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Tsuchiya

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(54) **CAMERA SYSTEM**

(71) Applicant: **OLYMPUS CORPORATION**, Hachioji-shi, Tokyo (JP)

(72) Inventor: **Hitoshi Tsuchiya**, Tokyo (JP)

(73) Assignee: **OLYMPUS CORPORATION**, Tokyo (JP)

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H04N 5/232 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 5/23287*** (2013.01); ***G03B 5/00*** (2013.01); ***G03B 17/14*** (2013.01); ***H04N 5/2254*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04N 5/23264; H04N 5/2328; H04N 5/23287
(Continued)

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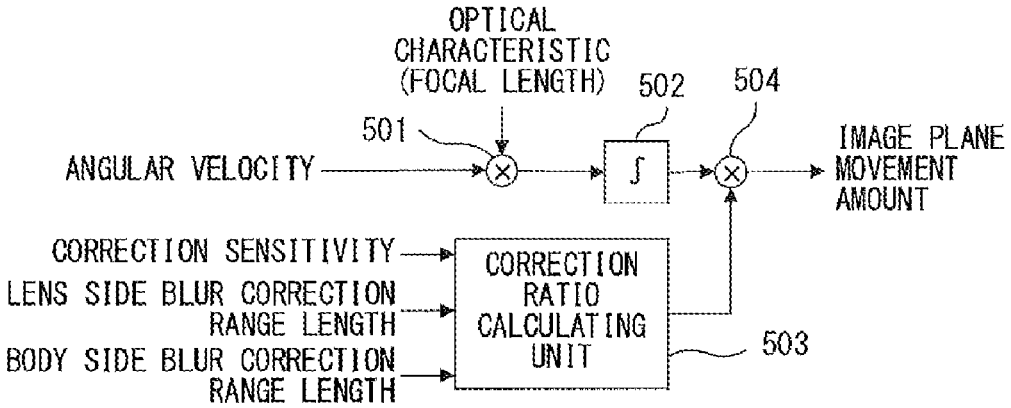
Primary Examiner — Anthony J Daniels
(74) *Attorney, Agent, or Firm* — Volpe and Koenig, P.C.

(57) **ABSTRACT**

In a camera system that includes a lens unit and a camera body, the camera body includes a blur correcting unit that performs blur correction in a plurality of directions, and a determining unit that determines whether the lens unit mounted onto the camera body is a lens unit that performs the blur correction in the plurality of directions. When the determining unit determines that the mounted lens unit is the lens unit that performs the blur correction in the plurality of directions, the camera body performs the blur correction in the plurality of directions at a camera body side blur correction ratio, and the lens unit performs the blur correction in the plurality of directions at a lens unit side blur correction ratio.

5 Claims, 11 Drawing Sheets



(51) **Int. Cl.**

G03B 5/00	(2006.01)
G03B 17/14	(2006.01)
H04N 5/225	(2006.01)

(52) **U.S. Cl.**
CPC ***H04N 5/23209*** (2013.01); ***H04N 5/23258*** (2013.01); *G03B 2205/0007* (2013.01)

(58) **Field of Classification Search**
USPC 348/208.5
See application file for complete search history.

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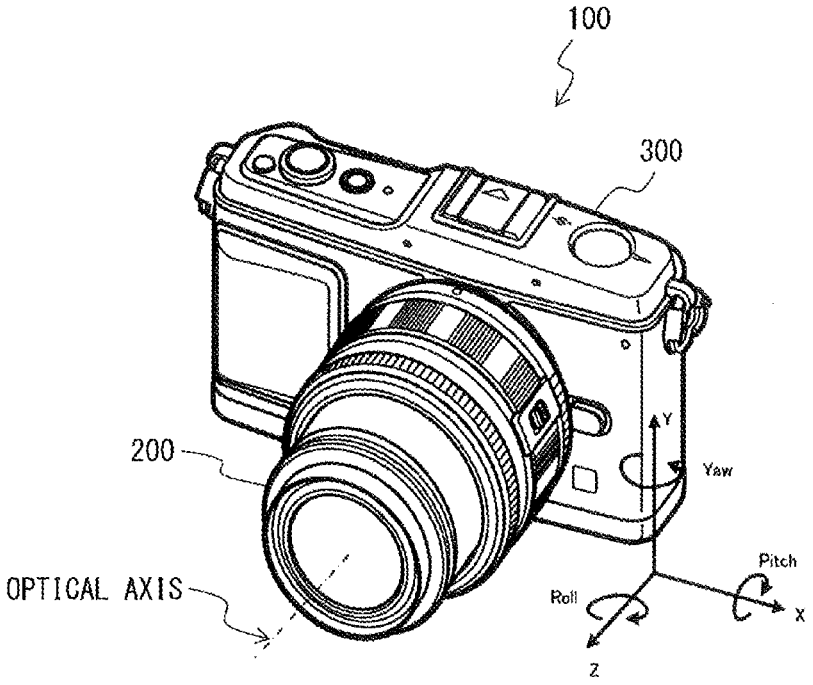

FIG. 1

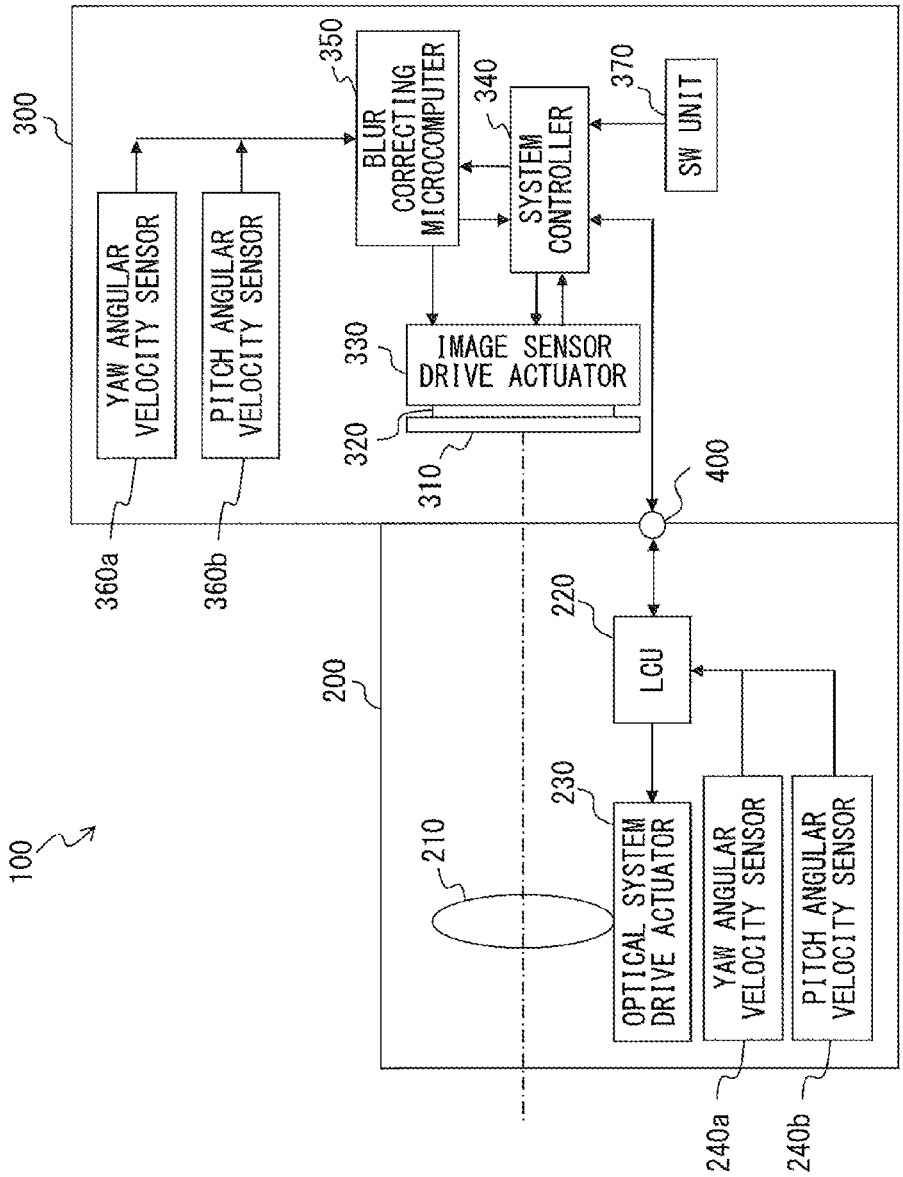
100
200
210
220
230
240a
240b
300
310
320
330
340
350
360a
360b
370
400
LCU
OPTICAL SYSTEM DRIVE ACTUATOR
YAW ANGULAR VELOCITY SENSOR
PITCH ANGULAR VELOCITY SENSOR
BLUR CORRECTING MICROCOMPUTER
SYSTEM CONTROLLER
SW UNIT
IMAGE SENSOR DRIVE ACTUATOR
YAW ANGULAR VELOCITY SENSOR
PITCH ANGULAR VELOCITY SENSOR

