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**Sakurabu**

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(54) **CONTROL DEVICE, IMAGING APPARATUS, CONTROL METHOD, AND CONTROL PROGRAM**

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(73) Assignee: **FUJIFILM Corporation**, Tokyo (JP)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 365 days.

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
***G06V 10/74*** (2022.01)
***G06T 7/20*** (2017.01)
***G06V 10/25*** (2022.01)

(52) **U.S. Cl.**
CPC ..... ***G06V 10/761*** (2022.01); ***G06T 7/20*** (2013.01); ***G06V 10/25*** (2022.01); *G06T 2207/10028* (2013.01); *G06T 2207/10148* (2013.01)

(58) **Field of Classification Search**
CPC ..... G06V 10/761; G06V 10/25; G06T 7/20; G06T 2207/10028; G06T 2207/10148
See application file for complete search history.

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"Notice of Reasons for Refusal" Office Action issued in JP 2021-178373; mailed by the Japanese Patent Office on Mar. 25, 2025.

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*Assistant Examiner* — Nhut Huy Pham
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(57) **ABSTRACT**

A control device controls an imaging apparatus and includes a processor, and the processor is configured to: based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, predict distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame; and based on a state of the subject, set a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame.

**13 Claims, 20 Drawing Sheets**

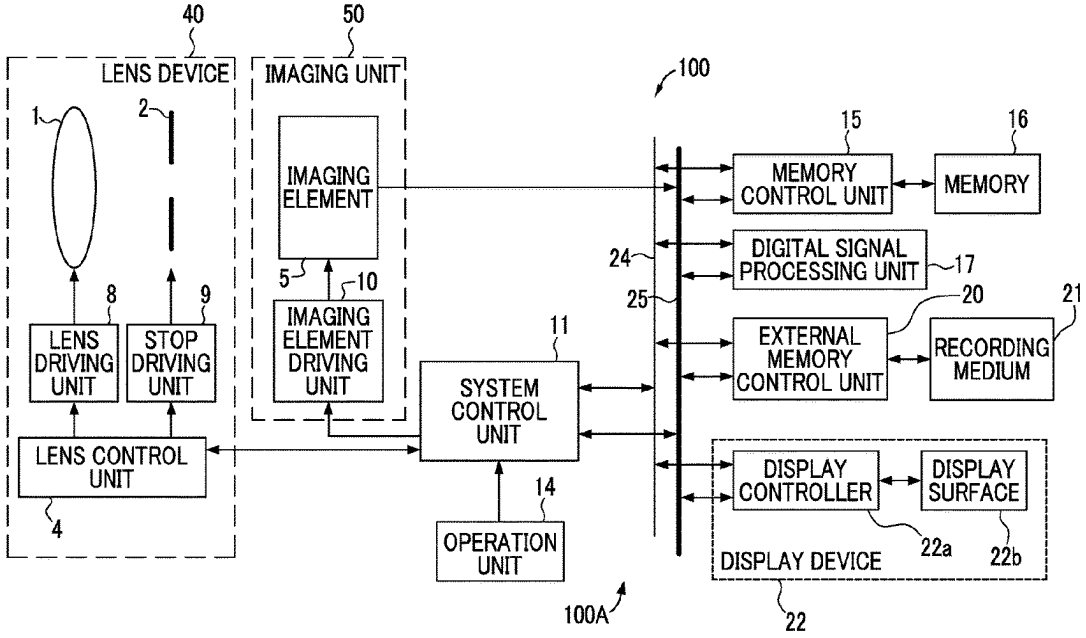


FIG. 1

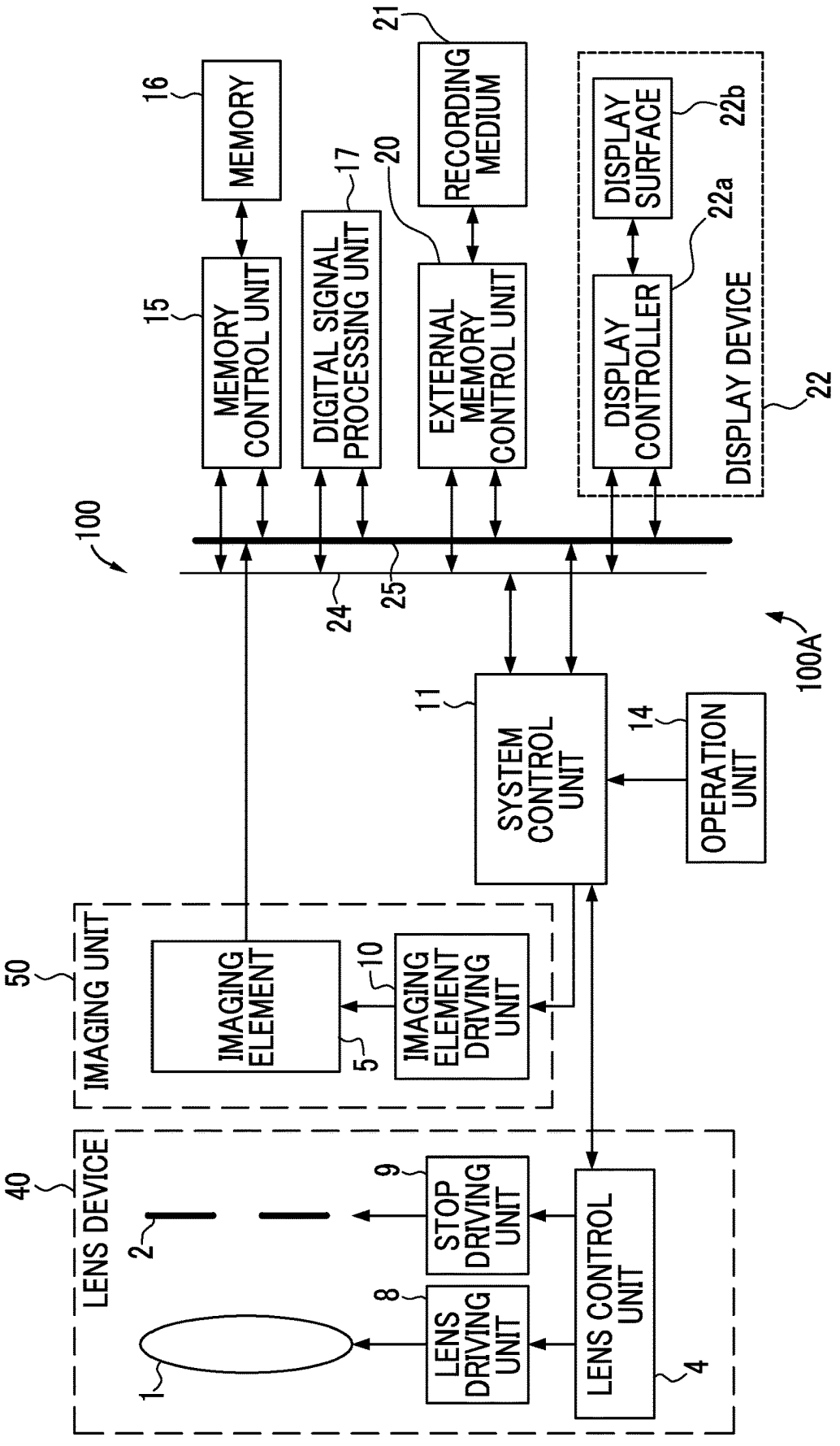

100
100A
16
MEMORY
15
MEMORY CONTROL UNIT
17
DIGITAL SIGNAL PROCESSING UNIT
20
EXTERNAL MEMORY CONTROL UNIT
21
RECORDING MEDIUM
22
DISPLAY DEVICE
22a
DISPLAY CONTROLLER
22b
DISPLAY SURFACE
24
25
11
SYSTEM CONTROL UNIT
14
OPERATION UNIT
50
IMAGING UNIT
IMAGING ELEMENT
5
10
IMAGING ELEMENT DRIVING UNIT
40
LENS DEVICE
2
9
STOP DRIVING UNIT
8
LENS DRIVING UNIT
1
LENS CONTROL UNIT
4

FIG. 2

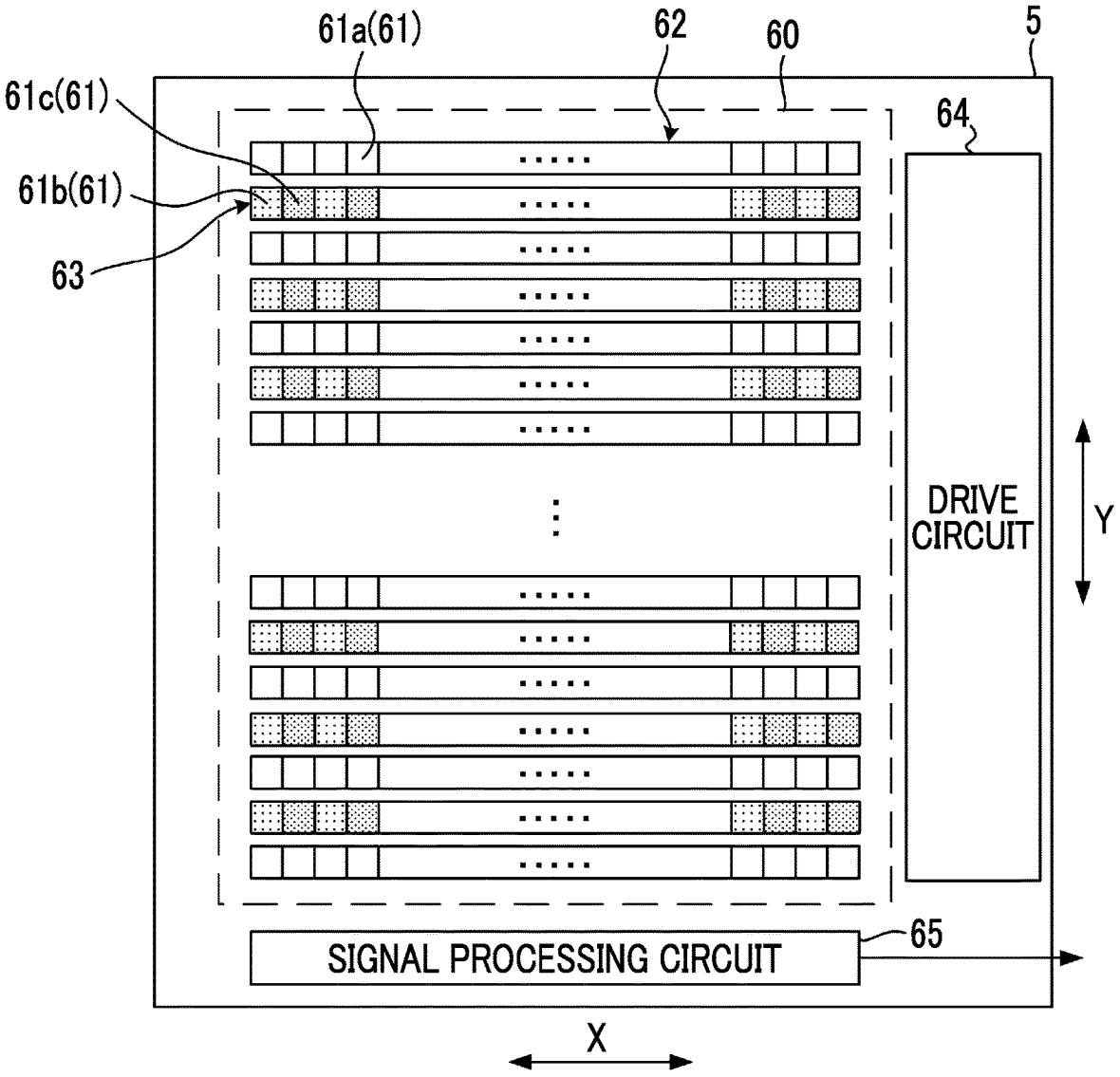

61a(61)
62
60
5
61c(61)
64
61b(61)
63
DRIVE CIRCUIT
Y
SIGNAL PROCESSING CIRCUIT
65
X

FIG. 3

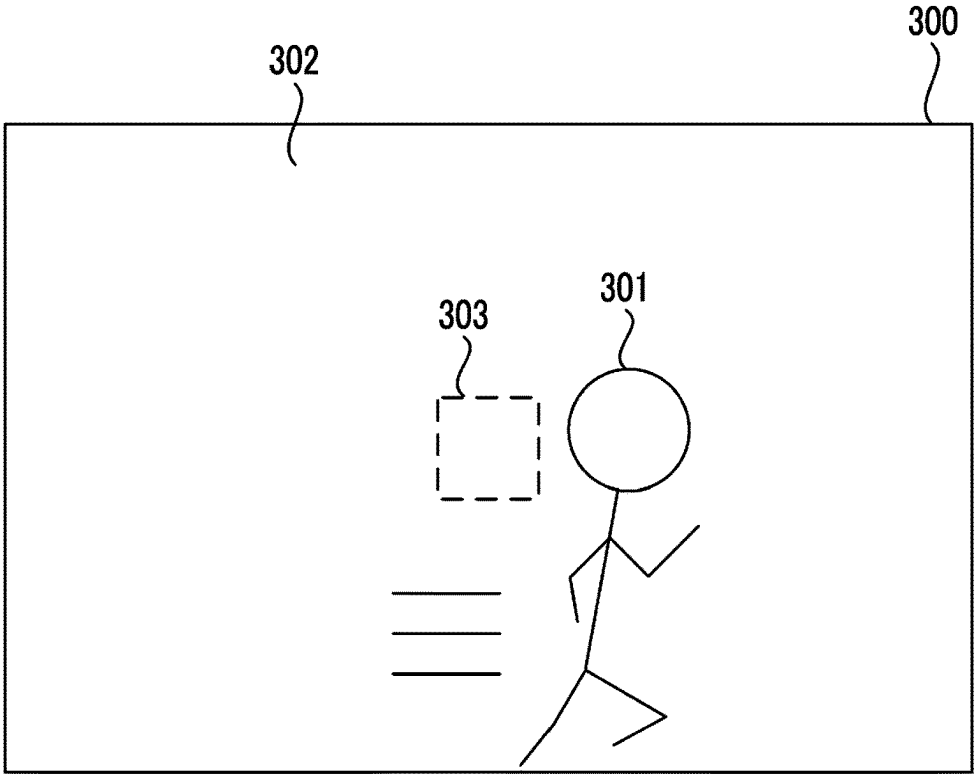



FIG. 4

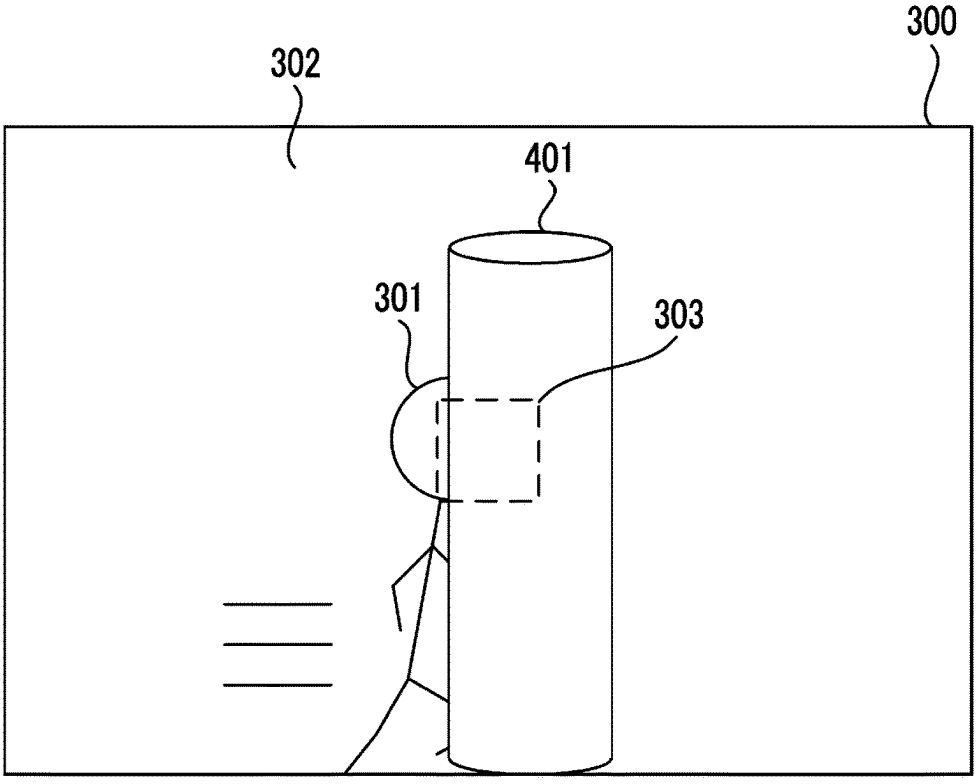


FIG. 5

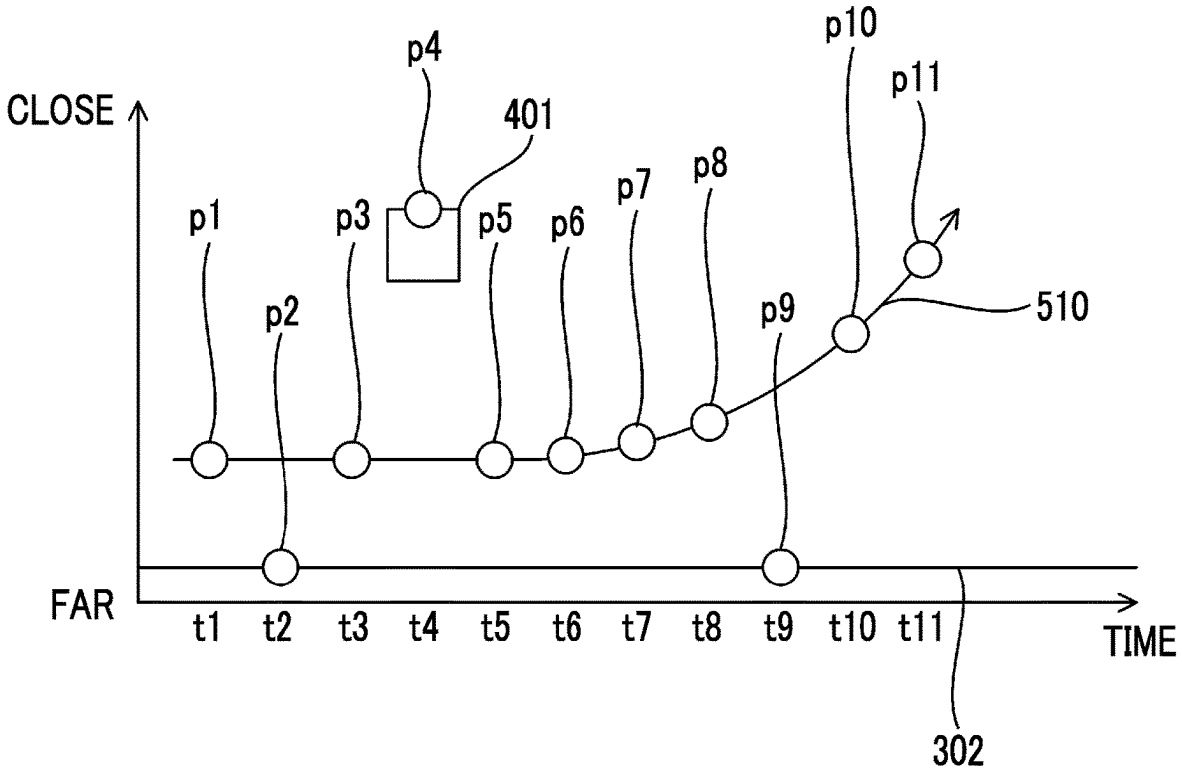

CLOSE
FAR
TIME
p1
p2
p3
p4
401
p5
p6
p7
p8
p9
p10
p11
510
302
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11

