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OPTICAL IMAGING DEVICE

Abstract

An optical imaging system includes a first lens, a second lens, a third lens, a fourth lens, and a fifth lens, disposed in order from an object side, and a first reflection member and a second reflection member, disposed on an object side of the first lens, each having a freeform surface.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a Continuation application of U.S. patent application Ser. No. 18/417,003, filed on Jan. 19, 2024, which is a Continuation application of U.S. patent application Ser. No. 17/163,948, filed on Feb. 1, 2021, now U.S. Pat. No. 11,921,269 issued on Mar. 5, 2024, which claims the benefit under 35 USC 119(a) of Korean Patent Application No. 10-2020-0144092 filed on Nov. 2, 2020, in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference for all purposes.

BACKGROUND
1. Field
[0002] The present disclosure relates to an optical imaging system including a reflection member formed to have a free curved surface.
2. Description of the Background
[0003] A camera module may be mounted on a mobile terminal device such as a smartphone, a laptop computer, or the like. A camera module, mounted on a mobile terminal device, is usually configured to capture an image of a subject positioned within a short range. However, with frequent outdoor photographing performed through a camera module of a mobile terminal device, there is a requirement for a camera module able to capture an image of a subject positioned at a long range. However, due to a limitation in mounting space of a camera module of a mobile terminal device, it may be difficult to design a camera module and an optical imaging system able to capture a long-range image.
[0004] The above information is presented as background information only to assist in an understanding of the present disclosure. No determination has been made, and no assertion is made, as to whether any of the above might be applicable as prior art with regard to the disclosure.
SUMMARY
[0005] This Summary is provided to introduce a selection of concepts in simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.
[0006] In one general aspect, an optical imaging system includes a first lens, a second lens, a third lens, a fourth lens, and a fifth lens, disposed in order from an object side, and a first reflection member and a second reflection member, disposed on an object side of the first lens, each having a freeform surface.
[0007] The first reflection member may have a concave reflective surface.
[0008] The second reflection member may have a convex reflective surface.
[0009] The first lens may have a convex object-side surface.
[0010] The second lens may have a concave object-side surface.
[0011] The third lens may have a convex object-side surface.
[0012] The fourth lens may have a convex object-side surface.
[0013] The fifth lens may have a concave object-side surface.
[0014] The ratio f/fL may be greater than 1.40 and less than 1.80, where f is a focal length of the optical imaging system, and fL is a composite focal length of the first to fifth lenses.
[0015] The optical imaging system may further include an optical path folding member disposed on

the object side of the first reflection member.
[0016] In another general aspect, an optical imaging system includes a lens group comprising a plurality of lenses disposed in order along an optical axis, an optical path folding member disposed on an object side of the lens group, and a first reflection member and a second reflection member, disposed between the optical path folding member and the lens group, each having a freeform surface, wherein $1.40<f/fL<1.80$, where f is a focal length of the optical imaging system, and fL is a focal length of the lens group.
[0017] The optical imaging system may further include a third reflection member disposed between the lens group and an imaging plane.
[0018] The ratio fm1/f may be greater than 0.8 and less than 1.40, where fm1 is a focal length of the first reflection member.
[0019] The ratio fm2/f may be greater than −1.0 and less than −0.4, where fm2 is a focal length of the second reflection member.
[0020] The absolute value of the ratio fm1/fm2 may be greater than 1.40 and less than 1.80.
[0021] The ratio TL/f may be greater than 0.40 and less than 0.9, where TL is a distance from an object-side surface of a lens, disposed in a frontmost position of the lens group, to an imaging plane.
[0022] In another general aspect, an optical imaging system includes a reflection element disposed between a lens group and an optical path folding member configured to bend an optical path between the optical path folding member and the lens group, wherein the reflection element includes a first reflection member having positive refractive power, and wherein the lens group includes a first lens having positive refractive power.
[0023] The reflection element may further include a second reflection member having negative refractive power. The lens group may further include a second lens having negative refractive power.
[0024] Other features and aspects will be apparent from the following detailed description, the drawings, and the claims.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0025] FIG. **1** is a diagram illustrating an optical imaging system according to a first example.
[0026] FIG. **2** is a graph illustrating distortion aberration of the optical imaging system according to the first example.
[0027] FIG. **3** is a diagram illustrating an optical imaging system according to a second example.
[0028] FIG. **4** is a graph illustrating distortion aberration of the optical imaging system according to the second example.
[0029] FIG. **5** is a diagram illustrating an optical imaging system according to a third example.
[0030] FIG. **6** is a graph illustrating distortion aberration of the optical imaging system according to the third example.
[0031] Throughout the drawings and the detailed description, the same reference numerals refer to the same elements. The drawings may not be to scale, and the relative size, proportions, and depictions of elements in the drawings may be exaggerated for clarity, illustration, and convenience.
DETAILED DESCRIPTION
[0032] Hereinafter, while examples of the present disclosure will be described in detail with reference to the accompanying drawings, it is noted that examples are not limited to the same.
[0033] The following detailed description is provided to assist the reader in gaining a comprehensive understanding of the methods, apparatuses, and/or systems described herein.

