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(54) ULTRASONIC DIAGNOSIS SYSTEM

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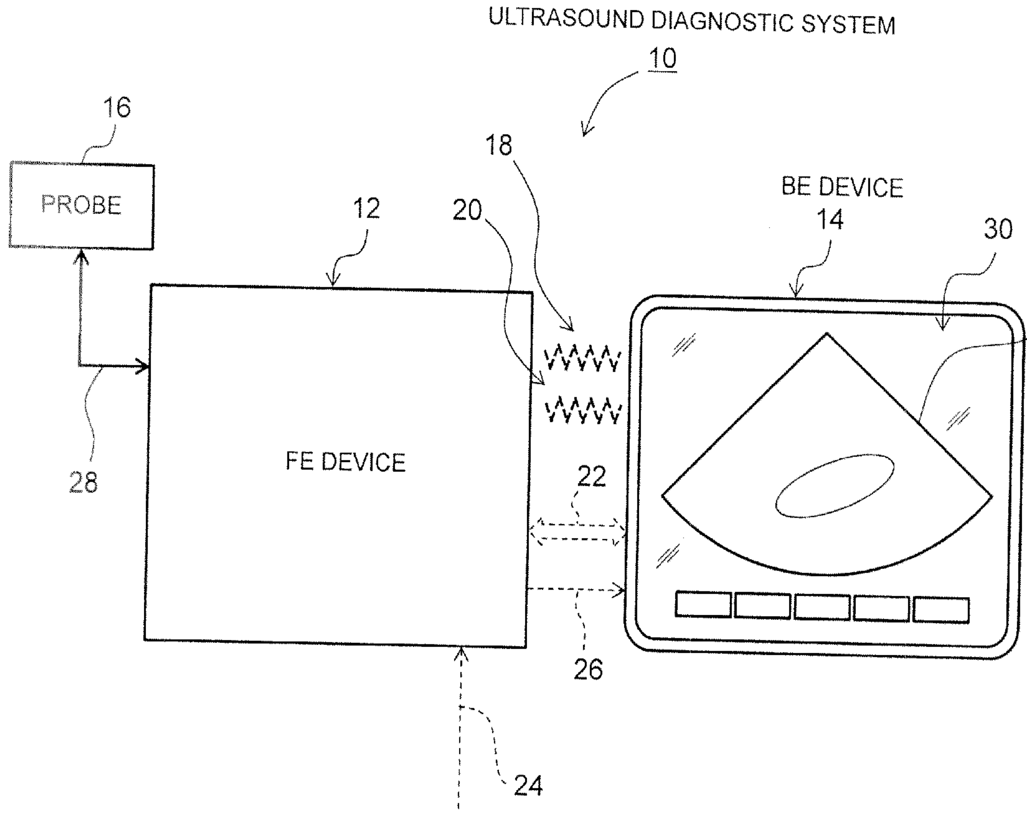
(57) **ABSTRACT**

Provided is an ultrasonic diagnosis system in which an ultrasonic diagnosis device is configured from a front-end (FE) device and a back-end (BE) device. The BE device is provided with two sensor pairs. Each sensor pair is configured from a light sensor and an object detection sensor. A control unit sets a backlight level adaptively on the basis of a light detection value when no object is detected. When an object is detected by either of the object sensors, the light detection value from the light detection sensor adjacent to said object is discarded.