FIG. 2

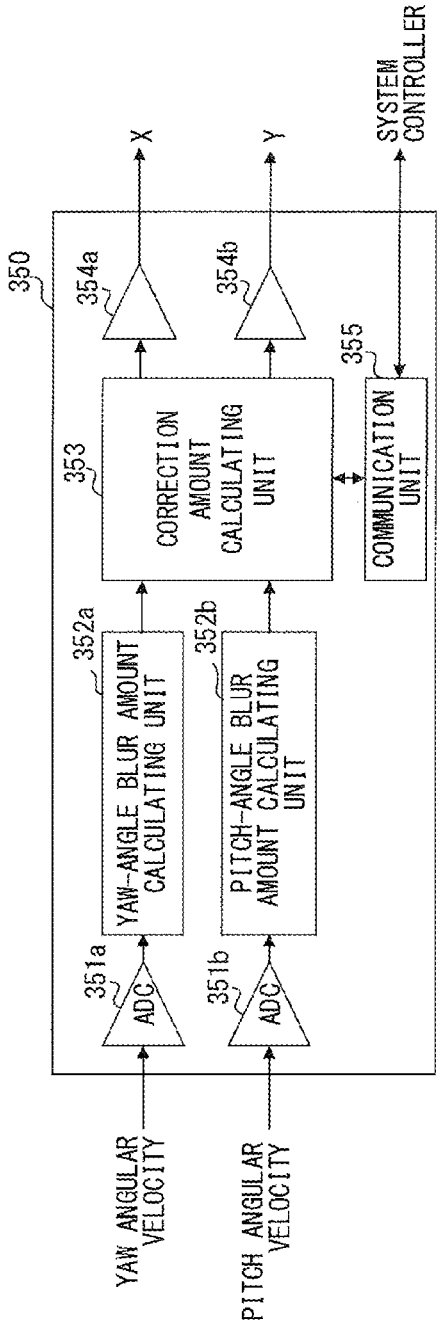
350
354a
354b
X
Y
SYSTEM CONTROLLER
355
353
CORRECTION AMOUNT CALCULATING UNIT
COMMUNICATION UNIT
352a
YAW-ANGLE BLUR AMOUNT CALCULATING UNIT
352b
PITCH-ANGLE BLUR AMOUNT CALCULATING UNIT
351a
ADC
351b
ADC
YAW ANGULAR VELOCITY
PITCH ANGULAR VELOCITY

FIG. 3

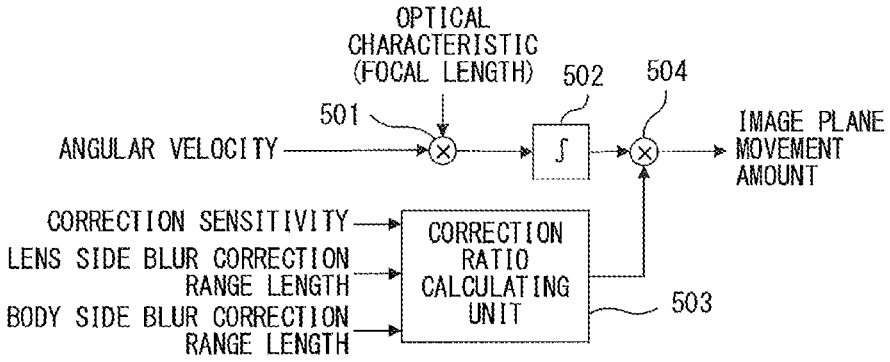
OPTICAL
CHARACTERISTIC
(FOCAL LENGTH)
501
502
504
ANGULAR VELOCITY
∫
IMAGE PLANE
MOVEMENT
AMOUNT
CORRECTION SENSITIVITY
LENS SIDE BLUR CORRECTION
RANGE LENGTH
BODY SIDE BLUR CORRECTION
RANGE LENGTH
CORRECTION
RATIO
CALCULATING
UNIT
503

FIG. 4

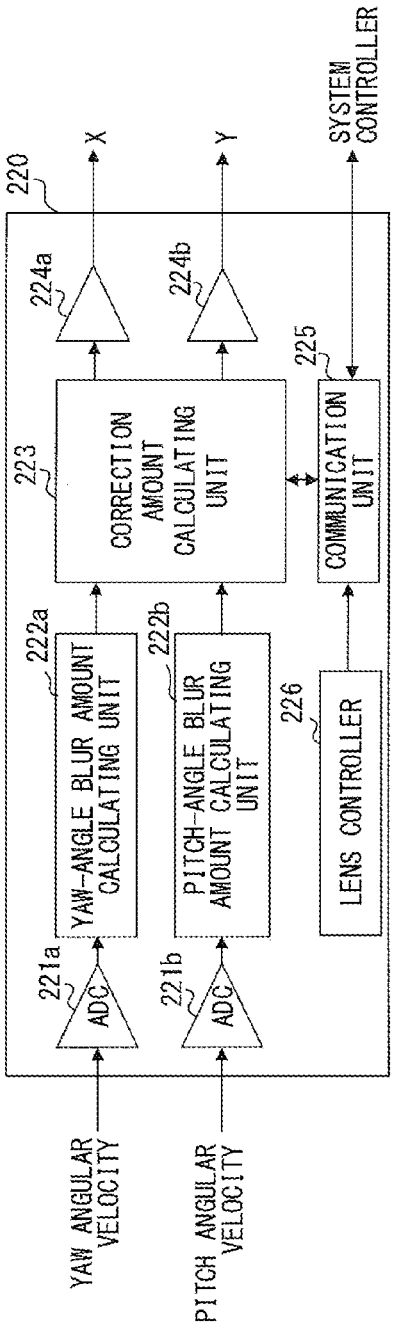
220
X
Y
SYSTEM CONTROLLER
224a
224b
225
223
CORRECTION AMOUNT CALCULATING UNIT
COMMUNICATION UNIT
222a
YAW-ANGLE BLUR AMOUNT CALCULATING UNIT
222b
PITCH-ANGLE BLUR AMOUNT CALCULATING UNIT
226
LENS CONTROLLER
221a
ADC
221b
ADC
YAW ANGULAR VELOCITY
PITCH ANGULAR VELOCITY

FIG. 5

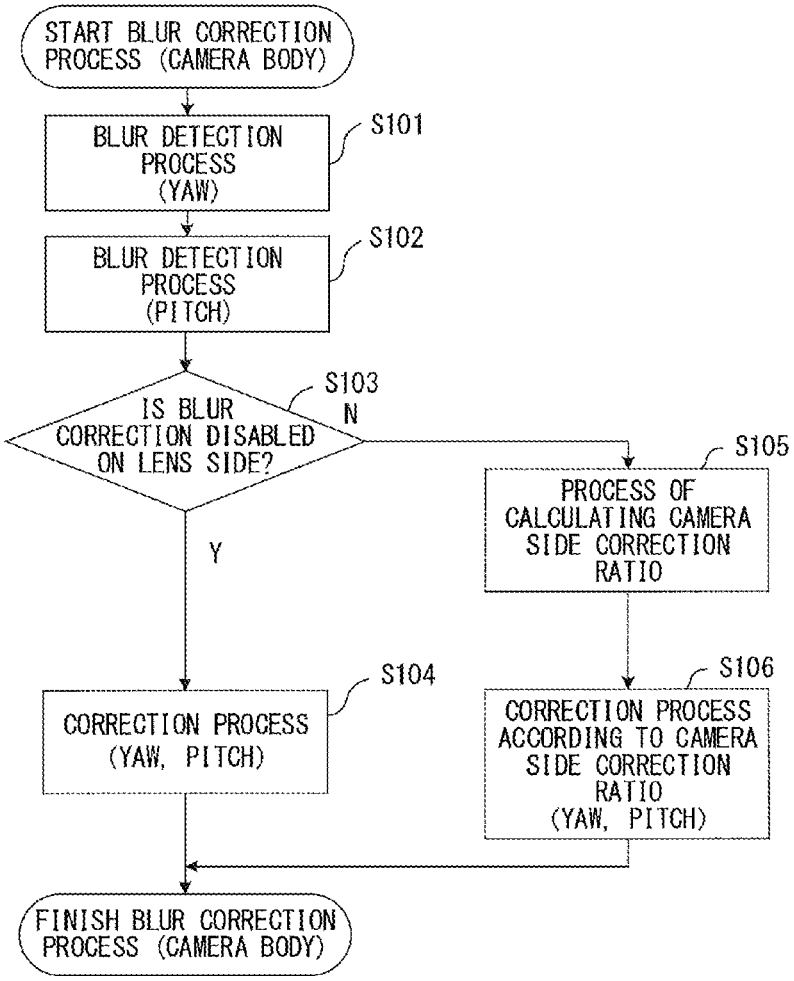
START BLUR CORRECTION PROCESS (CAMERA BODY)
BLUR DETECTION PROCESS (YAW)
S101
BLUR DETECTION PROCESS (PITCH)
S102
IS BLUR CORRECTION DISABLED ON LENS SIDE?
S103
N
Y
PROCESS OF CALCULATING CAMERA SIDE CORRECTION RATIO
S105
CORRECTION PROCESS (YAW, PITCH)
S104
CORRECTION PROCESS ACCORDING TO CAMERA SIDE CORRECTION RATIO (YAW, PITCH)
S106
FINISH BLUR CORRECTION PROCESS (CAMERA BODY)

