to simultaneously obtain signals from different anatomical structures.

[0048] After the basket structure 20 is positioned adjacent to the anatomical structure to be treated (e.g., left atrium or left ventricle of the heart), the processing system 32 is configured to record the activation signals from each electrode 24 channel related to intrinsic physiological activity of the anatomical structure, i.e. the electrodes 24 measure electrical activation signals intrinsic to the physiology of the anatomical structure.

[0049] The processing system 32 is further configured to generate a persistent display for output to the display device 40. The persistent display includes relevant characteristics pertaining to the sensed activation signals in such a manner that the relevant characteristics corresponding to an intrinsic event remains displayed or persists until the next intrinsic event. The persistent display is updated when a

subsequent intrinsic event is detected; therefore, relevant characteristics of the activation signals are not displayed during quiescent periods between the intrinsic events. The intrinsic events may include a cardiac contraction or beat, myocardial electrical activity, electrical signals within neurological pathways, a muscular contraction, or the like.

[0050] Figs. 4 and 5 illustrate an example of a persistent display at a time *t* and a later time *t+n*, respectively, at which a subsequent intrinsic event has been detected. During a real-time procedure, the display of FIG. 4 will remain persistent until a time period of *n* passes at which the subsequent intrinsic event occurs and is detected. The processing system 32 detects the intrinsic event and updates the persistent display as shown in FIG. 5. Relevant characteristics may include any one of an activation map 60a & 60b, a vector field showing propagation patterns 62a & 62b, a voltage propagation map such as a contour map of iso-potential lines 64a & 64b which is shown overlaid the vector field but can be also be a separate display, a phase propagation map such as a contour map of iso-phase lines which illustrates the phase propagating across the field of electrodes 24, a derivative map which illustrates the change in voltage over time across the field of electrodes 24, a two-dimensional reliability map (not shown) which indicates a reliability of an onset activation signal for each electrode channel during an intrinsic event under progress, an electrogram 66a & 66b indicating the sensed activation signals at each electrode channel, and the like.

[0051] It should be noted that the persistent display can function in a playback mode rather than a real-time mode such that the relevant characteristics remain persistently display until a subsequent intrinsic event is detected whether before a selected time *t*, as in a playback mode in a reverse direction, or after the selected *t*, as in a playback mode in a forward direction or in real-time. The user interface of the persistent display, as shown in FIGS. 4 & 5, can also be configurable with various selectable options to choose, for example, how many or which of the various relevant characteristics to be displayed or to view a previous intrinsic event or a future intrinsic event (during a playback mode). Additionally, multiples of a relevant characteristic can be displayed, such as three vectors fields or contour maps where one is designated to display a previous intrinsic event, another is designated to display the most recent intrinsic event, and the final is designated to display a future intrinsic event (during a playback mode). Other options may include highlighting

similar intrinsic events based on morphology or a similarity metric based on cross-correlation between the characteristic pattern representing each activity in the vector field map or iso-potential contour map, a similarity metric based on rates of change or patterns in propagation velocity between a given channel, and the like, in the relevant characteristics, e.g. the electrogram. Another option for the persistent display is to modify the vectors of the vector field such that various line weights or colors can denote relationships with previous intrinsic events. A vector to vector cross correlation can be employed by the processing system 32 to generate the changes in line weights or colors.

[0052] The processing system 32 determines the most recent intrinsic event before or after a selected time *t*. The intrinsic event will be described in terms of a cardiac contraction or heart beat (atrial or ventricular hear beat) but can include any measureable electrical signals in a patient's body including, but not limited to, muscle contractions, neurological signals, and the like. The processing system 32 can employ a number of methods to determine the most recent heart beat. In some embodiments, the processing system 32 can determine the most recent heart beat according to a median onset time for the sensed activation signals. An onset time refers to a time stamp associated with each activation signal indicating the initiation of the activation signal. When a heart beat occurs, the myocardial cells in a chamber of interest do not depolarize at the same time. Therefore, the mapping electrodes 24 will sense activation signals at various times within a small window depending on their location with respect to, for example, an electrical impulse node. By taking the median onset times of these activation signals, the processing system 32 can approximate a time stamp for the corresponding heart beat. If the time stamp is the same as the previous heart beat, then a subsequent heart beat has not been detected and the processing system does not update the persistent display, i.e. the information and/or data that is displayed persists until a subsequent heart beat is detected. Once the processing system 32 detects a median onset time which differs from a median onset time of a previously detected heart beat, the processing system 32 updates the persistent display with relevant characteristics derived from the activation signals associated with the current or most recently detected heart beat.