FIG. 6

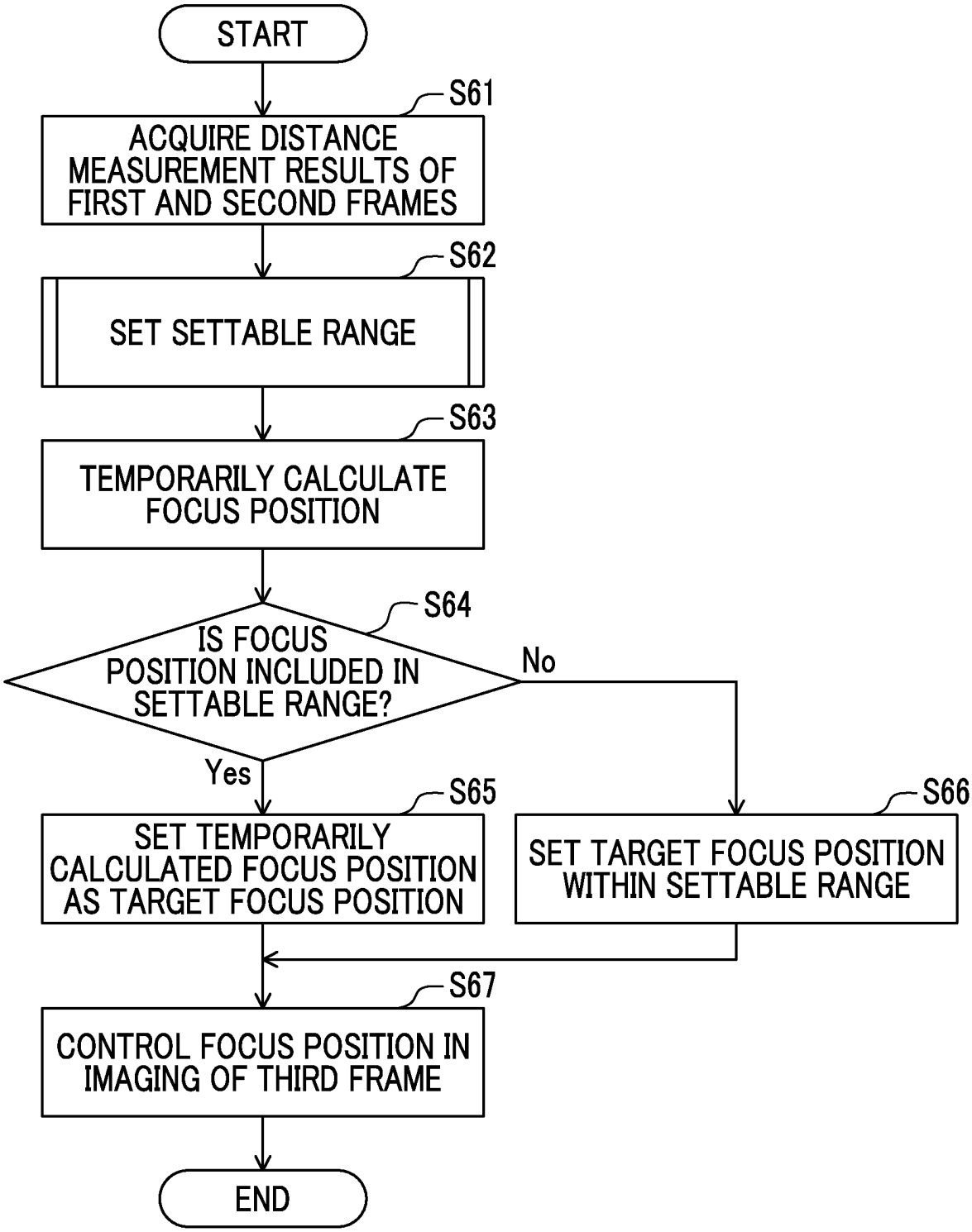

START
S61
ACQUIRE DISTANCE MEASUREMENT RESULTS OF FIRST AND SECOND FRAMES
S62
SET SETTABLE RANGE
S63
TEMPORARILY CALCULATE FOCUS POSITION
S64
IS FOCUS POSITION INCLUDED IN SETTABLE RANGE?
No
Yes
S65
SET TEMPORARILY CALCULATED FOCUS POSITION AS TARGET FOCUS POSITION
S66
SET TARGET FOCUS POSITION WITHIN SETTABLE RANGE
S67
CONTROL FOCUS POSITION IN IMAGING OF THIRD FRAME
END

FIG. 7A

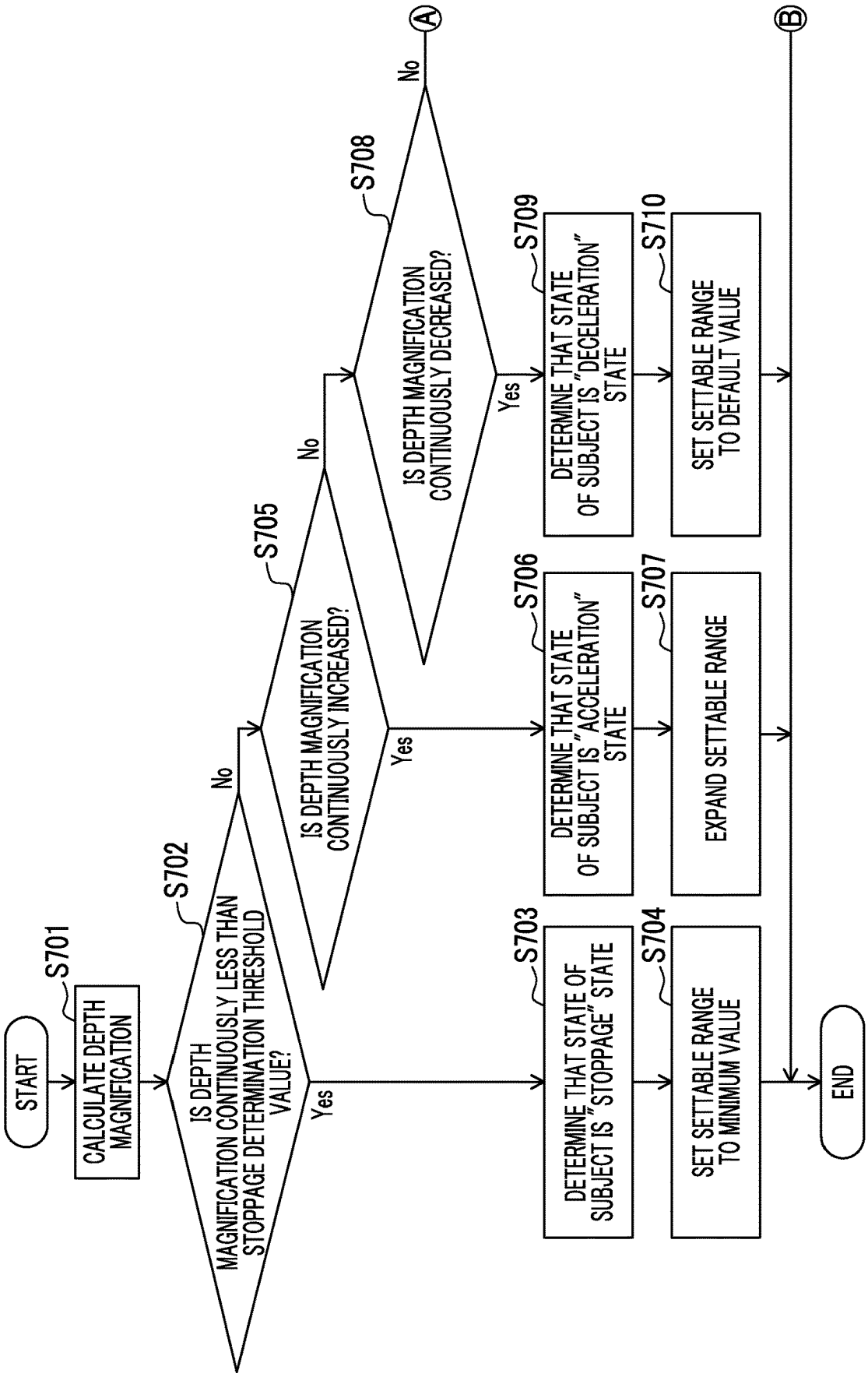

START
S701
CALCULATE DEPTH MAGNIFICATION
S702
IS DEPTH MAGNIFICATION CONTINUOUSLY LESS THAN STOPPAGE DETERMINATION THRESHOLD VALUE?
Yes
No
S703
DETERMINE THAT STATE OF SUBJECT IS "STOPPAGE" STATE
S704
SET SETTABLE RANGE TO MINIMUM VALUE
S705
IS DEPTH MAGNIFICATION CONTINUOUSLY INCREASED?
Yes
No
S706
DETERMINE THAT STATE OF SUBJECT IS "ACCELERATION" STATE
S707
EXPAND SETTABLE RANGE
S708
IS DEPTH MAGNIFICATION CONTINUOUSLY DECREASED?
Yes
No
S709
DETERMINE THAT STATE OF SUBJECT IS "DECELERATION" STATE
S710
SET SETTABLE RANGE TO DEFAULT VALUE
A
B
END

FIG. 7B

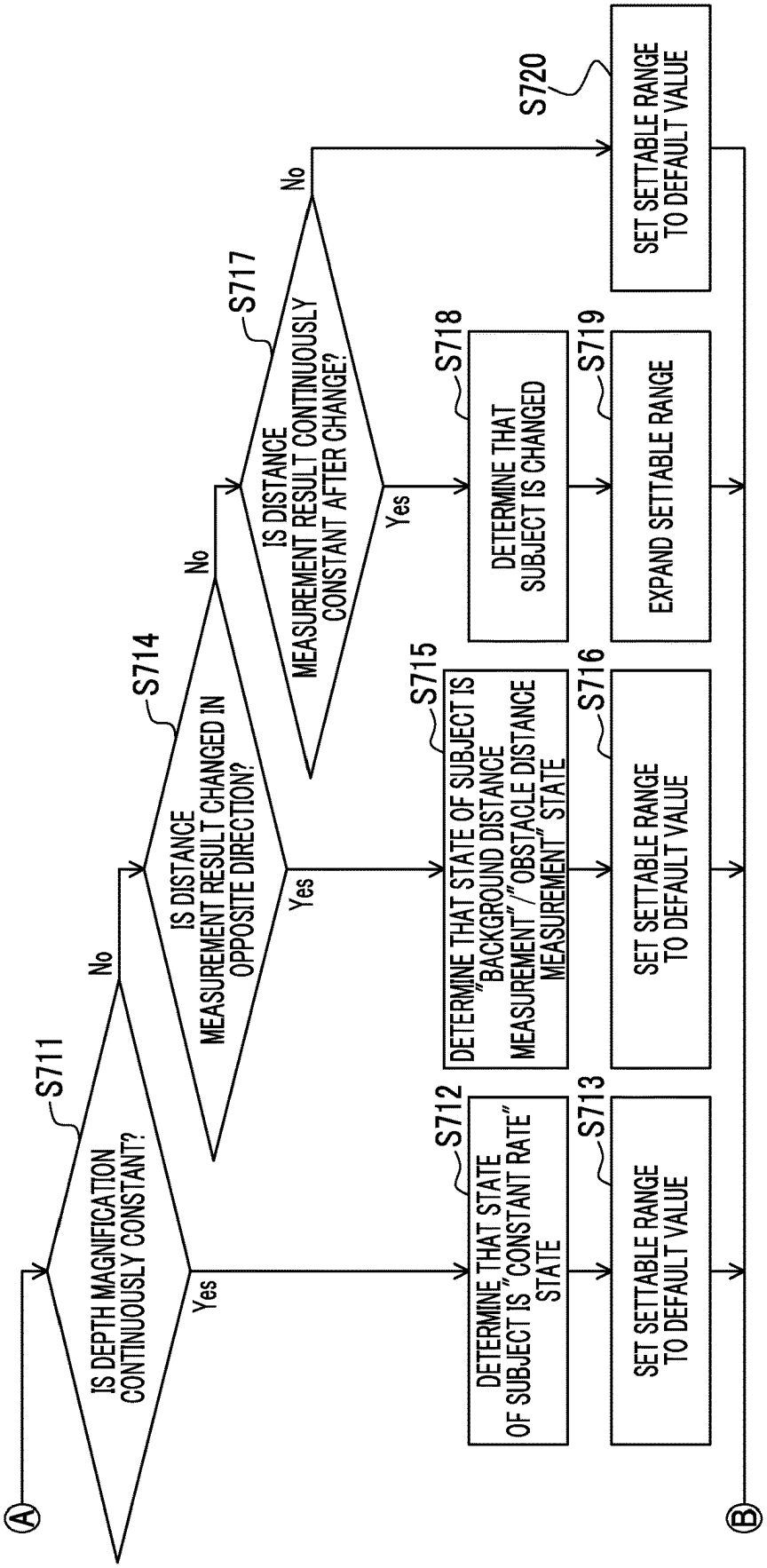

A
S711
IS DEPTH MAGNIFICATION CONTINUOUSLY CONSTANT?
No
Yes
S712
DETERMINE THAT STATE OF SUBJECT IS "CONSTANT RATE" STATE
S713
SET SETTABLE RANGE TO DEFAULT VALUE
S714
IS DISTANCE MEASUREMENT RESULT CHANGED IN OPPOSITE DIRECTION?
No
Yes
S715
DETERMINE THAT STATE OF SUBJECT IS "BACKGROUND DISTANCE MEASUREMENT"/"OBSTACLE DISTANCE MEASUREMENT" STATE
S716
SET SETTABLE RANGE TO DEFAULT VALUE
S717
IS DISTANCE MEASUREMENT RESULT CONTINUOUSLY CONSTANT AFTER CHANGE?
No
Yes
S718
DETERMINE THAT SUBJECT IS CHANGED
S719
EXPAND SETTABLE RANGE
S720
SET SETTABLE RANGE TO DEFAULT VALUE
B

FIG. 8

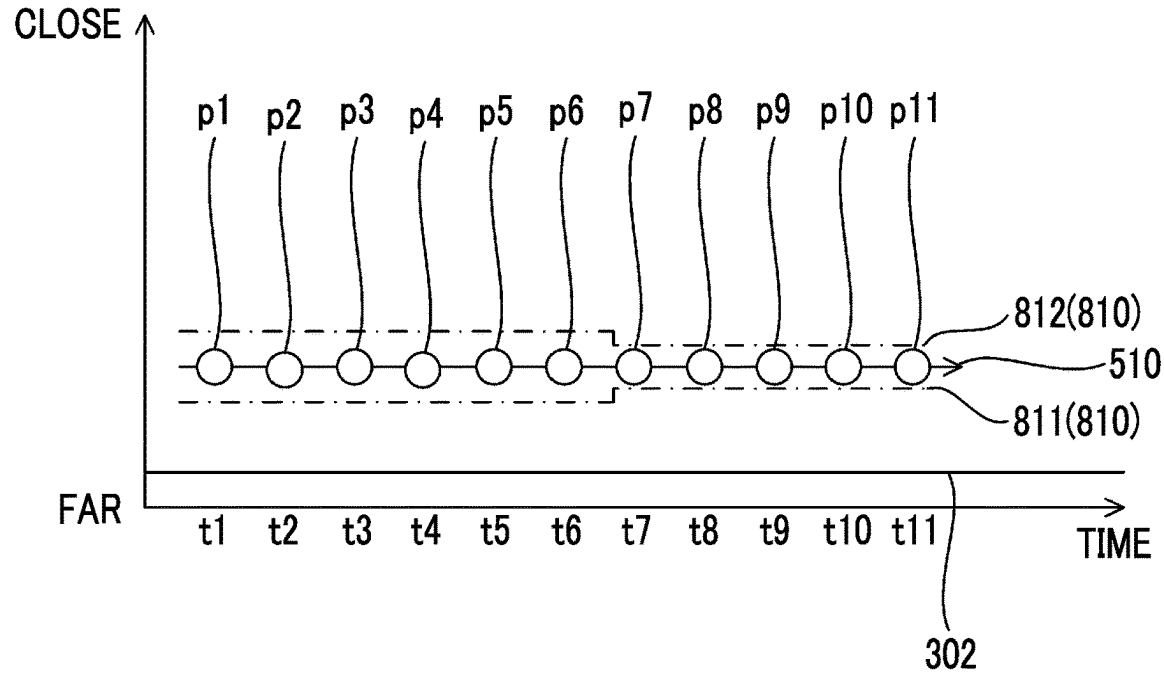

CLOSE
p1
p2
p3
p4
p5
p6
p7
p8
p9
p10
p11
812(810)
510
811(810)
FAR
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
TIME
302

FIG. 9

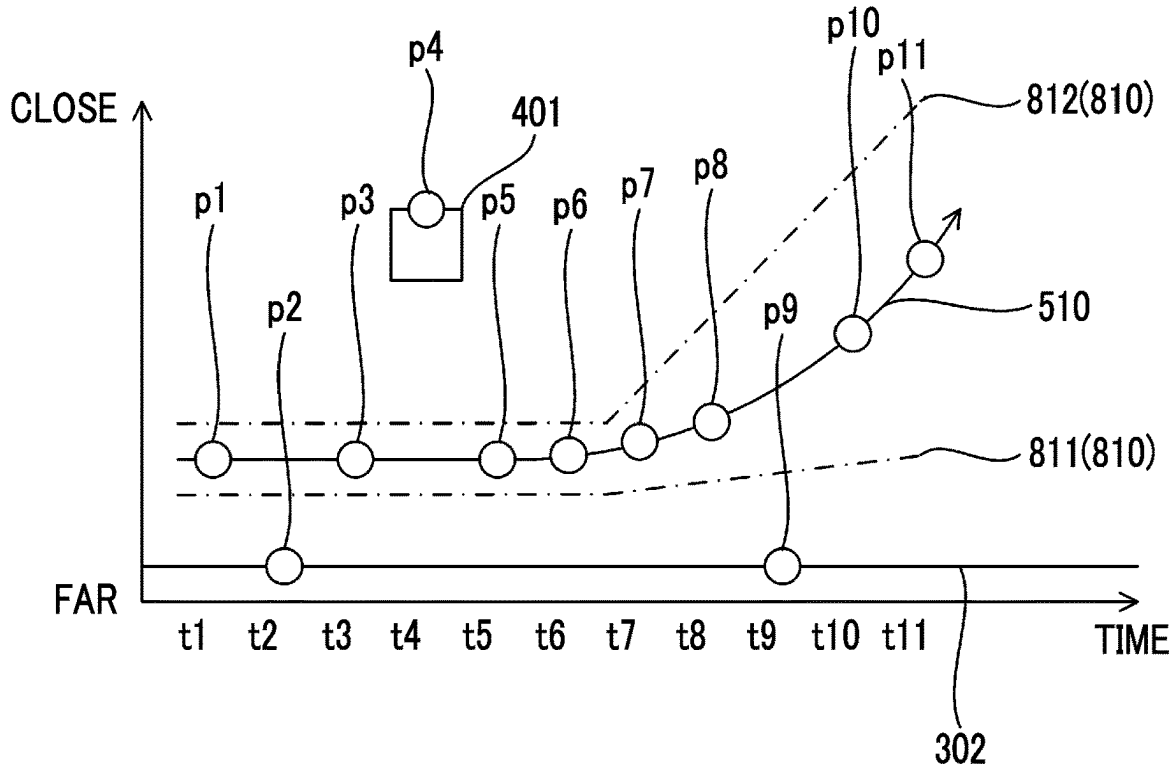

CLOSE
p4
401
p10
p11
812(810)
p1
p3
p5
p6
p7
p8
p2
p9
510
811(810)
FAR
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
TIME
302