FIG. 6

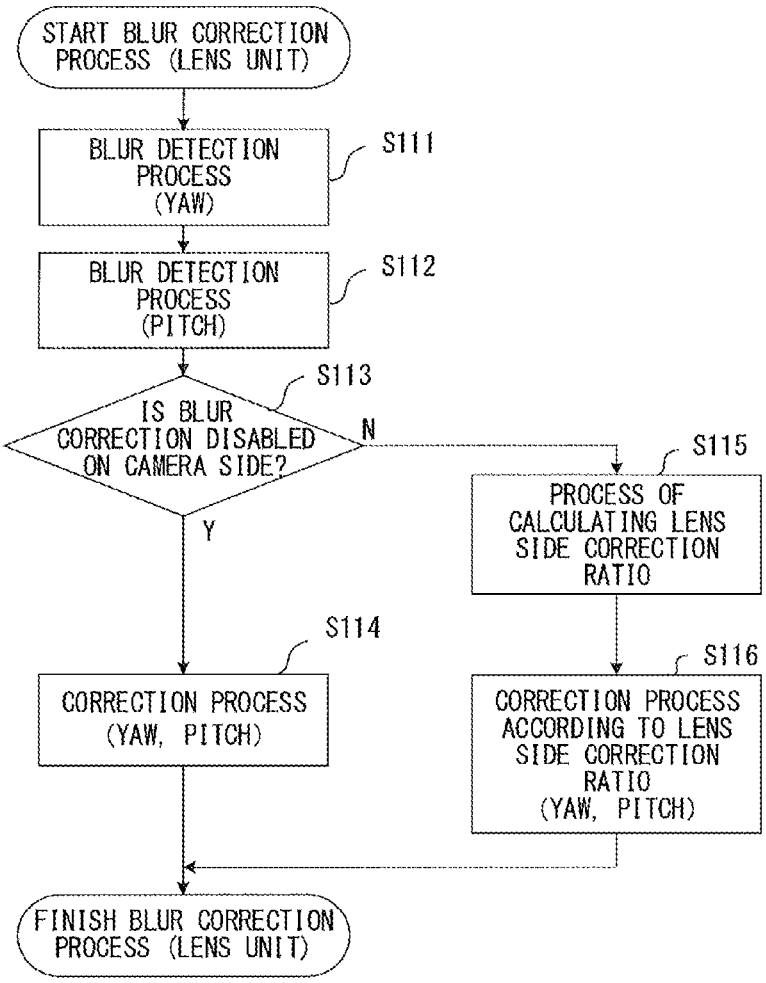
START BLUR CORRECTION PROCESS (LENS UNIT)
BLUR DETECTION PROCESS (YAW)
S111
BLUR DETECTION PROCESS (PITCH)
S112
S113
IS BLUR CORRECTION DISABLED ON CAMERA SIDE?
N
Y
S115
PROCESS OF CALCULATING LENS SIDE CORRECTION RATIO
S114
CORRECTION PROCESS (YAW, PITCH)
S116
CORRECTION PROCESS ACCORDING TO LENS SIDE CORRECTION RATIO (YAW, PITCH)
FINISH BLUR CORRECTION PROCESS (LENS UNIT)

FIG. 7

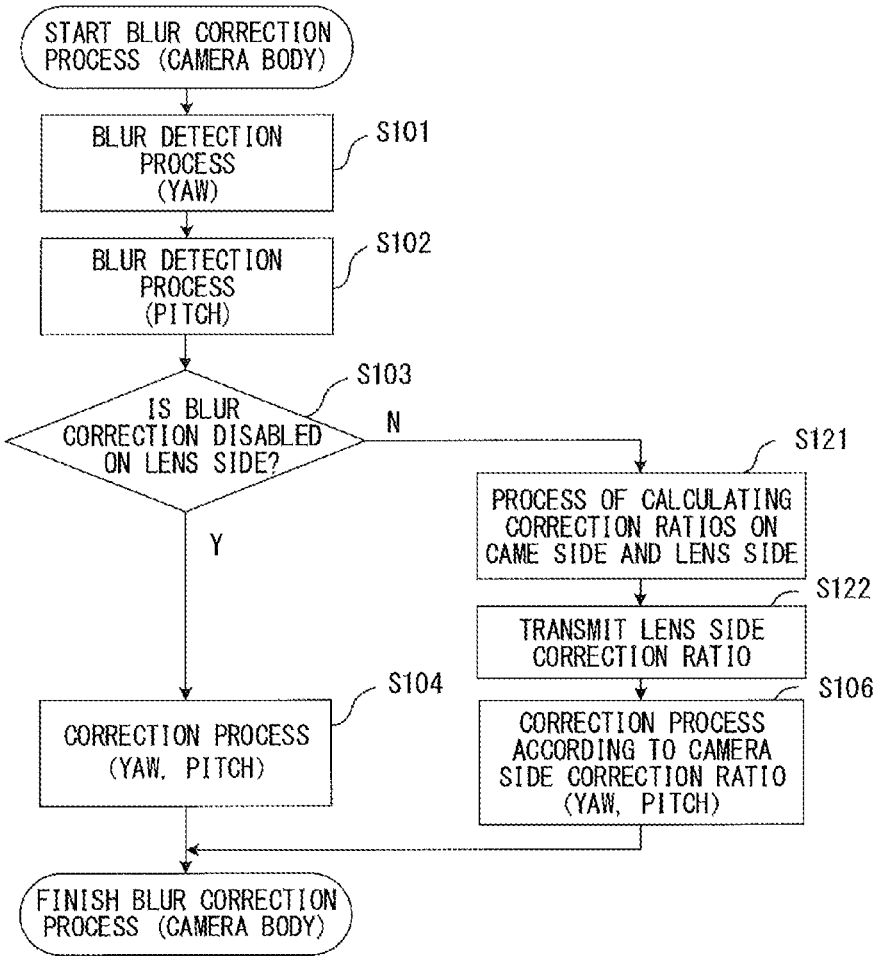
START BLUR CORRECTION PROCESS (CAMERA BODY)
BLUR DETECTION PROCESS (YAW)
S101
BLUR DETECTION PROCESS (PITCH)
S102
IS BLUR CORRECTION DISABLED ON LENS SIDE?
S103
N
Y
PROCESS OF CALCULATING CORRECTION RATIOS ON CAME SIDE AND LENS SIDE
S121
TRANSMIT LENS SIDE CORRECTION RATIO
S122
CORRECTION PROCESS (YAW, PITCH)
S104
CORRECTION PROCESS ACCORDING TO CAMERA SIDE CORRECTION RATIO (YAW, PITCH)
S106
FINISH BLUR CORRECTION PROCESS (CAMERA BODY)

FIG. 8

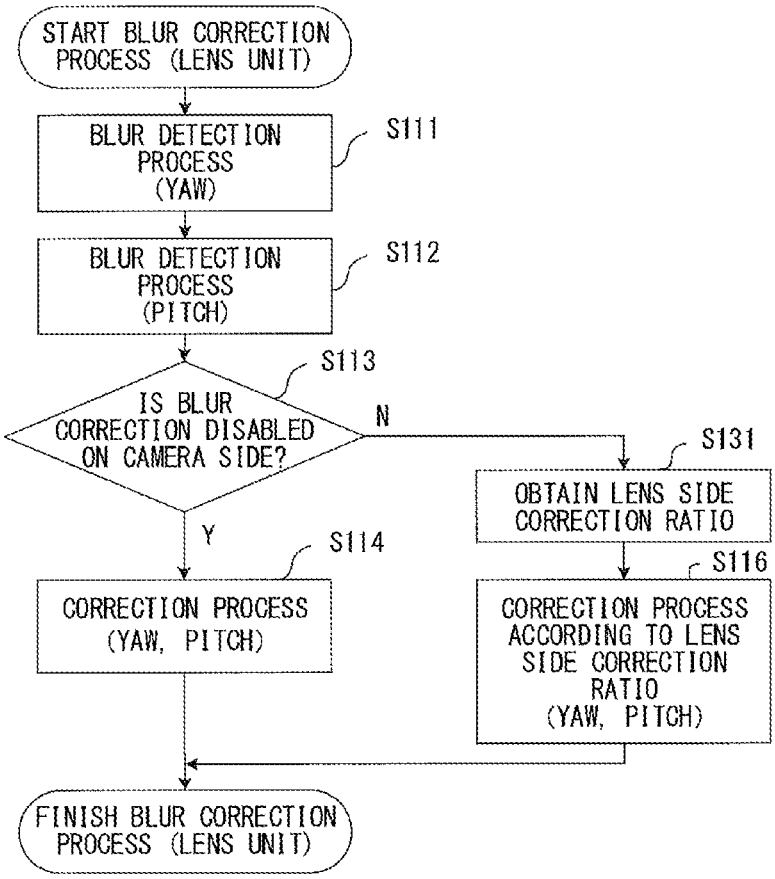
START BLUR CORRECTION PROCESS (LENS UNIT)
BLUR DETECTION PROCESS (YAW)
S111
BLUR DETECTION PROCESS (PITCH)
S112
S113
IS BLUR CORRECTION DISABLED ON CAMERA SIDE?
N
Y
S131
OBTAIN LENS SIDE CORRECTION RATIO
S114
CORRECTION PROCESS (YAW, PITCH)
S116
CORRECTION PROCESS ACCORDING TO LENS SIDE CORRECTION RATIO (YAW, PITCH)
FINISH BLUR CORRECTION PROCESS (LENS UNIT)