However, various changes, modifications, and equivalents of the methods, apparatuses, and/or systems described herein will be apparent after an understanding of this disclosure. For example, the sequences of operations described herein are merely examples, and are not limited to those set forth herein, but may be changed as will be apparent after an understanding of this disclosure, with the exception of operations necessarily occurring in a certain order. Also, descriptions of functions and constructions that would be well known in the art may be omitted for increased clarity and conciseness.

[0034] The features described herein may be embodied in different forms, and are not to be construed as being limited to the examples described herein. Rather, the examples described herein have been provided merely to illustrate some of the many possible ways of implementing the methods, apparatuses, and/or systems described herein that will be apparent after an understanding of this disclosure.

[0035] Herein, it is noted that use of the term “may” with respect to an example or embodiment, for example, as to what an example or embodiment may include or implement, means that at least one example or embodiment exists in which such a feature is included or implemented while all examples and embodiments are not limited thereto.

[0036] Throughout the specification, when an element, such as a layer, region, or substrate, is described as being “on,” “connected to,” or “coupled to” another element, it may be directly “on,” “connected to,” or “coupled to” the other element, or there may be one or more other elements intervening therebetween. In contrast, when an element is described as being “directly on,” “directly connected to,” or “directly coupled to” another element, there can be no other elements intervening therebetween. As used herein “portion” of an element may include the whole element or less than the whole element.

[0037] As used herein, the term “and/or” includes any one and any combination of any two or more of the associated listed items; likewise, “at least one of” includes any one and any combination of any two or more of the associated listed items.

[0038] Although terms such as “first,” “second,” and “third” may be used herein to describe various members, components, regions, layers, or sections, these members, components, regions, layers, or sections are not to be limited by these terms. Rather, these terms are only used to distinguish one member, component, region, layer, or section from another member, component, region, layer, or section. Thus, a first member, component, region, layer, or section referred to in examples described herein may also be referred to as a second member, component, region, layer, or section without departing from the teachings of the examples.

[0039] Spatially relative terms such as “above,” “upper,” “below,” “lower,” and the like may be used herein for ease of description to describe one element's relationship to another element as illustrated in the figures. Such spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, an element described as being “above” or “upper” relative to another element will then be “below” or “lower” relative to the other element. Thus, the term “above” encompasses both the above and below orientations depending on the spatial orientation of the device. The device may also be oriented in other ways (for example, rotated 90 degrees or at other orientations), and the spatially relative terms used herein are to be interpreted accordingly.

[0040] The terminology used herein is for describing various examples only, and is natto be used to limit the disclosure. The articles “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises,” “includes,” and “has” specify the presence of stated features, numbers, operations, members, elements, and/or combinations thereof, but do not preclude the presence or addition of one or more other features, numbers, operations, members, elements, and/or combinations thereof.

[0041] Due to manufacturing techniques and/or tolerances, variations of the shapes illustrated in

the drawings may occur. Thus, the examples described herein are not limited to the specific shapes illustrated in the drawings, but include changes in shape that occur during manufacturing.
[0042] The features of the examples described herein may be combined in various ways as will be apparent after an understanding of this disclosure. Further, although the examples described herein have a variety of configurations, other configurations are possible as will be apparent after an understanding of this disclosure.
[0043] An aspect of the present disclosure is to provide an optical imaging system which may perform long-range image capturing and may allow a camera module to be miniaturized.
[0044] An optical imaging system includes a plurality of lenses disposed along an optical axis. The plurality of lenses may be spaced apart from each other by predetermined distances along the optical axis.
[0045] For example, the optical imaging system includes a first lens, a second lens, a third lens, a fourth lens, and a fifth lens, sequentially disposed in ascending numerical order along the optical axis from an object side of the optical imaging system toward an imaging plane of the optical imaging system, with the first lens being closest to the object side of the optical imaging system and the fifth lens being closest to the imaging plane.
[0046] In each lens, an object-side surface or a first surface is a surface of the lens closest to the object side of the optical imaging system, and an image-side surface or a second surface is a surface of the lens closest to the imaging plane.
[0047] Unless stated otherwise, a reference to a shape of a lens surface refers to a shape of a paraxial region of the lens surface. A paraxial region of a lens surface is a central portion of the lens surface surrounding and including the optical axis of the lens surface in which light rays incident to the lens surface make a small angle θ to the optical axis, and the approximations $\sin\theta\approx\theta$, $\tan\theta\approx\theta$, and $\cos\theta\approx 1$ are valid.
[0048] In the examples, a first lens refers to a lens most adjacent to an object (or a subject), and a fifth lens refers to a lens most adjacent to an imaging plane (or an image sensor). In the examples, units of a radius of curvature, a thickness, a TL (a distance from an object-side surface of a first lens (or a frontmost lens) to an imaging plane), an IMGHT (one-half of a diagonal length of an imaging plane), and a focal length are indicated in millimeters (mm). A thickness of a lens, a gap between lenses, and a TL refer to a distance of a lens in an optical axis. Also, in the descriptions of a shape of a lens, the configuration in which one surface is convex indicates that an optical axis region of the surface is convex, and the configuration in which one surface is concave indicates that an optical axis region of the surface is concave. Thus, even when it is described that one surface of a lens is convex, an edge of the lens may be concave. Similarly, even when it is described that one surface of a lens is concave, an edge of the lens may be convex.
[0049] An optical imaging system according to the present disclosure may adjust ray aberration of light, reaching an image sensor, using a non-rotationally symmetrical reflection member. For example, an optical imaging system may include a reflection member having a free curved surface.
[0050] An optical imaging system according to examples described herein may be mounted on a camera module for a portable terminal device. However, the application range of an optical imaging system is not limited to a camera module for a portable terminal device. In addition, an optical imaging system according to the examples described herein may be selectively applied to a plurality of camera modules. As an example, an optical imaging system may be applied to one camera module, among two or more camera modules mounted on a portable terminal device. As another example, an optical imaging system according to the examples described herein may be applied to one or more camera modules, among three or more camera modules mounted on a portable terminal device.
[0051] Hereinafter, an optical imaging system according to one or more examples will be described.
[0052] An optical imaging system according to an example may include a plurality of lenses and a