[0053] In some embodiments, the processing system 32 is configured to determine the most recent beat calculate the sum of squares of the activation signals across a plurality of mapping electrode 24 channels wherein the resultant composite

signal peaks are indicative of beat timings. Alternatively, the processing system 32 can determines the most recent heart beat according to a convolution of a train of onset times for each electrode with a smoothing function such as a Gaussian function. The convoluted functions can be summed across a plurality of mapping electrode 24 channels wherein the peaks on the summed or composite signal can indicate beat timings.

[0054] In some embodiments, the processing system 32 determines the most recent heart beat according to a morphology comparison between the activation signals or relevant characteristics of a previous heart beat and the most recent heart beat. If a significant change in the morphology is detected by the processing system 32, the relevant characteristics of the persistent display will be updated based on the activation signals corresponding to the most recent heart beat.

[0055] Various modifications and additions can be made to the exemplary embodiments discussed without departing from the scope of the present invention. For example, while the embodiments described above refer to particular features, the scope of this invention also includes embodiments having different combinations of features and embodiments that do not include all of the described features. Accordingly, the scope of the present invention is intended to embrace all such alternatives, modifications, and variations as fall within the scope of the claims, together with all equivalents thereof.

CLAIMS

We claim:

1. A method for mapping an anatomical structure, the method comprising:

sensing activation signals of intrinsic events with a plurality of electrodes disposed in or near the anatomical structure;

determining a most recent intrinsic event at a first time based on the sensed activation signals;

generating a persistent display of at least one relevant characteristic of the sensed activation signals of the most recent intrinsic event; and

updating the persistent display upon detection of a subsequent intrinsic event.

2. The method according to claim 1, wherein the persistent display is generated in real-time as the activation signals are sensed.

3. The method according to claim 1, wherein the persistent display is generated off line after a plurality of activation signals are recorded and the most recent intrinsic event is before or after the first time.

4. The method according to claim 1, wherein the generated persistent display includes at least one of an activation map, a vector field representing an activation pattern, a voltage propagation map representing voltage propagation pattern, a phase propagation map representing phase propagation pattern, a derivative map representing a pattern in a change of voltage over time, and a reliability map representing a reliability pattern related to onset pick-up times of the activation signals.

5. The method according to claim 1, further including:

determining an onset time for the most recent activation signal at each of the plurality of electrodes;

calculating a median onset time based on an average of the determined onset times; and

identifying the subsequent intrinsic event according to the calculated median onset time.

6. The method according to claim 1, further including:

calculating a quadratic mean for the most recent activation signal for each of the plurality of electrodes;

determining a peak value from a sum of the quadratic means across the plurality of electrodes; and

identifying the subsequent intrinsic event according to the determined peak value.

7. The method according to claim 1, further including:

determining an onset time for the most recent activation signal at each of the plurality of electrodes;

convolving the onset times with a smoothing function;

determining a peak value from a sum of the convolved signals across the plurality of electrodes; and

identifying the subsequent intrinsic event according to the determined peak value.

8. The method according to claim 1, further including:

determining a morphology for each intrinsic event;

comparing the morphology of the most recent intrinsic event with a previous intrinsic event; and

updating the persistent display based on changes in morphology between the most recent and previous intrinsic event.

9. The method according to claim 1, wherein the persistent display is updated upon the detection of a plurality of subsequent intrinsic events.

10. A method for cardiac mapping, the method comprising:

sensing activation signals of cardiac activity with a plurality of electrodes disposed in or near in myocardial tissue;

detecting a most recent heart beat based on the sensed activation signals;

generating a persistent display of at least one relevant characteristic associated with the sensed activation signals of the most recent heart beat; and

updating the persistent display upon detection of a subsequent heart beat.