FIG. 9

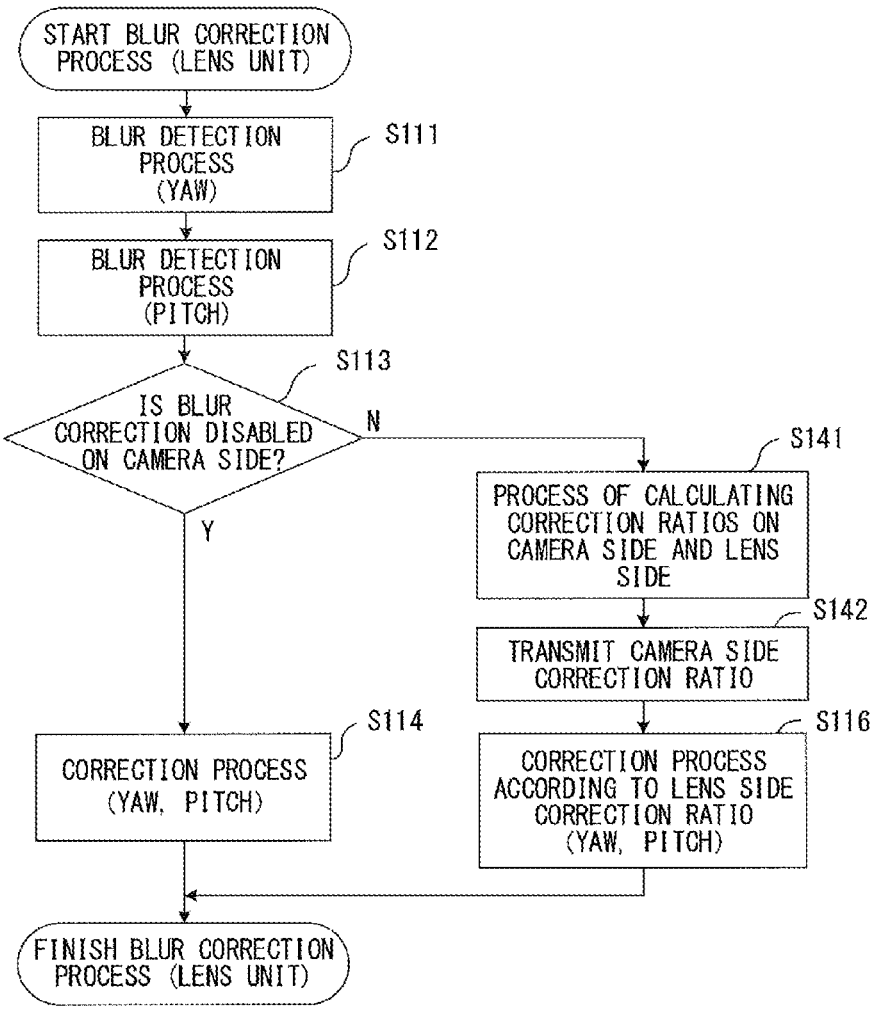
START BLUR CORRECTION PROCESS (LENS UNIT)
BLUR DETECTION PROCESS (YAW)
S111
BLUR DETECTION PROCESS (PITCH)
S112
IS BLUR CORRECTION DISABLED ON CAMERA SIDE?
S113
N
Y
PROCESS OF CALCULATING CORRECTION RATIOS ON CAMERA SIDE AND LENS SIDE
S141
TRANSMIT CAMERA SIDE CORRECTION RATIO
S142
CORRECTION PROCESS (YAW, PITCH)
S114
CORRECTION PROCESS ACCORDING TO LENS SIDE CORRECTION RATIO (YAW, PITCH)
S116
FINISH BLUR CORRECTION PROCESS (LENS UNIT)

FIG. 10

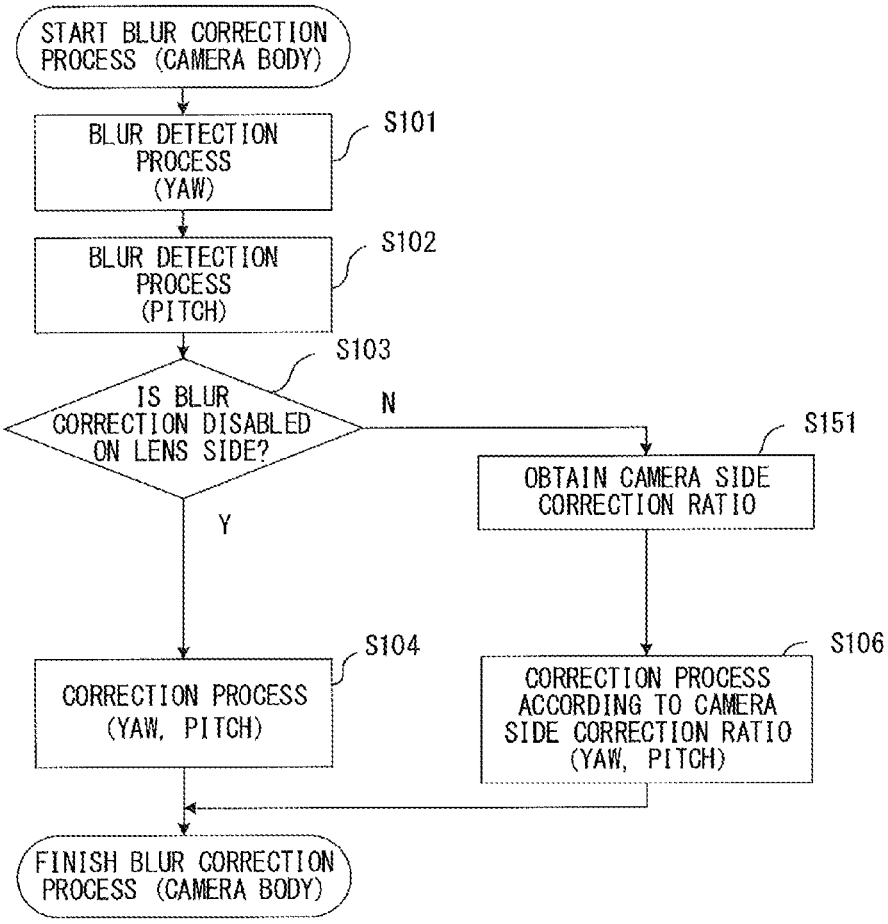
START BLUR CORRECTION PROCESS (CAMERA BODY)
BLUR DETECTION PROCESS (YAW)
S101
BLUR DETECTION PROCESS (PITCH)
S102
IS BLUR CORRECTION DISABLED ON LENS SIDE?
S103
N
Y
OBTAIN CAMERA SIDE CORRECTION RATIO
S151
CORRECTION PROCESS (YAW, PITCH)
S104
CORRECTION PROCESS ACCORDING TO CAMERA SIDE CORRECTION RATIO (YAW, PITCH)
S106
FINISH BLUR CORRECTION PROCESS (CAMERA BODY)

FIG. 11

CAMERA SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2014-015762, filed Jan. 30, 2014, the entire contents of which are incorporated herein by reference.

This is a Continuation Application of PCT Application No. PCT/JP2015/050126, filed Jan. 6, 2015, which was not published under PCT Article 21(2) in English.

FIELD

The present invention relates to a camera system that includes a lens unit and a camera body that the lens unit can be attached to or detached from, and in particular, a camera system having a blur correction function for correcting an image blur caused by camera shake or the like.

BACKGROUND

In recent years, cameras equipped with a blur correction function for correcting an image blur caused by camera shake or the like (hereinafter also referred to as an "image stabilization function") have become popular, and a photographer can capture a satisfactory image having no image blurring without paying any special attention to camera shake or the like.

As an example, there are two types of camera systems of a lens-interchangeable camera in which photographing lenses can be interchanged according to the purpose of photographing: a camera system in which the image stabilization function is installed onto an interchangeable lens; and a camera system in which the image stabilization function is installed onto a camera body. When the image stabilization function is installed onto an interchangeable lens, a sensor to detect the movement of a camera is mounted onto the interchangeable lens, and a portion of a photographing lens group is moved in a direction in which a detected camera shake is cancelled such that image stabilization is performed. When the image stabilization function is installed onto a camera body, a sensor to detect the movement of a camera is mounted onto the camera body, and an image sensor is moved in a direction in which a detected camera shake is cancelled such that image stabilization is performed. Whether the image stabilization function is installed onto the interchangeable lens or the camera body depends on a camera system or a manufacturer, because both types of camera systems have advantages and disadvantages.

In some of the camera systems having a common standard, both an interchangeable lens and a camera body have the image stabilization function.

As an example, a technology is known in which, in a camera system that includes an interchangeable lens including a blur correction system, an anti-vibration converter (a converter incorporating an image blur correction device), and a camera body, the interchangeable lens and the anti-vibration converter correct blurring at a ratio of 1:1, namely, each of the interchangeable lens and the anti-vibration converter corrects half of a blur amount (see Japanese Laid-Open Patent Publication No. 7-104338 and the like). In the technology above, inconvenience is not generated due to blur correction performed simultaneously by the interchangeable lens and the anti-vibration converter, and a photographer is not likely to fail in photographing. In this technology, the interchangeable lens and the converter perform blur correction, but a similar effect can be achieved even when the interchangeable lens and the camera body perform blur correction.

SUMMARY

In an aspect of the present invention, a camera system is provided that includes a lens unit and a camera body that the lens unit is freely attached to or detached from. The camera body includes a blur correcting unit that performs blur correction in a plurality of directions, and a determining unit that determines whether the lens unit mounted onto the camera body is a lens unit that performs the blur correction in the plurality of directions. When the determining unit determines that the mounted lens unit is the lens unit that performs the blur correction in the plurality of directions, the camera body drives the blur correcting unit so as to perform the blur correction in the plurality of directions at a camera body side blur correction ratio based on information relating to a blur correction range that the lens unit has, a correction sensitivity, and the blur correction range included in the camera body, and the lens unit performs the blur correction at a lens unit side blur correction ratio based on the information relating to the blur correction range that the lens unit has, the correction sensitivity, and the blur correction range included in the camera body. When L_b represents the blur correction range included in the camera body, L_l represents the blur correction range that the lens unit has, and K represents the correction sensitivity, the camera body side blur correction ratio is a value obtained by performing an operation of L_b/(L_b+L_l×K), and the lens unit side blur correction ratio is a value obtained by performing an operation of L_l/(L_b+L_l×K).

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram explaining directions of a camera system according to an embodiment.

FIG. **2** illustrates an exemplary configuration of a camera system according to an embodiment.

