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(54) MEDICAL IMAGE PROCESSING APPARATUS AND MEDICAL IMAGE PROCESSING METHOD

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(57) **ABSTRACT**

In a medical image processing apparatus **100** that is capable of extracting a contour of an organ or the like in a highly accurate manner within a short time, an image input unit **101** accepts ultrasound images or the like. An electrocardiographic information input unit **102** accepts electrocardiographic information (e.g. ECG waveform). A storage unit **103** stores image data representing the ultrasound images and the electrocardiographic information in association with each other. A dictionary storage unit **104** stores image patterns (dictionary images) used for pattern matching. A pattern dictionary selection unit **105** selects a dictionary image used for pattern matching with reference to the electrocardiographic information. A pattern search range setting unit **106** specifies a range in which pattern matching is to be performed, based on the electrocardiographic information. A cardiac area identification unit **107** detects a cardiac area in the image. A pattern comparison unit **108** identifies the position of each characteristic area in the image by pattern matching. A contour extraction unit **109** extracts a contour based on the position of each characteristic area and the ultrasound image. A display unit **110** displays the extracted contour.

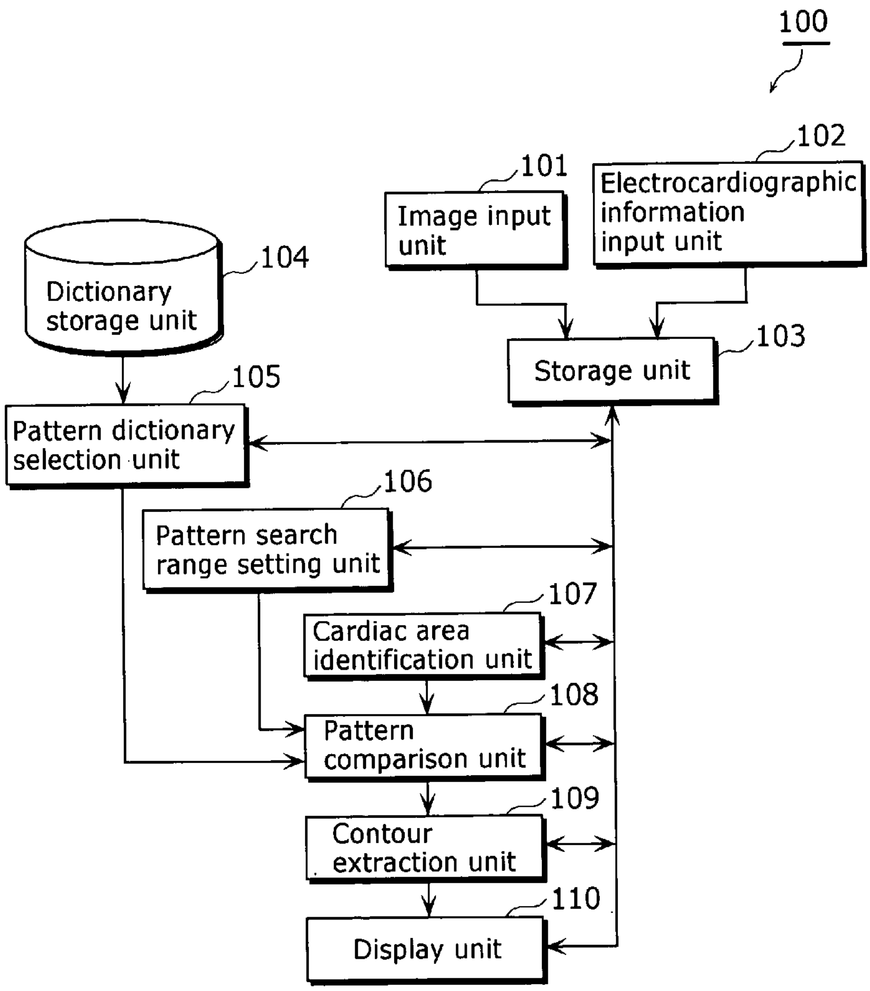


FIG. 1

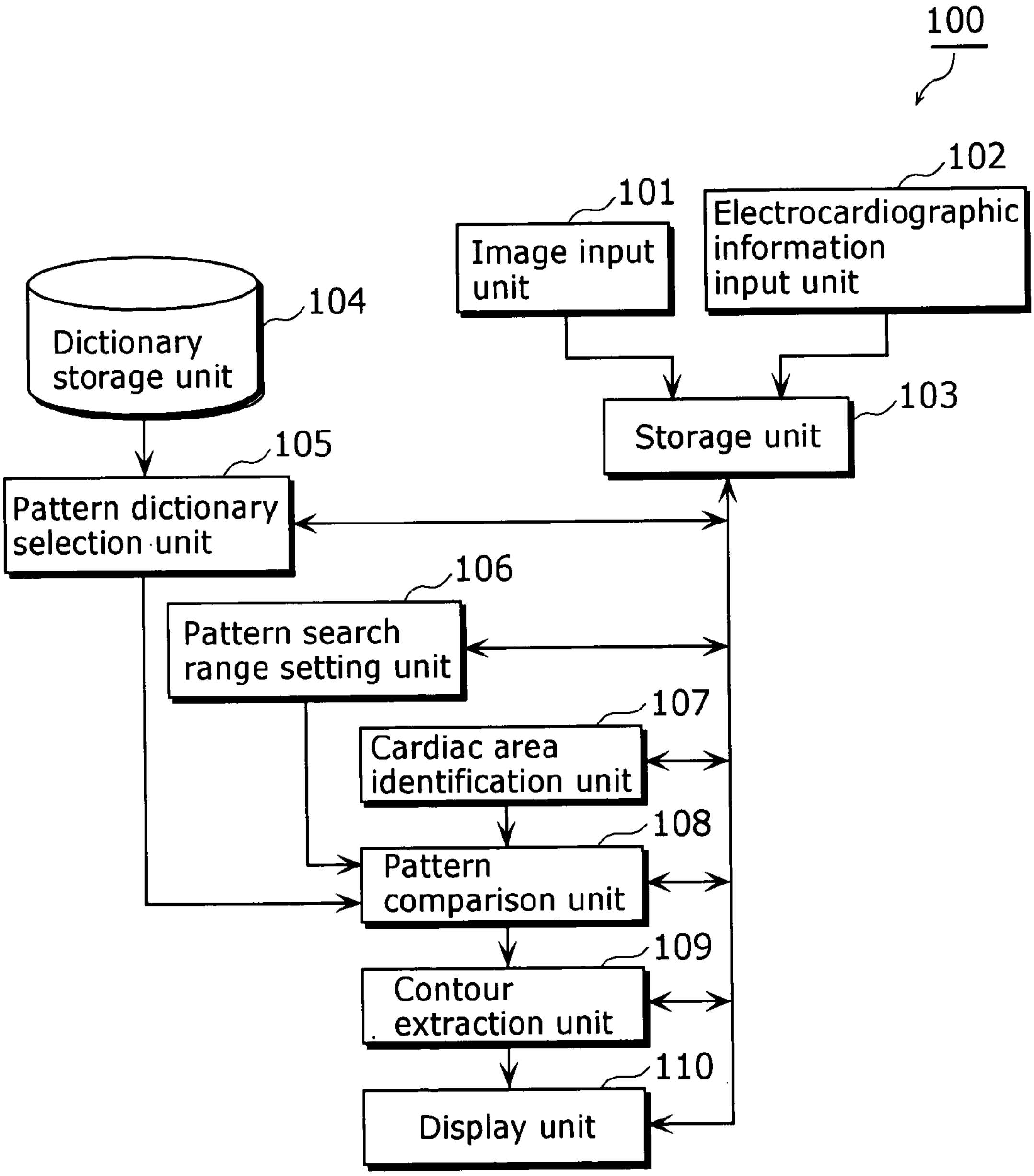

100
101
Image input unit
102
Electrocardiographic information input unit
104
Dictionary storage unit
103
Storage unit
105
Pattern dictionary selection unit
106
Pattern search range setting unit
107
Cardiac area identification unit
108
Pattern comparison unit
109
Contour extraction unit
110
Display unit