plurality of reflection members. For example, the optical imaging system may include a first lens, a second lens, a third lens, a fourth lens, and a fifth lens disposed in order from an object side. In addition, the optical imaging system may include a first reflection member and a second reflection member. The first reflection member and the second reflection member may be disposed to be closer to an object than the first to fifth lenses. For example, the first reflection member and the second reflection member may be disposed on an object side of the first lens. The first reflection member and the second reflection member may be configured to facilitate aberration correction. For example, the first reflection member and the second reflection member may be formed to have a freeform surface.

[0053] Each of the first reflection member and the second reflection member may be configured to have refractive power. For example, the first reflection member may have positive refractive power because a reflective surface thereof is formed to be concave, and the second reflection member may have negative refractive power because a reflective surface thereof is formed to be convex.

[0054] The optical imaging system according to an example may further include an optical path folding member. The optical path folding member may be disposed on the object side of the first reflection member. The optical path folding member may be configured in the form of a prism, a reflective mirror, or the like.

[0055] An optical imaging system according to another example may include a lens group, an optical path folding member, and a reflection element. The lens group may include a plurality of lenses. For example, the lens group may include two or more lenses disposed in order along an optical axis. The lens group may establish a predetermined numerical relationship with the optical imaging system. For example, a ratio of a focal length f of the optical imaging system to a focal length fL of the lens group (f/fL) may be greater than 1.40 to less than 1.80. The optical path folding member may be disposed on an object side of the lens group, and may be configured to bend an optical path between an object and the lens group. The optical path folding member may be in the form of a prism. The reflection element may include a plurality of reflection members. For example, the reflection element may include a first reflection member and a second reflection member. The reflection element may be configured to have a freeform surface. For example, a reflective surface of the first reflection member and a reflective surface of the second reflection member may be formed as freeform surfaces, respectively.

[0056] Hereinafter, features of the reflection members and the lenses, constituting the optical imaging system according to the present disclosure, will be described.

[0057] Each of the first reflection member and the second reflection member may be formed to have a curved surface. For example, the first reflection member may have a concave shape, and the second reflection member may have a convex shape.

[0058] The first lens may have refractive power. One surface of the first lens may be convex. For example, the first lens may have a convex object-side surface. The first lens may have an aspherical surface. For example, both surfaces of the first lens may be aspherical. The first lens may have a predetermined refractive index. For example, the refractive index of the first lens may be 1.5 or more to less than 1.6.

[0059] The second lens may have refractive power. One surface of the second lens may be concave. For example, the second lens may have a concave object-side surface. The second lens may have an aspherical surface. For example, both surfaces of the second lens may be aspherical. The second lens may have a predetermined refractive index. For example, the refractive index of the second lens may be 1.6 or more to less than 1.7.

[0060] The third lens may have refractive power. One surface of the third lens may be convex. For example, the third lens may have a convex object-side surface. The third lens may have an aspherical surface. For example, both surfaces of the third lens may be aspherical. The third lens may have a predetermined refractive index. For example, the refractive index of the first lens may be 1.6 or more to less than 1.7. The third lens may have a predetermined Abbe number. For

example, the Abbe number of the third lens may be 15 or more to less than 20.
[0061] The fourth lens may have refractive power. One surface of the fourth lens may be convex. For example, the fourth lens may have a convex object-side surface. The fourth lens may have an aspherical surface. For example, both surfaces of the fourth lens may be aspherical. The fourth lens may have a predetermined refractive index. For example, the refractive index of the fourth lens may be 1.6 or more to less than 1.7.
[0062] The fifth lens may have refractive power. One surface of the fifth lens may be concave. For example, the fifth lens may have a concave object-side surface. The fifth lens may have an aspherical surface. For example, both surfaces of the fifth lens may be aspherical. The fifth lens may have a predetermined refractive index. For example, the refractive index of the fifth lens may be 1.5 or more to less than 1.6.
[0063] A lens, constituting an optical imaging system, is formed of a material having a refractive index different from a refractive index of air. For example, the lens may be formed of a plastic material or a glass material. As described above, each of the first to fifth lenses may have an aspherical surface. An aspherical surface of a lens may be represented by Equation 1 as below:
[00001]

$$Z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}} + Ar^4 + Br^6 + Cr^8 + Dr^{10} + Er^{12} + Fr^{14} + Gr^{16} + Hr^{18} + Jr^{20} \quad \text{(Equation1)}$$