FIG. 10

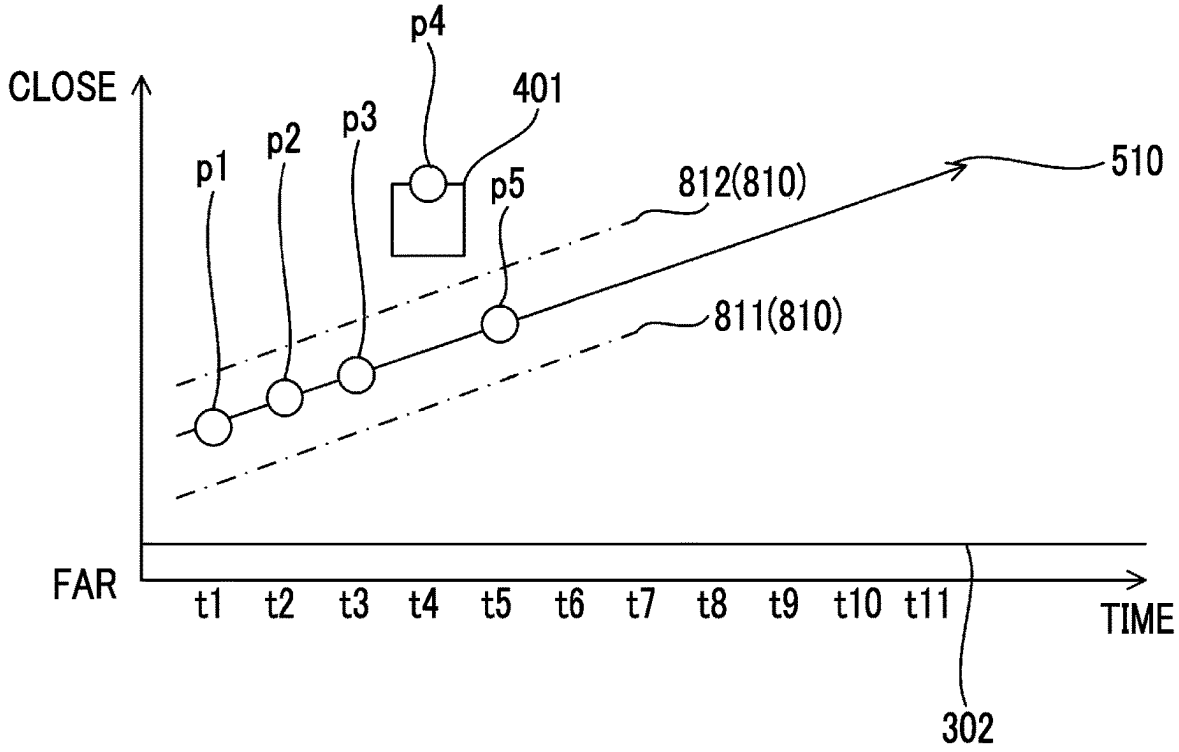

CLOSE
FAR
p1
p2
p3
p4
p5
401
812(810)
811(810)
510
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
TIME
302

FIG. 11

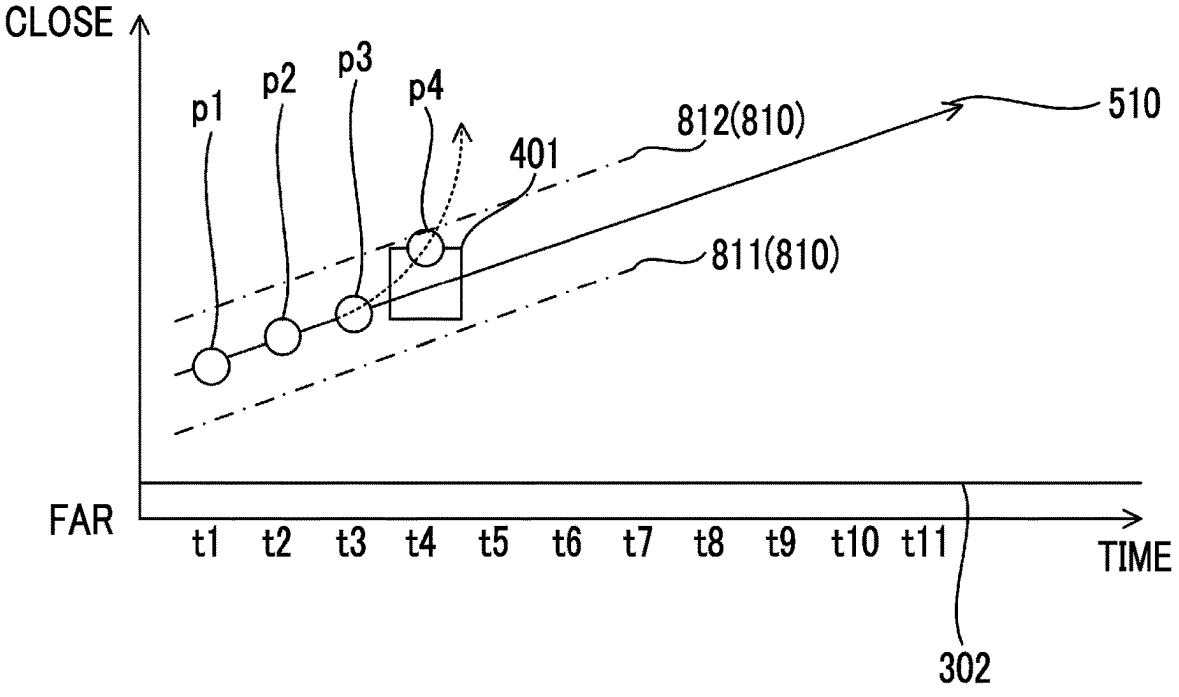

CLOSE
FAR
p1
p2
p3
p4
401
812(810)
811(810)
510
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
TIME
302

FIG. 12A

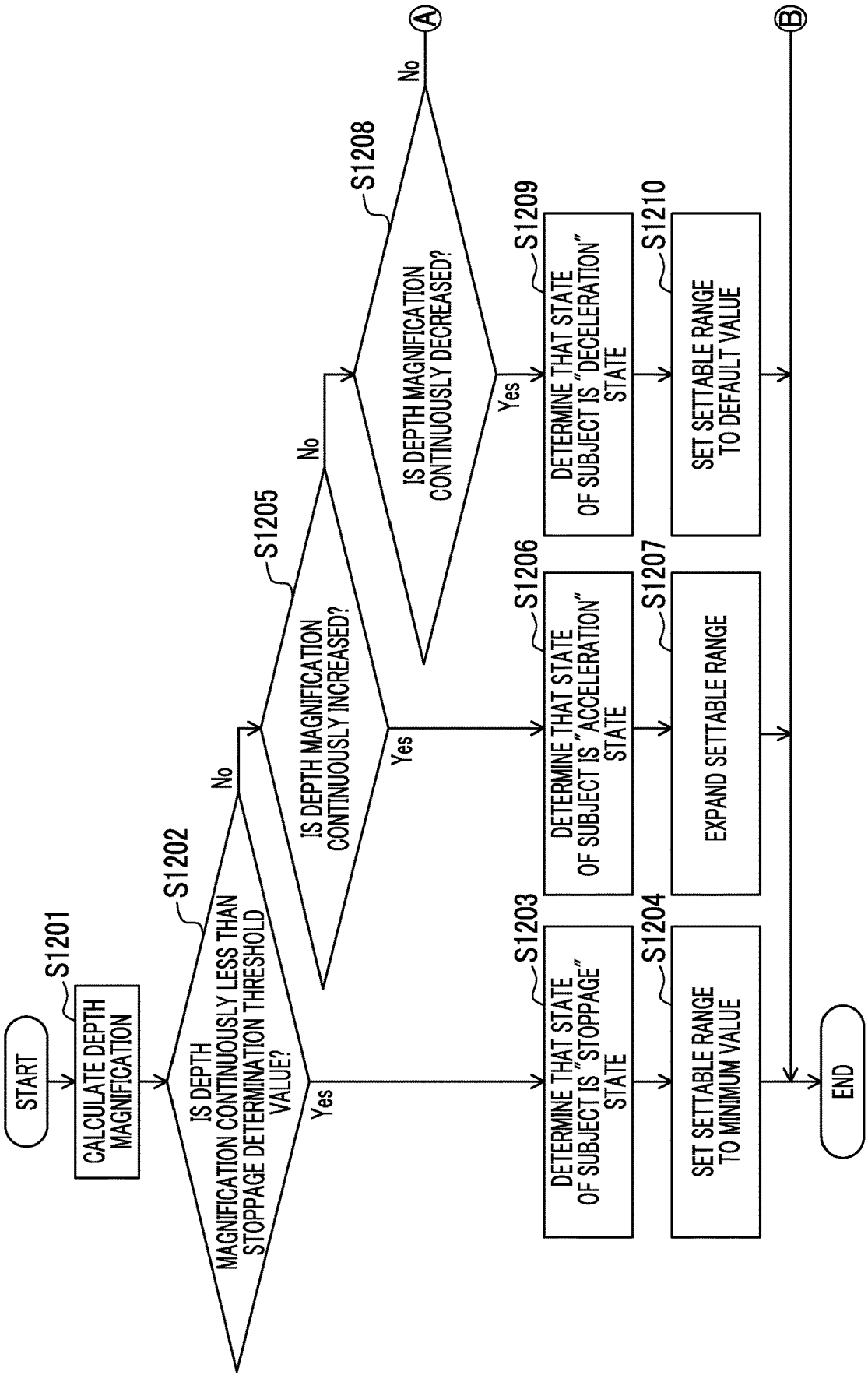

START
S1201
CALCULATE DEPTH MAGNIFICATION
S1202
IS DEPTH MAGNIFICATION CONTINUOUSLY LESS THAN STOPPAGE DETERMINATION THRESHOLD VALUE?
Yes
No
S1203
DETERMINE THAT STATE OF SUBJECT IS "STOPPAGE" STATE
S1204
SET SETTABLE RANGE TO MINIMUM VALUE
S1205
IS DEPTH MAGNIFICATION CONTINUOUSLY INCREASED?
Yes
No
S1206
DETERMINE THAT STATE OF SUBJECT IS "ACCELERATION" STATE
S1207
EXPAND SETTABLE RANGE
S1208
IS DEPTH MAGNIFICATION CONTINUOUSLY DECREASED?
Yes
No
S1209
DETERMINE THAT STATE OF SUBJECT IS "DECELERATION" STATE
S1210
SET SETTABLE RANGE TO DEFAULT VALUE
A
B
END

FIG. 12B

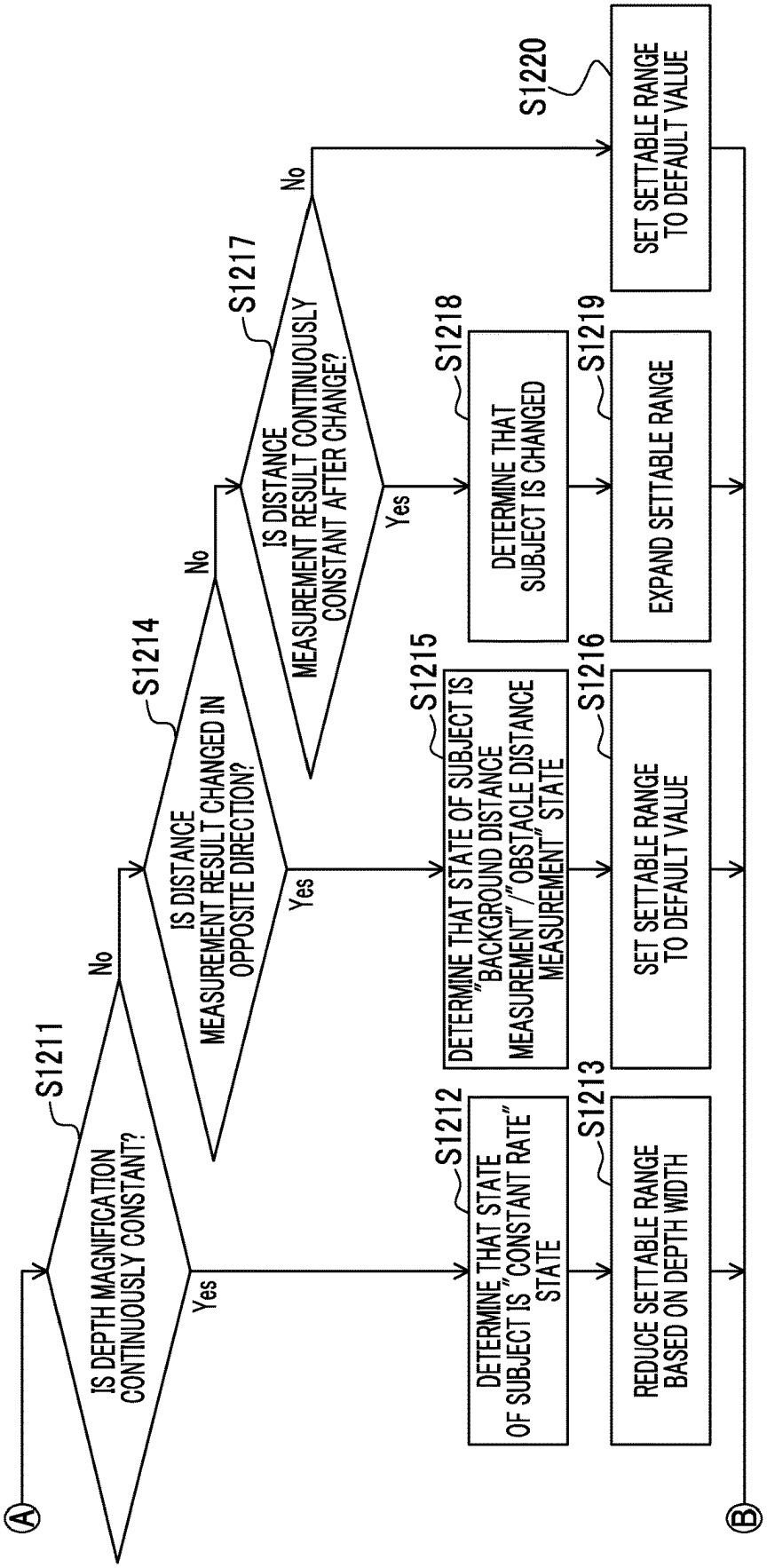

A
S1211
IS DEPTH MAGNIFICATION CONTINUOUSLY CONSTANT?
No
Yes
S1214
IS DISTANCE MEASUREMENT RESULT CHANGED IN OPPOSITE DIRECTION?
No
Yes
S1217
IS DISTANCE MEASUREMENT RESULT CONTINUOUSLY CONSTANT AFTER CHANGE?
No
Yes
S1212
DETERMINE THAT STATE OF SUBJECT IS "CONSTANT RATE" STATE
S1213
REDUCE SETTABLE RANGE BASED ON DEPTH WIDTH
S1215
DETERMINE THAT STATE OF SUBJECT IS "BACKGROUND DISTANCE MEASUREMENT"/"OBSTACLE DISTANCE MEASUREMENT" STATE
S1216
SET SETTABLE RANGE TO DEFAULT VALUE
S1218
DETERMINE THAT SUBJECT IS CHANGED
S1219
EXPAND SETTABLE RANGE
S1220
SET SETTABLE RANGE TO DEFAULT VALUE
B

FIG. 13

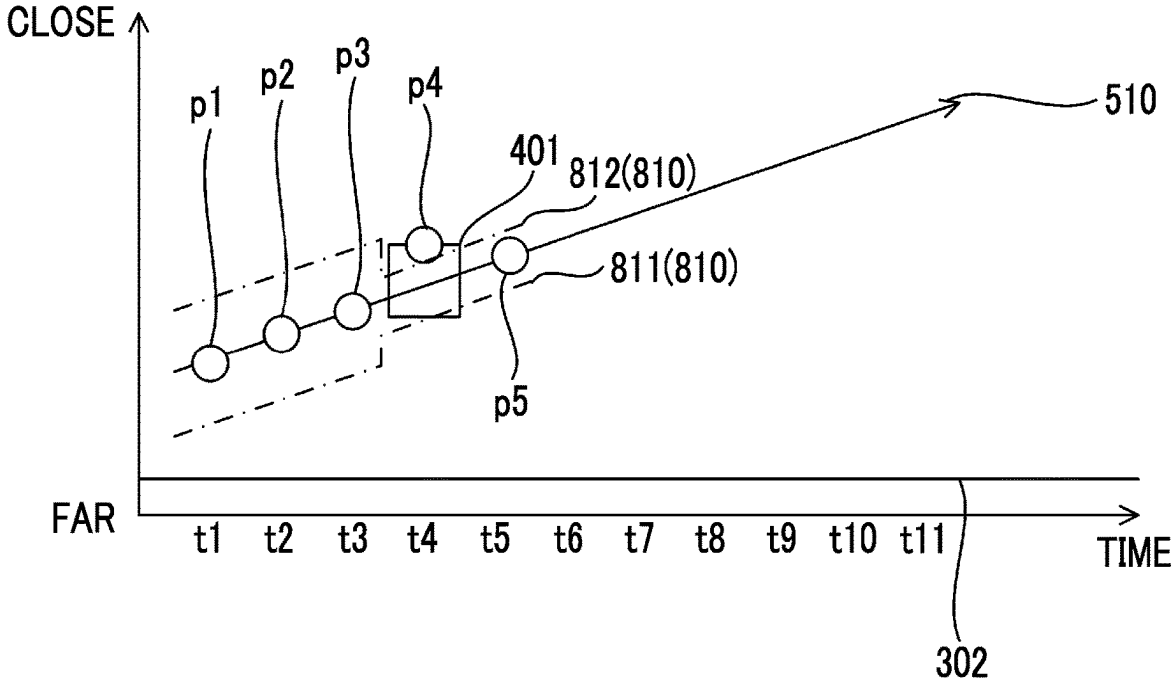

CLOSE
p1
p2
p3
p4
401
812(810)
510
811(810)
p5
FAR
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
TIME
302