FIG. 2

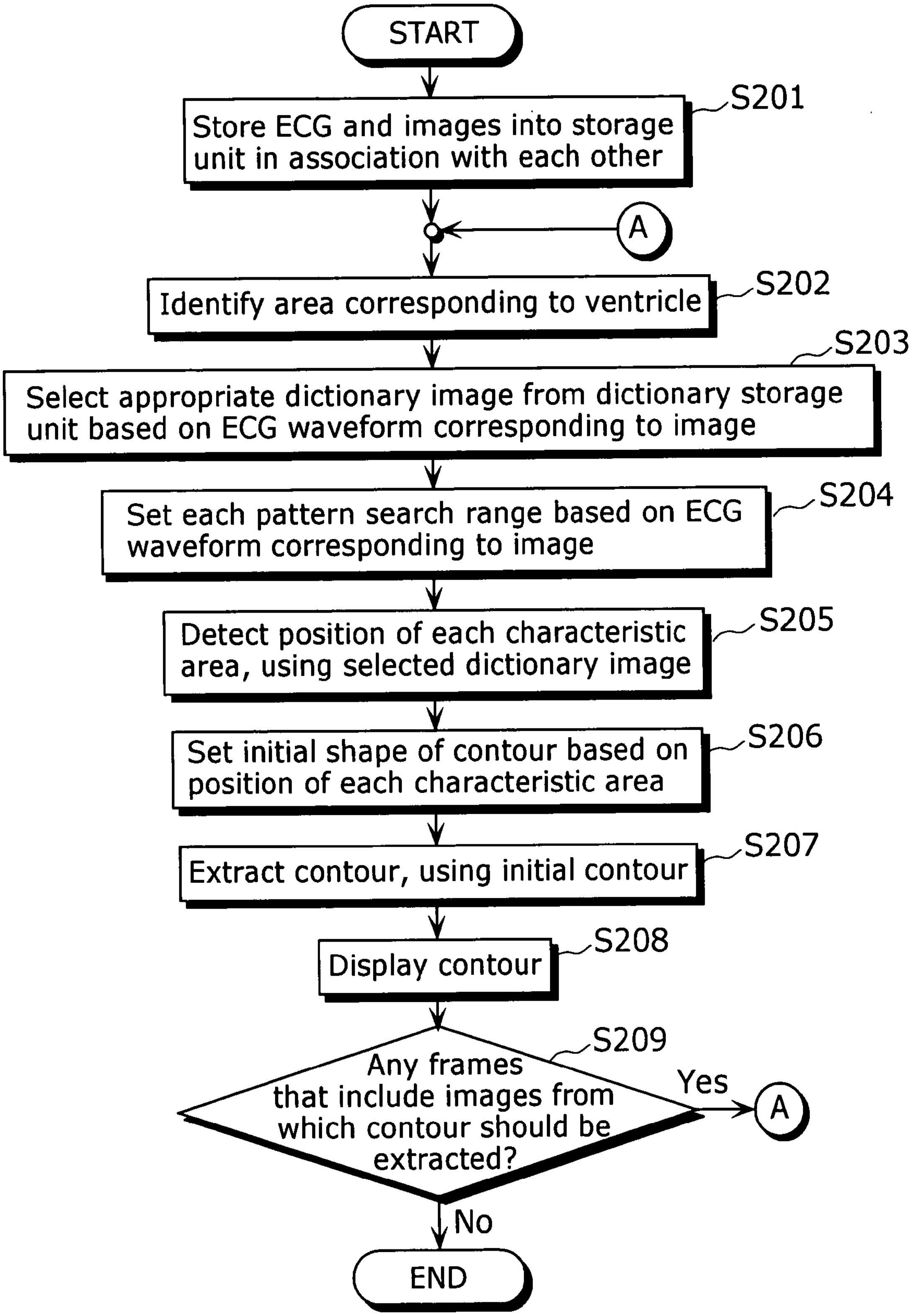

START
S201
Store ECG and images into storage unit in association with each other
A
S202
Identify area corresponding to ventricle
S203
Select appropriate dictionary image from dictionary storage unit based on ECG waveform corresponding to image
S204
Set each pattern search range based on ECG waveform corresponding to image
S205
Detect position of each characteristic area, using selected dictionary image
S206
Set initial shape of contour based on position of each characteristic area
S207
Extract contour, using initial contour
S208
Display contour
S209
Any frames that include images from which contour should be extracted?
Yes
A
No
END

FIG. 3

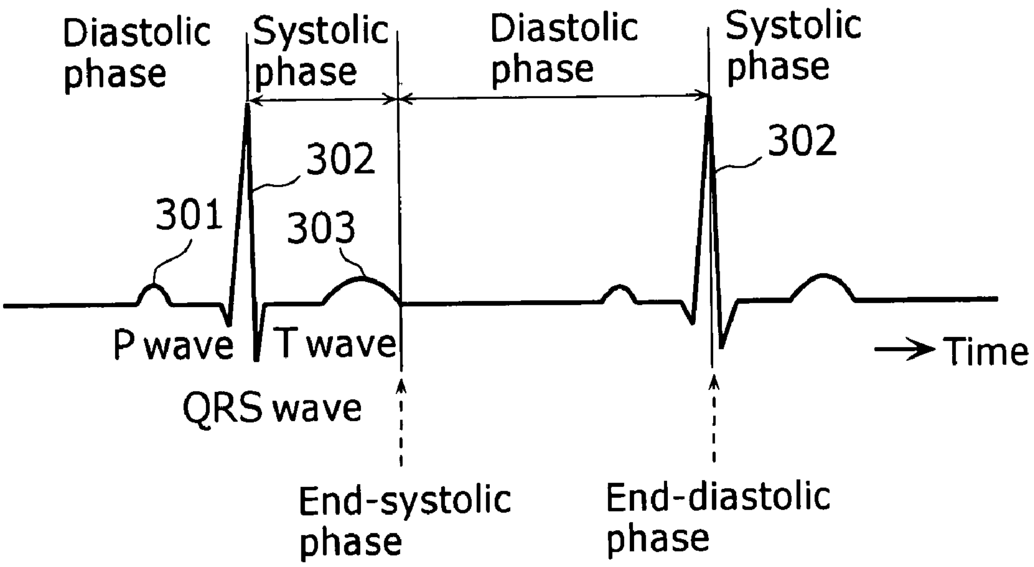

Diastolic phase
Systolic phase
Diastolic phase
Systolic phase
302
301
303
302
P wave
T wave
QRS wave
Time
End-systolic phase
End-diastolic phase

FIG. 4

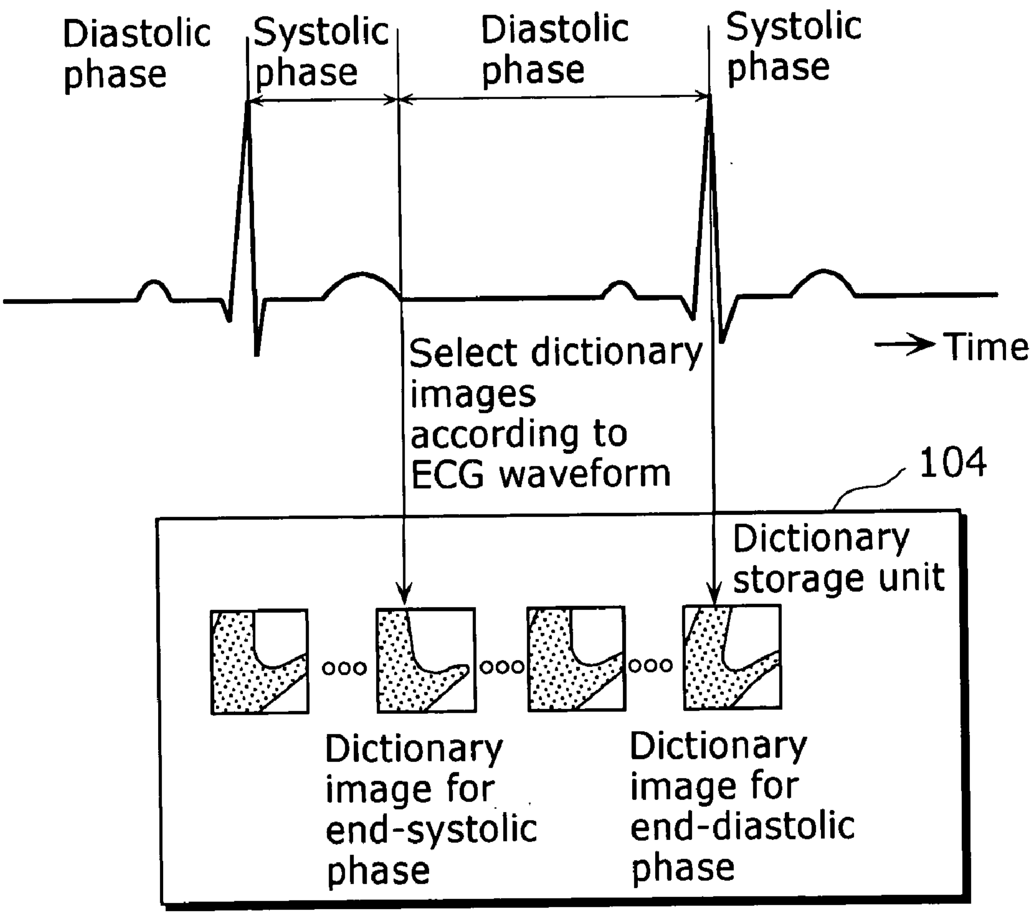

Diastolic phase
Systolic phase
Diastolic phase
Systolic phase
Time
Select dictionary images according to ECG waveform
104
Dictionary storage unit
ooo
ooo
ooo
Dictionary image for end-systolic phase
Dictionary image for end-diastolic phase