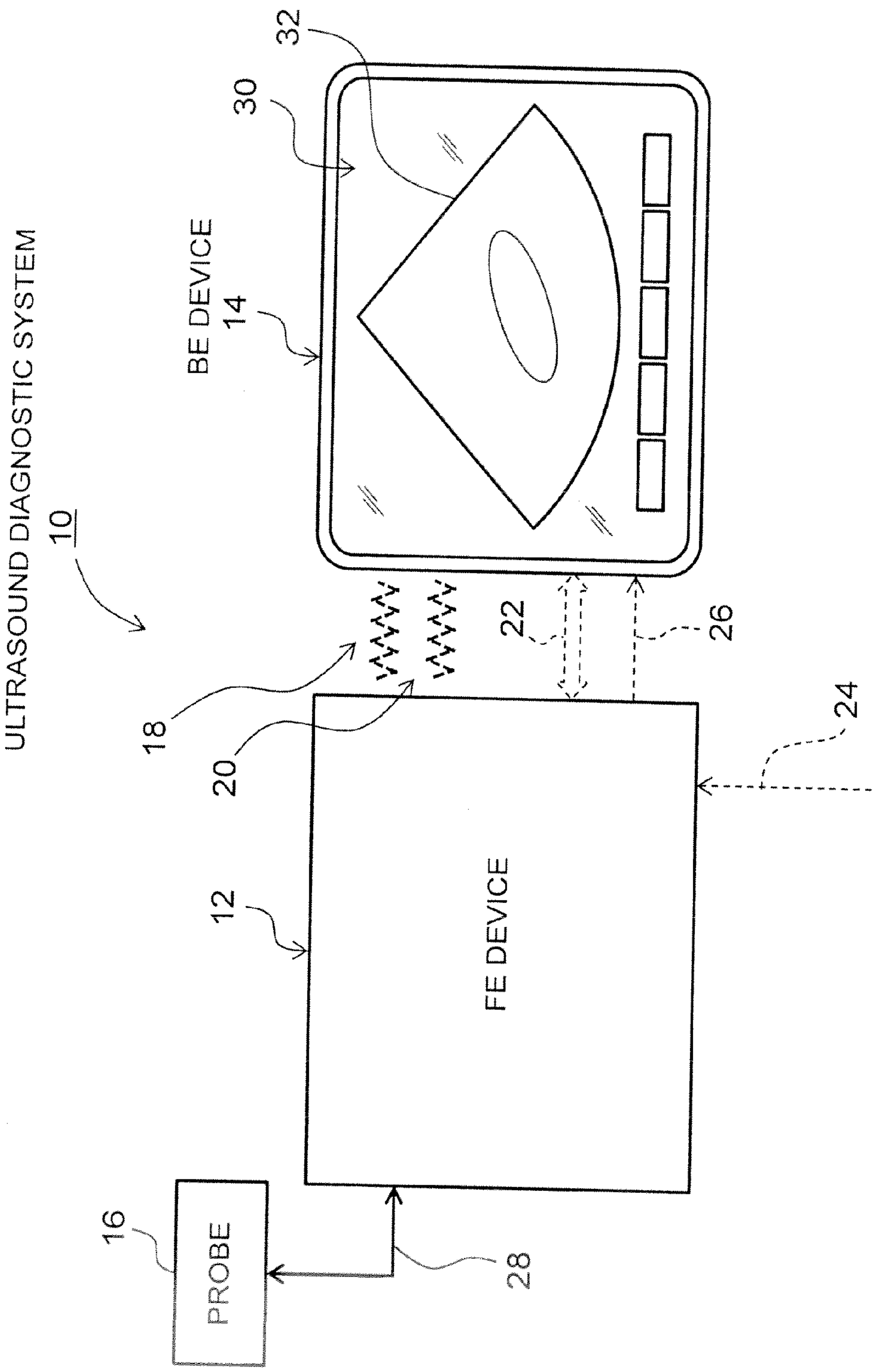

ULTRASOUND DIAGNOSTIC SYSTEM
10
BE DEVICE
14
30
32
18
20
22
26
24
FE DEVICE
12
PROBE
16
28

FIG. 1

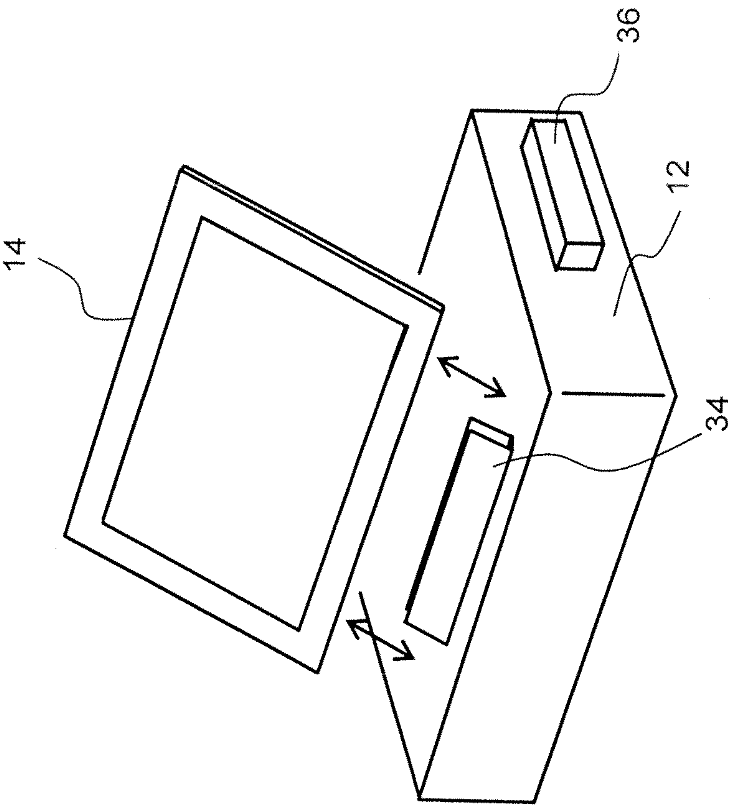


FIG. 2

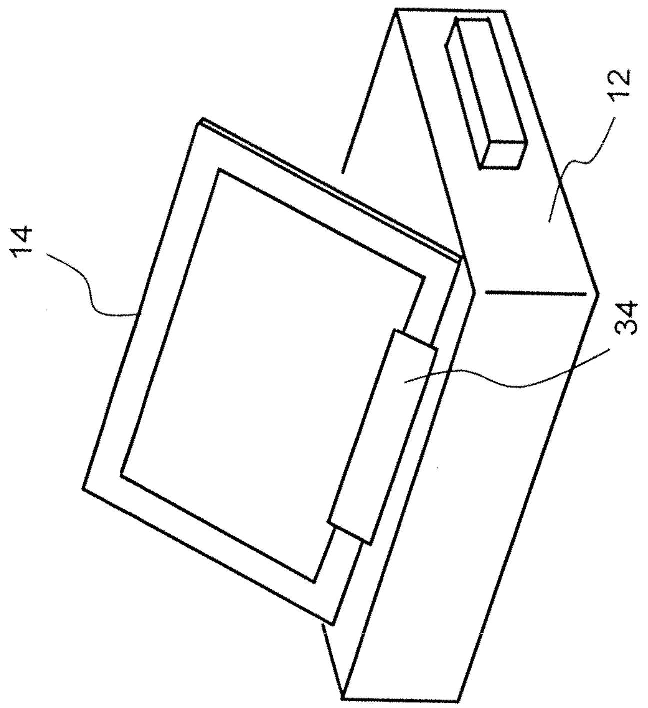


FIG. 3

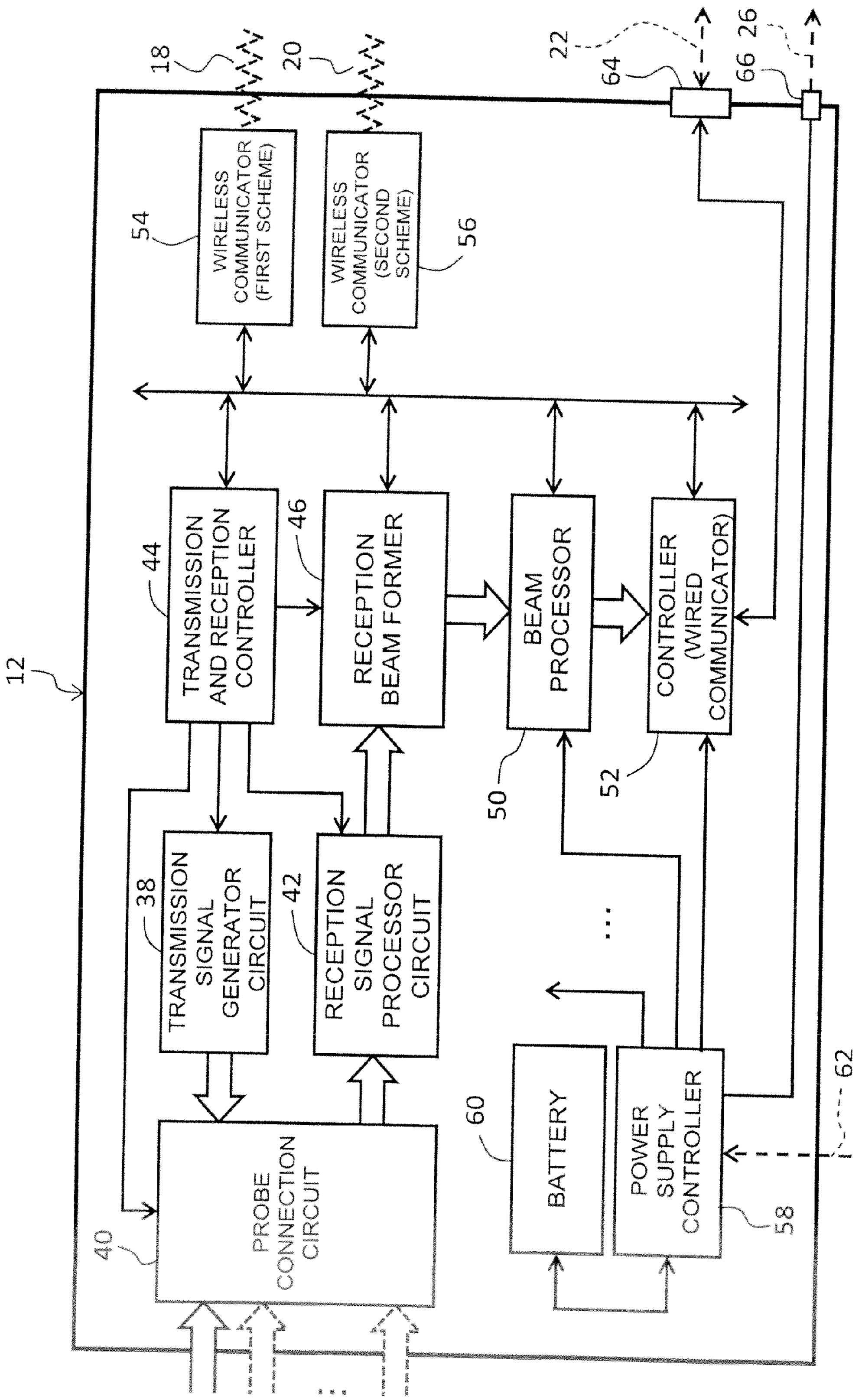

12
18
20
22
26
64
66
54
WIRELESS COMMUNICATOR (FIRST SCHEME)
WIRELESS COMMUNICATOR (SECOND SCHEME)
56
44
TRANSMISSION AND RECEPTION CONTROLLER
46
RECEPTION BEAM FORMER
BEAM PROCESSOR
50
CONTROLLER (WIRED COMMUNICATOR)
52
38
TRANSMISSION SIGNAL GENERATOR CIRCUIT
42
RECEPTION SIGNAL PROCESSOR CIRCUIT
PROBE CONNECTION CIRCUIT
40
60
BATTERY
POWER SUPPLY CONTROLLER
58
62

FIG. 4

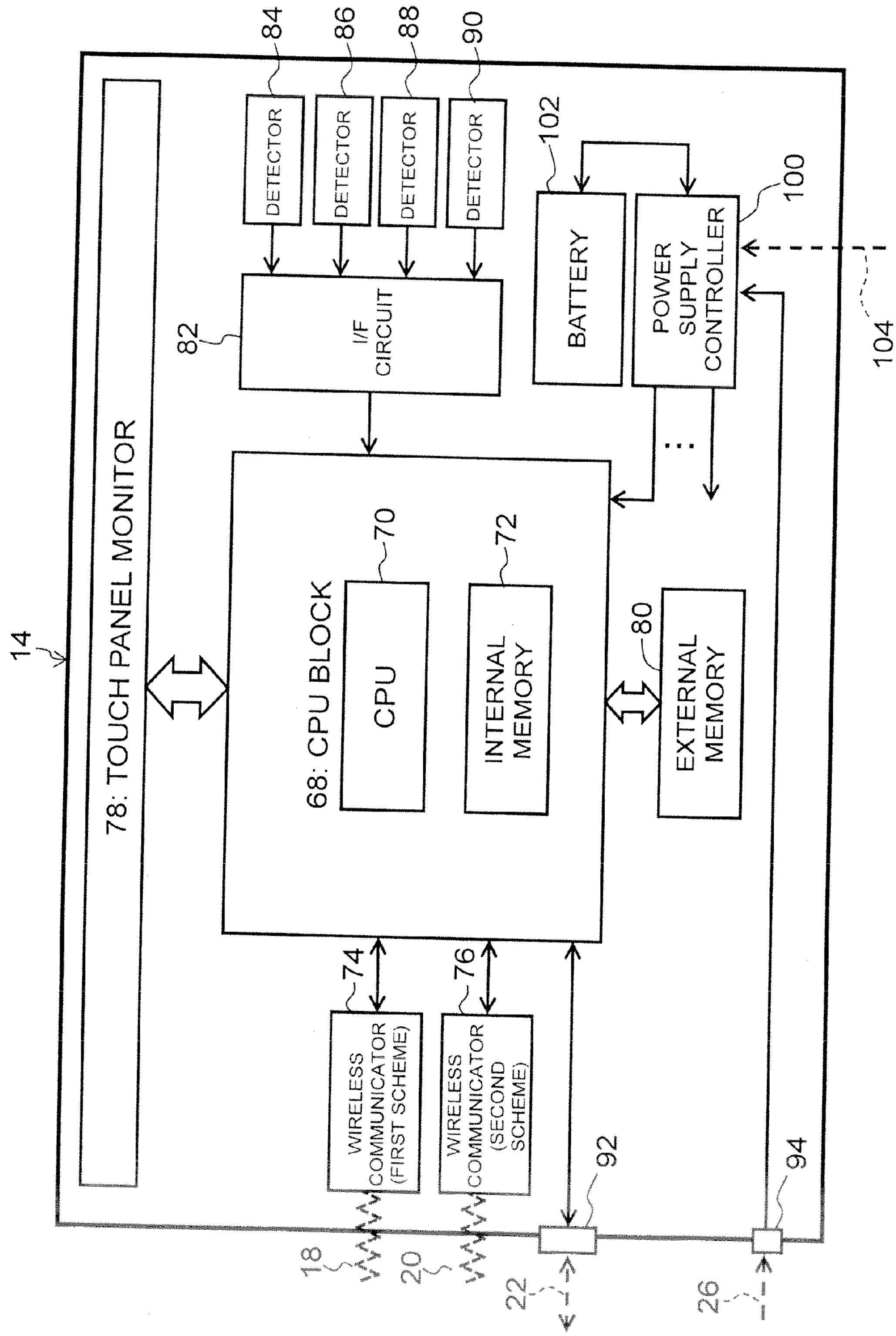

14
78: TOUCH PANEL MONITOR
84
86
88
90
DETECTOR
DETECTOR
DETECTOR
DETECTOR
82
I/F CIRCUIT
102
BATTERY
100
POWER SUPPLY CONTROLLER
104
68: CPU BLOCK
70
CPU
72
INTERNAL MEMORY
80
EXTERNAL MEMORY
74
WIRELESS COMMUNICATOR (FIRST SCHEME)
76
WIRELESS COMMUNICATOR (SECOND SCHEME)
92
94
18
20
22
26

FIG. 5

		116 CONTENT	118 DOCKED STATE	120 SEPARATED STATE
110	FIRST WIRELESS COMMUNICATION SCHEME	HIGH SPEED (IEEE 802.11)	SUSPENDED	USED
112	SECOND WIRELESS COMMUNICATION SCHEME	LOW SPEED/LOW POWER CONSUMPTION (IEEE 802.15.1)	SUSPENDED	USED
114	WIRED COMMUNICATION SCHEME	–	USED	SUSPENDED

