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(54) **GESTURE COMMANDS USER INTERFACE FOR ULTRASOUND IMAGING SYSTEMS**

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(57) **ABSTRACT**

The embodiments of the ultrasound imaging diagnostic apparatus include at least one non-touch input device for receiving a predetermined gesture as an input command. An optional sequence of predetermined gestures is inputted as an operational command and or data to the embodiments of the ultrasound imaging diagnostic apparatus. A gesture is optionally combined with other conventional input modes through devices such as a microphone, a mouse, a keyboard, a button, a panel switch, a touch command screen, a foot switch, a trackball, and the like.

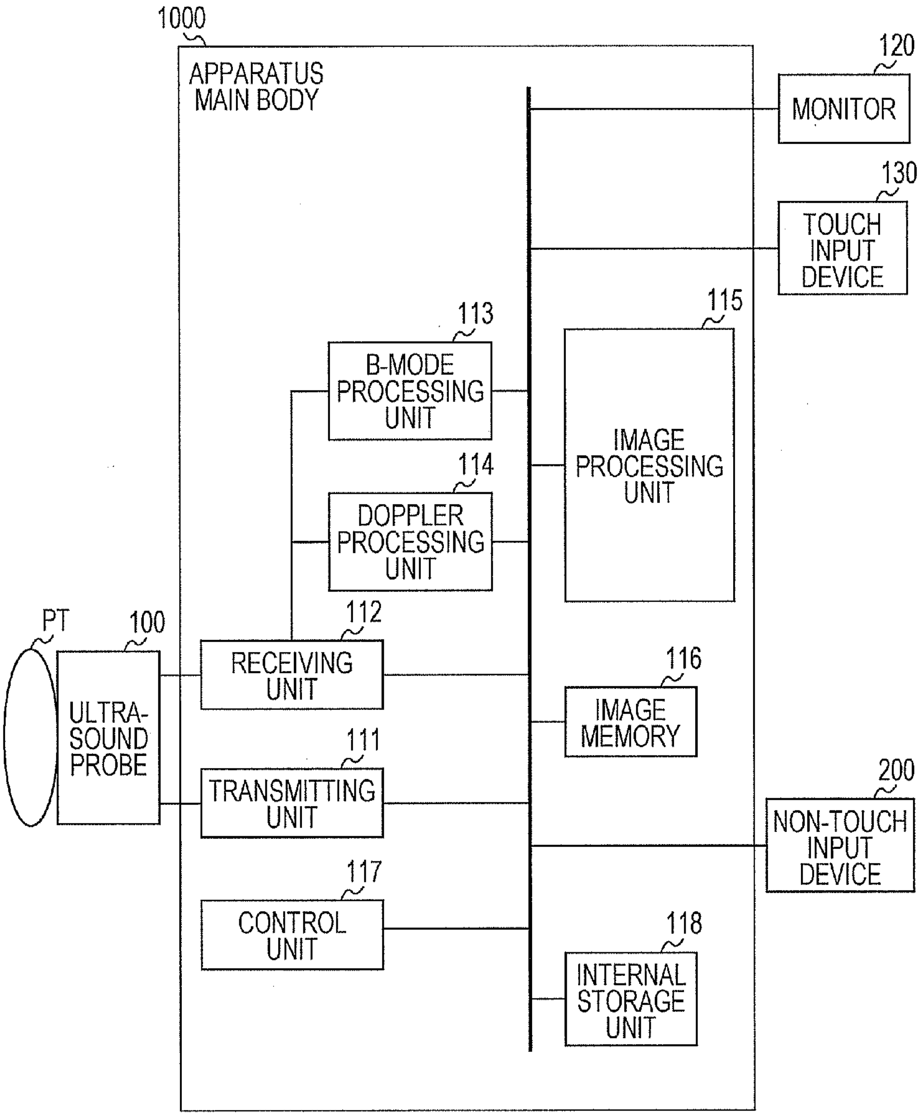


FIG. 1

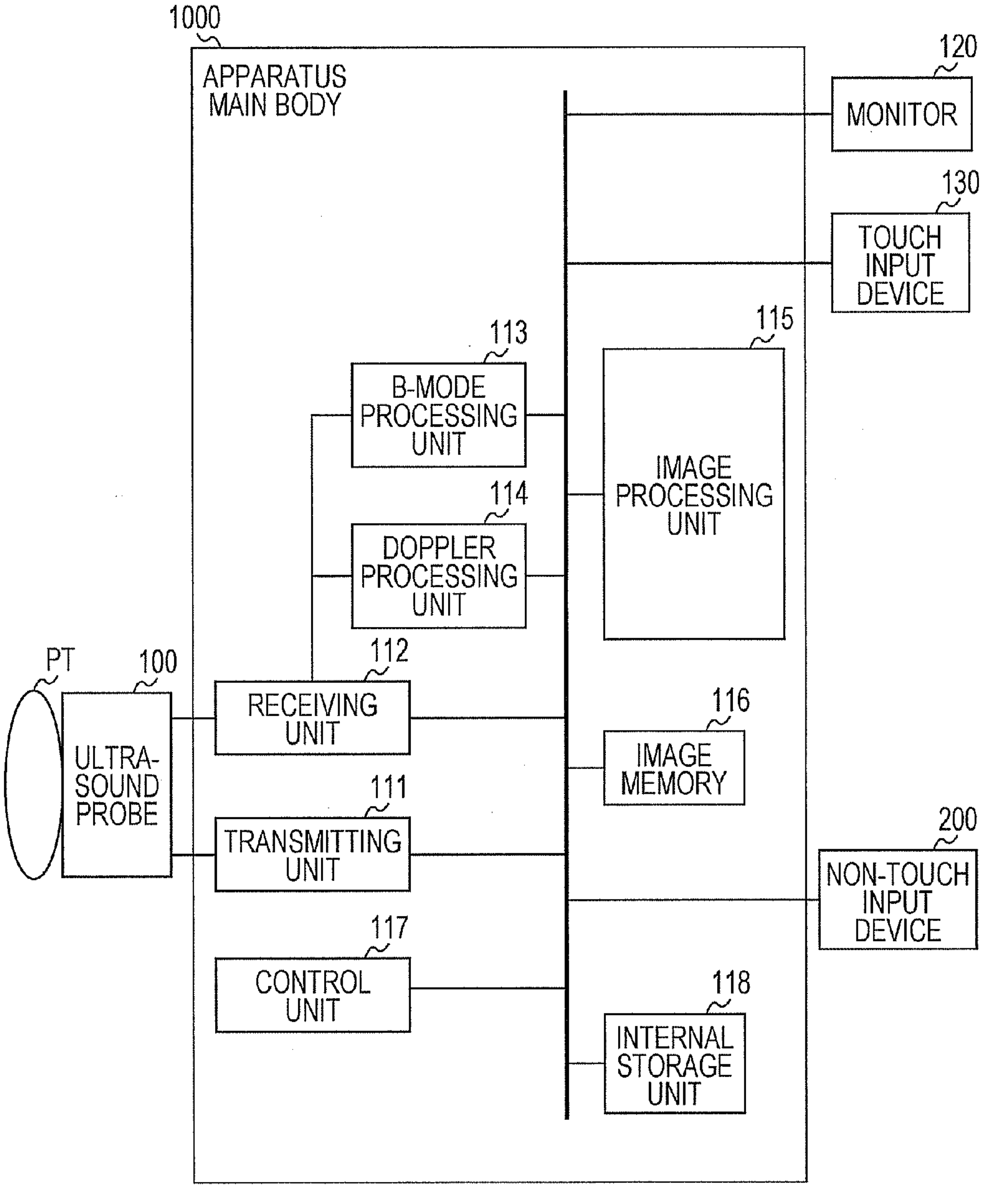

1000
APPARATUS MAIN BODY
120
MONITOR
130
TOUCH INPUT DEVICE
113
B-MODE PROCESSING UNIT
114
DOPPLER PROCESSING UNIT
115
IMAGE PROCESSING UNIT
PT
100
ULTRA-SOUND PROBE
112
RECEIVING UNIT
116
IMAGE MEMORY
111
TRANSMITTING UNIT
200
NON-TOUCH INPUT DEVICE
117
CONTROL UNIT
118
INTERNAL STORAGE UNIT