FIG. 5

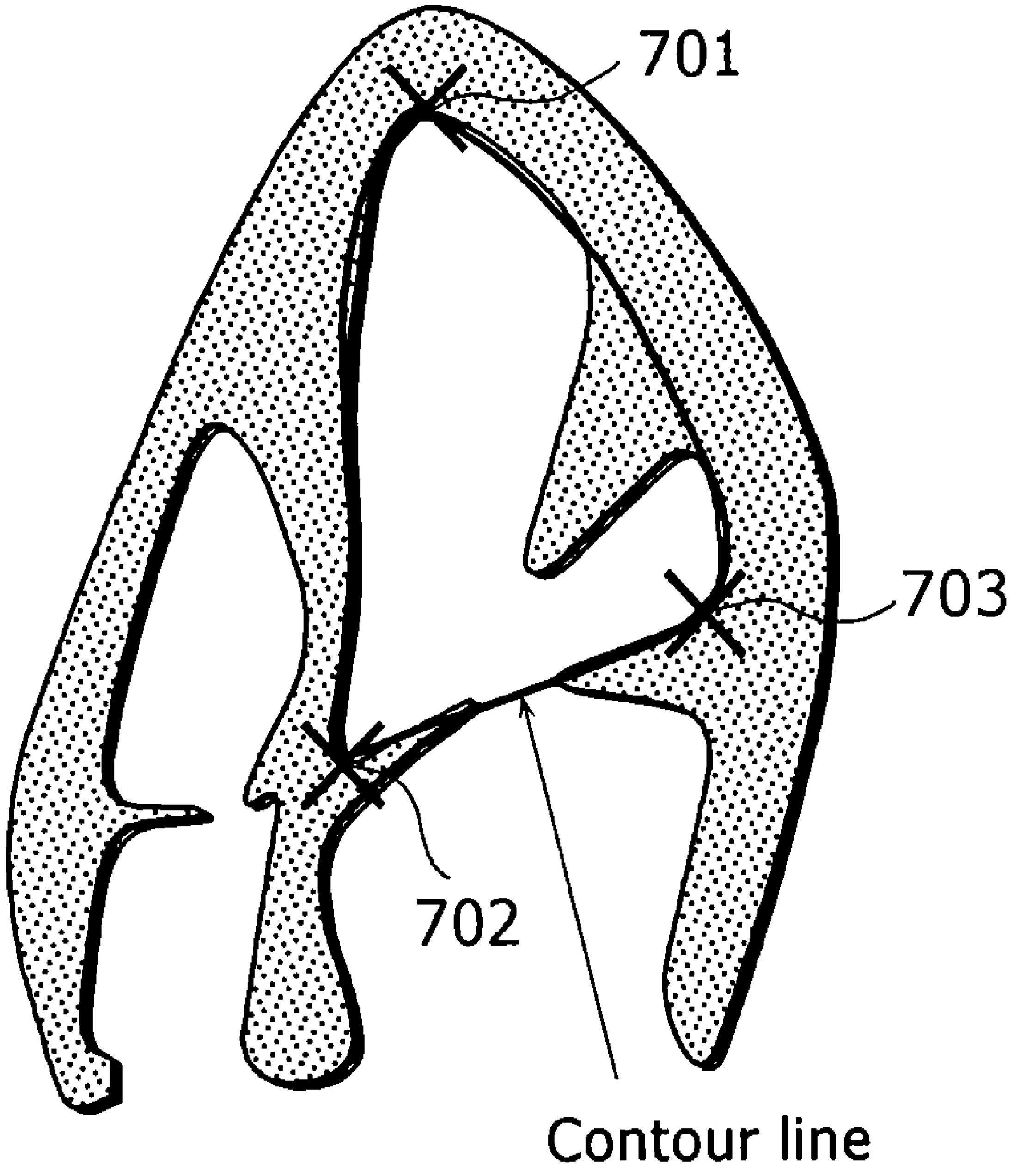
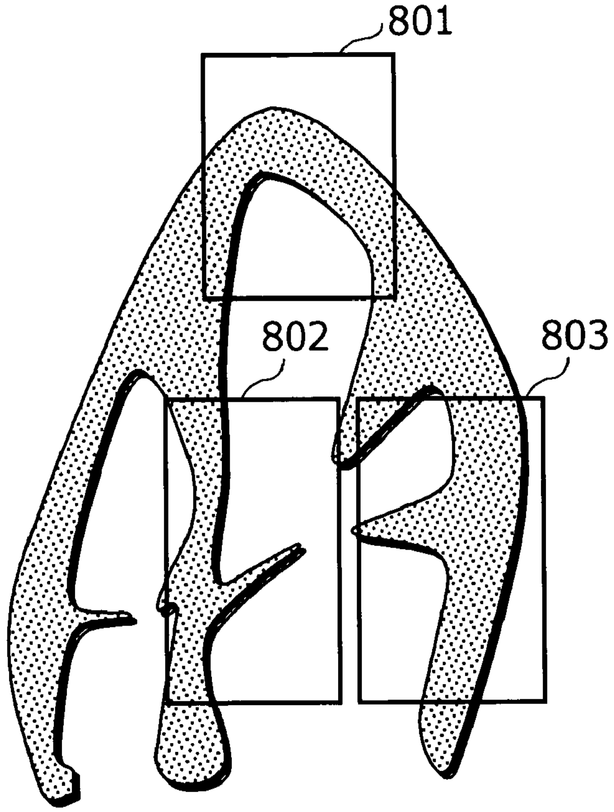
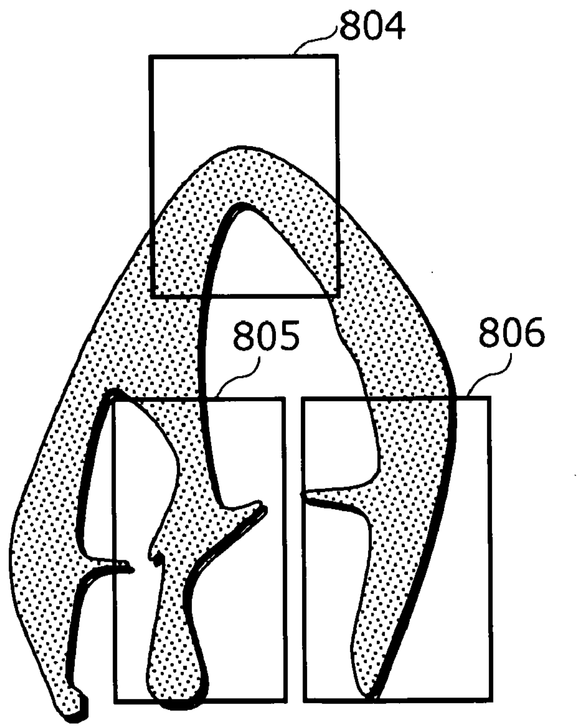