FIG. 6

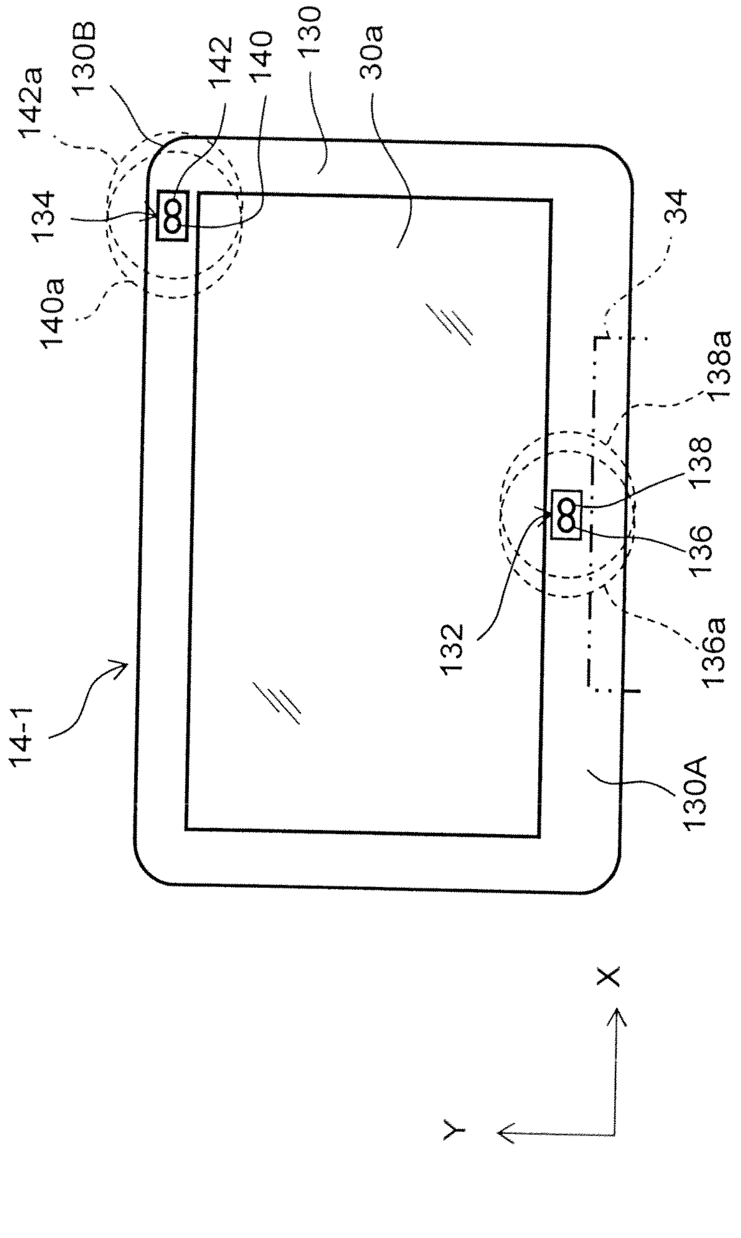

14-1
130B
142a
142
140
130
30a
134
140a
34
138a
138
136
132
136a
130A
X
Y

FIG. 7

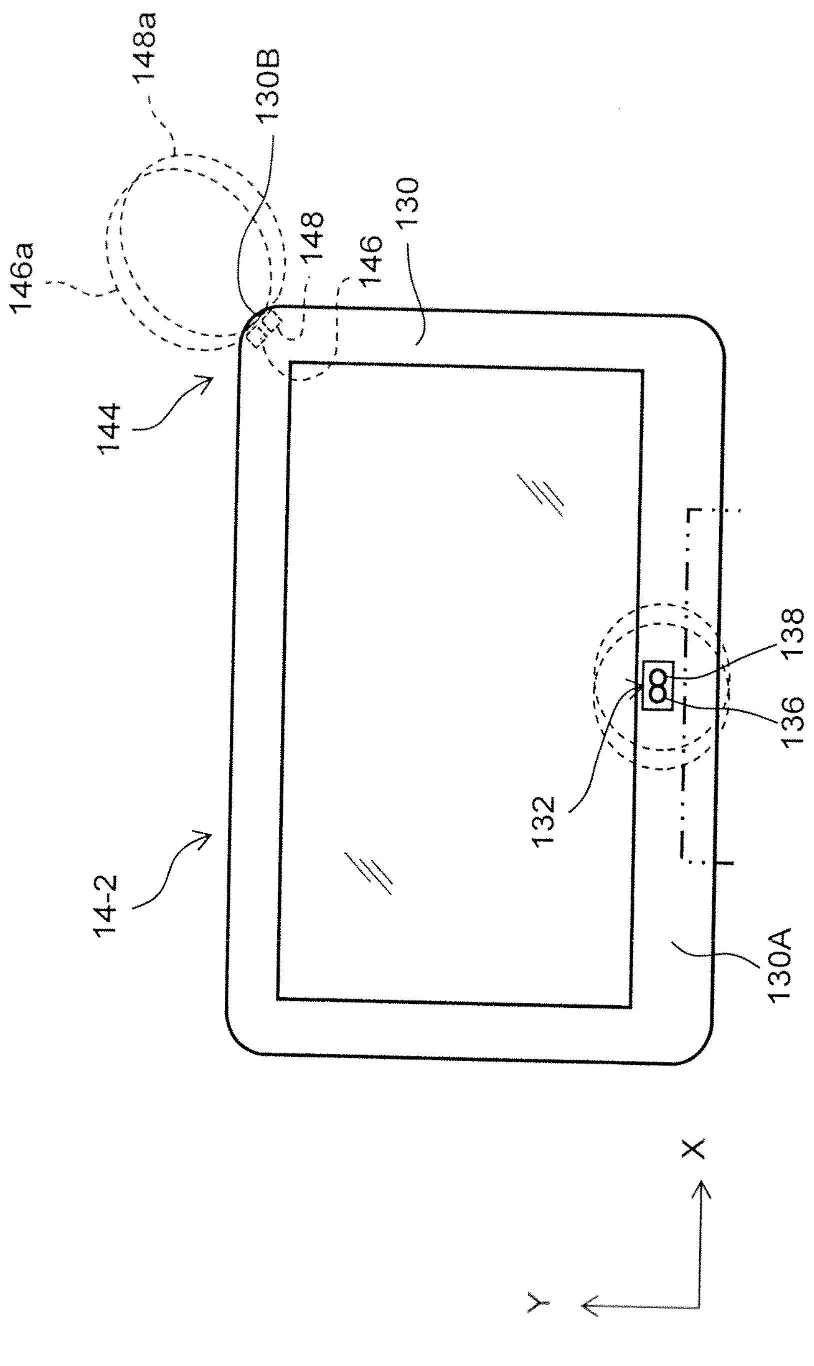


FIG. 8

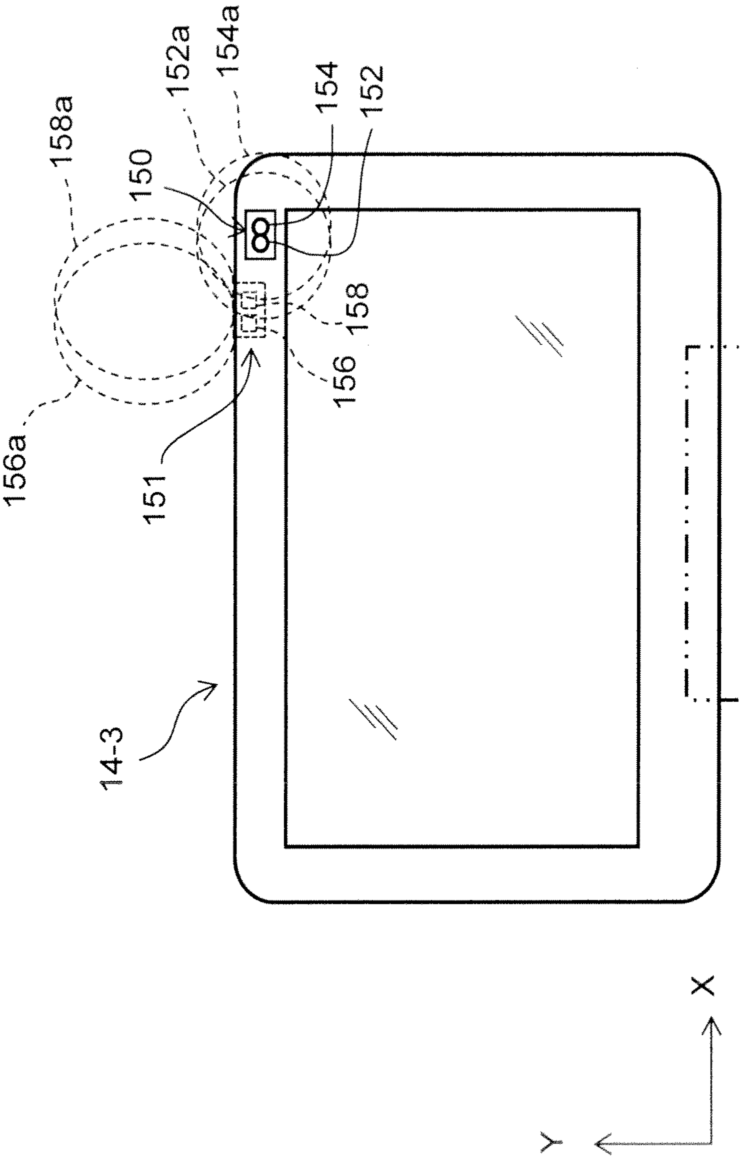


FIG. 9

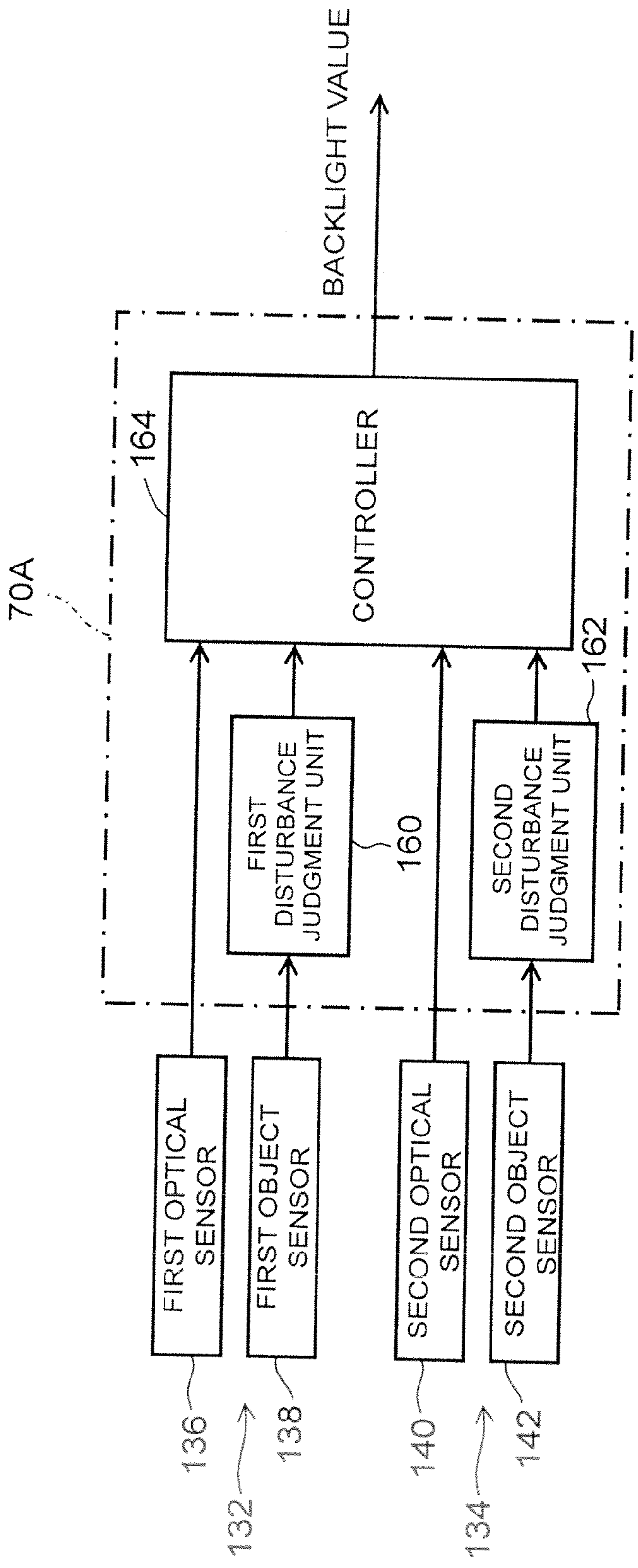

BACKLIGHT VALUE
70A
164
CONTROLLER
FIRST DISTURBANCE JUDGMENT UNIT
160
SECOND DISTURBANCE JUDGMENT UNIT
162
FIRST OPTICAL SENSOR
FIRST OBJECT SENSOR
SECOND OPTICAL SENSOR
SECOND OBJECT SENSOR
136
132
138
140
134
142

FIG. 10

	170	172	174	176
	FIRST DISTURBANCE JUDGMENT UNIT	SECOND DISTURBANCE JUDGMENT UNIT	REFERRED SIGNAL	CONTROL METHOD
178A	NO DISTURBANCE	NO DISTURBANCE	FIRST LIGHT DETECTION SIGNAL AND SECOND LIGHT DETECTION SIGNAL	ADAPTIVELY VARY BACKLIGHT VALUE ACCORDING TO AVERAGE
178B	NO DISTURBANCE	EXISTING DISTURBANCE	FIRST LIGHT DETECTION SIGNAL	ADAPTIVELY VARY BACKLIGHT VALUE ACCORDING TO FIRST LIGHT DETECTION VALUE
178C	EXISTING DISTURBANCE	NO DISTURBANCE	SECOND LIGHT DETECTION SIGNAL	ADAPTIVELY VARY BACKLIGHT VALUE ACCORDING TO SECOND LIGHT DETECTION VALUE
178D	EXISTING DISTURBANCE	EXISTING DISTURBANCE	(NONE)	MAINTAIN PAST BACKLIGHT VALUE

FIG. 11

	170	172	174	176
	FIRST DISTURBANCE JUDGMENT UNIT	SECOND DISTURBANCE JUDGMENT UNIT	REFERRED SIGNAL	CONTROL METHOD
178A	NO DISTURBANCE	NO DISTURBANCE	FIRST LIGHT DETECTION SIGNAL AND SECOND LIGHT DETECTION SIGNAL	ADAPTIVELY VARY BACKLIGHT VALUE ACCORDING TO AVERAGE
178E	NO DISTURBANCE	EXISTING DISTURBANCE	FIRST LIGHT DETECTION SIGNAL	ADAPTIVELY VARY BACKLIGHT VALUE ACCORDING TO FIRST LIGHT DETECTION VALUE AND SECOND LIGHT DETECTION VALUE IN PAST
178F	EXISTING DISTURBANCE	NO DISTURBANCE	SECOND LIGHT DETECTION SIGNAL	ADAPTIVELY VARY BACKLIGHT VALUE ACCORDING TO FIRST LIGHT DETECTION VALUE IN PAST AND SECOND LIGHT DETECTION VALUE
178D	EXISTING DISTURBANCE	EXISTING DISTURBANCE	(NONE)	MAINTAIN PAST BACKLIGHT VALUE

FIG. 12

ULTRASONIC DIAGNOSIS SYSTEM

TECHNICAL FIELD

[0001] The present disclosure relates to an ultrasound diagnostic system, and in particular, to a technique to automatically adjust a display luminance level or the like according to an ambient light level.

BACKGROUND

[0002] A typical ultrasound diagnostic system includes a body (cart) having a plurality of casters. An operation panel and a display are supported on the body. The operation panel has a plurality of buttons. Each button has a light emitter built therein. An ultrasound image is displayed on the display. The display is formed, for example, with a liquid crystal display (LCD). A brightness of a backlight may be varied. In addition to a cart-type ultrasound diagnostic system, ultrasound diagnostic systems formed from a plurality of devices which are independent from each other are also commercialized. In such systems, some or all of the plurality of devices are formed as a transportable device.

[0003] For example, Patent Literature 1 discloses an ultrasound diagnostic system having a first housing and a second housing. Patent Literature 2 discloses an ultrasound diagnostic system having a front-end device and a back-end device. In an ultrasound diagnostic system disclosed in Patent Literature 3, a device body and an ultrasound probe are connected wirelessly.

[0004] Normally, during ultrasound inspection, in order to observe the ultrasound image in detail, light of an inspection room is switched OFF, or the inspection room is set to a darkened state. On the other hand, in some cases, the ultrasound diagnostic system may be used in a bright general examination room, in a hospital room having a window, outdoors, or the like. Thus, it is desired to adaptively vary the brightness of the display and the brightness of each button according to an ambient light level.