FIG. 14

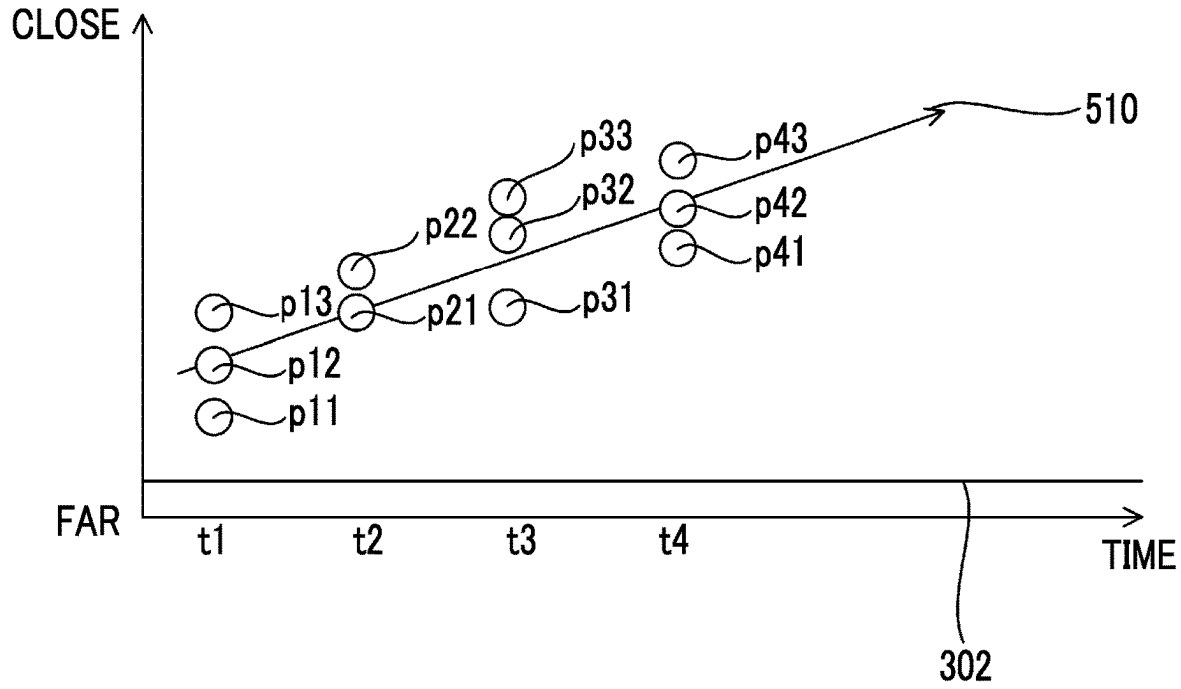

CLOSE
510
p33
p43
p32
p42
p22
p41
p13
p21
p31
p12
p11
FAR
t1
t2
t3
t4
TIME
302

FIG. 15

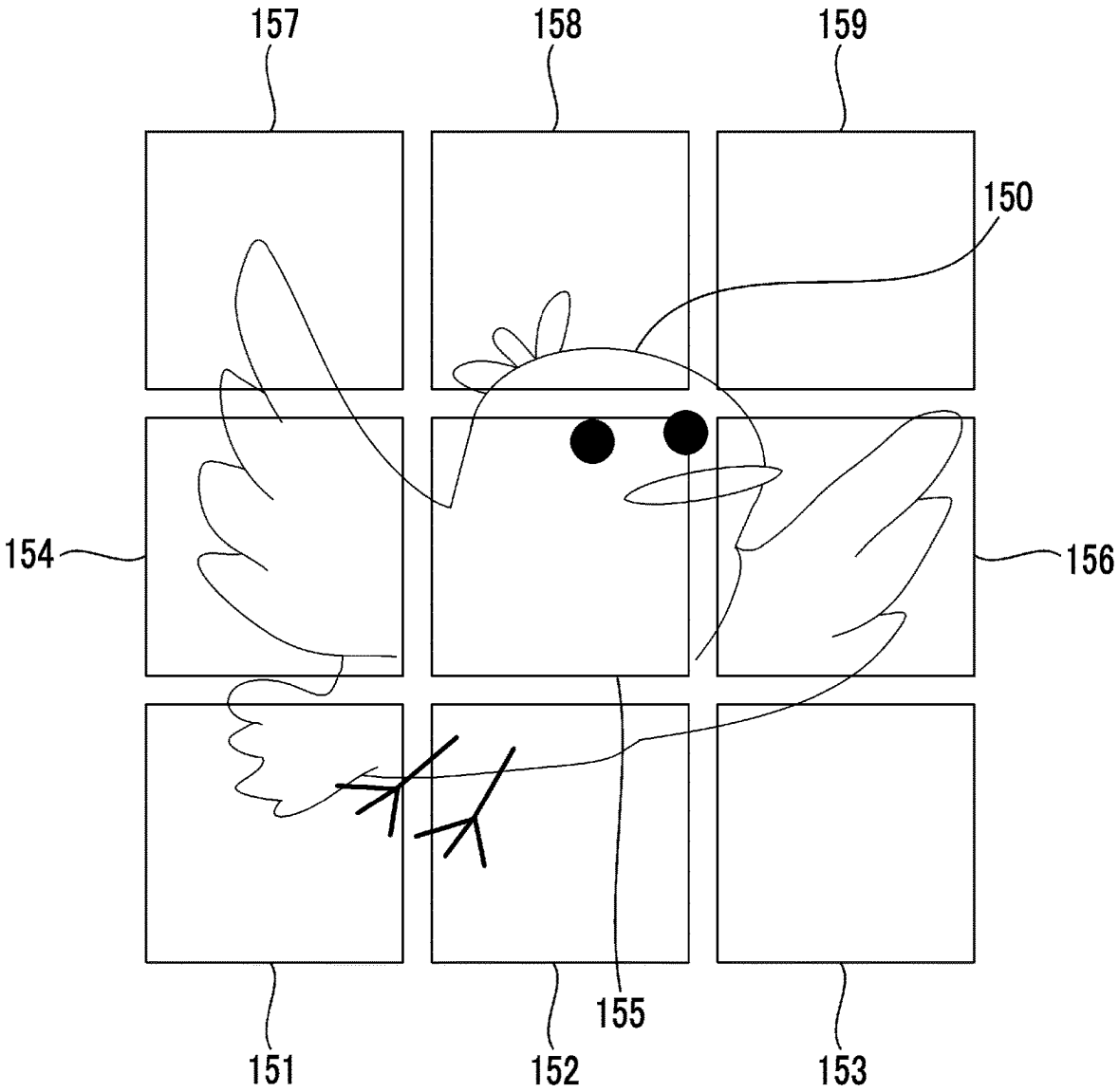


FIG. 16

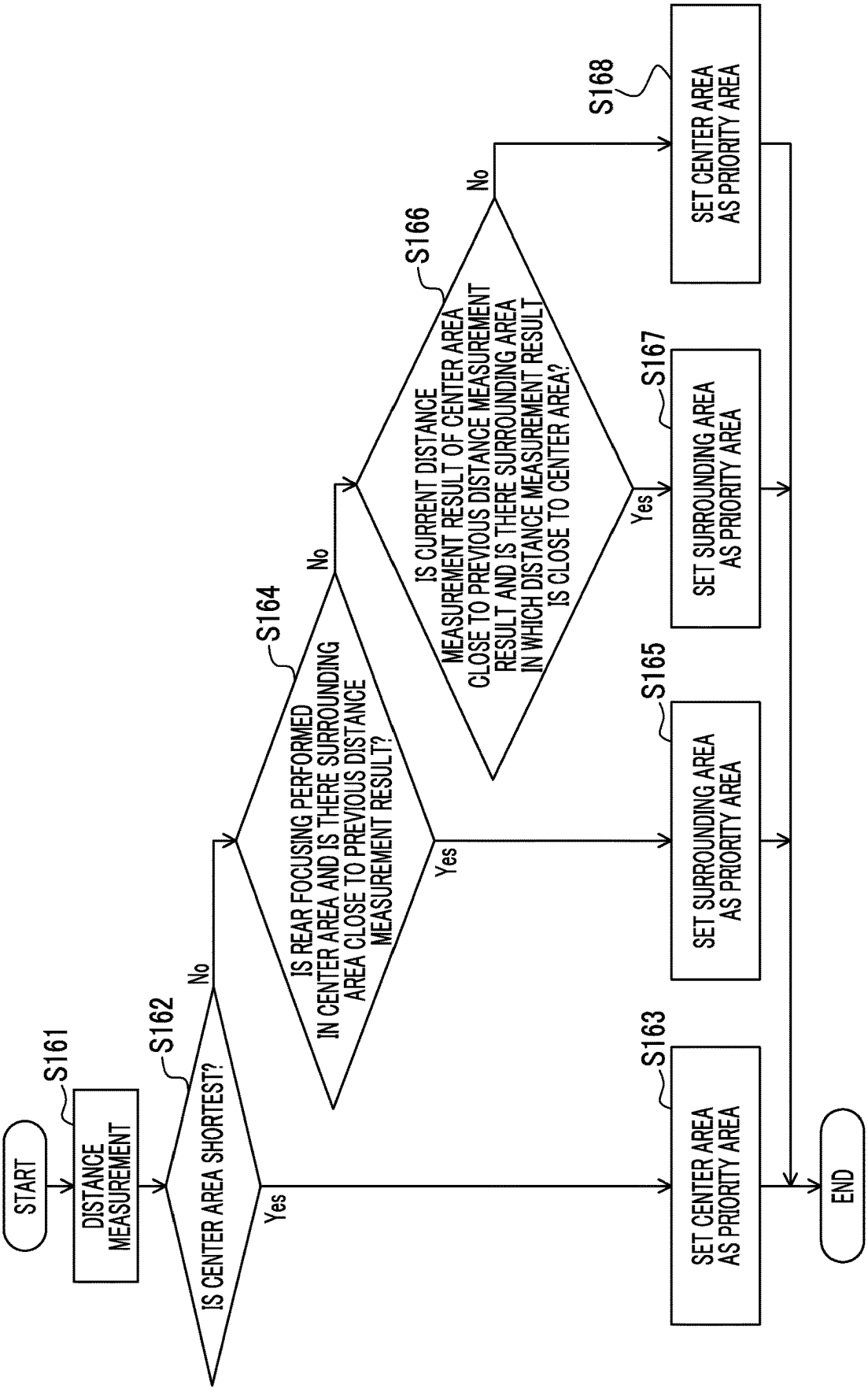

START
S161
DISTANCE MEASUREMENT
S162
IS CENTER AREA SHORTEST?
Yes
No
S163
SET CENTER AREA AS PRIORITY AREA
S164
IS REAR FOCUSING PERFORMED IN CENTER AREA AND IS THERE SURROUNDING AREA CLOSE TO PREVIOUS DISTANCE MEASUREMENT RESULT?
Yes
No
S165
SET SURROUNDING AREA AS PRIORITY AREA
S166
IS CURRENT DISTANCE MEASUREMENT RESULT OF CENTER AREA CLOSE TO PREVIOUS DISTANCE MEASUREMENT RESULT AND IS THERE SURROUNDING AREA IN WHICH DISTANCE MEASUREMENT RESULT IS CLOSE TO CENTER AREA?
Yes
No
S167
SET SURROUNDING AREA AS PRIORITY AREA
S168
SET CENTER AREA AS PRIORITY AREA
END