FIG. 6A



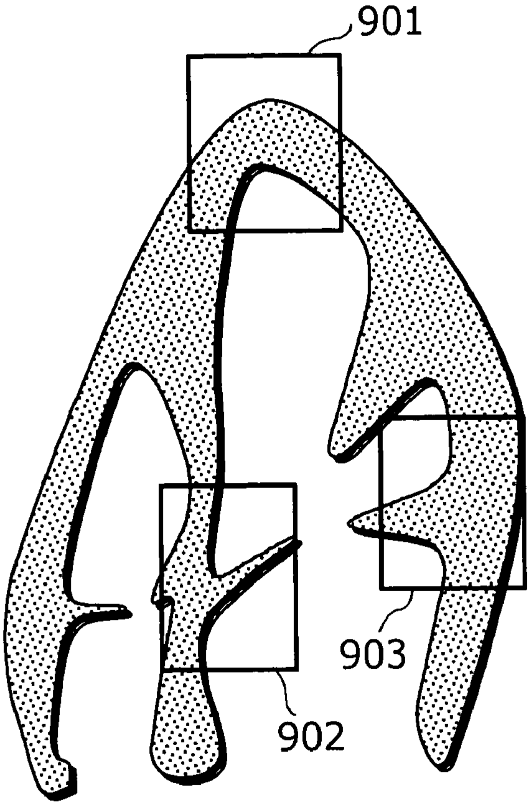
Model of end-diastolic phase

FIG. 6B



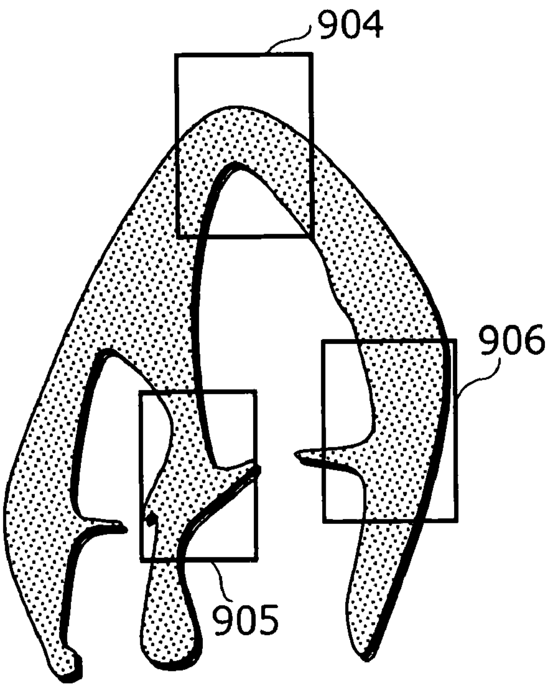
Model of end-systolic phase

FIG. 7A



Model of end-diastolic phase

FIG. 7B



Model of end-systolic phase

FIG. 8

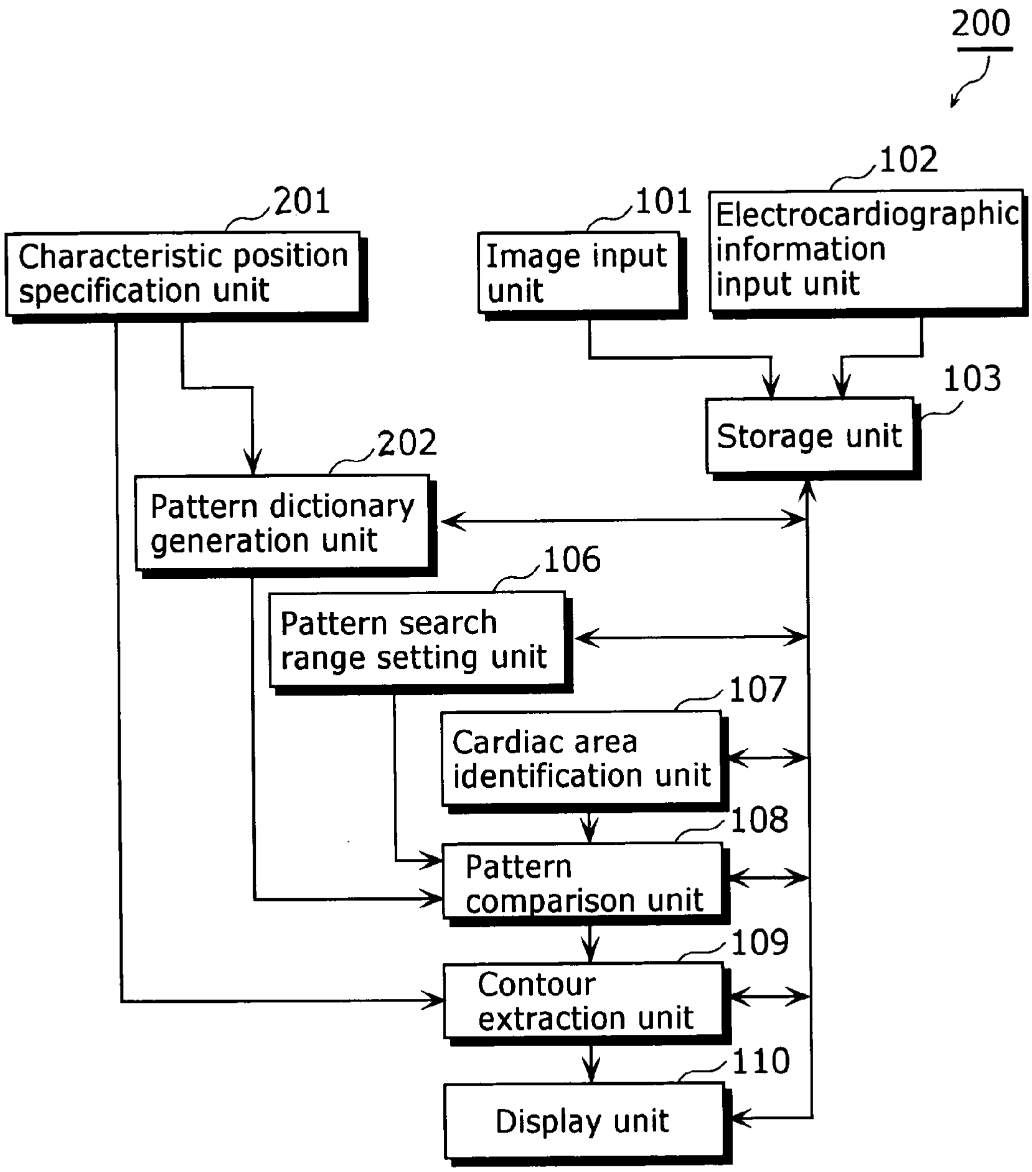

200
201
Characteristic position specification unit
101
Image input unit
102
Electrocardiographic information input unit
103
Storage unit
202
Pattern dictionary generation unit
106
Pattern search range setting unit
107
Cardiac area identification unit
108
Pattern comparison unit
109
Contour extraction unit
110
Display unit

FIG. 9

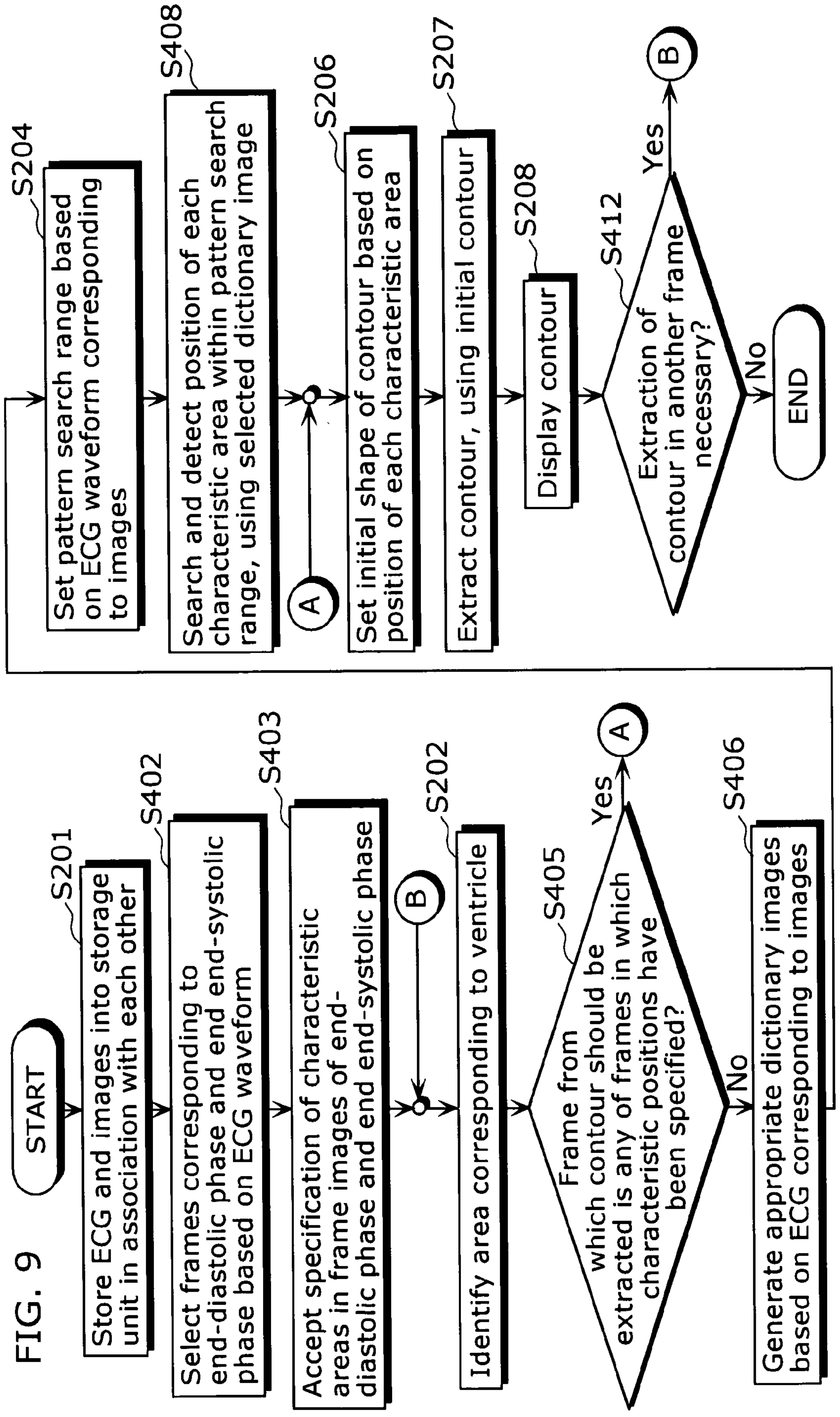
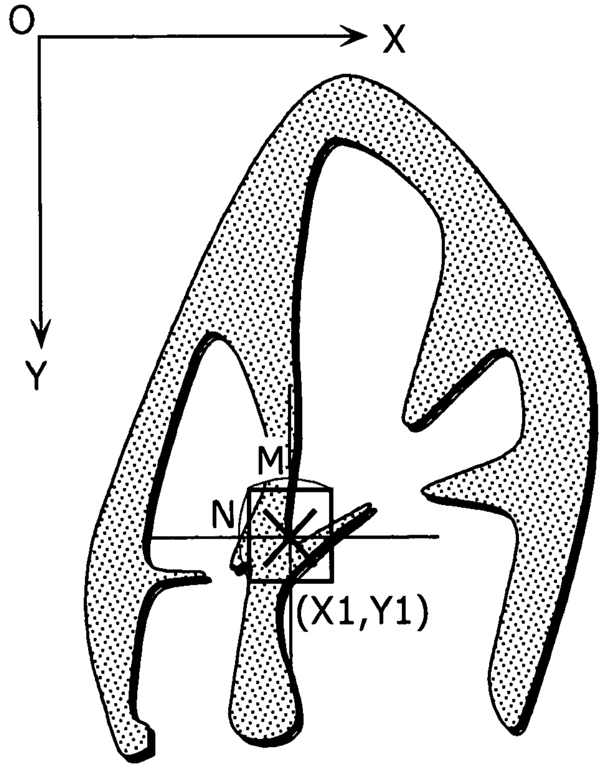
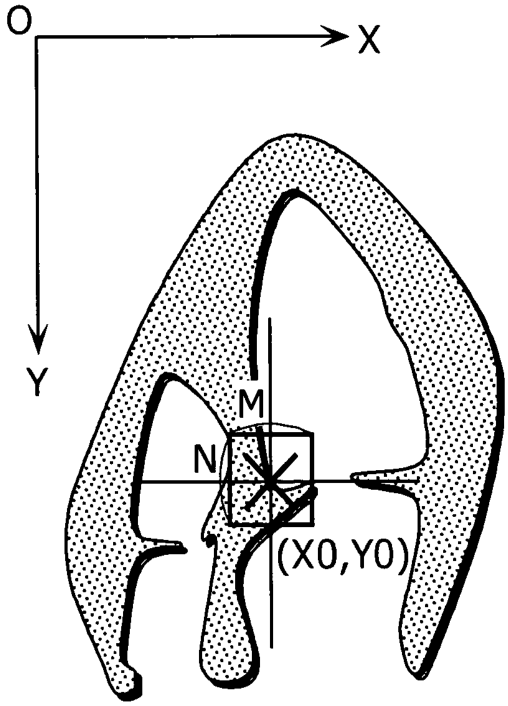