[0005] Patent Literature 4 discloses an ultrasound diagnostic apparatus which can reduce or stop light emission of an operation key according to the brightness of the environment. Patent Literature 5 discloses an ultrasound diagnostic apparatus having a function to automatically adjust an ultrasound image formation condition (opacity, gain, or the like) according to a detected value of an optical sensor. Patent Literature 6 discloses an ultrasound diagnostic apparatus having a function to automatically adjust a display condition according to the ambient light level.

CITATION LIST

Patent Literature

[0006] Patent Literature 1: JP 2011-5241 A
[0007] Patent Literature 2: JP 2008-114065 A
[0008] Patent Literature 3: JP 2011-87841 A
[0009] Patent Literature 4: JP 2006-305303 A
[0010] Patent Literature 5: JP 2006-20777 A
[0011] Patent Literature 6: JP 2008-272473 A

SUMMARY

Technical Problem

[0012] In an ultrasound diagnostic system, when a display luminance level or the like is to be adaptively set according to the ambient light level, an optical detector that detects the ambient light level is placed at some position on the ultrasound diagnostic system. When the optical detector is covered by a hand, a head, or the like of the inspector, the ambient light level cannot be accurately detected. In this case, the control of the display luminance level or the like becomes inappropriate.

[0013] For example, a configuration may be considered in which a tablet terminal, in which a display and an inputter are integrated, is used as a whole or a part of an ultrasound diagnostic system, and an optical detector is provided on the tablet terminal. In this case, when the user extends a hand to an upper part of the display surface for operation, the optical detector may be covered with the hand. When the input is to be done by a gesture or a hand motion, the hand is moved in a space in front of the display surface. In this case also, the optical detector may be covered by the hand. When a tablet terminal is used, a frame portion thereof is held with the hand. In this case, the optical detector may be hidden by the hand. In addition to these cases, when the inspector moves close to the tablet terminal and attempts to look into the tablet terminal, a shadow of the head may be cast on the optical detector. It is desired that the display luminance level or the like is not unnecessarily changed due to influences of these disturbances.

[0014] An advantage of the present disclosure lies in that, in an ultrasound diagnostic system, influence of disturbances are reduced when a display condition such as a display luminance level is adaptively set according to the ambient light level. An alternative advantage of the present disclosure lies in that, in an ultrasound diagnostic system, when a tablet terminal is used, visibility of the tablet terminal is improved without reducing operability of the tablet terminal.

Solution to Problem

[0015] According to one aspect of the present disclosure, there is provided an ultrasound diagnostic system comprising: a display that displays an ultrasound image which is formed based on a reception signal obtained by transmission and reception of ultrasound; a first optical detector that detects an ambient light; a first object detector that has an object detection field-of-view which is in a relationship of entirely or partially overlapping a light detection field-of-view of the first optical detector; and a control unit that adaptively sets a luminance level of the display based on a first light detection value of the first optical detector when no object is detected by the first object detector.