FIG. 17

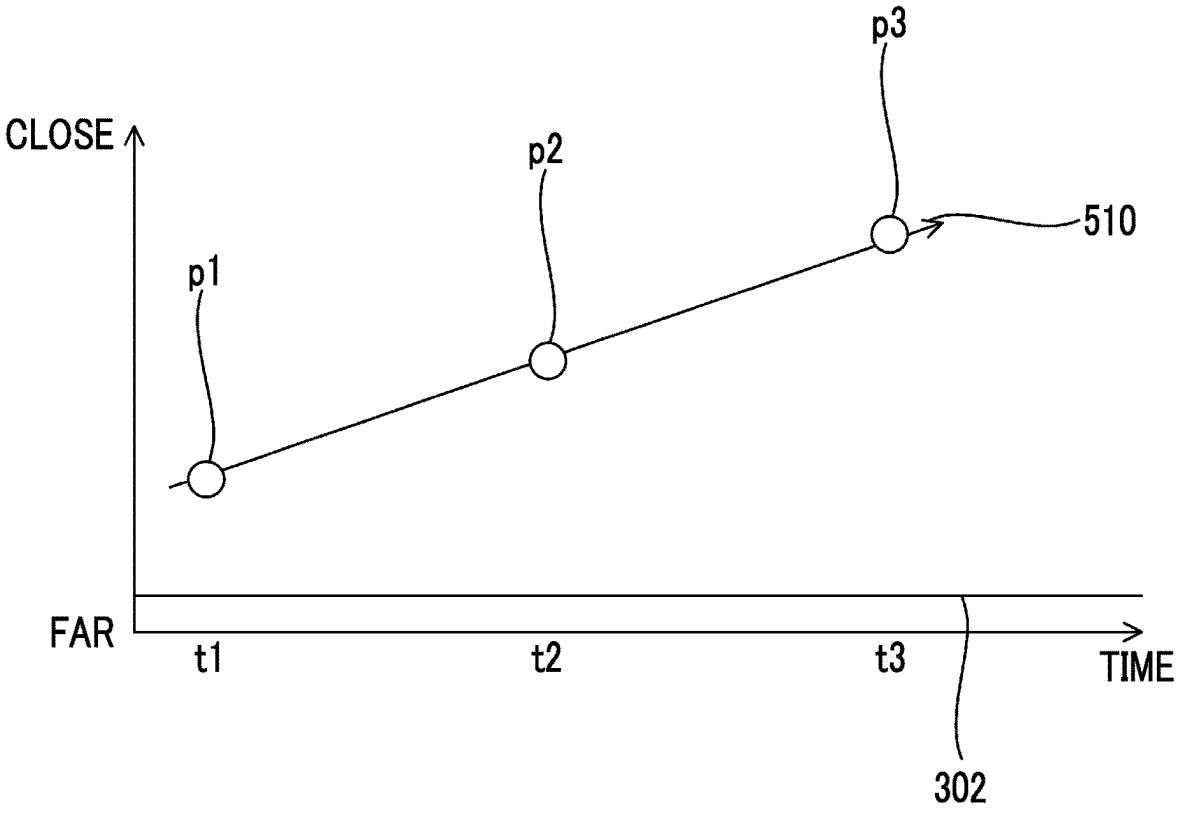


FIG. 18

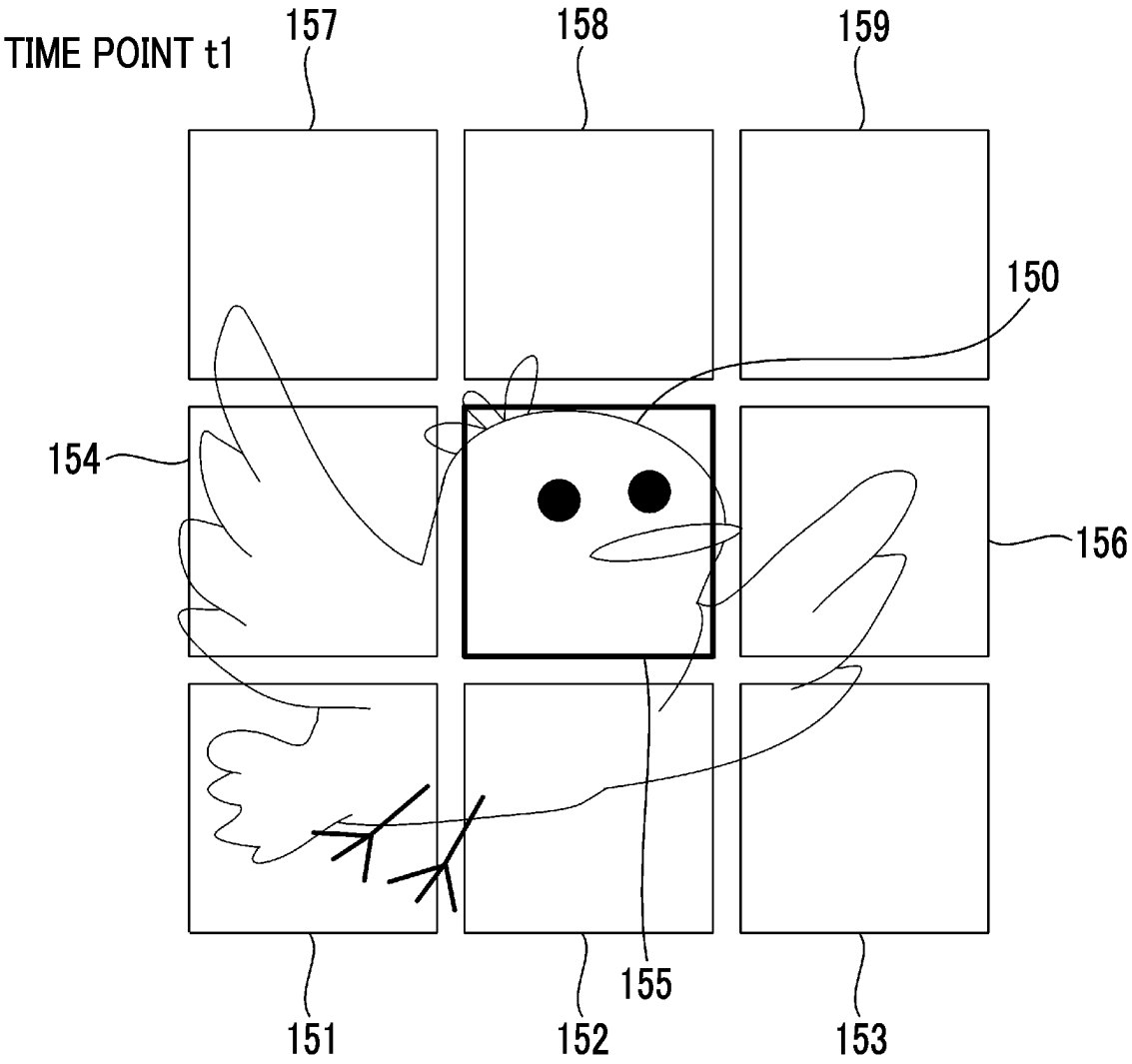


FIG. 19

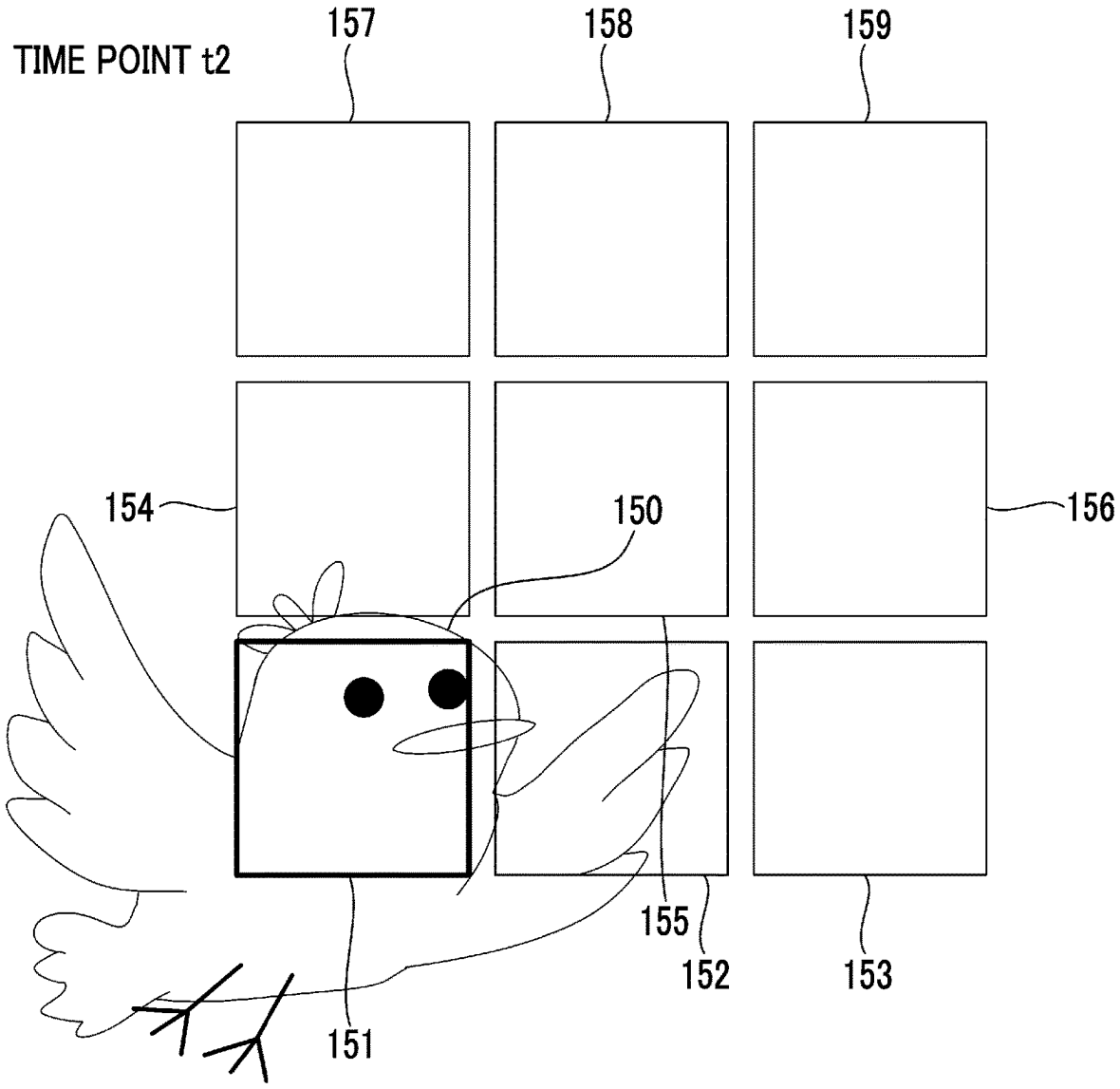


FIG. 20

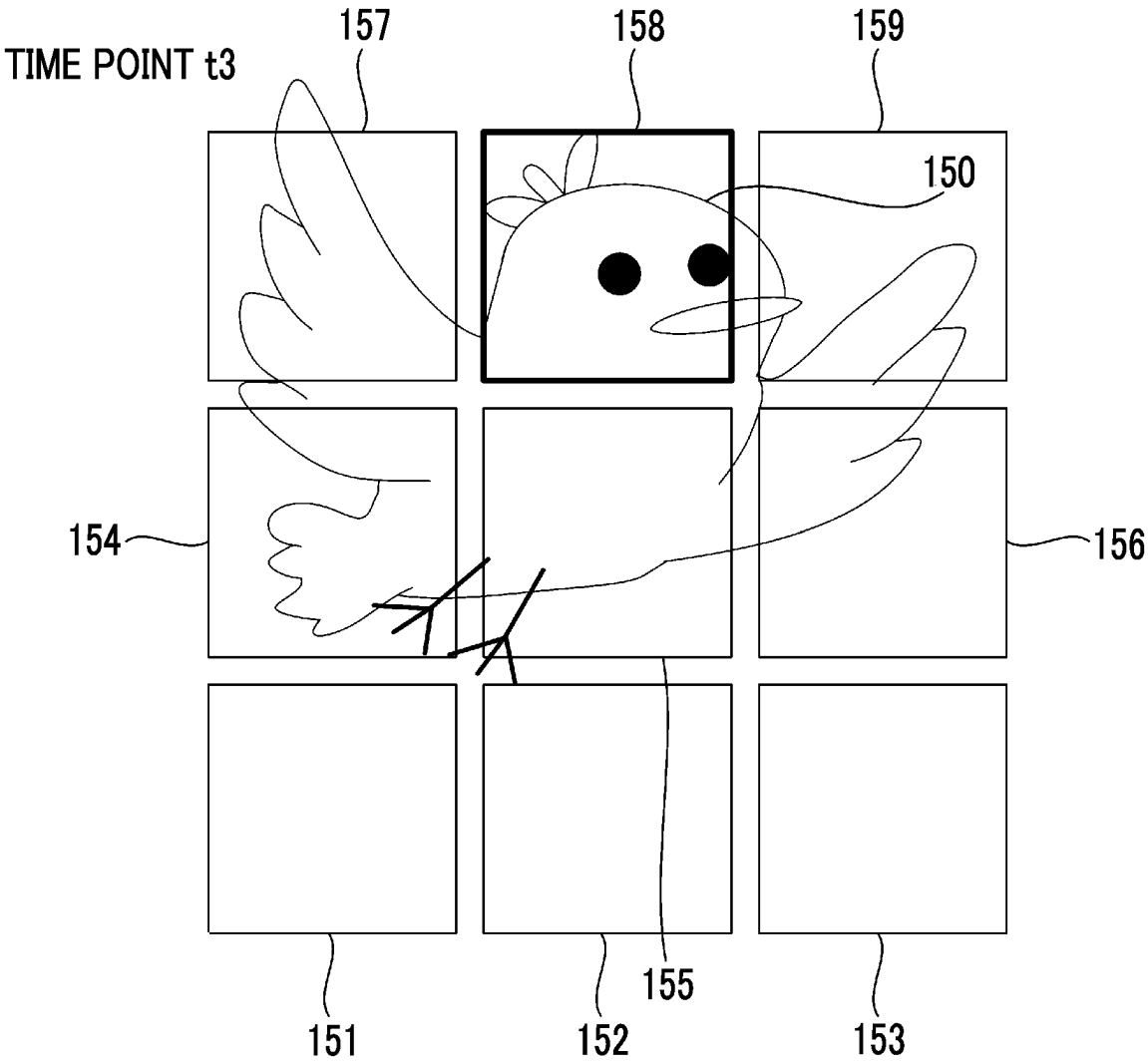


FIG. 21

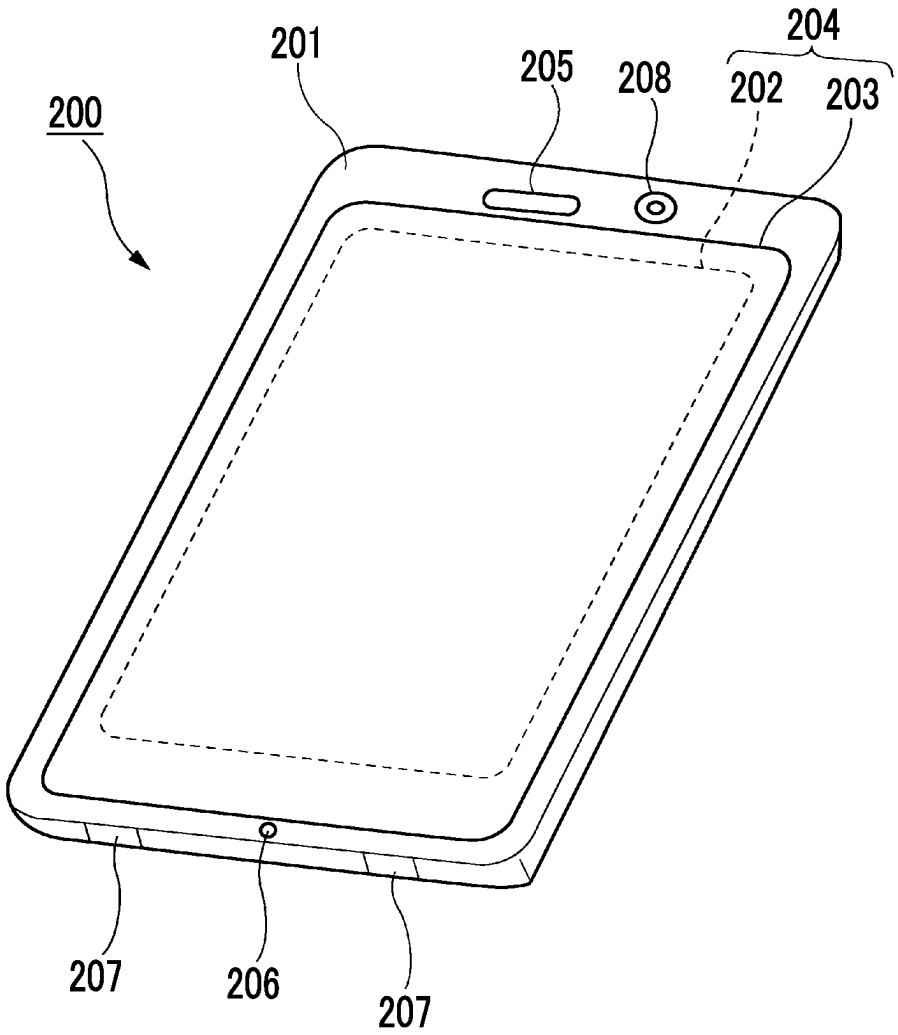
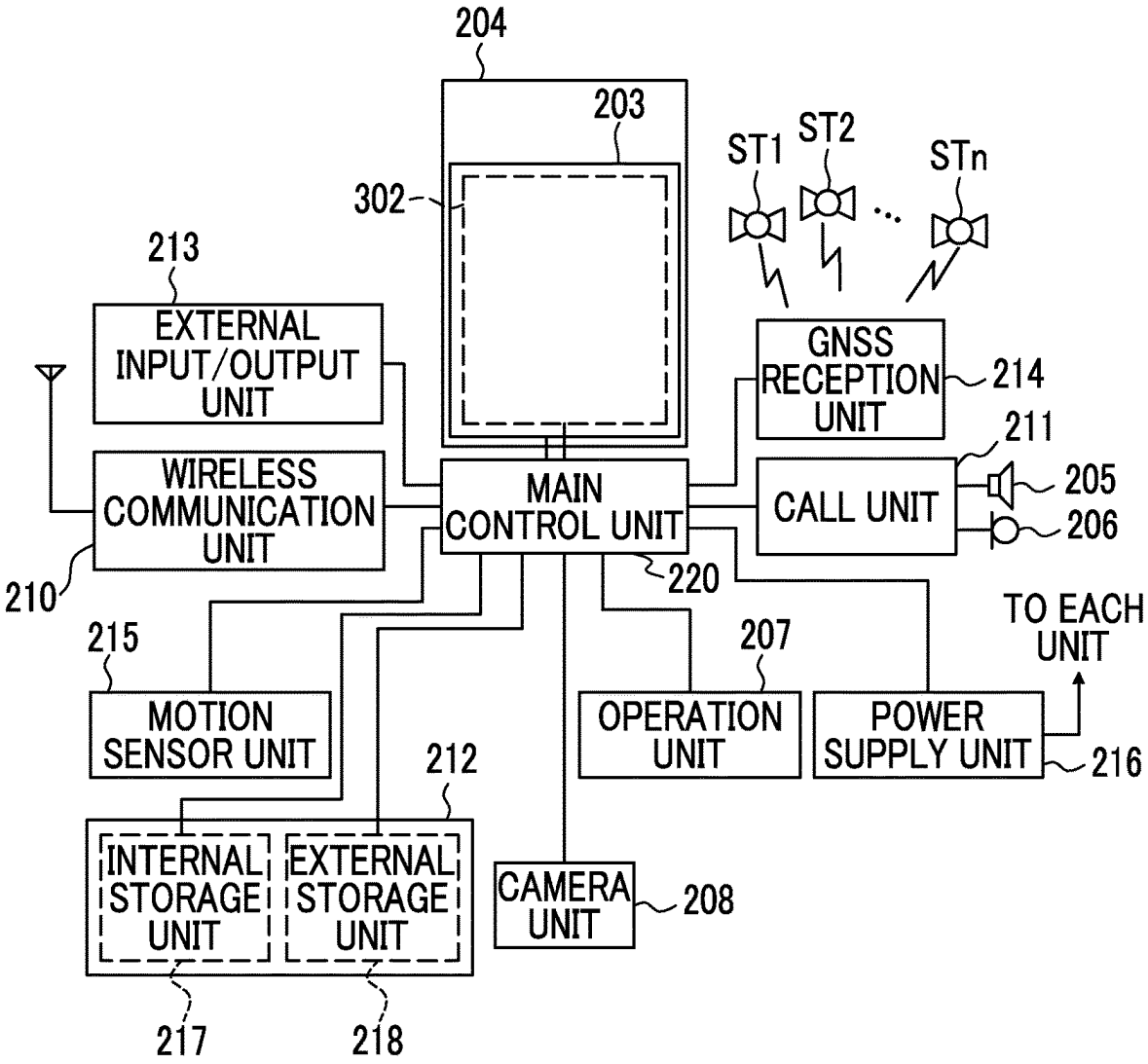


FIG. 22


204
203
302
ST1
ST2
STn
213
EXTERNAL INPUT/OUTPUT UNIT
GNSS RECEPTION UNIT
214
211
WIRELESS COMMUNICATION UNIT
MAIN CONTROL UNIT
CALL UNIT
205
206
210
220
TO EACH UNIT
215
207
MOTION SENSOR UNIT
OPERATION UNIT
POWER SUPPLY UNIT
216
212
INTERNAL STORAGE UNIT
EXTERNAL STORAGE UNIT
CAMERA UNIT
208
217
218

# CONTROL DEVICE, IMAGING APPARATUS, CONTROL METHOD, AND CONTROL PROGRAM

## CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority under 35 U.S.C. § 119 to Japanese Patent Application No. 2021-178373, filed on Oct. 29, 2021. The above application is hereby expressly incorporated by reference, in its entirety, into the present application.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a control device, an imaging apparatus, a control method, and a computer readable medium storing a control program.

### 2. Description of the Related Art

JPWO2017-057104A1 discloses a focusing control device that increases a movement allowable range in which movement of a focus lens is allowed, as a difference between a position of the focus lens before moving the focus lens based on a phase difference amount and a target focusing position of the focus lens based on the phase difference amount is increased. JP2009-273023A discloses an imaging apparatus that captures a live preview image by selecting a frame rate of the live preview image suitable for a movement speed of a subject and controlling an imaging element or the like at the frame rate.

## SUMMARY OF THE INVENTION

One embodiment according to the disclosed technology provides a control device, an imaging apparatus, a control method, and a computer readable medium storing a control program that can improve tracking of a subject (a subject to be imaged) by a focus position.

A control device according to an aspect of the present invention is a control device that controls an imaging apparatus, the control device comprising a processor, in which the processor is configured to, based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, predict distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame, and set a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame based on a state of the subject.

A control method according to another aspect of the present invention is a control method by a control device that includes a processor and controls an imaging apparatus, the control method comprising predicting, by the processor, based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame, and setting, by the processor, a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame based on a state of the subject.



A control program stored in a computer readable medium according to still another aspect of the present invention is a control program of a control device that includes a processor and controls an imaging apparatus, the control program causing the processor to execute a process comprising predicting, based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame, and setting a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame based on a state of the subject.

According to the present invention, a control device, an imaging apparatus, a control method, and a computer readable medium storing a control program that can improve tracking of a subject by a focus position can be provided.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating a schematic configuration of an imaging apparatus **100** that is one embodiment of an imaging apparatus according to the present invention.

FIG. **2** is a schematic plan view illustrating a schematic configuration of an imaging element **5** illustrated in FIG. **1**.

FIG. **3** is a diagram illustrating an example of a state where a subject is separated from an AF area.

FIG. **4** is a diagram illustrating an example of a state where an obstacle enters in front of the subject in the AF area.

FIG. **5** is a diagram illustrating an example of a temporally continuous distance measurement result by the imaging apparatus **100**.

FIG. **6** is a flowchart illustrating an example of focus setting processing by a system control unit **11**.

FIGS. **7**A and **7**B are flowcharts illustrating an example of setting a settable range by the system control unit **11**.

FIG. **8** is a diagram illustrating an example of minimizing the settable range in a "stoppage" state.

FIG. **9** is a diagram illustrating an example of expanding the settable range in an "acceleration" state.

FIG. **10** is a diagram illustrating an example of a control of a focus position in a case where it is determined that a state of the subject is an "obstacle distance measurement" state.

FIG. **11** is a diagram illustrating an example of erroneous determination in a case where a distance between an obstacle **401** and a subject **301** is short.

FIGS. **12**A and **12**B are flowcharts illustrating another example of setting a settable range **810** by the system control unit **11**.

FIG. **13** is a diagram illustrating an example of reducing the settable range **810** based on a depth width.

FIG. **14** is a diagram illustrating an example of a distance measurement result based on a plurality of AF areas of the imaging apparatus **100**.

FIG. **15** is a diagram illustrating an example of the plurality of AF areas of the imaging apparatus **100**.

FIG. **16** is a flowchart illustrating an example of processing of setting a priority area by the system control unit **11**.

FIG. **17** is a diagram (Part 1) illustrating an example of acquiring a distance measurement result of the priority area.

FIG. **18** is a diagram (Part 2) illustrating an example of acquiring the distance measurement result of the priority area.

FIG. **19** is a diagram (Part 3) illustrating an example of acquiring the distance measurement result of the priority area.

FIG. **20** is a diagram (Part 4) illustrating an example of acquiring the distance measurement result of the priority area.

FIG. **21** illustrates an exterior of a smartphone **200**.

FIG. **22** is a block diagram illustrating a configuration of the smartphone **200**.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, an embodiment of the present invention will be described with reference to the drawings.

Configuration of Imaging Apparatus **100** that is One Embodiment of Imaging Apparatus According to Present Invention

FIG. **1** is a diagram illustrating a configuration of an imaging apparatus **100** that is one embodiment of an imaging apparatus according to the present invention.

The imaging apparatus **100** illustrated in FIG. **1** is a digital camera comprising a lens device **40** that includes an imaging lens **1**, a stop **2**, a lens control unit **4**, a lens drive unit **8**, and a stop drive unit **9**; and a main body unit **100**A. The main body unit **100**A comprises an imaging unit **50**, a system control unit **11**, an operation unit **14**, a display device **22**, a memory **16** including a random access memory (RAM), a read only memory (ROM), and the like, a memory control unit **15** that controls data recording in the memory **16** and data readout from the memory **16**, a digital signal processing unit **17**, and an external memory control unit **20** that controls data recording on a recording medium **21** and data readout from the recording medium **21**.

The lens device **40** may be attachable and detachable with respect to the main body unit **100**A or may be integrated with the main body unit **100**A. The imaging lens **1** includes a focus lens or the like that can be moved in an optical axis direction. This focus lens is a lens for adjusting a focal point of an imaging optical system including the imaging lens **1** and the stop **2** and is composed of a single lens or a plurality of lenses. Moving the focus lens in the optical axis direction changes a position of a principal point of the focus lens along the optical axis direction, and a focal position on a subject side is changed. A liquid lens of which a position of a principal point in the optical axis direction can be changed under electric control may be used as the focus lens.

The lens control unit **4** of the lens device **40** is configured to be capable of communicating with the system control unit **11** of the main body unit **100**A in a wired or wireless manner. In accordance with an instruction from the system control unit **11**, the lens control unit **4** changes the position of the principal point of the focus lens by controlling the focus lens included in the imaging lens **1** through the lens drive unit **8** or controls an F number of the stop **2** through the stop drive unit **9**.

The imaging unit **50** comprises an imaging element **5** that images a subject through the imaging optical system including the imaging lens **1** and the stop **2**, and an imaging element drive unit **10** that drives the imaging element **5**.

The imaging element **5** includes an imaging surface **60** (refer to FIG. **2**) on which a plurality of pixels **61** are two-dimensionally arranged, converts a subject image formed on the imaging surface **60** by the imaging optical system into pixel signals by the plurality of pixels **61**, and outputs the pixel signals. A complementary metal-oxide-semiconductor (CMOS) image sensor is suitably used as the imaging element **5**. Hereinafter, the imaging element **5** will be described as a CMOS image sensor.

The system control unit **11** that manages and controls the entire electric control system of the imaging apparatus **100** drives the imaging element **5** through the imaging element drive unit **10** and outputs the subject image captured through the imaging optical system of the lens device **40** as an image signal.

The imaging element drive unit **10** drives the imaging element **5** by generating a drive signal based on an instruction from the system control unit **11** and supplying the drive signal to the imaging element **5**. A hardware configuration of the imaging element drive unit **10** is an electric circuit configured by combining circuit elements such as semiconductor elements.

A command signal from a user is input into the system control unit **11** through the operation unit **14**. The operation unit **14** includes a touch panel integrated with a display surface **22***b*, described later, and various buttons and the like.

The system control unit **11** manages and controls the entire imaging apparatus **100**. A hardware structure of the system control unit **11** corresponds to various processors that perform processing by executing programs including an imaging control program. The programs executed by the system control unit **11** are stored in the ROM of the memory **16**.

The various processors include a central processing unit (CPU) that is a general-purpose processor performing various types of processing by executing a program, a programmable logic device (PLD) that is a processor of which a circuit configuration can be changed after manufacturing like a field programmable gate array (FPGA), or a dedicated electric circuit or the like that is a processor having a circuit configuration dedicatedly designed to execute a specific type of processing like an application specific integrated circuit (ASIC). More specifically, a structure of the various processors is an electric circuit in which circuit elements such as semiconductor elements are combined.

The system control unit **11** may be configured with one of the various processors or may be configured with a combination of two or more processors of the same type or different types (for example, a combination of a plurality of FPGAs or a combination of a CPU and an FPGA).

The display device **22** comprises the display surface **22***b* configured with an organic electro luminescence (EL) panel, a liquid crystal panel, or the like and a display controller **22***a* that controls display on the display surface **22***b*.

The memory control unit **15**, the digital signal processing unit **17**, the external memory control unit **20**, and the display controller **22***a* are connected to each other through a control bus **24** and a data bus **25** and are controlled by instructions from the system control unit **11**.

Schematic Configuration of Imaging Element **5** Illustrated in FIG. **1**

FIG. **2** is a schematic plan view illustrating a schematic configuration of the imaging element **5** illustrated in FIG. **1**. The imaging element **5** includes the imaging surface **60** on which the plurality of pixels **61** are two-dimensionally arranged in a row direction X and a column direction Y orthogonal to the row direction X. The plurality of pixels **61** include a distance measurement pixel **61***b* for detecting a signal corresponding to a quantity of received light by receiving one of a pair of luminous fluxes passing through two different parts arranged in the row direction X in a pupil region of the imaging optical system, a distance measurement pixel **61***c* for detecting a signal corresponding to a quantity of received light by receiving the other of the pair

of luminous fluxes, and a normal pixel **61***a* for detecting a signal corresponding to a quantity of received light by receiving both of the pair of luminous fluxes.

In the example in FIG. **2**, a pixel line **62** obtained by arranging a plurality of the normal pixels **61***a* in the row direction X and a pixel line **63** obtained by alternately arranging the distance measurement pixel **61***b* and the distance measurement pixel **61***c* in the row direction X are alternately arranged in the column direction Y on the imaging surface **60**. The pixel line **63** may include a plurality of pairs of the distance measurement pixel **61***b* and the distance measurement pixel **61***c* and may also include the normal pixel **61***a* in addition to these pairs. Hereinafter, the pixel line **62** and the pixel line **63** will be simply referred to as a pixel line unless otherwise distinguished. The imaging element **5** further comprises a drive circuit **64** that drives the pixels **61** arranged on the imaging surface **60**, and a signal processing circuit **65** that processes a pixel signal read out to a signal line from each pixel **61** of each pixel line arranged on the imaging surface **60**.

Hereinafter, in FIG. **2**, an end part of the imaging surface **60** on one end side (an upper side in FIG. **2**) of the column direction Y will be referred to as an upper end, and an end part of the imaging surface **60** on the other end side (a lower side in FIG. **2**) of the column direction Y will be referred to as a lower end.

The drive circuit **64** performs resetting (discharge of charges accumulated in a photoelectric conversion element) of each pixel **61** included in each pixel line, reading out of a pixel signal corresponding to the charges accumulated in the photoelectric conversion element of each pixel **61** to a signal line, and the like by independently driving each pixel line based on a signal from the imaging element drive unit **10**.