FIG. 2A

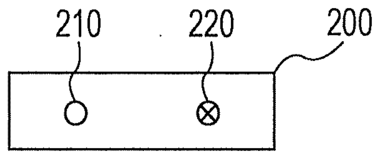


FIG. 2B

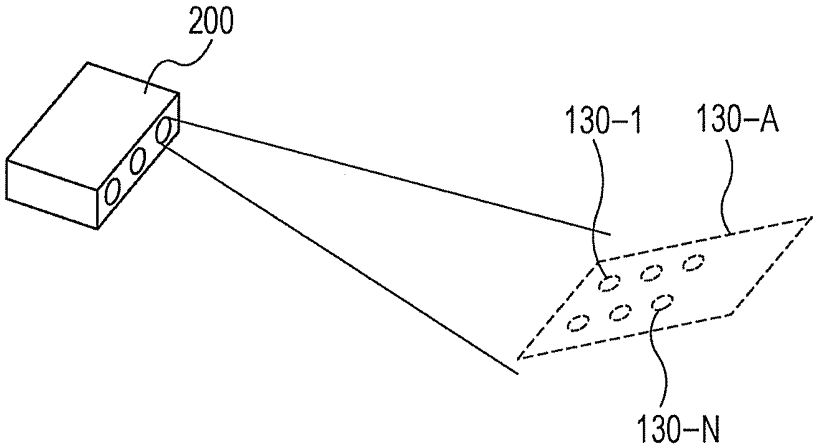


FIG. 3A

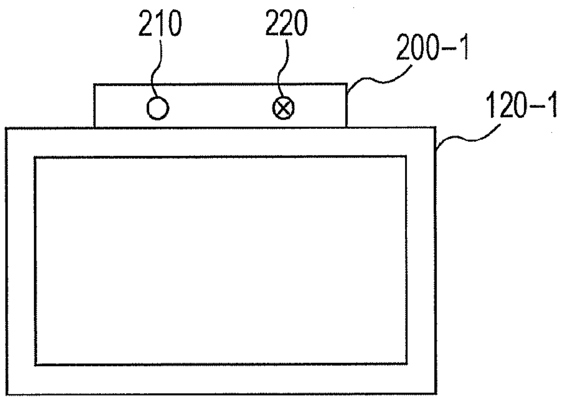


FIG. 3B

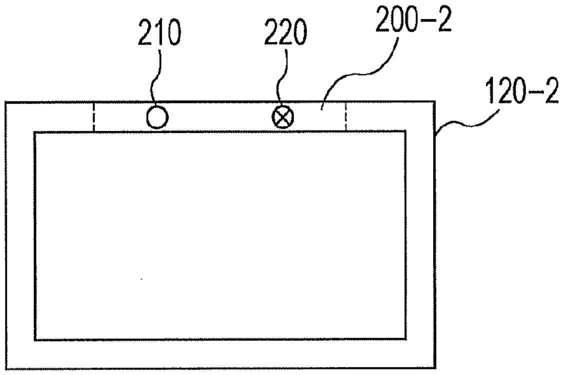


FIG. 3C

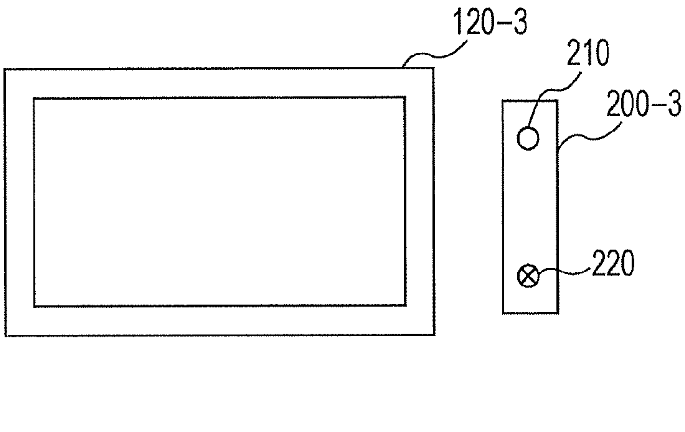


FIG. 4

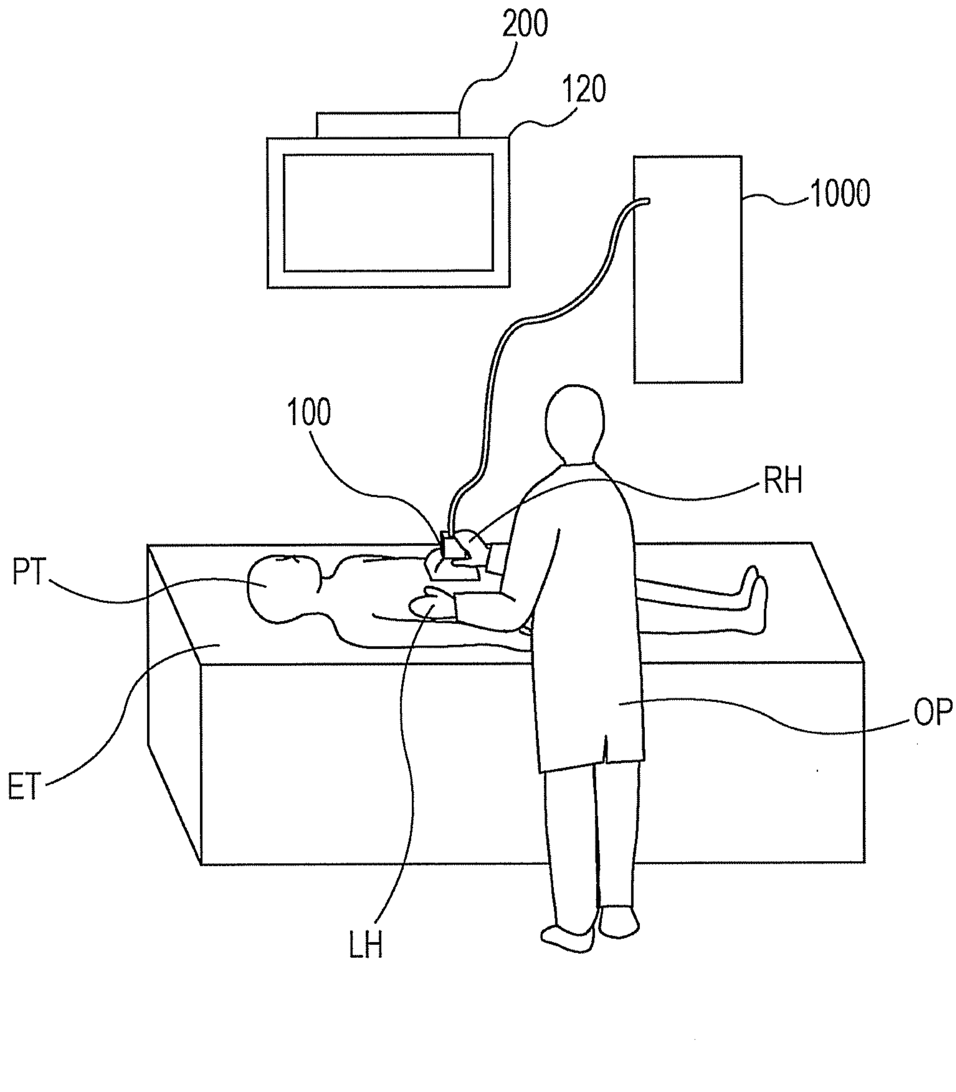