[0016] In the above-described configuration, the first object detector is provided with the first optical detector. The light detection field-of-view of the first optical detector and the object detection field-of-view of the first object detector entirely or partially overlap each other. Here, each field of view refers to a three-dimensional directive range (detection region). Therefore, for example, it becomes possible to detect a state where the first optical detector is covered by the hand of the operator (occurrence of disturbance) using the first object detector. By increasing a degree of match (degree of overlap) between the light detection field-of-view and the object detection field-of-view, a detection probability of occurrence of disturbance can be increased (at the same time, probability of erroneous detection or no detection can be reduced). When an object is detected by the first object detector, the control unit discards the first light detection value, and thus, in this case, the first light detection value is not referred to in the luminance level control. When the first object detector does not detect an object, it is highly likely that the first light detection value is a correct value which is not affected by a disturbance, the adaptive setting of the luminance level based on the first light detection value is executed. Alternatively, in place of or in addition to the luminance level control, an amount of light emission of the button or the like may be adaptively varied. Alternatively, in place of judging presence or absence of an object based on the detection value of the first object detector, an existence probability (degree) of an object may be judged and control may be executed based thereon.

[0017] According to another aspect of the present disclosure, the first optical detector and the first object detector form a first detector pair, a second detector pair is provided including a second optical detector that detects the ambient light, and a second object detector that has an object detection field-of-view which is in a relationship of entirely or partially overlapping a light detection field-of-view of the second optical detector, and the control unit adaptively sets the luminance level based on the first light detection value of the first optical detector when no object is detected by the first object detector, and a second light detection value of the second optical detector when no object is detected by the second object detector. By providing a plurality of detector pairs, it becomes possible to increase the probability that a light detection value which is not affected by the disturbance can be acquired when disturbance occurs partially or locally. Further, by referring to the plurality of light detection values even when there is no disturbance, it is possible to more accurately recognize the ambient light level. This is because the ambient light level which is detected varies depending on an orientation and a position of each sensor. For example, the luminance level may be determined based on an average value of a plurality of light detection values. For the adaptive variation of the luminance level, it is desirable to enable adjustment of the responsiveness.

[0018] According to another aspect of the present disclosure, the control unit discards the first light detection value when an object is detected by the first object detector, and discards the second light detection value when an object is detected by the second object detector. With such a configuration, it becomes possible to determine the luminance level based on light detection values which are not affected by the disturbance. For example, when it is judged that both of two light detection values are affected by the disturbance, both light detection values are discarded. In this case, the luminance level may be determined based on one or a plurality of detection values in the past, or the luminance level at that point may be maintained.

[0019] According to another aspect of the present disclosure, the first detector pair and the second detector pair are placed with orientations that are different from each other. With such a configuration, a plurality of light detection values can be obtained under a plurality of light detection conditions that are different from each other, and thus, it is possible to identify a more general ambient light level without depending too much on the directivity and placement position of the detectors.

[0020] According to another aspect of the present disclosure, the ultrasound diagnostic system comprises a front-end device having a transmission and reception circuit, and a back-end device serving as a tablet terminal having the display, the back-end device has a frame member provided around a display screen of the display, and the first detector pair and the second detector pair are provided on the frame member. According to another aspect of the present disclosure, the first detector pair is provided at or near a top right corner portion of the frame member, and facing a front side, and the second detector pair is provided at or near the top right corner portion of the frame member, facing a direction other than the front side. In the ultrasound diagnosis, the portion of the top right corner or a nearby region of the frame member is a portion where the probability of being held by the hand is relatively low. Therefore, by providing the two detector pairs there, it is possible to reduce the probability of the detector pairs being hidden by the hand. At the same time, the probability of a shadow of the hand, head, or the like being cast on the detector pairs can be reduced.

[0021] According to another aspect of the present disclosure, the first object detector is a motion detector that detects motion of a hand of an inspector, and the control unit discards the first light detection value of the first optical detector when the motion of the hand is detected by the first object detector. When a gesture input is executed to operate the screen by motion of the hand without contact in a space in front of the display screen, the probability of the shadow of the hand being cast on each optical detector becomes high. Therefore, it is desirable that the light detection value is not referred to during the gesture input, and the light detection value is referred to in a non-gesture input state in which no such input is present.

[0022] According to another aspect of the present disclosure, there is provided a back-end device serving as a tablet terminal forming a part of an ultrasound diagnostic system, the back-end device comprising: a first optical detector that detects an ambient light; a first object detector that has an object detection field-of-view which is in a relationship of entirely or partially overlapping a light detection field-of-view of the first optical detector; a second optical detector that detects the ambient light; a second object detector that has an object detection field-of view which is in a relationship of entirely or partially overlapping a light detection field-of-view of the second optical detector; and a control unit that adaptively sets a display condition of a display based on a first light detection value of the first optical detector when no object is detected by the first object detector, and a second light detection value of the second optical detector when no object is detected by the second object detector.

[0023] In the above-described configuration, the back-end device acts together with or cooperates with a front-end device, to execute ultrasound diagnosis. The above-described control is desirably executed when the back-end device is in a separated state, and also when the back-end device is in a docked state. Alternatively, a judgment condition or the like may be set differently between the separated state and the docked state.

Advantageous Effects of Invention

[0024] According to various aspects of the present disclosure, in an ultrasound diagnostic system, when a display condition such as a display luminance level is adaptively varied according to the ambient light level, the influence by the disturbance can be reduced. Alternatively, in an ultrasound diagnostic system, when a tablet terminal is used, visibility of the tablet terminal can be improved without reducing operability of the tablet terminal.

BRIEF DESCRIPTION OF DRAWINGS

[0025] FIG. **1** is a conceptual diagram showing an ultrasound diagnostic system according to an embodiment of the present disclosure.

[0026] FIG. **2** is a perspective diagram of an ultrasound diagnostic system in a separated state.

[0027] FIG. **3** is a perspective diagram of an ultrasound diagnostic system in a docked state.

[0028] FIG. **4** is a block diagram of a front-end device.

[0029] FIG. **5** is a block diagram of a back-end device.

[0030] FIG. **6** is a diagram showing a communication scheme in a docked state and a communication scheme in a separated state.

[0031] FIG. **7** is a diagram showing a first example placement of two sensor pairs.

[0032] FIG. **8** is a diagram showing a second example placement of two sensor pairs.

[0033] FIG. **9** is a diagram showing a third example placement of two sensor pairs.

[0034] FIG. **10** is a diagram showing an example structure for adaptive control of a backlight value.

[0035] FIG. **11** is a diagram showing a first example control by the controller shown in FIG. **10**.

[0036] FIG. **12** is a diagram showing a second example control by the controller shown in FIG. **10**.

DESCRIPTION OF EMBODIMENTS

[0037] An embodiment of the present disclosure will now be described with reference to the drawings.

(1) Ultrasound Diagnostic System

[0038] FIG. **1** schematically shows a structure of an ultrasound diagnostic system according to an embodiment of the present disclosure. An ultrasound diagnostic system **10** is a medical device used in a medical institution such as hospitals, and executes ultrasound diagnosis on a subject (living body). The ultrasound diagnostic system **10** is roughly formed from a front-end (FE) device **12**, a back-end (BE) device **14**, and a probe **16**. The FE device **12** is a device closer to the living body, and the BE device **14** is a device which is farther away from the living body. The FE device **12** and the BE device **14** are provided as separate structures, and each forms a transportable device. The FE device **12** and the BE device **14** can be operated in a separated state in which the devices are detached from each other, and can also be operated in a docked state where the devices are put together. FIG. **1** shows the separated state.

[0039] The probe **16** is a transmitting and receiving device which transmits and receives ultrasound in a state where the probe **16** contacts a surface of the living body. The probe **16** comprises a 1-D array transducer having a plurality of transducer elements arranged in a liner shape or an arc shape. An ultrasound beam is formed by the array transducer, and is repeatedly electrically scanned. For each electric scan, a beam scan plane is formed in the living body. As the electric scanning scheme, an electric linear scan scheme, an electric sector scan scheme, and the like are known. Alternatively, a 2-D array transducer which can form a three-dimensional echo data capturing space may be provided in place of the 1-D array transducer. In the example configuration of FIG. **1**, the probe **16** is connected to the FE device **12** via a cable **28**. The probe **16** may alternatively be connected to the FE device **12** by wireless communication. In this case, a wireless probe is used. Alternatively, in a state where a plurality of probes are connected to the FE device **12**, a probe **16** to be actually used may be selected from among the connected probes. Alternatively, a probe **16** which is to be inserted into a body cavity may be connected to the FE device **12**.

[0040] In the separated state shown in FIG. **1**, the FE device **12** and the BE device **14** are electrically connected to each other by a wireless communication scheme. In the present embodiment, the devices are connected to each other by a first wireless communication scheme and a second wireless communication scheme. In FIG. **1**, a wireless communication path **18** using the first wireless communication scheme and a wireless communication path **20** using the second wireless communication scheme are explicitly shown. The first wireless communication scheme is faster compared to the second wireless communication scheme, and in the present embodiment, ultrasound reception data is transferred from the FE device **12** to the BE device **14** using the first wireless communication scheme. That is, the first wireless communication scheme is used for data transfer. The second wireless communication scheme is a communication scheme which is slower and simpler than the first wireless transfer scheme, and in the present embodiment, control signals are transferred from the BE device **14** to the FE device **12** using the second wireless communication scheme. In other words, the second wireless communication scheme is used for control.

[0041] In the docked state in which the FE device **12** and the BE device **12** are physically combined, the FE device **12** and the BE device **14** are electrically connected to each other by a wired communication scheme. Compared to the above-described two wireless communication schemes, the wired communication scheme is significantly faster. In FIG. **1**, a wired communication path **22** between the two devices is shown. A power supply path **26** is for supplying direct current electric power from the FE device **12** to the BE device **14** in the docked state. The electric power is used for the operations of the BE device **14**, and is also used for charging a battery in the BE device **14**.