START
S201
Store ECG and images into storage unit in association with each other
S402
Select frames corresponding to end-diastolic phase and end end-systolic phase based on ECG waveform
S403
Accept specification of characteristic areas in frame images of end-diastolic phase and end end-systolic phase
B
S202
Identify area corresponding to ventricle
S405
Frame from which contour should be extracted is any of frames in which characteristic positions have been specified?
Yes
A
No
S406
Generate appropriate dictionary images based on ECG corresponding to images
S204
Set pattern search range based on ECG waveform corresponding to images
S408
Search and detect position of each characteristic area within pattern search range, using selected dictionary image
A
S206
Set initial shape of contour based on position of each characteristic area
S207
Extract contour, using initial contour
S208
Display contour
S412
Extraction of contour in another frame necessary?
Yes
B
No
END

FIG. 10A



Model of end-diastolic phase

FIG. 10B



Model of end-systolic phase

FIG. 11

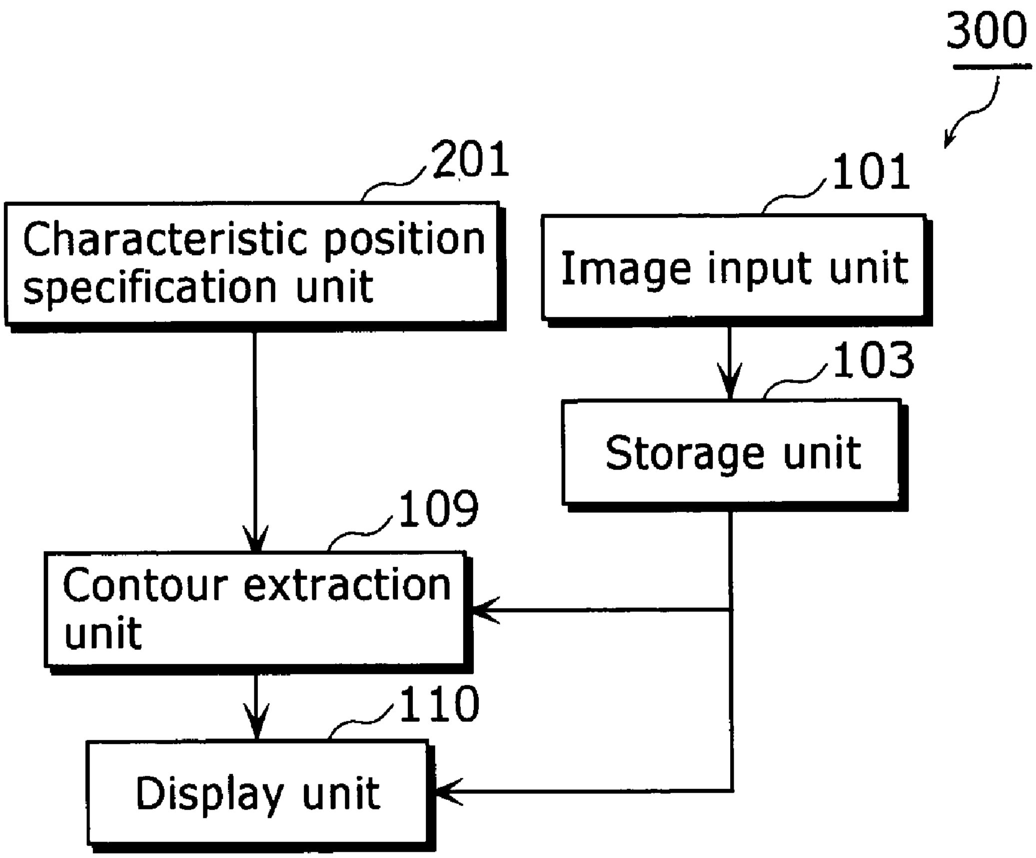
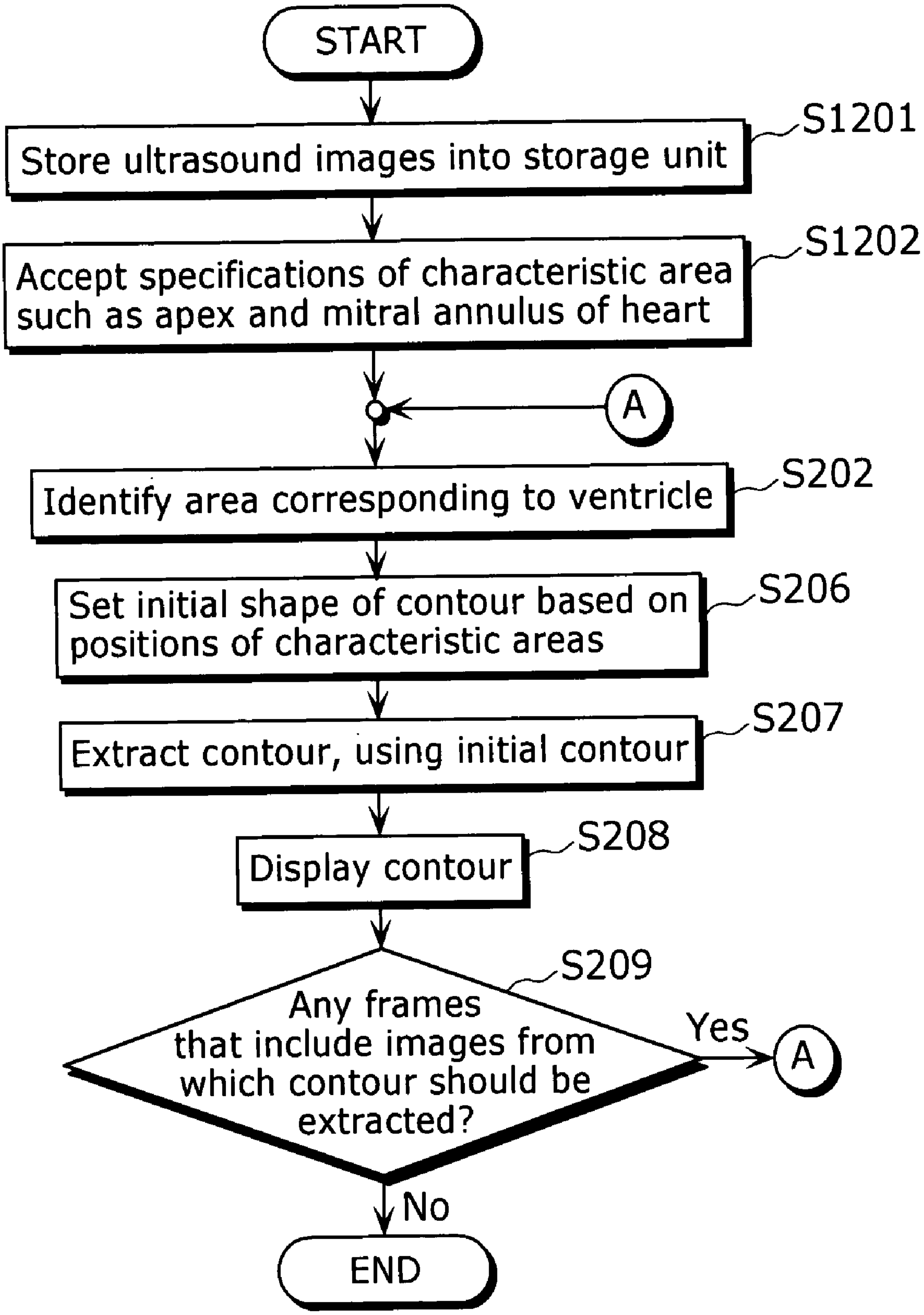

300
201
Characteristic position specification unit
101
Image input unit
103
Storage unit
109
Contour extraction unit
110
Display unit

FIG. 12


START
Store ultrasound images into storage unit
S1201
Accept specifications of characteristic area such as apex and mitral annulus of heart
S1202
A
Identify area corresponding to ventricle
S202
Set initial shape of contour based on positions of characteristic areas
S206
Extract contour, using initial contour
S207
Display contour
S208
Any frames that include images from which contour should be extracted?
S209
Yes
A
No
END

MEDICAL IMAGE PROCESSING APPARATUS AND MEDICAL IMAGE PROCESSING METHOD

BACKGROUND OF THE INVENTION

[0001] (1) Field of the Invention

[0002] The present invention relates to a medical image processing technology, and particularly to an image processing technology for identifying a region of interest, extracting a contour, and the like from medical images of an organ or the like such as a heart whose activity is cyclic, the medical images being obtained on a time series basis.