[0064] In equation 1, “c” is an inverse of a radius of a curvature of a respective lens, “k” is a conic constant, “r” is a distance from a certain point on an aspherical surface of the lens to an optical axis, “A” to “H” and “J” are aspheric constants, “Z” (or SAG) is a height from a certain point on an aspherical surface to an apex of the aspherical surface in an optical axis direction.
[0065] The optical imaging system may further include a filter, a stop, and an image sensor.
[0066] The filter may be disposed between the image sensor and a lens disposed to be closest to an image surface of the image sensor. The filter may block some wavelengths from incident light to improve a resolution of the optical imaging system. For example, the filter may block infrared wavelengths of incident light. The image sensor may be configured to convert an optical signal (optical image) into an electrical signal. The image surface of the image sensor may form an imaging plane disposed at the imaging plane of the optical imaging system.
[0067] The optical imaging system may further include a third reflection member, as necessary.
[0068] The third reflection member may be disposed between the lens group and the image sensor. For example, the third reflection member may be disposed between the image sensor and the fifth lens disposed to be closest to the image surface to bend an optical path between the fifth lens and the image sensor.
[0069] The optical imaging system may satisfy one or more of the following conditional expressions.

[00002]

$$0.4 < TL / f < 0.9$$
$$1.4 < f / fL < 1.8$$
$$0.7 < f / fm1 < 1.4$$
$$-3. < f / fm2 < -1.$$
$$0.4 < fL / fm1 < 0.8$$
$$-1.6 < fL / fm2 < -0.4$$
$$4. < f / f1 < 8.$$
$$-6. < f / f2 < -3.$$
$$1.2 < f / f3 < 2.$$
$$-1. < f / f4 < 2.$$
$$-8. < f / f5 < -2.$$
$$1. < f / f12 < 1.8$$
$$-3. < f / f345 < 3.$$

[0070] In the above conditional expressions, TL is a distance from an object-side surface of the first lens to an imaging plane, f is a focal length of the optical imaging system, fL is a focal length of the lens group, fm1 is a focal length of the first reflection member, fm2 is a focal length of the second reflection member, f1 is a focal length of the first lens, f2 is a focal length of the second lens, f3 is a focal length of the third lens, and f4 is a focal length of the fourth lens, f5 is a focal length of the fifth lens, f12 is the combined focal length of the first lens and the second lens, and f345 is a composite focal length of the third to fifth lenses.
[0071] In the description below, various examples of an optical imaging system will be described.
[0072] Hereinafter, an optical imaging system **100** according to a first example will be described with reference to FIG. **1**.
[0073] The optical imaging system **100** may include an optical path folding member P, a reflection element M, and a lens group **102**.
[0074] The optical path folding member P may be disposed in a frontmost position of the optical imaging system **100**. The optical path folding member P may be configured to bend a path of light incident on the optical imaging system **100**. For example, the optical path folding member P may refract or reflect a path of light, incident along an optical axis OP, in a direction of a first optical axis C**1** intersecting the optical axis OP. In the drawings of the optical path OP, the optical path OP may be in the direction of view and thus represented by a dot. The optical path folding member P may be configured in the form of a prism. However, the shape of the optical path folding member P is not limited to the prism. For example, the optical path folding member P may be configured in the form of a reflective mirror.
[0075] The reflection element M may be disposed between the optical path folding member P and the lens group **102**. The reflection element M may bend the optical path between the optical path folding member P and the lens group **102** to reduce an external size of the optical imaging system **100**. The reflection element M may include a first reflection member M**1** and a second reflection member M**2**.
[0076] The first reflection member M**1** may be configured to reflect light, emitted from the optical path folding member P, to the second reflection member M**2**. For example, the first reflection member M**1** may reflect light, incident along the first optical axis C**1**, in a direction of a second optical axis C**2**. The first reflection member M**1** may be formed to have a curved shape. For example, a reflective surface of the first reflection member M**1** may be concave. The first reflection member M**1** may have a freeform surface. For example, at least a portion of the reflective surface of the first reflection member M**1** may be formed as a freeform surface. The first reflection member M**1** may have predetermined refractive power. For example, the first reflection member M**1** may have positive refractive power.
[0077] The second reflection member M**2** may be configured to reflect light, incident from the first reflection member M**1**, to the lens group **102**. For example, the second reflection member M**2** may reflect light, incident along the second optical axis C**2**, in a direction of a third optical axis C**3**. The second reflection member M**2** may be formed to have a curved shape. For example, a reflective surface of the second reflection member M**2** may be convex. The second reflection member M**2** may have a freeform surface. For example, at least a portion of the reflective surface of the second reflection member M**2** may be formed as a freeform surface. The second reflection member M**2** may have predetermined refractive power. For example, the second reflection member M**2** may have negative refractive power.
[0078] The lens group **102** may include a plurality of lenses. For example, the lens group **102** may include a first lens **110**, a second lens **120**, a third lens **130**, a fourth lens **140**, and a fifth lens **150** disposed in order along the third optical axis C**3**.
[0079] The first lens **110** may have positive refractive power. The first lens **110** may have a convex object-side surface and a convex image-side surface. The second lens **120** may have negative refractive power. The second lens **120** may have a concave object-side surface and a concave