[0042] Reference numeral **24** represents a DC power supply line supplied from an AC adaptor (AC/DC converter). The AC adapter is connected to the FE device **12** as necessary. The FE device **12** also has a battery built therein, and can operate using the battery as a power supply. The FE device **12** has a box-like form, as will be described later. Structure and operation of the FE device **12** will be described later in detail.

[0043] Meanwhile, in the present embodiment, the BE device **14** has a tablet form or a flat plate form. The BE device **14** thus has a basic structure similar to a typical tablet computer. The BE device **14** is equipped with various dedicated software for ultrasound diagnosis, including an operation control program, an image processing program, or the like. The BE device **14** has a display panel **30** with a touch sensor. The display panel **30** functions as a user interface having functions of both an inputter and a display. In FIG. **1**, a B-mode tomographic image is displayed on the display panel **30** as an ultrasound image. The user executes various inputs using a group of icons displayed on the display panel **30**. It is also possible to execute a slide operation, an enlarging operation, or the like on the display panel **30**.

[0044] Depending on the diagnosis usage and preferences of the inspector, or the like, the ultrasound diagnosis system **10** can be operated in a usage form selected from the separated state and the docked state. Thus, an ultrasound diagnostic system can be provided having a superior usability.

[0045] In order to prevent the operations of the ultrasound diagnostic system **10** becoming unstable or inappropriate during a state change, in the present embodiment, during the state change, control is executed to forcefully put the ultrasound diagnostic system **10** into a freeze state. Specifically, in the process of transferring from the separated state to the docked state, the FE device **12** and the BE device **14** each judge a time immediately before the docking, based on a radio wave intensity or reception state indicating a distance between the FE device **12** and the BE device **14**, and control is executed in each of the devices **12** and **14** to transfer the operation state to the freeze state according to the judgment. After the docked state is established and an operation to release freeze by the inspector, the freeze states of the devices **12** and **14** are released. In the process of transfer from the docked state to the separated state, the FE device **12** and the BE device **14** individually detect that the devices are set in the separated state by line detection or other methods, and the devices are set in the freeze state. Then, after an operation to release the freeze, the freeze states of the devices **12** and **14** are released.

[0046] The BE device **14** may be separately connected to an in-hospital LAN via a wireless communication scheme or a wired communication scheme. The communication paths for these communications are not shown in FIG. **1**. Alternatively, the BE device **14** (or the FE device **12**) may be separately connected to other dedicated devices (for example, a remote controller) which functions for the ultrasound diagnosis, by a wireless communication scheme or a wired communication scheme.

[0047] FIG. **2** shows a separated state. The FE device **12** is placed, for example, on a desk. The FE device **12** has a holder **34** having an insertion port (slot). The holder **34** has a hinge mechanism, and can rotate about a horizontal axis. A connector provided on an end of a probe cable is attached on a given side surface of the FE device **12**. Alternatively, a compartment for housing the probe or the like may be formed inside the FE device **12**. Such a configuration is convenient when the ultrasound diagnostic system is transported, and can protect the probe. In FIG. **2**, the BE device **14** is separated from the FE device **12**, and the BE device **14** can be moved farther away from the FE device **12**, so long as the wireless communication is possible.

[0048] FIG. **3** shows a docked state. A lower end of the BE device **14** is inserted into the insertion port of the holder **34**. In this inserted state, the FE device **12** and the BE device **14** are in a wired connection state. In other words, the devices are connected by a wired LAN, and are connected by a wired power supply line. In the docked state, an angle of the BE device **14** can be arbitrarily varied, to change the orientation thereof. BE device **14** may be tilted completely to the back surface side thereof (upper surface side of the FE device **12**).

(2) Front-End Device

[0049] FIG. **4** is a block diagram of the FE device **12**. Each block in FIG. **4** is formed with hardware such as a processor, an electronic circuit, or the like. A transmission signal generator circuit **38** is a circuit which supplies a plurality of transmission signals in parallel to each other to the plurality of transducer elements in the probe via a probe connection circuit **40**. With the supply of the signals, a transmission beam is formed at the probe. When a reflection wave from within the living body is received by the plurality of transducer elements, a plurality of reception signals are output from the transducer elements, and are input to a reception signal processor circuit **42** via the probe connection circuit **40**. The reception signal processor circuit **42** includes a plurality of pre-amplifiers, a plurality of amplifiers, and a plurality of A/D converters, and the like. A plurality of digital reception signals which are output from the reception signal processor circuit **42** are sent to a reception beam former **46**. The reception beam former **46** applies phasing addition on the plurality of digital reception signals, and outputs beam data as a signal after the phasing addition. The beam data comprises a plurality of echo data corresponding to the reception beams and arranged in a depth direction. Reception frame data is formed by a plurality of beam data obtained by one electric scan.

[0050] A transmission and reception controller **44** controls the transmission signal generation and the reception signal process based on transmission and reception control data sent from the BE device. A beam processor **50** is a circuit which applies various data processes such as wave detection, logarithmic conversion, correlation, or the like on individual beam data which are input in a time sequential order. A control unit **52** controls an overall operation of the FE device **12**. In addition, the control unit **52** executes control for wired transfer or wireless transfer, to the BE device, of beam data which are sequentially sent from the beam processor **50**. In the present embodiment, the control unit **52** also functions as a wired communicator. A wireless communicator **54** is a module for executing communication in the first wireless communication scheme. A wireless communicator **56** is a module for executing communication in the second wireless communication scheme. Reference numeral **18** shows the wireless communication path according to the first wireless communication scheme, and reference numeral **20** shows the wireless communication path according to the second wireless communication scheme. The paths are bidirectional transfer paths, but in the present embodiment, a large amount of reception data is transferred from the FE device **12** to the BE device using the former, and control signals are transferred from the BE device to the FE device **12** using the latter. Reference numeral **64** shows a wired communication terminal, and the wired communication path **22** is connected thereto. Reference numeral **66** shows a power supply terminal, and the power supply line **26** is connected thereto. As described above, the power supply line **26** is a line for supplying the direct current electric power from the FE device **12** to the BE device.

[0051] A battery **60** is, for example, a lithium ion type battery, and charging and discharging therein are controlled by a power supply controller **58**. At the time of battery drive, the electric power from the battery **60** is supplied via the power supply controller **58** to the circuits in the FE device **12**. Reference numeral **62** shows a power supply line at the time when the AC adaptor is connected. At the time when the AC adaptor is connected, external electric power is supplied to the circuits in the FE device **12** by an action of the power supply controller **58**. In this process, if the charge of the battery **60** is less than 100%, the battery **60** is charged using the external electric power.

[0052] During an ultrasound diagnosis operation (during transmission and reception), the FE device **12** repeatedly executes supply of a plurality of transmission signals to the probe and processing of a plurality of reception signals obtained thereafter, according to the control from the side of the BE device. The time sequential beam data obtained as a result of this process is consecutively transferred to the BE device by the wireless communication in the separated state and by the wired communication in the docked state. In this process, individual beam data is converted into a plurality of packets, and individual beam data is transferred by a so-called packet transfer scheme.

[0053] As the operation mode, in addition to the B mode, there are known various modes such as a CFM mode, an M mode, and a D mode (a PW mode and a CW mode). Alternatively, transmission and reception processes for harmonic imaging and elasticity information imaging may be executed. In FIG. **1**, circuits such as a living body signal input circuit are not shown.

(3) Back-End Device

[0054] FIG. **5** is a block diagram of the BE device **14**. In FIG. **5**, each block shows hardware such as a processor circuit, a memory, or the like. A CPU block **68** comprises a CPU **70**, an internal memory **72**, or the like. The internal memory **72** functions as a working memory or a cache memory. An external memory **80** connected to the CPU block **68** stores an OS, various control programs, various processing programs, or the like. The latter includes a scan convert process program. The external memory **80** also functions as a cine-memory having a ring buffer structure. The cine-memory may alternatively be formed in the internal memory **72**.

[0055] The CPU block **68** generates display frame data by a scan convert process based on a plurality of beam data. The display frame data forms an ultrasound image (for example, a tomographic image). The process is consecutively executed, to generate a video image. The CPU block **68** applies various processes on the beam data or the image for ultrasound image display. In addition, the CPU block **68** controls the operation of the BE device **14**, and controls the ultrasound diagnostic system as a whole.

[0056] A touch panel monitor (display panel) **78** functions as an input device and a display device. Specifically, the touch panel monitor **78** includes a liquid crystal display and a touch sensor, and functions as a user interface. On the touch panel monitor **78**, a display image including the ultrasound image is displayed, and various buttons (icons) for operation are displayed.

[0057] A wireless communicator **74** is a module for the wireless communication according to the first wireless communication scheme. A wireless communication path for this wireless communication is shown with reference numeral **18**. A wireless communicator **76** is a module for the wireless communication according to the second wireless communication scheme. A wireless communication path for this wireless communication is shown with reference numeral **20**. The CPU block **68** also has a function to execute a wired communication according to a wired communication scheme. In the docked state, a wired communication line is connected to a wired communication terminal **92**. In addition, the power supply line **26** is connected to a power supply terminal **94**.

[0058] A plurality of detectors **84~90** are connected to the CPU block **68** via an I/F circuit **82**. The detectors include an illumination sensor (optical detector), a proximity sensor (object detector), a temperature sensor, or the like. Alternatively, a module such as a GPS may be connected. The I/F circuit **82** functions as a sensor controller.

[0059] A battery **102** is a lithium-ceramic type battery, and charging and discharging thereof are controlled by a power supply controller **100**. The power supply controller **100** supplies the electric power from the battery **102** to the circuits in the BE device **14** during a battery operation. During non-operation of the battery, the electric power supplied from the FE device or the electric power supplied from the AC adaptor is supplied to the circuits in the BE device **14**. Reference numeral **104** shows a power supply line via the AC adaptor.