[0003] (2) Description of the Related Art

[0004] Conventionally, in the case where a region of interest is identified in and the contour of an organ or the like is extracted from an image of a living body (e.g. ultrasound image and X-ray computed tomogram (CT) image), the spatial position of the obtained ultrasound image is identified first by means of pattern matching or the like. Then, pattern matching and a specification of each characteristic area using a pointing device are performed in combination, in addition to binarization, edge detection, or the like. The above pattern matching is performed by using the evaluation value as a similar reference image out of standard images for research use that are previously created based on an apical four chamber view of a heart being the search target (such reference image(s) are hereinafter referred to as "dictionary image(s)") (for example, refer to Japanese Laid-Open Patent application No. 2002-140689 (Related art 1) and Japanese Laid-Open Patent application No. 2002-140690 (Related art 2)). In the case of Related art 1, for example, the contour of an organ or the like that is difficult to be identified just by performing edge processing and binarization processing is extracted with reference to the position of a valve and then by further correcting the extracted contour.

[0005] However, according to the conventional arts such as Related arts 1 and 2, due to a small number of variations of dictionary images, the same dictionary image is used for most of the ultrasound images in many cases regardless of their positions in the organ or the like. This causes a problem that the accuracy of processing such as the identification of a region of interest becomes unstable, since the similarity can be low between the dictionary image and an ultrasound image being compared. Furthermore, while the above conventional arts are capable of narrowing the search range with reference to the position of a valve, it is possible that a search is not performed appropriately or that it takes a long time for making a search because the same search range is employed for all ultrasound images that have been shot at different timings.

[0006] In other words, since the above conventional arts use the same dictionary image regardless of the positions of the respective ultrasound images in an organ or the timing at which such ultrasound images have been shot. This causes a problem that the accuracy of contour extraction becomes low because a desirable result cannot be achieved for searches in ultrasound images corresponding to different positions and cycles. Furthermore, since a fixed search range is applied for all frames, it takes long for performing a search if a wide search range is set.

SUMMARY OF THE INVENTION

[0007] The present invention has been conceived in view of the above problems, and it is an object of the present invention to provide a medical image processing apparatus and a medical image processing method that are capable of extracting a contour of an organ or the like in a highly accurate manner within a short time.

[0008] In order to achieve the above object, the medical image processing apparatus according to the present invention is a medical image processing apparatus that extracts a contour of a predetermined part of a subject from a medical image, said apparatus comprising: an image generation unit that generates images in which the predetermined part is shown; a reference image holding unit that holds reference images corresponding to the generated images, the reference images being added with attribute information of the subject; an electrocardiographic information obtainment unit that obtains electrocardiographic information that represents changes in cardiac muscle movement of the subject; an image identification unit that identifies one of the generated images based on the electrocardiographic information; a pattern comparison unit that identifies a position of a characteristic area by comparing the identified image and the reference images; and a contour extraction unit that extracts the contour of the predetermined part from the identified image, based on the identified position of the characteristic area.

[0009] Since the present invention makes it possible to perform pattern matching only for a limited image that is identified based on electrocardiographic information and therefore to perform a pattern comparison in an accurate manner within a short time, it eventually becomes possible to extract a contour of an organ or the like in a highly accurate manner at high speed.

[0010] Furthermore, in order to achieve the above object, in the above medical image processing apparatus according to the present invention, said image identification unit identifies one of the generated images based on the electrocardiographic information corresponding to one of end-systolic phase and end-diastolic phase.

[0011] Since the present invention makes it possible to perform pattern matching only for a further limited image that is identified based on electrocardiographic information and therefore to perform a pattern comparison in an accurate manner within a short time, it eventually becomes possible to extract a contour of an organ or the like in a highly accurate manner at high speed.

[0012] It should be noted that the present invention is capable of being embodied as a medical image processing method that includes, as its steps, characteristic constituent elements that make up the above medical image processing apparatus, as well as being capable of causing a personal computer or the like to execute a program that includes all of such steps.

[0013] As described above, since the present invention is capable of extracting a contour of an organ or the like of a subject in an accurate manner at high speed in medical diagnosis and measurement, the effects produced by the present invention are enormous in the field of medicine.

[0014] The disclosure of Japanese Patent Application No. 2004-032658 filed on Feb. 9, 2004 including specification, drawings and claims is incorporated herein by reference in its entirety.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] These and other objects, advantages and features of the invention will become apparent from the following description thereof taken in conjunction with the accompanying drawings that illustrate a specific embodiment of the invention. In the Drawings:

[0016] **FIG. 1** is a block diagram showing a functional structure of a medical image processing apparatus according to a first embodiment;

[0017] **FIG. 2** is a flowchart showing a flow of processes performed by the medical image processing apparatus according to the first embodiment;

[0018] **FIG. 3** is a diagram showing an example of a typical electrocardiogram (ECG);

[0019] **FIG. 4** is a diagram showing how a pattern dictionary selection unit selects an appropriate dictionary image according to a waveform of an ECG received from a dictionary storage unit;

[0020] **FIG. 5** is a diagram showing the positions of characteristic areas;

[0021] **FIGS. 6A and 6B** are diagrams showing search ranges for the respective characteristic areas according to a conventional art that uses no ECG;

[0022] **FIGS. 7A and 7B** are diagrams showing search ranges for the respective characteristic areas that are narrowed by use of an ECG;

[0023] **FIG. 8** is a block diagram showing a functional structure of a medical image processing apparatus according to a second embodiment;

[0024] **FIG. 9** is a flowchart showing a flow of processes performed by the medical image processing apparatus according to the second embodiment;

[0025] **FIGS. 10A and 10B** are diagrams showing an example of positions specified by an operator;

[0026] **FIG. 11** is a block diagram showing a functional structure of a medical image processing apparatus according to a third embodiment; and

[0027] **FIG. 12** is a flowchart showing a flow of processes performed by the medical image processing apparatus according to the third embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] The following describes the embodiments of the present invention with reference to the drawings.

First Embodiment

[0029] **FIG. 1** is a block diagram showing a functional structure of a medical image processing apparatus **100** according to the first embodiment. The medical image processing apparatus **100** is a diagnostic apparatus for medical use, such as an ultrasonic diagnostic apparatus that generates ultrasound images based on echo signals of ultrasonic pulses emitted to a subject, an X-ray CT apparatus that generates tomograms based on the amount of X rays passing through a subject, and an MRI apparatus that generates magnetic resonance (MR) images based on electromagnetic waves released from a subject. The medical image processing apparatus **100** extracts an internal contour of an organ (e.g. heart and blood vessel) whose activity is cyclic, using moving images of such organ and an electrocardiogram (ECG) obtained from the subject, and displays the extracted contour or the like. Note that, for convenience sake, the following descriptions are provided on the assumption that the medical image processing apparatus **100** is an ultrasonic diagnostic apparatus that generates ultrasound images of a heart at the speed of 30 frames per second.

[0030] As shown in **FIG. 1**, the medical image processing apparatus **100** is comprised of an image input unit **101**, an electrocardiographic information input unit **102**, a storage unit **103**, a dictionary storage unit **104**, a pattern dictionary selection unit **105**, a pattern search range setting unit **106**, a cardiac area identification unit **107**, a pattern comparison unit **108**, a contour extraction unit **109**, and a display unit **110**.

[0031] The image input unit **101** accepts ultrasound images that are generated based on, for example, echo signals received via an ultrasound probe (not illustrated in the drawing). The electrocardiographic information input unit **102** obtains, from the subject, electrocardiographic information (e.g. data representing an ECG waveform in the time domain) via an electrode or the like that is put on the subject's hand, feet, or chest. Furthermore, the electrocardiographic information input unit **102** accepts, from the operator, attribute information related to the subject (e.g. age, height, weight, sex, body type, symptom, and the name of a disease).

[0032] The storage unit **103** is equipped with a hard disk device (HDD), for example, and stores the following information in association with one another: image data representing the ultrasound images inputted to the image input unit **101**; the electrocardiographic information obtained via the electrocardiographic information input unit **102**; and the attribute information of the subject. The dictionary storage unit **104**, which is a random access memory (RAM), an HDD, or the like, holds dictionary data for dictionary images used for pattern matching.

[0033] The pattern dictionary selection unit **105** selects a dictionary image corresponding to the timing specified by the operator (or a predetermined timing) for use for pattern matching, with reference to the electrocardiographic information stored in the storage unit **103**. The pattern search range setting unit **106** identifies (or limits) a range, in the input ultrasound image, within which pattern matching is to be performed. In this case, the range that is slightly larger than the size of the dictionary image is to be identified. The cardiac area identification unit **107** accepts, from the operator using a mouse or the like, a specification of the area in the inputted ultrasound image that includes the Left ventricle. The pattern comparison unit **108** detects the position of each characteristic area of the heart in the ultrasound image by means of pattern matching that utilizes dictionary image. The contour extraction unit **109** extracts, from the ultrasound image, the contour (e.g. an inner contour) of the ventricle or the like, based on the detected positions of the respective characteristic areas. In so doing, the contour extraction unit **109** may extract an initial contour first with reference to the detected positions of the respective characteristic areas, and then extract a more precise contour. The display unit **110**, which is a cathode-ray tube (CRT), for example, displays the ultrasound image or the like in which the extracted contour is included.

[**0034**] Next, a description is given of operations of the medical image processing apparatus **100** with the above structure. **FIG. 2** is a flowchart showing a flow of processes performed by the medical image processing apparatus **100**.