11. The method according to claim 10, wherein generated persistent display includes at least one of an activation map, a vector field representing an activation pattern, a voltage propagation map representing voltage propagation pattern, a phase propagation map representing phase propagation pattern, a derivative map representing a pattern in a change of voltage over time, and a reliability map representing a reliability pattern related to onset pick-up times of the activation signals.

12. The method according to claim 10, further including:

determining an onset time for a most recent activation signal at each of the plurality of electrodes;

calculating a median onset time based on an average of the determined onset times; and

detecting the subsequent heart beat based on the calculated median onset time.

13. The method according to claim 10, further including:

calculating a quadratic mean for a most recent activation signal for each of the plurality of electrodes;

determining a peak value from a sum of the quadratic means across the plurality of electrodes; and

detecting the subsequent heart beat based on the determined peak value.

14. The method according to claim 10, further including:

determining an onset time for a most recent activation signal for each of the plurality of electrodes;

convolving the onset times with a smoothing function;

determining a peak value from a sum of the convolved signals across the plurarity of electrodes; and

detecting the subsequent heart beat according to the determined peak value.

15. The method according to claim 10, further including:

determining a morphology for each heart;

comparing the morphology of the most recent heart beat with a previous heart beat; and

updating the persistent display based on changes in morphology between the most recent and previous heart beat.

16. An anatomical mapping system comprising:

a plurality of mapping electrodes configured to detect activation signals of intrinsic events within an anatomical structure, each of the plurality of mapping electrodes having an electrode location;

a processing system associated with the plurality of mapping electrodes, the processing system configured to record the detected activation signals and associate at least one of the plurality of mapping electrodes with

each recorded activation signal, the processing system further configured to determine a most recent intrinsic event, to generate a persistent display of at least one relevant characteristic of the detected activation signals of the most recent intrinsic event, and to update the persistent display with at least one relevant characteristic of a subsequent intrinsic event.