image-side surface. The third lens **130** may have positive refractive power. The third lens **130** may have a convex object-side surface and a concave image-side surface. The fourth lens **140** may have positive refractive power. The fourth lens **140** may have a convex object-side surface and a concave image-side surface. The fifth lens **150** may have negative refractive power. The fifth lens **150** may have a concave object-side surface and a concave image-side surface. An inflection point may be formed on the image-side surface of the fifth lens **150**.
[0080] The optical imaging system **100** includes a filter IF and an image sensor IP.
[0081] The filter IF may be disposed in front of the image sensor IP to block infrared rays, or the like, included in the incident light. The image sensor IP may include a plurality of optical sensors. The above-described image sensor IP may be configured to convert an optical signal into an electric signal.
[0082] Lens characteristics of the optical imaging system **100** according to the first example are listed in Table 1, aspherical values of the optical imaging system **100** according to the first example are listed in Table 2, and FIG. **2** is a view illustrating aberration curves of the optical imaging system **100** according to the first example.
TABLE-US-00001 TABLE 1 Surface Radius of Thickness/ Refractive Abbe No. Note Curvature Distance Index Number S1 Prism infinity 2.6300 1.722 29.500 S2 infinity 2.6300 S3 infinity 6.6400 S4 First Reflection −54.773 5.9550 1.298 100.000 Member S5 infinity 5.9550 S6 Second Reflection 31.33 5.0000 1.298 100.000 Member S7 infinity 1.5000 S8 First Lens 4.906 2.4380 1.534 55.650 S9 −5.836 0.0330 S10 Second Lens −7.205 0.2000 1.615 25.960 S11 8.443 1.4380 S12 Third Lens 4.836 0.5000 1.670 19.240 S13 6.676 2.9800 S14 Fourth Lens 12.42 0.3000 1.615 25.960 S15 162.239 1.6290 S16 Fifth Lens −3.314 0.4090 1.544 56.110 S17 6.503 1.4950 S18 Filter infinity 0.2800 1.519 64.200 S19 infinity 1.7970 S20 Imaging Plane infinity −0.0020
TABLE-US-00002 TABLE 2 Surface No. S8 S9 S10 S11 S12 K 0.68593991 0 0 0 0 A 0.00034719 −0.00008610 −0.00378702 −0.00226927 0.00079701 B 0.00000738 0.00042496 0.00123659 0.00038932 −0.00047113 C −0.00000517 −0.00007730 −0.00020181 −0.00003772 0.00010189 D 0.00000103 0.00000604 0.00001460 −0.00000042 −0.00000924 E −0.00000006 −0.00000016 −0.00000037 0.00000013 0.00000030 Surface No. S13 S14 S15 S16 S17 K 0 0 0 0 0 A −0.0012575 −0.0083559 −0.0013634 0.0227965 −0.0083414 B 0.0000598 −0.0013373 −0.0018170 −0.0279200 −0.0072253 C 0.0000016 0.0013471 0.0014167 0.0087864 0.0014776 D −0.0000008 −0.0003399 −0.0003368 −0.0010929 −0.0000062 E 0.0000000 0.0000282 0.0000284 0.0000471 −0.0000104
[0083] Hereinafter, an optical imaging system **200** according to a second example will be described with reference to FIG. **3**.
[0084] The optical imaging system **200** may include an optical path folding member P, a reflection element M, and a lens group **202**.
[0085] The optical path folding member P may be disposed in a frontmost position of the optical imaging system **200**. The optical path folding member P may be configured to bend a path of light incident to the optical imaging system **200**. For example, the optical path folding member P may refract or reflect a path of light, incident along an optical axis OP, in a direction of a first optical axis C**1** intersecting the optical axis OP. The optical path folding member P may be configured in the form of a prism. However, the shape of the optical path folding member P is not limited to the prism. For example, the optical path folding member P may be configured in the form of a reflective mirror.
[0086] The reflection element M may be disposed between the optical path folding member P and the lens group **202**. The reflection element M may bend an optical path between the optical path folding member P and the lens group **202** to reduce an external size of the optical imaging system **200**. The reflection element M may include a first reflection member M**1** and a second reflection member M**2**.
[0087] The first reflection member M**1** may be configured to reflect light, emitted from the optical

path folding member P, to the second reflection member M**2**. For example, the first reflection member M**1** may reflect light, incident along the first optical axis C**1**, in a direction of a second optical axis C**2**. The first reflection member M**1** may be formed to have a curved shape. For example, a reflective surface of the first reflection member M**1** may be concave. The first reflection member M**1** may have a freeform surface. For example, at least a portion of the reflective surface of the first reflection member M**1** may be formed as a freeform surface. The first reflection member M**1** may have predetermined refractive power. For example, the first reflection member M**1** may have positive refractive power.