[**0035**] First, the storage unit **103** stores, in association with each other, image data representing moving images (ultrasound images) obtained by the image input unit **101** and electrocardiographic information that have been obtained by the electrocardiographic information input unit **102** together with such image data (S**201**). Next, the cardiac area identification unit **107** identifies an ultrasound image of the heart that corresponds to a range and timing specified by the operator (such ultrasound image is hereinafter referred to as "frame image") (S**202**).

[**0036**] Next, after the cardiac area identification unit **107** identifies the frame image to be processed, the pattern dictionary selection unit **105** selects a dictionary image that is appropriate for identifying the position of each characteristic area (S**203**). More specifically, the pattern dictionary selection unit **105** judges how the heart is contracting from the electrocardiographic information corresponding to the identified frame image stored in the storage unit **103**, and selects an appropriate dictionary image from among those stored in the dictionary storage unit **104**. The dictionary storage unit **104** holds various dictionary images, on a per-characteristic area basis, corresponding to cardiac cycles starting from the end-systolic phase to the end-diastolic phase.

[**0037**] Here, a description is given of an ECG used in the present embodiment.

[**0038**] **FIG. 3** is a diagram showing a waveform in a typical ECG. In general, waveform signals known as a P wave **301**, a QRS wave **302**, and a T wave **303** are observed in an ECG. The occurrence of the QRS wave **302** marks the beginning of cardiac muscle contraction. A period from the beginning to the end of cardiac muscle contraction is referred to as "systole". When the contraction is complete, the T wave **303** is measured. The timing at which the T wave ends is referred to as the "end-systolic phase". After the end-systolic phase, the cardiac muscle becomes relaxed, and it enters diastole in which cardiac volume increases. From then on, the cardiac muscle contraction continues until it begins to dilate at the timing indicated by the occurrence of the QRS wave **302**. The timing indicated by the peak of QRS wave **302** is referred to as the "end-diastolic phase". The pattern dictionary selection unit **105** selects appropriate dictionary images based on the respective timings corresponding to the end-systolic phase and the end-diastolic phase.

[**0039**] **FIG. 4** is a diagram showing how the pattern dictionary selection unit **105** selects an appropriate dictionary image according to a waveform of an ECG received from the dictionary storage unit **104**. By selecting and using an appropriate dictionary image, it becomes possible to detect each characteristic area in a more accurate manner, compared with a conventional method that uses the common dictionary image.

[**0040**] Note that a higher accuracy can be achieved by generating dictionary images and selecting an appropriate dictionary image from such generated dictionary images that are categorized, on an item basis (for each of at least one item), according to the subject's age, height weight, sex, body type (e.g. thin build, standard type, corpulent), symptom (e.g. cardiac angina, valvular heart disease, cardiomyopathy), and the name of a disease, as well as being categorized according to timings indicated by a plurality of characteristic waveform signals in an ECG.

[**0041**] Then, the pattern search range setting unit **106** judges how the heart is contracting based on the electrocardiographic information corresponding to the identified frame image, and sets each search range in which pattern matching is to be performed (S**204**). The movement of the heart is cyclic, and so is the movement of each characteristic area. In the case of characteristic areas shown in **FIG. 5**, for example, a conventional method sets a search range for each characteristic area as illustrated in **FIGS. 6A and 6B**, but the present embodiment is capable of further narrowing a search range for each characteristic area by selecting a dictionary image that corresponds to the timing indicated by each characteristic waveform signal in an ECG and thus capable of having search ranges as illustrated in **FIGS. 7A and 7B**. Accordingly, by identifying an ultrasound image according to a waveform of an ECG, it becomes possible to shorten the time required for search since it is possible to narrow a range in the ultrasound image for which pattern matching is to be performed.

[**0042**] Furthermore, the pattern comparison unit **108** performs pattern matching based on the above-selected dictionary image and the above-set search range so as to identify each characteristic area (S**205**). Here, after the pattern dictionary selection unit **105** selects dictionary images from those stored in the dictionary storage unit **104**, the pattern comparison unit **108** identifies the positions of the respective characteristic areas by performing pattern matching within the respective ranges set by the pattern search range setting unit **106**, by use of the identified ultrasound images stored in the storage unit **103** and the selected dictionary images. Note that this pattern matching can be any of template matching, subspace method, and complex similarity method.

[**0043**] Next, the contour extraction unit **109** extracts an initial contour of the inner shape of the ventricle based on the characteristic areas that have been identified as being included in the above-set cardiac area (S**206**). Furthermore, the contour extraction unit **109** extracts an inner contour of the Left ventricle, based on the extracted initial contour (S**207**). Here, the contour line is extracted by detecting an edge, in the frame image, near the initial contour. The display unit **110** displays the detected contour together with the frame image stored in the storage auntie **103**, and presents them to the operator (S**208**). When it is necessary to extract a contour in another frame image, the above processes (S**202** to S**208**) are continuously performed.

[**0044**] As described above, the present embodiment is capable of shortening the time required for pattern matching since it is possible to narrow a range in an ultrasound image for which pattern matching should be performed, by selecting dictionary images that correspond to timings indicated by the respective characteristic waveform signal in an ECG.

Second Embodiment

[**0045**] The first embodiment describes an embodiment in which a pattern comparison is performed using a previously prepared dictionary image. The second embodiment describes an embodiment in which pattern comparison is performed using an ultrasound image or the like that is obtained in real-time at examination time.

[0046] **FIG. 8** is a block diagram showing a functional structure of a medical image processing apparatus **200** according to the second embodiment. The medical image processing apparatus **200**, an example of which is an ultrasonic diagnostic apparatus as in the case of the medical image processing apparatus **100** of the first embodiment, is an imaging diagnostic apparatus that extracts an inner contour of a heart or the like using an ECG and moving images of the heart generated at the speed of 30 frames per second, and displays the extracted contour or the like. Note that the components that are the same as those described in the first embodiment are assigned the same numbers and descriptions thereof are omitted.

[0047] As shown in **FIG. 8**, the medical image processing apparatus **200** is comprised of an image input unit **101**, an electrocardiographic information input unit **102**, a storage unit **103**, a characteristic position specification unit **201**, a pattern dictionary generation unit **202**, a pattern search range setting unit **106**, a cardiac area identification unit **107**, a pattern comparison unit **108**, a contour extraction unit **109**, and a display unit **110**.

[0048] The characteristic position specification unit **201** accepts an operator's specification of the position of each characteristic area. The pattern dictionary generation unit **202** generates a dictionary image for the position of each characteristic area specified by the operator.

[0049] Next, a description is given of operations of the medical image processing apparatus **200** with the above structure. **FIG. 9** is a flowchart showing a flow of processes performed by the medical image processing apparatus **200**.

[0050] First, moving images inputted via the image input unit **101** and electrocardiographic information inputted from the electrocardiographic information input unit **102** together with the moving images are stored into the storage unit **103** in association with each other (**S201**). Then, based on the electrocardiographic information, the display unit **101** selects frame images corresponding to the end-diastolic and end-systolic phases from the storage unit **103**, and displays the selected frame images (**S402**).

[0051] Next, when accepting, via the characteristic position specification unit **201**, a specification of each characteristic area from the operator looking at the display unit **101** (**S403**), the cardiac area identification unit **107** identifies an area corresponding to a ventricle from which a contour is to be extracted (**S202**). In response to this, the pattern dictionary generation unit **202** judges whether or not the frame images in which the positions of the characteristic areas have been specified by the characteristic position specification unit **201** include the frame image from which a contour should be extracted (**S405**).

[0052] First, a description is given for the case where the judgment is made in **S405** that the frame is not the one in which the position of each characteristic area is specified.

[0053] In order to extract the inner shape of the ventricle, the contour extraction unit **109** first extracts an initial contour, making a correction to the frame image on the basis of the cardiac area set in **S202** and the position of each characteristic area specified in **S403** (**S206**). Then, the contour extraction unit **109** extracts an inner contour of the ventricle using the above-generated initial contour (**S207**). Here, a contour line is extracted by detecting an edge, in the frame image, near the initial contour. The display unit **110** displays the frame image together with the extracted contour (**S208**). When it is necessary to extract a contour in another frame image, the above processes (**S202** to **S412**) are continuously performed.

[0054] Next, a description is given of the case where the judgment is made in **S405** that the frame image is not the one in which the position of each characteristic area is specified.