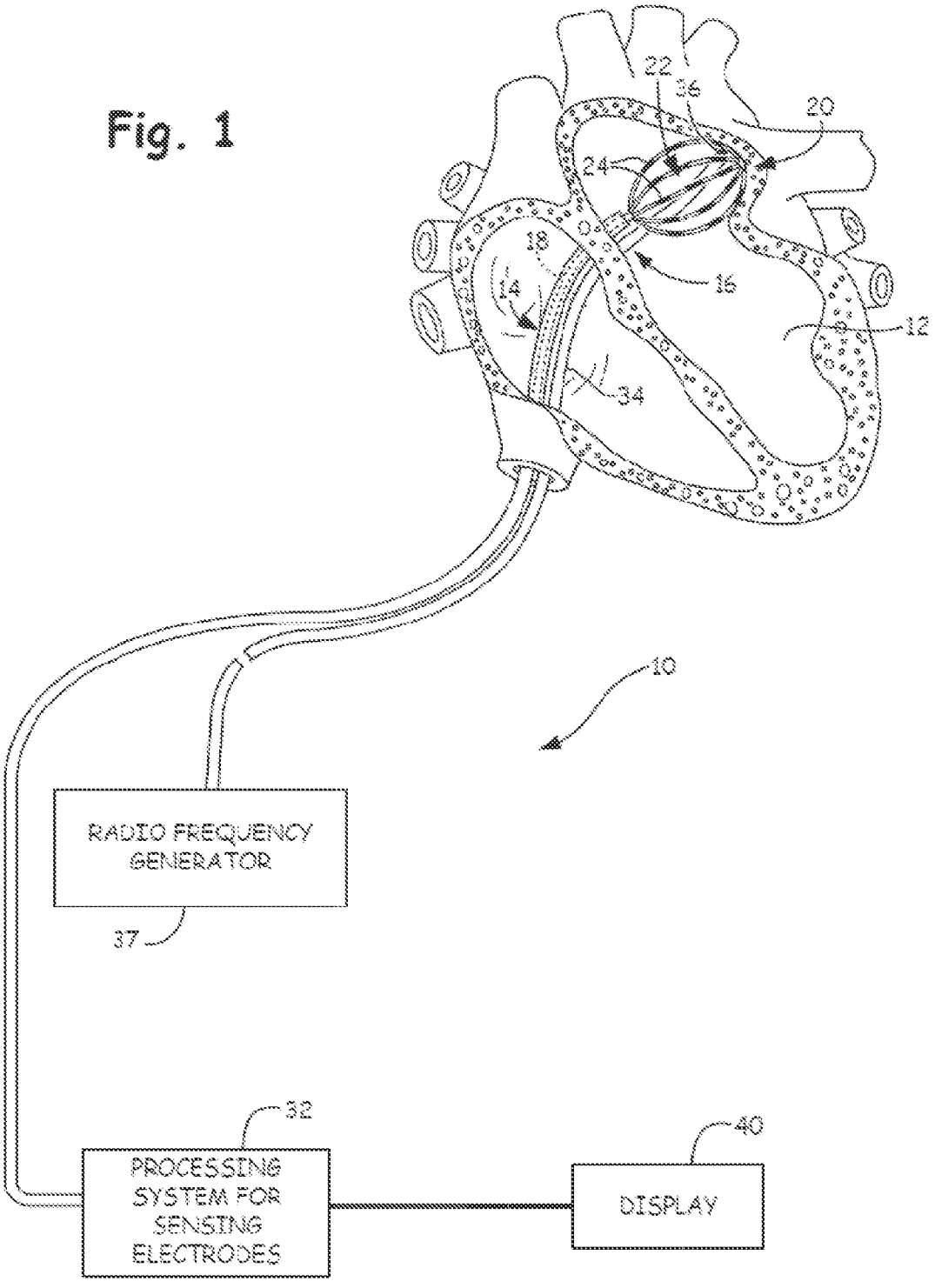
17. The anatomical system according to claim 16, wherein the persistent display includes at least one of an activation map, a vector field representing an activation pattern, a voltage propagation map representing voltage propagation pattern, a phase propagation map representing phase propagation pattern, a derivative map representing a pattern in a change of voltage over time, and a reliability map representing a reliability pattern related to onset pick-up times of the activation signals.

18. The anatomical system according to claim 16, wherein, to determine the most recent intrinsic event, the processing system is further configured to determine an onset time for the most recent activation signal at each of the plurality of electrodes, and to calculate a median onset time based on an average of the determined onset times.

19. The anatomical system according to claim 16, wherein, to determine the most recent intrinsic event, the processing system is further configured to calculate a quadratic mean for the most recent activation signal for each of the plurality of electrodes, and to determine a peak value from a sum of the quadratic means across the plurality of mapping electrodes.

20. The anatomical system according to claim 16, wherein, to determine the most recent intrinsic event, the processing system is further configured to determine an onset time for the most recent activation signal at each of the plurality of electrodes, convolve the onset times with a smoothing function, and determine a peak value from a sum of the convolved signals across the plurality of electrodes.

Fig. 1


22
36
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10
RADIO FREQUENCY GENERATOR
37
32
PROCESSING SYSTEM FOR SENSING ELECTRODES
40
DISPLAY