[0088] The second reflection member M**2** may be configured to reflect light, incident from the first reflection member M**1**, to the lens group **202**. For example, the second reflection member M**2** may reflect light, incident along a second optical axis C**2**, in a direction of a third optical axis C**3**. The second reflection member M**2** may be formed to have a curved shape. For example, a reflective surface of the second reflection member M**2** may be convex. The second reflection member M**2** may have a freeform surface. F or example, at least a portion of the reflective surface of the second reflection member M**2** may be formed as a freeform surface. The second reflection member M**2** may have predetermined refractive power. For example, the second reflection member M**2** may have negative refractive power.

[0089] The lens group **202** may include a plurality of lenses. For example, the lens group **202** includes a first lens **210**, a second lens **220**, a third lens **230**, a fourth lens **240**, and a fifth lens **250** disposed in order along the third optical axis C**3**.

[0090] The first lens **210** may have positive refractive power. The first lens **210** may have a convex object-side surface and a convex image-side surface. The second lens **220** may have negative refractive power. The second lens **220** may have a concave object-side surface and a concave image-side surface. The third lens **230** may have positive refractive power. The third lens **230** may have a convex object-side surface and a concave image-side surface. The fourth lens **240** may have negative refractive power. The fourth lens **240** may have a convex object-side surface and a concave image-side surface. The fifth lens **250** may have negative refractive power. The fifth lens **250** may have a concave object-side surface and a convex image-side surface. An inflection point may be formed on the image-side surface of the fifth lens **250**.

[0091] The optical imaging system **200** may include a filter IF and an image sensor IP.

[0092] The filter IF may be disposed in front of the image sensor IP to block infrared rays, or the like, included in the incident light. The image sensor IP may include a plurality of optical sensors. The above-described image sensor IP may be configured to convert an optical signal into an electric signal.

[0093] Lens characteristics of the optical imaging system **200** according to the second example are listed in Table 3, aspherical values of the optical imaging system **200** according to the second example are listed in Table 4, and FIG. **4** is a view illustrating aberration curves of the optical imaging system **200** according to the second example.

TABLE-US-00003 TABLE 3 Surface Radius of Thickness/ Refractive Abbe No. Note Curvature Distance Index Number S1 Prism infinity 2.6300 1.722 29.500 S2 infinity 2.6300 S3 infinity 5.0000 S4 First Reflection −66.106 6.5000 1.298 100.000 Member S5 infinity 6.5000 S6 Second Reflection 40.19 5.0000 1.298 100.000 Member S7 infinity 1.5134 S8 First Lens 4.747 1.8124 1.534 55.650 S9 −5.596 0.0300 S10 Second Lens −7.417 0.8129 1.615 25.960 S11 5.418 1.1341 S12 Third Lens 6.101 0.5191 1.670 19.240 S13 20.409 2.8518 S14 Fourth Lens 16.883 0.2000 1.615 25.960 S15 12.386 2.6397 S16 Fifth Lens −4.028 0.4296 1.544 56.110 S17 −15.53 1.2299 S18 Filter infinity 0.2295 1.519 64.200 S19 infinity 1.5957 S20 Imaging Plane infinity −0.0017

TABLE-US-00004 TABLE 4 Surface No. S8 S9 S10 S11 S12 K 0.6859399 0 0 0 0 A 0.0004901 0.0001193 −0.0043659 −0.0041689 −0.0009391 B −0.0000117 0.0006860 0.0015988 0.0012015 0.0004363 C −0.0000058 −0.0001415 −0.0003086 −0.0002737 −0.0001074 D 0.0000022 0.0000121 0.0000267 0.0000273 0.0000107 E −0.0000002 −0.0000004 −0.0000008 −0.0000010

−0.0000004 Surface No. S13 S14 S15 S16 S17 K 0 0 0 0 0 A −0.00212730 −0.01136750 −0.00631775 −0.01175663 −0.00927392 B 0.00042022 0.00024121 0.00106880 0.01196813 0.00189419 C −0.00008452 0.00093314 0.00065764 −0.00453065 −0.00012979 D 0.00000748 −0.00030695 −0.00024974 0.00080815 −0.00005190 E −0.00000020 0.00003100 0.00002886 −0.00005476 0.00000706

[0094] Hereinafter, an optical imaging system according to a third example will be described with reference to FIG. **5**.

[0095] The optical imaging system **300** may include an optical path folding member P, a reflection element M, and a lens group **302**.