[0060] The BE device **14** controls the FE device, sequentially processes beam data sent from the FE device to generate an ultrasound image, and displays the ultrasound image on the touch panel monitor **78**. In this process, an operation graphic image is also displayed with the ultrasound image. In a normal real-time operation, the BE device **14** and the FE device are electrically connected to each other wirelessly or with a wire, and, while the devices are synchronized, the ultrasound diagnosis operation is continuously executed. In the freeze state, in the BE device **14**, operations of the transmission signal generator circuit and the reception signal generator circuit are stopped, and operation of a voltage boosting circuit in the power supply controller **100** is also stopped. In the BE device, a static image display is set at the time of freeze, and the content is maintained. Alternatively, the BE device may be configured such that an external display may be connected to the BE device.

(4) Communication Schemes

[0061] FIG. **6** collectively shows communication schemes used in a docked state **118** and a separated state **120**. Reference numeral **110** shows the first wireless communication scheme, and reference numeral **112** shows the second wireless communication scheme. Reference numeral **114** shows the wired communication scheme. Reference numeral **116** shows contents of the wireless communication scheme. In the docked state **118**, the wired communication is selected, and the first wireless communicator and the second wireless communicator are set in an operation suspended state in the FE device and the BE device. With such a configuration, electric power can be saved. On the other hand, in the separated state **120**, the wireless communication is selected, and the first wireless communicator and the second wireless communicator operate in the FE device and the BE device. In this process, the wireless communication system is set in an operation suspended state. The first wireless communication scheme **110** is faster than the second wireless communication scheme **112**. In other words, the second wireless communication scheme **112** is slower than the first wireless communication scheme **110**, but is simpler and less expensive, and consumes less power. As the wired communication scheme, a TCP/IP protocol over Ethernet (Registered Trademark) may be exemplified. As the first wireless communication scheme, IEEE 802.11 may be exemplified, and, as the second wireless communication scheme, IEEE 802.15.1 may be exemplified. These are merely exemplary, and other communication schemes may be used. In any event, a secure communication scheme is desirably used.

[0062] In the present embodiment, the wireless communicator according to the second wireless communication scheme **112** has a function to automatically vary a transmission power according to a reception intensity (that is, distance). In other words, when the BE device comes near the FE device, control to reduce the transmission power is automatically executed in both devices. Therefore, it is possible to judge that the devices have moved close to each other based on the set transmission power. Alternatively, it is also possible to judge that the two devices have moved close to each other based on the reception intensity, a reception error rate, or the like, in place of the transmission power. Further alternatively, a proximity sensor may be used.

(5) Adaptive Adjustment of Display Luminance Level at the Back-End Device

[0063] FIG. **7** shows a first example placement of two sensor pairs. A BE device **14-1** corresponds to the BE device **14** shown in FIG. **1** or the like. That is, the BE device **14-1** forms a tablet terminal. The BE device **14-1** has a display screen **30***a*. The display screen **30***a* forms a display and also an inputter. Specifically, as shown in FIG. **5**, the BE device **14-1** has a touch panel monitor. A periphery around the display screen **30***a*, that is, a region outside of the display screen **30***a*, is a frame member **130**. The frame member **130** forms a bezel. In FIG. **7**, an X direction and a Y direction which are in an orthogonal relationship are defined. The display screen **30***a* is parallel to a plane defined by the X direction and the Y direction. A direction orthogonal to the X direction and the Y direction is a Z direction, and is a direction through the display screen **30***a*. The X direction is a left-and-right direction, and the Y direction is an up-and-down direction.

[0064] At a lower part of the frame member **130**, that is, on a lower side **130**A of the display screen **30***a*, a first sensor pair **132** is embedded. On the other hand, at or near a top right corner portion of the frame member **130**, a second sensor pair **134** is embedded. The first sensor pair **132** comprises a first optical sensor **136** and a first object sensor **138**. Reference numeral **136***a* indicates a detection field-of-view of the first optical sensor **136**, and reference numeral **138***a* indicates a detection field-of-view of the first object sensor **138**. In FIG. **7**, the forms of the detection fields-of-view are merely exemplary.

[0065] The detection fields-of-view **136***a* and **138***a*, which are in a paired relationship, substantially overlap each other. The first optical sensor **136** and the first object sensor **138** are provided such that the fields of view **136***a* and **138***a* at least partially overlap each other. In FIG. **7**, two circles indicated as the fields of view **136***a* and **138***a* show the width of the respective field of view in the XY plane. The sizes of the circles, however, are merely exemplary.

[0066] The first sensor pair **132** is provided in such a manner that, when the BE device **14** and the FE device are in the docked state, the sensor pair is not hidden by the holder **34** (refer to FIGS. **2** and **3**). That is, the first sensor pair **132** is placed on the BE device **14-1** so that the first sensor pair **132** is exposed more to an upper side than an upper side of the holder **34** in the docked state. In the example configuration of FIG. **7**, the first sensor pair **132** is provided at a center in the X direction in the lower side **130**A. Alternatively, the first sensor pair **132** may be provided on other positions, so long as the functions of the first sensor pair **132** can be realized.

[0067] The detection fields-of-view **136***a* and **138***a* may have a substantial hemispherical form. Alternatively, the fields of view may have a directivity which is more three-dimensionally narrowed. Further, the detection field-of-view may be a field of view covering the entirety of a front side of the display screen **30***a*.

[0068] The first optical sensor **136** is a sensor which detects an ambient light level. For example, an illumination sensor may be used as such a sensor. The first object sensor **138** is a sensor which detects presence/absence of an object in the detection field-of-view **138***a*. As such a sensor, an optical sensor, an ultrasound sensor, or the like may be used. Alternatively, as the object sensor **138***a*, a motion sensor or a gesture sensor may be provided. In this case, a two-dimensional sensor such as a CCD may be provided. In the present embodiment, two sensors **136** and **138** of the first sensor pair **132** are placed in proximity to each other. Alternatively, the two sensors **136** and **138** may be provided distanced from each other. Desirably, positions and orientations of the sensors are set such that the detection fields-of-view of the two sensors of the sensor pair substantially overlap each other as described above. In the example configuration of FIG. **7**, the two sensors **136** and **138** face in the Z direction. In other words, the central axes thereof face the front side.

[0069] In the first example placement of FIG. **7**, in addition to the first sensor pair **132**, a second sensor pair **134** is provided. As described above, the second sensor pair **134** is provided at or near the top right corner portion of the frame member **130**.

[0070] The second sensor pair **134** includes a second optical sensor **140** and a second object sensor **142**. The sensors **140** and **142** are placed in proximity to each other, and detection fields-of-view thereof are shown with reference numerals **140***a* and **142***a*, respectively. The detection fields-of-view **140***a* and **142***a* shown in the figure are merely for convenience, and various sizes may be conceived for the fields of view.

[0071] In the example configuration of FIG. **7**, the second sensor pair **134** basically has the same structure and function as the first sensor pair **132**. The first sensor pair **132** and the second sensor pair **134** only differ from each other in the placement positions. Therefore, the sensors **140** and **142** will not be described here in detail. When the first sensor pair **132** and the second sensor pair **134** are placed on the frame member **130**, the sensor pairs are placed while avoiding various switches, light emitters, or the like provided separately on the frame member. Because each of the sensor pairs **132** and **134** has a small size, a thickness and a width of the frame member **130** are not increased by the placement of the sensor pairs. The second sensor pair **134** may be placed at other positions so long as the functions of the second sensor pair **134** can be realized.

[0072] As will be described later with reference to FIG. **10**, a controlling unit; that is, a controller, adaptively sets a luminance level of the display screen **30***a* based on a group of signals which are output from the two sensor pairs **132** and **134**. In this case, when an object is detected by the first object sensor **138**, a detection value of the first optical sensor **136** is discarded, and similarly, when an object is detected by the second object sensor **142**, a detection value of the second optical sensor **140** is discarded. That is, the luminance level is adaptively set based on the light detection values when no object is detected. With such a configuration, an accurate luminance level control while removing or reducing the influence of the disturbances can be realized. In the present embodiment, an LCD is used as the display, and the adjustment of the luminance level is specifically realized by adjustment of a backlight level. However, the method of adjusting the luminance is not limited to such a configuration.

[0073] FIG. **8** shows a second example placement of the two sensor pairs. In the second example placement, the first sensor pair **132** is the same as that shown in FIG. **7**, and will not be described again.

[0074] In the second example placement of FIG. **8**, the second sensor pair **144** faces in a upwardly slanted direction. Specifically, the second sensor pair **144** is placed inside a top right corner portion **130**B of the frame member **130**, and includes a second optical sensor **146** and a second object sensor **148**. Directions of central axes of the sensors **146** and **148** are upwardly slanted directions, and more specifically, a 45-degree direction toward the top right of the XY plane. Reference numeral **146***a* shows a detection field-of-view of the second optical sensor **146**, and reference numeral **148***a* shows a detection field-of-view of the second object sensor **148**. The detection fields-of-view **146***a* and **148***a* overlap each other in their entire regions.

[0075] Therefore, in a BE device **14-2** shown in FIG. **8**, two sensor pairs **142** and **144** have different directions. Specifically, the first sensor pair **142** faces to the front, and the second sensor pair **144** faces in an upper right direction. According to such a configuration, a more general ambient light level can be identified without depending on the local strength/weakness of the light. In general, during ultrasound diagnosis, a left side of the frame member **130** is grabbed by the left hand of a right-handed inspector, and a probe is held in the right hand of the inspector or the input operation to the display screen is executed by the right hand. The placement positions of the first sensor pair **142** and the second sensor pair **144** are desirably determined assuming such a configuration, and targeting to reduce the probability that the sensors are hidden by the hands.

[0076] FIG. **9** shows a third example placement of the two sensor pairs. In a BE device **14-3**, a first sensor pair **150** and a second sensor pair **152** are placed at or near a top right corner portion of the frame member. In general, in many cases, at a lower part in the display screen, a plurality of operation buttons (icons) are displayed, arranged in the left-and-right direction, and thus the shadow of the hand is more likely to be cast on the lower part of the display screen by respective operations. On the other hand, the shadow of the hand of the inspector is less likely to be cast on the upper part of the frame member, and the shadow of the head of the inspector is also less likely to be cast on the upper part. In consideration of such circumstances, two sensor pairs **150** and **152** are provided at an upper part of the BE device **14-3**. The sensor pairs have different directions from each other.