FIG. 5

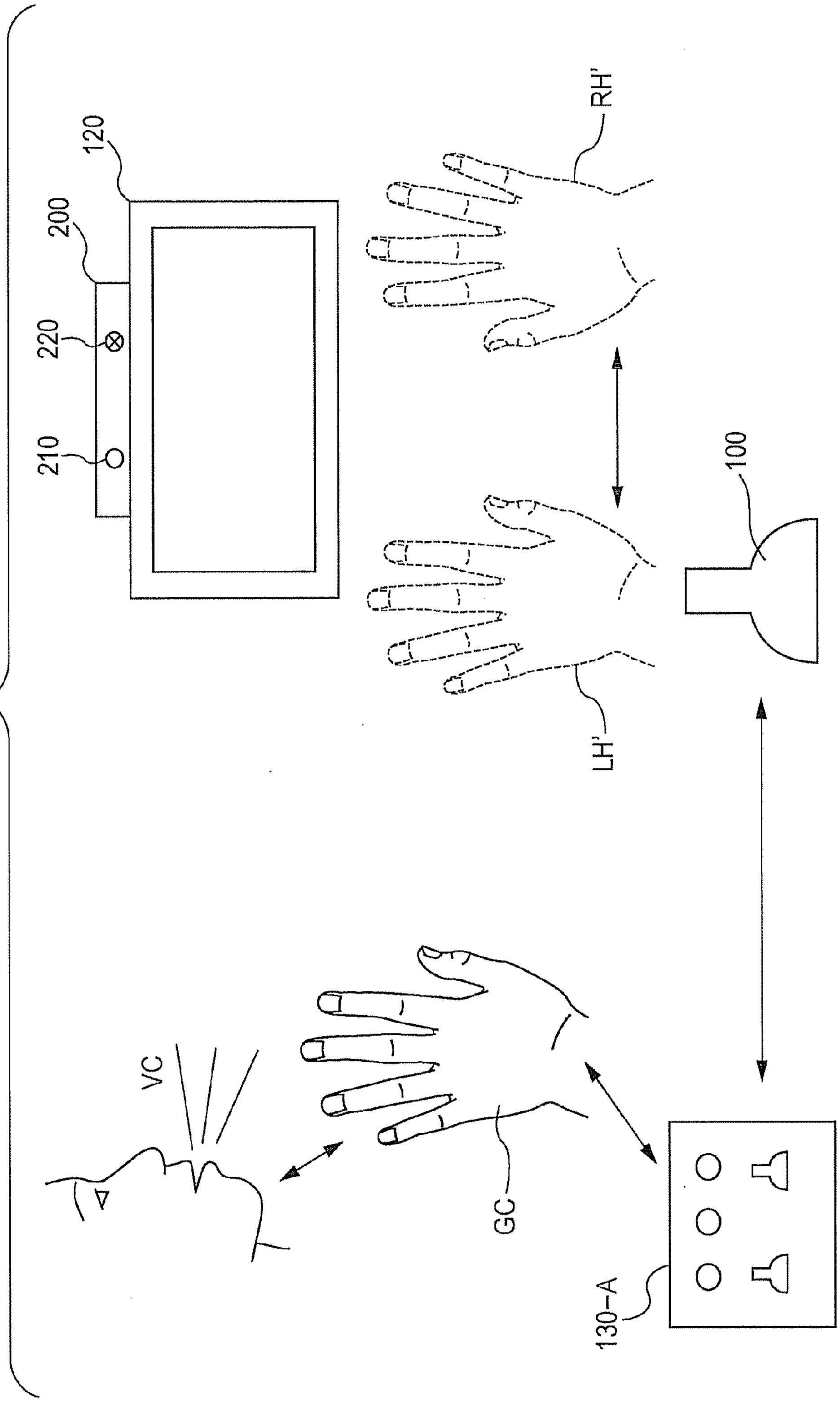


FIG. 6

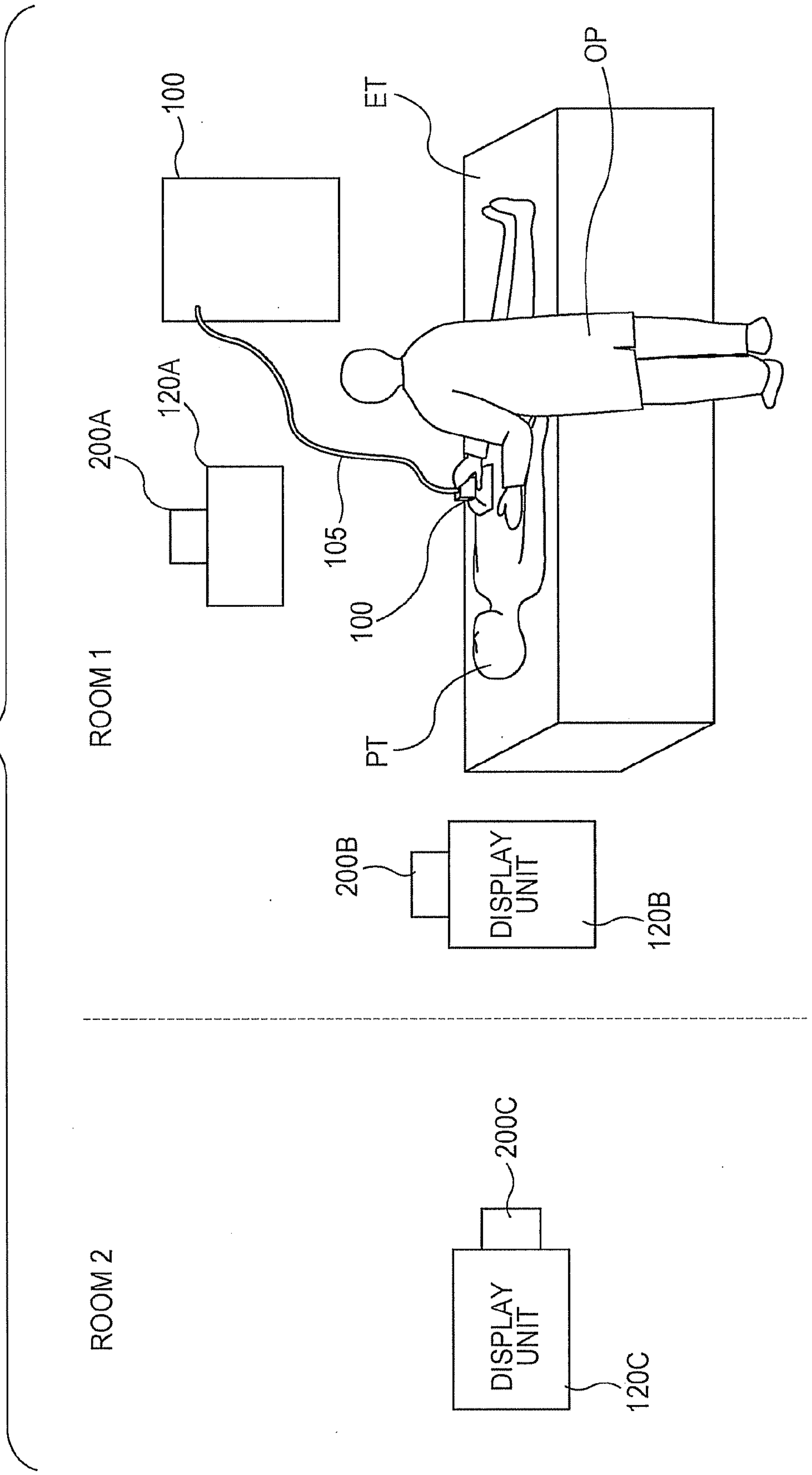

ROOM 1
100
ET
OP
200A
120A
105
100
PT
200B
DISPLAY UNIT
120B
ROOM 2
200C
DISPLAY UNIT
120C

FIG. 7

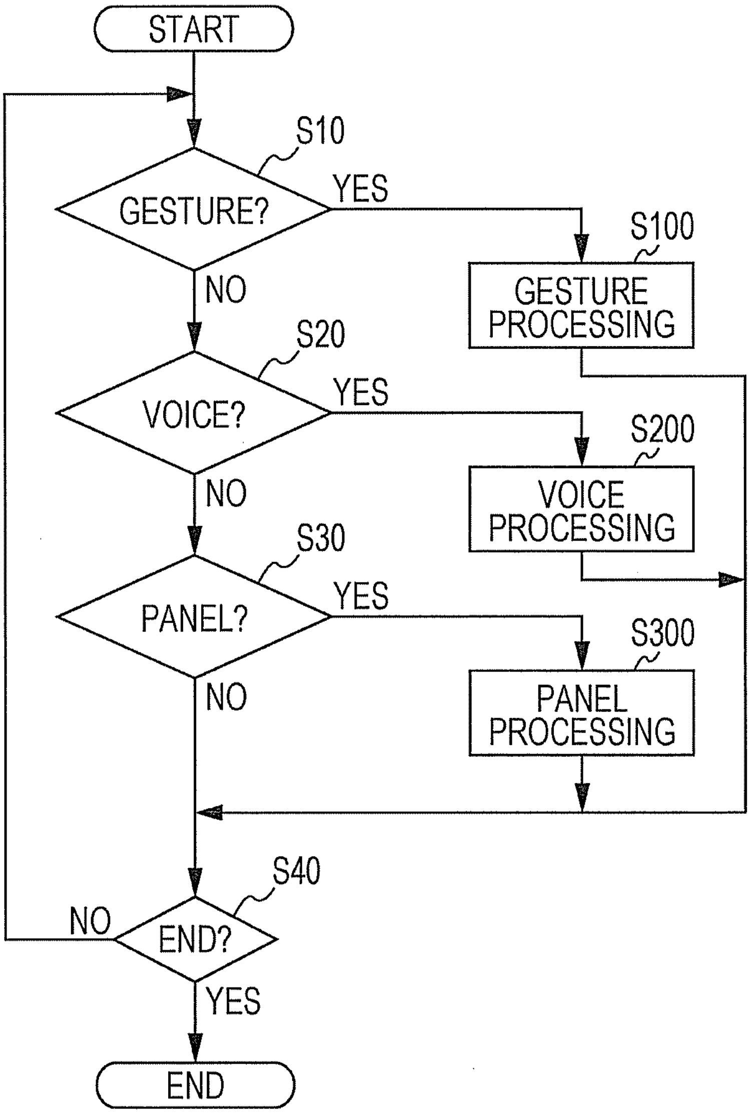
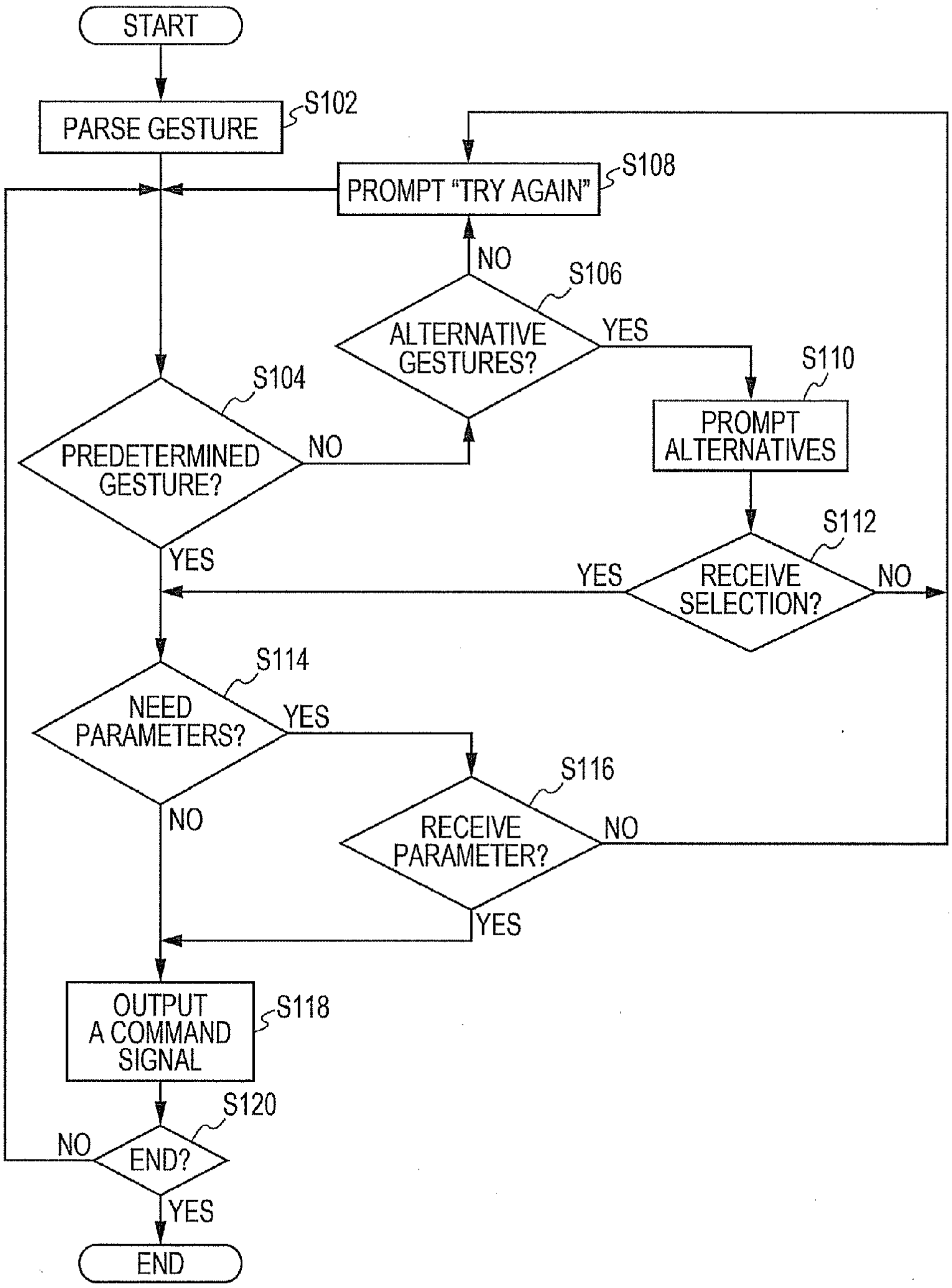