[0055] When a cardiac area is specified, the pattern dictionary generation unit **202** generates dictionary images that are appropriate for detecting the positions of the respective characteristic areas (**S406**). For example, referring to **FIGS. 10A and 10B**, suppose that the operator has specified, in the frame images corresponding to the end-diastolic phase and the end-systolic phase, a position P (**X0**, **Y0**) and a position Q (X1, Y1). In this case, image patterns with the size of M×N (pixels) are extracted to be used as basic patterns, by centering on the position P (**X0**, **Y0**) and the position Q (X1, Y1) which have been specified as the positions of the respective characteristic areas in the above two frame images. Then, a calculation is performed, based on the electrocardiographic information stored in the storage unit **103**, to determine the distance between the frame image from which a contour is to be extracted and the two frame images corresponding to the end-diastolic phase and the end-systolic phase in which the characteristic areas have been specified. Then, a dictionary image used for search is generated based on the generated two basic patterns and on the calculated distance from the frame images corresponding to the end-diastolic phase and the end-systolic phase. Letting the positions of the frame images corresponding to the end-systolic phase and end-diastolic phase in which the positions of the respective characteristic areas have been specified be "0" and "1", respectively, and the position of a dictionary image to be generated be "t", their respective patterns are represented as P_0, P_1, and P_t. In the case where alpha blending is used ("t" is regarded as "α"), pattern P_t can be represented by the following equation (1), where $0 \leqq x<M$, $0 \leqq y<N$, and $0 \leqq t \leqq 1$:

$$P_t(x, y)=(1-t)P_0(x, y)+tP_1(x, y) \quad (1)$$

[0056] Note that other than alpha blending, morphing or the like may be used for the generation of a dictionary image used for search. Then, the pattern search range setting unit **106** judges how the heart is contracting, based on the electrocardiographic information stored in the storage unit **103**, and sets each search range in which pattern matching is to be performed (**S204**). The search range is set based on the positions specified as the positions of characteristic areas corresponding to the end-diastolic phase and end-systolic phase, in consideration of the timings indicated by waveform signals in the ECG. Then, the characteristic areas are detected from the search range that has been identified using the generated dictionary image (**S408**). The detection of the characteristic areas are performed by making a comparison between (i) the dictionary image that has been generated based on images and electrocardiographic information stored in the storage unit **103** as well as on a specification of each characteristic area accepted by the characteristic position specification unit **201** and (ii) images stored in the storage unit **103**. Note that this comparison may be performed using any of template matching, subspace method, and complex similarity method, as in the case of the first embodiment. Accordingly, it becomes possible to detect the position of each characteristic area in the frame image. The subsequent processes are the same as those described above (**S206** to S412).

[**0057**] As described above, the present embodiment is capable of extracting a contour in a more accurate manner since it newly generates a dictionary image to use it for pattern matching in the case where there is no appropriate dictionary image corresponding to the timing indicated by a characteristic waveform in an ECG at the time of contour extraction.

Third Embodiment

[**0058**] **FIG. 11** is a block diagram showing a functional structure of a medical image processing apparatus **300** according to the third embodiment. The third embodiment describes an example usage of a contour extraction method, and the present medical image processing apparatus **300** is an imaging diagnostic apparatus that accepts ultrasound images of a heart or the like and extracts and displays an inner contour of the heart.

[**0059**] Referring to **FIG. 11**, the input unit **101** accepts image data. The storage unit **103** holds the image data. The characteristic position specification unit **201** accepts an operator's specification of the position of each characteristic area. The contour extraction unit **109** extracts an inner contour of a ventricle based on the specified characteristic positions and images stored in the storage unit **103**. The display unit **110** displays the extracted contour, the image information and the like.

[**0060**] Next, a description is given of operations of the medical image processing apparatus **300** with the above structure. **FIG. 12** is a flowchart showing a flow of processes performed by the medical image processing apparatus **300**.

[**0061**] First, ultrasound images of the heart are inputted to the image input unit **101** to be stored into the storage unit **103** (**S1201**). Next, an operator's specification of the position of each characteristic area (e.g. apex and mitral annulus) is accepted via the characteristic position specification unit **201** (**S1202**) so as to identify an area of a ventricle to be examined, based on the specified positions of the respective characteristic areas (**S202**).

[**0062**] An initial contour, which is used to extract an inner shape of the ventricle, is set after being corrected based on the area of the ventricle identified in **S202** and on the positions of the respective characteristic areas specified in S1202 (**S206**). Next, the contour extraction unit **109** extracts an inner contour of the ventricle, using the initial contour that has been corrected on the basis of the positions of the respective characteristic areas (**S207**). Here, a contour line is extracted by detecting an edge, in the frame image, near the initial contour. The display unit **110** displays the ultrasound image including the contour, based on the contour extracted in **S207** and the identified image stored in the storage unit **103** (**S208**). When it is necessary to extract a contour in another frame image, the above processes (**S202** to **S209**) are continuously performed.

[**0063**] Note that although the first, second, and third embodiments describe the case where an image input apparatus for obtaining an image (e.g. imaging apparatus) is implemented separately from the ultrasonic diagnostic apparatus **100**/**200**/**300**, but the present invention is applicable to the case where the image input apparatus is integrated into the ultrasonic diagnostic apparatus **100**/**200**/**300**. Furthermore, the processes according to the present invention may be implemented as software by using a personal computer or the like having image input function.

[**0064**] Although only some exemplary embodiments of this invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention.

INDUSTRIAL APPLICABILITY

[**0065**] The present invention is applicable to an ultrasonic diagnostic apparatus that handles an ECG, and other apparatuses such as an X-ray CT apparatus and an MRI apparatus capable of processing images that are synchronous with ECG waveform cycles.

What is claimed is:

1. A medical image processing apparatus that extracts a contour of a predetermined part of a subject from a medical image, said apparatus comprising:

an image generation unit operable to generate images in which the predetermined part is shown;

a reference image holding unit operable to hold reference images corresponding to the generated images, the reference images being added with attribute information of the subject;

an electrocardiographic information obtainment unit operable to obtain electrocardiographic information that represents changes in cardiac muscle movement of the subject;

an image identification unit operable to identify one of the generated images based on the electrocardiographic information;

a pattern comparison unit operable to identify a position of a characteristic area by comparing the identified image and the reference images; and

a contour extraction unit operable to extract the contour of the predetermined part from the identified image, based on the identified position of the characteristic area.

2. The medical image processing apparatus according to claim 1,

wherein said image identification unit is operable to identify one of the generated images based on the electrocardiographic information corresponding to one of end-systolic phase and end-diastolic phase.

3. The medical image processing apparatus according to claim 1, further comprising, in replacement of said pattern comparison unit, a characteristic position accepting unit operable to accept a specification of the position of the characteristic area included in the identified image,

wherein said contour extraction unit is operable to extract the contour of the predetermined part from the identified image, based on the specified position of the characteristic area.

4. The medical image processing apparatus according to claim 1,

wherein said reference image holding unit is further operable to generate a reference image based on the images generated by said image generation unit, and to hold the generated reference image.

5. The medical image processing apparatus according to claim 1,

wherein the attribute information of the subject includes at least one of the following attributes: age, height, weight, sex, body type, symptom, and a name of a disease, and

the medical image processing apparatus further comprises

a reference image selection unit operable to accept a specification of at least one of the attributes, and to select one of the reference images based on the accepted specification,

wherein said pattern comparison unit is operable to perform the comparison using the selected reference image.

6. The medical image processing apparatus according to claim 1,

wherein said image generation unit is operable to generate the images based on an echo signal of an ultrasonic pulse transmitted to the subject.

7. The medical image processing apparatus according to claim 1,

wherein said image generation unit is operable to generate the images based on an amount of X-rays passing through the subject.

8. The medical image processing apparatus according to claim 1,

wherein said image generation unit is operable to generate the images based on an electromagnetic wave released from the subject.

9. A medical image processing method for extracting a contour of a predetermined part of a subject from a medical image, said method comprising:

generating images in which the predetermined part is shown;

obtaining electrocardiographic information that represents changes in cardiac muscle movement of the subject;

identifying one of the generated images based on the electrocardiographic information;

identifying a position of a characteristic area by comparing the identified image and reference images corresponding to the generated images, the reference images being added with attribute information of the subject; and

extracting the contour of the predetermined part from the identified image, based on the identified position of the characteristic area.

10. The medical image processing method according to claim 9, further comprising, in replacement of said identifying of the position of the characteristic area,

accepting a specification of the position of the characteristic area included in the identified image,

wherein in said extracting of the contour, the contour of the predetermined part is extracted from the identified image, based on the specified position of the characteristic area.

11. The medical image processing method according to claim 9,

wherein the characteristic area is Apex.

12. The medical image processing method according to claim 9,

wherein the attribute information of the subject includes at least one of the following attributes: age, height, weight, sex, body type, symptom, and a name of a disease, and

the medical image processing method further comprises

accepting a specification of at least one of the attributes, and selecting one of the reference images based on the accepted specification,

wherein in said identifying of the position of the characteristic area, the comparison is performed using the selected reference image.

13. A program used for a medical image processing method for extracting a contour of a predetermined part of a subject from a medical image, said program causing a computer to execute:

generating images in which the predetermined part is shown;

obtaining electrocardiographic information that represents changes in cardiac muscle movement of the subject;

identifying one of the generated images based on the electrocardiographic information;

identifying a position of a characteristic area by comparing the identified image and reference images corresponding to the generated images, the reference images being added with attribute information of the subject; and

extracting the contour of the predetermined part from the identified image, based on the identified position of the characteristic area.

14. The program according to claim 13, further causing the computer to execute, in replacement of said identifying of the position of the characteristic area,

accepting a specification of the position of the characteristic area included in the identified image,

wherein in said extracting of the contour, the contour of the predetermined part is extracted from the identified image, based on the specified position of the characteristic area.

* * * * *

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摘要(译)

在能够在短时间内以高精度的方式提取器官等的轮廓的医学图像处理设备100中，图像输入单元101接受超声图像等。心电图信息输入单元102接收心电图信息（例如，ECG波形）。存储单元103将表示超声图像和心电图信息的图像数据彼此相关联地存储。字典存储单元104存储用于模式匹配的图像模式（字典图像）。模式字典选择单元105参考心电图信息选择用于模式匹配的字典图像。模式搜索范围设置单元106基于心电图信息指定要执行模式匹配的范围。心脏区域识别单元107检测图像中的心脏区域。图案比较单元108通过图案匹配识别图像中的每个特征区域的位置。轮廓提取单元109基于每个特征区域的位置和超声图像来提取轮廓。显示单元110显示提取的轮廓。