[0077] The first sensor pair **150** includes a first optical sensor **152** and a first object sensor **154**, and detection fields-of-view thereof are shown by reference numerals **152***a* and **154***a*, respectively. The second sensor pair **152** includes a second optical sensor **156** and a second object sensor **158**, and detection fields-of-view thereof are shown by reference numerals **156***a* and **158***a*, respectively.

[0078] As shown in FIG. **9**, the first sensor pair **150** is placed facing in the Z direction, that is, to the front, and the second sensor pair **152** is placed to face in the Y direction, that is, upwardly. With such an orthogonal relationship, a more standard ambient light level can be detected. Further, as described above, because the sensor pairs **150** and **152** are provided at the upper part of the BE device **14-3**, it is possible to reduce the possibility of the influence of disturbances on the sensor pairs. The sensor structures forming the sensor pairs **150** and **152** are identical to those of the structures shown in FIGS. **7** and **8**.

[0079] Next, adaptive control of the luminance level will be described with reference to FIG. **10**.

[0080] In FIG. **10**, the first sensor pair **132** includes the first optical sensor **136** and the first object sensor **138** in the illustrated example structure. The second sensor pair **134** includes the second optical sensor **140** and the second object sensor **142**. The sensors **132**, **134**, **140**, and **142** correspond to the detectors **84**, **86**, **88**, and **90** shown in FIG. **5**. A control unit **70**A shown in FIG. **10** corresponds to the CPU **70** shown in FIG. **5**.

Functions of the control unit **70**A are shown in FIG. **10** as a first disturbance judgment unit **160**, a second disturbance judgment unit **162**, and a controller **164**.

[0081] The first disturbance judgment unit **160** judges whether or not there is an occurrence of disturbance, based on an output signal of the first object sensor **138**. When an output signal of the first object sensor **138** is greater than or equal to a certain value, the first disturbance judgment unit **160** judges that there is occurrence of the disturbance. The second disturbance judgment unit **162** judges the presence/absence of disturbance based on an output signal of the second object sensor **142**, and a judgment principle thereof is identical to the judgment principle of the first disturbance judgment unit **160**.

[0082] The controller **164** adaptively sets a luminance level of the display, more specifically, the backlight level, based on a detection signal of the first optical sensor **136** and a detection signal of the second optical sensor **140**. In the present embodiment, when the first disturbance judgment unit **160** judges a disturbance, that is, when an object is detected, the detection signal of the first optical sensor **136** is discarded, and similarly, when the second disturbance judgment unit **162** judges disturbance, that is, when an object is detected, the detection signal of the second object sensor **142** is discarded. In other words, the controller **164** sets the luminance level based on the detection signals of the first optical sensor and the second optical sensor when there is no disturbance. This process will be described later in detail, with reference to FIGS. **11** and **12**. A backlight level of the display is actually set based on a signal showing a backlight value which is output from the controller **164**. Alternatively, the luminance signal level may be directly controlled in place of the backlight level, or display conditions such as the contrast and hue may be set.

[0083] FIG. **11** shows operation content of the controller shown in FIG. **10** as a table. A row shown by reference numeral **170** shows a judgment result of the first disturbance judgment unit. A row shown by reference numeral **172** shows a judgment result of the second disturbance judgment unit. A row shown by reference numeral **174** shows a signal which is referred to in the control. A row shown by reference numeral **176** shows a control method at the controller. At a state **178**A, that is, when the first disturbance judgment unit judges that there is no disturbance and the second disturbance judgment unit also judges that there is no disturbance, the controller variably sets the backlight value according to an average value based on the first light detection signal and the second light detection signal. Specifically, as neither is affected by the disturbance, the light signals for the two optical sensors are both referred to, and the backlight value is determined based on the average value thereof. Alternatively, in this case, a weight may be assigned to each detection value.

[0084] In a case of a state **178**B; that is, when the first disturbance judgment unit judges that there is no disturbance and the second disturbance judgment unit judges that there is a disturbance, the controller variably sets the backlight value based on the first light detection signal. In other words, the second light detection signal is discarded. This is because, due to the disturbance, the value is not reliable.

[0085] In a case of a state **178**C, that is, when the first disturbance judgment unit judges that there is a disturbance and the second disturbance judgment unit judges that there is no disturbance, the controller variably sets the backlight value based on the second light detection signal. In other words, the first light detection signal is deduced to be affected by the disturbance, and is discarded.

[0086] In a case of a state **178**D, that is, when the first disturbance judgment unit judges that there is a disturbance, and the second disturbance judgment unit also judges that there is a disturbance, both light detection signals are not reliable, and the controller executes control to maintain the past backlight value. Alternatively, a configuration may be employed in which, in this case, the current backlight value is calculated based on the light detection signals in a state of no disturbance. In either case, by discarding the light detection signals affected by the disturbance, it becomes possible to avoid a problem whereby an unexpected backlight value is set. With such a configuration, reduction of operability or reduction in visibility can be prevented.

[0087] FIG. **12** shows a second example control of the controller. Control identical to that shown in FIG. **11** is assigned the same reference numeral, and will not be described again.

[0088] In the example configuration of FIG. **12**, control in a state **178**E and in a state **178**F differs from the control shown in FIG. **11**. In a case of the state **178**E, that is, when the first disturbance judgment unit judges that there is no disturbance and the second disturbance judgment unit judges that there is a disturbance, in the second example control, the controller variably sets the backlight value based on the first light detection value and a second light detection value in the past. Thus, by also considering the second light detection value in the past which is not affected by the disturbance, it becomes possible to more accurately set the backlight value. Similarly, in a case of the state **178**F, that is, when the first disturbance judgment unit judges that there is a disturbance and the second disturbance judgment unit judges that there is no disturbance, the controller determines the backlight value based on a first light detection value in the past and the current second light detection value. Similar to the above, by also considering the first light detection value in the past which is not affected by the disturbance, it becomes possible to more suitably calculate the backlight value. The example controls or calculation methods shown in FIGS. **11** and **12** are merely exemplary.

[0089] When gesture input is executed with respect to the BE device, as described above, a motion sensor which detects the motion of the hand may serve as the above-described optical detector. Specifically, during the gesture input, the light detection signal may be discarded, and the display luminance level may be set based on the light detection signal in the case where the gesture input is not executed.

[0090] In the present embodiment, the above-described adjustment of the luminance level is executed in the separated state and the docked state. In this case, the control conditions may be set different according to the states. The two sensors of each sensor pair may be placed distanced from each other, but when the two sensors are placed in proximity to each other, it is easy to naturally set the detection fields-of-view to overlap over large portions thereof. In particular, a significant variation occurs in the detection value when a light receiving surface of the optical sensor is covered by a finger or a hand. Thus, in order to accurately detect such a state, desirably, the object sensor is provided in proximity to the optical sensor.

1. An ultrasound diagnostic system comprising:

a front-end device having a transmission and reception circuit; and

a back-end device serving as a tablet terminal, wherein

the front-end device and the back-end device operate in a state selected from a separated state in which the front-end device and the back-end device are separated, and a docked state in which the front-end device and the back-end device are put together,

the back-end device comprises:

a display that displays an ultrasound image which is formed based on a reception signal obtained by transmission and reception of ultrasound, that functions as a touch panel, and on which an input operation to a display screen is executed;

a frame member provided around the display screen of the display;

a first detector pair provided on the frame member facing a front side, the first detector pair including a first optical detector that detects ambient light, and a first object detector that has an object detection field-of-view which is in a relationship of entirely or partially overlapping a light detection field-of-view of the first optical detector;

a second detector pair provided on the frame member facing a direction other than the front side, the second detector pair including a second optical detector that detects the ambient light, and a second object detector that has an object detection field-of-view which is in a relationship of entirely or partially overlapping a light detection field-of-view of the second optical detector,

a disturbance judging unit that judges presence or absence of a disturbance based on an output signal of the first object detector, and that judges presence or absence of a disturbance based on an output signal of the second object detector; and

a control unit that adaptively sets a luminance level of the display based on a first light detection value of the first optical detector when it is judged that there is no disturbance based on the output signal of the first object detector, and a second light detection value of the second optical detector when it is judged that there is no disturbance based on the output signal of the second object detector, in both the separated state and the docked state, wherein

a disturbance judging condition in the disturbance judging unit differs between the separated state and the docked state, and is switched according to the state.

2. The ultrasound diagnostic system according to claim **1**, wherein

the control unit sets different conditions for the adaptive setting of the luminance level according to the state selected from the separated state and the docked state.

3. The ultrasound diagnostic system according to claim **1**, wherein

the control unit:

refers to the first light detection value and the second light detection value when it is judged that there is no disturbance based on the output signal of the first object detector and that there is no disturbance based on the output signal of the second object detector;

discards the first light detection value and refers to the second light detection value when it is judged that there is a disturbance based on the output signal of the first object detector and that there is no disturbance based on the output signal of the second object detector;

refers to the first light detection value and discards the second light detection value when it is judged that there is no disturbance based on the output signal of the first object detector and that there is a disturbance based on the output signal of the second object detector; and

discards the first light detection value and the second light detection value when it is judged that there is a disturbance based on the output signal of the first object detector and that there is a disturbance based on the output signal of the second object detector the control unit discards the first light detection value when an object is detected by the first object detector.

4.-**9**. (canceled)

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摘要(译)

提供了一种超声波诊断系统，其中超声波诊断装置由前端（FE）装置和后端（BE）装置构成。BE设备配有两个传感器对。每个传感器对都由光线传感器和物体检测传感器配置而成。当未检测到物体时，控制单元基于光检测值自适应地设置背光级。当物体传感器检测到物体时，来自与所述物体相邻的光检测传感器的光检测值被丢弃。