FIG. **3** illustrates an example of an internal configuration of a blur correcting microcomputer according to an embodiment.

FIG. **4** illustrates an example of an internal configuration of each of a yaw-angle blur amount calculating unit and a pitch-angle blur amount calculating unit according to an embodiment.

FIG. **5** illustrates an example of an internal configuration of an LCU according to an embodiment.

FIG. **6** is a flowchart illustrating the processing content of a blur correction operation performed by a camera body according to an embodiment.

FIG. **7** is a flowchart illustrating the processing content of a blur correction operation performed by a lens unit according to an embodiment.

FIG. **8** is a flowchart illustrating the processing content of a blur correction operation performed by a camera body according to a variation of the embodiment.

FIG. **9** is a flowchart illustrating the processing content of a blur correction operation performed by a lens unit according to a variation of the embodiment.

FIG. **10** is a flowchart illustrating the processing content of a blur correction operation performed by a lens unit according to another variation of the embodiment.

FIG. **11** is a flowchart illustrating the processing content of a blur correction operation performed by a camera body according to another variation of the embodiment.

DESCRIPTION OF EMBODIMENTS

An embodiment of the present invention is described below with reference to the drawings.

First, directions of a camera system according to the embodiment described below are defined.

FIG. **1** illustrates the directions.

As illustrated in FIG. **1**, a camera system **100** according to the embodiment has a configuration in which a lens unit **200** is mounted onto a camera body **300**. In the camera system **100**, an X direction, a Y direction, a Z direction, a pitch direction, a yaw direction and a roll direction are defined as below.

Rightward and leftward directions (a horizontal direction) of the camera body **300** mounted with the lens unit **200** are defined to be an X direction. For convenience of explanation, a rightward direction when viewing the camera system **100** from the front is defined to be a + (plus, positive) direction (a +X direction), and a leftward direction is defined to be a − (minus, negative) direction (a −X direction). The X direction corresponds to rightward and leftward directions of an imaging plane of an image sensor described later.

Upward and downward directions (a vertical direction) of the camera body **300** mounted with the lens unit **200** are defined to be a Y direction. For convenience of explanation, the upward direction is defined to be a + direction (a +Y direction), and the downward direction is defined to be a − direction (a −Y direction). The Y direction corresponds to upward and downward directions of the imaging plane of the image sensor described later.

An optical-axis direction of the camera body **300** mounted with the lens unit **200** is defined to be a Z direction. For convenience of explanation, a direction from a back surface to a front surface of the camera system **100** is defined to be a + direction (a +Z direction), and a direction from the front surface to the back surface of the camera system **100** is defined to be a − direction (a −Z direction).

A rotation direction with an X-direction axis as a rotary shaft is defined to be a pitch direction. For convenience of explanation, a leftward rotation with respect to the +X direction is defined to a + direction (a +pitch direction), and a rightward rotation with respect to the +X direction is defined to be a − direction (a −pitch direction).

A rotation direction with a Y-direction axis as a rotary shaft is defined to be a yaw direction. For convenience of explanation, a rightward rotation with respect to the +Y direction is defined to be a + direction (a +yaw direction), and a leftward rotation with respect to the +Y direction is defined to be a − direction (a −yaw direction).

A rotation direction with a Z-direction axis as a rotary shaft is defined to be a roll direction. For convenience of explanation, a leftward rotation with respect to the +Z direction is defined to be a + direction (a +roll direction), and a rightward rotation with respect to the +Z direction is defined to be a − direction (a −roll direction).

The positive/negative (+/−) direction defined above is dependent on a mounting direction of an angular velocity sensor described later, and of course, the positive/negative (+/−) direction is not limited to the definition above.

FIG. **2** illustrates an exemplary configuration of the camera system **100** according to the embodiment.

As illustrated in FIG. **2**, the camera system **100** according to the embodiment has a configuration in which the lens unit **200** is mounted onto the camera body **300**. The camera body **300** is configured in such a way that the lens unit **200** can be attached to or detached from the camera body **300**. The lens unit **200** is mounted onto the camera body **300** by a lens mount connector (not illustrated) provided in the lens unit **200** and a body mount connector (not illustrated) provided in the camera body **300** fitting into each other. Consequently, the lens unit **200** is fixed to the camera body **300**, and terminals provided in the respective mount connectors are electrically connected to each other. Accordingly, communication can be performed between the lens unit **200** and the camera body **300** via a contact **400**.

The lens unit **200** includes an optical system **210**, an LCU (lens control unit) **220**, an optical system drive actuator **230**, a yaw angular velocity sensor **240***a*, and a pitch angular velocity sensor **240***b*.

The optical system **210** includes a blur correcting lens group, and condenses a light flux from a subject so as to form an image as a subject image on an imaging plane of an image sensor **320**.

The optical system drive actuator **230** moves the blur correcting lens group that is a portion of the optical system **210** on a plane orthogonal to an optical axis, under the control of the LCU **220**.

The yaw angular velocity sensor **240***a* detects an angular velocity in the yaw direction. The pitch angular velocity sensor **240***b* detects an angular velocity in the pitch direction.

The LCU **220** communicates with a system controller **340** via the contact **400**, and controls the entire operation of the lens unit **200**. As an example, the LCU **220** transmits information relating to the lens unit **200** to the system controller **340**, or obtains, from the system controller **340**, information relating to the camera body **300** or an instruction to start or finish blur correction. As another example, the LCU **220** determines whether the camera body **300** mounted onto the lens unit **200** is a camera body that can perform blur correction on the basis of the information relating to the camera body **300**. In this determination, it is determined that, for example, a camera body that does not have a blur correction function, or a camera body having a blur correction function in which the blur correction function has been disabled, is not a camera body that can perform blur correction. The blur correction function can be disabled, for example, by a user operating an operating unit of a camera body (for example, a SW (switch) unit **370** described later of the camera body **300**). As an example, the LCU **220** controls the optical system drive actuator **230** so as to move the blur correcting lens group in a direction in which an image blur (blurring of the subject image formed on the imaging plane of the image sensor **320**) is cancelled, in accordance with the angular velocities detected by the yaw angular velocity sensor **240***a* and the pitch angular velocity sensor **240***b*. As another example, the LCU **220** performs focus control, diaphragm control, or the like. The internal configuration of the LCU **220** is described below with reference to FIG. **5**.

The camera body **300** includes a focal plane shutter (hereinafter simply referred to as a "shutter") **310**, an image sensor **320**, an image sensor drive actuator **330**, a system controller **340**, a blur correcting microcomputer **350**, a yaw angular velocity sensor **360***a*, a pitch angular velocity sensor **360***b*, and an SW unit **370**.

The shutter **310** is arranged on a front side of the imaging plane of the image sensor **320**. The shutter **310** includes an aperture blade, and the shutter **310** controls exposure time by opening or closing the aperture blade under the control of the system controller **340**.

The image sensor **320** converts the subject image formed on the imaging plane via the shutter **310** with the exposure blade opened into an electric signal, and outputs the electric signal as a video signal to the system controller **340**, under the control of the system controller **340**.

The image sensor drive actuator **330** moves the image sensor **320** in the X direction and the Y direction that are parallel to the imaging plane, under the control of the system controller **340**.

The system controller **340** communicates with the LCU **220** via the contact **400**, and communicates with the blur correcting microcomputer **350**, and the system controller **340** controls the entire operation of the camera body **300** and the camera system **100**. As an example, the system controller **340** obtains information relating to the lens unit **200** from the LCU **220**, or transmits, to the LCU **220**, information relating to the camera body **300** or an instruction to start or finish blur correction. As another example, the system controller **340** determines whether the lens unit **200** mounted onto the camera body **300** is a lens unit that can perform blur correction on the basis of the information relating to the lens unit **200**. In this determination, it is determined that, for example, a lens unit that does not have a blur correction function, or a lens unit having a blur correction function in which the blur correction function has been disabled, is not a lens unit that can perform blur correction. The blur correction function can be disabled, for example, by a user operating an operating unit provided in the lens unit. As an example, the system controller **340** converts the video signal output from the image sensor **320** into image data. As another example, the system controller **340** transmits, to the blur correcting microcomputer **350**, a portion of the information relating to the lens unit **200** (information relating to an optical characteristic of the optical system **210**, correction sensitivity, and a lens unit side blur correction range length), information relating to a camera body side blur correction range length, a determination result indicating whether the lens unit **200** is a lens unit that can perform blur correction, or an instruction to start or finish blur correction. The correction sensitivity, the lens unit side blur correction range length, and the camera body side blur correction range length are described below with reference to FIG. **4**.

The blur correcting microcomputer **350** communicates with the system controller **340**, and performs blur correction under the control of the system controller **340**. As an example, the blur correcting microcomputer **350** obtains, from the system controller **340**, a portion of the information relating to the lens unit **200** (information relating to the optical characteristic of the optical system **210**, the correction sensitivity, and information relating to the lens unit side blur correction range length), information relating to the camera body side blur correction range length, a determination result indicating whether the lens unit **200** is a lens unit that can perform blur correction, or an instruction to start or finish blur correction. As another example, the blur correcting microcomputer **350** controls the image sensor drive actuator **330** so as to move the image sensor **320** in a direction in which an image blur is cancelled, in accordance with the angular velocities detected by the yaw angular velocity sensor **360***a* and the pitch angular velocity sensor **360***b*. The internal configuration of the blur correcting microcomputer **350** is described below with reference to FIG. **3**.

The yaw angular velocity sensor **360***a* detects an angular velocity in the yaw direction. The pitch angular velocity sensor **360***b* detects an angular velocity in the pitch direction.