The signal processing circuit **65** performs correlative double sampling processing on the pixel signal read out to the signal line from each pixel **61** of the pixel line, converts the pixel signal after the correlative double sampling processing into a digital signal, and outputs the digital signal to the data bus **25** (refer to FIG. **1**). The signal processing circuit **65** is controlled by the imaging element drive unit **10**.

The digital signal processing unit **17** generates captured image data by performing signal processing such as demosaicing and gamma-correction processing on a pixel signal group output to the data bus **25** from the imaging element **5**.

The imaging apparatus **100** is equipped with a continuous shooting mode in which a plurality of pieces of captured image data are continuously generated and recorded on the recording medium **21** in accordance with one imaging instruction.

In the continuous shooting mode, the system control unit **11** drives the imaging element **5** to image the subject by the imaging element drive unit **10** based on a rolling shutter system. Driving based on the rolling shutter system includes rolling reset driving and rolling readout driving. The rolling reset driving is driving of sequentially performing processing of starting exposure of each pixel **61** by resetting each pixel **61** of the pixel line while changing the pixel line. The rolling readout driving is driving of sequentially performing processing of reading out a signal from each pixel **61** of an exposed pixel line and finishing the exposure of the pixel line while changing the pixel line.

In the continuous shooting mode, in a case where the imaging instruction is received, the system control unit **11** continuously performs a recording imaging control of outputting a pixel signal to be used for recording of the captured image data, display of a live view image on the display surface **22***b*, and distance measurement from the imaging element **5**. In addition, the system control unit **11** performs a display imaging control of outputting a pixel signal to be used for the display of the live view image on the display surface **22***b* and the distance measurement from the imaging element **5** at least once between each of a plurality of the recording imaging controls.

For example, the distance measurement is distance measurement of a phase difference method used in phase difference auto focus (AF). For example, the distance measurement is processing of performing correlation calculation between a first pixel signal group output from each distance measurement pixel **61***b* and a second pixel signal group output from each distance measurement pixel **61***c* included in the same pixel line **63** and deriving a drive amount of the focus lens necessary for focusing on a target subject based on a result of the correlation calculation.

The correlation calculation is processing of calculating an area S[d] surrounded by two data waveforms in a case where a data waveform consisting of the first pixel signal group and a data waveform consisting of the second pixel signal group are shifted by a shift amount d, by changing the shift amount d to a plurality of values.

State where Subject is Separated from AF Area and State where Obstacle Enters in Front of Subject in AF Area

FIG. **3** is a diagram illustrating an example of a state where the subject is separated from an AF area. FIG. **4** is a diagram illustrating an example of a state where an obstacle enters in front of the subject in the AF area. In FIG. **3** and FIG. **4**, an image **300** is a captured image (for example, a live preview image) obtained by the imaging apparatus **100**.

In the examples in FIG. **3** and FIG. **4**, a subject **301** and a background **302** are reflected in the image **300**. The subject **301** is the subject of imaging of the imaging apparatus **100** and is a running person in the examples in FIG. **3** and FIG. **4**. The background **302** is a background (for example, a sky or a building) behind the subject **301** in a view from the imaging apparatus **100**.

In addition, a frame line that indicates a currently effective AF area **303** among AF areas usable by the imaging apparatus **100** is superimposed on the image **300**. In the examples in FIG. **3** and FIG. **4**, the AF area **303** is one AF area positioned at a center of the imaging element **5**.

For example, in imaging the moving subject **301** by the imaging apparatus **100**, in a case where the subject **301** is moving in a horizontal direction in a view from the imaging apparatus **100**, the subject **301** may be separated from the AF area **303** as illustrated in FIG. **3**. In this case, distance measurement of the background **302** is performed in the AF area **303**. Thus, setting a focus position using a distance measurement result of the AF area **303** results in a so-called rear focusing state where the background **302** is focused.

Alternatively, as illustrated in FIG. **4**, an obstacle **401** may enter in front of the subject **301** in the AF area **303**. In this case, distance measurement of the obstacle **401** is performed in the AF area **303**. Thus, setting the focus position using the distance measurement result of the AF area **303** results in a so-called front focusing state where the obstacle **401** in front of the subject **301** is focused.

Temporally Continuous Distance Measurement Result by Imaging Apparatus **100**

FIG. **5** is a diagram illustrating an example of a temporally continuous distance measurement result by the imaging apparatus **100**. In FIG. **5**, a horizontal axis denotes time. Time points t**1**, t**2**, . . . on the horizontal axis are time points of continuous imaging frames. A vertical axis denotes a

distance from the imaging apparatus **100**, and the distance from the imaging apparatus **100** is decreased in an upward direction of the vertical axis.

A subject position change **510** is a change in the actual distance from the imaging apparatus **100** to the subject **301** along with an elapse of time. In the example in FIG. **5**, the subject **301** is initially at a constant distance from the imaging apparatus **100** and then, gradually accelerates to approach the imaging apparatus **100**.

Distance measurement results p**1** to p**11** are results of distance measurement performed using the AF area **303** at time points t**1** to t**11**, respectively. In the distance measurement results p**1**, p**3**, p**5** to p**8**, p**10**, and p**11**, distance measurement of the subject **301** is correctly performed. In the distance measurement result p**2**, the subject **301** is separated from the AF area **303** as illustrated in FIG. **3**, and distance measurement of the background **302** is performed. In the distance measurement result p**4**, the obstacle **401** enters in front of the subject **301** in the AF area **303** as illustrated in FIG. **4**, and distance measurement of the obstacle **401** is performed.

For example, the system control unit **11** has a subject holding function for avoiding setting of the focus position at which the background **302** is focused based on the distance measurement result p**2** or setting of the focus position at which the obstacle **401** is focused based on the distance measurement result p**4**. Specifically, the system control unit **11** performs a control of setting a settable range of the focus position based on the current focus position and not setting a focus position separated from the settable range.

Here, in a case where the settable range is excessively wide, the distance measurement result p**2** of the background **302** or the distance measurement result p**4** of the obstacle **401** is included in the settable range, and the background **302** or the obstacle **401** is focused. On the other hand, in a case where the settable range is excessively narrow, there is a problem that the subject **301** remains focused even in a case where the user intentionally moves the AF area **303** from the subject **301** to another subject, or the distance measurement result of the subject **301** is separated from the settable range because of rapid acceleration or the like of the subject **301**, and focus does not track the subject **301**. The system control unit **11** resolves these problems by dynamically changing the settable range.

Focus Setting Processing by System Control Unit **11**

FIG. **6** is a flowchart illustrating an example of focus setting processing by the system control unit **11**. For each continuous frame of imaging, for example, the system control unit **11** sets the focus position of imaging of the imaging unit **50** based on the processing illustrated in FIG. **6**.

Here, in the processing in FIG. **6**, the most recent frame in the past will be referred to as a second frame, a frame previous (for example, immediately previous) to the second frame will be referred to as a first frame, and a frame subsequent (for example, immediately subsequent) to the second frame will be referred to as a third frame. That is, in time series, the first frame, the second frame, and the third frame are acquired in this order by the imaging unit **50**. In this case, the system control unit **11** sets the focus position in the third frame based on the processing in FIG. **6**.

First, the system control unit **11** acquires the distance measurement result of each of the first frame and the second frame based on image data of each of the first frame and the second frame in the past (step S**61**). For example, the distance measurement result of each of the first frame and the second frame is acquired by distance measurement of a phase difference method as described above, based on the image data of each of the first frame and the second frame.

Next, the system control unit **11** determines a state or the like of the subject **301** and sets the settable range in which the focus position in the third frame can be set based on a determination result (step S**62**). The setting of the settable range in step S**62** will be described later (for example, refer to FIGS. **7**A and **7**B).

Next, the system control unit **11** temporarily calculates the focus position in the third frame based on the distance measurement result of each of the first frame and the second frame acquired in step S**61** (step S**63**). In step S**63**, for example, the system control unit **11** predicts the distance measurement result of the third frame by linear prediction or the like based on the distance measurement result of each of the first frame and the second frame and calculates a focus position corresponding to the predicted distance measurement result. The focus position temporarily calculated in step S**63** is a focus position at which the subject **301** is predicted to be focused, and is an example of distance information related to the distance between the imaging apparatus **100** and the subject **301**.

Next, the system control unit **11** determines whether or not the focus position temporarily calculated in step S**63** is included in the settable range set in step S**62** (step S**64**). In a case where the temporarily calculated focus position is included in the settable range (step S**64**: Yes), the system control unit **11** sets the temporarily calculated focus position as a target focus position in the third frame (step S**65**).

In step S**64**, in a case where the temporarily calculated focus position is not included in the settable range (step S**64**: No), the system control unit **11** sets the target focus position in the third frame within the settable range (step S**66**). For example, the system control unit **11** sets the target focus position set for the immediately previous second frame or the first frame as the target focus position in the third frame. Alternatively, the system control unit **11** may set the focus position corresponding to the distance measurement result predicted by linear prediction or the like with reference to also a frame previous to the first frame and the second frame as the target focus position in the third frame.

Next, the system control unit **11** controls the lens device **40** to set the focus position of the imaging lens **1** in imaging of the third frame to the target focus position set in step S**65** or step S**66** (step S**67**) and finishes the series of processing. For example, the control in step S**67** is performed by outputting a control signal to the lens control unit **4** by the system control unit **11**.

Setting of Settable Range by System Control Unit **11**

FIGS. **7**A and **7**B are flowcharts illustrating an example of setting the settable range by the system control unit **11**. In step S**62** illustrated in FIG. **6**, for example, the system control unit **11** sets the settable range based on the processing illustrated in FIGS. **7**A and **7**B.

First, the system control unit **11** calculates the current depth magnification (step S**701**). The depth magnification is a ratio of an amount of change in the distance between the imaging apparatus **100** and the subject **301** between frames and a depth of field, and is an example of movement distance information that is information related to the amount of change in the distance between the imaging apparatus **100** and the subject **301**.

For example, the system control unit **11** calculates the current depth magnification based on Expression (1) below. In Expression (1), an AF drive amount is the amount (absolute value) of change in the distance between the imaging apparatus **100** and the subject **301** between frames.

Specifically, the AF drive amount is a value obtained by converting a difference between the distance measurement result in the first frame and the focus position in the second frame into a drive amount of the focus lens of the imaging lens **1**. The depth of field is calculated based on an F number of the stop **2**, a focal length of the imaging lens **1**, and the distance between the imaging apparatus **100** and the subject **301**. For example, the distance between the imaging apparatus **100** and the subject **301** is the focus position in the second frame.

$$\text{Depth magnification} = \text{AF drive amount} / \text{depth of field} \quad (1)$$

Next, the system control unit **11** determines whether or not the depth magnification calculated in step **S701** is continuously less than a predetermined stoppage determination threshold value (step **S702**). For example, the system control unit **11** acquires the most recent N depth magnifications calculated in step **S701** in the past including the most recent depth magnification calculated in step **S701** and performs the determination in step **S702** by determining whether or not each of the acquired N depth magnifications is less than the stoppage determination threshold value. N is a natural number greater than or equal to 3. However, N in step **S702** is set to a sufficiently large number (for example, greater than or equal to 4) in order to be distinguished from a state, described later, where the subject is changed.

In step **S702**, in a case where the depth magnification is continuously less than a first threshold value (step **S702**: Yes), the system control unit **11** determines that a state of the subject **301** is a "stoppage" state (step **S703**). The "stoppage" state is a state where the distance between the imaging apparatus **100** and the subject **301** is almost constant as in a case where the subject **301** is stopped in one place, a case where the subject **301** is moving on a circumference centered at the imaging apparatus **100**, or the like.

In this case, the system control unit **11** sets the settable range in the third frame to a minimum value (step **S704**) and finishes the series of processing. For example, setting the settable range in the third frame to the minimum value is setting the settable range of a predetermined minimum width centered at the focus position in the immediately previous second frame as the settable range in the third frame. The minimum width is a width greater than 0.

In step **S702**, in a case where the depth magnification is not continuously less than the first threshold value (step **S702**: No), the system control unit **11** determines whether or not the depth magnification is continuously increased (step **S705**). For example, the system control unit **11** acquires the most recent N depth magnifications calculated in step **S701** in the past including the most recent depth magnification calculated in step **S701** and performs the determination in step **S705** by determining whether or not the acquired N depth magnifications are increased in chronological order.

In step **S705**, in a case where the depth magnification is continuously increased (step **S705**: Yes), the system control unit **11** determines that the state of the subject **301** is an "acceleration" state (step **S706**). The "acceleration" state is a state where the amount of change in the distance between the imaging apparatus **100** and the subject **301** is increased as in a state where the subject **301** starts running toward the imaging apparatus **100** or away from the imaging apparatus **100**, or the like.

In this case, the system control unit **11** expands the settable range in the third frame (step **S707**) and finishes the series of processing. For example, expanding the settable range in the third frame is setting a settable range that is centered at the focus position in the immediately previous second frame and is wider than the current settable range (for example, the settable range set for the second frame) as the settable range in the third frame.

In step **S705**, in a case where the depth magnification is not continuously increased (step **S705**: No), the system control unit **11** determines whether or not the depth magnification is continuously decreased (step **S708**). For example, the system control unit **11** acquires the most recent N depth magnifications calculated in step **S701** in the past including the most recent depth magnification calculated in step **S701** and performs the determination in step **S708** by determining whether or not the acquired N depth magnifications are decreased in chronological order.

In step **S708**, in a case where the depth magnification is continuously decreased (step **S708**: Yes), the system control unit **11** determines that the state of the subject **301** is a "deceleration" state (step **S709**). The "deceleration" state is a state where the amount of change in the distance between the imaging apparatus **100** and the subject **301** is decreased as in a state where the subject **301** who runs toward the imaging apparatus **100** or away from the imaging apparatus **100** starts walking, or the like.

In this case, the system control unit **11** sets the settable range in the third frame to a default value (step **S710**) and finishes the series of processing. For example, setting the settable range in the third frame to the default value is setting the settable range of a predetermined default width centered at the focus position in the immediately previous second frame as the settable range in the third frame. The default width of the settable range is a width greater than the minimum width of the settable range.

In step **S708**, in a case where the depth magnification is not continuously decreased (step **S708**: No), the system control unit **11** determines whether or not the depth magnification is continuously constant (step **S711**). For example, the system control unit **11** acquires the most recent N depth magnifications calculated in step **S701** in the past including the most recent depth magnification calculated in step **S701** and performs the determination in step **S711** by determining whether or not each difference between temporally continuous depth magnifications is less than or equal to a predetermined value.

In step **S711**, in a case where the depth magnification is continuously constant (step **S711**: Yes), the system control unit **11** determines that the state of the subject **301** is a "constant rate" state (step **S712**). The "constant rate" state is a state where the amount of change in the distance between the imaging apparatus **100** and the subject **301** is constant as in a state where the subject **301** is running or walking toward the imaging apparatus **100** or away from the imaging apparatus **100**, or the like. In this case, the system control unit **11** sets the settable range in the third frame to the default value (step **S713**) and finishes the series of processing.

In step **S711**, in a case where the depth magnification is not continuously constant (step **S711**: No), the system control unit **11** determines whether or not the distance measurement result is changed in the opposite direction (step **S714**). For example, the system control unit **11** acquires three distance measurement results within a constant period in the past from the present. In a case where the three distance measurement results are referred to as a first distance measurement result, a second distance measurement result, and a third distance measurement result in order from the oldest, the system control unit **11** determines that the distance measurement result is changed in the opposite direction in a case where the second distance measurement result is increased by a predetermined value or more from the first

distance measurement result and the third distance measurement result is decreased by a predetermined value or more from the second distance measurement result, or in a case where the second distance measurement result is decreased by a predetermined value or more from the first distance measurement result and the third distance measurement result is increased by a predetermined value or more from the second distance measurement result.

In step **S714**, in a case where the distance measurement result is changed in the opposite direction (step **S714**: Yes), the system control unit **11** determines that the state of the subject **301** is a "background distance measurement" state or an "obstacle distance measurement" state (step **S715**). In this case, the system control unit **11** sets the settable range in the third frame to the default value (step **S716**) and finishes the series of processing.

In step **S715**, the system control unit **11** determines that the state of the subject **301** is the "background distance measurement" state in a case where the second distance measurement result is increased by the predetermined value or more from the first distance measurement result and the third distance measurement result is decreased by the predetermined value or more from the second distance measurement result. For example, the "background distance measurement" state is a state where while the subject **301** is separated from the AF area **303** and distance measurement of the background **302** is performed instead of the subject **301**, the subject **301** enters the AF area **303** again and distance measurement of the subject **301** is performed.

In addition, in step **S715**, the system control unit **11** determines that the state of the subject **301** is the "obstacle distance measurement" state in a case where the second distance measurement result is decreased by the predetermined value or more from the first distance measurement result and the third distance measurement result is increased by the predetermined value or more from the second distance measurement result. For example, the "obstacle distance measurement" state is a state where while the obstacle **401** in front of the subject **301** in a view from the imaging apparatus **100** enters the AF area **303** and distance measurement of the obstacle **401** is performed instead of the subject **301**, the obstacle **401** is separated from the AF area **303** and distance measurement of the subject **301** is performed again.

In step **S714**, in a case where the distance measurement result is not changed in the opposite direction (step **S714**: No), the system control unit **11** determines whether or not the distance measurement result is continuously constant after change (step **S717**). For example, the system control unit **11** acquires four distance measurement results within a constant period in the past from the present. In a case where the four distance measurement results are referred to as a first distance measurement result, a second distance measurement result, a third distance measurement result, and a fourth distance measurement result in order from the oldest, the system control unit **11** determines that the distance measurement result is continuously constant after change in a case where a difference between the first distance measurement result and the second distance measurement result is greater than or equal to a predetermined value, a difference between the second distance measurement result and the third distance measurement result is less than or equal to a predetermined value, and a difference between the third distance measurement result and the fourth distance measurement result is less than or equal to a predetermined value.

In step **S717**, in a case where the distance measurement result is continuously constant after change (step **S717**: Yes), the system control unit **11** determines that the user has intentionally changed the subject from the subject **301** to another subject (step **S718**). In this case, the system control unit **11** expands the settable range in the third frame (step **S719**) and finishes the series of processing.

In step **S717**, in a case where the distance measurement result is not continuously constant after change (step **S717**: No), the system control unit **11** sets the settable range in the third frame to the default value (step **S720**) and finishes the series of processing.

In steps **S710**, **S713**, **S716**, and **S720**, since the subject **301** is moving, the immediately previous (for example, in the immediately previous second frame) settable range has the default value or is expanded from the default value. Accordingly, setting the settable range to the default value in steps **S710**, **S713**, **S716**, and **S720** maintains or reduces the settable range.

As illustrated in FIGS. **7**A and **7**B, in a case where the depth magnification (movement distance information) in a plurality of frames obtained by the imaging unit **50** is continuously less than a predetermined value, the system control unit **11** determines that the state of the subject **301** is the "stoppage" state and sets the settable range to the minimum value. Accordingly, a case where the subject **301** is separated from the AF area **303** and distance measurement of the background **302** is performed, or a case where the obstacle **401** enters the AF area **303** and distance measurement of the obstacle **401** is performed can be accurately detected. Thus, it is possible to suppress focusing of the background **302** or the obstacle **401** and improve tracking of the subject **301** by the focus position.

In addition, in a case where the depth magnification (movement distance information) in the plurality of frames obtained by imaging unit **50** is continuously increased, the system control unit **11** determines that the state of the subject **301** is the "acceleration" state and expands the settable range. Accordingly, it is possible to expand the settable range in a situation where the distance between the imaging apparatus **100** and the subject **301** is not easily predicted because of a change in motion of the subject **301**, and suppress separation of the focus position temporarily calculated based on the distance measurement result of each of the first frame and the second frame from the settable range because of acceleration of the subject **301**. Thus, it is possible to improve tracking of the subject **301** by the focus position.

In addition, in a case where the depth magnification (movement distance information) in the plurality of frames is continuously decreased, the system control unit **11** determines that the state of the subject **301** is the "deceleration" state and maintains or reduces the settable range. Accordingly, the settable range is maintained or reduced in a situation where the subject **301** is approaching the stoppage state, and it is possible to accurately detect a case where the subject **301** is separated from the AF area **303** and distance measurement of the background **302** is performed, or a case where the obstacle **401** enters the AF area **303** and distance measurement of the obstacle **401** is performed. Thus, it is possible to suppress focusing of the background **302** or the obstacle **401** and improve tracking of the subject **301** by the focus position.