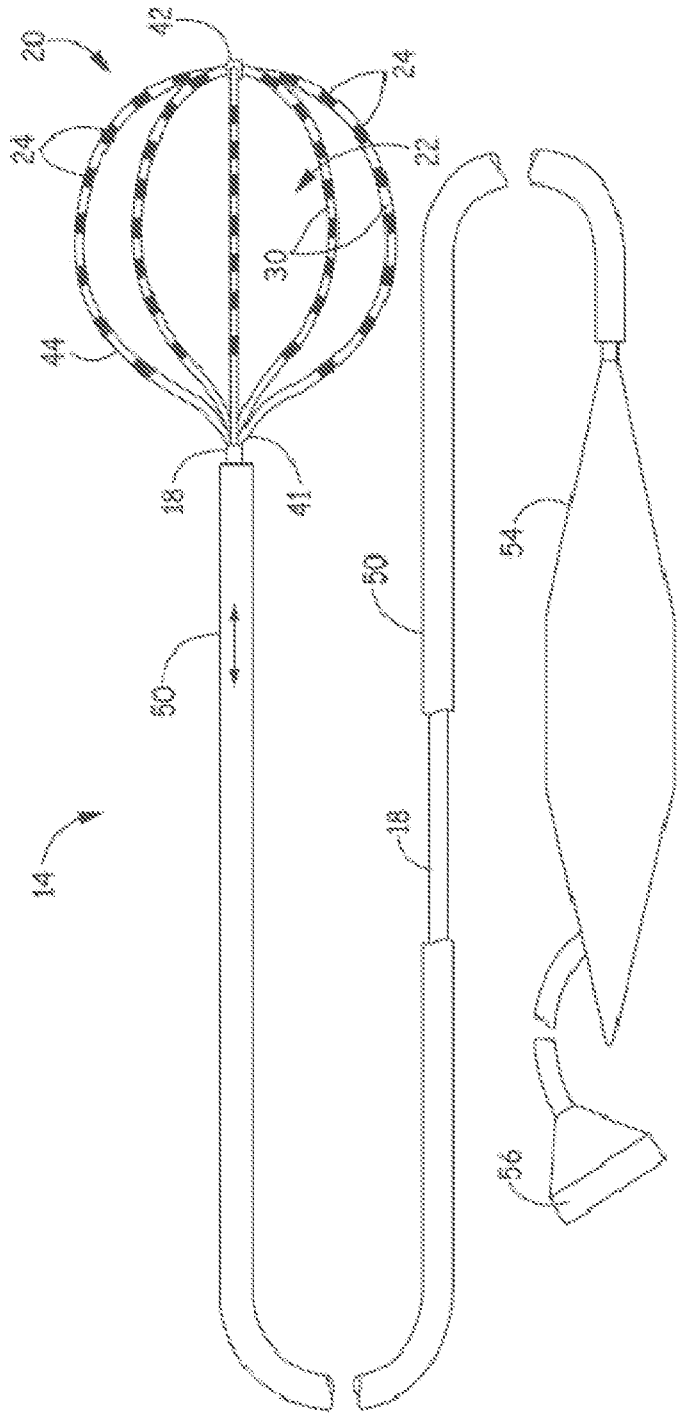

FIG. 2

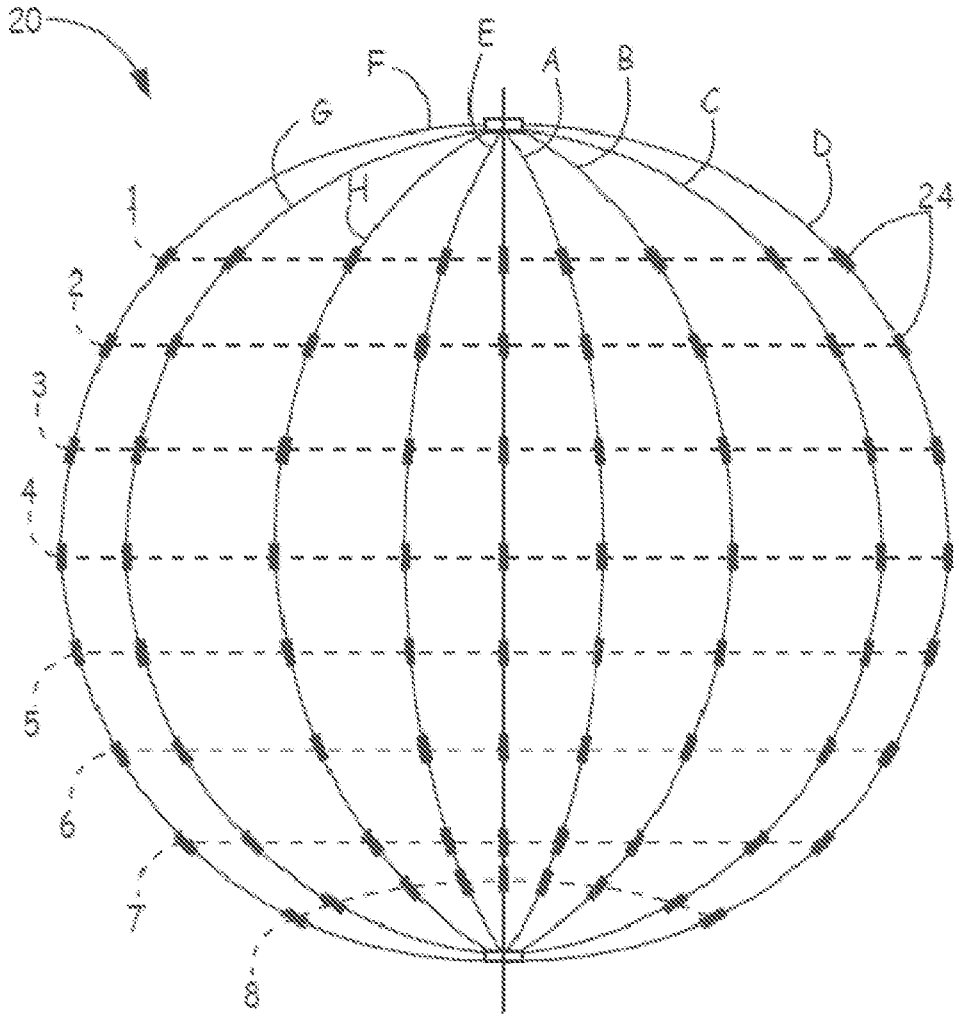

FIG. 3

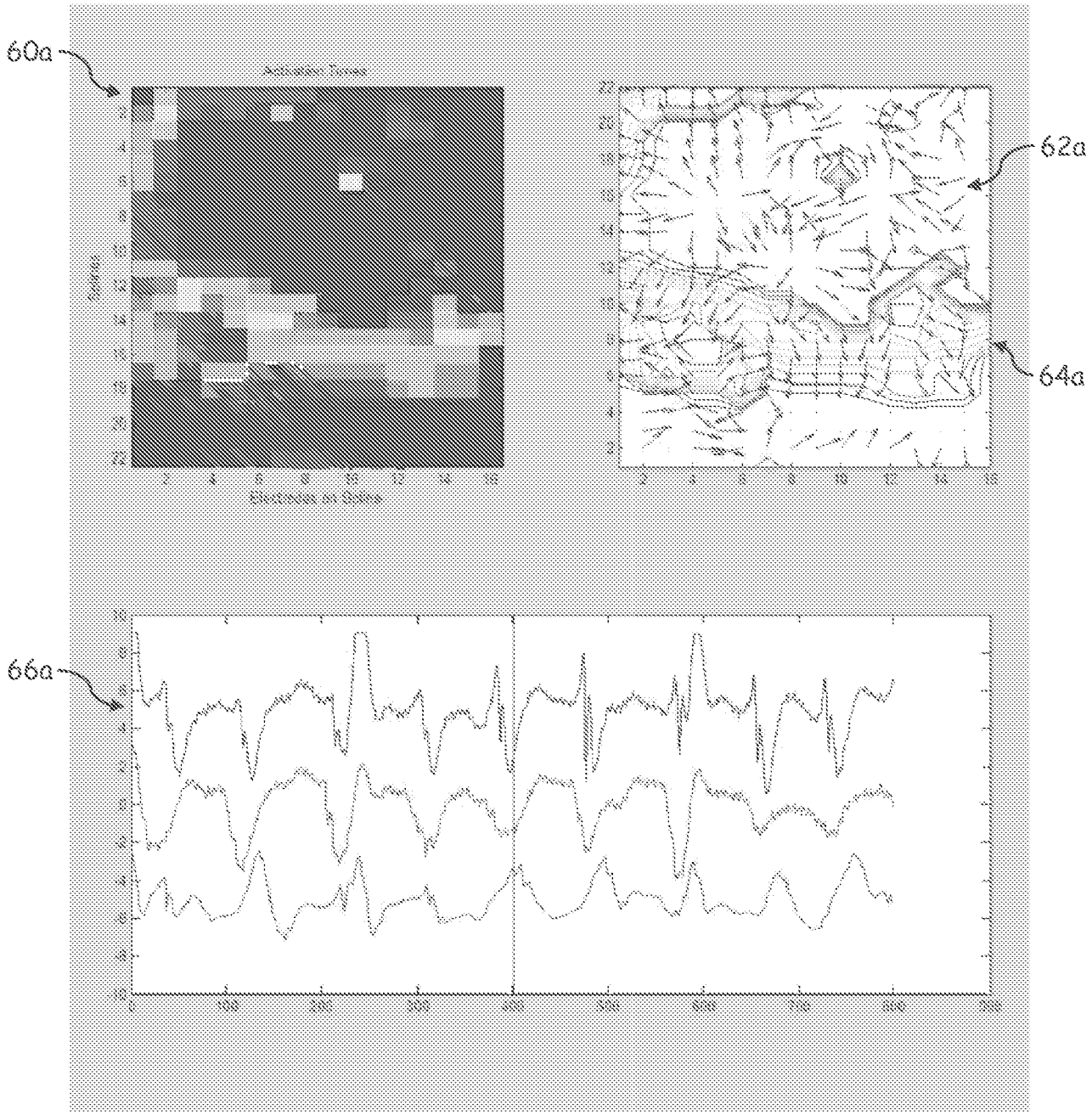

FIG. 4

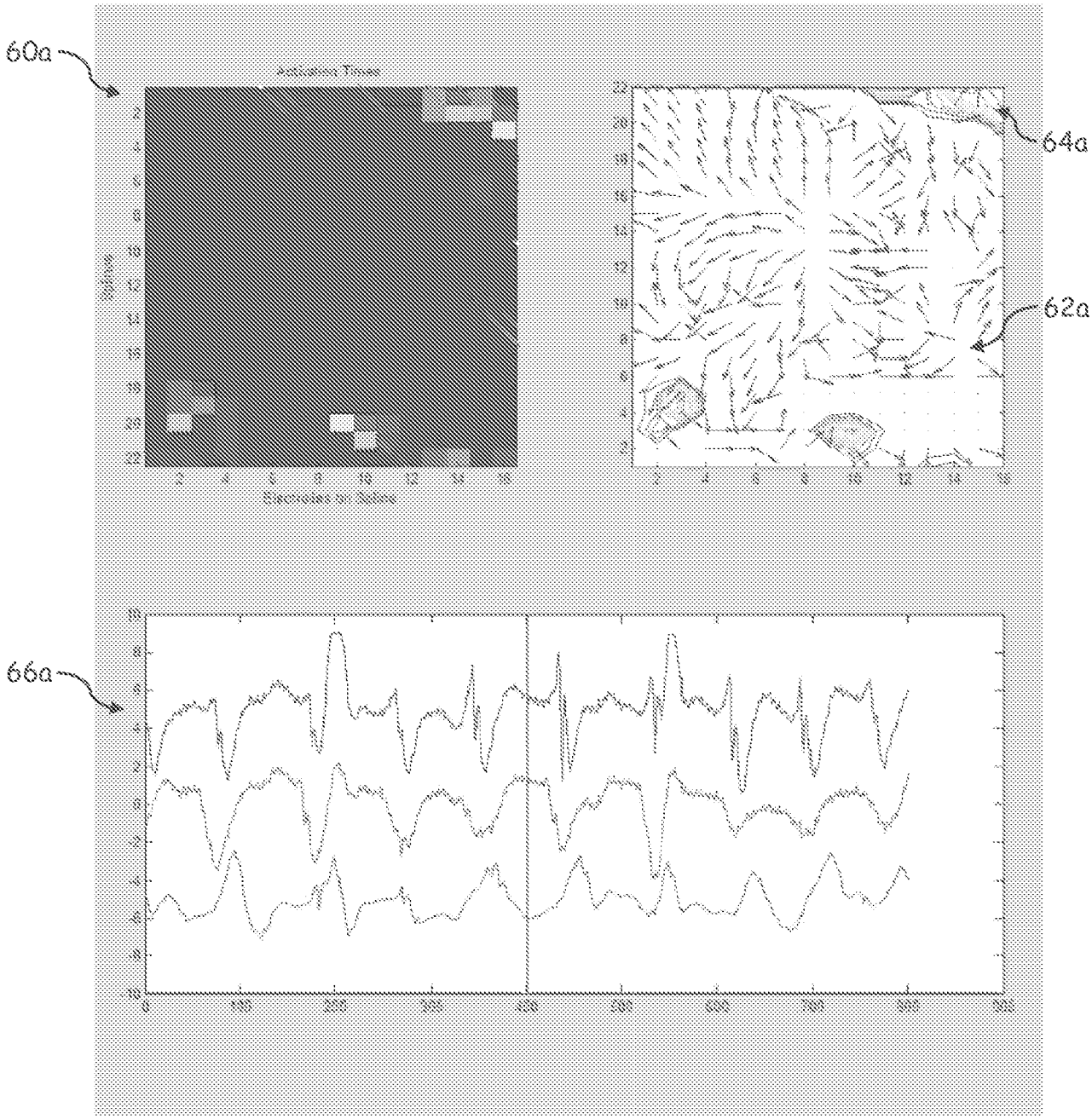

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/036939

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B5/044
ADD. A61B5/024 A61B5/042 A61B5/0452

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012/037471 A2 (CARDIOINSIGHT TECHNOLOGIES INC [US]; DUBOIS REMI [FR]; WODLINGER HAROL) 22 March 2012 (2012-03-22) paragraph [0005] - paragraph [0007]; figures 1,2,7 paragraph [0027] paragraph [0035] paragraph [0067] - paragraph [0070] -----	1-20