The SW unit **370** receives various instructions, such as an instruction to start photographing, from a user, and transmits the various instructions to the system controller **340**.

In the camera system **100**, each of the LCU **220**, the system controller **340**, and the blur correcting microcomputer **350** includes, for example, a CPU, a memory, and the like (not illustrated), and each of the LCU **220**, the system controller **340**, and the blur correcting microcomputer **350** controls the various operations described above and below by the CPU loading and executing a program stored in the memory.

In the camera system **100**, all of the yaw angular velocity sensors **240***a* and **360***a*, and the pitch angular velocity sensors **240***b* and **360***b* are angular velocity sensors having the same function, but of course, they are mounted in different directions according to a detection direction.

In the camera system **100**, the image sensor drive actuator **330** is an example of a blur correcting unit that performs blur correction in a plurality of directions. A portion of the system controller **340** is an example of a determining unit that determines whether a lens unit mounted onto a camera body is a lens unit that can perform blur correction in a plurality of directions. When the determining unit determines that a lens unit mounted onto a camera unit is a lens unit that can perform blur correction in a plurality of directions, the camera body performs blur correction in a plurality of direction at a camera body side blur correction ratio, and the lens unit performs blur correction in a plurality of directions at a lens unit side blur correction ratio, for example, as described below.

FIG. **3** illustrates an example of the internal configuration of the blur correcting microcomputer **350**.

As illustrated in FIG. **3**, the blur correcting microcomputer **350** includes ADCs (analog-to-digital converters) **351***a* and **351***b*, a yaw-angle blur amount calculating unit **352***a*, a pitch-angle blur amount calculating unit **352***b*, a correction amount calculating unit **353**, drivers **354***a* and **354***b*, and a communication unit **355**.

The ADC **351***a* converts a detection result that has been output as an analog signal by the yaw angular velocity sensor **360***a* into a digital signal. The ADC **351***b* converts a detection result that has been output as an analog signal by the pitch angular velocity sensor **360***b* into a digital signal.

The yaw-angle blur amount calculating unit **352***a* calculates an image plane movement amount in the X direction (an image blur amount associated with blurring in the yaw direction) on the basis of the angular velocity in the yaw direction that is indicated by a conversion result of the ADC **351***a* and an optical characteristic (a focal length of the optical system **210**). Alternatively, the yaw-angle blur amount calculating unit **352***a* calculates an image plane movement amount in the X direction according to the camera body side blur correction ratio on the basis of the angular velocity in the yaw direction that is indicated by a conversion result of the ADC **351***a*, the optical characteristic (the focal length of the optical system **210**), the correction sensitivity, the lens unit side blur correction range length, and the camera body side blur correction range length. The internal configuration of the yaw-angle blur amount calculating unit **352***a* is described below with reference to FIG. **4**.

The pitch-angle blur amount calculating unit **352***b* calculates an image plane movement amount in the Y direction (an image blur amount associated with blurring in the pitch direction) on the basis of the angular velocity in the pitch direction that is indicated by a conversion result of the ADC **351***b* and an optical characteristic (the focal length of the optical system **210**). Alternatively, the pitch-angle blur

amount calculating unit **352***b* calculates an image plane movement amount in the Y direction according to a camera body side blur correction ratio on the basis of the angular velocity in the pitch direction that is indicated by a conversion result of the ADC **351***b*, the optical characteristic (the focal length of the optical system **210**), the correction sensitivity, the lens unit side blur correction range length, and the camera body side blur correction range length. The internal configuration of the pitch-angle blur amount calculating unit **352***b* is also described below with reference to FIG. **4**.

The correction amount calculating unit **353** calculates movement amounts in the X direction and the Y direction to move the image sensor **320** in a direction in which an image blur is cancelled, on the basis of calculation results of the yaw-angle blur amount calculating unit **352***a* and the pitch-angle blur amount calculating unit **352***b*.

The driver **354***a* outputs, to the image sensor drive actuator **330**, a driving pulse signal according to the movement amount in the X direction calculated by the correction amount calculating unit **353**. The driver **354***b* outputs, to the image sensor drive actuator **330**, a driving pulse signal according to the movement amount in the Y direction calculated by the correction amount calculating unit **353**.

The communication unit **355** communicates with the system controller **340**, and obtains, for example, a portion of the information relating to the lens unit **200** (information relating to the optical characteristic of the optical system **210**, the correction sensitivity, and the lens unit side blur correction range length), information relating to the camera body side blur correction range length, a determination result indicating whether the lens unit **200** is a lens unit that can perform blur correction, or an instruction to start or finish blur correction.

FIG. **4** illustrates an example of an internal configuration of each of the yaw-angle blur amount calculating unit **352***a* and the pitch-angle blur amount calculating unit **352***b*.

As illustrated in FIG. **4**, each of the yaw-angle blur amount calculating unit **352***a* and the pitch-angle blur amount calculating unit **352***b* includes a multiplier **501**, an integrator **502**, a correction ratio calculating unit **503**, and a multiplier **504**.

The multiplier **501** multiplies an input angular velocity by an optical characteristic (the focal length of the optical system **210**). The integrator **502** time-integrates a multiplication result of the multiplier **501** so as to calculate an image plane movement amount.

The correction ratio calculating unit **503** calculates a camera body side blur correction ratio (a blur correction ratio on a camera body side) on the basis of the correction sensitivity, the lens unit side blur correction range length, and the camera body side blur correction range length, by using Expression (1) below.

$$Ratio_b = L_b/(L_b + L_l \times K) \quad \text{Expression (1)}$$

In this expression, Ratio_b represents a camera body side blur correction ratio, L_b represents a camera body side blur correction range length, L_l represents a lens unit side blur correction range length, and K represents a correction sensitivity.

The camera body side blur correction range length is a maximum movement range length of the image sensor **320** moved by the image sensor drive actuator **330**. In the embodiment, a camera body side blur correction range length in the X direction and a camera body side blur correction range length in the Y direction have the same value.

The lens unit side blur correction range length is a maximum movement range length of the blur correcting lens group moved by the optical system drive actuator **230**. The lens unit side blur correction range length may be constant regardless of a focal length, or may change according to the focal length. In the embodiment, a lens unit side blur correction range length in the X direction and a lens unit side blur correction range length in the Y direction have the same value.

The correction sensitivity is a change ratio at which an image plane movement amount (an image blur amount associated with the movement of the blur correcting lens group) changes with respect to the movement amount of the blur correcting lens group in accordance with a magnification of the optical system **210** (a magnification of an optical system in a rear stage of the blur correcting lens group). Accordingly, when the magnification of the optical system **210** changes, the correction sensitivity also changes.

According to a determination result indicating whether the lens unit **200** is a lens unit that can perform blur correction, the multiplier **504** multiplies a calculation result of the integrator **502** (the image plane movement amount) by a calculation result of the correction ratio calculating unit **503** (the camera body side blur correction ratio) so as to calculate an image plane movement amount according to the camera body side blur correction ratio. Alternatively, the multiplier **504** outputs the calculation result of the integrator **502** without performing the multiplication above.

FIG. **5** illustrates an example of an internal configuration of the LCU **220**.

As illustrated in FIG. **5**, the LCU **220** includes ADCs **221***a* and **221***b*, a yaw-angle blur amount calculating unit **222***a*, a pitch-angle blur amount calculating unit **222***b*, a correction amount calculating unit **223**, drivers **224***a* and **224***b*, a communication unit **225**, and a lens controller **226**.

The ADC **221***a* converts a detection result that has been output as an analog signal by the yaw angular velocity sensor **240***a* into a digital signal. The ADC **221***b* converts a detection result that has been output as an analog signal by the pitch angular velocity sensor **240***b* into a digital signal.

The yaw-angle blur amount calculating unit **222***a* calculates a movement amount in the X direction (a value obtained by converting an image blur amount associated with blurring in the yaw direction into a movement amount of the blur correcting lens group) on the basis of an angular velocity in the yaw direction indicated by a conversion result of the ADC **221***a* and an optical characteristic (a focal length of the optical system **210**/a correction sensitivity). Alternatively, the yaw-angle blur amount calculating unit **222***a* calculates a movement amount in the X direction according to a lens unit side blur correction ratio on the basis of the angular velocity in the yaw direction indicated by the conversion result of the ADC **221***a*, the optical characteristic (the focal length of the optical system **210**/the correction sensitivity), the correction sensitivity, the lens unit side blur correction range length, and the camera body side blur correction range length.

The pitch-angle blur amount calculating unit **222***b* calculates a movement amount in the Y direction (a value obtained by converting an image blur amount associated with blurring in the pitch direction into a movement amount of the blur correcting lens group) on the basis of an angular velocity in the pitch direction indicated by a conversion result of the ADC **221***b* and an optical characteristic (the focal length of the optical system **210**/the correction sensitivity). Alternatively, the pitch-angle blur amount calculating unit **222***b* calculates a movement amount in the Y

direction according to the lens unit side blur correction ratio on the basis of the angular velocity in the pitch direction indicated by the conversion result of the ADC **221***b*, the optical characteristic (the focal length of the optical system **210**/the correction sensitivity), the correction sensitivity, the lens unit side blur correction range length, and the camera body side blur correction range length.

Respective internal configurations of the yaw-angle blur amount calculating unit **222***a* and the pitch-angle blur amount calculating unit **222***b* are basically the same as the configuration illustrated in FIG. **4**, but they are different from the configuration illustrated in FIG. **4** in the following respect.

In the multiplier **501**, an optical characteristic by which an input angular velocity is multiplied is not the focal length of the optical system **210** but an optical characteristic calculated according to Expression (2) below.

$$OP=f/K \quad \text{Expression (2)}$$

In this expression, OP represents an optical characteristic, f represents a focal length of the optical system **210**, and K represents a correction sensitivity, as described above.