START
S10
GESTURE?
YES
NO
S100
GESTURE PROCESSING
S20
VOICE?
YES
NO
S200
VOICE PROCESSING
S30
PANEL?
YES
NO
S300
PANEL PROCESSING
S40
END?
NO
YES
END

FIG. 8


START
PARSE GESTURE
S102
PROMPT "TRY AGAIN"
S108
NO
S106
ALTERNATIVE GESTURES?
YES
S110
PROMPT ALTERNATIVES
S104
PREDETERMINED GESTURE?
NO
YES
S112
YES
RECEIVE SELECTION?
NO
S114
NEED PARAMETERS?
YES
S116
RECEIVE PARAMETER?
NO
NO
YES
OUTPUT A COMMAND SIGNAL
S118
S120
NO
END?
YES
END

GESTURE COMMANDS USER INTERFACE FOR ULTRASOUND IMAGING SYSTEMS

FIELD

[0001] Embodiments described herein relate generally to ultrasound diagnostic imaging systems for and method of providing a gesture-based user interface for ultrasound diagnostic imaging systems.

BACKGROUND

[0002] In the field of ultrasound medical examination, there have been some attempts to improve a user interface between the ultrasound imaging system and the operator. In general, an operator of an ultrasound scanner holds a probe in one hand so that the probe is placed on a patient in an area of interest for scanning an image. The operator observes the image on a display to ascertain accuracy and quality of the image during examination. At the same time, he or she has to adjust imaging parameters from time to time by reaching a control panel using the other hand in order to maintain accuracy and quality of the image.

[0003] Despite the above challenging tasks, prior art ultrasound imaging systems do not provide an easy-to-use interface to the operator. Because the display and the control panel are generally a part of a relatively large scanning device, the image scanning device cannot be placed between the patient and the operator. By the same token, because the operator must reach the control panel, the control panel cannot be placed across the patient from the operator either. For these reasons, the control panel and the display are usually located on the side of the operator within his or her reach. Consequently, during the use of the ultrasound imaging system, the operator must extend one hand to the side in order to control knobs and switches on the control panel and must hold the probe with the other hand while the operator has to turn his or her head in order to observe the image during the examination. Because of the above described physical requirements, the ultrasound imaging technicians are often subject to occupational injuries over the course of prolong and repetitive operations.

[0004] One prior-art attempt provided a hand-held remote control unit instead of the control panel for improving the ultrasound imaging system interface. Although the remote control unit alleviated some difficulties, the operator was required to hold the additional piece of equipment in addition to a probe. In other words, the operator's both hands were constantly occupied during the ultrasound imaging session. To adjust any setting that is not accessed through the remote control, the operator had to put the remote control down and later pick it up to resume during scanning. Consequently, the remote control often prevented the operator from easily performing other necessary tasks that require at least one hand during the examination.

[0005] Another prior-art attempt provided a voice control unit instead of the control panel for improving the ultrasound imaging system interface. Although the voice commands freed the operator from holding any additional piece of equipment other than a probe, the voice command interface experienced difficulties under certain circumstances. For example, since an examination room was not always sufficiently quiet, environment noise prevented the voice control unit from correctly interpreting the voice commands. Another example of the difficulties is accuracy in interpreting the voice command due to various factors such as accents. Although the accuracy might be improved with training to a certain extent, the system needed initial investment and the improvement was generally limited.

[0006] In view of the above described exemplary prior-art attempts, the ultrasound imaging system still needs an improved operational interface for an operator to control the imaging parameters as well as the operation during the examination sessions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a schematic diagram illustrating an embodiment of the ultrasound diagnosis apparatus according to the current invention.

[0008] FIG. **2**A is a diagram illustrating one embodiment of the non-touch input device in the ultrasound diagnosis apparatus according to the current invention.

[0009] FIG. **2**B is a diagram illustrating one embodiment of the non-touch input device for projecting a virtual control panel for inputting commands in the ultrasound diagnosis apparatus according to the current invention.

[0010] FIG. **3**A is a diagram illustrating a first embodiment of a non-touch input device mounted on a top of a display unit in the ultrasound diagnosis apparatus according to the current invention.

[0011] FIG. **3**B is a diagram illustrating a second embodiment of a non-touch input device, which is integrated in a top portion of a display unit in the ultrasound diagnosis apparatus according to the current invention.

[0012] FIG. **3**C is a diagram illustrating a third embodiment of a non-touch input device, which is a separate unit that is placed next to a display unit in the ultrasound diagnosis apparatus according to the current invention.

[0013] FIG. **4** is a diagram illustrating an exemplary operating environment of one embodiment of the ultrasound imaging and diagnosis system according to the current invention.

[0014] FIG. **5** is a diagram illustrating various combinations of the non-touch inputs to the non-touch input device according to the current invention.

[0015] FIG. **6** is a diagram illustrating another exemplary operating environment of one embodiment of the ultrasound imaging and diagnosis system according to the current invention.

[0016] FIG. **7** is a flow chart illustrating steps or acts involved in one method of processing input commands according to the current invention.

[0017] FIG. **8** is a flow chart illustrating steps or acts involved in one method of processing gesture commands according to the current invention.

DETAILED DESCRIPTION

[0018] According to one embodiment, an ultrasound diagnosis apparatus includes an image creating unit, a calculating unit, a corrected-image creating unit, a non-touch input device for a hand-free user interface and a display control unit. The image creating unit creates a plurality of ultrasound images in time series based on a reflected wave of ultrasound that is transmitted onto a subject from an ultrasound probe. The calculating unit calculates a motion vector of a local region between a first image and a second image that are two successive ultrasound images in time series among the ultrasound images created by the image creating unit. The corrected-image creating unit creates a corrected image from the second image based on a component of a scanning line direction of the ultrasound in the motion vector calculated by the calculating unit. A hand-free user interface unit is generally synonymous with the non-touch input device in the current application and interfaces the operator with the ultrasound diagnosis apparatus without physical touch or mechanical movement of the input device. The display control unit performs control so as to cause a certain display unit to display the corrected image created by the corrected-image creating unit.

[0019] Exemplary embodiments of an ultrasound diagnosis apparatus will be explained below in detail with reference to the accompanying drawings. Now referring to FIG. **1**, a schematic diagram illustrates a first embodiment of the ultrasound diagnosis apparatus according to the current invention. The first embodiment includes an ultrasound probe **100**, a monitor **120**, a touch input device **130**, a non-touch input device **200** and an apparatus main body **1000**. One embodiment of the ultrasound probe **100** includes a plurality of piezoelectric vibrators, and the piezoelectric vibrators generate ultrasound based on a driving signal supplied from a transmitting unit **111** housed in the apparatus main body **1000**. The ultrasound probe **100** also receives a reflected wave from a subject Pt and converts it into an electric signal. Moreover, the ultrasound probe **100** includes a matching layer provided to the piezoelectric vibrators and a backing material that prevents propagation of ultrasound backward from the piezoelectric vibrators.

[0020] As ultrasound is transmitted from the ultrasound probe **100** to the subject Pt, the transmitted ultrasound is consecutively reflected by discontinuity planes of acoustic impedance in internal body tissue of the subject Pt and is also received as a reflected wave signal by the piezoelectric vibrators of the ultrasound probe **100**. The amplitude of the received reflected wave signal depends on a difference in the acoustic impedance of the discontinuity planes that reflect the ultrasound. For example, when a transmitted ultrasound pulse is reflected by a moving blood flow or a surface of a heart wall, a reflected wave signal is affected by a frequency deviation. That is, due to the Doppler effect, the reflected wave signal is dependent on a velocity component in the ultrasound transmitting direction of a moving object.

[0021] The apparatus main body **1000** ultimately generates signals representing an ultrasound image. The apparatus main body **1000** controls the transmission of ultrasound from the probe **100** towards a region of interest in a patient as well as the reception of a reflected wave at the ultrasound probe **100**. The apparatus main body **1000** includes a transmitting unit **111**, a receiving unit **112**, a B-mode processing unit **113**, a Doppler processing unit **114**, an image processing unit **115**, an image memory **116**, a control unit **117** and an internal storage unit **118**, all of which are connected via internal bus.