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 July 2014	30/07/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Furlan, Stéphane

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/036939

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	YE H HE ET AL: "An interactive graphical system for automated mapping and display of cardiac rhythms", JOURNAL OF ELECTROCARDIOLOGY, vol. 32, no. 3, 1 July 1999 (1999-07-01), pages 225-241, XP055128661, ISSN: 0022-0736, DOI: 10.1016/S0022-0736(99)90105-X abstract page 226, column 1 Section "Activation Time Detection Scheme"; page 228 - page 229; figures 1-2 Sections "Bipolar Detection Scheme" and "Unipolar Detection scheme".; page 229 - page 230 page 237, column 1 - column 2	1-20
A	US 2012/184858 A1 (HARLEV DORON [US] ET AL) 19 July 2012 (2012-07-19) paragraph [0097] - paragraph [0099] paragraph [0110] - paragraph [0117] the whole document	1-20
A	US 5 687 737 A (BRANHAM BARRY H [US] ET AL) 18 November 1997 (1997-11-18) the whole document	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2014/036939

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2012037471 A2	22-03-2012	EP 2615969 A2	24-07-2013
		JP 2013537096 A	30-09-2013
		US 2013324871 A1	05-12-2013
		WO 2012037471 A2	22-03-2012
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		JP 2014503319 A	13-02-2014
		US 2012184858 A1	19-07-2012
		WO 2012097067 A1	19-07-2012
US 5687737 A	18-11-1997	NONE	

专利名称(译)	在实时或回放电生理学数据可视化期间持续显示最近的拍子特征		
公开(公告)号	EP2994039A1	公开(公告)日	2016-03-16
申请号	EP2014729167	申请日	2014-05-06
[标]申请(专利权)人(译)	波士顿科学西美德公司		
申请(专利权)人(译)	BOSTON SCIENTIFIC SCIMED INC.		
当前申请(专利权)人(译)	BOSTON SCIENTIFIC SCIMED INC.		
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IPC分类号	A61B5/00 A61B5/044 A61B5/024 A61B5/042 A61B5/0452		
CPC分类号	A61B5/0422 A61B5/044 A61B5/6858		
优先权	61/820142 2013-05-06 US		
外部链接	Espacenet		

摘要(译)

用于绘制解剖结构的系统和方法包括利用设置在解剖结构中或附近的多个电极感测内在生理活动的激活信号。基于所感测的激活信号确定在所选时间的最新固有事件，并且基于所感测的最近固有事件的激活信号生成相关特性的持久显示。在检测到后续固有事件时更新持久显示。