The reason why the value above is used as an optical characteristic is that an image plane movement amount changes with respect to a movement amount of the blur correcting lens group at a change ratio indicated by a correction sensitivity, as described above.

In the correction ratio calculating unit **503**, a lens unit side blur correction ratio (a blur correction ratio on a lens unit side) is calculated by using Expression (3) below.

$$Ratio_l=L_l\times K/(L_b+L_l\times K) \quad \text{Expression (3)}$$

In this expression, Ratio_l represents a lens unit side blur correction ratio, L_b, L_l, and K respectively represent a camera body side blur correction range length, a lens unit side blur correction range length, and a correction sensitivity, as described above.

According to a determination result indicating whether the camera body **300** is a camera body that can perform blur correction, the multiplier **504** multiplies a calculation result of the integrator **502** (the movement amount) by a calculation result of the correction ratio calculating unit **503** (the lens unit side blur correction ratio) so as to calculate a movement amount according to the lens unit side blur correction ratio. Alternatively, the multiplier **504** outputs the calculation result of the integrator **502** without performing the multiplication above.

The other configuration is similar to the configuration illustrated in FIG. **4**.

The correction amount calculating unit **223** calculates movement amounts in the X direction and the Y direction to move the blur correcting lens group in a direction in which an image blur is cancelled, on the basis of the calculation results of the yaw-angle blur amount calculating unit **222***a* and the pitch-angle blur amount calculating unit **222***b*.

The driver **224***a* outputs, to the optical system drive actuator **230**, a driving pulse signal according to the movement amount in the X direction that has been calculated by the correction amount calculating unit **223**. The driver **224***b* outputs, to the optical system drive actuator **230**, a driving pulse signal according to the movement amount in the Y direction that has been calculated by the correction amount calculating unit **223**.

The communication unit **225** communicates with the system controller **340** so as to, for example, transmit information relating to the lens unit **200**, or obtain information relating to the camera body **300** (including information relating to the camera body side blur correction range length) or an instruction to start or finish blur correction.

The lens controller **226** controls the entire operation of the LCU **220** (the lens unit **200**). As an example, the lens controller **226** performs control to transmit the information relating to the lens unit **200** to the system controller **340**. As another example, the lens controller **226** performs control to, for example, transmit, to the yaw-angle blur amount calculating unit **222***a* and the pitch-angle blur amount calculating unit **222***b*, information relating to an optical characteristic (f/K described above) of the optical system **210**, a portion of the information relating to the camera body **300** (information relating to the camera body side blur correction range length), and information relating to the lens unit side blur correction range length or the correction sensitivity. As yet another example, the lens controller **226** performs focus control, diaphragm control, and the like.

A blur correction operation of the camera system **100** according to the embodiment is described next.

The blur correction operation is performed under the control of the system controller **340**. During a period after an instruction to start blur correction is issued from the system controller **340** to the lens unit **200** and the camera body **300** and before an instruction to finish blur correction is issued, the following blur correction operations are respectively performed by the lens unit **200** and the camera body **300**. Here, a blur correction operation performed by the camera body **300** is described first, and a blur correction operation performed by the lens unit **200** is described next.

FIG. **6** is a flowchart illustrating the processing content of the blur correction operation performed by the camera body **300**.

As illustrated in FIG. **6**, the blur correcting microcomputer **350** that has received an instruction to start blur correction first performs a blur detection process in the yaw direction (S**101**). More specifically, the blur correcting microcomputer **350** calculates an image plane movement amount in the X direction (an image blur amount associated with blurring in the yaw direction) on the basis of a detection result of the yaw angular velocity sensor **360***a* by using the ADC **351***a*, and the multiplier **501** and the integrator **502** in the yaw-angle blur amount calculating unit **352***a*.

Then, the blur correcting microcomputer **350** performs a blur detection process in the pitch direction (S**102**). More specifically, the blur correcting microcomputer **350** calculates an image plane movement amount in the Y direction (an image blur amount associated with blurring in the pitch direction) on the basis of a detection result of the pitch angular velocity sensor **360***b* by using the ADC **351***b*, and the multiplier **501** and the integrator **502** in the pitch-angle blur amount calculating unit **352***b*.

The blur correcting microcomputer **350** then determines whether the lens unit **200** mounted onto the camera body **300** is a lens unit in which blur correction has been disabled (S**103**). This determination is performed according to a determination result transmitted from the system controller **340** indicating whether the lens unit **200** is a lens unit that can perform blur correction in the yaw direction and the pitch direction. Stated another way, when the determination result transmitted from the system controller **340** indicates that the lens unit **200** is a lens unit that can perform blur correction in the yaw direction and the pitch direction, the determination result in S**103** is No. When the determination result transmitted from the system controller **340** indicates that the lens unit **200** is not a lens unit that can perform blur correction in the yaw direction and the pitch direction, the determination result in S**103** is Yes.

When the determination result in S103 is Yes, the blur correcting microcomputer **350** performs a blur correction process on the basis of the calculation results in S101 and S102 (S104). More specifically, the blur correcting microcomputer **350** outputs, to the image sensor drive actuator **330**, a driving pulse signal according to the movement amounts in the X direction and the Y direction on the basis of the calculation results, by using the correction amount calculating unit **353** and the drivers **354***a* and **354***b*, and in response to the driving pulse signal, the image sensor drive actuator **330** moves the image sensor **320**. In this case, each of the yaw-angle blur amount calculating unit **352***a* and the pitch-angle blur amount calculating unit **352***b* outputs the calculation result of the integrator **502** to the correction amount calculating unit **353** without performing multiplication using the multiplier **504**.

When the determination result in S103 is No, the blur correcting microcomputer **350** performs a process of calculating a camera body side blur correction ratio (S105). More specifically, the blur correcting microcomputer **350** causes the correction ratio calculating unit **503** to calculate a camera body side blur correction ratio on the basis of the correction sensitivity, the lens unit side blur correction range length, and the camera body side blur correction range length by using Expression (1) above. The blur correcting microcomputer **350** then performs a blur correction process according to the camera body side blur correction ratio on the basis of the calculation results in S101 and S102 and the calculation result in S105 (S106). More specifically, the blur correcting microcomputer **350** causes the multiplier **504** to multiply each of the calculation results in S101 and S102 by the calculation result in S105, and the blur correcting microcomputer **350** causes the correction amount calculating unit **353** and the drivers **354***a* and **354***b* to output, to the image sensor drive actuator **330**, a driving pulse signal that corresponds to the movement amounts in the X direction and the Y direction according to the camera body side blur correction ratio on the basis of the calculation result. In response to the driving pulse signal, the image sensor drive actuator **330** moves the image sensor **320**.

When the process of S104 or S106 is completed, the processing is terminated.

The processing illustrated in FIG. **6** represents a blur correction operation in one cycle performed by the camera body **300**. Actually, the blur correction operation in one cycle is repeated until an instruction to finish blur correction is issued from the system controller **340** to the blur correcting microcomputer **350**.

FIG. **7** is a flowchart illustrating the processing content of the blur correction operation performed by the lens unit **200**.

As illustrated in FIG. **7**, the LCU **220** that has received an instruction to start blur correction first performs a blur detection process in the yaw direction (S111). More specifically, the LCU **220** calculates a movement amount in the X direction (a value obtained by converting an image blur amount associated with blurring in the yaw direction into a movement amount of the blur correcting lens group) on the basis of a detection result of the yaw angular velocity sensor **240***a*, by using the ADC **221***a*, and the multiplier **501** and the integrator **502** in the yaw-angle blur amount calculating unit **222***a*.

Then, the LCU **220** performs a blur detection process in the pitch direction (S112). More specifically, the LCU **220** calculates a movement amount in the Y direction (a value obtained by converting an image blur amount associated with blurring in the pitch direction into a movement amount of the blur correcting lens group) on the basis of a detection result of the pitch angular velocity sensors **240***b*, by using the ADC **221***b*, and the multiplier **501** and the integrator **502** in the pitch-angle blur amount calculating unit **222***b*.

The LCU **220** then determines whether the camera body **300** mounted onto the lens unit **200** is a camera body in which blur correction has been disabled (S113). This determination is performed according to information relating to the camera body **300** that has been transmitted from the system controller **340**. More specifically, when the information indicates that the camera body **300** is a camera body that can perform blur correction in the yaw direction and the pitch direction, the determination result in S113 is No. Otherwise, the determination result in S113 is Yes.

When the determination result in S113 is Yes, the LCU **220** performs a blur correction process on the basis of the calculation results in S111 and S112 (S114). More specifically, the LCU **220** causes the correction amount calculating unit **223** and the drivers **224***a* and **224***b* to output, to the optical system drive actuator **230**, a driving pulse signal according to the movement amounts in the X direction and the Y direction on the basis of the calculation result. In response to the driving pulse signal, the optical system drive actuator **230** moves the blur correcting lens group. In this case, each of the yaw-angle blur amount calculating unit **222***a* and the pitch-angle blur amount calculating unit **222***b* outputs a calculation result of the integrator **502** to the correction amount calculating unit **223** without performing multiplication using the multiplier **504**.