[0022] The transmitting unit **111** includes a trigger generating circuit, a delay circuit, a pulsar circuit and the like and supplies a driving signal to the ultrasound probe **100**. The pulsar circuit repeatedly generates a rate pulse for forming transmission ultrasound at a certain rate frequency. The delay circuit controls a delay time in a rate pulse from the pulsar circuit for utilizing each of the piezoelectric vibrators so as to converge ultrasound from the ultrasound probe **100** into a beam and to determine transmission directivity. The trigger generating circuit applies a driving signal (driving pulse) to the ultrasound probe **100** based on the rate pulse.

[0023] The receiving unit **112** includes an amplifier circuit, an analog-to-digital (A/D) converter, an adder and the like and creates reflected wave data by performing various processing on a reflected wave signal that has been received at the ultrasound probe **100**. The amplifier circuit performs gain correction by amplifying the reflected wave signal. The A/D converter converts the gain-corrected reflected wave signal from the analog format to the digital format and provides a delay time that is required for determining reception directivity. The adder creates reflected wave data by adding the digitally converted reflected wave signals from the A/D converter. Through the addition processing, the adder emphasizes a reflection component from a direction in accordance with the reception directivity of the reflected wave signal. In the above described manner, the transmitting unit **111** and the receiving unit **112** respectively control transmission directivity during ultrasound transmission and reception directivity during ultrasound reception.

[0024] The apparatus main body **1000** further includes the B-mode processing unit **113** and the Doppler processing unit **114**. The B-mode processing unit **113** receives the reflected wave data from the receiving unit **112**, performs logarithmic amplification and envelopes detection processing and the like so as to create data (B-mode data) that a signal strength is expressed by the brightness. The Doppler processing unit **114** performs frequency analysis on velocity information from the reflected wave data that has been received from the receiving unit **112**. The Doppler processing unit **114** extracts components of a blood flow, tissue, and contrast media echo by Doppler effects. The Doppler processing unit **114** generates Doppler data on moving object information such as an average velocity, a distribution, power and the like with respect to multiple points.

[0025] The apparatus main body **1000** further includes additional units that are related to image processing of the ultrasound image data. The image processing unit **115** generates an ultrasound image from the B-mode data from the B-mode processing unit **113** or the Doppler data from the Doppler processing unit **114**. Specifically, the image processing unit **115** respectively generates a B-mode image from the B-mode data and a Doppler image from the Doppler data. Moreover, the image processing unit **115** converts or scan-converts a scanning-line signal sequence of an ultrasound scan into a predetermined video format such as a television format. The image processing unit **115** ultimately generates an ultrasound display image such as a B-mode image or a Doppler image for a display device. The image memory **116** stores ultrasound image data generated by the image processing unit **115**.

[0026] The control unit **117** controls overall processes in the ultrasound diagnosis apparatus. Specifically, the control unit **117** controls processing in the transmitting unit **111**, the receiving unit **112**, the B-mode processing unit **113**, the Doppler processing unit **114** and the image processing unit **115** based on various setting requests that are inputted by the operator via the input devices, control programs and setting information that are read from the internal storage unit **118**. For Example, the control programs executes certain programmed sequence of instructions for transmitting and receiving ultrasound, processing image data and displaying the image data. The setting information includes diagnosis information such as a patient ID and a doctor's opinion, a diagnosis protocol and other information. Moreover, the internal storage unit **118** is optionally used for storing images stored in the image memory **116**. Certain data stored in the internal storage unit **118** is optionally transferred to an external peripheral device via an interface circuit. Lastly, the control unit **117** also controls the monitor **120** for displaying an ultrasound image that has been stored in the image memory **116**.

[0027] A plurality of input devices exists in the first embodiment of the ultrasound diagnosis apparatus according to the current invention. Although the monitor or display unit **120** generally displays an ultrasound image as described above, a certain embodiment of the display unit **120** additionally functions as an input device such as a touch panel alone or in combination with other input devices for a system user interface for the first embodiment of the ultrasound diagnosis apparatus. The display unit **120** provides a Graphical User Interface (GUI) for an operator of the ultrasound diagnosis apparatus to input various setting requests in combination with the input device **130**. The input device **130** includes a mouse, a keyboard, a button, a panel switch, a touch command screen, a foot switch, a trackball, and the like. A combination of the display unit **120** and the input device **130** optionally receives predetermined setting requests and operational commands from an operator of the ultrasound diagnosis apparatus. The combination of the display unit **120** and the input device **130** in turn generates a signal or instruction for each of the received setting requests and or commands to be sent to the apparatus main body **1000**. For example, a request is made using a mouse and the monitor to set a region of interest during an upcoming scanning session. Another example is that the operator specifies via a processing execution switch a start and an end of image processing to be performed on the image by the image processing unit **115**.

[0028] The above described input modes generally require an operator to touch a certain device such as a switch or a touch panel to generate an input signal. Since any of the touch input modes requires an operator to reach a corresponding input device at least with one hand while the operator is holding a probe with the other hand, it has been challenging under certain circumstances during a scanning session.

[0029] Still referring to FIG. **1**, a plurality of input devices in the first embodiment of the ultrasound diagnosis apparatus according to the current invention additionally includes a non-touch input device **200**. One embodiment of the non-touch input device **200** is connected to the apparatus main body **1000** via predetermined wired or wireless connection for receiving non-contact inputs such as commands and data for operating the ultrasound diagnosis apparatus according to the current invention. For example, the non-contact input includes at least a predetermined set of gestures, and the non-touch input device **200** receives at least a predetermined gesture. The gesture command is optionally a predetermined hand gesture that is either stationary or moving with respect to the non-touch input device **200**. However, the gesture is not limited to a hand gesture and optionally includes any non-contacting body posture and or movement. One example of the body movement is nodding that is optionally included as a predetermined gesture to be recognized by the non-touch input device **200**.

[0030] The non-touch input device **200** additionally recognizes non-contact inputs that are not necessarily based upon gestures or body posture of the user. The non-contact input to be recognized by the non-touch input device **200** optionally includes a relative position and a type of the ultrasound probe **100**. For example, when the probe **100** is moved off from a patient, the non-touch input device **200** generates an input signal to the apparatus main body **1000** to freeze a currently available image. By the same token, when the non-touch input device **200** detects a probe **100**, the non-touch input device **200** generates an input signal to the apparatus main body **1000** for setting certain predetermined scanning parameters that are desirable for the detected type of the probe **100**. Furthermore, the non-contact inputs to be recognized by the non-touch input device **200** optionally include audio or voice commands. For the above reasons, the non-touch input device **200** is synonymously called a hand-free user interface device in the sense that a user does not reach and touch a predetermined input device.

[0031] In the first embodiment of the ultrasound diagnosis apparatus according to the current invention, the non-touch input device **200** is not necessarily limited to perform the above described functions in an exclusive manner. In other embodiments of the ultrasound diagnosis apparatus according to the current invention, the non-touch input device **200** performs together with other devices such as the image processing unit **115** and the control unit **117** to accomplish the above described functions.

[0032] Now referring to FIG. **2**A, a diagram illustrates one embodiment of the non-touch input device **200** in the ultrasound diagnosis apparatus according to the current invention. The non-touch input device **200** generally includes an infra red (IR) light source and certain sensors such as an IR light sensor. The non-touch input device **200** optionally includes any combination of an image optical sensor, a 3D camera, an ultrasound transmitter, an ultrasound receiver and an accelerometer. The above sensors in the non-touch input device **200** alone or in combination with other sensors detect a shape, a depth and or a movement of a person so as to determine if a predetermined gesture is input. The above sensors are merely illustrative, and the non-touch input device **200** according to the current invention is not limited to a particular set of sensors or sensing modes for detecting a gesture command or a non-contacting hand-free signal from a person, an operator or a user. For example, other sensing elements include an ultrasound transmitter and an ultrasound receiver for detecting a gesture command or a non-contacting hand-free signal from a user. To facilitate the detection, the user optionally wears a lively colored glove so that a hand gesture is visibly enhanced. One exemplary embodiment of the non-touch input device **200** includes an IR light **210** and a depth image detector **220** for detecting a predetermined gesture so as to generate a corresponding input command according to the current invention.

[0033] Still referring to FIG. **2**A, one embodiment of the non-touch input device **200** optionally includes at least one microphone for sensing a voice command from a user in addition to the above described gesture command detectors. The non-touch input device **200** optionally detects voice commands in combination with the above described gesture commands. The voice commands are supplemental to the gesture commands under certain circumstances while the voice commands are alternative to the gesture commands under other circumstances. For example, after the user inputs a gesture commands such as "change scan depth," a parameter is needed as to which depth. Although the user optionally gestures a predetermined additional hand gesture for a particular depth as a parameter to the "change scan depth" command, the user instead inputs a voice command for a desirable depth following the "change scan depth" gesture command if the operating environment is sufficiently quiet. Repeated changes in scan depth may be easily accomplished by the voice commands as supplement to the initial change depth gesture command.

[0034] With respect to a voice command, one embodiment of the non-touch input device **200** optionally includes a microphone and an associated circuit for selectively processing the voice commands. For example, one embodiment of the non-touch input device **200** selectively filters the voice command for a predetermined person. In another example, the non-touch input device **200** selectively minimizes certain noise in the voice commands. Noise cancelation is achieved by use of multiple microphones and space selective filtering of room and system noises. Furthermore, the non-touch input device **200** optionally associates certain voice commands with selected gesture commands and vice versa. The above described additional functions of the non-touch input device **200** require predetermined parameters that are generally input during a voice command training session prior to the examination.