[0096] The optical path folding member P may be disposed in a frontmost position of the optical imaging system **300**. The optical path folding member P may be configured to bend a path of light incident to the optical imaging system **300**. For example, the optical path folding member P may refract or reflect a path of light, incident along an optical axis OP, in a direction of a first optical axis C**1** intersecting the optical axis OP. The optical path folding member P may be configured in the form of a prism. However, the shape of the optical path folding member P is not limited to the prism. For example, the optical path folding member P may be configured in the form of a reflective mirror.

[0097] The reflection element M may be disposed between the optical path folding member P and the lens group **302**. The reflection element M may bend an optical path between the optical path folding member P and the lens group **302** to reduce an external size of the optical imaging system **300**. The reflection element M may include a first reflection member M**1** and a second reflection member M**2**.

[0098] The first reflection member M**1** may be configured to reflect light, emitted from the optical path folding member P, to the second reflection member M**2**. For example, the first reflection member M**1** may reflect light, incident along the first optical axis C**1**, in a direction of a second optical axis C**2**. The first reflection member M**1** may be formed to have a curved shape. For example, the reflective surface of the first reflection member M**1** may be concave. The first reflection member M**1** may include a freeform surface. For example, at least a portion of the reflective surface of the first reflection member M**1** may be formed as a freeform surface. The first reflection member M**1** may have predetermined refractive power. For example, the first reflection member M**1** may have positive refractive power.

[0099] The second reflection member M**2** may be configured to reflect light, incident from the first reflection member M**1**, to the lens group **302**. For example, the second reflection member M**2** may reflect light, incident along the second optical axis C**2**, in a direction of a third optical axis C**3**. The second reflection member M**2** may be formed to have a curved shape. For example, the reflective surface of the second reflection member M**2** may be convex. The second reflection member M**2** may have a freeform surface. For example, at least a portion of the reflective surface of the second reflection member M**2** may be formed as a freeform surface. The second reflection member M**2** may have predetermined refractive power. For example, the second reflection member M**2** may have negative refractive power.

[0100] The lens group **302** may include a plurality of lenses. For example, the lens group **302** includes a first lens **310**, a second lens **320**, a third lens **330**, a fourth lens **340**, and a fifth lens **350** disposed in order along the third optical axis C**3**.

[0101] The first lens **310** may have positive refractive power. The first lens **310** may have a convex object-side surface and a convex image-side surface. The second lens **320** may have negative refractive power. The second lens **320** may have a concave object-side surface and a concave image-side surface. The third lens **330** may have positive refractive power. The third lens **330** may have a convex object-side surface and a concave image-side surface. The fourth lens **340** may have positive refractive power. The fourth lens **340** may have a convex object-side surface and a concave image-side surface. The fifth lens **350** may have negative refractive power. The fifth lens **350** may have a concave object-side surface and a concave image-side surface. An inflection point may be formed on the image-side surface of the fifth lens **350**.

[0102] The optical imaging system **300** may further include a third reflection member M**3**. The third reflection member M**3** may be disposed between the fifth lens **350**, disposed on a rearmost side of the lens group **302**, and the image sensor IP to bend an optical path. For example, the third reflection member M**3** may reflect light, incident along the third optical axis C**3**, in a direction of a fourth optical axis C**4**.

[0103] The optical imaging system **300** may include a filter IF and an image sensor IP.

[0104] The filter IF may be disposed in front of the image sensor IP to block infrared rays, or the like, included in the incident light. The image sensor IP may include a plurality of optical sensors. The above-described image sensor IP may be configured to convert an optical signal into an electric signal.

[0105] Lens characteristics of the optical imaging system **300** according to the third example are listed in Table 5, aspherical values of the optical imaging system **300** according to the third example are listed in Table 6, and FIG. **6** is a view illustrating aberration curves of the optical imaging system **300** according to the third example.

TABLE-US-00005 TABLE 5 Surface Radius of Thickness/ Refractive Abbe No. Note Curvature Distance Index Number S1 Prism infinity 2.6300 1.722 29.500 S2 infinity 2.6300 S3 infinity 4.8271 S4 First Reflection −61.383 5.8405 1.298 100.000 Member S5 infinity 5.8405 S6 Second Reflection 37.975 5.0000 1.298 100.000 Member S7 infinity 1.5000 S8 First Lens 5.009 2.4279 1.534 55.650 S9 −6.038 0.0300 S10 Second Lens −7.601 0.2500 1.615 25.960 S11 6.79 1.7548 S12 Third Lens 5.673 0.5525 1.670 19.240 S13 10.37 2.9827 S14 Fourth Lens 18.246 0.4442 1.615 25.960 S15 115.25 1.5579 S16 Fifth Lens −3.714 0.2000 1.544 56.110 S17 117.467 3.4949 S18 Third Reflection infinity 6.2302 Member S19 Filter infinity 0.2800 1.519 64.200 S20 infinity 4.4694 S21 Imaging Plane infinity −0.0021