In addition, in a case where a difference in the depth magnification (movement distance information) among the plurality of frames is within a predetermined range, the system control unit **11** determines that the state of the subject **301** is the "constant rate" state and maintains or reduces the settable range. Accordingly, the settable range is maintained

or reduced in a situation where the distance between the imaging apparatus **100** and the subject **301** is easily predicted, and it is possible to accurately detect a case where the subject **301** is separated from the AF area **303** and distance measurement of the background **302** is performed, or a case where the obstacle **401** enters the AF area **303** and distance measurement of the obstacle **401** is performed. Thus, it is possible to suppress focusing of the background **302** or the obstacle **401** and improve tracking of the subject **301** by the focus position.

In addition, in a case where a direction of change in the distance measurement result (distance information) among the plurality of frames is switched to the opposite direction, the system control unit **11** determines that the state of the subject **301** is the "background distance measurement" state or the "obstacle distance measurement" state and maintains or reduces the settable range. Accordingly, the settable range is maintained or reduced in a situation where distance measurement of the background **302** or the obstacle **401** is temporarily performed and distance measurement of the subject **301** is currently performed, and it is possible to accurately detect a case where the subject **301** is separated from the AF area **303** and distance measurement of the background **302** is performed, or a case where the obstacle **401** enters the AF area **303** and distance measurement of the obstacle **401** is performed. Thus, it is possible to suppress focusing of the background **302** or the obstacle **401** and improve tracking of the subject **301** by the focus position.

In addition, in a case where the distance measurement result (distance information) in the plurality of frames is continuously within a predetermined range after change by a predetermined value or more, the system control unit **11** determines that the subject is intentionally changed and expands the settable range. Accordingly, the settable range is expanded in a situation where the subject is changed and a new subject needs to be focused, and it is possible to suppress continuous focusing of the subject **301** before change regardless of the change of the subject.

In addition, in the processing illustrated in FIGS. **7**A and **7**B, the system control unit **11** may not use the distance measurement result separated from the set settable range in the determination or the like of the state of the subject **301**. Accordingly, for example, it is possible to suppress erroneous determination of the state of the subject **301** using the distance measurement result of the background **302** or the obstacle **401**.

While steps S**703**, S**706**, S**709**, S**712**, S**715**, and S**718** are included in processing of recognizing each state such as the "stoppage" state by the system control unit **11**, the system control unit **11** may perform the processing not including steps S**703**, S**706**, S**709**, S**712**, S**715**, and S**718** because the settable range may be set by transitioning to any of steps S**704**, S**707**, S**710**, S**713**, S**716**, and S**719** in accordance with a determination result in steps S**702**, S**705**, S**708**, S**711**, S**714**, and S**717**.

Minimization of Settable Range in "Stoppage" State

FIG. **8** is a diagram illustrating an example of minimizing the settable range in the "stoppage" state. A settable range **810** is the settable range set in step S**62** (specifically, the processing in FIGS. **7**A and **7**B) in FIG. **6**. For example, the settable range **810** is defined by a lower limit value **811** and an upper limit value **812**. That is, a range of greater than or equal to the lower limit value **811** and less than or equal to the upper limit value **812** is the settable range **810**.

In the example in FIG. **8**, the distance between the imaging apparatus **100** and the subject **301** is constant. In this case, the system control unit **11** determines that the state of the subject **301** is the "stoppage" state and sets the settable range **810** to the minimum value. Accordingly, it is possible to suppress focusing of the background **302** or the obstacle **401** and improve tracking of the subject **301** by the focus position.

Expansion of Settable Range in "Acceleration" State

FIG. **9** is a diagram illustrating an example of expanding the settable range in the "acceleration" state. In the example in FIG. **9**, the subject **301** is accelerating to approach the imaging apparatus **100**. In this case, the system control unit **11** determines that the state of the subject **301** is the "acceleration" state and expands the settable range **810**. Accordingly, it is possible to suppress separation of the distance measurement result of the subject **301** accelerating to approach the imaging apparatus **100** from the settable range **810** and improve tracking of the subject **301** by the focus position.

As described above, the system control unit **11** predicts (temporarily calculates) the focus position in the third frame subsequent to the first frame and the second frame based on the image data of the first frame and the image data of the second frame among the plurality of frames obtained by the imaging apparatus **100** (imaging unit **50**) (for example, refer to FIG. **6**).

In addition, the system control unit **11** sets the settable range that is a range of the focus position settable for the third frame based on the state of the subject **301**. Specifically, the system control unit **11** determines the state of the subject **301** based on the depth magnification (movement distance information) in the plurality of frames (for example, refer to FIGS. **7**A and **7**B).

The system control unit **11** sets the focus position of imaging in the third frame based on the predicted focus position and the set settable range (for example, refer to FIG. **6**).

Control of Focus Position in Case where it is Determined that State of Subject is "Obstacle Distance Measurement" State

FIG. **10** is a diagram illustrating an example of a control of the focus position in a case where it is determined that the state of the subject **301** is the "obstacle distance measurement" state. For example, as in the example illustrated in FIG. **10**, in a situation where the distance between the imaging apparatus **100** and the subject **301** is changing, it is assumed that the obstacle **401** temporarily enters in front of the subject **301** in the AF area **303** and distance measurement of the obstacle **401** is performed. In this case, for example, the system control unit **11** determines that the state of the subject **301** is the "obstacle distance measurement" state based on the distance measurement results p**3** to p**5**.

At this point, in a case where the system control unit **11** maintains the focus position at a time point of the distance measurement result p**3** that is before the subject **301** is hidden by the obstacle **401**, the subject **301** cannot be focused when the obstacle **401** is not present anymore between the imaging apparatus **100** and the subject **301**, because the subject **301** is moving even while the subject **301** is hidden by the obstacle **401**.

Regarding this point, the system control unit **11** predicts movement of the subject **301** based on the distance measurement results p**1** to p**3** previous to the distance measurement result p**4** that is the distance measurement result of the obstacle **401**, and moves the focus position based on a prediction result even while the subject **301** is hidden by the obstacle **401**. Thus, a state where a position close to the

subject **301** is focused when the obstacle **401** is not present anymore between the imaging apparatus **100** and the subject **301** can be set.

Erroneous Determination of Case where Distance Between Obstacle **401** and Subject **301** is Short

FIG. **11** is a diagram illustrating an example of erroneous determination in a case where a distance between the obstacle **401** and the subject **301** is short. For example, as in the example in FIG. **11**, in a case where the distance between the obstacle **401** and the subject **301** is short, setting the normal settable range **810** results in an erroneous determination that the state of the subject **301** is the "acceleration" state at a timing when the obstacle **401** in front of the subject **301** enters the AF area **303** in a situation where the obstacle **401** and the subject **301** cross. That is, an erroneous determination is easily made in a case where a position of the subject **301** is changing as illustrated by a dotted line arrow in FIG. **11**. Processing for suppressing the erroneous determination will be described using FIGS. **12**A and **12**B.

Another Example of Setting of Settable Range **810** by System Control Unit **11**

FIGS. **12**A and **12**B are flowcharts illustrating another example of setting the settable range **810** by the system control unit **11**. In step S**62** illustrated in FIG. **6**, for example, the system control unit **11** reduces the settable range based on the processing illustrated in FIGS. **12**A and **12**B.

Steps S**1201** to S**1220** illustrated in FIGS. **12**A and **12**B are the same as steps S**701** to S**720** illustrated in FIGS. **7**A and **7**B. However, in step S**1213** in a case where it is determined that the state of the subject **301** is the "constant rate" state, the system control unit **11** reduces the settable range **810** based on a depth width (step S**1213**). The depth width is a width of change in the depth magnification (drive depth width).

For example, the system control unit **11** acquires the most recent N depth magnifications calculated in step S**1201** in the past including the most recent depth magnification calculated in step S**1201** and calculates the width of change (for example, a difference between a minimum value and a maximum value) of the N depth magnifications as the depth width. As the calculated depth width is decreased, that is, as the subject **301** approaches a complete constant rate state, the system control unit **11** narrows the settable range **810**. Reduction of the settable range **810** based on the processing in FIGS. **12**A and **12** B will be described using FIG. **13**.

Reduction of Settable Range **810** Based on Depth Width

FIG. **13** is a diagram illustrating an example of reducing the settable range **810** based on the depth width. In the same situation as FIG. **10**, for example, the system control unit **11** calculates the depth width based on the distance measurement results p**1** to p**3** and reduces the settable range **810** based on the calculated depth width. Accordingly, the distance measurement result p**4** that is the distance measurement result of the obstacle **401** is separated from the settable range **810** and is not used in the determination or the like of the state of the subject **301**. Accordingly, for example, it is possible to suppress an erroneous determination that the state of the subject **301** is the "acceleration" state in the situation illustrated in FIG. **11**.

Distance Measurement Result Based on Plurality of AF Areas of Imaging Apparatus **100**

FIG. **14** is a diagram illustrating an example of the distance measurement result based on a plurality of AF areas of the imaging apparatus **100**. While processing based on the distance measurement result depending on one AF area **303** is described above, the imaging apparatus **100** may have a plurality of AF areas. In this case, a plurality of distance measurement results can be obtained for each frame.

In the example in FIG. **14**, distance measurement results p**11**, p**12**, and p**13** are obtained at time point t**1**. Distance measurement results p**21** and p**22** are obtained at time point t**2**. Distance measurement results p**31**, p**32**, and p**33** are obtained at time point t**3**. Distance measurement results p**41**, p**42**, and p**43** are obtained at time point t**4**.

For example, in predictive AF in which imaging is performed while a future motion of the subject that is a moving object is predicted, which subject is to be determined as a main subject is an objective. Regarding such an objective, in a general digital camera, there is a system for causing the user to select which AF area such as front priority, center priority, and auto is to be preferentially used in a customized manner. As illustrated in FIG. **15** to FIG. **20** described below, the imaging apparatus **100** includes a system for automatically selecting the main subject to a certain extent.

Plurality of AF Areas of Imaging Apparatus **100**

FIG. **15** is a diagram illustrating an example of the plurality of AF areas of the imaging apparatus **100**. For example, the imaging apparatus **100** may have AF areas **151** to **159**. The AF areas **151** to **159** are arranged in a 3×3 matrix, and the AF area **155** is a center area. The AF area **155** is an example of a first area near a center among the AF areas **151** to **159**. The AF areas **151** to **154** and **156** to **159** are an example of a second area around the first area.

A subject **150** is a subject of imaging of the imaging apparatus **100** and is a flying bird in the example in FIG. **15**. The distance between the subject **150** that is a bird and the imaging apparatus **100** is different depending on parts of the subject **150**. Thus, the distance measurement results of the AF areas **151** to **159** are different from each other.

The system control unit **11** sets an AF area of a part of the AF areas **151** to **159** as a priority area and performs each processing (for example, the processing in FIG. **6**) described above using the distance measurement result of the set priority area as the distance measurement result of a frame of the priority area. Alternatively, the system control unit **11** performs each processing (for example, the processing in FIG. **6**) described above using the distance measurement result calculated by preferentially considering the distance measurement result of the priority area as the distance measurement result of the frame of the priority area.

In this case, using the distance measurement result in which the distance from the imaging apparatus **100** is the smallest among the distance measurement results of the AF areas **151** to **159** is considered. However, in a case where there is a branch of a tree between the subject **150** and the imaging apparatus **100** and the branch of the tree enters any of the AF areas **151** to **159**, the branch of the tree is focused. In addition, for example, in a case where the subject **150** is a person standing on the ground, the ground is focused in a case where the ground between the subject **150** and the imaging apparatus **100** enters any of the AF areas **151** to **159**.

In addition, while using a center distance or the like of a distance range in which a large number of distance measurement results among the distance measurement results of the AF areas **151** to **159** are distributed is considered, there is a problem of front focusing or rear focusing.

Processing of Setting Priority Area by System Control Unit **11**

FIG. **16** is a flowchart illustrating an example of processing of setting the priority area by the system control unit **11**. For each continuous frame of imaging, for example, the

system control unit **11** sets the priority area from the AF areas **151** to **159** based on the processing illustrated in FIG. **16**.

First, the system control unit **11** performs distance measurement of the AF areas **151** to **159** (step S**161**). Next, the system control unit **11** determines whether or not the distance measurement result of the AF area **155** that is the center area is the shortest based on the distance measurement result of each of the AF areas **151** to **159** obtained in step S**161** (step S**162**). Specifically, the system control unit **11** determines whether or not the distance measurement result of the AF area **155** is the shortest by determining whether or not the distance measurement result of the AF area **155** indicates the shortest distance among the distance measurement results of the AF areas **151** to **159**.

In step S**162**, in a case where the distance measurement result of the AF area **155** is the shortest (step S**162**: Yes), the system control unit **11** sets the AF area **155** as the priority area (step S**163**) and finishes the series of processing.

In step S**162**, in a case where the distance measurement result of the AF area **155** is not the shortest (step S**162**: No), the system control unit **11** determines whether or not rear focusing is performed in the AF area **155** that is the center area and there is a surrounding area in which a distance measurement result close to the previous distance measurement result (for example, the distance measurement result of the previous priority area) is obtained among the AF areas **151** to **154** and **156** to **159** that are surrounding areas (step S**164**). The current distance measurement result is the distance measurement result of the second frame (for example, the most recent frame in the past). The previous distance measurement result is the distance measurement result of the first frame (for example, the frame immediately previous to the second frame).

In step S**164**, for example, the system control unit **11** determines whether or not rear focusing is performed in the AF area **155** by determining whether or not the distance measurement result of the AF area **155** is greater than a reference value based on the distance measurement result of each of the AF areas **151** to **154** and **156** to **159** by a predetermined degree or more. For example, the reference value based on the distance measurement result of each of the AF areas **151** to **154** and **156** to **159** may be an average value of the distance measurement results of the AF areas **151** to **154** and **156** to **159** or a minimum value of the distance measurement results of the AF areas **151** to **154** and **156** to **159**.

In addition, for each of the AF areas **151** to **154** and **156** to **159**, the system control unit **11** determines whether or not the current distance measurement result is close to the previous distance measurement result by determining whether or not a difference between the current distance measurement result and the previous distance measurement result (for example, the distance measurement result of the previous priority area) is less than a predetermined value.

In step S**164**, in a case where rear focusing is performed in the AF area **155** and there is a surrounding area in which the distance measurement result close to the previous distance measurement result is obtained, the surrounding area is set as the priority area (step S**165**), and the series of processing is finished. Accordingly, in a case where the AF area **155** cannot be used because of rear focusing in the AF area **155**, a surrounding area in which a distance measurement result close to the previous distance measurement result is obtained, that is, a surrounding area in which a possibility that the same part as in the previous priority area out of the subject **150** has entered is high, can be set as the priority area. In a case where there are a plurality of surrounding areas in which a distance measurement result close to the previous distance measurement result is obtained, the system control unit **11** sets the surrounding area in which a distance measurement result closest to the previous distance measurement result is obtained as the priority area.

In step S**164**, in a case where rear focusing is not performed in the AF area **155** or there is no surrounding area in which a distance measurement result close to the previous distance measurement result is obtained (step S**164**: No), the system control unit **11** determines whether or not the current distance measurement result of the AF area **155** that is the center area is close to the previous distance measurement result (for example, the distance measurement result of the previous priority area) and there is a surrounding area in which the distance measurement result is close to the AF area **155** among the AF areas **151** to **154** and **156** to **159** that are surrounding areas (step S**166**).

In step S**166**, for example, the system control unit **11** determines whether or not the current distance measurement result of the AF area **155** is close to the previous distance measurement result by determining whether or not a difference between the previous distance measurement result (for example, the distance measurement result of the previous priority area) and the current distance measurement result of the AF area **155** is less than a predetermined value. In addition, the system control unit **11** determines whether or not the distance measurement result is close to the AF area **155** for each of the AF areas **151** to **154** and **156** to **159** as a target surrounding area by determining whether or not a difference between the current distance measurement result of the AF area **155** and the current distance measurement result of the target surrounding area is less than a predetermined value.

In step S**166**, in a case where the current distance measurement result of the AF area **155** is close to the previous distance measurement result and there is a surrounding area in which the distance measurement result is close to the AF area **155** (step S**166**: Yes), the system control unit **11** sets the surrounding area as the priority area (step S**167**) and finishes the series of processing. Accordingly, in a case where the AF area **155** is not the shortest but is close to the previous distance measurement result, the surrounding area in which the distance measurement result is close to the AF area **155** can be set as the priority area. In a case where there are a plurality of surrounding areas in which the distance measurement result is close to the AF area **155**, the system control unit **11** sets the surrounding area in which the distance measurement result is the closest to the AF area **155** as the priority area.

In step S**166**, in a case where the current distance measurement result of the AF area **155** is not close to the previous distance measurement result or there is no surrounding area in which the distance measurement result is close to the AF area **155** (step S**166**: No), the system control unit **11** sets the AF area **155** that is the center area as the priority area (step S**168**) and finishes the series of processing.

For example, in the processing illustrated in FIG. **6**, the system control unit **11** uses the distance measurement result of the priority area set based on FIG. **17** among the distance measurement results of the AF areas **151** to **159** as the distance measurement result of a target frame. Alternatively, in the processing illustrated in FIG. **6**, the system control unit **11** may use the distance measurement result calculated

by preferentially considering the distance measurement result of the priority area as the distance measurement result of the target frame.

Acquisition of Distance Measurement Result of Priority Area

FIG. **17** to FIG. **20** are diagrams illustrating an example of acquiring the distance measurement result of the priority area. In FIG. **17**, the distance measurement result p**1** at time point t**1** is the distance measurement result of the priority area selected for time point t**1** from the AF areas **151** to **159** based on the processing in FIG. **16**. The distance measurement result p**2** at time point t**2** is the distance measurement result of the priority area selected for time point t**2** from the AF areas **151** to **159** based on the processing in FIG. **16**. The distance measurement result p**3** at time point t**3** is the distance measurement result of the priority area selected for time point t**3** from the AF areas **151** to **159** based on the processing in FIG. **16**.

FIG. **18** to FIG. **20** illustrate an example of a positional relationship between the AF areas **151** to **159** and the subject **150** at time points t**1** to t**3**, respectively. In FIG. **18** to FIG. **20**, the AF area selected as the priority area among the AF areas **151** to **159** is illustrated by a thick line.

As illustrated in FIG. **18**, at time point t**1**, a part of the subject **150** (for example, a beak of the bird) closest to the imaging apparatus **100** has entered the AF area **155**. In this case, in the processing in FIG. **16**, the AF area **155** that is the center area is determined to be the shortest, and the AF area **155** is set as the priority area in step S**163**. In this case, the distance measurement result p**1** at time point t**1** in FIG. **17** is the distance measurement result of the AF area **155** at time point t**1**.

As illustrated in FIG. **19**, at time point t**2**, a state where the subject **150** has not entered the AF area **155** and rear focusing is performed in the AF area **155** occurs. In addition, it is assumed that the distance measurement result of the AF area **151** at time point t**2** is close to the measurement result at time point t**1** (distance measurement result of time point t**1** of the AF area **155** set as the priority area at time point t**1**). In this case, in the processing in FIG. **16**, the AF area **151** is set as the priority area in step S**165**. In this case, the distance measurement result p**2** at time point t**2** in FIG. **17** is the distance measurement result of the AF area **151** at time point t**2**.

As illustrated in FIG. **20**, it is assumed that at time point t**3**, the distance measurement result of the AF area **155** is close to the measurement result at time point t**2** (distance measurement result of time point t**2** of the AF area **151** set as the priority area at time point t**2**). In addition, it is assumed that the distance measurement result of the AF area **158** is close to the distance measurement result of the AF area **155**. In this case, in the processing in FIG. **16**, the AF area **158** is set as the priority area in step S**167**. In this case, the distance measurement result p**3** at time point t**3** in FIG. **17** is the distance measurement result of the AF area **158** at time point t**3**.

As illustrated in FIG. **14** to FIG. **20**, the system control unit **11** sets the target focus position of the third frame based on the current (second frame) distance measurement result of each of the AF areas **151** to **159** and the previous (first frame) distance measurement result of each of the AF areas **151** to **159**. Accordingly, by using distance measurement results in time series in the past, the target focus position of the third frame can be set using an appropriate distance measurement result among the distance measurement results of the AF areas **151** to **159**. Thus, it is possible to improve tracking of the subject **150** by the focus position.