[0035] Referring to FIG. **2**B, a diagram illustrates one embodiment of the non-touch input device **200** for projecting a virtual control panel **130**-A in the ultrasound diagnosis apparatus according to the current invention. In one embodiment, the non-touch input device **200** includes a hologram projector for projecting the virtual control panel **130**-A in the vicinity of the user. One implementation of the virtual control panel **130**-A closely resembles the touch input device **130** in appearance and includes virtual switches and knobs **130-1** through **130**-N that correspond to the hand-control mechanisms of the touch input device **130**. One embodiment of the non-touch input device **200** continuously detects the user hand position with respect to the projected virtual control panel **130**-A and a certain predetermined hand movement for controlling any of the virtual switches and knobs **130-1** through **130**-N as indicated by dotted lines. Upon detecting the predetermined hand movement such as turning a knob or flipping a switch within a relative distance from one of the projected image portions **130-1** through **130**-N, the non-touch input device **200** generates a corresponding input command according to the current invention. According to the current invention, the projected virtual control panel **130**-A is not limited to a particular set of the control switches and or knobs of the real control panel of the touch input device **130**.

[0036] In the embodiment of the ultrasound diagnosis apparatus according to the current invention, the non-touch input device **200** is not necessarily limited to perform the above described functions in an exclusive manner. In other embodiments of the ultrasound diagnosis apparatus according to the current invention, the non-touch input device **200** performs together with other devices such as the image processing unit **115** and the control unit **117** to accomplish the above described functions.

[0037] Now referring to FIGS. **3**A, **3**B and **3**C, the non-touch input device **200** is implemented in various manners in the ultrasound diagnosis apparatus according to the current invention. FIG. **3**A illustrates a first embodiment of a non-touch input device **200-1**, which is mounted on a top of a display unit **120-1**. The mounting is not limited on the top of the display unit **120-1** and includes any other surfaces of the display unit **120-1** or even other units or devices in the ultrasound diagnosis apparatus according to the current invention. Depending upon implementation, the non-touch input device **200-1** is optionally mounted on the display unit **120-1** in a retrofitted manner in an existing ultrasound diagnosis apparatus system. One embodiment of the non-touch input device **200-1** includes the IR light **210** and the depth image detector **220** according to the current invention.

[0038] FIG. **3**B illustrates a second embodiment of a non-touch input device **200-2**, which is integrated in a top portion of a display unit **120-2** as indicated by the dotted lines. The integration is not limited to the top portion of the display unit **120-2** and includes any other portions of the display unit **120-2** or even other units or devices in the ultrasound diagnosis apparatus according to the current invention. One embodiment of the non-touch input device **200-2** includes the IR light **210** and the depth image detector **220** according to the current invention.

[0039] FIG. **3**C illustrates a third embodiment of a non-touch input device **200-3**, which is a separate unit that is placed next to a display unit **120-3**. The placement is not limited to the side of the display unit **120-3** and includes any other locations of the display unit **120-3** or even other units or devices in the ultrasound diagnosis apparatus according to the current invention. Depending upon implementation, the non-touch input device **200-3** is optionally placed near the display unit **120-3** or other devices in a retrofitted manner in an existing ultrasound diagnosis apparatus system. One embodiment of the non-touch input device **200-3** includes the IR light **210** and the depth image detector **220** according to the current invention.

[0040] Now referring to FIG. **4**, a diagram illustrates an exemplary operating environment of one embodiment of the ultrasound imaging and diagnosis system according to the current invention. In an exemplary environment, a patient PT is laid on an examination table ET while an operator OP holds the probe **100** with one hand and places it on the patient PT for scanning an ultrasound image. The probe **100** is wired or wirelessly connected to the main body **1000**, which is placed on the other side of the patient PT from the operator OP. The operator usually stands in front of the examination table ET and directly faces the patient PT and the display unit **120**, which is also placed across the patient PT for easy viewing. In the exemplary embodiment, the non-touch input device **200** is mounted on top of the display unit **120** and moves together with the display unit **120** as the display unit **120** is adjustably positioned for the operator OP.

[0041] Still referring to FIG. **4**, in the same exemplary environment, as the operator OP holds the probe **100** with his or her right hand RH and scans it over the patient PT, the operator OP directly faces the display unit **120**. In this forward-looking posture, the operator OP inputs predetermined gesture commands with his or her left hand LH to the non-touch input device **200** according to one exemplary operation of the current invention. In turn, the non-touch input device **200** receives the gesture commands and generates corresponding input signals to the main body **1000** for performing the operations as specified by the gesture commands. Accordingly, in the illustrated operating environment, the operator OP is substantially free from turning his or her body and reaching the knobs and the switches on a prior art control panel that is generally located at a lateral side of the operator OP. In other words, the operator OP maintains a substantially forward-looking posture for monitoring the display unit **120** and inputting the commands during the scanning session. Furthermore, since no equipment is located between the operator OP and the examination table ET, the operator is substantially unobstructed to move around the examination table ET during the scanning session.

[0042] In the above described exemplary environment, one embodiment of the non-touch input device **200** processes various types of inputs while the operator OP examines the patient using the ultrasound diagnosis apparatus according to the current invention. The input commands are not necessarily related to the direct operation of the ultrasound imaging diagnosis apparatus and include optional command for annotations, measurements and calculations in relation to the ultrasound images that have been acquired during the examination session. For example, the annotations include information on the region of interest, the patient information, the scanning parameters and the scanning conditions. An exemplary measurement includes a size of a certain tissue area such as a malignant tumor in the ultrasound images that have been acquired during the examination session. An exemplary calculation result in certain values such as a heart rate and blood flow velocity based upon the acquired ultrasound data that have been acquired during the examination session.

[0043] The embodiment of FIG. **4** is merely illustrative and is limited to the above described particular features of the exemplary embodiment in order to practice the current invention. For example, any combination of wired or wireless connections is applicable among the probe **100**, the display unit **120**, the non-touch input device **200** and the main body **1000** in practicing the current invention. Also in practicing the current invention, the location of the display unit **120** and the non-touch input device **200** is not limited to be directly in front of the operator OP and across the patient PT. By the same token, the operator is not required to hold the probe **100** with any particular hand in practicing the current invention and optionally switches hands or uses both hands to hold the probe **100** during the examination session. Furthermore, the above described exemplary embodiment is optionally combined with the input device **130** for receiving predetermined setting requests and operational commands from an operator of the ultrasound diagnosis apparatus. The input device **130** includes a mouse, a keyboard, a button, a panel switch, a touch command screen, a foot switch, a trackball, and the like. Lastly, the non-touch input device **200** optionally receives audio or voice commands.

[0044] FIG. **5** is a diagram illustrating various inputs to the non-touch input device **200** according to the current invention. One embodiment of the non-touch input device **200** is mounted on the display monitor **120** and includes at least a pair of the IR light **210** and the depth image detector **220**. For example, the non-touch input device **200** detects a predetermined gesture command GC as articulated by the operator so as to generate a corresponding input signal to the main body **1000** for performing the corresponding operation. In another example, the non-touch input device **200** also detects a predetermined voice command VC as articulated by the same operator. The non-touch input device **200** optionally includes a voice command unit and or a virtual control panel unit that are not shown in the diagram. In an alternative embodiment of the non-touch input device **200**, a voice command unit and or a virtual control panel unit are provided as separate units from the non-touch input device **200**.

[0045] Still referring to FIG. **5**, the non-touch input device **200** allows the operator to change the input mode as well as the input source in a flexible manner. For example, during a sequence of predetermined gestures, the operator is allowed to switch hands between a left hand LH' and a right RH' as indicated by a double-headed arrow. By the same token, the non-touch input device **200** receives from the operator a combination of the predetermined gesture command GC and the predetermined voice command VC as indicated by a vertical double-headed arrow. The input mode such as voice and gesture is optionally changed even during a single operational command. Furthermore, the non-touch input device **200** automatically generates a certain input signal to the main body **1000** without a voice or gesture command from the user. Since a certain embodiment of the non-touch input device **200** continuously detects a relative position of the probe **100** with respect to a patient, when the probe **100** is no longer on the patient body surface, the non-touch input device **200** generates the input signal corresponding to a "freeze an image" command so that the last available image is maintained on the monitor **120**. In the above example, the input source is optionally changed from the operator to the probe. Furthermore, the use of the virtual control panel **130**-A is optionally combined with any other input mode or source. For the use of the virtual control panel **130**-A, the detection of the hand position and the hand movement have been described with respect to FIG. 2B.

[0046] Now referring to FIG. **6**, a diagram is merely illustrative and is limited to the above described particular features illustrates an exemplary environment where one embodiment of the ultrasound imaging and diagnosis system is operated according to the current invention. In an exemplary embodiment, there exist multiple ones of the non-touch input device **200** and multiple sets of the touch input device **130** and the display unit **120** in the ultrasound imaging and diagnosis system. In another embodiment, only multiple sets of the display unit **120** exist in the ultrasound imaging and diagnosis system. In either embodiment, a combination of the non-touch input device **200** and the display unit **120** is located at a plurality of locations such as different rooms in the same building and or geographically remote locations anywhere in the world.