TABLE-US-00006 TABLE 6 Surface No. S8 S9 S10 S11 S12 K 0.6859399 0 0 0 0 A 0.0004403 0.0000076 −0.0036587 −0.0024304 0.0003933 B −0.0000149 0.0003737 0.0011680 0.0005014 −0.0001823 C −0.0000019 −0.0000650 −0.0001892 −0.0000640 0.0000365 D 0.0000008 0.0000049 0.0000136 0.0000016 −0.0000025 E 0.0000000 −0.0000001 −0.0000003 0.0000001 0.0000000 Surface No. S13 S14 S15 S16 S17 K 0 0 0 0 0 A −0.0013467 −0.0046307 0.0035661 0.0152888 0.0012432 B 0.0000625 −0.0033710 −0.0057502 −0.0205293 −0.0127683 C −0.0000048 0.0016937 0.0026297 0.0063692 0.0038696 D 0.0000007 −0.0003354 −0.0005000 −0.0008241 −0.0004879 E −0.0000001 0.0000240 0.0000376 0.0000408 0.0000232

[0106] Optical characteristics and conditional expression values of the optical imaging systems according to the first to third examples are listed in Tables 7 and 8.

TABLE-US-00007 TABLE 7 Note First Example Second Example Third Example fm1 27.3800 33.0500 30.6900 fm2 −15.6600 −20.0900 −18.9900 f1 5.4170 5.119 5.5488 f2 −6.2905 −4.9711 −5.7930 f3 23.5878 12.7891 17.8336 f4 21.8528 −76.918 35.1874 f5 −3.9764 −10.1294 −6.6135 TL 13.5010 13.4864 24.6724 f 31.6000 25.0000 30.0000 fL 18.4600 15.2000 18.5450

TABLE-US-00008 TABLE 8 Conditional Expression First Example Second Example Third Example TL/f 0.42725 0.53946 0.82241 f/fL 1.71181 1.64474 1.61769 f/fm1 1.15413 0.75643 0.97752 f/fm2 −2.01788 −1.24440 −1.57978 fL/fm1 0.67421 0.45991 0.60427 fL/fm2 −1.17880 −0.75660 −0.97657 |fm1/fm2| 1.74840 1.64510 1.61611 f/f1 5.8335 4.8838 5.4066 f/f2 −5.0234 −5.0291 −5.1787 f/f3 1.3397 1.9548 1.6822 f/f4 1.4460 −0.3250 0.8526 f/f5 −7.9469 −2.4681 −4.5362 f/f12 1.75100 1.22400 1.19200 f/f345 −2.81800 2.58160 −0.54800

[0107] As described above, an image of a long-range subject may be captured and a camera module may be miniaturized.

[0108] While specific examples have been illustrated and described above, it will be apparent after an understanding of this disclosure that various changes in form and details may be made in these examples without departing from the spirit and scope of the claims and their equivalents. The examples described herein are to be considered in a descriptive sense only, and not for purposes of limitation. Descriptions of features or aspects in each example are to be considered as being applicable to similar features or aspects in other examples. Suitable results may be achieved if the described techniques are performed in a different order, and/or if components in a described system, architecture, device, or circuit are combined in a different manner, and/or replaced or supplemented by other components or their equivalents. Therefore, the scope of the disclosure is to be defined not by the detailed description, but by the claims and their equivalents, and all variations within the scope of the claims and their equivalents are to be construed as being included in the disclosure.

Claims

1. An optical imaging system, comprising: a first lens, a second lens, a third lens, a fourth lens, and a fifth lens disposed in order from an object side toward an imaging plane; and a first reflection member and a second reflection member, disposed on an object side of the first lens, each of the first reflection member and the second reflection member having a freeform surface, wherein $1.4 < f / fL < 1.8$, where f is a focal length of the optical imaging system, and fL is a composite focal length of the first to fifth lenses.

2. The optical imaging system of claim 1, wherein the first reflection member has a concave reflective surface.

3. The optical imaging system of claim 1, wherein the second reflection member has a convex reflective surface.

4. The optical imaging system of claim 1, wherein the first lens has a convex object-side surface.

5. The optical imaging system of claim 1, wherein the fourth lens has a convex object-side surface.

6. The optical imaging system of claim 1, wherein the fifth lens has a concave object-side surface.

7. The optical imaging system of claim 1, further comprising: an optical path folding member disposed on the object side of the first reflection member.

8. The optical imaging system of claim 1, further comprising: a third reflection member disposed between the fifth lens and an imaging plane.

9. The optical imaging system of claim 1, wherein: $0.8 < fm1 / f < 1.4$, where fm1 is a focal length of the first reflection member.

10. The optical imaging system of claim 1, wherein: $-1. < fm2 / f < -0.4$, where fm2 is a focal length of the second reflection member.

11. The optical imaging system of claim 1, wherein: 1.4 < .Math. fm1 / fm2 .Math. < 1.8, where fm1 is a focal length of the first reflection member, and fm2 is a focal length of the second reflection member.

12. The optical imaging system of claim 1, wherein: $0.4 < TL / f < 0.9$, where TL is a distance from an object-side surface of the first lens to an imaging plane.