The system control unit **11** sets the target focus position of the third frame based on a comparison between the distance measurement result (distance information) of the AF area **155** (first area near the center) among the AF areas **151** to **159** (plurality of areas) and the distance measurement results of the AF areas **151** to **154** and **156** to **159** (surrounding second area) among the AF areas **151** to **159**. Accordingly, the target focus position of the third frame can be set using an appropriate distance measurement result among the distance measurement results of the AF areas **151** to **154** and **156** to **159** in accordance with a relationship with the distance measurement result of the AF area **155** that is generally set to the subject **150**. Thus, it is possible to improve tracking of the subject **150** by the focus position.

## MODIFICATION EXAMPLE 1

While the depth magnification calculated based on Expression (1) is described as an example of the movement distance information that is information related to the amount of change in the distance between the imaging apparatus **100** and the subject, the movement distance information is not limited to the depth magnification. For example, the movement distance information may be the AF drive amount in Expression (1).

In addition, the movement distance information may be an angle formed between a combined vector of an AF drive amount vector and a depth of field vector, and the depth of field vector. The AF drive amount vector is a vector indicating the AF drive amount in Expression (1). The depth of field vector is a vector indicating the depth of field in Expression (1). Accordingly, a range in which the movement distance information may be acquired is restricted to a constant range, and design of a threshold value or the like in determining the state or the like of the subject **301** is easily performed.

## MODIFICATION EXAMPLE 2

In the embodiment, while a case of using the phase difference method as a distance measurement method (AF method) is described, a contrast method used in contrast AF may be configured to be used as the distance measurement method. In addition, a hybrid method in which the phase difference method and the contrast method are combined may be configured to be used as the distance measurement method.

## MODIFICATION EXAMPLE 3

The imaging apparatus according to the embodiment of the present invention is not limited to the imaging apparatus **100** of which a main application is imaging, and can also be applied to various information terminals having an imaging function, such as a smartphone, a tablet terminal, and a laptop personal computer. Next, a configuration of a smartphone **200** that is another embodiment of the imaging apparatus according to the present invention will be described.

Exterior of Smartphone **200**

FIG. **21** illustrates an exterior of the smartphone **200**. The smartphone **200** illustrated in FIG. **21** includes a casing **201** having a flat plate shape and comprises a display and input unit **204** in which a display panel **202** as a display unit and an operation panel **203** as an input unit are integrated on one surface of the casing **201**.

The casing **201** comprises a speaker **205**, a microphone **206**, an operation unit **207**, and a camera unit **208**. The configuration of the casing **201** is not limited thereto and may employ, for example, a configuration in which the display unit and the input unit are independently disposed, or a configuration that has a folded structure or a sliding mechanism.

Configuration of Smartphone **200**

FIG. **22** is a block diagram illustrating a configuration of the smartphone **200**.

As illustrated in FIG. **22**, a wireless communication unit **210**, the display and input unit **204**, a call unit **211**, the operation unit **207**, the camera unit **208**, a storage unit **212**, an external input-output unit **213**, a global navigation satellite system (GNSS) reception unit **214**, a motion sensor unit **215**, a power supply unit **216**, and a main control unit **220** are comprised as main constituents of the smartphone.

In addition, a wireless communication function of performing mobile wireless communication with a base station apparatus BS, not illustrated, through a mobile communication network NW, not illustrated, is provided as a main function of the smartphone **200**.

The wireless communication unit **210** performs wireless communication with the base station apparatus BS included in the mobile communication network NW in accordance with an instruction from the main control unit **220**. By using the wireless communication, transmission and reception of various file data such as voice data and image data, electronic mail data, or the like and reception of web data, streaming data, or the like are performed.

The display and input unit **204** is a so-called touch panel that visually delivers information to the user by displaying images (still images and motion images), text information, or the like and detects a user operation with respect to the displayed information under control of the main control unit **220**. The display and input unit **204** comprises the display panel **202** and the operation panel **203**.

A liquid crystal display (LCD), an organic electro-luminescence display (OELD), or the like is used as a display device in the display panel **202**.

The operation panel **203** is a device that is placed such that an image displayed on the display surface of the display panel **202** can be visually recognized, is operated by a finger of the user or a stylus, and detects one or a plurality of coordinates. In a case where the device is operated by the finger of the user or the stylus, a detection signal generated by the operation is output to the main control unit **220**. Next, the main control unit **220** detects an operation position (coordinates) on the display panel **202** based on the received detection signal.

As illustrated in FIG. **22**, the display panel **202** and the operation panel **203** of the smartphone **200** illustrated as the imaging apparatus according to one embodiment of the present invention are integrated and constitute the display and input unit **204**. The operation panel **203** is arranged to completely cover the display panel **202**.

In a case where such arrangement is employed, the operation panel **203** may have a function of detecting the user operation even in a region outside the display panel **202**. In other words, the operation panel **203** may comprise a detection region (hereinafter, referred to as a display region) for an overlapping part overlapping with the display panel **202** and a detection region (hereinafter, referred to as a non-display region) for an outer edge portion other than the overlapping part that does not overlap with the display panel **202**.

A size of the display region and a size of the display panel **202** may completely match, but both sizes do not need to match. In addition, the operation panel **203** may comprise two sensitive regions of the outer edge portion and an inner part other than the outer edge portion. Furthermore, a width of the outer edge portion is appropriately designed depending on a size and the like of the casing **201**.

Furthermore, as a position detection method employed in the operation panel **203**, a matrix switch method, a resistive film method, a surface acoustic wave method, an infrared method, an electromagnetic induction method, an electrostatic capacitive method, and the like are exemplified, and any of the methods can be employed.

The call unit **211** comprises the speaker **205** or the microphone **206** and converts voice of the user input through the microphone **206** into voice data processable in the main control unit **220** and outputs the voice data to the main control unit **220**, or decodes voice data received by the wireless communication unit **210** or the external input-output unit **213** and outputs the decoded voice data from the speaker **205**.

In addition, as illustrated in FIG. **21**, for example, the speaker **205** can be mounted on the same surface as a surface on which the display and input unit **204** is disposed, and the microphone **206** can be mounted on a side surface of the casing **201**.

The operation unit **207** is a hardware key that uses a key switch or the like, and receives an instruction from the user. For example, as illustrated in FIG. **21**, the operation unit **207** is a push-button type switch that is mounted on a side surface of the casing **201** of the smartphone **200** and is set to an ON state in a case where the switch is pressed by the finger or the like, and set to an OFF state by restoring force of a spring or the like in a case where the finger is released.

In the storage unit **212**, a control program and control data of the main control unit **220**, application software, address data in which a name, a telephone number, or the like of a communication counterpart is associated, transmitted and received electronic mail data, web data downloaded by web browsing, and downloaded contents data are stored, and streaming data or the like is temporarily stored. In addition, the storage unit **212** is configured with an internal storage unit **217** incorporated in the smartphone and an external storage unit **218** that includes a slot for an attachable and detachable external memory.

Each of the internal storage unit **217** and the external storage unit **218** constituting the storage unit **212** is implemented using a storage medium such as a memory (for example, a MicroSD (registered trademark) memory) of a flash memory type, a hard disk type, a multimedia card micro type, or a card type, a random access memory (RAM), or a read only memory (ROM).

The external input-output unit **213** is an interface with all external apparatuses connected to the smartphone **200** and is directly or indirectly connected to other external apparatuses by communication (for example, Universal Serial Bus (USB), Institute of Electrical and Electronics Engineers (IEEE) 1394, Bluetooth (registered trademark), radio frequency identification (RFID), infrared communication (Infrared Data Association (IrDA) (registered trademark)), Ultra Wideband (UWB) (registered trademark), or ZigBee (registered trademark)) or through a network (for example, the Ethernet (registered trademark) or a wireless local area network (LAN)).

For example, the external apparatuses connected to the smartphone **200** include a wired/wireless headset, a wired/wireless external charger, a wired/wireless data port, a

memory card and a subscriber identity module (SIM)/user identity module (UIM) card connected through a card socket, an external audio and video apparatus connected through an audio and video input/output (I/O) terminal, a wirelessly connected external audio and video apparatus, a smartphone connected in a wired/wireless manner, a personal computer connected in a wired/wireless manner, and an earphone.

The external input-output unit **213** can deliver data transferred from the external apparatuses to each constituent in the smartphone **200** or transfer data in the smartphone **200** to the external apparatuses.

The GNSS reception unit **214** receives GNSS signals transmitted from GNSS satellites ST**1** to STn, executes positioning computation based on the received plurality of GNSS signals, and detects a position that includes a latitude, a longitude, and an altitude of the smartphone **200** in accordance with an instruction from the main control unit **220**. In a case where positional information can be acquired from the wireless communication unit **210** or the external input-output unit **213** (for example, a wireless LAN), the GNSS reception unit **214** can detect the position using the positional information.

The motion sensor unit **215** comprises, for example, a three-axis acceleration sensor and detects a physical motion of the smartphone **200** in accordance with an instruction from the main control unit **220**. By detecting the physical motion of the smartphone **200**, a movement direction or an acceleration of the smartphone **200** is detected. A detection result is output to the main control unit **220**.

The power supply unit **216** supplies power stored in a battery (not illustrated) to each unit of the smartphone **200** in accordance with an instruction from the main control unit **220**.

The main control unit **220** comprises a microprocessor, operates in accordance with the control program and the control data stored in the storage unit **212**, and manages and controls each unit of the smartphone **200**. The microprocessor of the main control unit **220** has the same function as the system control unit **11**. In addition, the main control unit **220** has a mobile communication control function of controlling each unit of a communication system and an application processing function for performing voice communication or data communication through the wireless communication unit **210**.

The application processing function is implemented by operating the main control unit **220** in accordance with the application software stored in the storage unit **212**. For example, the application processing function is an infrared communication function of performing data communication with an opposing apparatus by controlling the external input-output unit **213**, an electronic mail function of transmitting and receiving electronic mails, or a web browsing function of browsing a web page.

In addition, the main control unit **220** has an image processing function such as displaying an image on the display and input unit **204** based on image data (data of a still image or a motion image) such as reception data or downloaded streaming data.

The image processing function refers to a function of causing the main control unit **220** to decode the image data, perform image processing on the decoding result, and display an image on the display and input unit **204**.

Furthermore, the main control unit **220** executes a display control for the display panel **202** and an operation detection control for detecting the user operation through the operation unit **207** and the operation panel **203**.

By executing the display control, the main control unit **220** displays an icon for starting the application software or a software key such as a scroll bar or displays a window for creating an electronic mail. The scroll bar refers to a software key for receiving an instruction to move a display part of a large image or the like that does not fit in the display region of the display panel **202**.

In addition, by executing the operation detection control, the main control unit **220** detects the user operation through the operation unit **207**, receives an operation with respect to the icon and an input of a text string in an input field of the window through the operation panel **203**, or receives a request for scrolling the display image through the scroll bar.

Furthermore, by executing the operation detection control, the main control unit **220** is provided with a touch panel control function of determining whether the operation position on the operation panel **203** is in the overlapping part (display region) overlapping with the display panel **202** or the other outer edge portion (non-display region) not overlapping with the display panel **202** and controlling the sensitive region of the operation panel **203** or a display position of the software key.

In addition, the main control unit **220** can detect a gesture operation with respect to the operation panel **203** and execute a preset function depending on the detected gesture operation.

The gesture operation is not a simple touch operation in the related art and means an operation of drawing a trajectory by the finger or the like, designating a plurality of positions at the same time, or drawing a trajectory for at least one of the plurality of positions as a combination thereof.

The camera unit **208** includes the imaging unit **50** in the imaging apparatus **100** illustrated in FIG. **1**.

Captured image data generated by the camera unit **208** can be stored in the storage unit **212** or be output through the external input-output unit **213** or the wireless communication unit **210**.

In the smartphone **200** illustrated in FIG. **21**, the camera unit **208** is mounted on the same surface as the display and input unit **204**. However, a mount position of the camera unit **208** is not limited thereto. The camera unit **208** may be mounted on a rear surface of the display and input unit **204**.

In addition, the camera unit **208** can be used in various functions of the smartphone **200**. For example, an image acquired by the camera unit **208** can be displayed on the display panel **202**, or the image of the camera unit **208** can be used as one of operation inputs of the operation panel **203**.

In addition, in a case where the GNSS reception unit **214** detects the position, the position can be detected by referring to the image from the camera unit **208**. Furthermore, by referring to the image from the camera unit **208**, an optical axis direction of the camera unit **208** of the smartphone **200** can be determined, or the current usage environment can be determined without using the three-axis acceleration sensor or by using the three-axis acceleration sensor together. The image from the camera unit **208** can also be used in the application software.

Besides, image data of a still picture or a motion picture to which the positional information acquired by the GNSS reception unit **214**, voice information (may be text information acquired by performing voice to text conversion by the main control unit or the like) acquired by the microphone **206**, posture information acquired by the motion sensor unit **215**, or the like is added can be stored in the storage unit **212** or be output through the external input-output unit **213** or the wireless communication unit **210**.

Even in the smartphone **200** having the above configuration, it is possible to improve tracking of the subject by the focus position as in the imaging apparatus **100**.

As described above, the following matters are disclosed in the present specification.

(1) A control device that controls an imaging apparatus, the control device comprising a processor, in which the processor is configured to, based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, predict distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame, and set a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame based on a state of the subject.

(2) The control device according to (1), in which the processor is configured to set the focus position in the third frame based on the predicted distance information in the third frame and the set settable range.

(3) The control device according to (1) or (2), in which the processor is configured to, based on image data of the plurality of frames, acquire movement distance information that is information related to an amount of change in the distance between the imaging apparatus and the subject, and set the settable range for the third frame based on the movement distance information in the plurality of frames.

(4) The control device according to (3), in which the processor is configured to set the settable range for the third frame based on a difference in the movement distance information among the plurality of frames.

(5) The control device according to (3) or (4), in which the processor is configured to expand the settable range in a case where the movement distance information in the plurality of frames is increased.

(6) The control device according to any one of (3) to (5), in which the processor is configured to maintain or reduce the settable range in a case where the movement distance information in the plurality of frames is decreased.

(7) The control device according to any one of (3) to (6), in which the processor is configured to maintain or reduce the settable range in a case where a difference in the movement distance information among the plurality of frames is within a predetermined range.

(8) The control device according to any one of (3) to (7), in which the processor is configured to maintain or reduce the settable range in a case where a direction of change in the distance information among the plurality of frames is switched to an opposite direction.

(9) The control device according to any one of (3) to (8), in which the processor is configured to expand the settable range in a case where the distance information in the plurality of frames is within a predetermined range after change by a predetermined value or more.

(10) The control device according to any one of (3) to (9), in which the movement distance information is a ratio of an amount of change in the distance of the imaging apparatus and the subject between frames and a depth of field.

(11) The control device according to any one of (1) to (10), in which the processor is configured to acquire a plurality of pieces of the distance information corresponding to a plurality of areas of an image represented by the image data and predict the distance information of the third frame based on the plurality of pieces of distance information of the first frame and the plurality of pieces of distance information of the second frame.

(12) The control device according to (11), in which the processor is configured to predict the distance information of the third frame based on a comparison between the distance information of a first area near a center among the plurality of areas and the distance information of a second area around the first area among the plurality of areas.

(13) An imaging apparatus comprising the control device according to any one of (1) to (12).

(14) A control method by a control device that includes a processor and controls an imaging apparatus, the control method comprising predicting, by the processor, based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame, and setting, by the processor, a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame based on a state of the subject.

(15) A control program of a control device that includes a processor and controls an imaging apparatus, the control program causing the processor to execute a process comprising predicting, based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame, and setting a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame based on a state of the subject.

The present invention is particularly applied to a digital camera or the like to provide high convenience and effectiveness.

## EXPLANATION OF REFERENCES

**1**: imaging lens
**4**: lens control unit
**5**: imaging element
**8**: lens drive unit
**9**: stop drive unit
**10**: imaging element drive unit
**11**: system control unit
**14**, **207**: operation unit
**15**: memory control unit
**16**: memory
**17**: digital signal processing unit
**20**: external memory control unit
**21**: recording medium
**22**: display device
**22***a*: display controller
**22***b*: display surface
**24**: control bus
**25**: data bus
**40**: lens device
**50**: imaging unit
**60**: imaging surface
**61**: pixel
**61***a*: normal pixel
**61***b*, **61***c*: distance measurement pixel
**62**, **63**: pixel line
**64**: drive circuit

**65**: signal processing circuit
**100**: imaging apparatus
**100**A: main body unit
**150**, **301**: subject
**151** to **159**, **303**: AF area
**200**: smartphone
**201**: casing
**202**: display panel
**203**: operation panel
**204**: display and input unit
**205**: speaker
**206**: microphone
**208**: camera unit
**210**: wireless communication unit
**211**: call unit
**212**: storage unit
**213**: external input-output unit
**214**: GNSS reception unit
**215**: motion sensor unit
**216**: power supply unit
**217**: internal storage unit
**218**: external storage unit
**220**: main control unit
**300**: image
**302**: background
**401**: obstacle
**510**: subject position change
**810**: settable range
**811**: lower limit value
**812**: upper limit value
ST**1** to STn: GNSS satellite

What is claimed is:

**1**. A control device that controls an imaging apparatus, the control device comprising:
a processor,
wherein the processor is configured to:
based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, predict distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame;
based on image data of the plurality of frames, acquire movement distance information that is a ratio of a depth of field and an amount of change, in the distance between the imaging apparatus and the subject, between frames; and
based on the movement distance information in the plurality of frames, set a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame.

**2**. The control device according to claim **1**,
wherein the processor is configured to:
set the focus position in the third frame based on the predicted distance information in the third frame and the set settable range.

**3**. The control device according to claim **1**,
wherein the processor is configured to:
set the settable range for the third frame based on a difference in the movement distance information among the plurality of frames.

**4**. The control device according to claim **1**,
wherein the processor is configured to:
expand the settable range in a case where the movement distance information in the plurality of frames is increased.

**5**. The control device according to claim **1**,
wherein the processor is configured to:
maintain or reduce the settable range in a case where the movement distance information in the plurality of frames is decreased.

**6**. The control device according to claim **1**,
wherein the processor is configured to:
maintain or reduce the settable range in a case where a difference in the movement distance information among the plurality of frames is within a predetermined range.

**7**. The control device according to claim **1**,
wherein the processor is configured to:
maintain or reduce the settable range in a case where a direction of change in the distance information among the plurality of frames is switched to an opposite direction.

**8**. The control device according to claim **1**,
wherein the processor is configured to:
expand the settable range in a case where the distance information in the plurality of frames is within a predetermined range after change by a predetermined value or more.

**9**. The control device according to claim **1**,
wherein the processor is configured to:
acquire a plurality of pieces of the distance information corresponding to a plurality of areas of an image represented by the image data and predict the distance information of the third frame based on the plurality of pieces of distance information of the first frame and the plurality of pieces of distance information of the second frame.

**10**. The control device according to claim **9**,
wherein the processor is configured to:
predict the distance information of the third frame based on a comparison between the distance information of a first area near a center among the plurality of areas and the distance information of a second area around the first area among the plurality of areas.

**11**. An imaging apparatus comprising:
the control device according to claim **1**.

**12**. A control method by a control device that includes a processor and controls an imaging apparatus, the control method comprising:
predicting, by the processor, based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, distance information related to a distance between the imaging apparatus and a subject in a third frame subsequent to the first frame and the second frame;
acquiring, by the processor, based on image data of the plurality of frames, movement distance information that is a ratio of a depth of field and an amount of change, in the distance between the imaging apparatus and the subject, between frames; and
setting, by the processor, a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame based on the movement distance information in the plurality of frames.

**13**. A non-transitory computer readable medium storing a control program of a control device that includes a processor and controls an imaging apparatus, the control program causing the processor to execute a process comprising:
predicting, based on image data of a first frame and image data of a second frame among a plurality of frames obtained by the imaging apparatus, distance information related to a distance between the imaging appara-

tus and a subject in a third frame subsequent to the first frame and the second frame;

acquiring, based on image data of the plurality of frames, movement distance information that is a ratio of a depth of field and an amount of change, in the distance between the imaging apparatus and the subject, between frames; and

setting, based on the movement distance information in the plurality of frames, a settable range that is a range of a focus position of imaging of the imaging apparatus settable for the third frame.

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