[0047] Still referring to FIG. **6**, a diagram illustrates one example where a patient PT is laid on an examination table ET in Room **1**. An operator OP holds the probe **100** with one hand and places it on the patient PT for scanning an ultrasound image. The probe **100** is wired or wirelessly connected to the main body **1000**, which is placed across the patient PT from the operator OP. The operator usually stands in front of the examination table ET and directly faces the patient PT and the display unit **120**A, which is also placed across the patient PT for comfortable viewing. In the exemplary embodiment, the non-touch input device **200**A is mounted on top of the display unit **120**A and moves together with the display unit **120**A as the display unit **120**A is adjustably positioned for the operator OP.

[0048] In this example, another set of a non-touch input device **200**B and a display unit **120**B is also located in Room **1** for additional personnel who are not illustrated in the diagram. The additional personnel in Room **1** either passively observe the display unit **120**B or actively participate in the scanning session by articulating operational commands to the non-touch input device **200**B during the same scanning session as the operator OP scans the patient PT via the probe **100**. For example, several students simply observe the scanning session through the display monitor **120**B for learning the operation of the ultrasound imaging and diagnosis system. Another example is that a doctor articulates an operational command such as a predetermined gesture to the non-touch input device **200**B for acquiring additional images that are not recorded by the operator OP as the doctor observes the scanning session via the display monitor **120**B. In case of anticipating multiple operational commands from various input devices, a rule is established in advance and stored in the main body **1000** for resolving conflicting commands or prioritizing a plurality of commands.

[0049] Still referring to FIG. **6**, a diagram also illustrates yet another set of a non-touch input device **200**C and a display unit **120**C, which is located in Room **2** for additional personnel who are not illustrated in the diagram. In one implementation, Room **2** is located in the same building as Room **1**. For example, Room **1** is an operating room while Room **2** is an adjacent observation room. Alternatively, in another implementation, Room **2** is located at a different location from Room **1** outside of the building anywhere in the world. For example, Room **1** is an examination room in one city while Room **2** is a doctor's office in another city. In any case, the additional personnel in Room **2** either passively observe the display unit **120**C or actively participate in the scanning session by articulating operational commands to the non-touch input device **200**C during the same scanning session as the operator OP scans the patient via the probe **100** in Room **1**. For example, several students simply observe the scanning session via the display monitor **120**C for learning the operation of the ultrasound imaging and diagnosis system. Another example is that a doctor articulates an operational command such as a predetermined gesture to the non-touch input device **200**C for acquiring additional images that are not recorded by the operator OP as the doctor observes the scanning session via the display monitor **120**C. Yet another example is that a patient is located in an operating room in one city while a doctor in another city observes the operation by remotely using the ultrasound imaging and diagnosis system according to the current invention so as to offer his or her expert advice for the operation. By providing the multiple input sources for the gesture commands, people a plurality of locations are able to control the scanning images in an interactive manner to share and learn expert knowledge. In case of anticipating multiple operational commands from various input devices, a rule is established in advance and stored in the main body **1000** for resolving conflicting commands or prioritizing a plurality of commands.

[0050] The embodiment of FIG. **6** is merely illustrative and is not limited to the above described features of the exemplary embodiment in order to practice the current invention. For example, any combination of wired or wireless connections is applicable among the probe **100**, the display units **120**A-C, the non-touch input devices **200**A-C and the main body **1000** in practicing the current invention. Also in practicing the current invention, the location of the display unit **120**A and the non-touch input device **200**A is not limited to be directly in front of the operator OP and across the patient PT. By the same token, the operator is not required to hold the probe **100** with any particular hand in practicing the current invention and optionally switches hands or uses both hands to hold the probe **100** during the examination session. Furthermore, the above described exemplary embodiment is optionally combined with the input device **130** for receiving predetermined setting requests and operational commands from an operator of the ultrasound diagnosis apparatus. The input device **130** includes a mouse, a keyboard, a button, a panel switch, a touch command screen, a foot switch, a trackball and the like. Lastly, any one of the non-touch input devices **200**A-C optionally receives audio or voice commands.

[0051] Now referring to FIG. **7**, a flow chart illustrates steps or acts involved in one method of processing input commands according to the current invention. The exemplary method initially distinguishes and later processes both non-touch input commands as well as touch-input commands. In general, the non-touch input commands include gesture commands and voice commands without touching any physical input devices. On the other hand, the touch input commands involve mechanically or electronically activated signals that are caused by the operator via input devices such as a mouse, a keyboard, a button, a panel switch, a touch command screen, a foot switch, a trackball and the like.

[0052] Still referring to FIG. **7**, to distinguish a type of an operator input, one exemplary method of the hand-free user interface for an ultrasound imaging system performs a series of determining steps as illustrated in the flow chart. In a gesture determining step **S10**, the exemplary method determines as to whether or not an input is a gesture command. If the input is from a device or unit that processes some movement and or image of the operator, it is determined in the step **S10** that the input is a potential gesture command and the exemplary method proceeds to a gesture processing step **S100**. On the other hand, if the input is not from a device or unit that processes movement and or image of the operator, it is determined in the step **S10** that the input is not a potential gesture command and the exemplary method proceeds to a voice determining step **S20**. If the input is from a device or unit that processes voice of the operator and ambient noise, it is determined in the step **S20** that the input is a potential voice command and the exemplary method proceeds to a voice processing step **S200**. On the other hand, if the input is not from a device or unit that processes voice and or ambient noise, it is determined in the step **S20** that the input is not a potential voice command and the exemplary method proceeds to a panel input determining step **S30**. If the input is from a device or unit that processes tactile inputs from the operator or electrical signals caused by a mechanical input device, it is determined in the step **S30** that the input is a potential command from a control panel or other tactile input devices and the exemplary method proceeds to a panel processing step **300**. On the other hand, if the input is not from a device or unit that processes tactile inputs, it is determined in the step **S30** that the input is not a potential tactile input command and the exemplary method proceeds to an end determining step **S40**. In the ending step, it is determined as to whether not there is any more input. If there is no input, the exemplary method stops. On the other hand, if there is additional input, the exemplary method goes back to the step **S10**.

[0053] The method of FIG. **7** is merely illustrative and is not limited to the above described steps of the exemplary process in order to practice the current invention. Although the exemplary method illustrates the processing steps for gesture, voice and tactile inputs, other processes according to the current invention optionally include additional steps of processing other input types such as relative probe positional data. Furthermore, the process is optionally parallel or parallel-serial combination in processing the commands.

[0054] Now referring to FIG. **8**, a flow chart illustrates steps or acts involved in one method of processing gesture commands according to the current invention. The exemplary flow chart for processing the gesture commands is merely illustrative of one implementation in the hand-free user interface for an ultrasound imaging system according to the current invention. The gesture processing is not limited to any particular steps in a flow chart and optionally includes additional or alternative steps in order to practice current invention. In general, the exemplary gesture processing ultimately determines an output command signal to the ultrasound imaging system so that a user specified task is performed according to the gesture command.

[0055] Still referring to FIG. **8**, a flow chart illustrates steps that ascertain the integrity of the potential gesture command and ultimately generates a corresponding output command signal to the ultrasound imaging system according to the current invention. In a step **S102**, the potential gesture command is parsed if the potential gesture command includes more than a single gesture element. After parsing in the step **S102**, it is generally assumed that a first or initial gesture element is a major command portion in the potential gesture command. Although it is not always the case, the major command portion is often a verb in the potential gesture command. In a step **S104**, it is determined as to whether or not the first or initial gesture element is one of the predetermined gesture commands. If it is determined in the predetermined gesture determining step **S104** that the first or initial gesture element is one of the predetermined gesture commands, the exemplary gesture processing proceeds to a step **S114**, where it is determined whether or not a parameter is necessary for the first or initial gesture element.

[0056] On the other hand, if it is determined in the predetermined gesture determining step **S104** that the first or initial gesture element is not one of the predetermined gesture commands, the exemplary gesture processing proceeds to an alternative gesture processing step **S106**, where an alternative gesture flag has been initialized to a predetermined NO value to indicate a first time. If the alternative gesture flag is NO, the exemplary gesture processing proceeds to prompt in a step **S108** a "TRY Again" feedback to the user via audio and or visual prompt on a monitor so that a user can try to repeat the previously unrecognized gesture command or gesture a different gesture command. After the prompt, the alternative gesture processing step **S106** sets the alternative gesture flag to a predetermined YES value. Thus, the exemplary gesture processing goes back to the step **S104** to process another potential gesture command after the prompting step **S108**.

[0057] In contrast, if the alternative gesture flag is YES in the step **S106**, the exemplary gesture processing proceeds to a step **S110** to prompt a set of the predetermined gesture commands to the user via audio and or visual prompt on a monitor so that the user now selects one of the predetermined gesture commands for the previously unrecognized gesture command or selects a different gesture command. After the prompt in the step **S110**, the alternative gesture selecting step **S112** sets the alternative gesture flag to the predetermined NO value if a selection is received in the step **S112** and the exemplary gesture processing proceeds to a step **S114**. Alternatively, the alternative gesture selecting step **S112** leaves the alternative gesture flag to the predetermined YES value if a selection is not received in the step **S112** and the exemplary gesture processing goes back to the step **S108** and then to the step **S104**.