When the determination result in S103 is No, the LCU **220** performs a process of calculating a lens unit side blur correction ratio (S115). More specifically, the LCU **220** causes the correction ratio calculating unit **503** to calculate a lens unit side blur correction ratio on the basis of the correction sensitivity, the lens unit side blur correction range length, and the camera body side blur correction range length, by using Expression (3) above. The LCU **220** performs a blur correction process according to the lens unit side blur correction ratio on the basis of the calculation results in S111 and S112 and the calculation result in S115 (S116). More specifically, the LCU **220** causes the multiplier **504** to multiply each of the calculation results in S111 and S112 by the calculation result in S115, and the LCU **220** causes the correction amount calculating unit **223** and the drivers **224***a* and **224***b* to output, to the optical system drive actuator **230**, a driving pulse signal that corresponds to the movement amounts in the X direction and the Y direction according to the lens unit side blur correction ratio on the basis of the calculation result. In response to the driving pulse signal, the optical system drive actuator **230** moves the blur correcting lens group.

When the process of S114 or S116 is completed, the processing is terminated.

The processing illustrated in FIG. **7** represents a blur correction operation in one cycle performed by the lens unit **200**. Actually, the blur correction operation in one cycle is repeated until an instruction to finish blur correction is issued from the system controller **340** to the LCU **220**.

In the camera system **100** according to the embodiment, when the lens unit **200** that can perform blur correction in the yaw direction and the pitch direction is mounted onto the camera body **300** that can perform blur correction in the yaw direction and the pitch direction, blur correction is performed by the lens unit **200** and the camera body **300** at a blur correction ratio based on a ratio of the camera body side blur correction range length to the lens unit side blur correction range length, and blur correction ranges on a camera body side and a lens unit side are used up effectively.

Accordingly, a problem as in a conventional technology does not occur wherein either the blur correction range on the camera body side or the blur correction range on the lens unit side reaches a limit, and therefore blur correction cannot be performed any further. A blur correction range in the entirety of a camera system can increase, and this allows a blur correction performance to be improved.

Various variations to the camera system **100** according to the embodiment can be made.

As an example, each of the yaw-angle blur amount calculating unit **352***a* and the pitch-angle blur amount calculating unit **352***b* is configured to time-integrate a value obtained by multiplying an input angular velocity by an optical characteristic and to multiply the time-integrated value by a blur correction ratio, as illustrated in FIG. **4** (the same applies to each of the yaw-angle blur amount calculating unit **222***a* and the pitch-angle blur amount calculating unit **222***b*). However, an operation order is not limited to this. If a finally calculated value is the same, as an example, an input angular velocity, an optical characteristic, and a blur correction ratio may be multiplied before time-integration, or the input angular velocity may be multiplied by a value obtained by multiplying the optical characteristic by the blur correction ratio.

As another example, in the camera system **100** according to the embodiment, a camera body side blur correction ratio is calculated on a camera body side, and a lens unit side blur correction ratio is calculated on a lens unit side. However, the lens unit side blur correction ratio and the camera body side blur correction ratio may be calculated on the camera body side or the lens unit side, as described below with reference to FIGS. **8** to **11**.

FIGS. **8** and **9** are flowcharts illustrating an example of the processing content of a blur correction operation performed by the camera system **100** in a case in which a lens unit side blur correction ratio and a camera body side blur correction ratio are calculated on a camera body side. In the flowchart illustrated in FIG. **8**, the process of **S105** in the flowchart illustrated in FIG. **6** is replaced with the processes of **S121** and **S122**. In the flowchart illustrated in FIG. **9**, the process of **S115** in the flowchart illustrated in FIG. **7** is replaced with the process of **S131**. Only the replaced processes are described here, and the description of the other processes are omitted.

As illustrated in FIG. **8**, in the camera body **300**, when the determination result in **S103** is No, the blur correcting microcomputer **350** performs a process of calculating a lens unit side blur correction ratio and a camera body side blur correction ratio (**S121**). More specifically, the blur correcting microcomputer **350** first performs a process similar to the process of **S105** in FIG. **6** so as to calculate a camera body side blur correction ratio, and calculates a lens unit side blur correction ratio by subtracting the camera body side blur correction ratio from 1. The blur correcting microcomputer **350** then transmits the lens unit side blur correction ratio calculated in **S121** to the LCU **220** via the system controller **340** (**S122**). More specifically, the blur correcting microcomputer **350** transmits the lens unit side blur correction ratio to the system controller **340**, and the system controller **340** transmits the lens unit side blur correction ratio to the LCU **220**. In **S106**, a blur correction process is performed at the camera body side blur correction ratio calculated in **S121**.

As illustrated in FIG. **9**, in the lens unit **200**, when the determination result in **S113** is No, the LCU **220** obtains the lens unit side blur correction ratio transmitted from the system controller **340** (**S131**). In **S116**, a blur correction process is performed at the lens unit side blur correction ratio obtained in **S131**.

By performing the blur correction operation above in the camera system **100**, as an example, in the LCU **220**, each of the yaw-angle blur amount calculating unit **222***a* and the pitch-angle blur amount calculating unit **222***b* does not need to include the correction ratio calculating unit **503**. Accordingly, a simpler configuration can be employed, and an operation load can be reduced.

FIGS. **10** and **11** are flowcharts illustrating an example of the processing content of a blur correction operation performed by the camera system **100** in a case in which a lens unit side blur correction ratio and a camera body side blur correction ratio are calculated on a lens unit side. In the flowchart illustrated in FIG. **10**, the process of **S115** in the flowchart illustrated in FIG. **7** is replaced with the processes of **S141** and **S142**. In the flowchart illustrated in FIG. **11**, the process of **S105** in the flowchart illustrated in FIG. **6** is replaced with the process of **S151**. Only the replaced processes are described here, and the description of the other processes is omitted.

As illustrated in FIG. **10**, in the lens unit **200**, when the determination result in **S113** is No, the LCU **220** performs a process of calculating a lens unit side blur correction ratio and a camera body side blur correction ratio (**S141**). More specifically, the LCU **220** first performs a process similar to the process of **S115** in FIG. **7** so as to calculate a lens unit side blur correction ratio, and calculates a camera body side blur correction ratio by subtracting the lens unit side blur correction ratio from 1. The LCU **220** transmits the camera body side blur correction ratio calculated in **S141** to the blur correcting microcomputer **350** via the system controller **340** (**S142**). More specifically, the LCU **220** transmits the camera body side blur correction ratio to the system controller **340**, and the system controller **340** transmits the camera body side blur correction ratio to the blur correcting microcomputer **350**. In **S116**, a blur correction process is performed at the lens unit side blur correction ratio calculated in **S141**.

As illustrated in FIG. **11**, in the camera body **300**, when the determination result in **S103** is No, the blur correcting microcomputer **350** obtains the camera body side blur correction ratio transmitted from the system controller **340** (**S151**). In **S106**, a blur correction process is performed at the lens unit side blur correction ratio obtained in **S151**.

By performing the blur correction operation above in the camera system **100**, as an example, in the blur correcting microcomputer **350**, each of the yaw-angle blur amount calculating unit **352***a* and the pitch-angle blur amount calculating unit **352***b* does not need to include the correction ratio calculating unit **503**. Accordingly, a simpler configuration can be employed, and an operation load can be reduced.

The embodiment above describes a specific example of the present invention in order to easily understand the invention, and the present invention is not limited to the embodiment above. Various variations or modifications of the present invention can be made without departing from the spirit of the present invention specified in the claims.

As described above, according to the present invention, a camera system can be provided in which, when both a lens unit and a camera body have a blur correction function, both the lens unit and the camera body perform blur correction at a blur correction ratio at which blur correction ranges of both the lens unit and the camera body are used up effectively

such that a blur correction range in the entirety of a camera system can increase and a blur correction performance can be improved.

What is claimed is:

1. A camera system that includes a lens unit and a camera body that the lens unit is freely attached to or detached from, wherein

the camera body includes:

a blur corrector that performs blur correction in a plurality of directions; and

a determiner that determines whether the lens unit mounted onto the camera body is a lens unit that performs the blur correction in the plurality of directions,

when the determiner determines that the lens unit mounted onto the camera body is the lens unit that performs the blur correction in the plurality of directions, the camera body drives the blur corrector so as to perform the blur correction in the plurality of directions at a camera body side blur correction ratio based on information relating to a blur correction range that the lens unit has, a correction sensitivity, and the blur correction range included in the camera body, and the lens unit performs the blur correction at a lens unit side blur correction ratio based on the information relating to the blur correction range that the lens unit has, the correction sensitivity, and the blur correction range included in the camera body, and

when L_b represents the blur correction range included in the camera body, L_l represents the blur correction range that the lens unit has, and K represents the correction sensitivity, the camera body side blur correction ratio is a value obtained by performing an operation of L_b/(L_b+L_l×K), and the lens unit side blur correction ratio is a value obtained by performing an operation of L_l×K/(L_b+L_l×K).

2. The camera system according to claim **1**, wherein

the camera body further includes a first correction ratio calculator that calculates the camera body side blur correction ratio, and

the lens unit further includes a second correction ratio calculator that calculates the lens unit side blur correction ratio.

3. The camera system according to claim **1**, wherein

the camera body further includes a correction ratio calculator on a camera body side that calculates the camera body side blur correction ratio and the lens unit side blur correction ratio, and

the camera body transmits, to the lens unit, the lens unit side blur correction ratio calculated by the correction ratio calculator on the camera body side.

4. The camera system according to claim **1**, wherein

the lens unit further includes a correction ratio calculator on a lens unit side that calculates the camera body side blur correction ratio and the lens unit side blur correction ratio, and

the lens unit transmits, to the camera body, the camera body side blur correction ratio calculated by the correction ratio calculator on the lens unit side.

5. The camera system according to claim **1**, wherein

the plurality of directions are two directions, a yaw direction and a pitch direction that are respectively rotation directions having axes in directions perpendicular to optical axis directions of the lens unit and the camera body.

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