[0058] After a first or initial gesture element is determined either in the step **S104** or **S112**, the exemplary gesture processing ascertains if a parameter is necessary for the first or initial gesture element in the step **S114**. If it is determined in the step **S114** that a parameter is necessary for the first or initial gesture element according to a predetermined gesture command list, the exemplary gesture processing in a step **S116** determines as to whether or not a parameter is received from the user. If the necessary parameter is not received in the step **S116**, the exemplary gesture processing goes back to the step **S108** and then to the step **S104**. In other words, the exemplary gesture processing requires the user to start the gesture command from the beginning in this implementation. On the other hand, if the necessary parameter is received in the step **S116**, the exemplary gesture processing proceeds to a step **S118**, where a corresponding command signal is generated and outputted. If it is determined in the step **S114** that a parameter is not necessary for the first or initial gesture element according to the predetermined gesture command list, the exemplary gesture processing also proceeds to the step **S118**. In an ending step **S120**, it is determined as to whether not there is any more potential gesture command. If there is no more potential gesture command, the exemplary gesture processing stops. On the other hand, if there are additional potential gesture commands, the exemplary gesture processing goes back to the step **S102**.

[0059] The method of FIG. **8** is merely illustrative and is not limited to the above described steps of the exemplary process in order to practice the current invention. Although the exemplary gesture processing requires in this implementation the user to start the gesture command from the beginning in case of failing to match the required parameter in the potential gesture command, other processes according to the current invention optionally include additional steps of prompting only for a partial gesture for the required parameter.

[0060] Now referring to Table 1, an exemplary set of the gesture commands is illustrated for implementation in the ultrasound imaging system according to the current invention. Some of the tasks such as "change scan depth" as represented by the gesture commands are related to ultrasound imaging while others such as "select patient data" are generic to other modalities. The left column of Table 1 lists tasks to be performed by the ultrasound imaging system according to the current invention. The middle column of Table 1 describes prior art user interface for inputting a corresponding command for each of the tasks to be performed by the ultrasound imaging system according to the current invention. The right column of Table 1 describes a predetermined gesture for each of the tasks to be performed by the ultrasound imaging system according to the current invention.

TABLE 1

Task	Conventional U/I	Gesture Command
Select ultrasound transducer	Press buttons to navigate and select an attached transducer probe.	User picks up the transducer probe and image recognition feature automatically selects that probe.
Select patient data/exam type	Press select patient data and exam buttons to navigate and type.	User points at the system display monitor and the hand becomes a pointing device on a virtual control panel. A cursor on the display tracks hand motion. A tapping gesture presses buttons. Open palm gesture to exit virtual control panel.
Adjust overall image gain	Turning a knob to increase/decrease overall gain.	Hand gesture mimics twisting motion to adjust overall gain.

TABLE 1-continued

Task	Conventional U/I	Gesture Command
Change scan depth	Turning a knob to increase/decrease scan depth.	Hand gesture mimics raising and lowering scan depth
Freeze image	Press button to freeze current image.	Remove transducer from patient to freeze on current image.
Review acquired images (cine playback after freeze)	Move trackball to review cine images.	Flicking gesture left or right to mimic trackball motion.
Zoom in on image	Twist knob to zoom in/out	Pinching gesture to zoom in/out

[0061] Still referring to Table 1, the list is not limited by the examples in order to practice the current invention. The list is merely illustrative and is not a comprehensive list of the commands. The list also illustrates mere exemplary gesture for each of the listed commands, and the same gesture command is optionally implemented by a variety of gestures that the users prefer. In this regard, the gestures are optionally custom-made or selected for each of the gesture command from predetermined gestures. Lastly, as described above with respect to FIG. **6**, the gesture commands are used by any combination of the operator and the non-operator of the ultrasound imaging system according to the current invention.

[0062] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel methods and systems described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope of the inventions.

[0063] Furthermore, the above embodiments are described with respect to examples such as devices, apparatus and methods. Another embodiment to practice the current invention includes computer software such as programs for hand-free operation of the ultrasound system that is loaded into a computer form a recording medium where it is stored.

What is claimed is:

1. An ultrasound imaging system, comprising:

a probe for acquiring ultrasound imaging data from a patient, a first operator holding said probe over the patient;

at least a non-touch input device for receiving a combination of gesture commands and for generating input commands according to the combination of the gesture commands;

a processing unit operationally connected to said probe and said non-touch input device for processing the ultrasound imaging data and generating an image according to the input commands; and

at least a display unit operationally connected to said processing unit for displaying the image.

2. The ultrasound imaging system according to claim **1** further comprising a hand-driven control unit connected to said processing unit for generating the input commands.

3. The ultrasound imaging system according to claim **1** wherein said non-touch input device is placed on said display unit.

4. The ultrasound imaging system according to claim **1** wherein said non-touch input device is integrated into said display unit.

5. The ultrasound imaging system according to claim **1** wherein one of said non-touch input devices is placed near a second operator to receive the commands from the second operator.

6. The ultrasound imaging system according to claim **1** wherein said non-touch input device wirelessly communicates with said processing unit.

7. The ultrasound imaging system according to claim **6** wherein said processing unit is remotely placed from said non-touch input device.

8. The ultrasound imaging system according to claim **1** wherein said non-touch input device captures at least an image and motion.

9. The ultrasound imaging system according to claim **1** wherein said non-touch input device receives additional combination of predetermined voice commands.

10. The ultrasound imaging system according to claim **1** wherein said display unit wirelessly communicates with said processing unit.

11. The ultrasound imaging system according to claim **10** wherein said display unit is remotely placed from said processing unit.

12. The ultrasound imaging system according to claim **1** wherein at least one of said non-touch input devices is placed in front of the first operator so that the first operator maintains a predetermined position facing the patient while the patient is examined by the first operator.

13. The ultrasound imaging system according to claim **1** wherein said non-touch input device detects a relative position of said probe with respect to the patient for generating and input command for freezing a currently available image.

14. The ultrasound imaging system according to claim **1** wherein said non-touch input device detects a type of said probe for generating and input command for setting scanning parameters corresponding to the detected type.

15. The ultrasound imaging system according to claim **1** further comprising a virtual input device for generating the input commands.

16. A method of providing hand-free user interface for an ultrasound imaging system, comprising:

examining a patient using the ultrasound imaging system;

articulating any combination of predetermined gesture commands while the patient is examined by an operator; and

generating inputs to the ultrasound imaging system according to the commands.

17. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the operator maintains a predetermined position facing the patient while the patient is examined by the operator.

18. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the commands are articulated in said articulating by a combination of the operator and a non-operator.

19. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein said articulating further includes additional combinations of predetermined voice commands.

20. The method of providing hand-free user interface for ultrasound imaging system according to claim **19** wherein the voice commands are selectively filtered for a predetermined person.

21. The method of providing hand-free user interface for ultrasound imaging system according to claim **19** wherein certain noise is selectively minimized in the voice commands.

22. The method of providing hand-free user interface for ultrasound imaging system according to claim **19** wherein the voice commands and the gesture commands are associated as they are trained in advance.

23. The method of providing hand-free user interface for ultrasound imaging system according to claim **19** further comprising of annotating using a combination of the voice commands and the gesture commands while the patient is examined, the voice commands inputting text information for annotation.

24. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the image is remotely generated.

25. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the combination further includes inputs through predetermined hand-driven input devices.

26. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the patient is examined as ultrasound imaging data is acquired from the patient through a probe.

27. The method of providing hand-free user interface for ultrasound imaging system according to claim **26** wherein the ultrasound imaging data is measured.

28. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** further comprising of selecting a probe, the selected probe automatically associating a predetermined image recognition feature.

29. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the predetermined gesture commands include a first predetermined hand gesture for performing a combination of a selecting task and an activating task over displayed data.

30. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the predetermined gesture commands include a second predetermined hand gesture for adjusting a level of image gain.

31. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the predetermined gesture commands include a third predetermined hand gesture for adjusting a scan depth.

32. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the predetermined gesture commands include a fourth predetermined hand gesture for freezing an ultrasound image.

33. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** further comprising of removing a probe from the patient to freeze an ultrasound image.

34. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** wherein the predetermined gesture commands include a fifth predetermined hand gesture for reviewing cine images.

35. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** further comprising of detecting a relative position of a probe with respect to the patient for freezing a currently available image.

36. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** further comprising of detecting a type of a probe for setting scanning parameters corresponding to the detected type.

37. The method of providing hand-free user interface for ultrasound imaging system according to claim **16** further comprising of projecting a virtual input device for inputting the commands.

38. A method of retrofitting existing ultrasound imaging systems, comprising:

providing an existing ultrasound imaging system; and

retrofitting the existing ultrasound imaging system with a hand-free user interface unit for generating inputs to the ultrasound imaging system according to any combination of predetermined gesture commands while the patient is examined.

39. The method of retrofitting existing ultrasound imaging systems according to claim **38** wherein said hand-free user interface unit generates the inputs to the ultrasound imaging system according to additional combinations of predetermined voice commands.

40. The method of retrofitting existing ultrasound imaging systems according to claim **38** wherein the voice commands alone are selectively filtered for a predetermined person.

41. The method of retrofitting existing ultrasound imaging systems according to claim **38** wherein the voice commands and the gesture commands are associated as they are trained in advance.

42. The method of retrofitting existing ultrasound imaging systems according to claim **38** wherein certain noise is selectively minimized in the voice commands.

* * * * *

patsnap

专利名称(译)	手势命令用于超声成像系统的用户界面		
公开(公告)号	US20130225999A1	公开(公告)日	2013-08-29
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申请(专利权)人(译)	BANJANIN，ZORAN WOODS，RAYMOND F.		
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摘要(译)

超声成像诊断设备的实施例包括至少一个非触摸输入设备，用于接收预定手势作为输入命令。将可选的预定手势序列作为操作命令和/或数据输入到超声成像诊断设备的实施例。手势可选地通过诸如麦克风，鼠标，键盘，按钮，面板开关，触摸命令屏幕，脚踏开关，轨迹球等设备与其他传统输入模式组合。